THE GLOBALIZATION OF R&D AND INNOVATION, PARTS I–IV

HEARINGS

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY

ONE HUNDRED TENTH CONGRESS

FIRST SESSION

June 12, 2007,
July 26, 2007
October 4, 2007,
and November 6, 2007

Serial No. 110–39,
Serial No. 110–49,
Serial No. 110–62,
and Serial No. 110–71

Printed for the use of the Committee on Science and Technology

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THE GLOBALIZATION OF R&D AND INNOVATION, PART I

TUESDAY, JUNE 12, 2007

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The Committee met, pursuant to call, at 1:10 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Bart Gordon [Chairman of the Committee] presiding.

BART GORDON, TENNESSEE
CHAIRMAN

RALPH M. HALL, TEXAS
RANKING MEMBER

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COMMITTEE ON SCIENCE AND TECHNOLOGY

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Hearing on:

The Globalization of R&D and Innovation

2318 Rayburn House Office Building
Washington, D.C.

June 12, 2007
1:00 p.m.

WITNESS LIST

Dr. Alan Blinder
Director
Center for Economic Policy Studies
Princeton University

Dr. Martin Baily
Senior Fellow
Peter G. Peterson Institute for International Economics

Dr. Ralph Gomory
President
Alfred P. Sloan Foundation

Dr. Thomas J. Duesterberg
President and CEO
Manufacturers Alliance/MAPI

HEARING CHARTER

COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

The Globalization of R&D and Innovation, Part I

TUESDAY, JUNE 12, 2007
1:00 P.M.–3:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose

On Tuesday, June 12, 2007, the Committee on Science and Technology will hold a hearing to consider the implications of innovation offshoring for U.S. workers and the economy. Technological innovation is the key to improving America's standard of living, but science and engineering work—the fundamental building block of innovation—has become increasingly vulnerable to offshoring. This hearing will explore the implications of this trend on the U.S. workforce, the U.S. science and engineering education pipeline, competitiveness, economic growth, and our innovation system.

2. Witnesses

Dr. Alan S. Blinder is Professor of Economics at Princeton University and director of Princeton's Center for Economic Policy Studies. He served as Vice Chairman of the Board of Governors of the Federal Reserve System from June 1994 until January 1996.

Dr. Ralph E. Gomory is President of the Alfred P. Sloan Foundation. He was Director of Research at IBM Corporation from 1970 to 1986.

Dr. Martin N. Baily is senior fellow at the Peterson Institute for International Economics and senior adviser to McKinsey Global Institute. He was Chair of the President's Council of Economic Advisers from 1999 to 2001.

Dr. Thomas J. Duesterberg is the President and CEO of the Manufacturers Alliance/MAPI.

3. Brief Overview

- Some analysts estimate that between 30 to 40 percent of *all* U.S. jobs will be vulnerable to offshoring. This vulnerability means that a large share of previously non-tradable jobs are now tradable, putting downward pressures on wages for U.S. workers in those occupations. Other analysts dispute these estimates, claiming they are too high.
- Science, technology, engineering and mathematics (STEM) jobs are amongst the most vulnerable to offshoring, with computer programming topping the list of all occupations. According to a study conducted by Alan Blinder, nearly all (35 of 39) STEM occupations are offshorable, including 10 of 12 engineering disciplines.
- High-wage jobs, requiring advanced education and skills, are also offshorable, so more education and training will not necessarily immunize workers against offshoring. Instead, some have suggested that we refocus our educational investments towards training for jobs that will be difficult to offshore.
- There is no consensus on the likely impacts of offshoring. Some argue that it will be as dramatic as the industrial revolution, requiring significant policy changes, while others view it as a minor phenomenon. The ambiguity is aggravated by the very poor quality data we have about offshoring.
- China, India and other developing countries have government policies to actively attract innovation jobs and work. For example, the Chinese government often requires technology transfer as a condition on investments in China by multinational corporations, and India offers tax holidays for any exports from its information technology services industry.

3. Background

Several analysts, using a variety of estimating methods, have separately concluded that a significant share of U.S. jobs is vulnerable to offshoring. Vulnerability means that jobs that were once safe from being relocated offshore or competition from workers in other countries are no longer so. While the independent estimates by economists such as Alan Blinder, Lori Kletzer, Robert Atkinson, and Ashok Bardhan, cover a wide range, from 20 to 40 percent of U.S. jobs, even the low-end estimates indicate that tens of millions of jobs can be affected by offshoring. Dr. Blinder finds that *nearly all (35 of 39) STEM occupations are offshorable.* Particular occupations are highly vulnerable. For example, seven of the 11 computer-related occupations are considered highly vulnerable, with computer programming topping the list for *all* occupations. Dr. Blinder also finds that 10 of the 12 engineering occupations are offshorable, including biomedical and electronics engineering; fields where the U.S. currently holds technological leadership. The two exceptions are aerospace and health and safety engineering.

Newspaper reports and company announcements seem to confirm that the offshoring of high-skill high-technology work is increasing, with even research moving offshore. For example, Accenture's CEO announced that it will have more workers in India than any other country, including the U.S., by this August. And IBM is projected to have 100,000 workers in India by 2010, more than one-quarter of its workforce, rivaling the U.S. as the leading country for workers. At the same time, firms are investing in plants and R&D facilities in low-cost countries. Companies like General Electric, Eli Lilly, Google, and Microsoft are expanding R&D centers in India and China, which will work on cutting edge research and new product development rivaling their centers in the U.S. A recent University of Texas study found that of the 57 major announcements of locations of global telecom R&D facilities in the past year, more than 60 percent (35) were located in Asia, whereas, a meager nine percent (five) were located in the U.S.

The consequences of these changes are still being sorted out. Some predict that in the long run we will be better off at the new equilibrium, but the road to that new equilibrium will be very bumpy, causing great hardships for many. Others agree that the new equilibrium will be better but also assert that the scale and speed of offshoring has been exaggerated. They emphasize the flexibility of the U.S. economy and labor markets, buffering workers from any significant hardships, and they point to all of the new opportunities and markets that globalization create. Still others disagree with the notion that the new equilibrium for the U.S. will actually be better with offshoring. They say losing our technological leadership in STEM fields could make us worse off as offshoring erodes our comparative advantages.

Nearly everyone agrees about a few things. First, the quality of the data on offshoring is very poor. This makes it difficult to discern the trajectory for offshoring. Second, technologically driven innovation is the key to improving America's standard of living. Third, STEM education will play a key role in our future competitiveness. But according to the Computing Research Association (CRA), enrollment in computer science programs is down an astounding 40 percent over the past four years. One of the reasons that students shy away from these and other STEM majors is the fear and uncertainty surrounding long-term career stability. In response to concerns about offshoring, a number of universities have changed course curricula for vulnerable fields. Some are substituting management courses for technical ones or creating interdisciplinary programs; for example, integrating biology into traditional electrical engineering curricula. Both measures are predicated on the hope that they will better inoculate students from offshoring. However, the changes are based on little objective information, leaving open the question of whether students, educators, and workers are making informed decisions.

4. Issues and Concerns

What is the scale and the scope of offshoring in science and engineering jobs and work? What is its potential?

The amount of offshoring will determine the impact on the U.S., but we do not have reliable data and forecasts. Some analysts believe that offshoring's impact will be something akin to the industrial revolution, while others claim it is too small to worry about.

What are offshoring's expected effects on the U.S. economy and workforce?

While many believe that increased international trade guarantees a 'win-win' for both countries, economic theory is more ambiguous. A country that loses its comparative advantages to trading partners can experience lower standards of living. Given that science and engineering is our core competency and drives our comparative advantages, will offshoring R&D and innovation undercut these advantages, resulting in losses for the U.S. as a whole?

How much R&D is being offshored?

A recent University of Texas study found that of the 57 major announcements of locations of global telecom R&D facilities in the past year, more than 60 percent (35) were located in Asia, whereas, a meager nine percent (five) were located in the U.S. Since innovation is key to economic growth, should we be especially concerned by these trends? Do we need policies to keep R&D in the U.S.? For R&D that is being done offshore, do we have the infrastructure to capture and assimilate it?

Does offshoring of science and engineering lead to lesser spillover benefits from R&D?

The primary rationale for government subsidies of R&D is the capture of downstream benefits by companies operating in the U.S. Does offshoring of science and engineering work mean that those benefits are more likely to quickly leak outside the country?

What policies are other countries using to attract innovation work?

China, India and other developing countries have government policies to actively attract innovation jobs and work. For example, the Chinese government often requires technology transfer as a condition on investments in China by multinational corporations, and India offers tax holidays for any exports from its information technology services industry. Do these policies meet the principles of free trade? Should we be adopting similar measures? What criteria do companies use to make decisions about locating their innovation work?

What STEM fields are most vulnerable?

Computer science undergraduate enrollments are down 40 percent in the past four years, but not because our K–12 education system has not adequately prepared students. Instead, the culprit has been fear by students that their future jobs might be offshored. Is this fear well-founded? Students, educators and workers need better data and estimates to make informed career and educational choices. How do we ensure that STEM fields are still attractive?

Should we be investing in all STEM fields or only those where we expect will be rooted in America?

Should a reallocation of resources be made to concentrate efforts on the fields that are most likely to stay in the U.S.? Should educators adjust their curricula to teach skills that buffer workers from offshoring? If so, what content should it have?

What happens to STEM workers who are displaced?

One of the expected outcomes of offshoring is displacement of incumbent STEM workers. How many of these workers re-enter the STEM workforce? At what pay level? Are STEM workers hurt even worse than the typical worker by extended periods of unemployment given how quickly technological obsolescence occurs?

Do corporate interests diverge from the country's long-term interest in offshoring?

Companies seek competitive advantages by moving operations offshore, but increasing the competitiveness of a company may not directly translate into increased competitiveness of the country. Where do these interests diverge and how should they be reconciled?

Chairman GORDON. Welcome, everyone, to this afternoon's hearing on the offshoring of research, development and innovation.

I also want to welcome our very distinguished witnesses. All are leading experts in the impacts of globalization, and we look forward to hearing your thoughts.

As is widely recognized, our competitiveness and our high standard of living are derived largely from our technological superiority. But almost on a daily basis, we read announcements that more high-tech jobs are being offshored to developing countries.

For example, Accenture's CEO announced that it will have more employees in India than in the United States by August.

At the same time, many firms are investing in R&D facilities in low-wage developing countries. These centers are working on cutting-edge research and new products development rivaling their U.S. centers. A recent University of Texas study, you will appreciate, found that of the 57 major announcements of locations of global technological R&D facilities in the past year, more than 60 percent were located in Asia versus a mere nine percent located in the United States.

But this seems to be only the tip of the iceberg. One of our witnesses, Dr. Alan Blinder, has estimated that more than one in four American jobs are vulnerable to offshoring. Even more striking is his finding that most American science and engineering jobs are vulnerable to offshoring.

We have already seen how offshoring is adversely affecting student choices to pursue science and technology careers. According to Computing Research Association, enrollment in undergraduate computer science programs has dropped an astonishing 40 percent over the last four years.

And I will make clear that I am not casting blame. Companies are simply responding to an increasingly globalized marketplace and high-tech workforce. What we want to do is make certain that companies find that the U.S. engineers, scientists and students are the best in the world. That is the Committee's goal. We want to make sure that we enact policies that keep us from having to offshore our future.

Unless the United States maintains its edge in innovation, which is founded on a well-trained, creative workforce, the best jobs may soon be found offshore. If current trends continue, for the first time in our nation's history our children may grow up with a lower standard of living than their parents.

There is no single cause for this concern being raised. There is no single policy prescription available to address them. But looking the other way and hoping for the best is irresponsible. The stakes are simply too high to adopt a "don't worry, be happy" approach.

In this Congress, we have already done a lot of work to address this set of issues. We have passed a number of legislative initiatives based on the recommendations of experts from the National Academies. But this should be viewed only as a necessary start. There is much more work to be done.

Today's hearing is the first in a series of fact-finding explorations of the implications of offshoring to U.S. competitiveness. We will listen to all sides, soliciting the best expertise and advice so that we can develop the policies that will lead to a strong economic future for our country.

[The prepared statement of Chairman Gordon follows:]

PREPARED STATEMENT OF CHAIRMAN BART GORDON

I want to welcome everyone to this afternoon's hearing on the offshoring of research and development and innovation.

I also welcome our distinguished witnesses—all are leading experts on the impacts of globalization. We look forward to hearing your thoughts on the impacts of offshoring science, engineering, and innovation jobs and work.

The Science and Technology Committee has been working hard to address one of the country's most pressing issues, U.S. competitiveness. We began addressing this issue in the 109th Congress, and are eager to continue our legislative and oversight work.

As is widely recognized, our competitiveness and high standard of living are derived largely from our technological superiority.

But almost on a daily basis we read announcements that more high-tech jobs are being offshored to developing countries.

For example, Accenture's CEO announced that it will have more employees in India than the U.S. by this August. And IBM is projected to have 100,000 workers in India by 2010, more than one-quarter of its worldwide workforce.

At the same time, firms are investing in R&D facilities in low-wage, developing countries. Companies like General Electric, Eli Lilly, Google, and Microsoft are expanding R&D centers in India and China. These centers are working on cutting edge research and new product development, rivaling their U.S. centers.

A recent University of Texas study recently found that of the 57 major announcements of locations of global telecom R&D facilities in the past year, more than 60 percent were located in Asia, versus a meager nine percent located in the U.S.

But this seems to be only the tip of the iceberg.

One of our witnesses, Dr. Alan Blinder, has estimated that more than one in four American jobs are vulnerable to offshoring. Even more striking is his finding that most American science and engineering jobs are vulnerable to offshoring.

We're already seeing how offshoring is adversely affecting student choices to pursue science and technology careers. According to the Computing Research Association, enrollment in undergraduate computer science programs has dropped an astonishing 40 percent over the past four years.

Are we offshoring our future?

I want to make clear that I'm not casting blame or making accusations. Companies are simply responding to an increasingly globalized marketplace and high-tech workforce.

What we want to do is make certain that companies find that U.S. engineers, scientists, and students are the best in the world. That is the Committee's goal. We want to make sure that we enact the policies that keep us from offshoring our future.

Unless the United States maintains its edge in innovation, which is founded on a well-trained, creative workforce, the best jobs may soon be found overseas. If current trends continue, for the first time in our nation's history our children may grow up with a lower standard of living than their parents.

Providing high-quality jobs for hard-working Americans must be our first priority. Indeed, it should be the central goal of any policy in Congress to advance U.S. competitiveness.

There is no single cause for the concerns being raised, and there is no single policy prescription available to address them.

But looking the other way and hoping for the best—not to mention suppressing government studies—is irresponsible. The stakes are simply too high to adopt a "don't worry be happy" approach.

In the last Congress and in the first hundred days of this Congress, we've already done a lot of work to address this set of issues. We fought hard to get an offshoring report released from the Commerce Department which the Administration tried to suppress, and we've passed a number of legislative initiatives based on the recommendations of experts from the National Academies. But this should be viewed only as a necessary start. There is much more work to be done.

Today's hearing is the first in a series of fact-finding explorations of the implications of offshoring on U.S. competitiveness. We will listen to all sides, soliciting the best expertise and advice, so that we can develop the policies that will lead to a strong economic future for our country.

Chairman GORDON. Now I would like to recognize my colleague, the Ranking Member from Texas, Mr. Hall, for an opening statement.

Mr. HALL. Mr. Chairman, I thank you, and this must be a special group here, a highly recognized group because it is the first time in my 27 years I have been here that they have given you 10 minutes to state your position, and I am anxious to hear it, so I will be as quick as I can—thank you, Mr. Chairman.

I appreciate you holding this hearing on globalization of R&D and innovation, an issue that is going to affect our country and economy as we know it for a lot of years to come, and this could be one of the most important hearings that we have had in a long, long time. I am looking forward to the hearing and the statements from all the witnesses, each of whom is considered an expert in the field, and I know it is going to be an educational and very informative debate.

I think what we hear today is going to dovetail with some of the testimony heard from the authors of *"Rising Above the Gathering Storm"* report, and a lot of people have argued that we really know very little about the types of jobs that are being offshored. Once upon a time, it was thought that only low-skilled jobs were in danger of being offshored. However, it seems that highly educated people in good-paying jobs are now just as threatened by the phenomenon of offshoring.

Last year China graduated 219,600 engineers representing 39 percent of all the Bachelor's degrees in that country. The United States, on the other hand, graduated only 59,500 engineers, or five percent of all the Bachelor's degrees. Furthermore, 58 percent of all degrees awarded last year in China were in physical sciences and engineering compared to 17 percent in the United States, a figure that is dropping by about one percent a year.

Of the U.S. science and technology workforce, 38 percent of the Ph.D.s were foreign born in the year 2000. I don't know what it has been in the years since that time, or if there are any figures on that, but in this global economy, our children are going to be competing head to head with Chinese and Indian students, but many say that they aren't taking the necessary classes or making their education work for them. When our children graduate from high school they have taken consistently fewer classes in math and science than their contemporaries across the globe. And yet, how much do we really know about offshoring?

Many have argued that we haven't adequately measured the effects of offshoring on our workers or on our economy. Our government needs to do a better job developing metrics that will give us the information we need to make informed decisions about trade and the economy.

Many jobs and many plants have been offshored over the past several years and we all know examples from our home states, but I think what is even more concerning is the amount of R&D that is being permanently offshored and will not be coming back to the United States.

As the authors of *"Rising Above the Gathering Storm"* wrote, and I quote, "It is easy to be complacent about U.S. competitiveness and preeminence in science and technology. We have led the world for decades and we continue to do so in many fields. But the world is changing rapidly, and our advantages are no longer unique."

So if we continue to lose our R&D and high-tech work to foreign competitors, we are going to have a long, steep hill to climb to keep our economy going.

Mr. Chairman, I still applaud you for holding this hearing to highlight the issue of globalization and offshoring and I look forward to working with you in subsequent hearings on this important issue, and I thank these four gentlemen for the time it took them to get to the position where they are as important as they are and to take their time off here to give us the benefits of their knowledge and the time it will take to get back to their homes today. I appreciate them and I appreciate you.

I yield back.

[The prepared statement of Mr. Hall follows:]

PREPARED STATEMENT OF REPRESENTATIVE RALPH M. HALL

Thank you Mr. Chairman. I appreciate you holding this hearing on the Globalization of R&D and Innovation. This issue will affect our county and economy for years to come. Indeed this may be one of the most important hearings we have all year.

I am looking forward to hearing the statements from all of the witnesses, each of whom is considered an expert in this field. I know this will be an educational, informative debate.

I think what we will hear today dovetails with some of the testimony heard from the authors of the *"Rising Above the Gathering Storm"* report.

Many people have argued that we really know very little about the types of jobs that are being offshored. Once upon a time it was thought that only low-skilled jobs were in danger of being offshored. However, it seems that highly educated people in good paying jobs are now just as threatened by the phenomena of offshoring.

Last year China graduated 219,600 engineers, representing 39 percent of all the Bachelor's degrees in that country. The U.S., on the other hand, graduated 59,500 engineers, or five percent of all Bachelor's degrees. Furthermore, 58 percent of all degrees awarded last year in China were in physical sciences and engineering, compared to 17 percent in the United States—a figure that is dropping by about one percent a year.

Moreover, of the U.S. science and technology workforce, 38 percent of the Ph.D.s were foreign born in 2000.

In this global economy our children will be competing head-to-head with Chinese and Indian students, but they aren't taking the necessary classes or making their education work for them. When our children graduate from high school they have taken consistently fewer classes in math and science than their contemporaries across the globe.

And yet, how much do we really know about offshoring?

Many have argued that we haven't adequately measured the effects of offshoring on our workers or our economy. Our government needs to do a better job developing metrics that give us the information we need to make informed decisions about trade and the economy.

Many jobs and many plants have been offshored over the past several years—we all know examples from our home states. But I think what is even more concerning is the amount of R&D that is being permanently offshored and will not be coming back to the U.S.

As the authors of *"Rising Above the Gathering Storm,"* write:

> *It is easy to be complacent about U.S. competitiveness and pre-eminence in science and technology. We have led the world for decades, and we continue to do so in many fields. But the world is changing rapidly, and our advantages are no longer unique.*

If we continue to lose our R&D and high tech work to foreign competitors, we will have a very steep hill to climb to keep our economy growing.

Mr. Chairman, I really applaud you holding this hearing to highlight the issue of globalization and offshoring. I look forward to working with you in the subsequent hearings on this important topic.

Chairman GORDON. Thank you, Mr. Hall. We will hear more about that University of Texas report today, too.

If there are additional Members who would wish to submit opening statements, your statements will be made a part of the record.

[The prepared statement of Mr. Carnahan follows:]

PREPARED STATEMENT OF REPRESENTATIVE RUSS CARNAHAN

Mr. Chairman, thank you for hosting this hearing to examine the implications of offshoring technological innovation on the U.S. workforce, STEM education, American competitiveness, and economic growth.

As American science and engineering jobs become increasingly vulnerable to offshoring, the predicted impact of such relocation is a matter of contention. Numerous analysts over the past few years have concluded that 30 to 40 percent of U.S. jobs may be susceptible to overseas outsourcing, threatening tens of millions of jobs. China, India, and other developing countries are actively seeking to attract high-skill high-technology jobs through government policies, threatening America's comparative advantage.

Today's hearing focuses on the expected effects of technology offshoring on the U.S. economy, as well as possible resource re-allocation to maximize educational curricula and retain innovation work. I am eager to hear our witnesses' assessments of offshoring's economic implications so that we can reflect on the successes and inefficiencies of our policies and programs, and seek to make modifications for improvement. Your first-hand experiences are vital to maintaining U.S. competitiveness.

To all the witnesses—thank you for taking time out of your busy schedules to appear before us today. I look forward to hearing your testimony.

Chairman GORDON. We are very lucky to have this very distinguished panel of witnesses before us today to launch the first in a series of hearings addressing the topic of offshoring. Dr. Alan Blinder is Professor of Economics at Princeton and former Vice Chair of the Board of Governors of the Federal Reserve System. Dr. Ralph Gomory is President of the Alfred P. Sloan Foundation and was head of IBM Research for 16 years. Dr. Martin Baily is senior fellow at the Peterson Institute of International Economics and senior advisor to Mackenzie Global Institute. And Dr. Thomas Duesterberg is the President of the Manufacturing Alliance and former Assistant Secretary of International Economic Policy at the Commerce Department. You are a very distinguished group, and as Mr. Hall said, it is unusual that we are expanding our time but we want to hear from you.

Let me give the Members and our witnesses a little update. It is expected that we are going to have votes at 2:00, which means at about 2:10 we are going to dash out of here, and unfortunately, it is going to be a series of votes and a photograph, and so, if we can, I think that we need to do our—in full respect to you coming here, but I think we will be better off to try to accomplish this before then, if we can, so that we don't have to let our panel continue to wait.

And with that, I will be quiet and call on Dr. Blinder.

STATEMENT OF DR. ALAN S. BLINDER, DIRECTOR, CENTER FOR ECONOMIC POLICY STUDIES; GORDON S. RENTSCHLER MEMORIAL PROFESSOR OF ECONOMICS, PRINCETON UNIVERSITY

Dr. BLINDER. Thank you, Mr. Chairman, Members of the Committee, and thanks for the opportunity to take part in this hearing. I was asked to talk about the offshoring of American jobs in general, and with specific attention to science and technology issues; and I want to start with some general observations and then get to some specifics.

To start with, Americans don't have any biological superiority to workers in developing countries and yet we earn much higher wages. So why is that? Well, one factor is that we are, on average, much better educated. But the average is not the only relevant thing. Millions of skilled workers in developing countries are educated about as well and, in some cases, better than Americans are, and importantly, those numbers are bound to increase as poor countries continue to participate more vigorously and effectively in the world economy.

Apart from better education and skills, the other main reason why U.S. workers earn so much more than workers in, say, India or China, is that Americans work with much better technology and with much better physical capital, again on average. But physical capital, financial capital, and technology are all increasingly mobile these days. So, in particular, the capital and the technology can move to where the cheap labor is, and we see that this is happening.

This is all very old hat. It describes a situation that has been familiar to U.S. manufacturing workers and businesses for decades as millions of manufacturing jobs have been offshored from the United States and also other rich countries—this is not an American story to an ever-changing list of poorer countries which, if you go way back, included Japan, which is not a poor country anymore, but these days, of course, is headed by China.

The new wrinkle today is in services, where a similar process is unfolding, or I really should say just beginning to unfold. Advances in electronic communications have decreased and, in some cases obliterated, the advantages of physical proximity in a wide variety of service jobs simply because the work can be performed anywhere and delivered by telephone or by Internet or by some other method.

While still in its infancy, electronic offshoring has already begun to move well beyond traditional low-end jobs like call center operators to highly skilled jobs such as computer programming, engineering, and security analysis, just to name a few. I think there is little doubt that both the range and the number of jobs that will be able to be delivered electronically is going to increase greatly as the technology improves and as countries like India, China, and others educate more and more skilled workers. In the case of India in particular, these are going to be English-speaking workers, which is quite germane.

So what is novel about service offshoring? At the basic conceptual level, the pure economics, nothing much. The same basic market forces that govern trade in goods also govern trade in services. The novelty, to my mind, comes at the practical level. Specifically, I have in mind three things. First, there are many, many more service jobs than manufacturing jobs in all the rich countries. In the United States, the ratio is about five to one, five times as many service jobs as manufacturing and construction jobs. Second, unlike factory workers, the people who hold these jobs are not accustomed to competing with low-cost foreign labor, and you can be sure that they are not going to like it any more than the manufacturing workers did when this phenomenon hit manufacturing. And third, many of the white-collar professionals who will feel threatened by offshoring, if they don't already, are vocal and politically engaged.

You can all judge for yourselves better than I can, but this strikes me as a potentially potent political brew.

With that said, I want to turn to some specifics. First, which service jobs are the most vulnerable to offshoring? It would be nice to say that only low-skilled jobs are vulnerable while high-skilled jobs will remain in America. And as Mr. Hall said, we may have believed that once, but it doesn't appear to be the case. My research finds hardly any correlation at all between either the educational attainment of an occupation or its average wages on the one hand and the degree of offshorability of the occupation.

So what is the critical factor that determines which jobs can easily be offshored and which cannot? I argue that it is a little discussed and often unnoticed job characteristic: the importance of face-to-face contact. I mean by that face-to-face contact with people outside the work unit, not with your fellow workers. For lack of a pre-existing vocabulary, I have called the jobs in which face-to-face contact is vital to performing the service personal services and the occupations in which it is not impersonal services.

So, for example, services that can be delivered by telephone or Internet, like call centers and financial analysis, are by this DEFINITION impersonal, and that means they are potentially tradable across national borders just like manufactured goods. But services that have to be delivered physically, or face-to-face, like driving a cab or brain surgery or serving in Congress, I might add, or services whose quality deteriorates markedly when they are delivered electronically—such as, say, high school teaching or psychoanalysis—those are personal services. They are not going to be traded internationally, at least probably not.

My central claims about this phenomenon are two. The first is that market pressures emanating from trade and globalization will force, and I want to underscore the verb force, more and more Americans to leave impersonal service and manufacturing jobs and to seek employment in personal service jobs instead. And second, that we will be better off as a nation if government, businesses and the schools approach the coming occupational migration—and that is what it is, a large-scale occupational migration—deliberately, thoughtfully, and with appropriate policy responses rather than letting it take us by surprise.

Now, in voicing those views, I seem to have created a bit of a media stir, as some of you may know. So I would like first to quickly avoid three confusions that are often made.

Some people have misinterpreted my estimate of 30 to 40 million U.S. jobs as potentially offshorable to mean that all those jobs will be lost. They won't be. We haven't lost all manufacturing jobs, and they are all offshorable. We will not lose all of these impersonal service jobs.

Second, some have interpreted my writings as being hostile to trade. That is just not true. I have always been an advocate of open trade, and I still am. Protectionism is a loser's game. It's not a game that America should be playing.

Third, some people have misinterpreted my writings as hostile toward India in particular. I mentioned the relevance of India. That is not true. On the contrary, I applaud India. I think they are doing exactly the right thing for their people: exploiting the comparative advantage they have in English, building up service offshoring industries, and not incidentally, in the process contributing vitally to the reduction of world poverty. This is all terrific.

On the other hand, the one criticism of my work to which I do plead guilty, but I want to explain, the guilt is emphasizing the downsides of service offshoring rather than the upsides. There are both. I do that for a very simple reason: because I think that Americans in general and especially American policy-makers need to focus on and think about ameliorating the downsides of offshoring, both for basic fairness reasons and if we are to preserve the open trading system against the forces of protection. The people who win from offshoring won't object to it one little bit, and the markets will produce the upsides without the government lifting a finger. But offshoring, and trade more generally, don't look so attractive to the people that lose their jobs in the process. And that is where the government needs to help.

Having just ruled out the "Stop the world, I want to get off" approach, the question is what Congress can do to make this transition a bit easier. I actually see three large policy agendas, and given the time, I am just going to be able to tick them off, basically. Maybe we can come back if there is a question period.

First, there is a safety net agenda. Put very simply, the U.S. Government now offers disgracefully little help to workers who are displaced from their jobs, whether that is because of trade or for any other reasons. Without going into great detail, I am talking about stingy unemployment insurance, very weak trade adjustment assistance, the prospect of losing your health insurance and your pension rights, and so on, and also, by the way, very scant opportunities for retraining. I can't believe that our country can't do better than that, and I know other countries do better than that.

Second, there is an educational agenda. I would like to put it this way. We built our educational system in the 19th century to produce legions of factory workers for the first Industrial Revolution. It was a great success, but that success is over, and we haven't really adapted yet to the second Industrial Revolution, which is the shift to services. Having not done that, we now have to adapt to what I think might be a third Industrial Revolution, which is the shift away from impersonal services to the personal service jobs that will remain in America. And virtually nobody in this country is thinking about how to do this right now.

Third, and closest to the hearts of this committee, I believe, is the innovation agenda, and I would just like to give an illustrative example of why this is important. If you think about the television manufacturing industry, not television shows but TV set manufacturing, it began here; and once upon a time, lots of Americans had good jobs making televisions, but then, as this became a commodity, it migrated offshore, and as I am sure you all know, the number of TV sets made in America is zero and has been for years. As a result of that, television manufacturing often held up as an example of industrial failure—because we started it and then we lost it. I think it is important that we think of that as an example of industrial success instead. The leader, and that is our role, must constantly innovate and move on like the cowboy in the Westerns, and that is just what we did in this case. We got there first, then we left as the industry migrated aboard. Both parts of that process are very important: getting there first and then letting go when it is time to let go. Fifty-two seconds?

Mr. BLINDER. I am sorry.

Chairman GORDON. Yeah, go ahead and conclude.

Mr. BLINDER. I just want to conclude with what does that mean? It means that we have to remain the hotbed of business creativity and innovation in the United States. So that goes to support for basic research, for industrial R&D, for creative business management, for the entrepreneurial culture that we are so good at, for open and vibrant but honest capital markets. These are the things I think that we need to think about in order to move forward and maintain the leadership position that America has had for so long.

Thank you all for listening.

[The prepared statement of Dr. Blinder follows:]

PREPARED STATEMENT OF ALAN S. BLINDER

Mr. Chairman, Members of the Committee, thank you for the opportunity to take part in this hearing. I was invited here to talk about the offshoring of American jobs in general, with special attention to science and technology issues. I'd like to start with some general observations about offshoring, and then go on to some specifics.

Looking across the world, if you hold occupation and education constant, Americans earn much higher wages than workers in developing countries. But we Americans have no biological or neurological superiority to these foreign workers. It is true that we are far better educated on average. However, millions of skilled workers in developing countries are educated about as well as Americans are. And those numbers are bound to increase as poor countries, notably China and India, continue to participate more vigorously and effectively in the world economy.

Apart from better skills and more education, the other main reasons why U.S. workers earn so much more than workers in, say, India or China is that Americans work with much better technology and with much more physical capital. But in an increasingly globalized economy, physical capital, financial capital, and technology are all increasingly mobile. So, in particular, the capital and technology can move to where the cheap labor is, thereby raising labor productivity (and wages) there.

All this is old hat, and none of it is controversial. It describes a situation that has been familiar to U.S. manufacturing workers for decades. One consequence of these forces has been the offshoring of millions of manufacturing jobs from the United States (and other rich countries) to an ever-changing list of poorer countries—a list that once included Japan, but is now headed by China.

Today's new wrinkle is in services, where a similar process is unfolding. Advances in electronic communications have decreased or obliterated the advantages of physical proximity in a wide variety of service jobs, where the work can now be performed abroad and the work products delivered to the U.S. by telephone or computer networks. Notice that "shipping" electrons is a lot easier and cheaper than shipping physical goods.

While still in its infancy, electronic offshoring has already begun to move well beyond traditional low-end jobs, such as call center operators, to highly-skilled jobs such as computer programmers, scientists and engineers, accountants, security analysts, and some aspects of legal work—to name just a few. And I think there is little doubt that the range and number of jobs that can be delivered electronically is destined to increase greatly as technology improves and as India, China, and other nations educate more and more skilled workers—in the case of India, English-speaking workers.

What's novel about service offshoring? At the *conceptual* level, nothing much. The same basic market forces that govern trade in goods also govern trade in services. The novelty comes at the *practical* level. Specifically, I have in mind three distinguishing features:

- First, in the U.S. and other rich countries, there are many more service jobs than manufacturing jobs. In the U.S., there are about five times as many.
- Second, unlike factory workers, the people who hold these jobs are not accustomed to competing with low-cost foreign labor. They will not welcome this new competition any more than manufacturing workers did.
- Third, many of the professionals who are seeing, or will see, their jobs become offshorable are vocal and politically engaged.

You can judge for yourselves, but this trio strikes me as a politically potent brew. Members of Congress will hear from many actual and prospective job losers, clamoring for protection.

Now let me move to specifics. First, which service jobs are the most vulnerable to offshoring? It would be nice to say that only low-skilled jobs are vulnerable while the high-skilled jobs will remain in America. We may have once believed that, but it does not appear to be so. I have estimated that there is very little correlation between the educational attainment of an occupation and its susceptibility to offshoring.[1] It would be similarly reassuring if low-*wage* jobs were more vulnerable to offshoring than high-wage jobs. But that, too, appears to be untrue. According to my estimates, there is no correlation between an occupation's average wages and its degree of offshorability.

What, then, is the critical factor that determines which jobs can easily be offshored and which cannot? I have argued that it is a little-discussed, and often unnoticed, job characteristic: the importance of face-to-face contact with people outside the work unit (whether upstream suppliers or downstream customers). For lack of a pre-existing vocabulary, I have labeled the jobs in which face-to-face contact is important as *personal services* and the occupations in which face-to-face contact is unimportant as *impersonal* services.

For example, services that come (or could come) to their end-users by, say, telephone or Internet (e.g., call centers, financial analysis) are impersonal. They are tradable across national borders, just as manufactured goods are. But services that must be delivered physically or face-to-face (e.g., driving a cab, brain surgery) or whose quality deteriorates markedly when they are delivered electronically (e.g., high school teaching, psychoanalysis) are personal and cannot be traded internationally. Serving in Congress is a personal service job. I leave it to you to decide whether giving Congressional testimony is a personal or an impersonal service.

My central claims—which apparently are controversial—are two: first, that market pressures emanating from trade and globalization (especially international differences in labor costs) will force more and more Americans to leave impersonal service and manufacturing jobs and seek employment in personal service jobs instead. And second, that we will be better off as a nation if government, businesses, and the schools approach that occupational migration deliberately, thoughtfully, and with appropriate policy responses, rather than letting it take us by surprise.

In voicing these views in recent months, I seem to have created something of a media stir. (You should see my fan mail!) So, before going further, I'd like to dispel some possible confusions.

- First, some people have misinterpreted my estimate that 30–40 million U.S. jobs are *potentially offshorable* to mean that *all* of those jobs will actually be lost. They won't be, any more than globalization has eliminated all manufacturing employment in the U.S. (It hasn't.) Besides we will also be gaining jobs from globalization. Mass unemployment is not in America's future.
- Second, some have misinterpreted my writings as hostile to trade. Nothing could be further from the truth. I remain an advocate of open trade, just as I have always been. Protectionism is a loser's game, and I believe our country stands to be a big winner from globalization—eventually. Besides, how do you stop electrons at the border?
- Third, some have misinterpreted my writings as hostile toward India, where many of the offshored service jobs are going. I am not. In fact, I applaud India for doing exactly the right thing for its people—exploiting its comparative advantage in English, building up its service offshoring industries, and in the process, contributing to the reduction of world poverty.

There is, however, one legitimate criticism of my writings on this subject:

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[1] This and the other estimates in this paper come from Alan S. Blinder, "How Many U.S. Jobs Might Be Offshorable?," CEPS Working Paper No. 142, Princeton University, March 2007. (March 2007).

- Some people have accused me of overemphasizing the *downsides* of service offshoring—such as job losses and downward pressures on wages—and underemphasizing the *upsides*—such as job gains and cost reductions.

There is truth to this criticism, but I have a reason. I believe that American policy-makers must focus on and ameliorate the downsides of offshoring—both for basic fairness reasons and to preserve the open trading system. The winners from offshoring will not object to its upsides, which markets will produce quite handily without any government assistance (other than avoiding protectionism). But offshoring, and trade more generally, will not look so good to the people who lose their jobs. That's where the government needs to help.

Having just ruled out the "Stop the world, I want to get off" approach, what can Congress do to make the transition to large-scale service offshoring more palatable and less painful? While I realize that many of the appropriate policy responses fall outside the purview of this committee, I see three large policy agendas, each of which encompasses many specific policy initiatives.

First comes the *safety net agenda.* Simply put, the U.S. Government now offers disgracefully little help to workers who are displaced from their jobs—whether by trade or for other reasons. Without delving into the details, I am referring here to such problem areas as stingy unemployment insurance, weak trade adjustment assistance, loss of health insurance, pension rights that are often not portable, and scant opportunities for retraining—to name just a few. I can't believe that my country can't do better. We know that other rich countries do.

Second, there is an *education agenda.* Put starkly, our K–12 education system was designed in the 19th century to produce cadres of factory workers for the First Industrial Revolution. It succeeded mightily, but it has barely adapted to the Second Industrial Revolution: the shift from manufacturing to services. Having failed to do that, it now needs to gear up for a possible Third Industrial Revolution: the offshoring of impersonal service jobs. I believe we need to educate more young people for the personal service jobs that will account for a rising share of U.S. employment. But hardly anyone in the education business is now thinking about how to do this. And, by the way, similar changes are called for in the community colleges and perhaps even in the four-year colleges.

Third, there is the *innovation agenda.* Since this one is closest to the concerns of this committee, I will deal with it at greater length—starting with an illustrative example.

The television *manufacturing* industry began here and, decades ago, provided good jobs for many American factory workers. But as TV sets became "just a commodity," their production moved offshore to locations with much lower wages. And for years now, the number of television sets manufactured in the United States has been zero. In consequence, TV manufacture is often held up as an example of industrial failure: We started the industry, then lost it. Actually it should be viewed as a success story. The world's industrial leader—the United States—must constantly innovate and move on, like the cowboy hero in the Western movies. In the case of TV sets, we got there first, but then left. Both were appropriate.

This example illustrates an important point: It is crucial for the United States to remain the incubator of new business ideas and the first mover when it comes to providing new goods and services. If we are to remain big exporters as the rest of the world advances, we must specialize in the sunrise industries, not the sunset ones. We must do this not because we like the job destruction in the old industries that we lose, but because we want and need the job creation in the new industries that we gain, *even if those jobs won't stay here forever.*

Trying to name concrete examples of future industrial winners is a fool's errand, and I won't go there. Who could have told President Jefferson in 1802 where the new jobs would come as the share of Americans earning their living on farms collapsed from 84 percent to two percent? Moving up in time, who could have told President Eisenhower in 1953 where the new jobs would come from as the share of Americans earning their living in manufacturing dwindled from 32 percent to 10 percent? But both industrial transitions happened, and Americans found plenty of work to do.

While I'm not foolish enough to try to name the new industrial winners, we all know that many new goods and services will be invented and/or commercialized in the coming decades. As the world's leading nation, the United States must grab the first-mover advantage in a disproportionate share of these. And that, in turn, requires that we remain a hotbed of business creativity and innovation. To accomplish this, basic research, industrial R&D, creative and aggressive business management, an entrepreneurial culture, an active venture capital industry, and the like must all remain integral parts of the American success story. But that does not seem too tall an order. It is, after all, how we got here in the first place.

Most of the necessary changes will be accomplished by the private sector, which has proven its flexibility and adaptability time and time again. Nonetheless, there are a number of vital roles for the Federal Government in such areas as fostering basic science and R&D, supporting scientific and engineering education, returning both the tax code and the budget to sanity, maintaining competition and open trade, and keeping the capital markets vibrant but honest. (This list is not exhaustive.) Several of these areas fall under the purview of this particular Committee. And all of them fall under the purview of the U.S. Congress. There is much to do, and the time to start is now.

Thank you for listening.

BIOGRAPHY FOR ALAN S. BLINDER

ALAN S. BLINDER is the Gordon S. Rentschler Memorial Professor of Economics at Princeton University and Co-Director of Princeton's Center for Economic Policy Studies, which he founded in 1990. He is also Vice Chairman of the Promontory Interfinancial Network, and Vice Chairman of the G7 Group.

Dr. Blinder served as Vice Chairman of the Board of Governors of the Federal Reserve System from June 1994 until January 1996. In this position, he represented the Fed at various international meetings, and was a member of the Board's committees on Bank Supervision and Regulation, Consumer and Community Affairs, and Derivative Instruments. He also chaired the Board in the Chairman's absence. He speaks frequently to financial audiences.

Before becoming a member of the Board, Dr. Blinder served as a Member of President Clinton's original Council of Economic Advisers from January 1993 until June 1994. There he was in charge of the Administration's macroeconomic forecasting and also worked intensively on budget, international trade, and health care issues. During the 2000 and 2004 presidential campaigns, he was an economic adviser to Al Gore and John Kerry. He also served briefly as Deputy Assistant Director of the Congressional Budget Office when that agency started in 1975, and testifies frequently before Congress on a wide variety of public policy issues.

Dr. Blinder was born on October 14, 1945, in Brooklyn, New York. He earned his A.B. at Princeton University in 1967, M.Sc. at London School of Economics in 1968, and Ph.D. at Massachusetts Institute of Technology in 1971—all in economics. Dr. Blinder has taught at Princeton since 1971, and chaired the Department of Economics from 1988 to 1990.

Dr. Blinder is the author or co-author of 17 books, including the textbook *Economics: Principles and Policy* (with William J. Baumol), now in its 10th edition, from which over two million college students have learned introductory economics. He has also written scores of scholarly articles on such topics as fiscal policy, monetary policy, and the distribution of income. From 1985 until joining the Clinton Administration, Dr. Blinder wrote a lively monthly column in *Business Week* magazine. Currently, he is a regular commentator on PBS's *Nightly Business Report* and appears frequently on CNBC, CNN, Bloomberg TV, and elsewhere.

Dr. Blinder is the immediate past President of the Eastern Economic Association and was previously Vice President of the American Economic Association. He is a member of the Bretton Woods Committee, the Bellagio Group, and the Council on Foreign Relations, and a former governor of the American Stock Exchange. Dr. Blinder also serves on the academic advisory panels of the Federal Reserve Bank of New York, the FDIC Center for Financial Research, and the Hamilton Project.

He has been elected to the American Philosophical Society and the American Academy of Arts and Sciences.

Dr. Blinder and his wife, Madeline, live in Princeton, NJ. They have two sons, Scott and William, and two grandsons, Malcolm and Levi.

Chairman GORDON. Thank you, Dr. Blinder.

Let me also remind everybody that this is being televised, so all the folks, while different committees and things are going on, our staff, as well as Members, are watching from here so more are gaining this information than just the ones here directly.

So Dr. Ralph Gomory, please—oh, it is Dr. Baily? All right. We will go—then Dr. Baily.

STATEMENT OF DR. MARTIN N. BAILY, SENIOR FELLOW, PETER G. PETERSON INSTITUTE FOR INTERNATIONAL ECONOMICS, WASHINGTON, DC

Dr. BAILY. I will start. Thank you, Mr. Chairman, and thank you to the Committee for giving me this opportunity to talk. Like Alan, I was a member of the Clinton Administration and I support virtually all the policies that he described. I am very much in tune with that part of what he said, and I suspect I will probably agree with many of the policies that Dr. Gomory proposes. On the other hand, the tone that I want to use is a bit more favorable towards globalization and its benefits to the United States than Alan—the remarks Alan made, and I suspect the ones that Dr. Gomory is going to make, based on his opinions that I have heard before. Alan mentioned that the benefits of globalization are going to come anyway. In other words, you don't have to advocate those; you are going to get them and it is important to point to some of the costs that do need to be ameliorated by actions in the policy environment.

Well, to some extent I agree with that, but globalization is getting such a bad rap at the moment that I want to try to level that intellectual playing field a little bit because it has brought tremendous benefits to the United States. It has made the United States much more competitive, more productive. We have had access to better technology. We have access to capital, and by the way, I would mention that one of the comments that Alan made, other people make it as well: U.S. capital is going to flow overseas. The fact of the matter is, about 80 percent of the available capital in the global economy is actually coming to the United States, only 15 percent to other countries, so we are benefiting from a tremendous inflow. There are costs to that inflow also.

The problem is, a couple of things. One is that we have gotten our exchange rate out of whack, and that is one reason that globalization has got a bad name because it has made it very hard for manufacturers, and now service industries, to compete. We have a natural comparative advantage in service industries, which you can see even today in the trade surplus that we have in services. So, we are actually inshoring service sector jobs to the United States and have been for many years. But we are facing an uphill struggle there because of the exchange rate, and that has certainly been true of manufacturing where we have got a huge deficit and have had for a long time. The other problem, and I agree with the one that Alan mentioned, is that we do very little to help with training workers, with adjustments of workers. I am actually just back from a trip to Europe, and I met with a number of leaders in Brussels, including those form Denmark, that developed a so-called flex security system there, which gives their workforce a great deal of flexibility, but it also gives it a great deal of security that you get trained, you get pushed towards another job. It is a very tough-minded system. You can't just stay on benefits for forever. You have to go get another job. You are required to do that. But at the same time, you are not left out there on your own. I think the United States is very good at the flexibility side. It has not been so good at the security part. Europe is very good at the security and has not been very good at flexibility. And both have to be there. I don't think we could transmit the Danish system, as it is, to the United States, but there are some important lessons to be learned there.

Let me turn now more on the science and technology side, and I am going to mention more on the benefits, and then, I will deal with what I see as some of the challenges or problems. The United States actually has benefited substantially from an inward brain drain. The OECD in a report published in February of this year notes that nearly 26 percent of the doctorates in the United States are foreign born. Of these, 54 percent have become naturalized U.S. citizens. I am one of them, I might note. Most of these come from Asia and Europe and many of them actually received their doctorates with foreign educations. So we are actually, even though we are the richest country or the richest large country in the world, we are actually benefiting from the education that is being provided to people overseas. There are actually very few U.S. citizens that go overseas, and the people that come to the United States cite the economic opportunities here and the tremendous infrastructure that we have here, the scientific and technological community that really leads the—continues to lead the world.

Okay. Let me talk on the challenges side. A lot of the concerns about offshoring are around the computer and high-tech industry and programming industry, and I understand why. There are huge numbers of jobs being created in R&D centers and programming centers overseas including China and India. This is an industry that has, for a number of years, been very globalized. It really is. The production, the manufacturing, a lot of that is done overseas. A lot of the companies are American but that has been—you know, that industry has been sliced and diced and put overseas. One thing I would say though to qualify that, and that is in Table 1 in my testimony developed by one of my colleagues at the Institute, and it shows that even in the computer and high-tech fields, employment is growing in the United States in the higher level areas. It has gone down in a lot of basic programming areas and some of the call center stuff. Those kinds of jobs have gone overseas and they are not—I wouldn't want to minimize the cost of that, but a lot of those high-tech jobs are still growing in the United States even though the high-tech sector itself has seen a substantial kind of downturn since 1999, the period that I start with.

I also want to say that the United States benefits from low-cost hardware that is produced around the world, and we benefit from the software that is made around the world. As software is developed in India and China and used here in the United States, we gain the benefits of that for the productivity of our companies.

On the policy side—I see I am racing through my time before I got halfway through my comments here. On the policy side here, at some level we have to embrace the fact that science and technology is a global endeavor. It really is. I don't think we can shut it off in any way. That means we have to allow foreign-born scientists and engineers to come to the United States, and I have talked to some of them. They get pretty lousy treatment when they apply these days. So there are scientists and technologists that want to come to the United States, want to become Americans, want to create American jobs, and they get treated guilty before they have—and have to prove their innocence. So, I think that is something that needs to be done there. Obviously we have to protect the United States. We can't have another 9/11. I understand that concern, but I don't think it is necessary for us to treat those people badly.

Second point is, we certainly have to fund scientific research, and we are funding scientific research. I know this Committee is in favor of that, so I am preaching to the choir here. But obviously, in a time of budget tightness, we really do need to make sure that we keep up our scientific community. We put a lot of money on medical research, and that is fine. We just need to make sure that things like material science and the whole scientific endeavor gets adequate funding.

And then, as Alan said, on education support, India has done a good job of training its college gradates, its computer programmers. I would note that the Indian education system, as a whole, is pretty awful. They have huge rates of illiteracy. So I don't think we would look to the Indian system as a good system, but one part of it that is good that really has been the push of their education system is at the higher end, and they have done a good job of creating programmers and people with mathematics and science skills, and here in the U.S. we need to do a better job in that dimension. Now, a lot of Americans don't want to study those things. They don't want to take mathematics and science, and so what we can we do there? Well, I think there is a certain amount that can be done with funding on that area. If we provide scholarships, I think more people will go to graduate school in science and technology.

And finally, the other part of embracing the global nature of this is that, both as businesses and as a society, we need to be open to the innovation that is made around the world. Somebody has called that rather inelegantly blowback innovation. That is an unfortunate name, but it means that a lot of stuff that is going on around the world can come back and make the United States more productive.

Let me say a word about offshoring. I was involved in a study that looked at offshoring. We did a lot of interviews of companies. We went and looked at those people with their educational qualifications, all the engineers coming out of China, how many of them really have serious engineering qualifications, how many of them can speak English, would actually substitute for American workers, how many people are involved in face-to-face stuff like that. We came up with a more conservative number than Alan did. Now, part of this is the time horizon, but I don't think that is the ultimate question because we concluded that only 11 percent of jobs could ultimately be offshored, not the number that Alan has. The number that will be offshored over the next few years is certainly smaller, as Alan agreed.

Let me conclude by saying that I think the United States has been, and still is, a great place for science and technology and innovation. It has been one of our huge strengths. So the issue should be to let us build on this strength. Let us not be too scared of what is happening around the world. Let us build on the strength we have and make sure we remain in that position.

Thank you.

[The prepared statement of Dr. Baily follows:]

PREPARED STATEMENT OF MARTIN N. BAILY[1]

Globalization has provided many benefits to the U.S. economy. My Peterson Institute colleagues, Gary Hufbauer et al., have estimated that the U.S. is a trillion dollars richer today than it would have been if there had been no reduction in trade barriers after the end of World War II.[2] Many studies of productivity carried out at the McKinsey Global Institute have shown that productivity in an industry is enhanced when it is exposed to global competition, particularly competition against the world's leaders.[3] You have to compete against the best if you want to be the best. The Organization for Economic Cooperation and Development found that openness to international trade had provided an important stimulus to growth among the member countries of that organization.[4]

The United States benefits from globalization because it results in lower prices for U.S. consumers, provides greater access to new technologies and business practices from around the world, allows U.S. companies to take advantage of economies of scale, and because it forces companies to improve their own performance. One sign of the benefits of the open and competitive market in the U.S. is the fact that productivity growth has been strong for the past ten years. From 1995 to 2006 output per hour in the non-farm business sector of the U.S. economy has been nearly 2.9 percent a year, much faster than the pace achieved for 20 years prior to 1995 and faster than most other advanced economies.

At the same time, there are legitimate concerns about the impact of globalization on Americans. There is concern is over the impact of globalization on the skilled workforce and on the science and technology base of the U.S. economy—the topic of this hearing. Strength in science and technology has been a key part of the success of the United States over its history. In addition there is concern over the huge trade and current account deficits and the slow growth of wages and incomes for lower skilled workers.

Scientific Research has Always been a Global Endeavor

The history of science tells us that major contributions have been made to scientific knowledge from countries and regions around the world. The United States came to the fore in scientific research during the 20th century, relying on its great universities and taking advantage of outstanding scientists and engineers that came to the U.S. from the rest of the world. Today, the U.S. remains unquestionably the global leader in science, judged by the size and quality of its research community and on the metric of Nobel prizes.

U.S. leadership is not unchallenged, however. Other countries are determined to build up their own scientific research and are funding research projects. What are the lessons for U.S. policy?

- Scientific research is not a zero-sum game. Scientific breakthroughs made around the world have benefited Americans and will do so in the future. One of the strengths of the U.S. economy has been its ability to learn from developments made elsewhere and adapt them to the needs of the economy.
- Maintaining U.S. strength in science depends heavily on embracing its global character. This means that trained scientists from around the world must be able to come to the United States and participate in the research being carried out here. It means that students from around the world must be allowed to come to U.S. graduate schools and remain in this country for post-doc work.
- It is not just a matter of the number of visas granted. The treatment given to people applying to enter the U.S. has sometimes been unpleasant in ways that do not materially assist our national security. Ultimately this will weaken our universities and our scientific base.

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[2] Scott Bradford, Gary Clyde Hufbauer, and Paul Grieco "The Payoff to America from Global Integration," in C. Fred Bergsten ed., Foreign Economic Policy for the Next Decade, Peterson Institute for International Economics, 2006.

[3] For a list of productivity studies see *www.mckinsey.com/mgi*

[4] OECD *Economic Policy Reforms: Going for Growth 2007,* Paris, 2007.

- Scientific research depends upon funding from the government and foundations because no private company finds it worthwhile to support large-scale research that does not provide it with proprietary returns. The U.S. government does support scientific research and must continue to do so, even during periods of budget tightness. Moreover, the allocation of funds must be on the basis of the underlying science and technology. Allocating too large a share of scarce research dollars to celebrity diseases or big spectacular projects should be avoided.
- There is also a case for government support of pre-commercial technology development. This is research that is closer to commercial application than pure scientific study, but that is too broad and general for companies to do. There are areas of material science, for example, that fall into this category. This type of research must be carefully handled, however. Sometimes such projects continue too long because it is not easy to admit failure. Failure is part of research, but that means that projects must be turned off as well as turned on.

Off-shoring Services and Science and Technology

Historically, the United States has been a preferred location for employment in science and technology and has a robust comparative advantage in services. In 2006 the U.S. ran a $72 billion surplus in services trade, despite the fact that goods trade was in a huge international deficit. As part of the $72 billion services surplus, the U.S. ran a surplus of $35 billion in royalties and licenses, much of that coming from technology, as well as movies and other media. These figures in fact greatly understate the global revenues generated by technology activity in the U.S. U.S.- and foreign-based multinational companies draw on the technological base they have developed through R&D and business development here in the U.S. and use it in operations throughout the world. The returns come back as net income to U.S. companies.

The U.S. also runs a trade surplus in education reflecting the foreign students that are educated in U.S. institutions. The only major service categories in which the U.S. ran a deficit were insurance and transportation.

The very large trade deficits in manufactured goods experienced by the U.S. have been the result largely of a value of the dollar that has made U.S. production too expensive relative to other countries and the dollar has also hurt U.S. services trade. The values of the Euro, the British pound, the Canadian dollar and other currencies have adjusted upwards and this has made the U.S. a more competitive economy for locating production facilities and also R&D and other technology facilities. This should help to boost U.S. employment in technology fields going forward. Some Asian currencies, notably the Chinese renminbi and the Japanese yen, remain undervalued, according to several of my Peterson Institute colleagues, and if these currencies adjust upwards in the future this will add to the desirability of the U.S. as a location for high technology research, as well as tradable services more broadly.

On balance, the U.S. service sector as a whole has sustained its position as a net exporter through a challenging overall environment for trade. Many countries around the world have off-shored their R&D and technology employment to the U.S., pharmaceutical R&D by U.S. and European companies in New Jersey, for example.

This is not to downplay the competitive challenges now facing the U.S. service sector and the pressure being felt by some mid-level occupational categories in the U.S. Table 1, prepared by the Peterson Institute's Jacob Kirkegaard, shows employment in a number of computer and technology related occupations, as well as employment in lower-skilled service occupations that are subject to relocation off-shore. The upper half of the table reveals that call-center type occupations and low-wage technology workers have experienced a substantial decline in employment, about 800,000 between 1999 and May 2006. This decline is in part the result of off-shoring, moving these jobs to lower-cost locations. Not all the employment decline is trade-related, however. Some of the largest declines are for data entry keyers and word processors and typists. These occupations have been heavily affected by changes in the technology itself, making it easier to read and transfer data electronically and allowing many white-collar workers to enter their own documents or spreadsheets directly into the computer, bypassing the need for secretarial assistance.

This is an important point. The book by Frank Levy and Richard Murnane points out that the characteristics that make it possible to off shore a particular job also make it possible to automate that job.[5] This means that off shoring and automation are often alternatives. It is misleading to look at jobs that have "moved" to India and assume these jobs would have remained in the U.S. In many cases, the jobs would have been automated if there had not been the opportunity to buy the service overseas.

The lower part of the panel shows employment for mid-level workers and high-wage technology workers. The mid-level employment has risen nearly 52,000 and the high-wage workers have increased by about 428,000 between 1999 and 2006. Despite the impact of the technology crash in 2000–2001, and despite the impact of service sector off-shoring, employment in these job categories on average has increased substantially—by nearly 20 percent. Within the high-wage categories, however, there is one that stands out: computer programmers have seen a decline in employment of about 133,000. The decline in employment in this area comes because of the end of the tech boom, but also because many programming jobs have been re-located off-shore. The person who heard that programming was the way to ensure a good job and took some courses to learn the basics has found that the jobs are not there. Those that upgraded their programming and computer systems skills have been in demand.

The Economics of Service Sector Off-Shoring[6] One of the things that scare Americans is the idea that almost any job today could be off-shored. That is not true. A careful estimate has found that about 11 percent of all jobs could theoretically be carried out in a remote location. There are higher estimates around, but these do not take into account adequately some of the difficulties of performing tasks remotely, including the difficulty of complex, one-on-one interactions that are required in many operations.[7]

Even though 11 percent of employment is a lot smaller than some of the scare-numbers out there, it is still a very large number of jobs. Civilian employment in the U.S. was about 146 million in 2006, so 11 percent would be over 16 million. But in fact the likely number of jobs that will be off shored over the next few years is much smaller than this. The main determinant of the number of jobs off shored is the extent to which U.S. businesses judge that it is economic to do so. For some sectors the cost advantage from moving off shore is very small and not worth the risks involved. This is becoming increasingly true for off shoring to India, where wages are rising very rapidly for skilled workers. For many sectors it is not possible to disaggregate their value chains and move parts of them overseas because the business processes are just not suitable. Many small businesses do not have the scale to make off shoring worthwhile. For some sectors there are issues of regulation or intellectual property protection that preclude off shoring. On balance, it can be expected that no more than four million jobs will be off shored over the next five years, or about 2.7 percent of civilian employment in the U.S. Figure 1 illustrates the different factors that influence the off-shoring decisions companies make.

Overall, the growth of off-shoring is demand driven because there is an adequate supply of workers located in other countries that are qualified to perform the tasks that U.S. companies will look for. There are a couple of important qualifications on the supply side, however. One of the arguments often used to argue that U.S. jobs and wages are threatened is to claim that there are billions of new workers in the global labor market competing directly with American workers. This is not the case. After careful interviews with a number of companies, the McKinsey study found that the number of suitable workers available is much, much smaller. Based on educational qualifications alone there were about 33 million workers available in 2003, but after assessing their language skills and suitability and availability to work for multinational companies, the number dropped to about four million. The number of suitable workers is growing over time, of course, and so the overall supply will be more than adequate to meet the U.S. demand of around four million over the next five years, but talking about billions of competing workers is just misleading.

The second qualification is that the number of suitable engineers, particularly software engineers, in the global economy may not be adequate to meet demand,

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[5] Frank Levy and Richard J. Murnane, *The New Division of Labor: How Computers are Creating the Next Job Market,* 2005

[6] This section draws on *The Emerging Global Labor Market,* 2006, a study of the McKinsey Global Institute on which I was an advisor, see *www.mckinsey.com/mgi*

[7] Alan Blinder in "Off-Shoring: The Next Industrial Revolution," *Foreign Affairs,* March-April 2006, makes a rough estimate that 28 to 42 million jobs are susceptible to off-shoring. Blinder does not mention the possibility of service jobs that come to the U.S. as a result of trade. J. Bradford Jensen and Lori Kletzer in "Tradable Services: Understanding the Scope and Impact of Services Outsourcing," Peterson Institute, Working Paper 05–9, September 2005 use an original empirical approach and indicate a pretty large number of jobs that could theoretically be off-shored, although the authors believe only a fraction of this total are actually vulnerable.

leaving unmet engineering needs and/or rising relative wages for this group. Countries such as India and China are growing at an amazing pace and increasing their own demand for skilled workers. High tech in the U.S. is a rapidly growing sector again. If demand growth exceeds current estimates there will be a shortage of trained workers globally.

Globalization and Technology: Evolving Models The nature of service sector off shoring is changing. Initially, companies took part of their value chain and sent it overseas—call centers or basic programming. What is happening now is that U.S. companies are forming partnerships with companies in India and elsewhere. The new models have the following characteristics:

- **Cooperation—**both parties work together to achieve the goals of a common work force
- **Productivity and innovation—**drive for productivity gains and the centralizing of key processing capabilities
- **Transparency—**sharing both financial and operating details
- **Movement between operating models—**The client can move processes (and staff) between the operating models to meet changing business demands
- **Third party vendors—**May be deployed to perform specialist services
- **Multiple sites—**Operations across multiple physical centers and geographies

As is to be expected, the opening up of service activities to globalization has triggered a new round of interactions. The overseas suppliers of services are developing skills that allow them to work with U.S. multinationals to increase productivity, the range of activities that can off shored and the different geographies that supply services. *As off-shoring matures as an activity, it takes on new roles which focus on improving productivity and efficiency in U.S. operations, not just moving jobs.* Note also that leading Indian off-shoring companies are rapidly increasing their operations in the U.S. and Europe. Many of the outsourced services being provided to U.S. companies are being supplied by employees of outsourcing companies that are based in here in the U.S., creating American jobs.

The Shifting Mix of Jobs The U.S. economy has sustained low rates of unemployment for the last twenty years and currently has an unemployment rate of 4.5 percent, so our economy can create jobs, indeed many companies report they have trouble recruiting workers. The challenge for the U.S. labor market is that the distribution of wages has become much wider over time. How serious this problem is and the extent to which it is the result of trade or technology is a matter of controversy that I will not address here, but there is no question that the off-shoring process has resulted in a shift in the composition of employment. As we saw in Table 1, in computer and other occupations that have been subject to off-shore competition, there has been a decline in basic jobs and an increase in higher skill jobs, on balance. Although off-shoring is not large enough to be a main driver of the distribution of income in the U.S., it will contribute to some extent.

Policy Implications of Off-Shoring

- The most important features of the U.S. economy that make it attractive as a location for science and technology production are the tremendous base of activity already in place; the favorable climate for business; the range of customers eager to make use of new technologies; and the flexibility of the economy that encourages business experimentation. Policy must make sure that these advantages stay in place. Efforts to regulate against off-shoring would discourage companies from locating science and technology jobs in the U.S. and undermine the very jobs these efforts were attempting to save.
- One of the most acute problems facing the U.S., one that is likely to worsen over time, is the rising cost of health care. To the extent that support and technical jobs in this sector can be performed at lower cost overseas, this will help not only the fiscal deficit, but all Americans that use the health care system. Policy-makers should encourage the use of the global economy to increase competitive pressure in the health care market and cut costs. It makes no sense to lament the fact that so many Americans lack health insurance and then stand in the way of measures that could lower health care costs by taking advantage of the global economy.
- The U.S. is already a major exporter of services and could become a larger exporter if foreign markets were more open. The U.S. has a lot to gain from trade negotiations that would open up service sectors around the world.
- Compared to most other advanced countries the U.S. spends very little on worker training. Many companies report that they are unable to find skilled

workers but many companies are unwilling to provide the training that would create the needed skills. Given the high rate of turnover in the U.S. labor market that is not surprising because companies do not want to train someone only to see them move to a competitor. An important step that Congress could take to help U.S. workers find better jobs and compete in the global market is to create financial incentives for companies to train workers, and financial penalties for companies that do not train. Our best companies today that do train their workers would benefit from such a policy.

Education, Globalization and the Science and Technology Workforce

We know that the American education system is not providing adequate skills to many Americans, skills that would allow them to get better jobs and that would increase the number of people that can work in R&D and technology jobs here in the U.S. This is a hard problem to fix, and part of the difficulty is that many students are unwilling to study technical subjects. We could help, however, by increasing opportunities and incentives. Higher education has become more expensive for low-income families because the value of government scholarships and awards has not kept pace with rising education costs. Congress could help solve this problem by providing additional grant money for students that lack the resources to attend.

Americans do respond to incentives. Many people, including myself, believe that it is in the interest of the economy as a whole to have an increase in the number of people educated in science and technology and hence a case for public support of science and technology education. Having a strong science and technology workforce based in the U.S. helps generate good jobs and preserve our current strength in this area. Congress could add to the size of this workforce by providing more graduate scholarships in science and technology subjects that are available to U.S. citizens and permanent residents. It is contradictory to talk about the need to protect our technology infrastructure if we are unwilling to pay the modest amounts needed to strengthen it directly.

Conclusions

Globalization is being blamed for problems that have been created by failures in other areas. The U.S. does not save enough; job transitions are too costly because they can cause a loss of health insurance; workers that lose or leave jobs are not given adequate income or retraining support to help them find new jobs that are better than the ones they may have lost. Denmark has developed a system of "flexicurity" that gives them a flexible labor market but provides substantial but tough-minded support for workers. Most of the rest of Europe has income support but not enough flexibility. The U.S. has flexibility but not enough support. The Danish model is not one that could be translated directly to the U.S., but there are lessons for the U.S. here. Denmark has more people employed than does the U.S., relative to population, and sustains a lot of good jobs.

For a number of years the value of the U.S. dollar against many currencies was out of line with the level that would allow U.S. workers to compete effectively and exploit the underlying strength and productivity of the U.S. economy—it is still out of line against some currencies. The most important way to make sure the U.S. economy retains its strength as a center of technology jobs is to increase national saving and reduce our dependence on capital inflows from overseas, inflows that are the counterpart and enabler of our trade deficit. The Federal Government has run very large cumulative budget deficits for many years. We need a fiscal policy in which there are budget surpluses during periods of full employment.

Trying to strengthen the R&D and technology jobs base of the U.S. by subtle or overt protectionism is a mistake. The U.S. is already an attractive location for these activities and it will become more attractive if we can take advantage of the global economy to reduce costs. In particular, Americans will be much better off if we can use the global economy to reduce the crushing costs of health care.

Table 1 Detailed US IT-Related Occupations 1999-May 2006

Occupations	1999	May-06	Total Change	Percentage Change	Annual Wage May 2006
Call-Center Occupations					
Telemarketers	485,650	385,700	-99,950	-20.6%	24,190
Telephone Operators	50,820	26,350	-24,470	-48.2%	32,710
Low-wage Technology Workers					
Switchboard operators, including answering service	248,570	172,060	-76,510	-30.8%	23,640
Computer operators	198,500	123,750	-74,750	-37.7%	35,010
Data entry keyers	520,220	295,650	-224,570	-43.2%	25,640
Word Processors and Typists	271,310	153,530	-117,780	-43.4%	30,540
Desktop Publishers	37,040	30,440	-6,600	-17.8%	36,120
Electrical and electronic equipment assemblers	387,430	211,460	-175,970	-45.4%	27,510
Semiconductor processors	42,110	41,520	-590	-1.4%	34,730
Total Call-Center and Low-Wage Tech. Workers	**2,241,650**	**1,440,460**	**-801,190**	**-35.7%**	**$ 27,227**
Mid-Level IT Workers					
Computer Support Specialists	462,840	514,460	51,620	11.2%	44,350
High-wage Technology Workers					
Computer and information scientists, research	26,280	27,650	1,370	5.2%	96,440
Computer programmers	528,600	396,020	-132,580	-25.1%	69,500
Computer software engineers, applications	287,600	472,520	184,920	64.3%	82,000
Computer software engineers, systems software	209,030	329,060	120,030	57.4%	87,250
Computer systems analysts	428,210	446,460	18,250	4.3%	72,230
Database administrators	101,460	109,840	8,380	8.3%	67,460
Network and computer systems administrators	204,680	289,520	84,840	41.5%	65,260
Network systems and data communications analysts	98,330	203,710	105,380	107.2%	67,460
Computer hardware engineers	60,420	74,480	14,060	23.3%	91,260
Electrical engineers	149,210	147,670	-1,540	-1.0%	78,900
Electronics engineers, except computer	106,830	131,880	25,050	23.4%	82,820
Total High-wage Tech. Workers	**2,200,650**	**2,628,810**	**428,160**	**19.5%**	**$ 75,819**

Source: *Bureau of Labor Statistics CES Data, 1999, 2000, 2001, 2002, May 2003, November 2003, May 2004, November 2004, May 2005, and May 2006 National Occupational Employment and Wage Estimates*

Source: Kirkegaard, Jacob F.

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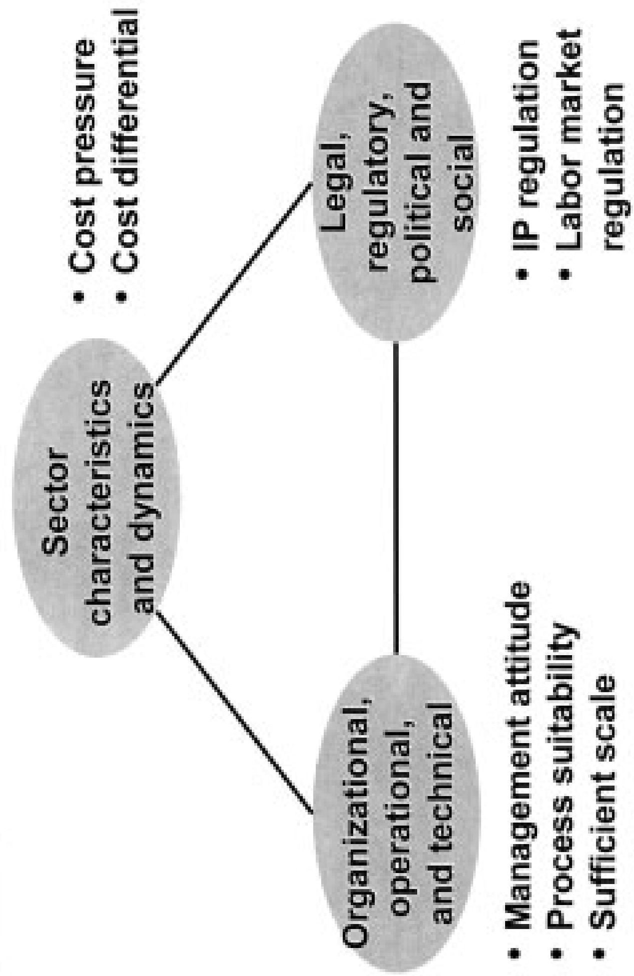
Figure 1:

FACTORS THAT INFLUENCE DEGREE OF ADOPTION



Source: McKinsey Global Institute, *The Emerging Global Labor Market*

Chairman GORDON. Thank you, Dr. Baily.

And now Dr. Gomory, we will now get to you.

STATEMENT OF DR. RALPH E. GOMORY, PRESIDENT, ALFRED P. SLOAN FOUNDATION

Mr. GOMORY. Thank you, Mr. Chairman.

Mr. Chairman, Members of the Committee, thank you for the opportunity to take part in this important hearing. The subjects we are going to discuss today are the ones to which I have devoted much of my life, and so this opportunity means a great deal to me, and I thank you.

I will make only one basic point in all my testimony, and it is this: In this new era of globalization, the interests of companies and countries have diverged and this divergence of goals enormously complicates the issue of national competitiveness. Countries have always looked to their companies to be productive and, thus, to be able to be provide productive and high-paying jobs and contribute strongly to the total output of the country, its GDP, gross domestic product. GDP is what countries want from their companies. Companies have always needed profits, both to survive and to do something for their shareholders, and these two different sounding goals were once tightly linked, but that has changed. Globalization has now made it possible for global corporations to pursue their profits by building capabilities abroad. Instead of investing in the United States and using R&D to increase their U.S. productivity, corporations today have the option of producing goods and services abroad using low-cost labor and import the goods or services into the United States. But in creating their profits in this way, they are building up the total output of goods and services of other countries while breaking their once tight links with America's own GDP, America's output.

The effect on the United States of the internationalization of the scientific and technical enterprise must be understood as one part of this revolutionary process of globalization. The role of science and technology in globalization is very special. S&T does not contribute to a nation's wealth by employing large numbers of people in high-value-added or high-wage jobs. It contributes by supporting a relatively small number of people whose work is intended to give a competitive edge to the end products, whether those end products are goods like cars and computers or services like call centers or advanced medical services. It is these end products, not the R&D itself, that make up the bulk of a country's output and most of a corporation's revenues and support of the jobs and wages of its employees. It is the competitive edge that is obtained from R&D.

If in the process of globalization the production or delivery of services and of the end product moves overseas, so do the wages. Even if R&D should remain behind, which in the long run it tends not to do, the vast bulk of value creation has moved to another country, and it is there that it supports the wages and GDP of that country, and this is an important shift. The productivity, the ability to produce goods and services of both countries have changed. It is at this point that a common confusion enters. The theory of free trade is invoked to say that although such shifts are painful to those who lose their jobs, they will find new ones, and the result is cheaper and better goods that benefit consumers so that, overall, the country comes out ahead. However attractive this idea, it is in fact an incorrect characterization of the theory of free trade.

Free trade owes its deserved appeal to the sound notion that if all countries produce the things at which they are relatively best and then trade these goods and services with countries which themselves produced what they supply best, then the global community and all its people will benefit. This is free trade, and I am a supporter of it. But in the economic analysis that produces this very favorable view of free trade, productive capabilities to make goods and services are taken as fixed. It is goods that are traded, but the ability to produce them is fixed, and that is not just a limitation of the theory, because it is easy to show that the uniformly benign results of free trade theory simply do not apply if there are also productivity shifts. Globalization, therefore, is not free trade because it does involve productivity shifts.

When the United States trades semiconductors for Asian sneakers, for example, that is trade, and the conclusion of economic theory is that this type of exchange clearly benefits both countries, but when U.S. companies build semiconductor plants and R&D facilities in Asia rather than the United States, then that is a shift in productive capability and neither economic theory nor common sense asserts that that shift is automatically good for the United States. Since globalization, as I said, does involve productivity changes, free trade theory does not apply, and the forecast of a benign outcome is not based on that theory. Again, globalization is not free trade.

However, economic theory is not a blank on this subject. What economic theory does show about productivity shifts is they tend to benefit the home country when its trading partner is a relatively undeveloped country. As the trading partner becomes more developed, the benefits decrease and pretty soon you reach a point where further development of the trading partner is detrimental to the home country. You are losing more to the new competitive ability of your trading partner than you gain from cheaper goods. Although it is common to propose tariffs under these circumstances, the only real antidote in this situation is to do the things that increase U.S. productivity, and in a globalized world, that is not easy. The desire to increase productivity often translates into asking for improved education and more money for R&D, often K–12 education. Proposals of this sort about education and R&D can, in themselves, only be helpful. They can only be harmful if they create the belief that these measures are enough to deal with the problem. They are only a first step but a good one.

The difficulties in improving education are well known, and those improvements are slow to come by, and also, there are limits to what can be done by education. We cannot expect education to turn out Americans who are so productive that they are worth hiring in place of the four or five Asians that can be hired for the same amount of money. More R&D, too, can only help but the R of R&D, basic research, that knowledge is spread around the world rapidly today so it becomes the common property of those who are developed enough to know how to use it, and there are more of these than ever before. Development, the D, may well result in greater productivity, but that productivity may well today in a globalized company itself be abroad, and it will not result, therefore, in the greater productivity of American workers or of the American economy. These measures are all good. They were even better in the past, but in today's globalized world their effect is somewhat weakened by globalization.

However, there are measures that work, even in a globalized world, because they tend to align company and country interests, and in looking at such approaches, we will be following in the footsteps of the Asian countries themselves. The Asian countries have made it profitable, and that is what companies need, for foreign, often U.S. corporations to create high-value jobs in their countries, and they do this by offering tax and other incentives as well as an undervalued currency that make it profitable for corporations to locate high-value jobs in their countries, and we should consider incentives that reward companies in the United States for the same thing. If we want high-value-added jobs, let us reward the companies for producing such jobs whether they produce that through the use of R&D, through the use of more-efficient manufacturing, through marketing, through a better way to deliver a service or through any form of American ingenuity by any means, at all. Let us reward the end result.

To show that incentives exist, let me briefly outline one, and this is only suggestive. We could have a corporate tax rate that would be scaled to the value added per American worker, full-time-equivalent worker, of corporations operating in the USA. Companies with high value add per U.S. employee would get a low rate, a low tax rate. A company with low value add per U.S. employee would get a high rate. This tax could be made revenue-neutral—very important. It would be an incentive for companies with high-value-added jobs to locate and keep their operations in the United States and it could be as strong or as weak an incentive as desired.

Let me finish by saying that in this country, we have had a remarkable culture of entrepreneurship that has helped ideas to become reality and which provides rich rewards for those accomplishments. Though we have had corporations in which it was recognized that it was in their own interest to invest alongside the U.S. workforce and make it possible for that workforce to increase its productivity, we need to consider incentives such as the tax mentioned above to realign the profit interests of corporations with interests of the country, and since we are dealing with globalization, not free trade, that alignment today is not automatic.

Thank you very much for listening.

[The prepared statement of Dr. Gomory follows:]

PREPARED STATEMENT OF RALPH E. GOMORY

Mr. Chairman, Members of the Committee, thank you for the opportunity to take part in this hearing. The subjects that we are to discuss today are the ones to which I have devoted much of my life. I was for almost 20 years the head of the research effort of a major international corporation, (IBM), for the last 17 years as the head of a major foundation (Alfred P. Sloan) deeply interested in science and technology. In addition, for almost my entire adult life, I have been active as an individual researcher first in mathematics and more recently in economics, I am pleased and honored to be here today and to have this opportunity to testify.

I will make only one basic point in my testimony: *In this new era of globalization the interests of companies and countries have diverged. In contrast with the past,* *what is good for America's global corporations is no longer necessarily good for the American people.*

The effect on the United States of the internationalization of the scientific and technical enterprise can only be understood as one part of the revolutionary process of globalization, which is fundamentally revising the relation of companies to the countries from which they have originated. In this new era of globalization the interests of companies and countries have diverged. *What is good for America's global corporations is no longer necessarily good for the American economy.*

In 1953 when General Motors Chairman Charlie Wilson told the U.S. Senate that "For years I thought what was good for the country was good for General Motors and vice versa"; he was articulating a philosophy and belief that when American corporations were successful it was generally good for the American people. But that was before globalization.

What "Engine Charlie" Wilson thought was largely true then because American corporations invested and prospered right alongside the American worker. Whether it was in GM manufacturing plants or in IBM's research and development labs *companies gave American workers the tools to outproduce the rest of the world.*

Companies thrived by having the best plants and equipment and information processing, not through having the longest work year in the world. And the workers and the American people more generally shared in that productivity and prosperity.

Misalignment of Company and Country

But over the last decade, what is good for the country and what is good for corporate America have gotten out of alignment. Today, most companies emphasize, to the exclusion of nearly everything else, corporate profitability and shareholder benefit. By measuring themselves only on profit in a globalized world, American companies may be able to succeed, but America the Nation and American workers cannot.

We understand that profit is a creative force. Companies come into existence to create profits, and in turn they create GDP, the goods and services that constitute a nation's economic output. And in constantly striving for more profits, companies become ever more efficient and create ever more GDP. As Adam Smith pointed out, "It is not from the benevolence of the butcher, the brewer or the baker that we expect our dinner, but from their regard to their own interest."

But globalization has now made it possible for global corporations to pursue their profits by building capabilities abroad. *Instead of investing alongside U.S. workers and using their investment and R&D to increase their productivity, corporations today can produce goods and services abroad using low-cost labor and import them into the U.S.* But in creating their profits this way, they are building up the GDP of other countries while breaking their once tight links with America's own GDP.

All of this is part of the process of globalization.

Globalization of Science and Technology

The role of science and technology in globalization needs to be understood. S&T does not contribute to a nation's wealth directly by employing large numbers of people in high value-added or high wage jobs. It contributes by supporting a small number of people whose work is intended to give a competitive edge to the end product, whether that is goods or services. It is these end products, whether they are cars or computers or medical services that make up the bulk of a corporation's revenues and support the wages of its employees.

If in the process of globalization the production (or delivery in the case of services) of the end product moves overseas, so do the wages. Even if R&D remains behind, the vast bulk of value creation has moved to another country and it is there that it supports the wages of employees. This is an important shift. It is important, because in the long run a country cannot consume more value than it produces and this shift decreases the value it produces.

Of course what we see is that R&D is also moving offshore, so that form of value creation is also moving to other countries.

It is at this point that a common confusion enters. If these production, delivery of services and/or R&D shifts occur as the free and unfettered actions of corporations the theory of free trade is invoked to say that although this is painful for those who lose their jobs, the result is cheaper and better goods that benefit consumers, so that overall the country comes out ahead.

However that is an incorrect characterization of the theory of free trade.

Trade and Productivity Changes—Globalization Is Not Free Trade

Free trade owes its deserved appeal to the sound notion that if all countries produce the things at which they are best, and then trade those goods and services with countries which themselves produce what they supply best, then the global community and its workers will all benefit. Economic theory uses the phrase "the gains from trade" to describe this.

In their analysis of trade economists usually take *productive capabilities as fixed* and describe trade in the goods and services that those capabilities provide. It is this narrow meaning of trade that economic theory clearly shows to be superior for both parties over failure to trade. Hence economists emphatic rejection of tariffs and other barriers to trade.

But when productivity capabilities are not fixed but are changed in the countries that are trading with each other, as they are in globalization and as they are changing today especially in Asia, the world finds itself in a whole new ball game. The end result of that change, even when the period of adjustment is over, may be better for one's country or it may be worse, depending on the circumstances.[1] And globalization is clearly replete with productivity changes.

Conclusions about trade in the narrow sense with fixed capabilities should not be confused with conclusions about the effect of productivity shifts. *There is nothing in either common sense or economic theory which says that improvement in the productivity capabilities of other countries is necessarily good for your country.* This observation holds true even if these productivity shifts are brought about by the free and unfettered actions of corporations.[2]

When the U.S. trades semiconductors for Asian t-shirts, for example, that is trade in the narrow sense.[3] And the conclusion of the most basic economic theories is that this exchange clearly benefits both countries. But when U.S. companies build semiconductor plants and R&D facilities in Asia rather than in the U.S., then that is a shift in productive capability, and neither economic theory nor common sense asserts that shift is automatically good for the U.S. even in the long run.

Since *globalization is free trade plus productivity changes* the benign conclusions of the free trade model with fixed capabilities simply do not apply to globalization.

However, even in these circumstances theory does continue to point steadily to the benefits of free trade. If there is a productivity change, the free trade outcome with the pre-change productivities is better than one with tariffs, and the free trade outcome with the new productivities is a also better than it would be with tariffs. Free trade does not guarantee that the productivity change is good for both countries, but both the before and after outcomes would be worse without it.

Harmful and Helpful Productivity Shifts

Productivity shifts have often figured in the common discussions of trade. For a long time it was an article of faith that whenever a productivity shift occurs the U.S. will automatically be certain to export unproductive low paying jobs, while our workers are moved up to more productive, more highly paid positions—and for an equally long time, this was, indeed, a reasonable description of the productivity shifts that the U.S. experienced. But that is not the picture before us today.

Since productivity changes are an essential element in globalization, and they can be harmful as well as helpful it is evidently essential to determine when they help and when they harm. Together with well-known economist William Baumol I have written a book [Ref. 6] and a number of papers on this subject using the most standard of economic models [References], and I will summarize our conclusions below. However, first we need to discuss just why the answer matters.

As we pointed out in our book [Ref. 6, pp. 71–73] there can be a divergence of interests between multinational firms and their home country. An overseas investment decision that results in productivity increases abroad may prove to be very good for the profits of a multinational firm, but it is far from automatic that it will also be good for the firm's own country as a whole. So the answer does bear on what people are seeing and are concerned about.

Our analysis shows that the impact on the home country of productivity increases in its trading partner can be favorable if the productivity increases occur in a very low wage country. American imports from that country become cheaper, trade expands for both nations and the result is mutual gain. But this becomes less true as the developing nation acquires greater capabilities and assumes a larger share of world production. At some point further development of the newly developing partner *becomes harmful* to the more industrialized country. Then, a firm that is

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[1] In Reference [5] Gomory and Baumol discuss when productivity shifts are mutually beneficial and when there is in fact a conflict in national interests.

[2] In fact the economic literature has a long history of both general theories and specific examples by distinguished economists showing that improvements in the productivity of a trading partner, even if unaccompanied by a diminution of productivity at home, can be harmful to the home country. References [1], [2], [3], [4] and [5].

[3] Generations of economist have been trained on the England makes textiles, Portugal makes wine model. In these discussions no productivity shift was involved.

moving production of goods and services overseas may find that it is generating greater profits for the company, but the same action can also result in an actual loss of national income for the company's home country. The home country will still be better off than it would be if trade were cut off altogether, but its position will be inferior to what it was before the improvement in the productive capacity of its developing trading partner.

Why Does This Happen?

We obtain this result unequivocally from a careful mathematical analysis using the actual and standard equations employed by economists in their study of economic equilibrium. But the logic can also be understood in common sense terms.

In the simplest models of trade,[4] wages of countries reflect the proportions of world value they produce. A country that produces more than its population share of world value[5] will be a high wage country; one that produces little will be a low wage country. Consider a low wage developing country, Devland, with which the more developed Homeland is trading a variety of products. Suppose that Devland succeeds in increasing to near Homeland levels the productivity with which it produces a commodity, clothtex that it has been importing from Homeland. Because of its low wage, it can now produce clothtex at a new low price and so it succeeds in taking over all or part of the clothtex market. As the new situation settles down we would expect the wage in Devland to have increased relative to the wage in Homeland as Devland now makes a larger proportion of the world's goods.

The overall economic effects on Homeland are then: (1) consumers in Homeland get clothtex at lower prices and (2) because of the new higher relative Devland wage, the prices of the other goods imported into Homeland from Devland go up. With clothtex having become cheaper for Homeland consumers, while the other imports have become more expensive. This can either be a good or bad outcome for Homeland, depending on how much the price of clothtex has declined and how much else is being imported from Devland. For this reason such productivity shifts may often not be benign.

We emphasize that a negative outcome for the home country is not exceptional or rare. The simplest example is provided by the standard England (cloth)—Portugal (wine) model often used to illustrate the benefits of free trade. If we add to that familiar model the effect of production shifts by allowing a cloth industry to emerge in Portugal, the effect is to lower the standard of living of England and raise that of Portugal. [see Endnote]

More generally how do these two effects balance out? The favorable effect of each individual industry shift is not likely to grow as Devland develops since Devland is most likely, to take over the industries in which low wage matters most, or industries in which they have some level of natural advantage such as climate or culture. However, the unfavorable effect will steadily become more important as the Devland develops further and Homeland imports more and more from them.

We can now see why the result we described above occurs. *At some point ever-further development of the newly developing partner becomes harmful to the more industrialized country.*

Where Are We Now?

Our calculations tend to show that we move from benefit to loss when the wage of a country with which we are trading rises to one-fourth or one-third of the U.S. wage. The size of the trading partner also matters, and we get into losing territory earlier when the trading partner has a large population. If we had to guess, we would venture that we are now at that point in relation to some of the Asian countries.

Of course, one may well argue that even that is a benign outcome for the world. Perhaps we are too rich and we *should* give up something to those who are poorer. That is a perfectly defensible position. However, that is not the way globalization and offshoring are usually described to the American people. Rather, we are assured that it is bound to make us richer in the long run, after the pain of change has been absorbed.

To summarize: The most standard basic economic theory deals with the universal benefit of free trade between countries with fixed productivities. Most discussions, however, lump that conclusion with those valid for the effects of developments that change the capabilities of the trading partners. The uniformly benign features of the fixed productivity case are then claimed for the more general one as well. There is no basis for these claims. Analysis shows that the results can go either way, so the

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[4] Often referred to as Ricardian models.

[5] As measured by current prices.

people of this country should not count on some long-range outcome that must inevitably make up for present pain. That day may never come.

Alan Blinder recently pointed out in *Foreign Affairs,*[6] that the effect of the production shifts that are likely to occur may well be so large that it is hard to think of them as even reasonably benign. Our calculations show the same thing, a developed country trading with a much larger (in population) country that is initially undeveloped and then increases its productivity capabilities, can suffer a precipitous drop in its standard of living. But our analysis shows no reason to expect that to be only a temporary pain.

Protectionism and Globalism

One might well wonder how two such mistaken concepts, protectionism, in which we forgo the gains from trade, and the automatic win-win view of globalization which we will refer to as "Globalism" which at times put our economy at risk, can persist with so little rational underpinning, but the answer is not hard to find.

Protectionism thrives, and will continue to thrive, because of the support it gives to the immediately affected domestic manufacturers and their employees. Similarly globalism is thriving today at least partly because it supports and gains support from a group that is very powerful today, the multinational corporations. For that reason we think that both protectionism and globalism will be with us for a long time to come whatever the rationality of these views from the point of view of economic theory.

In addition both protectionism and globalism have a natural structure that contributes to their persistence. Tariffs and other impediments to trade may provide large benefits to the limited set of firms in the protected industries and their employees, while the diffused damage to the rest of the Nation, though far greater in total, may only have a small effect on each of the many individuals upon whom the burden falls. Similarly, outsourcing may substantially benefit a small group of firms at the expense of widely diffused costs falling on the rest of the Nation to a degree hardly noticed by each affected individual. Thus, the proponents of socially damaging trade protection or socially damaging outsourcing are likely to be organized and strongly motivated, with little effective opposition from the remainder of the community, though the latter, in total, bear the brunt of the damage.

Can Anything Be Done?

This testimony does not pretend to take on in any systematic way the task of answering the question, "What is to be done?" I will be content if I can contribute to clarification of the some of the issues. However just the distinctions about trade we have made are suggestive.

To obtain the benefits of trade in the narrow sense we need free trade. This means, in particular, that we need to address the major distortions in the market caused by the systematic mispricing of Asian currencies. If we do not have a free market in currencies we cannot claim that the benefits of free trade are being achieved.

At the same time, turning back to the issue of changing productivities, we must continue to improve U.S. productivities relative to those of the Asian nations. This often translates into asking for improved K–12 education and more money for R&D. Improved education is hard to come by and it is hard to imagine an improvement in education so profound that it turns out Americans who are so productive that they are worth hiring in place of the four or five Asians who can be hired for the same wage. More R&D can only help but it should be clear from the discussion above that R&D, even if it remains in the U.S., can have only a limited impact. *Proposals of this sort about education and R&D can only be helpful. They can only be harmful if they create the mistaken belief that these measures can deal with the problem.*

I think that effective measures will have to tackle the problem more directly. Asian countries have made it profitable for foreign (often U.S.) corporations to create high value added jobs in their countries by offering tax and other incentives that make it *profitable* for corporations to locate high value added jobs in their countries. We need to look hard at incentives that reward companies in the U.S. for the same thing. If we want high value added jobs let us reward the companies for producing such jobs whether they do that through R&D, or just plain American ingenuity or by any means.

One such possibility is a corporate tax rate that would be scaled by the value added per FTE by the workers of corporations operating in the U.S. A company with high value add per U.S. employee would get a low rate, a company with low value

[6] Reference to Blinder article.

add per U.S. employee would get a high rate. This tax could be made revenue neutral. It would be an incentive for companies with high value added jobs to locate and keep their operations in the U.S. It could be as strong or as weak an incentive as desired.

Many incentives, some natural and some much less so, have worked in the U.S.'s favor and have helped to create a long history of economic growth. We have had a great range of natural resources, and a remarkable culture of entrepreneurship that helps ideas to become reality, and which provides rich rewards for that accomplishment. We have had corporations in which it was recognized that it was in their own interest to invest alongside their U.S. workforce and make it possible for them to increase their productivity. *We need to consider incentives, such as the tax mentioned above, that realign the profit interest of corporations with the interest of the country.* In short, we think it likely that there is a major problem facing this country and we also think there are actions, most as yet largely unexplored, that can make a significant and beneficial difference.

References

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[3] Krugman, Paul R. 1985. A "Technology Gap" Model of International Trade in K. Jungenfelt and D. Hague eds. *"Structural Adjustment in Developed Open Economies,"* New York, St. Martin's Press pp. 39–45.

[4] George E. Johnson, Frank P. Stafford "International Competition and Real Wages," *American Economic Review,* Vol. 83, No. 2, Papers and Proceedings of the Hundred and Fifth Annual Meeting of the American Economic Association (May, 1993), pp. 127–130.

[5] Samuelson, Paul A, 2004, Where Ricardo and Mill Rebut and Confirm Arguments of Mainstream Economists Supporting Globalization, *Journal of Economic Perspectives,* Volume 18, Number 3, pp. 135–146.

[6] Ralph E. Gomory and William J. Baumol, 2001, *Global Trade and Conflicting National Interests,* MIT Press.

Endnote

Even the familiar England-Portugal textile-wine model shows this effect. We assume, as usual, that England is much more productive in textiles and Portugal is much more productive in wine. With free trade and no productivity shifts England makes all the textiles and Portugal makes all the wine. If consumers spend a larger proportion of their incomes on textiles than on wine, England's wage will be higher than Portugal's, but both countries are better off than if they did not trade.

Now let us consider globalization that adds productivity shifts to the free trade model. Through globalization Portugal learns textile manufacturing and enhances its productivity in textiles to something close to England's. Because of its lower wage, Portugal can now enter the textile market. However textiles are still England's only products. To remain in the textile market and meet the new lower price for textiles, wages must go down in England relative to Portugal, so there is a new exchange rate.

At the new equilibrium, because of the exchange rate shift, the price of wine has gone up in England and consumers in England can afford less wine. English consumers with their new lower wage may consume about the same amount as before of the now cheaper textiles. However, with less imported wine, their standard of living will have fallen under globalization.

Portugal still exports wine to England and imports textiles. But it imports a smaller quantity of textiles, since it now has the home grown product as well. Portuguese consumers can now afford to consume more textiles because they are cheaper. They consume the same amount of wine as before. Their standard of living will have improved.

BIOGRAPHY FOR RALPH E. GOMORY

Ralph E. Gomory has been President of the Alfred P. Sloan Foundation since June 1989 Gomory received his B.A. from Williams College in 1950, studied at Cambridge University and received his Ph.D. in mathematics from Princeton University in 1954. He served in the U.S. Navy from 1954 to 1957.

Gomory was Higgins Lecturer and Assistant Professor at Princeton University, 1957–59. During this period he invented the first integer programming algorithm. He joined the Research Division of IBM in 1959, was named IBM Fellow in 1964. In 1970 he became IBM Director of Research with line responsibility for the IBM Research Division. Under his leadership the Research division made major contributions to the computer industry, such as the invention of the Relational data base, and also won two Nobel Prizes. While retaining responsibility for IBM's Research, Gomory became an IBM Vice President in 1973 and Senior Vice President in 1985. In 1986 he became IBM Senior Vice President for Science and Technology. In 1989 he retired from IBM and became President of the Alfred P. Sloan Foundation. There he has led the foundation into areas involving the scientific and technical work force, the study of individual industries, and issues of globalization.

Gomory has served in many capacities in academic, industrial and governmental organizations, and is a member of the National Academy of Science, the National Academy of Engineering, and the American Philosophical Society He was elected to the Governing Councils of all three societies. He was a Trustee of Hampshire College and of Princeton University. He served for a number of terms on the National Academies' Committee on Science, Engineering and Public Policy (COSEPUP). He served on the President's Council of Advisors on Science and Technology (PCAST) from 1984 to 1992, and from 2002 to the present.

Gomory has been a director of several Fortune 500 companies including the Washington Post Company, the Bank of New York, and Lexmark International, Inc., and of two small start-up companies. He was named one of America's ten best directors by *Director's Alert* magazine in 2000.

He has been awarded eight honorary degrees and many prizes including the Lanchester Prize in 1963, the John von Neumann Theory, Prize in 1984, the IEEE Engineering Leadership Recognition Award in 1988, the National Medal of Science awarded by the President in 1988, the Arthur M. Bueche Award of the National Academy of Engineering in 1993, the Heinz Award for Technology, the Economy and Employment in 1998, the Madison Medal Award of Princeton University in 1999, the Sheffield Fellowship Award of the Yale University Faculty of Engineering in 2000, he was elected to the International Operations Research Hall of Fame in 2003 and awarded the Lardner Prize of the Canadian Operations Research Society in 2006.

Gomory has remained an active researcher with interests in mathematics, computers, and economics. In recent years, he has written on the nature of technology and product development, industrial competitiveness, technological change, and on economic models of international trade. He is the author of the MIT Press book (with Professor William J. Baumol) entitled *"Global Trade and Conflicting National Interests."*

Chairman GORDON. Thank you, sir, and Dr. Duesterberg.

STATEMENT OF DR. THOMAS J. DUESTERBERG, PRESIDENT AND CEO, MANUFACTURERS ALLIANCE/MAPI

Dr. DUESTERBERG. Thank you very much, Mr. Chairman, for having me at this important hearing, and in the spirit of your admonition that this is a fact-finding hearing, I provided a lot of facts and figures in my testimony and I will refer to some of the charts in my testimony as I go through my brief synopsis.

The subject of this hearing is of vital importance to manufacturers for the simple reason that this sector is more engaged in the global economy than the much larger services sector. It is also a leader in innovation, accounting for over 60 percent of private-sector research and development in the United States and more than three-quarters of patents granted in the United States. Moreover, it has been subjected to foreign competition for the last 30 or 40 years so the experience of the manufacturing sector may shed some light on the future trajectory of the impact of globalization.

In fact, the pressures of globalization have forced manufacturers to become leaders in finding ways to adapt to this competition. One of the major results of this competition has been to require them to find new ways to do things in a much more efficient way. They have realized the benefits of strong productivity gains. Figure 3 on page 3 of my testimony illustrates the strong acceleration of manufacturing labor productivity since the 1980s and the superior performance in productivity of the manufacturing sector in our economy.

Productivity gains have created what is often referred to as a paradox of manufacturing. The sector is smaller in some very visible respects, such as employment and percentage of GDP, but it is much more global. While smaller, manufacturing has maintained its global marketshare, the chart, which is on page 5, shows that the U.S. share of global manufacturing output has actually increased slightly from about 22.9 percent in 1980 to 23.8 percent in 2003. More impressively, Figure 7 shows that the U.S. manufacturers' share of global high-tech output increased from approximately 25 percent in 1980 to 42.5 percent by 2005, which is the latest year for which we have data, which is a subject in and of itself.

A few myths and beliefs about globalization viewed from the perspective of multinational manufacturers who are the most engaged in the global economy in the first place, there is not a rapid offshoring on a net basis of jobs. Figure 9 shows that the employment share of U.S. parent multinationals has remained relatively flat as a share of total non-bank private industry between 1988 and 2004. The data show that an increase in employment at foreign affiliates is positively correlated with growth in jobs at the domestic parent. While overall job losses do affect the domestic manufacturing sector, they are not amongst the most globally engaged parts of the manufacturing sector.

There are myriads of benefits from engagement abroad, not the least of which is access to foreign markets, which are in many cases the fastest growing on a relative basis in the world. And in fact the reason, the primary reason for locating a manufacturing facility abroad, is for access to local and regional markets. In fact, 90 percent of the production of foreign affiliates of U.S. manufacturers are sold into the local markets and less than 10 percent back to the United States. Finally, I would note that 64 percent of U.S. employees of foreign affiliates are in high-wage countries such as Europe and Japan and Canada, and overall, the employment at multinational corporations, including the United States records that about 90 percent of the employment is still in high-wage countries.

Now let us turn to a little bit of data on the globalization of innovation. In fact, most of the data that we have refers to research and development. R&D is the least globalized activity of U.S. multinationals. Foreign affiliates represent 31 percent of all sales and 28 percent of employment, but R&D only represents about 13.7 percent among foreign affiliates. This is up slightly from 11 percent in 1990. Furthermore, more R&D is insourced into the United States than is outsourced. Companies such as Siemens and others do a great deal of research as well as the German auto companies, Japanese auto companies. The growth of R&D spending by U.S. parent companies in the United States increased at a 6.1 percent annual rate since 1990, while the increase in R&D spending among foreign affiliates grew at a 6.2 percent rate, so that the vast amount of the research remains in the United States, and again, I would emphasize that more R&D is insourced than is outsourced.

In sum, while R&D activity and technological excellence is being globalized, and there is evidence that, as I believe the Chairman cited and the Ranking Member cited as well in the Texas study, there is some evidence of increased globalization of R&D in countries such as China, partly through tax incentives and other means of increasing their R&D activity, but nonetheless, the U.S. maintains a commanding presence in research and development activity.

I would emphasize, though, that while R&D activity is certainly of interest, it is only one component of a very complex ecosystem that produces what has come to be known as innovation. Whether R&D offshoring, if it accelerates, is indicative of the true globalization of a broad class of activities that enter into the innovation process is, at the moment, a very open question. Many other factors—technical work force, legal protection for intellectual property, financial innovation and more qualitative factors such as propensity for risk-taking—all figure prominently into the generation of innovation. Unfortunately, there is a paucity of data available that has left many crucial questions about the globalization of innovation activity basically unanswerable at this point in time.

We at the Alliance have done a little bit of research to try to understand better the complex activity of innovation. Without going into a great deal of depth, we have tried to explain both product innovation and process innovation, the way you make things, which is of equal importance. Our results show that variables such as capital investment, university-industry linkages and the employment of science and engineering personnel are important ingredients for innovation. The results of our empirical work that are particularly interesting are those regarding basic R&D expenditures at universities and colleges. Our research indicates that a 10 percent increase, for example, in nominal dollar expenditures on basic science at universities and colleges generates after a lag a 4.1 percent increase in utility patent approvals and with a little bit longer lag of four years a nearly two percent increase in the multi-factor productivity growth in manufacturing. All of this suggests that we need to do a great deal further work on fully understanding the process of innovation and the data is just not available yet. A lot of data needs to be gathered in order to accomplish this. This is especially true given the anecdotal evidence of the potential globalization of R&D activities and the fear that innovation will be outsourced in its wake. We at the Alliance are undertaking some of this research along with many other institutions around the country.

Finally, in terms of the policy implications of what I have reported here today, we think that our efforts should be directed to expanding the extent of free trade while working to end the many unfair trading practices that still plague our ability to access foreign markets. It is a poorly understood fact that only five percent of the trade deficit in manufactured goods, which is of course 75 percent of our overall deficit, is with countries where we have free trade agreements while these same countries account for 30 percent of our imports and over 44 percent of our exports. To remain globally competitive, we need, first and foremost, to keep our domestic economy strong with a sensible monetary policy that we have been blessed with for a number of decades and maintain the low-tax, spending constrained, low-deficit fiscal policy that still satisfies the needs of crucial social goals. Over time we will need to increase national savings both to curb our trade deficit and to fund needed capital and social investment. Moreover, we need to be increasingly mindful of the structural costs that our businesses face in a world where capital is increasingly mobile, an issue investigated in depth in some of our studies. In particular, we need to address high differentials in corporate taxes, tort litigation costs—of course, we spend more on tort litigation than we do on R&D in the United States—high natural gas costs, health care costs that are borne by employers and regulatory burdens of U.S. firms as compared with our leading global competitors. Finally, we need to combat the mercantilist policies, such as maintaining undervalued currencies, which Martin alluded to, theft of intellectual property and subsidizing export industries practiced by competitors, such as China and other Asian nations.

Finally, we need to put our own house in order, as the others have mentioned. We need to ratchet up investment in the sciences and engineering disciplines so crucial to innovation and to attracting domestic students to these fields, and finally, we need to think seriously about creating a better career path for U.S. scientists and engineers.

Mr. Chairman, thank you very much for this opportunity to appear before your group.

[The prepared statement of Dr. Duesterberg follows:]

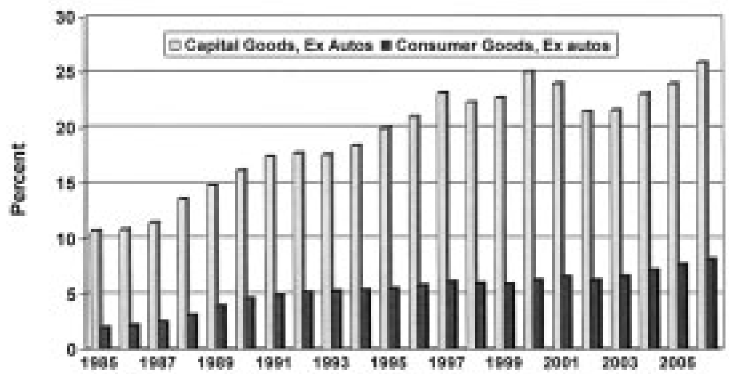
PREPARED STATEMENT OF THOMAS J. DUESTERBERG

Mr. Chairman and Members of the Committee, I want to thank you for holding this hearing on a subject of vital and timely importance to U.S. manufacturers. My organization represents over 500 leading manufacturing firms whose products range from basic materials to advanced manufacturing and leading-edge technology and associated services. The Alliance itself is primarily a research and executive education provider, but we do advocate public policies benefiting our member companies. Notwithstanding the support of our member companies, the views I will present today are mine alone and do not necessarily represent the unanimous opinion of our members.

I. The U.S. Manufacturing Sector: Evolution and Adaptation

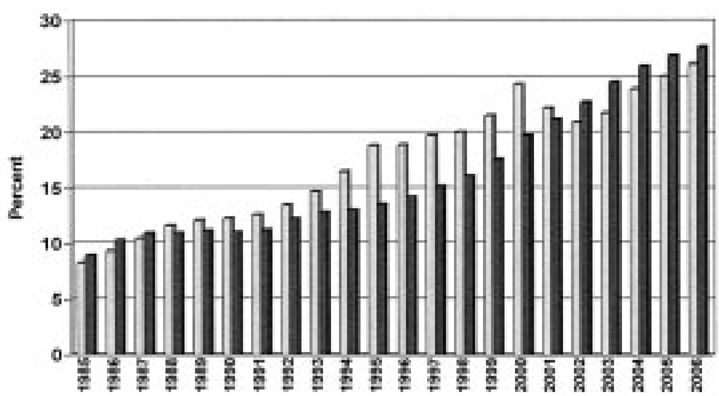
The subject of the hearing today is of vital importance to manufacturers for the simple reason that this sector has been much more engaged in the global economy than the much larger services sector. It is also a leader in innovation, accounting for over 60 percent of private sector research and development (R&D) in the United States and more than three-quarters of patents granted in the United States. For this reason, it is necessary to understand the manufacturing sector's response to globalization in order to fully appreciate the many issues surrounding the globalization of innovative activity. Figures 1 and 2 illustrate the strong pattern of manufacturing globalization of the past two decades. As shown in Figure 1, capital goods exports as a share of U.S. manufacturing output grew from 11 percent in 1985 to 26 percent by 2006, while the share of consumer goods exports quadrupled from two percent to eight percent during the same time frame. Both innovation and constant research and development efforts are required to stay competitive. For capital goods, the path of import growth has been somewhat similar to the path of export growth. As shown in Figure 2, capital goods imports as a share of manufacturing output grew from eight percent in 1985 to 26 percent by 2006, while consumer goods exports skyrocketed from nine percent to 27 percent. As a result, the trade deficit, which is 75 percent or more in manufactured goods, is largely a function of our imbalance in consumer goods and raw materials such as oil. We are roughly in balance—and fairly competitive in capital goods—particularly those which embed high technology and require substantial scientific and engineering resources.

Figure 1
Capital and Consumer Goods Exports
Share of U.S. Manufacturing Output
1985-2006



Source: Bureau of Economic Analysis

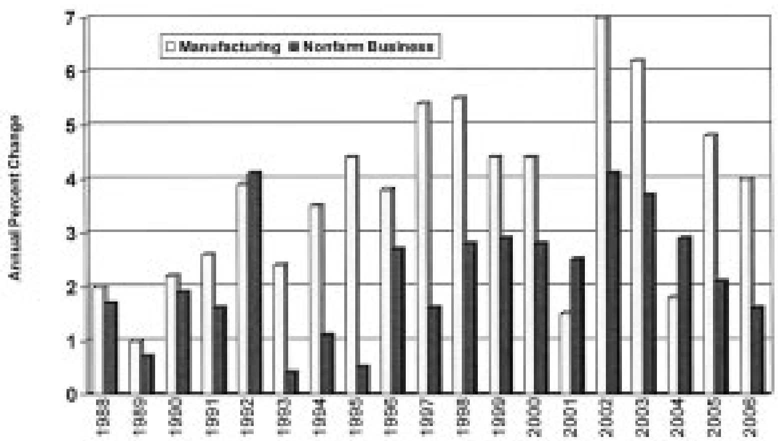
Figure 2
Capital and Consumer Goods Imports
Share of U.S. Manufacturing Output
1985-2006



Source: Bureau of Economic Analysis

The pressures of globalization have forced manufacturers to become leaders in finding ways to adapt to international competition. They have quickly realized that cost containment and the relentless pursuit of both process and product innovation are the keys to survival. Constant improvement programs such as lean manufacturing and six sigma have rapidly become the norm in multinational manufacturing enterprises. Partially as a result, the manufacturing sector as a whole has realized the benefits of strong productivity gains, although some argue that these gains are limited to R&D intensive, high-technology industries. Figure 3 illustrates the strong acceleration of manufacturing labor productivity growth since the late 1980s. And while the data aren't strictly comparable, it is quite evident that manufacturing productivity growth has far exceeded productivity gains for the economy as a whole. There is anecdotal evidence that service-sector firms are beginning to mimic manufacturing productivity improvement practices. In fact, some studies show that those service industries most closely tied to manufacturing, such as wholesale trade, are the leaders in productivity enhancement.

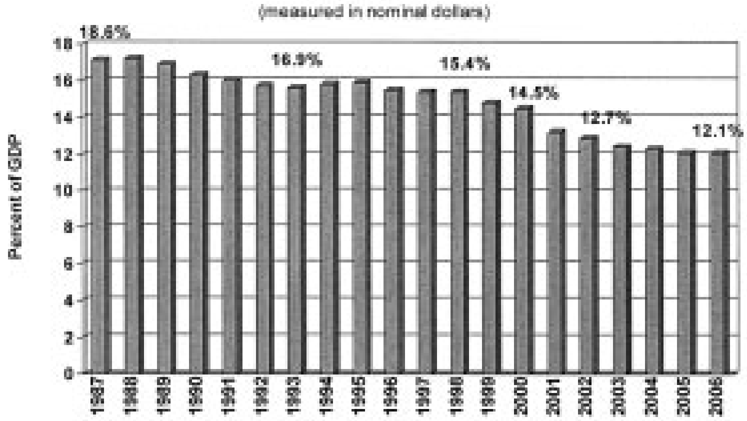
Figure 3
Manufacturing and Non-Farm Business
Labor Productivity Growth



Source: Bureau of Labor Statistics

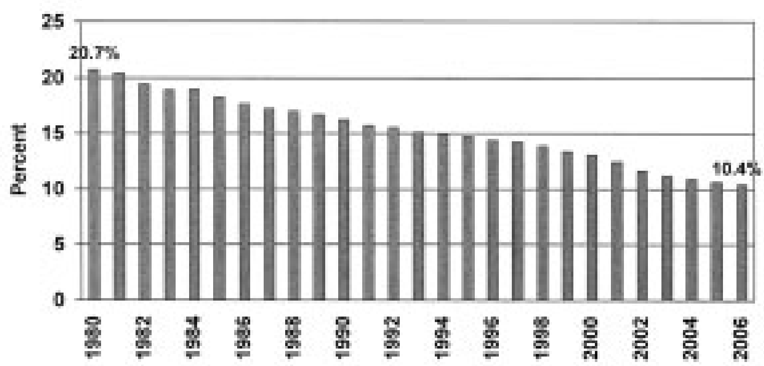
Productivity gains have created what is often referred to as the "paradox of manufacturing." The sector is smaller in some very visible respects but more global. Figure 4 shows that the manufacturing share of the U.S. economy has declined from 18.6 percent in 1987 to 12.1 percent by 2006. Part of this decline, but by no means all, is explained by the productivity induced price effect engendered, in turn, by global competition. Additionally, global competition has restrained pricing power in manufacturing to a much greater extent than in services, so that manufacturing's nominal share of GDP declines despite continued growth in physical output at about the same pace as the overall economy. Figure 5 shows the even more dramatic employment decline. As shown, the manufacturing workforce has declined from 20.7 percent of the U.S. workforce in 1980 to 10.4 percent by 2006. And in fact data show that manufacturing employment has been declining as a share of the U.S. workforce since the early 1950s, suggesting that the reasons for the employment decline are fundamental to the factory sector's evolution and are not simply a result of the current challenges presented by emerging markets. But while smaller, manufacturing has maintained its global position. Figure 6 shows that the U.S. share of global manufacturing output has actually increased slightly from 22.9 percent in 1980 to 23.8 percent in 2003. And more impressively, Figure 7 shows that the U.S. manufacturers' share of global high-tech output increased from approximately 25 percent in 1980 to 42.5 percent by 2003 (the latest year for which data are available). Clearly, the sometimes painful domestic adaptations have allowed the U.S. manufacturing sector to survive and compete in the global business environment in which it now operates.

Figure 4
Manufacturing Share of the Economy:
1987-2006
(measured in nominal dollars)



Source: U.S. Department of Commerce, Bureau of Economic Analysis

Figure 5
Manufacturing Share of the U.S.
Non-Farm Workforce
1980-2006



Source: U.S. Department of Labor, Bureau of Labor Statistics

Figure 6
U.S. Share of Global Manufacturing Ouput,
1980-2003

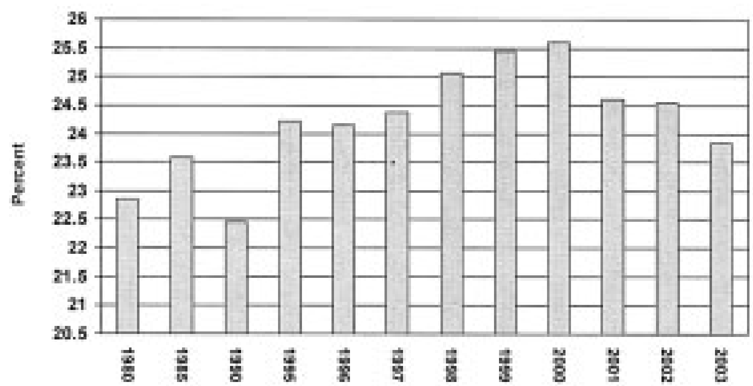
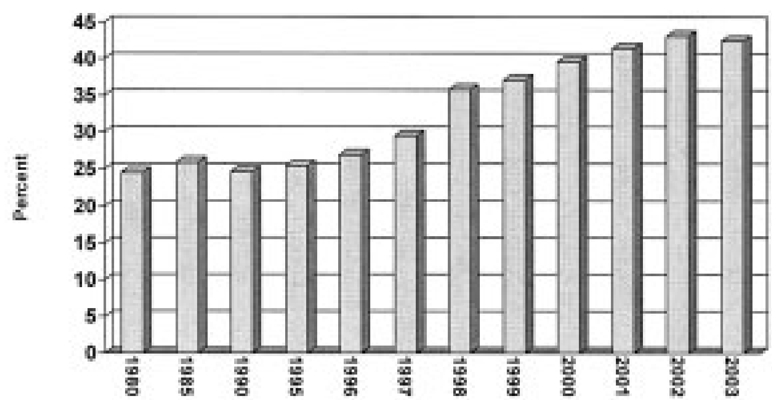


Figure 7
U.S. Share of Global High-Tech Manufacturing,
1980-2003

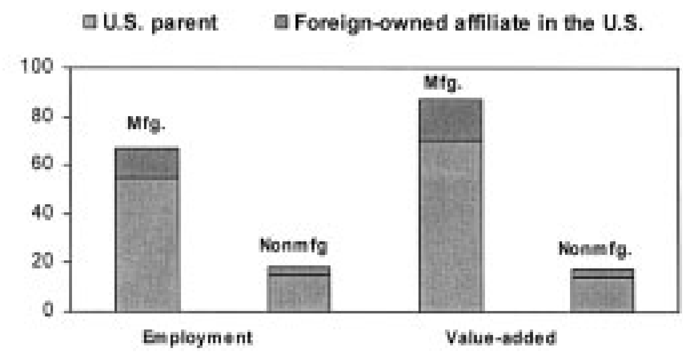


Source: National Science Foundation

II. U.S. Multinational Foreign Direct Investment: Myths and Benefits

While the macro data presented above illuminate the broad sectoral response to globalization, a fuller understanding of the key issues related to jobs, capital investment, and innovation requires a more focused study of the multinational firms that dominate the U.S. manufacturing sector. Along these lines, MAPI's Chief Economist, Dan Meckstroth, recently published a comprehensive essay on the role of multinationals and the benefits and costs of multinational activity.[1] Popular myth often creates the incorrect perception that multinational corporations (MNCs) are the agents of U.S. job and capital loss in a globally integrated world. But Dr. Meckstroth's paper provides a wealth of data and empirical research to show that the business dealings of U.S. multinationals with their affiliates abroad complements rather than substitutes for the domestic economic growth. Figure 8 illustrates the large footprint that multinationals (including foreign-owned MNCs operating in the United States) have in the manufacturing sector in spite of only accounting for less than one percent of all manufacturing firms. As shown, during 2004 multinationals accounted for about two-thirds of manufacturing employment and about 85 percent of U.S. manufacturing GDP.

Figure 8
Multinational Corporations' Share of U.S. Employment and Value-Added by Industrial Sector, 2004
Percentage of U.S. Nonbank Private Industry



Source: U.S. Department of Commerce, Bureau of Economic Analysis

Contrary to common myth, multinationals aren't transferring jobs out of the United States, even as they increase production among their foreign affiliates. Figure 9 shows that the employment share of U.S. parent multinationals has remained relatively flat as a share of total non-bank private industry employment, while foreign-owned multinational employment in the United States actually increased slightly between 1988 and 2004. Domestic employment growth in both manufacturing and non-manufacturing MNCs generally equals or exceeds the growth of other companies in the same sector over the past 20 years. Finally, the data show that an increase in employment at foreign affiliates is positively correlated with growth in jobs at the domestic parent. While overall job losses do affect the domestic manufacturing sector, they are much less among MNCs.

As the Meckstroth paper explains, expansion abroad through foreign direct investment is the only way to accelerate the pace of growth beyond what is possible in the domestic marketplace. Demand is growing rapidly around the world in such places as China, India, and Southeast Asia at a faster pace than in the United States. The data of the past three decades show clearly that multinationals invest abroad primarily to gain access to fast-growing markets for their products and services. Table 1 shows considerable growth in affiliate sales as a share of total global sales for MNCs, from 1999 to 2004 foreign affiliate sales grew at a 10 percent rate, faster than the 3.5 percent rate of domestic parents. Figure 10 shows the destination for the sales of U.S. manufacturing affiliates since 1989. In 2004, only 10 percent of these affiliate sales were back to the U.S. parent corporation, and that share has declined modestly over the past 15 years. Although not shown separately in the

[1] Daniel J. Meckstroth, "Globalization Complements Business Activity in the United States," Manufacturers Alliance/MAPI, ER–624e, January 2007. I wish to thank Dr. Meckstroth, Cliff Waldman, and Ernest Preeg for their assistance in preparing this testimony.

figure, only one percent to two percent of U.S. foreign-affiliate sales are exported back to the United States to third parties. The vast majority of the sales of U.S. affiliates, about 90 percent are either to the country in which the affiliate is located or to the nearby region. This pattern dates back at least to the 1920s and 1930s when U.S. automakers began to produce in Europe and elsewhere to access local and regional markets. These problems apply to the sales of non-manufacturing affiliates as well.

Figure 9
Multinational Corporations' Share of U.S. Employment By Corporate Nationality, 1988 to 2004
Percentage of U.S. Nonbank Private Industry

Source: U.S. Department of Commerce, Bureau of Economic Analysis

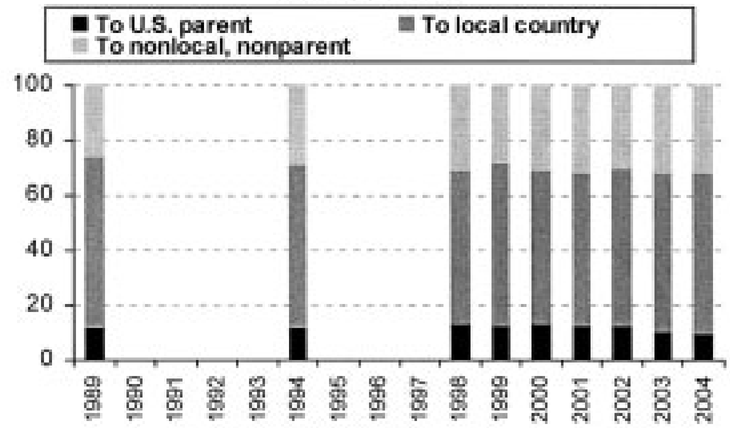
Table 1
U.S. Multinationals Sales and Exports, 1999-2004

	Manufacturing		Non-Manufacturing	
Year	MOFA sales % of global sales	Number of times MOFA sales larger than parent exports	MOFA sales % of global sales	Number of times MOFA sales larger than parent exports
1999	34.7	4.0	19.2	11.0
2000	35.4	4.4	18.7	12.5
2001	36.1	4.6	18.6	14.0
2002	37.8	5.1	18.2	14.1
2003	40.2	5.7	19.5	15.8
2004	41.7	6.2	19.9	16.6

Source: U.S. Department of Commerce, Bureau of Economic Analysis
Note: MOFA is Majority-Owned Foreign Affiliate.

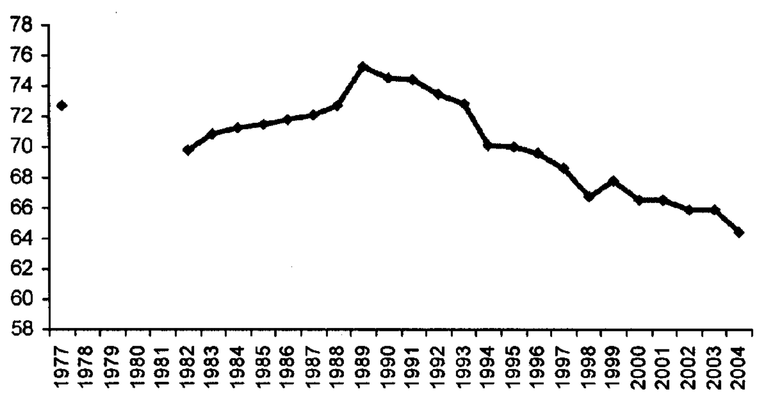
The issue of low-wage country arbitrage is perhaps the most contentious and difficult one in analyzing outsourcing. Figure 11 shows that the share of U.S. majority-owned foreign affiliate employment in high-income countries remained large in 2004 at 64 percent. But it nonetheless fell steadily from a peak of 75 percent in 1989. Further, Table 2 shows the considerable growth of employment of U.S. majority-owned foreign affiliates in China, India, and to a lesser extent Mexico. If China and India are excluded, affiliate employment growth in the low and middle income countries is marginal, reinforcing the notion that foreign investment largely seeks fast-growing, large markets like China and India.

Figure 10
Destination of U.S. Majority-Owned Manufacturing Foreign-Affiliate Sales
By Industry of Affiliate, 1989 to 2004
Percentage of total sales



Source: U.S. Department of Commerce, Bureau of Economic Analysis

Figure 11
High-Income[a] Country Share of Employment by U.S. Majority-Owned Foreign Affiliates, 1977 to 2004
Percentage of total employment



Source: U.S. Department of Commerce, Bureau of Economic Analysis
[a]The high-income classifications are determined by the World Bank.

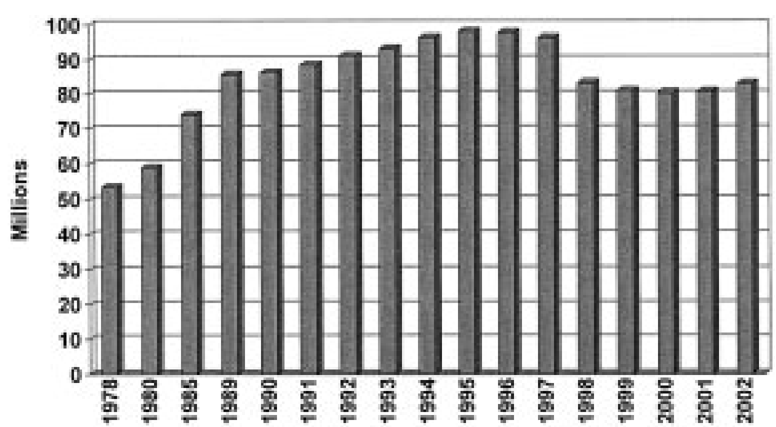
Table 2
Employment Growth
Majority-Owned Foreign Affiliates of U.S. Multinationals
By Income Classification/Country, 1997-2004

Income Classification/Country	Number of Countries	Employment Annual Percent Growth
Low-Income	**20**	**12**
India	1	19
Excluding India	19	0
Low-Middle Income	**33**	**5**
China	1	13
Excluding China	32	3
High-Middle Income	**30**	**3**
Mexico	1	4
Excluding Mexico	29	2
High-Income	**37**	**3**

Source: U.S. Department of Commerce, Bureau of Economic Analysis

While the trend toward low-wage country foreign direct investment is growing, Dr. Meckstroth's paper notes that anecdotal evidence suggests that market expansion, not costs, is the primary driver of U.S. entry into these high-potential emerging market countries. The absence of understanding of this simple fact has created misguided perceptions about job exporting that are often belied by actual data. For example, the fear that manufacturing jobs are "being lost to China" is somewhat undermined by the weakness in manufacturing employment growth in China during the late 1990s and early 2000s, shown in Figure 12.

Figure 12
Manufacturing Employment in China



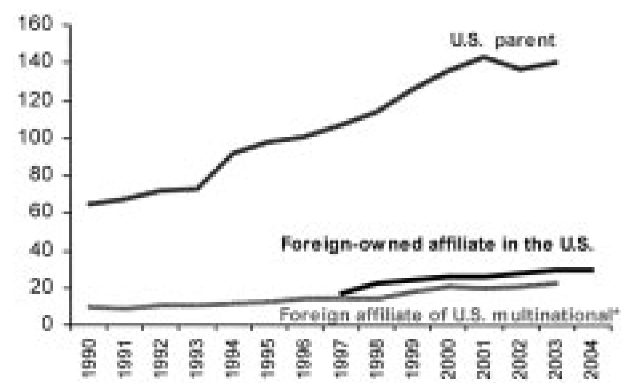
Source: China Statistical Yearbook, 2006

The MAPI study also highlights the indirect benefits to the domestic U.S. economy from multinational global profit-seeking behavior. U.S. businesses and consumers gain from lower cost products, improved services, higher quality goods and services, longer product life cycles, higher profits, and higher quality jobs. U.S. firms are motivated to produce abroad to avoid tariffs and other barriers to adapt products to those markets, and—as I will discuss later—tap local talent and other resources. And far from being substitutes for domestic activity, the paper points to credible research which shows that when foreign affiliates expand, their U.S. parents also expand domestic operations. Finally, many studies show that low wages and fast growth in foreign countries do not in and of themselves attract foreign investment. That is why foreign investment is still high in developed countries, including increased investment into the United States. Ninety percent of the employees of U.S. MNCs are in high wage countries, including employment at the domestic parent plants.

III. The Next Wave: The Globalization of Innovation

While much public debate has been centered on the consequences of globalization for U.S. job and investment growth, the potential globalization of innovation supply chains has received far less attention. The reason is quite clear. At the moment, as pointed out by the Meckstroth paper, R&D is the least globalized activity within multinationals. Foreign affiliates represent 31 percent of all sales and 28 percent of employment among U.S. multinationals. These firms have, however, been reluctant to globalize research activity for fear of losing intellectual property protection for what are often their core competences. Consequently, foreign affiliates' share of multinational R&D spending has not changed appreciably during the 13 years from 1990 when it was 11.4 percent to 2003 (the latest data available) when it was 13.7 percent. Figure 13 shows the total R&D spending by U.S. MNCs at the parent and among foreign affiliates. It is also worth noting that more R&D by non-U.S. firms is insourced than is outsourced by U.S. firms; the United States remains an outstanding destination for R&D by European, Japanese, and other Pacific Rim developed countries.

Figure 13
Multinational Corporations' Research and Development Spending By Corporate Nationality, 1990 to 2004
Billions of dollars



Source: U.S. Department of Commerce, Bureau of Economic Analysis
*Majority-owned
R&D spending for foreign-owned affiliates in the United States was not available prior to 1997.

To understand the motivation for and the benefits of expanding production and the limited offshoring of R&D networks around the world, some extended discussion is warranted. Global production and sourcing can, first, improve the rate of return on product innovation by extending the life cycle of products. New products (such as computers or medical diagnostic devices) introduced in the United States, Western Europe, and Japan tend to have high value propositions. Early in the product life cycle, production costs are relatively high because firms are producing first-generation products on a small scale, using relatively high-skilled workers and employing specialized capital equipment. The relatively high price of products at the early stage of a product's life, however, compensates for the start-up costs and risk. Over time, newer product generations are introduced, and the market for the older generation matures. The longer the products embodying old technology stay on the market, the more likely competitors will be to commoditize them. Intense competition may lead to falling prices, and eventually products in the mature stage of the product cycle do not have a large enough market and revenue stream to support U.S. production costs. Globalization, however, can preempt discontinuation of such mature product lines and provide them with a new life. An old-technology product or a significant portion of the product can be manufactured using less expensive capital and low-wage labor in developing countries.[2] Otherwise the product would simply be supplanted by foreign competitors. The ability to generate profits on a product over a longer life cycle increases the rate of return on innovation and promotes more new product development in industrialized countries.

Research evidence also finds that multinationals benefit from global research and development and from an expanded international knowledge network. Economists Chiara Crascuolo, Jonathan E. Haskel, and Matthew J. Slaughter[3] examined data on several thousand firms in the United Kingdom and found that globally engaged firms generate more innovation outputs than firms not globally engaged. In the 1998 to 2000 time frame, only 18 percent of firms with domestic-only operations had made some significant product or process innovation. The average number of patents applied for among the non-multinationals was just 0.1 per firm. Among firms that were multinational parents, however, 45 percent reported either product or process innovation during the time period, and they averaged ten patent applications each.

An important finding from the research on how globalization improves innovation concerns the way multinationals achieved superior knowledge generation. MNCs are more innovative than non-multinationals not just because they have more researchers, but because they have an expanded global knowledge network. In the case of patents, increased innovation is derived from collaboration and networking with other researchers in universities around the world. When it comes to production process and product innovation, multinationals are able to learn more than non-multinationals from both domestic sources of applied knowledge and a wide network of international sources, such as suppliers, customers, and their foreign affiliates[4] The resulting productivity gains from multinationals' innovation directly benefit Americans' standard of living, and the knowledge spillover indirectly benefits domestic firms that supply and/or are customers of multinationals.

The availability of technical talent overseas and the rapid growth of foreign markets provide further incentives for U.S. multinationals to expand international research centers. The reason that foreign-affiliate R&D shown in Figure 13 is such a small proportion of the total is that R&D is a core value generator for U.S. multinationals. U.S. multinationals are reluctant to globalize the activity and risk losing protection for their intellectual property.

Another way to illustrate the point that the United States is not rapidly offshoring R&D activity to foreign affiliates is to look at R&D spending growth. From 1990 to 2003, R&D spending by U.S. parent companies increased at a 6.1 percent annual rate of growth, and majority-owned foreign-affiliate R&D spending grew at a 6.2 percent annual rate of growth—expanding essentially at the same pace.

Although R&D spending by U.S. parent companies kept pace with R&D spending by foreign affiliates from 1990 to 2003, there is some evidence that the future pace of R&D globalization may be accelerating. The United Nations Conference on Trade and Development (UNCTAD) found in a 2006 survey that developing countries are likely to grow in importance as R&D locations for multinational firms. Fifty-seven percent of multinational firms surveyed already have an R&D presence in China, India, or Singapore,[5] and 67 percent of U.S. firms indicate that their foreign R&D is set to increase over the next five years.[6] While the lion's share of global R&D clearly remains with industrialized countries, emerging economies, most notably China and India, are becoming more important innovation centers. A recent survey of 186 of the world's largest firms found that 77 percent of R&D centers over the next three years are likely to be in China and India.[7] My colleague Ernie Preeg has shown that China is expanding R&D expenditures at the rate of 22 percent per year, far above the six percent in the United States and five percent in the Euro-

[2] Craig K. Elwell, *Foreign Outsourcing: Economic Implications and Policy Responses,* Congressional Research Service Report for Congress, Order Code RL32484, June 21, 2005, p. 15.

[3] Chiara Crascuolo, Jonathan E. Haskel, Matthew J. Slaughter, "Global Engagement and the Innovation Activities of Firms," National Bureau of Economic Research, Working Paper 11479, June 2005, pp. 1–46.

[4] *Ibid,* p. 5.

[5] United Nations Conference on Trade and Development, *UNCTAD Survey on the Internationalization of R&D, Current Patterns and Prospects on the Internationalization of R&D,* UNCTAD/WEB/ITE/IIA/2005/12, December 12, 2005, p. 1.

[6] *Ibid,* p. 11.

[7] See "R&D Outsourcing," *Business Week,* May 10, 2006.

pean Union and Japan.[8] Of course some of the attraction to perform R&D in China is due to the tax breaks and other subsidies provided by both Beijing and regional governments. Additionally, China frequently tries to leverage research and knowledge transfer in return for access to its huge and fast-growing market.[9]

Despite the enthusiasm for developing country R&D, the United States remains a commanding R&D presence in the world, although China especially is becoming more attractive when future investments are considered. When UNCTAD asked non-U.S. multinationals from around the world what their preferred location was for new R&D projects abroad, the United States was listed second most often. China was mentioned most often, and India was listed third most often, followed by Japan and the United Kingdom.[10] The survey demonstrates that the United States is a preferred location for R&D among multinationals headquartered in other developed and emerging countries.

In sum, while R&D activity and technological excellence is being globalized, the United States maintains a commanding presence at this time. An often overlooked fact is that the United States has a surplus in R&D and service payments among multinationals. Figure 13 shows that foreign-owned firms spend more on R&D in the U.S. than foreign affiliates of U.S. multinationals spend abroad. As noted earlier, R&D insourcing thus exceeds outsourcing among multinationals in the United States. Furthermore, the United States has a trade surplus in royalties and licensing fees ($62 billion in receipts versus $26 billion in payments in 2006) and a trade surplus in business, professional, and technical services ($41.3 billion in receipts versus $33.2 billion in payments in 2005). At the same time that U.S. multinationals are looking abroad for technology, research, and collaboration, the rest of the world is coming to the United States for the same services. Globalization thus clearly complements innovation in the United States.

While R&D activity is certainly of interest, it is only one component of a complex ecosystem that produces what has come to be known as innovation. Whether R&D offshoring, if it accelerates, is indicative of the true globalization of the broad class of activities that enter into the innovation process is, at the moment, an open question. Many other factors, technical workforce, legal protection for intellectual property, financial innovation, and more qualitative factors such as propensity for risk taking all figure into the generation of innovation. The potential emergence of innovation supply chains that originate in the U.S. and other major manufacturing centers raises a number of questions for U.S. policy-makers. Research is needed to expand understanding of the globalization of innovation and to provide needed insights to inform the domestic U.S. policy response. Unfortunately, a paucity of data has left many crucial questions about the globalization of U.S.-based innovation activity unanswerable.

The existing literature on the globalization of innovation suffers from a number of crucial shortcomings. First, the myopic focus on R&D as the sole indicator of innovative activity has distorted results and hidden key policy implications. The absence of a coherent framework and statistical robustness has also plagued these studies. For the moment, it is reasonable to conclude that we fall far short of a full understanding of the innovation globalization dynamic as well as the forces that are driving innovation offshoring decisions.

IV. MAPI Innovation Research Program: Conclusions and Implications

To contribute to understanding of the forces that impact innovation in the manufacturing sector, both domestic and international, two of my MAPI colleagues, Cliff Waldman and Jeremy Leonard began collaborating on a significant innovation research program in the early part of 2006. The purpose of the initial work was to specify and estimate a simple, yet utilitarian model of innovation in the U.S. manufacturing sector and to derive comprehensive indicators of product and process innovation.

Their research provided robust statistical evidence that the drivers of innovation extend well beyond the business R&D spending that is typically thought to be the principal source of innovation.[11] Our results show that variables such as capital investment, university-industry linkages, and the employment of science and engi-

[8] Ernest H. Preeg, *The Emerging Advanced Technology Superstate,* Manufacturers Alliance/MAPI, June 2005.

[9] *Ibid,* pp. 46–50, for a discussion of Chinese tax and other incentives to attract investment in the semiconductor industry.

[10] UNCTAD, *op. cit.,* p. 13.

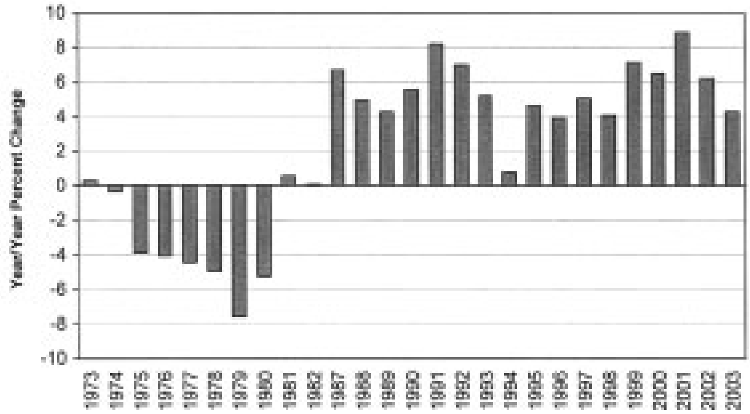
[11] Jeremy A. Leonard and Clifford Waldman, *An Empirical Model of Innovation in the U.S. Manufacturing Sector,* Manufacturers Alliance/MAPI, ER–614e, August 2006, and Leonard and Waldman, *Innovation and Its Determinants: A Review of the Literature and Outline of a New Model,* Manufacturers Alliance/MAPI, ER–601e, February 2006.

neering personnel are also important ingredients for innovation. The results were particularly interesting with regard to basic R&D expenditures in universities and colleges. Our equations indicate that a 10 percent increase in nominal dollar expenditures on basic science research at universities and colleges generates a 4.16 percent increase in a four-year moving average of U.S. utility patent approvals after a lag of six years and a nearly two percent increase in multi-factory productivity growth in manufacturing five years hence. Basic R&D in universities and colleges as well as the employment of science and engineering personnel proved to be important ingredients for both process and product innovation.

To aid those who need to track innovation growth we used these equations to develop composite indicators of both product and process innovation. These indicators show the fluctuation in productivity and patents (which we used to proxy process and product innovation) if those variables were only influenced by our postulated innovation drivers. The authors corrected for such things as changed patent laws, which impact patent activity, and the multitude of cyclical and institutional factors that impact multi-factor productivity. The two indicators are nothing more than the fitted values of their respective equations. For each year, it is the equation's prediction of either productivity or patents. By using the fitted value series as a measured index, we are allowing the user to view the fluctuation in productivity or patents as if they were *only* influenced by our postulated innovation indicators. Neither productivity or patents are pure measures of innovation output. Productivity is impacted by the business cycle and institutional factors. And patents are impacted by patent law. But by creating a fitted value series for our equations, we are coming as close as we can (both statistically and theoretically) to observing pure innovation output series.

Figures 14 and 15 present the results of our predictions for the innovation proxies. They show that our product and process indicators appear to map out a plausible history. Clearly the 1970s and early 1980s were troublesome times for U.S. manufacturing product innovation. As shown in Figure 14, sizable year/year declines in product innovation characterized numerous years of this period. The reasons are clear. Manufacturing R&D intensity fell below three percent during the 1977 to 1979 period. The growth of funding for basic university R&D decelerated from 11.3 percent during the 1965 to 1969 period to 5.9 percent during the 1970 to 1975 period. But the growth of the U.S. tradable goods sector and the resulting growth of international competition subsequently forced domestic changes. Manufacturing R&D intensity grew from 3.0 percent in 1980 to 4.6 percent during 1987. And the growth of academic research expenditures accelerated from 5.9 percent during the 1970 to 1975 period to 10.5 percent by the 1980 to 1985 period. Consequently, product innovation growth, while it has been volatile, has averaged a solid five percent since 1987.

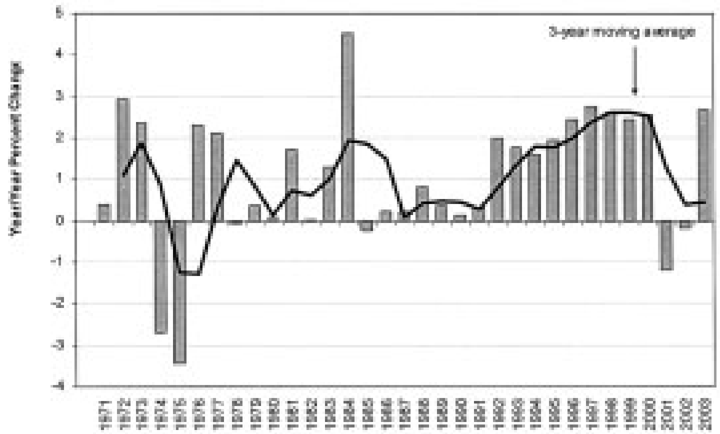
Figure 14
Composite Product Innovation Index, 1973-2003
(percent change from previous year)



Note: The jump from 1982 to 1987 is due to missing values of input variables.

Regarding process innovation growth, shown in Figure 15, the 1970s were characterized by wide annual swings in growth but the average over the decade was a paltry 0.5 percent. During this period, high inflation eroded the real value of investment and academic R&D, and international competitive pressures were much less severe than they are today (indeed the United States typically ran a trade surplus in manufactured goods). There were far fewer incentives for business process improvement. During the 1980s, manufacturing process innovation growth accelerated to an average of 1.0 percent, but much of this was in the early years of the decade. The particularly sharp accelerations in 1983 and 1984 were undoubtedly catalyzed in part by the dramatic tax cuts of 1981, which, among other things, accelerated depreciation of capital spending and boosted investment growth. Considerable concern about the future of the U.S. manufacturers at the beginning of the 1980s refocused attention on competitiveness, though little progress was made in the latter half of the decade. Finally, the rapid growth in unit labor costs, driven by double-digit inflation that occurred from mid-1979 to late-1981, forced manufacturers to reorganize production methods to remain profitable. The 1990s saw a further acceleration in process innovation growth, particularly in the latter half of the decade during which process innovation consistently grew in the two percent to three percent range. The 2001–2002 decline in process innovation growth was primarily due to a sharp decline in investment during the 2001 recession.

Figure 15
Composite Process Innovation Index, 1971-2003
(percent change from previous year)



While our statistical work adds considerably to understanding the manufacturing innovation process, we realize that the global dynamic must be studied much more extensively to complete our understanding. This is especially true given the anecdotal evidence of the potential globalization of R&D activities, and the fear that innovation will be outsourced in its wake. Thus, our next project addresses the void of data and understanding on innovation globalization through the use of a large-scale survey of manufacturers. We will design a survey to gather data on manufacturer's innovation offshoring activities (going well beyond simply measuring R&D location) as well as the factors driving those activities. We further intend to gauge the innovative capacity of key target countries for U.S. manufacturing innovation investment by reconstructing our U.S. product and process indices where data are available, or by performing innovation case studies for countries where the necessary data are not available. The results of this new proposed study will allow for an assessment of the implications of innovation offshoring for the domestic U.S. manufacturing base, particularly as to whether emerging markets post significant competitive threats.

V. Some Policy Implications

As globalization proceeds, many public officials, frustrated especially by the slow progress with China on such issues as currency and intellectual property protection, have begun to call for policies to protect markets via trade barriers and other means. Nothing could be worse for U.S. economic progress in a globalizing world. By closing markets, we negatively impact global economic growth, thus negatively impacting our own export opportunities. Export demand, in recent years, has been a key source of growth in the manufacturing sector, due partially to surprisingly muted domestic business investment demand. Further, by erecting protectionist barriers, we lose the growth, R&D, and productivity benefits that exposure to foreign markets has clearly afforded us. We might also lose the ability to access talent pools and new technology being developed around the world.

Our efforts should instead be directed to expanding the extent of free trade while working to end the many unfair trading practices that still plague our ability to access foreign markets. It is a poorly understood fact that only 5 percent of the trade deficit in manufactured goods is with countries where we have free trade agreements, while these same countries account for 30 percent of our imports and 44 percent of our exports. But an avoidance of blatantly protectionist policies does not, in any way, imply that U.S. policy-makers should not be putting forth an aggressive set of policies for maximizing U.S. competitiveness in the ever-changing global environment.

To be globally competitive, we need first and foremost to keep our domestic economy strong with the sensible monetary policy that we have been blessed with for a number of decades and with a low-tax, spending constrained, low-deficit fiscal policy that nonetheless satisfies the needs of critical social goals. Over time we will need to increase national savings both to curb our trade deficit and fund needed capital and social investment. Moreover, we need to be increasingly mindful of the structural costs that our businesses face in a world where capital is increasingly mobile, an issue investigated in great depth in two MAPI studies.[12] In particular, we need to address the high differentials in corporate taxes, tort litigation costs, natural gas costs, health care costs born by employers, and regulatory burdens of U.S. firms, as compared to our leading global competitors. Finally, we need to combat the mercantilist policies, such as maintaining undervalued currencies, theft of intellectual property, and subsidizing export industries, practiced by competitors such as China and other Asian nations.

To put our own house in order, we need to ratchet up investment in the sciences and engineering disciplines so crucial to innovation and to attracting the domestic students to these fields. Our research shows a clear link of university research with innovation. The experience of the massive investment in sciences in the 1960s, when nearly one percent of GDP was devoted to federally funded, non-defense, scientific research, which led to many of the technological breakthroughs at the core of American manufacturing success in the 1980s and 1990s, should also guide our thinking. We also need to think seriously about creating a better career path for U.S. scientists and engineers.

The need for a globally competitive level of innovation to compete with both low-cost producers and technologically advanced competitors by expanding our product offerings and market opportunities is clear. But economists do not have a full understanding of the innovation process and there is a particular void as regards the globalization of innovation activity. Recent MAPI research supports the notion that an innovation policy extends well beyond a focus on R&D investment. While private sector R&D is clearly important, we have provided robust statistical evidence regarding the high returns that can be realized from investment in university and college R&D. Further, we have learned that the science workforce and capital spending matter to innovation output, as well. Anecdotal evidence that emerging market nations might grow as significant global innovation centers shows the critical need for data and analysis on the globalization of innovation. Only then can we understand the extent and nature of the dynamic, the factors that are driving location decisions, and the implications for the domestic U.S. economy.

Biography for Thomas J. Duesterberg

Dr. Thomas J. Duesterberg is President and Chief Executive Officer of the Manufacturers Alliance/MAPI. He also serves as President of The Institute for Technological Advancement, an affiliate of The Manufacturers Alliance; and is a member of the Board of Directors of The Manufacturing Institute, an affiliate of the National Association of Manufacturers. Prior to joining the Alliance, Dr. Duesterberg was Senior Fellow and Director of the Washington Office of the Hudson Institute. Former positions include serving as Chief of Staff to Congressman Chris Cox (1995–96); U.S. Assistant Secretary of Commerce for International Economic Policy (1989–93), where he was responsible for international trade and investment issues, trade promotion, and advocacy programs to assist U.S. exporters and investors; Administrative Assistant to U.S. Senator Dan Quayle (1981–89); Senior Research Analyst, International Business Services (1979–81); and Associate Instructor, Stanford University (1978–79). Dr. Duesterberg is co-author of two books and numerous magazine, journal, and op-ed articles on international trade, information technology, and global economics. He also edited and wrote chapters in two books: *Riding the Next Wave: How This Century Will Be a Golden Age for Workers, the Environment, and Developing Countries* (Hudson Institute; 2001); and *U.S. Manufacturing: The Engine of Growth in a Global Economy* (Praeger; 2003). He writes a regular column for *Industry Week* called "The Competitive Edge." He graduated magna cum laude from Princeton University in 1972 and received an M.A. and a Ph.D. from Indiana University.

The Alliance is a policy research organization with approximately 500 member companies representing a broad spectrum of industries from machinery and components, primary metals, automotive, chemicals, oil and gas, electronics, telecommuni-

[12] Jeremy A. Leonard, *The Escalating Cost Crisis: An Update on Structural Cost Pressures Facing U.S. Manufacturers,* Manufacturers Alliance/MAPI and The Manufacturing Institute of the National Association of Manufacturers, September 2006.

cations, computers, office systems, aerospace, and similar high-technology industries. The Alliance conducts original research in issues critical to the economic performance of the private sector and offers an executive development program with more than 2,000 senior executives participating.

DISCUSSION

Chairman GORDON. Thank you to the panel. There were a lot of common denominators, a little bit of controversy, but a lot of common denominators. As we discussed earlier, we do have something of a time crunch. I had a chance to make a statement earlier, so I am going to yield my question time to Mr. Baird, who I think was our first person to come in.

Mr. BAIRD. I thank the Chairman.

Chairman GORDON. And I would ask maybe we might try to keep it to three or four minutes, rather than five, and hopefully, we will have most people get a chance to participate.

Mr. BAIRD. I thank the Chairman very much. I have got a number of questions, but I will be brief.

Dr. Gomory, I thought your point about the possible export of technology and innovation was interesting, but it seems companies are in a bind. Let us suppose you make an aircraft and the country says, "We won't buy your aircraft unless you outsource a portion of your manufacturing process," and so you say, "Okay, you can make the compass wings." Then they acquire the knowledge of the compass wings. How do you deal with that?

Dr. GOMORY. Well, that is a very good point, and I would like to stress that the problems here are system problems. The companies are doing what anyone else would have to do. It is not that they are disregarding. It is that the incentives that are provided are irresistible, and I think basically we have to provide counter incentives. There is just no other way.

Mr. BAIRD. What will a counter incentive look like?

Dr. GOMORY. In that case, I would have to think. I just don't know.

Mr. BAIRD. Okay.

Dr. Duesterberg, this point you made at the end, I am not sure I fully understand it. Maybe you can explain it to me a little bit. It is a poorly understood fact that only five percent of the trade deficit of manufactured goods with countries we have free trade agreements, but et cetera, et cetera. Elaborate on that for just a second.

Dr. DUESTERBERG. Well, we have NAFTA, we have CAFTA, we have some free trade agreements with smaller countries. The only point of this was that our trade deficit with the countries with which we have FTAs is only a very minor part of our overall trade deficit.

Mr. BAIRD. Explain what——

Dr. DUESTERBERG. Well, the overall majority is, of course, with the Asian countries. We don't have FTAs with them. So the simple point is that countries with which we have FTAs, we seem to do better with.

Mr. BAIRD. Your point being that an FTA alone is not the cause for our trade deficit——

Dr. DUESTERBERG. That is correct.

Mr. BAIRD.—or the export of jobs?

Dr. DUESTERBERG. That is correct.

Mr. BAIRD. How are we to proceed in keeping innovation domestically? If you could do one thing, what would it be, very briefly, each of you, starting with Dr. Blinder. What would the one thing be? Dr. Baily.

Dr. BAILY. Well, I think that is right. That is probably the one thing I would do. We have to make sure that our corporate tax system does not encourage people to move jobs overseas also.

Mr. BAIRD. Dr. Gomory.

Dr. GOMORY. I think if we reward the creation of high-value-added jobs with a low tax rate, we will see a surge of invention, of ways to take things that are today very labor intensive and make them into high-value jobs. It is the need for end jobs that drives both invention and ultimately scientific and engineering jobs. Many people are shying away from scientific and engineering jobs not because of lack of education. More people enter college wanting to get an engineering or science degree than we would ever know. That is a fact. That it not a well-known one. But they do not see a good career. So we have to create a demand if we are going to have a larger stream, and just having, you know, fellowships and things won't do it.

Mr. BAIRD. So just encouraging people to do more math and science and all the stuff we have been——

Dr. GOMORY. I think that is all good, but if there is no demand, people are too smart to do that.

Mr. BAIRD. Dr. Duesterberg.

Dr. DUESTERBERG. Well, this is not original, but I would go back to the experience of the 1960s and 1970s when we had an excitement about science and technology programs, partly driven by the threat of Sputnik, first of all. Then we had the Apollo program, which was visionary. We spent nearly three-quarters of one percent of GDP on the Apollo program at its height, so we need to have adequate level of funding for the basic research, but we also need to value at a national level the sorts of tasks, jobs, training that go into motivating people who want to be a part—make the sacrifices to be a part of the process.

Mr. BAIRD. Thank you.

I yield back, Mr. Chairman.

Chairman GORDON. Thank you, Mr. Baird.

Mr. Hall.

Mr. HALL. Mr. Chairman, thank you.

Dr. Blinder, you estimated that there are potentially 30 to 40 million jobs that could be offshored, but then as you read your testimony on through, it seemed like you ameliorated that a little bit by saying that not all will be. How do you arrive at that number, and what do you mean by not all will be? What changed that?

Dr. BLINDER. Sure. Let me take the questions backward. If you think about the manufacturing sector, where we have had offshoring for a very long time, we still have about 10 percent of Americans working in the manufacturing sector. We have not lost all those jobs. All, or almost all, of them are potentially offshorable in the sense that one could build a factory to do this or that in another country and then ship the goods back to America. The crucial defining characteristics to me, in trying to make the separation between potentially-offshorable and not-potentially-offshorable jobs, are two. The less important was requiring physical proximity. So, if you sell hot dogs in Yankee Stadium, you have to be at Yankee Stadium. That is the less important one. The more important one, covering many more jobs, is the importance of face-to-face contact. If it is either absolutely essential that it be done face-to-face, or if the task is done very much better face to face, so that if you try to electronically deliver it you lose a lot in the process, then those jobs are not very likely to be offshored. So that goes to cultural sensibility, feel and touch, that kind of thing. Jobs that require that as essential inputs are not going to be replaced by Internet messages.

Mr. HALL. Dr. Duesterberg, in your testimony you say that an increase in employment at foreign affiliates is possibly correlated with growth in jobs in its domestic parent. How does this mesh with the overall American manufacturing job losses over the past decade, and how would you characterize the role of domestic entrepreneurship and the innovation strategies of multinational companies? What is happening here? You gave good advice to Chris Cox and Dan Quayle just yesterday. How about giving us some leadership on this?

Dr. DUESTERBERG. Well, the seeming paradox is that the companies that are most globally engaged tend to be the ones that are avoiding job losses, and in fact, increasing in a very slight way their——

Mr. HALL. Like?

Dr. DUESTERBERG. Well, like Intel, like a Microsoft, like a Nike, like a General Electric. I will offend everybody else by not mentioning them, but globally engaged companies that are successful. Boeing is another example. The ones that are hurt are the companies that are unable to make the sorts of investments both here and abroad to be competitive with the growing competition from low-cost producers in China and elsewhere. So the job losses tend to be concentrated in those sorts of smaller—frequently smaller industries that just don't have the wherewithal to become as globally engaged as they could. What should we do? We should do everything we can to maintain the environment here in the United States that supports innovation. We are a very litigious society. We have all talked about the problems with the education system. We are not providing enough good scientists, engineers. There are very real issues with access to foreign markets as well. Martin mentioned the currency undervaluation of China and for many years many other Asian currencies. That is a real problem. Subsides to production abroad are a very real problem. After all, China used to give, a few years ago, a five-year tax break, full tax break to companies that located there for the purpose of exporting outside of the country plus five more years at half tax rates. They have recently changed that, but that sort of activity certainly doesn't help. So it is a two-pronged approach: do what we can to make the environment for innovation and for entrepreneurship strong here, combat unfair trade practices abroad.

Mr. HALL. Let me just wind up with one last question. We are talking science and math and how we are going to do to get these kids interested in it and participating in it and how great it is going to be for them and paying teachers more and all that. Other than that, what can we do to change our educational system so our students are going to be ready to compete with the youngsters from China and India and anywhere else? Dr. Duesterberg.

Dr. DUESTERBERG. Well, as I mentioned in an earlier question, I think sort of the culture is not necessarily as supportive as it should be of people entering these fields. I mean, I remember I went to college in the 1960s. Everybody wanted to be an aerospace engineer because we were doing the Apollo program. It was exciting. Commercial aviation was just taking off. It was a very remunerative field. Or they wanted to go into IBM where Ralph was working because we were, you know, inventing the computing industry. Now things have changed. We don't value that sort of activity as much culturally. There are a million other things that we could do to strengthen our educational system. I happen to like Chairman Gordon's idea of helping to produce better math and science educators at the secondary and elementary school level.

Chairman GORDON. You are such a wise person. I hate to cut you off, but I would like as many people to participate as possible.

So Dr. Wu, you are recognized.

Mr. WU. Thank you, Mr. Chairman, for always giving me that promotion to doctor. My mother really appreciates it.

For the witnesses, I have been thinking about the aspect of offshoring R&D and academic work. I mean, you all have talked about service jobs and manufacturing jobs. I used to represent academic institutions, and I know that there are certain deals that folks cut. The Federal Government supports research. It is unlikely to support research at foreign institutions, but the private sector supports much more research, and that money is hot money. It is mobile money. It can go to a U.S. university or it can go elsewhere. Are you all concerned about foreign institutions, educational institutions in essence cutting our private sector or global companies a better deal on R&D and the true outsourcing of innovation so that, for example, with respect to this panel, if we were to do hearing in 10 or 20 years, instead of having someone from Princeton, we would have someone from Prague. Instead of the rest of you all, you know, we would be bringing in experts from New Delhi or Beijing instead. Is that a real issue or not?

Dr. BLINDER. Well, of course, nobody really knows the answer to that, but my guess is, at least for the time being, it is not too much of an issue. We still—I don't want to say we have a monopoly, which we don't have a huge comparative advantage in higher education. The great preponderance of the great research universities of the world are in the United States, and I think that is likely to be true for a long time. That said, it is only natural for the rest of the world gradually to catch up to us. So, we can't expect to hold this hegemonic position forever.

Dr. BAILY. I agree with Alan on that. I am willing to bet there are quite a lot of foreign graduate students in your classes so I suspect Alan's own job actually is a little dependent on the global economy. If we maintain the strength of our universities, not just, you know, the top ten, which are so strong, but a lot of our State and local universities as well, we will maintain our position. And as Alan said, there is nothing wrong with other countries doing academic research, and by the way, there are foreign companies that support academic research in the United States.

Mr. WU. I yield back.

Chairman GORDON. Thank you.

Ms. Biggert.

Ms. BIGGERT. Thank you, Mr. Chairman, and thank you all for really a very informative presentation. We in this committee have been talking about the globalization, about being competitive in a global economy, but I think you put all the pieces together, and I don't think we are doing a good enough job. I don't think we are doing a good enough job in education. You are talking about the universities, but I also serve on the Education Committee, and we have been looking at the results of No Child Left Behind, and I think it is pretty dismal actually. We have increased average yearly progress, we have increased performance, but when you think about that it is only 40, 45 percent of the students even meeting grade level, and we say that that is great. We are not going to attract kids to science and math if we are not really giving them the basic education starting out and the will to study. Look at China, and the kids are going to school all year long. They are practically sleeping at their desks and there is a real drive, you know, to excel and to surpass us, and I don't think that we want the quality of life for our kids to go to school seven days a week, 24 hours, but I think that we do need to maybe—we have a nation at risk, and you are talking about Sputnik and all the things that challenge us, but what can we do to really change that and make—people have a love of learning, I guess, that they don't seem to have now. We have got a love of leisure and grade inflation and things like that that really troubles me, besides our immigration policies that we are not bringing in students from other countries, mainly because we cut off a lot of that since 9/11. We talk about that innovation and creativity are the only ways that we are going to stay ahead, and yet, we are not. I think Members of Congress have finally realized research and development is so important, but a lot of people don't realize that yet. Can somebody help me out with that, or is that too broad?

Dr. BLINDER. I will take a little stab. I can't really give you detail because this is a huge question and there aren't clear answers. But to hearken back to something I wrote in the testimony, I think we need to move away faster, than we are doing from the 19th century educational system that we put in—which features sitting at your desk, being quiet and rote learning where you fill in the little box with the electronic pencil. Life is not like that. And to the limited extent life is like that, it is either done better by a computer or by a low-wage person in a developing country rather than by an American. We need to get our kids doing more playing with ideas, more creativity, less rote learning. If you don't mind my saying so, since you mentioned you are on the Education Committee, that is not because of accountability reasons, which I am all for, but because of the focus on standardized rote learning tests and the teachers teaching to those tests, which we see all over America. No Child Left Behind is pushing us in the wrong direction, I believe that.

Ms. BIGGERT. Thank you.

I yield back.

Chairman GORDON. Thank you.

Since you were so nice, let us let Mr. Reichart have the remaining portion of your time, two minutes.

Mr. REICHART. I will just make it real quick. Thank you, Mr. Chairman.

Russia has lightweight strong titanium. Boeing manufactures the struts for the 787 in Russia. Is that the cheapest way to do it, manufacture in Russia and ship the finished struts to the United States or is it cheaper to ship the titanium and manufacture in the United States? And a follow-up question, our Coast Guard helicopters are re-engining, and they are buying their engines from France, and I am told that the only reason they are buying them from France is because it is the only place that makes them. Why doesn't the United States make engines that fit our Coast Guard helicopters?

Dr. DUESTERBERG. Those are two different questions.

Mr. REICHART. Yes.

Dr. DUESTERBERG. With respect to how Boeing carries out its sourcing, it is frequently constrained by the demands of countries, which are its customers, to do part of their production in that country so that they can sell. This sort of activity is by and large, if not discouraged, it is made illegal by the global trading system, but it is often left unchallenged and not sanctioned. Whether it is the best way to produce is a technical question, and I am not capable of answering, but I think we ought to look very carefully about the requirements by foreign countries for local production as a reason for buying the product. And along those lines, we need to think more seriously as a nation about what our core competencies are in technologies that are related to our national defense. I don't think we have done a very good job of that in the past, and that is something that we are not capable of assessing, but somebody at the Pentagon and elsewhere, while they look at these, should be spending, I think, more time looking at these sorts of questions.

Chairman GORDON. Thank you, Mr. Reichart.

Dr. BAILY. Can I quickly make a quick comment?

That industry, the aircraft industry and, of course, the military hardware is something where the United States has a fairly substantial advantage. Obviously Boeing is in a struggle with Airbus, but quite a lot of the Airbuses are actually made in the United States, I mean, the engines are made and a good part of the aircraft, a significant part of it. So I think we are also the beneficiary of some of that.

Chairman GORDON. Thank you. And let me suggest that all Members will have the opportunity to submit questions and all panelists will have opportunity to submit additional testimony, and Mr. Lipinski, I would like to yield the balance of our time and whatever nerve you have to stay as long as you would like.

Mr. LIPINSKI. How much time do we have left in the vote, Mr. Chairman? All right.

Well, I will try to keep this short. I will shorten to a couple quick comments and a question. The first thing is, as I waited for the vote that I thought was going to happen earlier, I listened to all your testimony from back in my office. I appreciate all your very thoughtful testimony. A critical issue—I want to point out one thing, Dr. Gomory. The high-value-added jobs, I think that is critical that we keep talking about high-value-added jobs because I understand, and I am not sure everyone does, that some jobs are better jobs than others, not just individually for those that are employed there but for the implications, the multiplicative impact they have on the economy, especially on local communities. As I see manufacturing jobs leave from my district just because a guy can go down the street, get a job flipping burgers, he makes much less money but also has an impact on the community that is very significant and other jobs that are there. So, we have to keep focusing on that, and I also think that it is important that we can take care of our national defense, because when it comes time, we are—I don't want to rely on another country to produce things for us for our national defense. We need to take care of our exchange rates. I thank Dr. Duesterberg, Dr. Gomory, doctor and doctor, for mentioning those things. Exchange rates, we need to have fair trade.

The question I have very quickly, and maybe get some comments later from you in writing, Dr. Duesterberg talked about the impact that basic research has on our economy. I just want to open that up. I want to ask you if you have any more information on that, if you can provide any more, and maybe I will just invite everyone else on the panel, if you have something really quick to say right now, let us know and, if you can provide any additional information on what impact do we see, do we have facts and figures on the impact that this research done at our universities has on our economy. Does anyone want to say anything quick, or we are just going to——

Dr. BAILY. There has been quite a bit of academic literature written on the spillovers from university research to private sector research, and you can see that in action. I mean, Silicon Valley is in some sense a reflection of the strength of Stanford and Berkeley. You see around Boston the strength of the high-tech sector there, Austin also with the strength of the University of Texas. So there has definitely been quite a bit written about the benefits that you get, the spillover benefits. If you have a very strong academic center, you also get private sector benefits and private sector jobs created.

Mr. LIPINSKI. [Presiding] Thank you. Mr. Gordon has to leave so we have to run for votes. I can stay here and ask more questions. I think I am going to slow down my run. I want to thank you for your testimony, and if I can adjourn the hearing from here instead of over in that official chair, I adjourn this hearing. Thank you.

[Whereupon, at 2:29 p.m., the Committee was adjourned.]

Appendix 1:

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Alan S. Blinder, Director, Center for Economic Policy Studies; Gordon S. Rentschler Memorial Professor of Economics, Princeton University

Questions submitted by Chairman Bart Gordon

Q1. During your oral testimony you recommended that we increase the number of students in math and science fields, but your research finds that these fields are highly vulnerable to offshoring. How do students pursuing these fields buffer themselves from having their jobs offshored? Should we be iuvesting in all science, technology, engineering, and mathematics (STEM) fields or only those that we expect will be rooted in America?

A1. I do believe that we should try to increase the numbers of U.S. students in science and math, even though many scientific jobs are vulnerable to offshoring. But, if we are to be smart about it, we will specialize in producing engineers and scientists for the jobs that are more difficult to offshore. For example, in the computer programming field, writing code for canned software programs is extremely easy to offshore. But it is very hard to offshore the jobs of people who customize software for use by specific companies and/or organizations, and who may therefore have to interact personally with people in those organizations to understand their business needs. It is wiser, in my view, to try to train people for these sorts of jobs, many of which blend people skills and business knowledge with scientific skills, than it is to try to decide which scientific fields are more promising.

Q2. Could you comment on how your view of the economics of globalization differs from Dr. Gomory? Specifically, do you agree with Dr. Gomory's assessment that productivity shifts through globalization could make America worse off?

A2. At the conceptual level, I don't think Dr. Gomory's views on globalization and mine differ much, if at all. In principle, it is definitely possible that increased trade brought about by productivity improvements abroad could make America worse off, as he says. However, I am a bit skeptical that this has happened much in practice.

Q3. During your testimony you mentioned that one of America's major sources of comparative advantage is its superior higher-education system. A number of universities are opening, or are considering opening, overseas campuses in the very countries getting many of the jobs being offshored. How does this activity affect the national economy?

A3. I don't have a clear answer to this question. It seems to me that the answer depends almost entirely on what goes on at these overseas campuses. For example: Do we attract top students from abroad, who then want to bring their skills to America? Or do we encourage top-flight American students to emigrate? (I suspect there is more of the former than the latter.) Similar questions arise related to the research done at these campuses.

Q4. Are there specific steps that this committee should do to address the offshoring of STEM occupations?

A4. Like most economists, I believe that incentives (some, but not all, of them financial) have powerful effects on career choices. If the market refuses to reward scientists and engineers more highly, there is not a lot the Federal Government can or should do about it. But the government can do quite a bit to reduce the costs of getting a scientific education—e.g., graduate fellowships, undergraduate scholarships, grants to universities to subsidize scientific teaching and/or laboratories, and so on.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Martin N. Baily, Senior Fellow, Peter G. Peterson Institute for International Economics, Washington, DC

Questions submitted by Chairman Bart Gordon

Q1. How is my view of globalization contrasted with that of Dr. Gomory? And specifically, what is my view on the issue of whether globalization can make the U.S. worse off.

A1. I agree with Dr. Gomory that globalization creates winners and losers. In order to gain the full benefits of globalization, I believe that US policy-makers must put in place adequate programs to help workers change jobs when needed and to acquire the skills for good jobs. Many employers today, including manufacturing firms, are crying out for skilled workers. There are good jobs out there. There would be more good jobs if the U.S. would balance its budget, save more, let the dollar adjust and reduce the trade deficit. I believe that on balance the U.S. benefits from globalization, where Dr. Gomory is more skeptical.

If I understood him correctly, Dr. Gomory cited a recent article by Professor Paul Samuelson to the effect that globalization could hurt the U.S. as other countries develop economically. Professor Samuelson was one of my teachers at MIT and I respect him enormously. I thought that this particular article was technically correct but very misleading in its implications. In a key model in the article, the rich country (the U.S.) suffers when the poor country (China) grows rapidly. The reason for this is that in the initial situation (when China is still very poor) there is a substantial amount of trade from which the U.S. benefits greatly. As the poor country develops, the level of trade declines, according to the model. The rich country (the U.S.) is hurt by the reduction of trade between the countries. I see no relevance of this article to the situation of the U.S. and China where trade is expanding rapidly. This article actually points to the benefits of trade.

Dr. Gomory wants to make sure that U.S. corporations face the right tax incentives to encourage them to locate production in the U.S. With some qualifications, I agree with him on this point.

Q2. Is the OES Data valid for time series comparisons?

A2. There have been definitional changes, but I believe the conclusions from the table remain valid. This table in my testimony is taken from my colleague Jacob Funk Kirkegaard. He was kind enough to write an extended response to your question, which is attached at the end of this document.

Q3. The question refers to the McKinsey Global Institute estimate that the U.S. gains 12 cents on every dollar of off-shoring. Doesn't it show that workers lose as a result?

A3. As noted earlier, trade creates winners and losers but can be expected to provide net positive gains to the U.S. The McKinsey study provided a pioneering effort to quantify *both the gains and potential losses* from this form of trade, facing up to both sides of the story, but concluding there are net gains to the U.S.

The estimates made of cost savings of 65–70 percent were based on a very careful analysis, a series of company interviews and visits to Indian offshoring locations. Actual gains may vary depending on the activity being offshored and the skill with which the offshoring is carried out. Some companies may report smaller savings, as your question indicates. In addition, wages are rising rapidly in India for persons engaged in offshored work and the U.S. dollar is falling, so the cost savings may well be changing year by year.

I note that if the cost gains are in fact smaller than McKinsey estimated, as small as 15 percent, then the amount of offshoring in the future will be very small. Dire predictions about massive impacts from offshoring are absurd if the costs gains are in fact so small.

The McKinsey estimate of the losses to workers was deliberately chosen to emphasize potential problems, and in fact may be too high. It assumes that any activity involving service imports results in a displaced worker in the U.S. and that the employment experience of such workers matches that of "displaced" workers as studied by economists such as Lori Kletzer of the Peterson Institute.

a. In practice, some offshoring will not result in job losses, as workers are deployed to other activities. For example, there have been predictions that ATMs and offshoring would sharply reduce jobs in banks. In practice, banks are finding it hard to recruit enough people.

b. The turnover rate in U.S. call-center operations is extremely high. A key to business success in U.S.-based call centers is figuring out which potential hires will be willing to stay more than three months. Many of the people leaving call center jobs are leaving voluntarily.

c. Companies that offshore some activities can reduce costs, become more competitive, and increase other employment in the U.S.

d. The U.S. has had full employment for most of the past twenty years; indeed it has had close-to-full employment since 1945. There is no overall shortage of jobs. The expansion of international trade over the past sixty years has not adversely affected the overall level of employment.

That said: I agree that we need to be aware of the painful losses encountered by some workers as a result of job displacement, whether this displacement is caused by goods trade, service sector offshoring, technological change, or the rise and fall of different U.S. companies. As I said in my testimony, the U.S. has a very flexible labor market, with advantages that go with this, but it does not provide adequate security or training. In addition, workers need health insurance and pensions they can count on.

Q4. Is the number of high-wage technology jobs below the BLS occupational projections?

A4. Data of this type is uncertain and projections are even more uncertain. As I said in my testimony, it appears that employment in basic programming jobs in the U.S. has been reduced by offshoring to India. Overall, technology employment is growing, but the technology industry has grown much more slowly since 1999 than was predicted before the technology bubble burst. This is primarily due to the slower growth of demand here in the U.S.

Q5. Policies used by other countries to encourage innovation.

A5. Other countries have poured money into science and technology research and into venture capital funding. These efforts have made some difference but there have also been moneys wasted. Government efforts overseas to mimic the U.S. venture capital industry have not been very successful. Flagship technology projects such as the CERN accelerator or the space station may or may not be worth the money, but are unlikely to provide major benefits to commercial technology.

Innovation is largely demand driven and occurs where there are flexible and competitive markets and customers that are looking for new products and services and are pressing for cost reductions. When combined with its remarkable strength in science and technology, the U.S. provides a wonderful cauldron for innovation.

When locating R&D, companies look at the availability of a trained workforce and they locate where there customers are located. They want to locate where other companies locate their R&D and where there are strong universities. They consider the tax consequences of their decisions and the regulatory environment.

Q6. Science and technology workers displaced.

A6. I have not studied this question specifically. My understanding is that in locations such as Silicon Valley workers whose companies go bankrupt can often find jobs with other companies in the same industry. However, in the technology crash in 2001, there were many workers who lost very high paid jobs and have not recovered from this.

Q7. The surplus in services.

A7. Yes it is true that trade in services is hard to measure. Both imports and exports may be understated in the official data. Note, however, that BEA works hard to capture services trade. Recently, several people, including me, argued that BEA was understating service imports from India in comparison to data provided by the Indian group NASSCOM. BEA investigated this claim and found that NASSCOM was counting a lot of activity that was not in fact exported to the U.S. BEA defended its estimates very well.

Response to Question 2 by Jacob Funk Kirkegaard of the Peterson Institute.

The Bureau of Labor Statistics at the Occupational Employment Statistics, Frequently Asked Question #27 (*http://www.bls.gov/oes/oes_ques.htm#Ques27*) lists several methodological considerations that may cause employment or wage comparisons of OES data over time to be less valid. The BLS lists seven different methodological concerns;

1) Changes in occupational classification;

2) Changes in industrial classification;
3) Changes in geographical classification;
4) Changes in the way the data are collected;
5) Changes in the survey reference period;
6) Changes in mean wage estimation methodology, and;
7) Permanent features of OES methodology.

However, these methodological considerations are, for the following reasons, not of a magnitude that jeopardizes the conclusions drawn in this testimony;

a. **Data Presented Covers Only Data For Occupations From the Same Occupational Classification System—the 2000 SOC;** Prior to the data presented in Table 1, the OES survey used its own occupational classification system through 1998. The 1999 OES survey data provide estimates for all the occupations presented in Table 1 in the 2000 Standard Occupational Classification (SOC) system. Hence the data in Table 1 is not affected directly from changes in "1) Changes in occupational classification." However, only in 2004 did the OES survey estimate all "residual categories" and a small indirect effect from different estimations of "residual categories," spread out over the period from 1999–2004 cannot be ruled out. Yet, any such indirect effect is likely to be very small and not materially affect the data presented in a systematically biased manner.

b. **Data Presented Unaffected By Four of Seven Methodological Concerns;** Given the national coverage of the data used, immediately 2) and 3) are of no concern. As little if any seasonal variation in the occupations used can be expected, 5) is also less of a concern. Table 1 has no time comparison of mean wages, and hence 6) is of no concern.

c. **Data Presented Not Systematically Biased By Changes the Way OEC Data is Collected;** The BLS voices concern in 4) that "In the past, employment in some occupations in an industry may have been reported in a residual category rather than in the specific occupation." Given that all occupations presented in Table 1 has been collected throughout the 1999–2006 period, it is unlikely that this concern can lead to any systematic bias in the results over the period.

d. **Data Presented Compares a Seven-year Time Span and Is Thus Less Affected By 7)'s Permanent OES Feature of Three-year Rolling Averages;** The OES data set at any given reference period is a benchmark of six consecutive semi-annual panels and hence represents a moving average of the entire U.S. economy. Hence sudden changes in employment and wages will only show up gradually. However, given the seven-year span of the comparisons made in Table 1, the longer-term trend captured by the comparisons should not be materially affected by this feature.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Ralph E. Gomory, President, Alfred P. Sloan Foundation

Questions submitted by Chairman Bart Gordon

Q1. In one of your remarks you seemed to imply that there is no shortage of American scientists and engineers. This is important as much thought has gone into recommendations to increase the supply of U.S. scientists and engineers. Please give us your opinion on this subject.

A1. You have correctly interpreted my remarks. There is little or no evidence of any shortage of scientists and engineers.

The House Science and Technology Committee should be especially aware of this possibility since it already has had the embarrassing duty of investigating false claims of shortages that it had accepted in the past. For a good historical survey of present and past shortages claims, including the role played by this committee, I am attaching an article by the well known demographer Michael Teitelbaum who heads the Sloan Foundation program in this area. For further discussion of this set of issues I suggest the well known labor economist Richard Freeman of Harvard who has spent a number or years heading a project on the Science and Engineering workforce.

Q2. Could you explain how your view of the economic theory and implications of globalization differs from Dr. Blinder and from Dr. Baily?

A2. On theory I am not sure that Alan Blinder and I are terribly different. He says that according to his view there can be a huge negative impact on the U.S. from globalization and the benefits will be so long in coming that they may not matter. He thinks that new areas will eventually be found to replace the huge array of industries and services that will be lost but thus may take decades. I don't see in any of the standard theory any indication that there will be a resurgence after the terrible loss. Nor do I from my long exposure to industry think that it is likely that we can replace the loss of so much of our services and production with equally remunerative and productive employment. Our differences however are about the distant future.

Martin Bailey doesn't see that there is an overall problem at all. In addition he uses the terms globalization and free trade interchangeably. There is no basis for saying this as can be shown by the simplest examples. See for example my testimony which shows the difference between free trade and globalization in the most standard economic model, the standard England-Portugal Textiles-Wine example. And the difference is of the utmost importance, free trade will benefit us, globalization will almost certainly hurt. (See my written testimony.)

Q3. What is your opinion on free trade?

A3. I am an advocate of free trade. However I am aware, as most people are not, that economic theory points to the fact that the home country may be worse off trading in a free trade environment with a trading partner that has become more developed than when it was trading with that trading partner when it was less developed. In our case that trading partner is Asia. Therefore I point out very clearly in my written testimony that under globalization, which includes the development of many Asian industries and services, we can be worse off than before, not because of free trade, but because of the emergence and development of many rival industries in Asia that were not there before. I point out clearly that not having free trade is worse yet, and that the only real path to retaining prosperity is increased productivity in the U.S., and that will not be obtained through tariffs. I advocate a productivity focus as a response to the industrial development in Asia.

Q4. You express concern about the long run impacts on the U.S. economy, but aren't these the same things that were said about Japan, and we've done just fine with Japan?

A4. I am not at all sure what is meant by the statement "we have done just fine with Japan" I am not aware of any analysis that can show with all the other nations in the world interacting and growing that we have done either fine or not fine with Japan. Certainly we have lost major shares of electronics, computers, steel, etc., to Japan and Taiwan. These losses have both a beneficial and a negative effect and I am not sure how anyone can sort that out and untangle that from the effect of just plain technological progress.

More importantly I don't quite understand how "things that were said about Japan" even if they were not correct bear on the present. The effect of Japan was on manufacturing and one result is that we have today a smaller manufacturing sector as a proportion of our economy than do Germany or Japan. Is this good? People will argue about that but the Science and Technology Committee should be award that is where most R&D is.

However the challenge today is not from a small country with a limited labor force specializing successfully in a few industries, but from populations that dwarf ours and an across the board approach that leaves no room for escape. Furthermore the progress of communication technology has made services contestable as well as manufactured goods. The developing Asia of today is certainly not the developing Japan of the 1970's and 1980's and that difference shows up if one analyzes the standard trade models as well as uses common sense.

Do we need more scientists?

MICHAEL S. TEITELBAUM

FOR much of the past two decades, predictions of an impending shortage of scientists and engineers in America have gained increasingly wide currency. The country is failing to produce scientists and engineers in numbers sufficient to fulfill its economic potential, the argument runs. The supposed causes are weaknesses in elementary, secondary, or higher education, inadequate financing of the fields, declining interest in science and engineering among American students, or some combination of these. Thus it is said that the United States must import students, scientists, and engineers from abroad to fill universities and work in the private sector—though even this talent pool may dry up eventually as more foreign nationals find attractive opportunities elsewhere.

Yet alongside such arguments—sometimes in the very

The views expressed are those of the author and not necessarily of the Alfred P. Sloan Foundation.

same publications in which they appear—one learns of layoffs of tens of thousands of scientists and engineers in the computer, telecommunications, and aerospace industries, of the deep frustration and even anger felt by newly minted Ph.D.s unable to find stable employment in traditional science and engineering career paths, and of senior scientists and engineers who are advising undergraduates against pursuing careers in their own fields. Why the contradictory reports on professions routinely deemed critical to the success of the American economy? Is it possible that there really is no shortage in these fields?

A history of gloomy forecasts

Pronouncements of shortages in American science and engineering have a long history. They date at least to the late 1950s, around the time the USSR launched Sputnik, the first orbiting satellite, prompting concerns that an era of Soviet technological advantage over the United States had emerged. The United States responded with massive public investments in science and engineering education. This led to sharp increases in the numbers pursuing such studies, and a surfeit in the 1970s of entry-level scientists and engineers.

The recent history of shortage forecasts begins in the mid 1980s, when the then-leadership of the National Science Foundation (NSF) and a few top research universities began to predict "looming shortfalls" of scientists and engineers in the next two decades. Their arguments were based upon quite simplistic demographic projections produced by a small policy office reporting to the NSF director—projections that earlier had been sharply criticized by the NSF's own science and engineering workforce experts.

Only a few years later, it became apparent that the trends actually pointed toward a growing surplus of scientists and engineers. In 1992, the House Committee on Science, Space and Technology's Subcommittee on Investigations and Oversight conducted a formal investigation and hearing about the shortfall projections, leading to much embarrassment at the NSF. In his opening remarks at the hearing, the subcommittee's Chairman, Democrat Howard Wolpe of Michigan, declared that the "credibility of the [National Science] Foundation is seriously damaged when it is so careless about its own product." Sherwood Boehlert, the subcommittee's ranking Republican and now chair of the full House Science Committee, called the NSF director's shortfall predictions "the equivalent to shouting 'Fire' in a crowded theater." They were "based on very tenuous data and analysis. In short, a mistake was made," he said. "Let's figure out how to avoid similar mistakes, and then move on."

Boehlert's advice was not heeded. Only five years later, during the high-tech boom of the late 1990s, an industry association known as the Information Technology Association of America (ITAA) began to produce a series of reports asserting burgeoning gaps and shortages of information-technology workers, based on proprietary surveys of what it termed "job openings." The first ITAA report claimed that some 190,000 information-technology jobs could not be filled in 1997. The second concluded that there were 346,000 open positions in 1998. The Department of Commerce then produced its own report, which drew heavily upon the findings of the two ITAA reports.

The General Accounting Office (GAO) published a sharply critical assessment of these three related reports in 1998. It concluded that all of their shortfall estimates were questionable due to the studies' weak methodologies and very low response rates. Unabashed, ITAA returned to the fray in 2000. Its third report asserted that over 843,000 information-technology positions would go unfilled that year due to a shortfall of qualified workers. Despite withering criticism from the GAO, the ITAA reports provided useful political support for the successful lobbying campaign for dramatic expansion—to the current level of 195,000 per year—of the H-1B visa, the temporary-visa program for foreign "specialty workers" that comprise the bulk of foreign science and engineering professionals being admitted to work in the United States.

Remarkably, even the recent economic downturn does not seem to have deterred proponents of the workforce shortage theory. Take NASA administrator Sean O'Keefe, who invoked a shortage argument during testimony before the House Science Committee in October 2002 on NASA's hiring problems. "Throughout the Federal government, as well as the private sector, the challenge faced by a lack of scientists and engineers is real and is growing by the day," O'Keefe told the committee.

The following month a new organization called Building Engineering and Science Talent (BEST) published a report entitled "The Quiet Crisis: Falling Short in Producing American Scientific and Technical Talent." This "quiet crisis," the report's authors noted, "stems from the gap between the nation's growing need for scientists, engineers, and other technically skilled workers and its production of them.... This 'gap' represents a shortfall in our national scientific and technical capabilities."

Some business leaders and academics are also advancing the shortage thesis despite the economic downturn. Two reports with findings similar to the BEST study subsequently emerged in the spring of 2003. One was a report addressed to the Government-University-Industry Research Roundtable (GUIRR) of the National Academies, and the other was prepared by the Committee for Economic Development (CED), an organization of business and education leaders.

Even some associated with the NSF seem unchastened by the embarrassing failure of the "shortfall" projections of a decade ago. In June 2003, the National Science Board, the NSF's governing body, released for public comment a draft task-force report addressing the "unfolding crisis" in science and engineering. "Current trends of supply and demand for [science and engineering] skills in the workplace indicate problems that may seriously threaten our long-term prosperity, national security, and quality of life," it said.

The evidence

The profound irony of many such claims is the disjuncture between practice in the scientific and engineering professions—in which accurate empirical evidence and careful analyses are essential—and that among promoters of "shortage" claims in the public sphere, where the analytical rigor is often, to be kind, quite weak. Few, if any, of the market indicators signaling shortages exist. Strong upward pressure on real wages and low unemployment rates relative to other education-intensive professions are two such indicators conspicuously absent from the contemporary marketplace.

A RAND study released earlier this year assembled the available data from its own research, the NSF, the Census Bureau, the Bureau of Labor Statistics (BLS), the National Research Council (NRC), and several scientific associations. What RAND found largely discredits the case being made for labor shortages. First, RAND noted the obsolescence of the available data, the newest of which refers mostly to 1999 or 2000. RAND called this "especially unfortunate" given that "the [science and engineering] workforce situation has arguably changed significantly" since those heady times of the dot-com, information technology, and telecom booms. But more importantly, RAND's analysis of even data from the boom period showed that "neither earnings patterns nor unemployment patterns indicate [a science and engineering] shortage in the data we were able to find."

Recent government unemployment data tend to confirm these findings. Data for the first and second quarters of 2003 released by the Bureau of Labor Statistics showed surprisingly high unemployment rates in science and engineering fields. Even the recently "hot" computer and mathematical occupations are experiencing unemployment of 5.4 to 6 percent. For computer programmers, the numbers range from 6.7 to 7.5 percent. All engineering (and architecture) occupations taken together are averaging 4.4 percent unemployment, while the rates for the high-tech fields of electrical and electronic engineering are in the range of 6.4 to 7 percent. Reported unemployment in the life, physical, and social sciences ranges from 2.8 to 4.1 percent. Many of these numbers are remarkably high for such high-skill occupations. Unemployment for the whole of the U.S. workforce averaged about 6 percent over the same period, and highly educated groups such as scientists and engineers normally have substantially *lower* unemployment rates than the national average.

In the natural-science disciplines, which employ far fewer people than engineering, numerous reports by leading scientists have been pointing to increasingly unattractive career prospects for newly minted Ph.D.s. As one example among many, a 1998 National Academy of Sciences (NAS) committee on careers in the life sciences—the largest field in the natural sciences—reported that "recent trends in employment opportunities suggest that the attractiveness to young people of careers in life-science research is declining." More recent data from 2002 showed that key indicators of career problems had continued to deteriorate since then, prompting Shirley Tilghman, the NAS committee's chair and current president of Princeton University, to tell *Science* magazine that she found the 2002 data "appalling." She said the data reviewed earlier by the committee looked "bad" at the time, "but compared to today, they actually look pretty good." The 2003 RAND study concurred. "Altogether, the data ... do not portray the kind of vigorous employment and earnings prospects that would be expected to draw increasing numbers of bright and informed young people into [science and engineering] fields," RAND concluded.

It is of course quite possible to have "appalling" early career problems in some areas of science and engineering alongside very good career prospects in others. Administrators of federal technical agencies such as NASA do face special problems such as hiring freezes or other ongoing personnel or financial constraints. Senior personnel at NASA and other agencies have been offered substantial early retirement incentives while hiring procedures to replace them tend to be cumbersome and slow. In "hot" fields that are new or growing rapidly, like bioinformatics, human resources are inevitably in short supply. And truly exceptional scientists and engineers will always be few in number and vigorously pursued by employers.

Still, in most areas of science and engineering at present, the available data show sufficient numbers or even surpluses of highly qualified candidates with extensive postgraduate education. This is especially the case in the academy, which has become risk-averse about replacing departing tenured faculty with tenure-track junior positions. Instead, many universities in the United States have been filling such open slots with temporary and part-time appointees they find in ample pools of highly educated applicants. Indeed, advertisements for a single tenure-track assistant professorship often attract hundreds of applications from recent Ph.D.s. Similar circumstances prevail for engineers and scientists in large sectors of the U.S. economy such as telecommunications, computing, and software, sectors in which lurching market collapses and large bankruptcies have greatly weakened demand for their services.

What does the future hold?

Many recent shortage claims point not to current circumstances, but to projections of future demand. What can be said with reasonable assurance about such predictions?

Unfortunately, labor-market projections for scientists and engineers that go more than a few years into the future are notoriously difficult to make. An expert workshop convened by the National Research Council in 2000 reported universal dissatisfaction with past projection efforts, and stated declaratively that "accurate forecasts have not been produced."

The workshop report commented in particular upon one such study that is often cited by shortage proponents: the Bureau of Labor Statistics' "Occupational Outlook." The most recent "outlook," completed in 2001, projected that over the next decade computer-related fields, including software engineers, computer-network and systems administrators and analysts, would likely be the fastest growing occupations nationwide. But the NRC workshop report noted the limitations inherent in such projections:

> The omission of behavioral responses makes the BLS outlook unreliable as a basis for decisions on federal funding designed to respond to anticipated shortages.... The BLS outlook neglects many dimensions in which adjustment may occur, including training and retraining, and especially in response to changes in wages.... No response is built into time trends in relative occupational wages on either the demand side (where employers substitute capital for labor when relative wages rise) or the supply side (where students move toward occupations in which relative wages are rising).

One might add that many science and engineering fields are heavily influenced by federal funding, which makes projections of future workforce demand dependent upon quite unpredictable political decisions and world events. To their credit, the authors of the BLS Occupational Outlook themselves emphasize the need for caution. "The BLS projections were completed prior to the tragic events of September 11 ... [and] the nature and severity of longer-term impacts [of the terror attacks] remains unclear," the authors write. "At this time, it is impossible to know how individual industries or occupations may be affected over the next decade."

Owing to such events and unforeseeable changes in the market, no one can know what the U.S. economy and its science and technology sectors will look like in 2010. It follows that no credible projections of future "shortages" exist on which to base sensible policy responses.

Misdirected solutions

Not only are claims of current or future shortages inconsistent with all available quantitative evidence, but alas many of the solutions proposed to deal with the putative "crisis" are profoundly misdirected. The most popular proposed solutions seem to focus mainly on the supply side, urging action to increase the numbers of U.S. students pursuing degrees in science and engineering. Recommendations often include calls for reform of the U.S. elementary and secondary education systems, especially inadequacies in science and mathematics; informational efforts to promote knowledge of such careers among U.S. secondary school students and of the science and math prerequisites required to pursue them at university level; financial and other incentives to increase interest in such fields among U.S. students; and increases in the number of "role models" in science and engineering fields for women and underrepresented minorities. Other commentators, apparently more pessimistic about the abilities of U.S. students, recommend increasing the numbers of students or workers from abroad to meet the needs of the U.S. economy.

This focus on supply to the virtual exclusion of considering demand is not warranted. However desirable many of these proposals may be on other grounds, they are unlikely to be very effective in attracting U.S. students to careers in science and engineering unless employment in these fields is sufficiently attractive to justify the large personal investments needed to enter them. Surprisingly enough, it is far from common to hear this rather obvious point raised in public discussions of the subject. To put the matter more succinctly, those who are concerned about whether the production of U.S. scientists and engineers is sufficient for national needs must pay serious attention to whether careers in science and engineering are attractive relative to other career opportunities available to American students. And yet little such attention has been forthcoming in recent years.

The qualifications for careers in engineering and especially in science involve considerable personal investments. The direct financial costs of higher education in the sciences can be staggering, depending on the financial circumstances of undergraduates and their families, whether the institution is private or public, whether postbaccalaureate education is required, and whether such education is subsidized.

Engineering and science differ substantially in these characteristics. For engineering, only the baccalaureate is normally required for entry into the profession. Most engineering B.S. degrees are earned at state universities, which are heavily subsidized by state governments. In addition, direct financial aid is often available for those in financial need. In contrast, professional careers in the sciences now commonly require completion of the Ph.D. and increasingly require subsequent postdoctoral work. The direct financial costs of this extensive graduate and postdoctoral work are typically heavily subsidized by both government and universities. Yet even with such subsidies, the personal costs to qualify as a scientist can be quite high—mainly due to the lengthening time required to attain the degree and complete postdoctoral training.

The extreme case is that of the biosciences, which account for half of all Ph.D.s awarded in the natural sciences. Over the past couple of decades, the average period of required postbaccalaureate study has increased dramatically, to between nine and twelve years from about seven to eight years. The Ph.D. itself has stretched out to seven or eight years from about six, while the now-essential postdoctoral apprenticeship has lengthened to between two and five years from one or two in decades past. In career terms, this means that most young bioscientists cannot begin their careers as full-fledged professionals until they are in their early thirties or older, and those in academic positions usually are not able to secure the stable employment that comes with tenure until their late thirties. Unsurprisingly, the idea of spending nine to twelve years in postbaccalaureate studies before one is qualified for a real job may be unattractive to substantial numbers of would-be young scientists.

There are also concerns about negative impacts on scientific creativity. Wendy Baldwin, until recently the deputy director for extramural research at the National Institutes of Health (NIH), notes concerns arising at NIH over "the long-held observation that a lot of people who do stunning work do it early in their careers." Bruce Alberts, in his 2003 President's Address to the National Academy of Sciences, described as "incredible" the fact that even though NIH funding has doubled in only the past five years, the average age of first-time grant recipients has continued increasing. "Many of my colleagues and I were awarded our first independent funding when we were under 30 years old ... [now] almost no one finds it possible to start an independent scientific career under the age of 35," Alberts told the academy. Nobel laureate and co-discoverer of DNA structure James Watson agrees. As he put it in characteristically pithy terms in a 1992 interview, "I think you're unlikely to make an impact unless you get into a really important lab at a young age.... People used to be kings when they were nineteen, generals. Now you're supposed to wait until you're relatively senile."

It's not hard to see why this also portends ill for science careers at a personal level. Delaying career initiation until one's thirties poses inherent conflicts with marriage and family life. Many who might be attracted to careers in science are justifiably concerned that such a career choice comes at too high a personal cost.

The problem has not gone unnoticed. Many scientific societies have decried the trend toward longer degrees and postdoctoral apprenticeships, and U.S. universities have created more than 70 new two-year graduate science degrees designed for those who wish to pursue scientific careers outside of the academy. (Start-up costs of many of these have been supported by Sloan Foundation grants.) These new degrees, called "Professional Science Master's degrees," have been attracting interest among U.S. science majors who might otherwise choose paths leading to business or law school.

Opportunity costs

Some senior scientists stress that no one should pursue a science career to get rich, which is a point well taken. Yet it would be unwise simply to ignore how alternative career paths compare in strictly economic terms. The nine-to-twelve year period that a would-be bioscientist now must spend in a student role or low-paid postdoctoral position means that a substantial fraction of lifetime income that would otherwise be earned must be foregone. This is what economists term "opportunity costs," and these are by no means insignificant. A 2001 study conducted by a team of leading economists and biologists for the American Society for Cell Biology found that bioscientists experience a "huge lifetime economic disadvantage" on the order of $400,000 in earnings discounted at 3 percent compared to Ph.D. fields such as engineering, and about $1 million in lifetime earnings compared with medicine. When expected lifetime earnings of bioscientists are compared with those of M.B.A. recipients from the same university, the study's conservative estimates indicate a lifetime earnings differential of $1 million exclusive of stock options. When stock options are included, the differential doubles to $2 million.

In smaller scientific fields such as physics and chemistry, where Ph.D. programs are shorter and lengthy postdoctoral work less universal, the differentials are smaller but still substantial. Given the direct financial costs and opportunity costs, careers in science and engineering must offer significant attractions relative to other career paths available to American students. College graduates with demonstrated talent and interest in science and mathematics can choose to go to medical school, law school, or business school; they can pursue other professional education; or they can enter the workforce without graduate degrees.

The options available to most foreign students—at least for those from poorer countries—are completely different. Most do not have the option to study at U.S. medical, law, or business schools (due to the high costs and lack of subsidies) nor can they easily enter the U.S. workforce directly. In contrast, science Ph.D. programs at many American universities actively recruit and subsidize graduate students and postdoctoral fellows from China, India, and elsewhere, from which positions many are able to move on to employment in the United States.

There are, of course, many significant noneconomic rewards associated with careers in science and engineering: the intellectual challenge of research and discovery; the life of the mind in which fundamental puzzles of nature and the cosmos can be addressed; the potential to develop exciting and useful new technologies. For some, these attractions make science and engineering careers worthy of real sacrifices—they are "callings" rather than careers, analogous to those of religious or artistic vocations. Happily, a number of talented students will decide, based on personal values and commitments, to pursue graduate degrees and careers in science or engineering, even with full knowledge that the career paths may be unattractive in relative terms. Yet it is also true that others with strong scientific and mathematical talents will decide that a better course for their lives would be to go directly into the workforce rather than to follow additional scientific studies, or instead to pursue professional degrees in business, law, or other fields.

The politics of shortages

Public discourse about these issues is mired in paradox. There are energetic claims of "shortages" of engineers, while unemployment rates are high and mid-career engineers face increasing job instability. There are reprises of earlier "shortage" claims about scientists, while undergraduates demonstrating high potential in science and math increasingly seem to be attracted to other careers. Some emphasize the need for K-12 reform, even though very large numbers of entering college freshmen intend to major in science or engineering but later choose otherwise. The NIH research budget has doubled within only a few years, but the average age at which scientists win their first research grants is rising. Why are shortage claims so persistent despite so much evidence to the contrary?

On this issue, where one stands depends upon where one sits. Most of the assertions of current or impending shortages, gaps, or shortfalls have originated from four sources: university administrators and associations; government agencies that finance basic and applied research; corporate employers of scientists and engineers and their associations; and immigration lawyers and their associations.

The economist Eric Weinstein has uncovered documentary evidence suggesting that the real intent of some of those involved in the 1980s "shortfall" alarms from NSF may have been to limit wage increases for Ph.D. scientists. Whether or not such motivations underlay that episode, we can certainly appreciate the various incentives that may currently spur some to endorse such claims. Universities want to fill their classrooms with undergraduates who pay their fees and finance their research with external funding, and to do so recruit graduate students and postdoctoral fellows to teach undergraduates and to staff their research laboratories. Government science-funding agencies may find rising wages problematic insofar as they result in increased costs for research. Meanwhile, companies want to hire employees with appropriate skills and backgrounds at remuneration rates that allow them to compete with other firms that recruit lower-wage employees from less affluent countries. If company recruiters find large numbers of foreign students in U.S. graduate science and engineering programs, they feel they should be able to hire such noncitizens without large costs or lengthy delays. Finally, immigration lawyers want to increase demand for their billable services, and especially demand from the more lucrative clients such as would-be employers of skilled foreign workers.

None of these groups is seeking to do harm to anyone. Each finds itself operating in response to incentives that are not entirely of its own making. But a broad commonality of interests exists among these disparate groups in propagating the idea of a "shortage" of native-born scientists and engineers. Moreover, claims of shortages in these fields are attractive because they have proven to be effective tools to gain support from American politicians and corporate leaders, few of whom would claim to be experts on labor markets. As noted earlier, the dubious reports from the ITAA were used successfully to convince the Congress to triple the size of the H-1B visa program in 2000. In late 2002, a leading lobbyist for the National Association of Manufacturers, responding to criticism that shortage claims cannot be supported by credible evidence, put the matter succinctly: "We can't drop our best selling point to corporations," he explained.

Such a short-term view is naturally attractive to lobbyists because it works politically. But it may turn out to be a serious error over a longer period of time. Claims of impending shortages can easily become self-fulfilling prophecies if, as in the past, government responds by subsidizing education or increasing visas for foreign workers without seriously considering the effects such actions may have upon the attractiveness and sustainability of career paths for such professionals. Action along these lines could create an even larger surfeit of scientists and engineers—one that drives down the number of Americans willing to enter these professions and, paradoxically, creates the very problem it seeks to address.

Instead of raising the false flag of shortages, those concerned about the future of science and engineering in the United States should encourage objective appraisals of current career paths, as well as innovations in higher and continuing education designed for more agile adjustments to inevitable changes in these dynamic fields. The overarching goal should be to find ways to make these careers attractive relative to the alternatives, for this is the only sustainable way to ensure a supply commensurate with the United States' science and engineering needs.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Thomas J. Duesterberg, President and CEO, Manufacturers Alliance/MAPI

Questions submitted by Chairman Bart Gordon

Q1. Dr. Gomory says that multinational company interests are not always aligned with America's. Do you agree with his assessment? In which areas do you believe he is correct?

A1. This is a very broad question which can only be partially answered. Dr. Gomory's argument largely turns on his analysis that *productivity-enhancing* activities are increasingly being sent offshore by U.S. firms, so that the mutual benefits of trade are reduced in favor of non-U.S. operations. I generally do not agree with his assessment for several reasons. First, as I demonstrated in my testimony, productivity in the United States, especially in the globally engaged manufacturing sector, has done very well in recent decades, and especially since 1995. In terms of its *relative* performance, the United States has gained against most global competitors in terms of productivity in this period.[1] Second, the large majority of research and development activities by U.S. firms, especially those related to cutting-edge new products or processes, are still performed in the United States. However one measures national performance, per capita income, national wealth, relative market shares, relative purchasing power, or raw GDP, the United States is continuing to advance in both absolute and relative terms. I also argued in my testimony that it is in the interest of U.S. firms to be active in foreign markets due to the superior growth prospects in areas such as China and India and listed a variety of ways in which such participation *strengthens* U.S. firms—and hence our domestic economy. The one area where we do need to be vigilant, which I emphasized in my oral testimony and in response to questions, is in industries and products related to national defense. The national interest in maintaining superiority in defense-related industries and products clearly must be carefully aligned with the interests of U.S. firms in gaining world market share. We have sufficient policies in place to accomplish this balancing act, but they are in constant need of updating to reflect changing global distribution of capabilities.

Q2. A recent BusinessWeek *cover story says that the real costs of offshoring are being under-counted, and that domestic production has been overstated. How does this finding affect the figures in your testimony?*

A2. In response to this question, I offer as an attachment a recent paper by my colleague Jeremy Leonard addressing the *BusinessWeek* analysis. At this point, not enough work has been done to cause us to think that the data used in my testimony can and should be revised.

Q3. What share of the millions of American manufacturing jobs lost over the past seven years has been due to offshoring? What share was due to other causes?

A3. Little, if any data exist to accurately address this offshoring question. The Bureau of Labor Statistics maintains a Mass Layoff series whereby closings and layoffs of 50 or more from business establishments that employ 50 or more workers are identified with the use of administrative data. Employer interviews are conducted to identify events that last more than 30 days and to supplement administrative data with information on the nature of the layoff itself, including the reason for the separation.

Beginning in January 2004 the BLS, motivated by growing interest in the outsourcing issue, added two questions to the employer interview component:

1. Did this layoff include your company moving work from this location(s) to a different geographic location(s) within your company?
2. Did this layoff include your company moving work that was performed in-house by your employees to a different company through contractual arrangements?

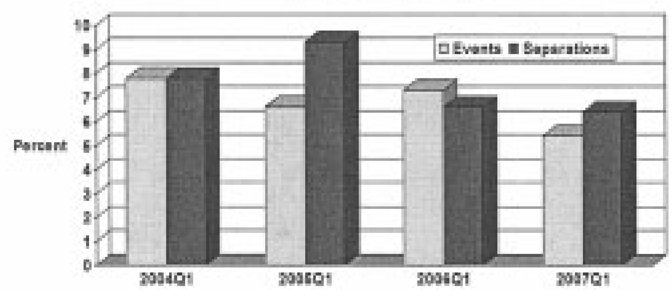
If employers responded "yes" to either question, then they were asked "Is this location inside or outside the United States?" and "How many layoffs were a result of this relocation?" "Offshoring" is indicated by movement of work out of the United

[1] See Krzysztof Bledowski, *Industrial Performance of Europe Versus America: Trends in Labor, Productivity, and Costs,* Manufacturers Alliance/MAPI, ER–635e, July 2007.

States, while “outsourcing” the movement of work that was conducted in-house to a different company which may be inside or outside the United States.

As shown in Figure 1, the share of mass layoff events and separations in the U.S. manufacturing sector that has been accompanied by movement of work overseas has been below 10 percent since the series was initiated in 2004. (These data are not seasonally adjusted and thus we use first quarter data from each year to display the trend.) The first quarter 2007 shares are well below those seen in 2004, with the events share falling more than the separation share. BLS cautions that these data represent a new series, that many employers refuse to answer the questions or do not know if layoffs were associated with outsourcing, and thus are subject to major refinement in coming years.

Figure 1
Share of Mass Layoff Events and Separations in the U.S. Manufacturing Sector That Has Been Accompanied by Movement of Work Outside of the U.S.



Source: Bureau of Labor Statistics, July 2007

Data related to the services sector show even fewer reports of mass layoffs accompanied by movement of work outside the United States. Between 1.6 percent and 1.4 percent of such services sector layoffs meet this criterion.

The data generated by these new questions, and by the Mass Layoff survey in general, have, at best, a limited use. For one thing, mass layoffs are only a subset of the larger job loss picture. Further, these data do not reflect the trend in hiring, which many analysts believe to be a more critical component of the manufacturing job dynamic since 2000. Nor do they reflect *jobs not created* in the United States due to growth of market share by foreign firms. But, more importantly, conceptual problems prohibit the use of any data to make precise inferences about the substitution of a foreign for a domestic job. A March 2004 study prepared by an analyst at the Bureau of Economic Analysis clearly explains the issues as they pertain to U.S. multinationals, which have a large footprint in the U.S. manufacturing sector.[2] As noted in the Meckstroth paper cited in MAPI’s June 12 testimony, U.S. parent multinationals (MNC) account for 55 percent of all employment by U.S. manufacturing firms and about 70 percent of U.S. manufacturing value-added. The article notes that while BEA’s data on the operations of U.S. MNCs indicate a relatively stable mix of domestic and foreign operations, the inferences that can be drawn from these data about production strategies and the ultimate impact of multinational activity on the U.S. and foreign economies are limited. The U.S. parent share of U.S. MNC activity can change for a number of reasons and these changes do not uniformly correspond to either additions or subtractions from production and employment in the United States. Specifically, the impact of new direct investment abroad by U.S. MNCs will vary depending on the form of the investment and the reason it was undertaken. Affiliate employment will always rise regardless of whether the form of the direct investment is a Greenfield plant (i.e., built from the ground up), the acquisition of a successful existing enterprise, or the acquisition of a failed enterprise. But the impact on host country employment will differ. And the

[2] See Raymond J. Mataloni, Jr., “A Note on Patterns of Production and Employment by U.S. Multinational Companies,” *Survey of Current Business,* March 2004, pp. 52–56.

host country impact is not simply a function of MNC operations alone. It is determined by a wide range of macroeconomic factors that include the total level of employment. Many studies show that in the United States, in the aggregate, growth in foreign affiliated employment is generally accompanied by growth in domestic employment.

A consideration of the reasons for the direct investment by the U.S. MNC is instructive. Affiliate employment shares will rise regardless of whether the direct investment is a result of the shifting of production from parents to affiliates or because of the opening of new overseas markets that can only be serviced through a local enterprise. In the case of production shifting, the rise in employment might come partially or totally at the expense of parent employment. If, on the other hand, overseas markets are generating new affiliate activity, domestic U.S. employment might rise because of the need to provide new headquarter services. Further, many other factors might be associated with a change in the parent and affiliate shares of MNC activity. These include different rates of productivity growth in U.S. parents and affiliates and changes in foreign government policies toward direct investment.

Finally, the article notes a significant data limitation in tracking employment changes in U.S. parents and affiliates. Except for the data (collected during benchmark study years) on the number of production workers of foreign affiliates in manufacturing, BEA does not collect data on the *types* of jobs held by employees of either U.S. parents or foreign affiliates. Consequently, it is not possible to determine the relative changes in the types of jobs offered by parents and affiliates either in terms of the occupation or the skill set required for the job. On top of the above-discussed market complexities of domestic and foreign job changes, this data limitation prevents any inference at all about the substitution of foreign for domestic jobs.

From a policy point of view, an understanding of the forces that have been impacting manufacturing employment is more valuable than estimates regarding the precise impact of offshoring on domestic employment, which is murky at best. In a 2004 paper, Kristin Forbes, currently an Associate Professor at MIT's Sloan School of Management and formerly a member of President Bush's Council of Economic Advisers, discussed a number of the forces that catalyzed the large manufacturing job loss that occurred between 2001 and 2004.[3] The unusual character of the 2000–2001 recession and subsequent period of slow growth needs to be understood to appreciate the reasons for the severe factory job losses. As measured by the decline in real GDP, the recession was quite mild by historical standards. But business investment and exports, the two primary demand generators for U.S. manufactured products, suffered disproportionately. The significant business investment decline came on the heels of what many economists still view as an investment bubble that reached a peak in the latter years of the 1990s. The sizable export decline was, in large measure, due to stubbornly persistent growth difficulties in the Eurozone and Japan.

But on top of these short-term issues, Forbes discusses the long-term improvement in manufacturing productivity growth accompanied by the very long-term decline of manufacturing employment. She notes that during the second half of the 20th century, manufacturing productivity growth has been stronger than for the economy as a whole. And, very strikingly, the manufacturing share of total employment actually peaked in the early 1940s. As noted in MAPI's testimony, the very long-term nature of the manufacturing employment decline suggests that the reasons are fundamental to the factory sector's evolution and not simply a result of the current challenges presented by emerging markets, a point that is accentuated by the fact that many of the challenges facing U.S. manufacturers are not unique to the United States. Other large economies such as Japan and China also suffered large manufacturing job losses in the early years of the 21st century.

Q4. Do we need policies to keep R&D in the U.S.? If so, why?

A4. I don't believe the United States needs any *new* policies to keep R&D in the country, but existing ones can and should be strengthened. This is especially the case since R&D is currently the *least* globalized activity of multinationals, as less than 14 percent of R&D is conducted by foreign affiliates, up very modestly from 11.4 percent in 1990. First, the research and experimentation tax credit should be simplified and made permanent. Second, the current high (relative to most internationally competitive economies) corporate tax rate discourages the capital investment needed for commercializing R&D, and, in some cases, discourages location in the United States. The corporate tax rate should be lowered to provide a level playing field for U.S. firms. Third, federally funded basic research in the physical sciences and engineering has languished, in relative and absolute terms, in recent

[3] Kristin J. Forbes, "U.S. Manufacturing: Challenges and Recommendations," *Business Economics,* Vol. 39. No. 3, pp. 30–37.

decades. This class of research is important to manufacturers and needs to be increased. Fourth, the education system that supplies trained and creative talent to conduct cutting-edge R&D needs to be improved, and creative ways to enhance the career paths of aspiring scientists and engineers need to be conceived and put into place. Fifth, the legal regime (both domestic and international, through the World Trade Organization) which encourages and protects intellectual property, needs to be strengthened and updated. It is, finally, worth noting that we need to allow our global corporations to capture the positive benefits of emerging innovation clusters around the world, which may require some local investment. Likewise, some local R&D presence may aid in adapting products to local markets. There is no reason that positive spillover impacts, which are well documented in the research literature, could not arise from overseas universities and industrial research clusters as well as those in the United States. Such spillovers, too, could strengthen domestic U. S. firms.

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The Effect of Offshoring on U.S. Manufacturing Productivity and Compensation

by
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One of the surprising aspects of manufacturing productivity in recent years is that it has remained strong despite a long and deep recession early in the decade. Trend productivity growth accelerated steadily through the 1990s to reach 4.5 percent by 2000. Just as importantly, while annual swings have been large since then, productivity growth was sustained at this level through the 2000-2002 manufacturing recession and beyond. This performance is unprecedented in the post-World War II era, and provides strong evidence that U.S. manufacturers are reducing costs as they face more intense global competition.

Recent research, however, has called into question the measured strength of the manufacturing productivity boom. In a widely cited paper, Susan Houseman of the W.E. Upjohn Institute for Employment Research advances the hypothesis that offshoring and outsourcing have generated upward bias in recent productivity numbers, such that a significant portion of measured growth does not reflect improvements in the efficiency and productivity of U.S. workers.[1]

The basic intuition underlying the argument is as follows. If a company outsources part of its operations, it is effectively substituting its own employees for workers who are not on the company's payroll. In terms of the productivity data, this results in a decrease in hours worked (which includes only hours worked by a company's own employees) and an increase in purchased inputs (the cost of the outsourced employees). If the cost of the outsourced operations are not significantly different from the company's internal cost (as is often the case when companies outsource certain functions to domestic providers), then productivity is essentially unchanged. However, if such costs are significantly lower (as in the case of offshoring to low-wage countries), measured labor productivity can increase markedly. Table 1 illustrates the dynamics with a simple example, showing that offshoring 10 percent of production to a contract manufacturer whose costs are 60 percent lower will increase recognized labor productivity by almost 7 percent.

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[1] Susan Houseman, "Outsourcing, Offshoring and Productivity Measurement in U.S. Manufacturing," Upjohn Institute Staff Working Paper No. 06-130, revised April 2007. The findings of this paper, as well as other productivity measurement issues, were the subject of a cover story in the June 18, 2007 issue of *BusinessWeek*.

Table 1
Illustration of the Impact of Outsourcing and Offshoring on Measured Manufacturing Productivity
(average annual percentage change)

	Base scenario	Company outsources several corporate functions (totaling 5 percent of labor input) at 90 percent of internal cost	Company offshores 10 percent of production to contract manufacturer at 40 percent of internal cost
Output	$50,000	$50,000	$50,000
Change in purchased input costs	N/A	$2,250	$2,000
Adjusted domestic output	50,000	$47,750	$48,000
Hours worked by payroll employees	500	475	450
Productivity (adjusted net output per hour worked)	$100	$100.53	$106.67

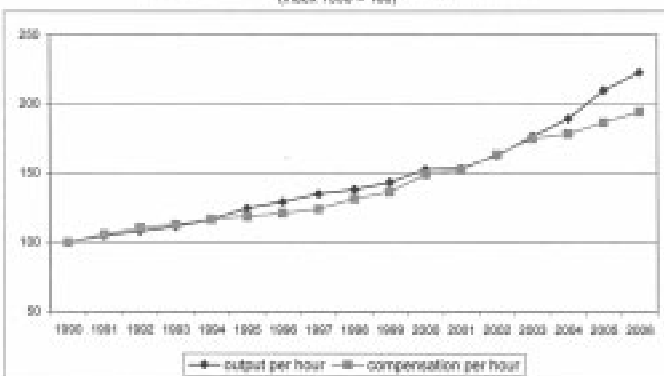
Houseman adjusts published manufacturing productivity figures for the use of outsourced employment services and finds that the reported annual growth of 4.1 percent from 1995 to 1999 would have been only 3.4 percent without the outsourcing effect. Unfortunately, lack of data prevented her from extending the analysis past the 2000-2002 recession.

What the critics of offshoring fail to admit is that productivity growth due to outsourcing and offshoring is just as desirable as "organic" productivity growth entailing greater efficiency of existing employees, because it lowers production costs which improves competitiveness. The cost savings are eventually passed on to consumers in the form of low (sometimes falling) prices for manufactured goods. However, Houseman and others worry that productivity growth due to offshoring is indicative of adverse effects on U.S. manufacturing workers, arguing that it puts downward pressure on compensation, thus breaking the historically tight correlation between labor productivity growth and real hourly compensation.

A comparison of inflation-adjusted data shows that hourly compensation growth has trailed that of productivity in recent years by a substantial margin. The gap is not primarily due to offshoring effects, rather, it is a function of the different price indexes that are used to deflate each measure. With regard to labor productivity, manufacturing output is adjusted for inflation by using industry sales price indexes, which include only manufacturing output. Compensation, in contrast, is adjusted using consumer price indexes, which include all goods and services that are purchased by consumers. Because the prices of manufactured goods have risen much more slowly (and in many years have actually declined) than those of services, much of the productivity-compensation gap in manufacturing is a question of relative prices, not offshoring.

To answer the question of whether the benefits of increasing manufacturing productivity are accruing to U.S. manufacturing workers, it is more appropriate to compare ***non-inflation-adjusted*** measures, which are shown in Chart 1. Removing the effects of differences in price measurement paints a very different picture: from 1990 to 2003, compensation per hour closely tracked output per hour.

Chart 1
Inflation-Adjusted Growth in Manufacturing Output Per Hour and Compensation per Hour, 1990-2006
(index 1990 = 100)



Source: Bureau of Labor Statistics, Bureau of Economic Analysis and author's calculations

It is also clear that the output-compensation gap in manufacturing has widened since 2003. From 2003 to 2006, output per hour increased by 26 percent, while compensation per hour increased by only 11 percent. Such divergences are not unprecedented. In the mid-1990s, output per hour exceeded compensation per hour by nearly 10 percent, but the gap closed by 2000. It is common for labor compensation growth to lag productivity growth in periods of high investment, because conscious decisions on the part of companies to allocate a larger share of corporate revenues to investment rather than employee compensation. These investments will eventually improve worker productivity, allowing compensation per hour to catch up.

Thus, while it is true that the output-compensation gap since 2003 coincides with increasing prevalence of offshoring, it also coincides with a strong recovery in manufacturing investment. After several years of declines, capital equipment spending in U.S. manufacturing has grown by 25 percent since 2002, comparable to rates seen in the mid-1990s. Houseman's research provides suggestive evidence that offshoring is one of the culprits, but it is equally plausible that stronger capital spending (which in fact strengthens U.S. productivity) is at work. The effect of offshoring on U.S. manufacturers is still poorly understood, and the Alliance will continue to monitor and report on research findings and developments on this critical question.

Appendix 2:

Additional Material for the Record

TESTIMONY OF THE
COMPUTING RESEARCH ASSOCIATION

FOR THE
HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY
HEARING ON

"The Globalization of R&D and Innovation"

June 12, 2007

TESTIMONY OF THE
COMPUTING RESEARCH ASSOCIATION

FOR THE
HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY
HEARING ON

"The Globalization of R&D and Innovation"

June 12, 2007

Thank you, Chairman Gordon and Ranking Member Hall, for convening this hearing and for your committee's continued support of the U.S. science and engineering enterprise. In organizing this hearing the committee has identified a number of important issues and concerns surrounding the globalization of research and development work, including the implications for the U.S. science and engineering pipeline and its impact on the nation's future competitiveness. As an organization representing more than 200 PhD-granting university computer science and computer engineering departments, 26 industrial research labs, and six affiliated computing societies, the Computing Research Association (CRA) shares your concerns and hopes that, through this testimony and future interactions, we can help provide valuable input to the committee as it seeks to understand these issues.

CRA is primarily focused on the health of the computing research community in North America. As a result, we are an organization with a deep interest in the U.S. educational system, because that is the pipeline by which U.S. research strength is maintained. We are therefore concerned not only with the effects of globalization on first-order effects of investment in R&D, but on the larger system of knowledge discovery and application, including the educational pipeline. Our testimony will be focused on three relevant "Issues and Questions" raised by the committee in its comprehensive Hearing Charter.

Issue One

Does offshoring of science and engineering lead to lesser spillover benefits from R&D?
The primary rationale for government subsidies of R&D is the capture of downstream benefits by companies operating in the U.S. Does offshoring of science and engineering work mean that those benefits are more likely to quickly leak outside the country?

It is the nature of fundamental research to "leak" across borders – science does not move forward without this free flow of ideas. However, capitalizing on the fruits of this research requires creating an environment for innovation to flourish. Innovation requires a home where there is intellectual curiosity, respect for creativity, an environment that fosters experimentation and rewards for discovery. An obvious metaphor is of tossing seeds in a field. If the field is fertilized, plowed and kept well-irrigated, you get a crop; if not, the only sprouts are accidental, or in another field where the wind carries them.

Indeed, as the amount of research performed elsewhere increases, it is even more important that we nurture our own innovation ecosystem at home. The only way that we can take similar advantage of work done in other places in the world is if we have a vibrant, robust, and inspired national research enterprise here at home that is current in the same fields and able to understand

and follow-up what is being done elsewhere. Fortunately, the United States has an innovation ecosystem that remains the envy of the world – and a key piece of that ecosystem is the federal government's continued support for fundamental research, particularly at our universities and national labs.

There are many reasons that support for fundamental research is an appropriate role for the federal government and enormously beneficial to the nation. As representatives of the computing research community, the most obvious way for us to demonstrate this is to look at a case-study of our own field: information technology.

In IT, there is certainly a strong economic case to be made. The importance of computing research in enabling the new economy is well documented. The resulting advances in information technology have led to significant improvements in product design, development and distribution for American industry, provided instant communications for people worldwide, and enabled new scientific disciplines like bioinformatics and nanotechnology that show great promise in improving a whole range of health, security, and communications technologies. Federal Reserve Board Chairman Alan Greenspan has said that the growing use of information technology has been the distinguishing feature of this "pivotal period in American economic history." Recent analysis suggests that the remarkable growth the U.S. experienced between 1995 and 2002 was spurred by an increase in productivity enabled almost completely by factors related to IT. A report by the Information Technology and Innovation Foundation released in March 2007 noted: "In the new global economy information and communications technology (IT) is the major driver, not just of improved quality of life, but also of economic growth…In fact, in the United States IT was responsible for two-thirds of total factor growth in productivity between 1995 and 2002 and virtually all of the growth in labor productivity."

Information technology has also changed the conduct of research, becoming an essential third leg of scientific research – complementing theory and experiment with computational approaches. Innovations in computing and networking technologies are enabling scientific discovery across every scientific discipline – from mapping the human brain to modeling climatic change. Researchers, faced with research problems that are ever more complex and interdisciplinary in nature, are using IT to collaborate across the globe, simulate experiments, visualize large and complex datasets, and collect and manage massive amounts of data.

There is also a compelling national security case for federal support of fundamental research in IT R&D. Information technology is at the heart of our military's strategic advantage over our adversaries. "Network-centric warfare" – the ability of our military to collect, process and distribute information to all pieces on, above and around the modern battlefield – forms the core of our military's ability to maintain its dominant position, even over numerically superior enemies. The U.S. needs to continue to be at the leading edge of the IT sector if we are to preserve that technological advantage. Staying at that leading edge will require a continued supply of new ideas and, just as importantly, people – especially those who can be cleared to work on classified material. Both are products of U.S. universities.

The National Research Council noted this in a 1995 report when they found that a significant reason for the dramatic advance in IT and the subsequent increase in innovation and productivity is the "extraordinarily productive interplay of federally funded university research, federally and privately funded industrial research, and entrepreneurial companies founded and staffed by people who moved back and forth between universities and industry." That report, and a subsequent 1999 report by the President's Information Technology Advisory Committee (PITAC), emphasized the "spectacular" return on the federal investment in long-term IT research and development.

The 1995 NRC report, *Evolving the High Performance Computing and Communications Initiative to Support the Nation's Information Infrastructure*, included a compelling graphic illustrating this spectacular return. The graphic was updated in 2002 and is included with this testimony. (See figure 1.)

It is worth a moment to consider the graphic. The graphic charts the development of technologies from their origins in industrial and federally-supported university R&D, to the introduction of the first commercial products, through the creation of billion-dollar industries and markets. The original 1995 report identified 9 of these multibillion-dollar IT industries (the categories on the left side of the graphic). Seven years later, the number of examples had grown to 19 – multibillion-dollar industries that are transforming our lives and driving our economy. If the chart were to be redone today, at least three new billion-dollar sectors would need to be added: search technologies, social networking, and internet video. Every one of these multibillion-dollar sectors bears the stamp of federally supported research.

But one important aspect of federally-supported university research that is only hinted at in the flow of arrows on this complex graphic is that it produces people – researchers and practitioners

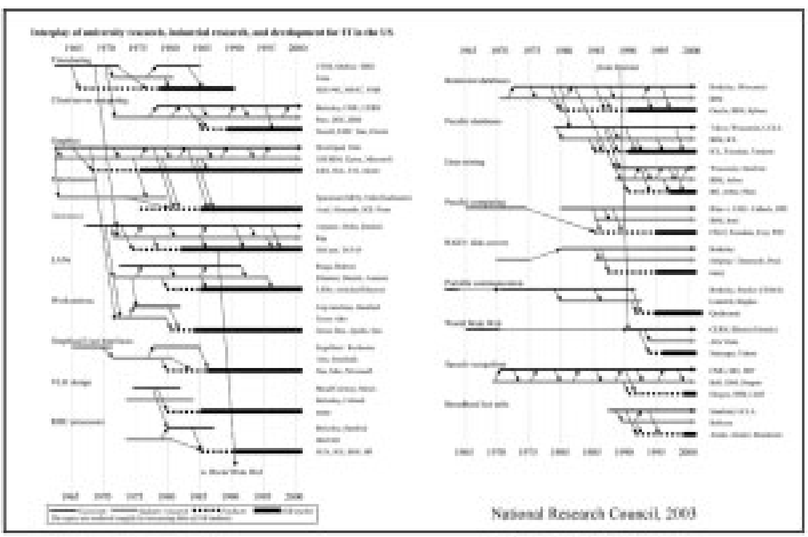


Figure 1.

– as well as ideas. This is especially important given the current outlook for IT jobs in the coming decade. Despite current concerns about offshoring and the end of the IT boom times, the U.S. Bureau of Labor Statistics in 2005 released projections that continue to show a huge projected shortfall in IT workers over the next 10 years. As figure 2 illustrates, the vast majority of the entire projected workforce shortfall in all of science and engineering is in information technology. These are jobs that require a Bachelors-level education or greater. In addition to people, university research also produces tangible products, such as free software and programming tools, which are heavily relied upon in the commercial and defense sectors. Continued support of university research is therefore crucially important in keeping the fires of innovation lit here in the U.S.

Also required is for the U.S. to continue to be well positioned to attract the best minds and talent in the world. Failing to do so will put us at a serious competitive disadvantage. Right now, our university system ranks as the finest in the world, continuing to be a magnet drawing the best talent to our shores. A recent report by the Ewing Marion Kauffman Foundation emphasizes this, finding that a quarter of technology and engineering companies launched in the U.S. between 1995 and 2005 had at least one foreign-born founder, and the majority of those foreign-born entrepreneurs came to the U.S. to attend a U.S. university.[1] These enterprises generated $52 billion in 2005 and provided jobs to more than 450,000 workers.

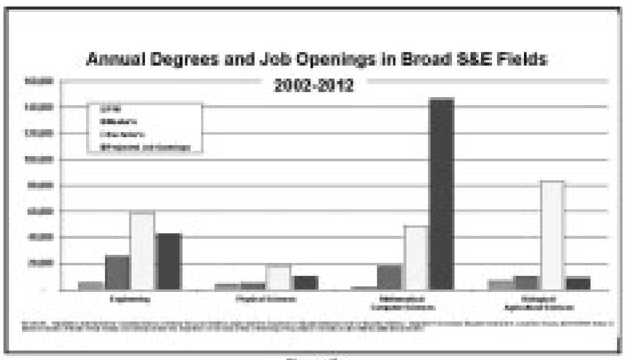


Figure 2.

Issue Two

What STEM fields are most vulnerable?
Computer science undergraduate enrollments are down 40 percent in the past four years, but not because our K-12 education system has not adequately prepared students. Instead, the culprit has been fear by students that their future jobs might be offshored. Is this fear well-founded? Students, educators and workers need better data and estimates to make informed career and educational choices. How do we ensure that STEM fields are still attractive?

In the case of computer science, the prevailing perception of the problem appears to be far more serious than the problem itself. In 2004, the Association for Computing Machinery (ACM) sponsored a Job Migration Task Force to examine the issue of the globalization and offshoring of software. After an extensive review of all the available studies and data, the task force released a re-

[1] http://www.kauffman.org/items.cfm?itemID=869

port[2] in 2006 that found that the impact of offshoring on the U.S. IT jobs had been overstated – it then affected only 2 to 3 percent of the overall IT workforce – and that, in truth, the job market in IT in the U.S. was really quite strong. In fact, the Task Force found that, despite perceptions to the contrary, more people in the U.S. were working in IT fields in 2005 than at the height of the "dot com" boom (Nov 2000). The most recent projections from the U.S. Department of Labor, Bureau of Labor Statistics, also suggest that, despite an assumed rise in the use of offshore outsourcing, job growth in the IT sector will dwarf growth in all other science and engineering disciplines. (See figure 2)

Yet perceptions of the IT job market are far more pessimistic than these figures would suggest they should be – and it appears that those perceptions have had an impact on the number of students enrolling in computer science programs. While this is cause for concern within the computing community – and indeed, has triggered much discussion and activity, including efforts to work with schools and policymakers to help improve the "pipeline" of students from grades K-12 into science and engineering disciplines, to revamping undergraduate curriculum to attract more good students into CS – it is also necessary to keep some perspective. Student demand in the field has historically been cyclic (see figure 3) and the latest data appears to show enrollments beginning to rebound. Also, the number of computer science bachelors degrees granted in 2005 were more than all the other physical and mathematical sciences degrees combined.

And while it is clear that perceptions about the current and future state of the job market are likely impacting interest in computer science (or science and engineering, generally) among incoming college freshman, it is not clear that those perceptions are the sole factors, or even the primary ones in influencing student interest. The computing community is also looking at other aspects of the issue, including a poor "image" of what a career in computing is really like, and the need to do a better job evangelizing the richness of the field's intellectual footing and the grand challenges yet left to be solved. In this effort the computing community is not alone. Across the science and engineering disciplines, task forces, committee, panels, workshops are being convened and pushed forward in an effort to increase the participation of American students in science and engineering. Congress can be helpful in this effort by supporting efforts to reach populations that are currently underrepresented in science and engineering and by demonstrating a continued commitment to the federal fundamental research enterprise.

Figure 3.

Issue Three

Should we be investing in all STEM fields or only those where we expect will be rooted in America?

Should a reallocation of resources be made to concentrate efforts on the fields that are most likely to stay in the U.S. Should educators

[2] Available at http://www.acm.org/globalizationreport/

adjust their curricula to teach skills that buffer workers from offshoring? If so, what content should it have?

The United States has the world's largest economy and the world's best system of higher education and research training. We are unique in the world in our ability to lead the world in a wide array of science and technology areas. This is not merely a special opportunity for the US to show global leadership – though it is that and we have been leaders for many decades. It is in our own self-interest. We prevailed during the perilous risks of the second half of the 20th century in large part because of our technological superiority. The challenges we face now are no less grave, and we will depend on technological superiority even more than in the past to see our way through. This does not mean we can or should go it alone – science and technology are increasingly global, and so are the problems we must confront. We are already partnering with others, and this partnering will grow. But we still have a leadership role to play in helping to show the way, finding the right mix of technological strength and moral purpose so that our technological solutions to global problems also reinforce our democratic values. To lead in this way, we must be superior in our knowledge of where the science and technology is going – and this comes only through maintaining research and development strengths in all the fields of importance to our welfare.

Thank you for the opportunity to provide input to the committee on this important issue. Globalization is already bringing considerable change to the U.S. innovation ecosystem. If we are to ensure the nation's continued global leadership and the continued high standard of living of Americans, we must ensure that all elements of that ecosystem are poised to take advantage of the opportunities created by those changes. We would counsel you to recommit to support for all STEM disciplines. The US is in an ideal position to capitalize on new discoveries wherever they are made in the world, but this requires that we continue to have a robust, innovative and broadly-based R&D infrastructure of our own. The best way to cope with globalization is not to retreat from some fields, but to increase our efforts and thus maintain leadership.

THE GLOBALIZATION OF R&D AND INNOVATION, PART II: THE UNIVERSITY RESPONSE

THURSDAY, JULY 26, 2007

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The Committee met, pursuant to call, at 10:05 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Brian Baird [Acting Chairman of the Committee] presiding.

BART GORDON, TENNESSEE
CHAIRMAN

RALPH M. HALL, TEXAS
RANKING MEMBER

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE AND TECHNOLOGY

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Hearing on

The Globalization of R&D and Innovation, Pt. II: The University Response

2318 Rayburn House Office Building
Washington, D.C.

Thursday, July 26, 2007
10:00 a.m.

WITNESS LIST

Dr. David J. Skorton
President
Cornell University

Dr. Gary Schuster
Provost and Vice President for Academic Affairs
Georgia Institute of Technology

Mr. Mark Wessel
Dean
H. John Heinz III School of Public Policy and Management
Carnegie Mellon University

Dr. Philip Altbach
Director of the Center for International Higher Education
Boston College

HEARING CHARTER

COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

The Globalization of R&D and Innovation, Part II: The University Response

THURSDAY, JULY 26, 2007
10:00 A.M.–12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose

On Thursday, July 26, 2007, the Committee on Science and Technology will hold a hearing to consider how globalization affects America's universities, and its implications for the U.S. science and engineering enterprise. The U.S. higher education system is a principal source of America's preeminence in science, technology, engineering, and mathematics (STEM) fields. As STEM offshoring increases competition for U.S. STEM workers, universities are responding by modifying their curricula to help their STEM students better compete. Globalization also enables American universities to venture abroad—to build programs and campuses overseas to serve the growing demand of foreign STEM students. This hearing will explore the globalization and internationalization of American universities and the implications for America's competitiveness.

2. Witnesses

Dr. David J. Skorton is President of Cornell University.

Dr. Gary Schuster is Provost and Vice President for Academic Affairs of Georgia Institute of Technology.

Mr. Mark Wessel is Dean of the H. John Heinz III School of Public Policy and Management at Carnegie Mellon University.

Dr. Philip Altbach is the Director of the Center for International Higher Education and the J. Donald Monan SJ Professor of Higher Education at Boston College.

3. Brief Overview

- Enrollments in some STEM fields, particularly computer sciences, are down significantly over the past few years in part because students believe these jobs are vulnerable to offshoring. In response, universities are modifying STEM curricula in order to give their students an advantage over emerging competitors from low-cost countries. Some curricular strategies include: substituting technical classes with business ones; offering interdisciplinary technical degree programs such as bio-engineering with electrical engineering; and, providing international exposure to technical students such as study abroad, foreign language trainings, and collaborative projects with students in other countries.
- According to the American Council on Education (ACE) approximately one percent of American students participate in study abroad programs. For engineering students the number is even smaller, so some engineering colleges are encouraging more of their students to participate in international experiences. Rensselaer Polytechnic Institute (RPI) has set a goal to send 25 percent of its 2010 class overseas through partnerships with universities around the world.
- America's higher education is considered the best in the world. *The Economist* reports that America has seventeen of the top twenty universities and employs 70 percent of the world's Nobel prize-winners. American academics also produce 30 percent of the world's peer-reviewed scientific and technical journal articles, according to the National Science Foundation's (NSF) *Science and Engineering Indicators 2006.*

- American universities have traditionally attracted large numbers of foreign students, particularly advanced degree STEM students. Now, some American universities are taking their education to foreign students by building campuses and offering STEM degree programs in other countries. While there are no definitive counts of foreign campuses and programs established by American universities, experts believe that more universities, particularly high-prestige ones, are venturing abroad. The World Bank estimates that 150 of the 700 foreign degree programs operating in China are American.
- The American Council on Education (ACE) identifies eight different drivers of the internationalization of American universities, including: increasing revenue, enhancing prestige, enhancing international research collaborations, serving rapidly growing demand from China and India, and enhancing study abroad opportunities for U.S. students.

4. Issues and Concerns

What factors lead universities to establish branch campuses overseas and how widespread is this trend? What are the benefits and costs of this trend to the U.S. national interest in maintaining an edge in international economic competitiveness—and to overall U.S. national interests?

Experts predict that the number of foreign campuses and degree programs operated by American universities will increase significantly in the near future. The goals of these operations include increasing revenue, enhancing prestige, serving rapidly growing demand from China and India, and enhancing study abroad opportunities for U.S. students. The World Bank estimates that 150 of the 700 foreign degree programs in China are from American universities.

Do STEM educational programs offered at foreign campuses slow down or speed up the offshoring of STEM jobs? Are we exporting one of the principal sources of our comparative advantage? Are we training American workers' competitors?

The burgeoning demand for quality STEM education in India and China is driven in part by the rise of offshoring technology work to India and manufacturing work to China.

As U.S. STEM workers increasingly compete directly with workers based in low-cost countries, much of their competitive advantage will come from superior education. Have U.S. universities made curricular changes to give U.S. STEM students a durable advantage? Are the changes common across most U.S. universities and are they effective?

Some STEM programs are substituting technical classes like computer science with business classes such as project management. Other programs are combining technical disciplines like biomedical engineering with electrical engineering to create interdisciplinary graduates.

How do foreign educational programs and campuses affect the flow of foreign graduate students to American universities?

If foreign students are able to get the same degree in their home countries for less money, they may forgo studying in the U.S. On the other hand, foreign campuses may expand the pool of students seeking graduate degrees in the U.S.

5. Background

The U.S. higher education system is a principal source of America's preeminence in science, technology, engineering, and mathematics (STEM) fields. *The Economist* reports that America's higher education is the best in the world, home to seventeen of the top 20 universities and 70 percent of the world's Nobel prize-winners. The National Science Board reports that American academics produce 30 percent of the world's science and engineering articles. But globalization is re-shaping how and where STEM work is done, and American universities are adapting to globalization and offshoring by internationalizing STEM curricula and by increasing their global footprint.

American STEM students face increased competition and career vulnerability in the wake of offshoring and globalization. As a result, U.S. students are shying away from STEM fields they deem vulnerable to offshoring. The most prominent example is computer science, where undergraduate enrollments are down 40 percent over the past four years. Universities are responding to those concerns by modifying their STEM curricula and offering more international exposure for their U.S. students.

To make their students more desirable in the job market, engineering colleges are providing more international experience for them. Currently, engineering students participate in study abroad programs in disproportionately small numbers, so a number of engineering colleges have set goals to increase these numbers. About half of Worcester Polytechnic Institute's (WPI) graduating class goes overseas in some capacity. And through partnerships with universities around the world, Rensselaer Polytechnic Institute (RPI) has set a goal to have 25 percent of its 2010 class study or travel abroad. Other universities, like the University of Rhode Island, are approaching internationalization of STEM education by emphasizing foreign language training. Still others, like Purdue University, match up its students with students in other countries on international design teams.

American universities are also seeking to increase their global presence by venturing abroad—building campuses and STEM degree programs overseas. American universities have traditionally attracted large numbers of foreign students, particularly in STEM fields at the graduate level. Now, American universities are taking their education to foreign students by building campuses and offering STEM degree programs in other countries. Some, like Cornell, already identify themselves as "transnational universities."

As part of its strategic plan to increase its global footprint Carnegie-Mellon has established programs in Greece, Japan, Taiwan, South Korea, Australia and India. Georgia Tech is building a campus in Andhra Pradesh, India, to offer Master's and Ph.D. degree programs. And Cornell University operates a medical school in Qatar.

Offshoring is giving high quality foreign students job opportunities in their home countries they never had before, making it less desirable to come to the U.S. to study. As a result prominent universities are expanding their global footprints, to tap a more geographically diffuse student pool especially in India and China.

While there are no definitive counts of foreign campuses and programs established by American universities, experts believe that more universities, particularly high-prestige ones, are venturing abroad. And the World Bank estimates that 150 of the 700 foreign degree programs operating in China are American. ACE identifies eight different drivers of the internationalization of American universities. Some of these include: increasing revenue, enhancing prestige, enhancing international research collaborations, exponential growth in demand in emerging economies of China and India, and enhancing study abroad opportunities for U.S. students.

The hearing will explore the trends, motivations, and consequences of the globalization of American universities on the U.S. science and engineering enterprise.

Mr. BAIRD. [Presiding] I call the Committee to order, and welcome everyone to this morning's hearing on globalization of American universities and the impact on national competitiveness.

I want to offer welcomes to our distinguished witnesses, all leaders and experts on the emerging trend of university globalization, and we look forward to hearing your thoughts on the globalization of universities and the implications for American competitiveness.

Chairman Gordon, did you want to offer some comments? I know you have to leave early. Did you want to offer some comments before I offer my introductory remarks?

Chairman GORDON. Thank you, Mr. Chairman, and I thank you for continuing this. As you know, this is a very important issue to us. We have been working on this in a bipartisan way for the last few years. I am very hopeful that we are close to an agreement with the Senate on our Competitiveness Bill. I know that you are very aware of the *Rising Above the Gathering Storm,* and I think we are going to be able to get that done. I hope that you will soon see the results of it, and may come back and visit us in a year or so, to let us know how it is working, and how to fine-tune it, and how we need to move beyond that.

Today is also going to be a very interesting hearing concerning STEM education. As we know, just to get a STEM education these days, even from a substantial university, like we have here today, is no guarantee of a lifetime of good employment. And so we want to learn more about that. We want to learn what you are learning from overseas, and maybe lessons that can be brought home to us.

So, again, we thank you for being here, and as Chairman Baird said, I have a markup shortly, and I will have to leave, but I will be staying in touch, and want to learn more about what you have to say. So thank you.

[The prepared statement of Chairman Gordon follows:]

PREPARED STATEMENT OF CHAIRMAN BART GORDON

I would like to thank the witnesses for appearing at today's important hearing on the university response to the globalization of R&D.

The Science and Technology Committee has been a leader in creating policies that strengthen science, technology, engineering, and mathematics education in the United States. The institutions represented on this panel are key contributors to our country's preeminent STEM education enterprise.

However, as they know all too well, having a STEM degree, even from a top school, no longer guarantees lifelong employment in a well-paying job in the United States. Our students are increasingly competing with well-trained, low cost employees in countries such as India and China.

Universities are our first line of defense in ensuring our leadership in the global economy by giving our scientists and engineers the special skills they need to set themselves apart from the global competition. I am eager to hear about the new efforts you are undertaking to prepare students for the 21st century economy.

I also am curious to learn more about international programs being established by American universities to educate foreign students in their home countries.

While opportunities for international exchange are a key part of improving curriculum, I am eager to hear what the motivations were for your universities to establish campuses offshore, what sorts of opportunities and challenges you are now facing, and what effects you anticipate in the years to come.

Mr. BAIRD. Thank you, Mr. Chairman. Mr. Gordon, as you all know, has been just fantastic working here along with Ranking Member Hall and Mr. Ehlers and others on both sides, in a bipartisan way, on expanding STEM education in a host of important ways, and we are grateful for your participation.

As you all know, corporations have been globalizing for decades, and we know the effects on U.S. competitiveness are complex, including positives, such as lower prices for consumers, but also, some negatives, as job and wage loss have impacted other American workers.

But we know relatively little about how university globalization will impact America's competitiveness. America's higher education system is a principal source of our preeminence in science, technology, engineering, and math fields, so-called STEM fields, and as The Economist reports, U.S. higher education is the best in the world, home to 17 of the top 20 universities and 70 percent of the world's Nobel Prize winners. I think we swept those prizes last year, in fact. The National Science Board reports that American academics produce 30 percent of the world's science and engineering articles.

However, off shoring is reshaping how and where STEM education work is done. As a result, international competition has shifted increasingly to the individual worker level, and multinational companies are responding to competition by using more workers in lower cost countries. Those companies' American workforce now compete against workers in low cost nations like China and India.

American workers must respond by either increasing their productivity or lowering their wages. Obviously, the only acceptable solution is for our workers to increase productivity, but this is becoming more difficult as a larger share of jobs become vulnerable to offshoring, and many of workers' traditional advantages, infrastructure, better tools and technology, proximity to largest consumer market, are also being eroded.

Therefore, our higher education system will become an even more critical factor in helping American workers differentiate themselves from workers in lower cost countries. At the same time, American universities are beginning to globalize in new ways, which we will hear about today. With many more jobs requiring international work teams, universities are preparing their STEM students by providing more international experience through study abroad and other cross-border collaborations.

Universities are also modifying their STEM curricula to better prepare students for jobs that will stay in America. In some respects, American universities have been global for many, many years. We have attracted large numbers of foreign students, particularly in STEM fields, at the graduate level, but offshoring is giving high quality foreign students outstanding job opportunities in their home countries. This may make it less likely that foreign students will stay in the U.S. after graduation, and may make it less desirable to come to the U.S. to study in the first place.

Therefore, American universities are taking their education to the foreign students by building campuses and offering STEM degree programs in other countries. Today, we will hear what our witnesses have to say about the trends, motivations, and consequences of globalization of universities on our U.S. science and engineering enterprise, its workforce, and our nation's competitiveness.

With that, I would like to now recognize my friend and colleague, the Ranking Member, Mr. Hall from Texas, for an opening statement.

[The prepared statement of Chairman Baird follows:]

PREPARED STATEMENT OF CHAIRMAN BRIAN BAIRD

I want to welcome everyone to this morning's hearing on the globalization of American universities and its impact on national competitiveness. I want to offer welcomes to our distinguished witnesses—all leaders and experts on the emerging trend of university globalization.

We look forward to hearing your thoughts on the globalization of universities and its implications for America's competitiveness.

Corporations have been globalizing for decades. And we know its effects on U.S. competitiveness are complex, including positives such as lower prices for consumers as well as negatives such as job and wage loss for some American workers. But we know very little about how university globalization will impact America's competitiveness.

America's higher education system is a principal source of America's preeminence in science, technology, engineering, and mathematics (STEM) fields. *The Economist* reports that U.S. higher education is the best in the world, home to seventeen of the top twenty universities and 70 percent of the world's Nobel prizewinners. The National Science Board reports that American academics produce 30 percent of the world's science and engineering articles.

But offshoring is reshaping how and where STEM work is done. As a result, international competition has shifted increasingly to the individual worker level. Multinational companies are responding to international competition by using more workers in lower-cost countries. Those companies' American workforce now competes against workers in low cost countries like China and India.

American workers must respond by either increasing their productivity or lowering their wages. Obviously, the only acceptable solution is for our workers to increase their productivity. But this is becoming more difficult as a larger share of jobs become vulnerable to offshoring. And many of our workers' traditional advantages—better infrastructure, better tools and technologies, and proximity to the largest consumer market—are being eroded. Therefore, our higher education system will become an even more critical factor in helping American workers differentiate themselves from workers in low cost countries.

At the same time American universities are beginning to globalize in new ways. With many more jobs requiring international work teams, universities are preparing their STEM students by providing more international experience through study abroad and other cross-border collaborations. And universities are modifying their STEM curricula to better prepare their students for the jobs that will stay in America.

In some respects American universities have been global for many years. They have attracted large numbers of foreign students, particularly in STEM fields at the graduate level. But offshoring is giving high quality foreign students outstanding job opportunities in their home countries. This may make it less likely that foreign students will stay in the U.S. after graduation, and may make it less desirable to come to the U.S. to study in the first place. So, American universities are taking their education to foreign students by building campuses and offering STEM degree programs in other countries.

We look forward to hearing what our witnesses have to say about the trends, motivations, and consequences of the globalization of universities on the U.S. science and engineering enterprise, its workforce, and America's competitiveness.

Mr. HALL. Mr. Chairman, thank you very much.

You have covered it very well, and I am amazed at the gentlemen we have before us here, their background, their ability, and their willingness to give. I certainly know that there is no doubt that the American higher education system is one of our nation's crown jewels, and an increasing demand for U.S. degrees and escalating use of our higher education system as a model by other countries reflects decades of hard work and investment by the American people and by dedicated professionals, like you four men on the panel and others that will be before us.

While congratulations are in order, I think we should take care not to rest on our laurels, while the world around us continues to invest and improve their research and educational facilities.

Today, I look forward to discussing one way in which U.S. institutions of higher education are trying to continue their record of leadership. Scores of universities are now looking overseas for opportunities to expand. Many have partnered with foreign universities to offer joint programs and degrees, while others have opened new branches, complete with classrooms, laboratory space, and dormitories. Some universities offer a limited curriculum overseas, and require students to complete their training in the U.S., while others offer complete degree programs abroad.

This wide range of models makes it difficult, I think, to confidently predict how the globalization of higher education might affect U.S. institutions and the U.S. economy overall. However, we have a panel before us today that can help us map out the pros and cons of these trends.

In addition to the schools represented here today, I would like to take a moment to mention the work of Texas A&M in some faraway areas. I think that it is highlighted in the American Council of Education report, *Venturing Abroad: Delivering U.S. Degrees Through Overseas Branch Campuses and Programs.* Starting under the presidency of Secretary of Defense Robert Gates, Texas A&M continues to build a substantial engineering program in these areas. The inaugural class began in September of 2003, with 29 students, and has grown from there. Currently, Texas A&M offers four engineering degrees in this one area, in one location, with a faculty of 52 and student body of 200.

This course work meets the same standards of those in College Station, including a course on Texas history. I hope he leaves out the part that Sam Houston had to burn the bridge to be assured that his folks wouldn't abandon him until the battle was over, and had to tell them there was no retreat. That is kind of embarrassing, as I look back on it, but there, and I have had a lot of people, Tennesseans and folks from Kentucky really saved Texas. Really, but for them, there wouldn't be any Texas, and the answer, I think, that Chairman Barton gave to me, well, there wouldn't be a Texas anyway if the Alamo had had a backdoor in it, so I don't know if that is so or not, but we are going to stand up for Texas.

There are a few questions that I am eager to have addressed today. First of all, who are the students that take advantage of U.S. programs abroad, and where do they go after graduation? Do significant numbers work for American firms after graduation, either in their home country, or in the U.S.? Do more U.S. students abroad study abroad when branch campuses are available?

Next, I am interested in our panel's thoughts on the ability of their international efforts to serve as centers for business development. Do these centers provide a foot in the door for U.S. businesses, or do they largely stimulate growth only within the foreign country?

Finally, I think we should also consider the role these international arrangements have in further projecting America's image. Many of these programs are located in areas of the world where the U.S. has a strategic interest in being on the ground. These are some questions that I think probably you will answer, and I look forward to hearing them. I do look forward to your testimony, for the opportunity to continue this discussion during the questioning.

And Mr. Chairman, I yield back.

[The prepared statement of Mr. Hall follows:]

PREPARED STATEMENT OF REPRESENTATIVE RALPH M. HALL

Mr. Chairman, there is no doubt that the American higher education system is one of our nation's crown jewels. An increasing demand for U.S. degrees and an escalating use of our higher education system as a model by other countries reflect decades of hard work and investment by the American people and by dedicated professionals like those on the panel before us. While congratulations are in order, we should take care not to rest on our laurels while the world around us continues to invest and improve their research and educational facilities.

Today I look forward to discussing one way in which U.S. institutions of higher education are trying to continue their record of leadership. Scores of universities are now looking overseas for opportunities to expand. Many have partnered with foreign universities to offer joint programs and degrees while others have opened new branches complete with classrooms, laboratory space, and dormitories. Some universities offer a limited curriculum overseas and require students to complete their training in the U.S. while others offer complete degree programs abroad. This wide range of models makes it difficult to confidently predict how the globalization of higher education may affect U.S. institutions and the U.S. economy overall. However, we have a panel before us today that can help us map out the pros and cons of these trends.

In addition to the schools represented here today, I would like to take a moment to mention the work of Texas A&M in Qatar, which is highlighted in the American Council of Education (ACE) report, *Venturing Abroad: Delivering U.S. Degrees through Overseas Branch Campuses and Programs.* Started under the presidency of Secretary of Defense Robert Gates, Texas A&M continues to build a substantial engineering program in Qatar. The inaugural class began in September, 2003, with twenty-nine students and has grown from there. Currently, Texas A&M offers four engineering degrees in Qatar, with a faculty of fifty-two, and student body of two hundred. The course work in Qatar meets the same standards of those in College Station, including a course on Texas history, I might add.

There are a few key questions that I am eager to have addressed today. First of all, who are the students that take advantage of U.S. programs abroad and where to they go after graduation? Do significant numbers work for American firms after graduation, either in their home country or in the U.S.? Do more U.S. students study abroad when branch campuses are available? Next, I'm interested in our panel's thoughts on the ability of their international efforts to serve as centers for business development. Do these centers provide a foot in the door for U.S. businesses, or do they largely stimulate growth only within the foreign country? Finally, I think we should also consider the role these international arrangements have in further projecting America's soft power. Many of these programs are located in areas of the world where the U.S. has a strategic interest in being on the ground.

I look forward to our panel's testimony and for the opportunity to continue this discussion in earnest during the question and answer period.

Mr. BAIRD. I thank you, Mr. Hall, and as is the custom of this committee, if other Members wish to offer opening statements for the record, we will accept them into the record.

[The prepared statement of Mr. Costello follows:]

PREPARED STATEMENT OF REPRESENTATIVE JERRY F. COSTELLO

Good morning. Mr. Chairman, thank you for calling this important hearing to continue to examine the globalization of science technology, engineering, and mathematic (STEM) fields, and to further look at the impact of our universities expanding their campuses overseas. These actions will affect American students, U.S. competitiveness, and our overall economy.

In 2005, Congressman Gordon and I hosted a roundtable discussion to examine the offshoring trend. At that time, we learned from our witnesses that it is difficult to determine how many jobs we have actually lost because of a lack of sufficient and accurate information on the problem. However, while the overall effect of offshoring jobs in our economy is still uncertain, it has become clear that it is hurt-ing American workers. What is good for America's global corporations no longer necessarily means good-paying jobs for American workers.

Today, we are focusing on high prestige universities building campuses and expanding their programs overseas. I have major concerns with this direction and the effect this will have on our students, U.S. competitiveness and our economy today and in the future. I want to be sure that we continue to make the maximum effort to recruit and retain American students in the math and science fields.

Yesterday, the *Chicago Tribune* ran an article, "As wages fall, workers slip from middle class." The article talks about a woman who realized her $30-an-hour assembly line manufacturer job was not going to be around forever. She took the necessary steps to prevent financial devastation and completed a Bachelor's degree before the plant closed. Even with a four-year Bachelor degree, she is currently making far less than before, a plight that has reached highly skilled technology workers as well.

Mr. Chairman, I look forward to hearing from our witnesses on how these actions will impact America's competitiveness and, more importantly, what steps the universities are taking to strengthen the U.S. STEM curriculum to ensure American students remain competitive in these areas.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF REPRESENTATIVE EDDIE BERNICE JOHNSON

Thank you, Mr. Chairman.

In October 2005, this committee held a hearing on out-sourcing of technology jobs in the United States.

During that hearing, Norm Augustine, principal author of the *Rising Above the Gathering Storm* report, stated that,

> "Eight different studies conducted in recent decades indicate that public investments in science and technology have produced societal returns that range from 20 to 67 percent per year.
>
> Various other studies have concluded that between 50 and 85 percent of the Nation's growth in GDP per capita during the last half-century can be attributed to science and engineering progress."

Multiple indicators tell us our nation is falling behind, when it comes to world competitiveness in science, technology, engineering and math.

Congress and the President must support universities, industry and the public education system to remain competitive.

I am interested to know how globalization affects America's universities.

Today's witnesses will provide an important perspective on how universities are responding to the growing pressure and also how they have addressed the growing influx of international students on campus.

Thank you, Mr. Chairman. I yield back.

Mr. BAIRD. So again, I am very delighted by this extremely distinguished and accomplished panel of experts here to enlighten us.

Dr. David Skorton is President of Cornell University. Dr. Gary Schuster is Provost and Vice President for Academic Affairs at the Georgia Institute of Technology. Mr. Mark Wessel is Dean of the Heinz School of Public Policy at Carnegie Mellon University. Dr. Philip Altbach is Monan Professor of Higher Education and Director of the Center for International Higher Education at Boston College.

Thank you gentlemen very much for being here. As we discussed, the custom of the Committee is to allow five minutes of testimony, far too brief for something this important, but that will be followed by a very good give-and-take. There is a small box on your table there that illustrates when your time is running low, and as my dear friend Dr. Ehlers used to say, if we pass much past five minutes, a trap door emerges and you disappear—something you wish you had in your faculty meetings, I am sure.

Please, we will begin with Dr. Skorton, and thank you all for being here.

STATEMENT OF DR. DAVID J. SKORTON, PRESIDENT, CORNELL UNIVERSITY

Dr. SKORTON. Good morning Chairman Baird, Ranking Member Hall, and Members of the Committee. My name is David Skorton. I am President of Cornell University. I want to start, Mr. Hall, by saying that Cornell does not have a position on Texas history at the Alamo.

Cornell is located in Ithaca, New York, with campuses or programs in New York City; Geneva, New York; Appledore Island, Maine; Arecibo, Puerto Rico; France; England; Italy; Singapore; China; Tanzania; Qatar; and 45 other countries as Cornell Abroad destinations. It is not only the largest and most comprehensive school in the Ivy League, it is also the Land Grant university for New York State.

Our enrollment is approximately 20,000, with students from every state, and more than 3,000 students from 120 other countries, studying under an internationally renowned faculty. We are one of the most international of American universities.

I thank you for having the hearing, and for inviting me to share one university's perspective on the globalization of research, development, and innovation. You have asked us to address three questions, the first regarding our motivations and decision factors in establishing overseas branch campuses. The second, how our internationalization impacts the global research enterprise, and the third, how we prepare our students to compete in a globalized marketplace.

The most important message, though, that I want to emphasize today, is the enormous role higher education plays and can play in intercultural exchange, and thereby, in American diplomacy. I firmly believe that international education, research, and capacity building are among our country's most effective diplomatic assets.

I have answered each of the Committee's questions in detail in my written statement and two appendices, but will summarize the key points for you now.

First, the Weill Cornell Medical College in Doha, Qatar, is the first American medical school to offer an M.D. overseas. In 2001, we were invited to establish this campus by the government of Qatar through the Qatar Foundation for Education, Science, and Community Development in Education City, which also houses campuses of Virginia Commonwealth University, Georgetown University, Texas A&M University, and Carnegie Mellon University.

As with all of our long-term academic alliances with international entities, we ask ourselves two key questions: one, what makes the relationship worth pursuing; and two, what will make the relationship work? The guiding principle is always twofold. The benefits must be compelling, and the risks must be manageable, and we have made public in the appendix to my comments the exact checksheet that we have used in negotiating and considering other branch campus or joint degree activities.

Cornell saw the Qatar Foundation's invitation as an opportunity for students from the Middle East to obtain a quality medical education in their own region to improve the quality of health care in that region. In addition, we saw an unprecedented opportunity for our faculty to teach and understand another culture, and to broaden their research to investigate the unique medical problems of the region.

The Qatar Foundation assumes all the expenses of the building, operating the school, and we estimate that to be $750 million over the first decade of operation. We are looking forward to awarding the first medical degrees in Doha in the spring of 2008, and we will be carefully monitoring the success of the degree candidates on standardized tests, and on employment placements as two measures to gauge the rigor of the program.

The second question. It is not clear what the effect of our branch campuses will be on the global science and technology enterprise, as Mr. Hall mentioned. It is still too early and there are too many variables, but while globalization may be a new concept in the public rhetoric, Cornell and these schools have a long history of internationalization, in our case, going back to our first international students in 1868, and now involving all of our colleges and professional schools, and nearly every program on campus.

Based on this long experience, we know that any cooperation across borders can play an important role in promoting cross-cultural understanding, and that real and substantial benefits accrue to the U.S. and to the process of innovation, the driver of our global economic competitiveness.

The third question. Much of what we do as a university is, of course, aimed at ensuring the success of our graduates. In this regard, we are responding to the demands of our students in STEM fields for instruction in critical needs languages, such as Arabic, Mandarin, Russian, Hindi, and Farsi, which are among the more than 40 languages taught at Cornell.

We encourage students to study abroad, and we have created internationally focused undergraduate programs, such as a new major in China and Asia-Pacific studies, which is designed to train leaders equipped to negotiate the delicate complexities of U.S.-China operations.

Just as important as sending students overseas, Cornell welcomes thousands of international students each year. These students contribute to the diversity of the campus, to the community, and to education of all students. Our international graduates who stay in this country, especially in science and engineering fields, help fill a crying need for scientific and technical talent not currently being filled by American students.

Those who return home often maintain contact with Cornell or other American colleagues, laying the foundation for continuing collaboration. In addition, our many international collaborations help prepare Cornell students for a place in the global economy, by addressing problems and issues in which both societies have a stake.

I want to make the Committee aware that in keeping with the conversation with India's Prime Minister in January, Cornell will be working with other U.S. universities and Indian counterpart institutions to create a faculty-led Indo-U.S. Working Group to develop joint research agendas on critical challenges of interest to both nations.

In concluding my remarks, I want you to consider, please, the concept of universities as the catalyst for capacity building in the developing world. The initiatives aimed at strengthening competitiveness and education in STEM disciplines, both from this committee's leadership and from the Administration, are pointing us, as a nation, in the right direction, but just as you are right to be concerned about the U.S. losing ground potentially to China and India, we must also be concerned about the socioeconomic inequalities that threaten our country and our world.

Universities are perfectly positioned to play a central role, like the Marshall Plan did 60 years ago in Europe. Through aid and joint planning, the Nation's great research universities, working with governments, the private sector, NGOs, and our colleagues overseas, can offer a more focused application of our own resources to improve the quality of life here and abroad.

Chairman Baird, thank you again for inviting me to participate. I am pleased to answer any questions the Committee may have.

[The prepared statement of Dr. Skorton follows:]

PREPARED STATEMENT OF DAVID J. SKORTON

Good morning Chairman Baird, Ranking Member Hall, Members of the Committee. My name is David Skorton. I am the President of Cornell University. Cornell University, located in Ithaca, N.Y., with campuses or programs in New York City, Geneva, NY, Appledore Island, ME, Arecibo, PR, France, England, Italy, Singapore, China, Tanzania, Qatar and elsewhere, is the largest and most comprehensive school in the Ivy League and is the land-grant university of the State of New York. Founded in 1865, it is composed of 10 privately endowed and four State contract colleges, including seven undergraduate colleges and seven graduate and professional units. Our four contract colleges are units of the State University of New York (SUNY). Enrollment is approximately 20,000, with students from every state and more than 120 countries studying under an internationally renowned faculty. Forty Nobel Prize winners have been affiliated with Cornell University as alumni or faculty members, and three Nobel laureates currently are on the faculty, in chemistry and physics.

Cornell is among the top 10 research universities in the Nation, based on research expenditures. It is home to four national research centers, in physics, astronomy, and nanotechnology. In addition, it has many interdisciplinary research centers, covering advanced materials, manufacturing, agriculture, astronomy and atmospheric science, biotechnology, electronics, environment, computing and mathematics. Cornell also boasts the Nation's first colleges devoted to hotel administration, industrial and labor relations, and veterinary medicine. The university's Weill Cornell Medical College in New York City is a pioneer in biomedical technology, with special-treatment and research facilities including the Center for Reproductive Medicine, the AIDS Care Center, the Hypertension Center, the Institute of Genetic Medicine, and the Burn Center.

Thank you for inviting me to share one university's perspective on the globalization of research, development, and innovation. I commend the Members of the Science and Technology Committee for your continuing interest in this important and timely issue. This committee, along with your Senate counterparts, directed the National Academies to produce the *Rising Above the Gathering Storm* report. I am proud of Cornell's contributions to that effort—our Vice Provost for Research, Dr. Robert Richardson, was a member of the Committee that produced the report.

In many ways, that document provided a wake-up call for policy-makers by compiling a lot of the things we already knew about American competitiveness in one place, and, more importantly, by making a series of recommendations for actions we must take to maintain our position as a world leader in technology, research, and innovation. In the area of higher education, the *Gathering Storm* focused on things we can do at home: increasing federal funding for basic research; providing undergraduate scholarships and graduate fellowships for science, math, and engineering students; and rationalizing the immigration process for international students, faculty, scientists, engineers, and researchers who study and work in U.S. universities and industry.

The Science and Technology Committee has gone a long way toward implementing those recommendations, and I thank you for your efforts. I am also grateful that the *Gathering Storm* is just the starting point of your inquiry into globalization.

By calling this hearing, you recognize that it is not just what we do at home that matters; it is what we are doing in the rest of the world that will ultimately determine whether we succeed in the twenty-first century.

COMMITTEE QUESTIONS

The Committee has asked me to address three questions:

1. What was the general motivation for your institution to establish branch campuses overseas? What factors did you consider in making the decision to expand overseas, especially in terms of locations, costs, staffing, and the impact on the home campus?
2. What do you anticipate the effects of these overseas branch campus programs will be on the overall global science and technology enterprise, especially in terms of jobs available to your home and branch campus graduates? What sorts of data and information are you collecting to determine if the effects are matching your original goals?
3. How are you adjusting your home campus science and engineering to better respond to the increasingly globalized economy?

I will address the first question, as it relates to Cornell's branch campus in Education City, Doha, Qatar, later in my testimony.

Regarding the second question, let me say that it is not yet clear what the effects of branch campuses will be on the global science and technology enterprise. The opportunity to expand the pool of knowledge for interactions, collaborations, and the exchange of ideas will benefit all nations. The specific outcomes will depend on several factors beyond the purview of higher education including the regulatory environment, the political environment, the economic climate supported by the host country and foreign investment, as well as our ability to attract and retain American students in STEM fields. Our past experience, though, indicates that institution-to-institution cooperation can play an important positive role in promoting cross-cultural understanding and that real and substantial benefits accrue to the U.S., to our institutions, to our students, staff and faculty, and to the process of innovation, which is the driver of our economic competitiveness in a globalized world. Data will be gathered concerning performance on standardized examinations and employment outcomes of students in the branch campus programs.

Regarding question three, concerning adjustments we are making on our own campus to the challenges of globalization, we are responding to the increasing demands of our students for language instruction, including in the critical need languages of Arabic, Mandarin, Russian, Hindi, and Farsi. We are encouraging students to pursue study abroad, and we have created new undergraduate programs, such as our undergraduate major in China and Asia-Pacific Studies, which is designed to train future leaders who are equipped to address the inevitable challenges and negotiate the delicate complexities in U.S.–China relations. Our faculty are encouraged to undertake collaborative research and engage in joint teaching ventures. We consider it imperative that both our students and faculty learn to understand world cultures as well as business practices and norms.

GENERAL COMMENTS ON INTERNATIONAL COLLABORATIONS

Before I elaborate on the questions posed by the Committee about Cornell's international programs, I would like to emphasize that the issue of globalization for universities is much broader than whether and in what form we export our students, educational programs, and research enterprise. Science and engineering are already international and have been to an increasing extent for decades. University scientists and engineers collaborate with colleagues from throughout the world. Specialized "big science" facilities like CERN in Switzerland and Cornell's High Energy Synchrotron Source attract an international cadre of researchers. International scientific and professional meetings provide opportunities for scholarly exchange and networking. All these enterprises help advance knowledge and provide learning opportunities for American students and faculty members as well as for their colleagues from other nations.

International collaborations also provide unique research opportunities for American faculty in fields from population genetics to economics, sociology and global health, and they can provide unique resources, such as genetic material that can be useful in breeding more stress-resistant, flavorful or productive crops. They can also address problems and issues in which the U.S. and international collaborators both have a stake. For example, in keeping with a conversation with India's Prime Minister Singh in January of this year, Cornell will work with other U.S. universities and Indian counterpart institutions to create a faculty-led Indo-U.S. working group to develop joint research agendas on critical challenges of mutual or complementary interest to the two nations.

One of the greatest contributions that research and land grant universities have made over time is the development of human capacity through the dissemination of our research, teaching, and outreach. I understand that the Science and Technology Committee does not have jurisdiction over foreign affairs or international aid programs, but I do not think we can talk about what universities are doing overseas without considering our capacity to address global inequalities.

I firmly believe that the enhancement of human capacity relies on and ensures political stability, security, robust public health, and effective education, which, in turn, lead to inquiry, discovery, and innovation in places where they are most needed. Since the Industrial Revolution, and increasingly in the last half century, innovation has led to enormous economic growth; the foundation of innovation is research; and the seat of fundamental research is the university. The university is also the seat of undergraduate, graduate, and professional education—education that leads to new generations of those who inquire, who discover, who innovate.

For the U.S. to retain its strength in science and technology and its leadership in the global economy and to contribute meaningfully to the solution of the world's problems, we must attract the best and brightest students, staff and faculty members to our universities and to our business and industry irrespective of their national origins; we must instill an international perspective in all our students; and we must collaborate with others internationally as never before—for their benefit and ours and for inter-cultural understanding. I firmly believe that international education and research are among our country's most effective diplomatic assets.

The Science Committee has jurisdiction over the programs that fund the research that can be deployed by universities, through their international programs, and by governments, NGOs and others, to raise living standards, improve health, provide economic opportunities, and promote peace in the poorest nations in the world. I believe we can draw on a lesson from our nation's history. Just as Secretary of State George Marshall proposed a massive program of aid and redevelopment for a war-ravaged Europe, I am calling for a new national approach, with university teaching, research, and outreach at its center, to address the socioeconomic inequalities that threaten our nation and the world and to spur economic growth through innovation and capacity building as the Marshall Plan did 60 years ago through aid and joint planning.

CORNELL'S APPROACH TO GLOBALIZATION

While "globalization" is a relatively new concept, Cornell, like many American universities, has a long international history. Ours dates back to our founding, when five international students enrolled in the first class in 1868. Since then, Cornell has educated thousands of international students. Currently we enroll more than 3,000 international students from 120 countries on campus. We rank thirteenth among the top 25 leading host institutions for international students in the U.S., even though our total enrollment is much lower than many of the other institutions on that list.

Whether these students return to their home countries or stay in the U.S. to work or continue their studies, they contribute to America's strength. Those that stay in this country, especially in the sciences and engineering fields, help fill a real need for scientific and technical talent within universities and in industry. Those who return to their home countries often maintain contact with their former professors and students in their academic programs, laying the foundation for continuing collaboration and admissions referrals to our graduate programs.

While enrolled at Cornell, international students contribute to the diversity of the campus community and contribute positively to the education of all students. This helps broaden the US students' knowledge and understanding of world cultures, which they will need as they enter the marketplace and seek jobs in our international economy.

Today Cornell's international programs involve all of our colleges and professional schools and nearly every program on campus. Most visibly—and perhaps of greatest interest to the Committee—we opened a branch campus of our medical school in Doha, Qatar in 2001. We offer a joint degree program in Singapore (hotel/hospitality) and dual degree programs in China (Asian studies/political science) and India (agriculture). We operate our own study abroad programs in France, Rome, Tanzania, Nepal, Berlin and Tokyo. About 500 Cornell students each year enroll in a Cornell study abroad program or at an international university, with assistance from Cornell Abroad, for a semester or a year.

In forging long-term academic alliances with foreign entities, we ask two key questions: What makes the relationship worth pursuing? What will make the relationship work? The guiding principle governing the evaluation, planning, negotiation, approval, establishment and operation of an academic alliance abroad is twofold: the benefits must be compelling and the risks must be manageable. (See Appendix A)

Our approach to globalization is essentially one of building capacity—we believe that as part of our mission we have a responsibility to carry out research on issues where new knowledge could make a difference, to extend ourselves to institutions of higher learning in other parts of the world, and to ensure access to our own system of higher education here at home. As I noted above, we do this in a number of ways:

- through our branch campus in Qatar;
- through interdisciplinary majors and joint or dual degree programs with overseas universities chosen to be of mutual benefit;
- through formal agreements with overseas universities to promote international exchanges in specific programs;
- through foreign study at Cornell centers in other countries; and through study abroad programs that focus on one student at a time.

Through organizations like Engineers for a Sustainable World, which was founded at Cornell and is now a nationwide organization, students can apply their engineering knowledge to address the needs of communities in the developing world. Many of our students have a strong interest in engaging in public service as part of their academic programs, and programs of this sort provide opportunities to learn while performing service on an international scale.

We offer instruction in more than 40 languages including the critical need languages of Arabic, Hindi, Farsi, Mandarin, and Russian. Four of our area studies programs—East Asia, South Asia, Southeast Asia, and Europe—are recognized as National Resource Centers by the U.S. Department of Education. This designation signifies the breadth and excellence that these programs maintain in areas critical to U.S. national interests. Supported in part by federal funds, the programs directly promote the teaching of languages and also make their expertise available to the regional community by presenting films; organizing lectures, seminars, and workshops; and publishing books and working papers.

International Outreach and Collaboration

Cornell's first significant international outreach project—the Cornell-Nanking Crop Improvement Program—began in the 1920s with three Cornell plant breeders who led a team that developed new strains of higher yielding rice, wheat, and other staple crops. Its most important legacy was the development of a generation of Chinese plant breeders who could carry on the work in China once Cornell's formal involvement ended. You may have read about the project—Pearl S. Buck, M.A. '25, accompanied her husband John, an agricultural economist, to Nanking and wrote about her experiences in *The Good Earth.*

Today we have well over 150 agreements for programs in more than 50 countries that run the gamut of arts and sciences, engineering, the professions, agriculture, and labor relations. Our peers offer many of the same types of international programs as we do, but Cornell is among the leaders in the scale and scope of its international efforts.

Research and extension carried out abroad can provide valuable assistance to the host country while frequently also creating knowledge that can be applied to problems in the U.S. In the case of agricultural research, for example, cooperation with agricultural scientists abroad creates opportunities to share germ plasm that can be used to enhance pest resistance, flavor, drought or cold resistance, productivity and other characteristics that can increase the value of U.S. crops. To improve apples, for example, genetic diversity is critical for such important traits as insect resistance and fruit quality. Toward this end, researchers from the Cornell University-based Plant Genetic Resources Unit at Geneva, New York have organized and led expeditions to Kazakhstan's wild apple groves since 1989, and now maintain a living library of apple species that is used by researchers at the Experiment Station and worldwide.

Our work in India goes back more than 50 years, and with the formation of the new Indo-U.S. working group I mentioned earlier, we see potential for addressing issues and research areas that will benefit both nations. Similarly, we need the capabilities of other universities to address such world problems as global climate change, alternative energy, AIDS/HIV and other global health issues.

In engineering and other high technology fields, a strong presence internationally helps us attract the very best students in the world to study in the U.S. While some of these students will return to their home countries, others will find employment with U.S. companies, contributing to the ability of those companies to innovate. This will be increasingly important to U.S. companies as the current "baby boom" generation of scientists and engineers nears retirement age.

Yet, even now, fewer of the best students from Asia are coming to the U.S. to study. We will not have the workforce to conduct necessary research that leads to innovation and prosperity without international students. We will also have a hard time replacing the current generation of faculty members at our universities and scientists and engineers in our industries without international students. We must continue these international collaborations and exchanges as we build our capacity as well as capacity overseas.

The Committee's questions suggest that in creating international collaborations and partnerships, we are giving something away. Let me stress again, as strongly as I can, that the benefits of these collaborations accrue to the U.S. at least as much as to our partners abroad. A new national plan to build capacity at home and abroad is, in my view, essential to establishing strong and economically vibrant nations and to ensuring world peace.

EXAMPLES OF INTERNATIONAL PARTNERSHIPS

The following examples of Cornell international programs are illustrative of the types of our overseas initiatives. It would be impractical for me to list every one of our international programs in my written statement—the Mario Einaudi Center for International Studies, which has coordinated Cornell's international programs since 1961, has compiled an exhaustive list of our international centers, programs, and initiatives in its 121-page annual report. I am providing a copy of this report for the hearing record. Interested readers can read or download the annual report at *http://www.einaudi.cornell.edu/initiatives/ar.asp*

Branch Campus—Weill Cornell Medical College-Qatar

Weill Cornell Medical College in Qatar (WCMC–Q) is the first American medical school to offer its degree overseas; it is also the first coeducational institution of higher education in Qatar. It is one of five American universities to be represented in Education City, Doha, Qatar. The others are Carnegie Mellon University, Virginia Commonwealth University, Texas A&M University, and Georgetown University.

Cornell was invited to open our medical school by the government of Qatar through the Qatar Foundation for Education, Science and Community Development. The school was established in April 2001 as a partnership between Cornell and the Qatar Foundation. The Qatar Foundation is a private, non-profit organization set up in 1995 by Sheikh Hamad Bin Khalifa Al-Thani, Emir of the State of Qatar, and headed by his wife, Sheikha Mouza Bint Nasser Al-Misnad. The Foundation assumed all the expenses of construction, operation, and maintenance of the campus. Those costs are estimated to be $750 million over ten years.

Cornell saw this invitation to establish a new medical school in Qatar as an opportunity to provide medical education in an important region of the world and thereby become part of the developing trend in medical education, which takes advantage of modern communication and transportation, and enhances Cornell's reputation as an international university. The new school provides an opportunity for students from the Middle East to obtain a quality medical degree in their home region of the world and improve the quality of health care in the region. It provides opportunities for our faculty to experience the challenges of teaching in another culture and to investigate the unique medical problems of the region through research in population genetics and other fields. Just recently Qatar announced that they would devote 2.8 percent of the country's gross domestic product to research. It is also a potential source of international patient referral to our medical center in New York City.

Cornell has full authority and discretion to select and supervise the academic and administrative staff; admit, enroll and instruct students Cornell deems qualified; establish manageable personnel appointment and student enrollment benchmarks and time lines; ensure equal opportunity and non-discrimination anchored in U.S. and New York State law to students, faculty and staff; and prescribe plans and set standards governing the operation of the pre-medical and medical programs of Cornell caliber and quality.

Pre-medical faculty hold appointments at Cornell University; medical faculty are members of academic departments at Weill Cornell Medical College. The pre-medical program is a non-degree set of courses in the sciences basic to medicine, with seminars in writing and medical ethics. The medical program, which replicates the curriculum taught at Weill Cornell in New York City, features a variety of learning experiences, including problem-based learning, case-based conferences, journal clubs, lab work, and lectures.

The pre-medical program began in 2002, with 25 students enrolled. The medical program matriculated its first class of 16 students in 2004. By 2006, the pre-medical program had matriculated 46 first-year students, while the medical program had matriculated 26 first-year students. We are looking forward to awarding the first medical degrees in Qatar in the spring of 2008, and we will be monitoring the success of the degree candidates as a way to gauge the rigor of the program. We are hoping that many of these students will stay in the Middle East, which desperately needs more qualified physicians.

More information about Cornell's branch campus in Qatar and the medical education program at WMCC–Q is available at *http://www.qatar-med.cornell.edu/* and in Appendix B.

Joint Programs

- **Singapore.** The Master of Management in Hospitality Program is a joint degree program. This year long, three-semester program can be taken either completely in Ithaca or by spending six months in Ithaca and six months at the Nanyang Institute of Hospitality Management at Nanyang Technological University in Singapore.
- **India.** The Agriculture in Developing Nations Course is a joint Cornell-India distance education course. Students in the course, from Cornell and from three Indian universities, listen to the same lectures. The Indian students come to Cornell at the end of the fall semester for a two-week tour of agriculture/agribusiness facilities on the Cornell campus in Ithaca and at Cornell's New York State Agriculture Experiment Station in Geneva, and elsewhere in the Central New York area. In January, Cornell students in the course join their counterparts in India for tours of Indian agricultural and agribusiness sites and prepare team projects. The College of Agriculture and Life Sciences has offered this course for 30 years, to prepare students to work in a global economy. A complementary (and older) version of the course focuses on agriculture in South and Central America.
- **Tanzania.** The Weill Bugando University College of Health Sciences and the Weill Bugando Medical Center in Mwanza, Tanzania have formal affiliations with Weill Cornell Medical College. Through this affiliation, Weill Cornell Medical College students and faculty gain valuable international clinical and research experience. This program helps address the immediate health needs of people in Tanzania and train more physicians for a country that currently has only one doctor for 25,000 people compared to one per 400 people in the U.S.

Scholarly Exchange Programs

- **China.** The Tsinghua University-Cornell College of Engineering Partnership is a scholarly exchange program, primarily involving faculty, in areas where both institutions have knowledge to share. Building on many years of informal faculty and graduate student exchanges, Cornell and Tsinghua University signed a formal exchange agreement in 2004. My predecessor, Hunter Rawlings opened the first Tsinghua-Cornell workshop, which focused on information science and computer engineering, in Beijing in November 2005. A group from Tsinghua came to Cornell the following spring (2006) for sessions on nanotechnology. Faculty from the Cornell Center for the Environment went to Tsinghua in June 2006 to share perspectives on environmental research. This year Tsinghua will send some 30 faculty members to Cornell for sessions on energy, environmental quality and global climate change. We have a similar agreement for research collaboration and scholarly exchange with Jiao Tong University in Shanghai.
- **Developing Nations.** The Cornell International Institute for Food, Agriculture, and Development (CIIFAD) is an international extension and outreach program that pairs faculty and students from Cornell's College of Agriculture and Life Sciences with partners in Africa, Asia and Latin America. The CIIFAD program initiates and supports innovative programs that contribute to improved prospects for global food security, sustainable rural development, and environmental conservation around the world. Many of these programs seem to increase food security in developing countries by linking scientists and farmers in Asia, Africa, and South America with agricultural

researchers in advanced labs in developed countries. CIIFAD, for example, help promotes a system of rice intensification to increase the productivity of irrigated rice by changing the management of plants, soil, water and nutrients. The system, which can double yields while requiring only half as much water, is now being tried in nearly 40 countries around the world.

- **United Nations University Food and Nutrition Programme for Human and Social Development (UNU–FNP).** The UNU–FNP, created to address issues of world hunger, has been housed at Cornell University since June 1996. It has developed networks of scholars and universities which include nutritional scientists, food scientists, agronomists, biochemists, biostatisticians, epidemiologists, economists, sociologists, and others, to assist in the application of nutrition knowledge to combat hunger and address global nutrition issues. Cornell works jointly with Wageningen University, the Netherlands and Tufts University, to administer the UNU–FNP.
- **France.** Cornell University Center for Documentation on American Law in Paris is a scholarly partnership with the French court system. The center, which opened two weeks ago on July 16, is located within the court in the Palais de Justice. It houses 13,000 law books from Cornell's Law Library and offers special training and instruction in online research by Cornell law librarians. This new partnership supplements Cornell Law School's current relationships in France, including its 14-year joint venture with the University of Paris 1 (Panthéon-Sorbonne), the Summer Institute of International and Comparative Law in Paris, and a four-year American/French law degree program.

Undergraduate Majors

- **China-Asia Pacific Studies.** The China and Asia-Pacific Studies Program is an interdisciplinary, international undergraduate major for Cornell students. The CAPS program combines intensive study of Mandarin, Chinese history, culture and foreign policy with study and work/internship experiences in Washington, D.C. and at Peking University in Beijing. It is designed to equip students for leadership roles in a variety of fields including business, government service, diplomacy, education and journalism. A maximum of 20 students are admitted as CAPS majors each year.

Cornell International Facilities

- **Italy.** The Cornell in Rome Program is an educational program for Cornell students based at a Cornell facility. For 20 years, Cornell's College of Architecture, Art and Planning has offered students an opportunity to study in Rome with a home base at a Cornell facility. The curriculum for the Rome Program includes art and architecture studios, core courses in planning, art and architectural history, theory and criticism, photography, drawing, Italian language and culture, and cinema. On average about 55 students participate each semester.

Study Abroad

- The Cornell Abroad program offers Cornell undergraduate students a way to spend a semester or an academic year abroad as an integral part of the undergraduate experience. Study abroad programs are largely tailored to individual students' needs, and may be run directly by Cornell, by other American colleges and universities, by free-standing study abroad agencies, or directly by programs that have been developed to meet the special academic interests of Cornell students. Every year, approximately 500 Cornell students participate in this program, studying in 45 countries around the world.

CONCLUSIONS AND RECOMMENDATIONS

As I conclude my remarks, I would like to go back to the concept of universities as the catalyst for a new approach to capacity building in the developing world. Much of the work and resources must come from governments through traditional vehicles, such as the U.S. Agency for International Development, as well as promising new approaches such as the Millennium Challenge Corporation and others. The initiatives aimed at strengthening competitiveness and STEM education, both from this committee and the administration, are pointing us as a nation in the right direction. However, universities must play a central role—through capacity building based on comprehensive programs of teaching, research and outreach—to assist countries struggling to meet the needs of their citizens.

Indeed, the development of human capacity is the basis for the most robust strategies for ameliorating global inequalities and is one of the most significant contributions that our great universities make. No single university, acting alone, can achieve what will be needed in tomorrow's world. Together, however, the Nation's great research universities—public and private, land grant and Ivy league—working with our government, the private sector, NGOs and, most critically, our colleagues overseas—can offer a more focused application of our own resources to reach out, materially and directly, to assist and improve the quality of life elsewhere.

Chairman Baird, thank you again for inviting me to testify at this hearing. I would be pleased to answer any questions the Committee may have.

APPENDIX A

FORGING LONG-TERM ACADEMIC ALLIANCES WITH FOREIGN ENTITIES

James J. Mingle
University Counsel and Secretary of the Corporation
Cornell University

Key questions:

1. What makes the relationship worth pursuing?
2. What will make the relationship work?

Main features of proposed program:

- degree granting program?
- major research collaboration?
- both?
- U.S. university degree?
- dual degrees by U.S. and foreign universities?
- joint degree?
- long-term or
- short-term relationship?

Guiding principle governing the evaluation, planning, negotiation, approval, establishment and operation of an academic alliance abroad:

1. the benefits must be compelling, and
2. the risks must be manageable

Three-phased approach:

I. exploratory phase

II. due diligence and planning phase

III. decision and contract formation phase

I. EXPLORATORY PHASE

- identify potential benefits
- check with other U.S. universities who have programs in the foreign country (or considered, but declined)
- gauge university's negotiating leverage
- visit the foreign venue and meet the potential partners
- determine the principal players: who will commit financial resources to the project, and who will contract on the foreign entity's behalf:
  - the government?
  - governmental agency?
  - a university?
  - private organization, foundation?
  - combination of these entities?
- take stock whether "distance," "climate" or different "culture, customs" are positives or possible impediments
- deal with the "deal breakers" upfront—threshold conditions, commitments before launching the due diligence phase:
  - ownership of capital assets?
  - academic freedom and non-discrimination?
  - nature of degree (sole, joint or dual)?
  - academic autonomy (standards, curriculum, admissions)?
  - operational control (complete or shared)?
  - financial resources? management fee?
  - accrediting and licensing implications?

  - legal relationship (subsidiary corp'n, management contract)?
  - use of university name?
  - governance arrangement? joint advisory board?
  - term and exit strategies?
  - other?
- settle on planning costs (who pays?) and due diligence timetable
- craft, sign "fundamental principles" letter
- brief president, board and faculty leadership

II. DUE DILIGENCE AND PLANNING PHASE

- map things out:
  - drawing from "fundamental principles" letter, outline key "academic," "business/finance," and "legal/risk" issues
  - form internal project team and assign areas of inquiry; designate chair
  - engage external consultants as needed (e.g., business, legal, security, architects)
  - enlist a few board members as advisory group
- anticipate and address "daunting" aspects of project:
  - attracting ample pool of prospective students
  - developing or adapting curriculum
  - faculty and administrative recruiting, staffing
  - dilution of home campus management time/energy
  - dealing with distance, climate, different cultures
  - immigration, local sponsorship issues
- probe, protect against "main risks":
  - reputational risk
    - academic control?
    - governance oversight?
  - financial risk
    - no real property ownership?
    - operational costs covered?
    - tax exempt status?
    - legal safeguards?
    - exit strategies?
  - geopolitical risk
    - dependability of partner?
    - education a priority?
    - hospitable, stable environment?
- develop budget, business plan for full term of relationship
- brief governing board and invite suggestions
- negotiate detailed "term sheet" with foreign partner, confirming all key "academic," "business/financial," and "legal/risk" elements
- is project team convinced concerning "compelling benefits" and "manageable risks"? Is university leadership on-board?

III. DECISION AND CONTRACT PHASE

- review, approval of appropriate faculty governance groups
  - school/college faculty?
  - university faculty senate?
  - both?
- review, approval of university governing board
  - standing committee?
  - executive committee?

  - full board?
- craft comprehensive contract covering all points in “term sheet”, plus specific legal safeguards:
  - letters of credit
  - indemnification and insurance
  - early termination for “cause” or “emergency”
  - disengagement costs
  - monetary damages limitations
  - internal dispute resolution and international arbitration
  - U.S. law controls
  - intellectual property ownership
  - local (foreign venue) “liaison office”
- contract signing and press releases
- appoint program director
  - program implementation

APPENDIX B

The Weill Cornell Medical College in Qatar

Rationale

- Cornell presence in an important part of the world
- Increase quality of education and health care in the regionAn inn
- Innovative and pioneering project
- A first for an American university
- Research opportunities
- Unique partnership with the Qatar Foundation
- Potential source of international patient referral to NYC

Governance and Operational Control

Governance

- The Dean of the Weill Cornell Medical College in Qatar (WCMC–Q) reports to the Dean/Provost of Weill Cornell Medical College (WCMC) and through him to the President of Cornell University (CU), WCMC Board of Overseers and CU Board of Trustees.
- The Cornell Boards of Overseers and Trustees are responsible and provide oversight for the operation of the academic programs. Cornell University has final authority on all budgets.
- The Qatar Foundation (QF) provides and is responsible for oversight of the facilities.
- To advise and assist the parties and the Dean of WCMC–Q, a Joint Advisory Board has been established with four members selected by the Cornell Boards and four by the QF. An additional three independent members are selected jointly.
- The Joint Advisory Board meets twice annually. The first meeting was held on December 9, 2001 in London. Currently the Board is co-chaired by Dean Gotto and H.H. Ghalia Bint Mohammed Al-Thani, M.D., Chairperson of the Board of Directors of the National Health Authority of Qatar.

Operational Control

Cornell has full authority and discretion to:

- Select and supervise academic and administrative staff.
- Admit, enroll and instruct students Cornell deems qualified.
- Establish manageable personnel appointment and student enrollment benchmarks and timelines.
- Ensure equal opportunity and non-discrimination anchored in U.S. and New York State law to students, faculty, and staff.
- Prescribe plans and set standards governing the operation of the pre-medical and medical programs of Cornell caliber and quality.

Curriculum, Academic Freedom and Non-Discrimination

Corneli has autonomy in:

- Developing and adapting a suitable curriculum that is comparable in quality and structure to the program in New York.
- Applying principles of academic freedom that animate classroom teaching and research.
- Establishing a program of study that will be co-educational.

Academic Credits and M.D. Degree

- Transferable credits for two-year Pre-medical Program.
- M.D. degree will be granted by Cornell University upon completion of four-year Medical Program.

Key Academic and Business Provisions

Implementation Timetable

- Academic Bridge Program[1] 2001–2002
- Pre-medical Program 2002–2004
- Medical Program 2004–2008

Program History

- Pre-medical program initiated on schedule in September 2002 in temporary facilities.
- Program moved to permanent facilities during Summer 2003 in time for start of second year of Pre-medical program in September 2003.
- New building dedicated October 2003.
- Medical program initiated in September 2004.
- First medical class will graduate May 2008.

Faculty Appointments

- Review of credentials and appointment of faculty to WCMC–Q by CU faculty in accordance with CU policies and by WCMC faculty in accordance with Medical College policies.

Students Per Class

- Capacity exists for 60 students in each of the Pre-medical classes, and for 50 students in each of the Medical classes.
- A higher number may be admitted to the Pre-medical Program, assuming a sufficient number of qualified applicants.
- Pre-medical Program First Year Matriculated Students:
    - 2002—25 students
    - 2003—31 students
    - 2004—48 students
    - 2005—58 students (inclusive of 5 students repeating the first year program)
    - 2006—46 students
- Medical Program First Year Matriculated Students:
    - 2004—16 students
    - 2005—18 students
    - 2006—26 students

Qatari Admissions Priority

- WCMC–Q will admit to its Pre-medical and Medical programs classes that reflect at least 70 percent representation by Qatari citizens, assuming a sufficient number of qualified applicants. Current student body composition reflects approximately 17–18 percent Qatari students.
- Students who successfully complete the pre-medical program have priority for admission to the medical program.

Admissions

- WCMC admission standards apply, including principles of need-blind admissions and non-discrimination.
- WCMC–Q recommends candidate students to the WCMC Admissions Committee for admission to the Medical program.

Teaching Facilities

- Basic Sciences (pre-medical and medical)
    - New building was erected in Education City by the Qatar Foundation and was completed July 2003.
    - Approximately 400,000 sq. feet built to Cornell specifications.
    - The WCMC–Q building was officially opened October 12, 2003.
- Clinical Sciences
    - Hamad General Hospital
    - Sidra Medical and Research Center (planned for commissioning in late 2010)
    - Primary Care Clinics (n=22)

[1] Designed by the Texas International Education Consortium

BIOGRAPHY FOR DAVID J. SKORTON

David J. Skorton became Cornell University's 12th President on July 1, 2006. He holds faculty appointments at the rank of Professor in Internal Medicine and Pediatrics at Weill Cornell Medical College in New York City and in Biomedical Engineering at the College of Engineering on Cornell's Ithaca campus. He is also Vice Chair and Chair-Elect of the Business-Higher Education Forum, an independent, non-profit organization of Fortune 500 CEOs, leaders of colleges and universities, and foundation executives.

A seasoned administrator, board-certified cardiologist, biomedical researcher, musician and advocate for the arts and humanities, President Skorton aims to make Cornell a model combination of academic distinction and public service. He has vowed, among other goals, to continue and accelerate the transformation of the undergraduate experience in order to make Cornell the finest research university and provider of undergraduate education in the world; to integrate the activities of the Weill Cornell Medical College campuses in New York City and Doha, Qatar with the activities of the university's Ithaca and Geneva campuses in order to encourage interdisciplinary collaboration; to support appropriately the arts, humanities and social sciences, as well as scientific, technical and professional disciplines; and to use the university's vast and varied resources and talents to positively impact the world. In support of these goals, he launched, in October 2006, the most ambitious fund-raising campaign in Cornell history, a $4 billion, five-year effort.

Reflecting his personal commitment to diversity, President Skorton joined with Cornell Provost Biddy Martin to establish and co-chair the University Diversity Council. He serves as a house fellow at the Carl Becker House, one of the West Campus residential houses for continuing students. He also writes a monthly column for the *Cornell Daily Sun* and a bi-monthly column for the *Cornell Alumni Magazine,* and hosts a periodic radio program, Higher Education in the Round, on WEOS–FM, a local public radio station.

Before coming to Cornell, President Skorton was President of the University of Iowa (UI) for three years, beginning in March 2003, and a faculty member at UI for 26 years. Co-founder and Co-Director of the UI Adolescent and Adult Congenital Heart Disease Clinic at the University of Iowa Hospitals and Clinics, President Skorton has focused his research on congenital heart disease in adolescents and adults, cardiac imaging, and computer image processing.

He has published over 200 articles, reviews, book chapters, and two major texts in the areas of cardiac imaging and image processing. President Skorton has been the recipient of over 30 grants for research.

A national leader in research ethics, President Skorton was charter President of the Association for the Accreditation of Human Research Protection Programs, Inc., the first entity organized specifically to accredit human research protection programs. He has served on the boards and committees of many other national organizations, including the American College of Cardiology, the American Heart Association, the American Institute of Ultrasound in Medicine, the American Society of Echocardiography, the Association of American Universities, the Council on Competitiveness, and the Korea America Friendship Society. He has traveled widely in Europe and Asia on behalf of both academic and community projects, and he engages in service to the community, and particularly in regional and State economic development, as a member of the board of directors of the Metropolitan Development Association of Syracuse and Central New York, Inc.

President Skorton earned his Bachelor's degree in psychology in 1970 and an M.D. in 1974, both from Northwestern University. He completed his medical residency and held a fellowship in cardiology at the University of California, Los Angeles.

Mr. BAIRD. Thank you, Dr. Skorton. Dr. Schuster.

STATEMENT OF DR. GARY SCHUSTER, PROVOST AND VICE PRESIDENT FOR ACADEMIC AFFAIRS, GEORGIA INSTITUTE OF TECHNOLOGY

Dr. SCHUSTER. Chairman Baird, Ranking Member Hall, Members of the House Committee on Science and Technology. I am the Provost of Georgia Institute of Technology, and I am honored to speak about Georgia Tech's overseas programs.

Georgia Tech's international activities fall under the rubric of its mission, which is to define the technological research university of the 21st Century, and educate the leaders of a technology-driven world. Recognizing that innovation increasingly happens all around the globe, we are developing mutually beneficial research and education platforms overseas, with high quality international partners, whose research and educational interests align with ours.

In selecting the locations and partners for these platforms, Georgia Tech observes a number of core principles. Platforms are chosen to provide a strategic advantage for Georgia Tech, and they have a research-driven motive, and a clear educational benefit for our own students. They operate within the parameters of the laws of the United States and Georgia, as well as the host nation. The activities must preserve the quality and integrity of Georgia Tech's reputation. Finally, we strive to operate them in a self-supporting and revenue-neutral manner, relative to our other operations.

Our oldest and largest international campus is Georgia Tech Lorraine in Metz, France, which was founded in 1990, and includes research as well as graduate and undergraduate education programs. A unique research unit between Georgia Tech Lorraine and the French National Center for Scientific Research, which is the largest and most influential research agency in Europe, allows us to collaborate with French researchers, and gives us early access to technology being developed in France. As an example, because France has a high level expertise in aspects of network security, we stand to gain from what we can learn from this partnership, to benefit the State of Georgia and the United States.

Similarly, Singapore, where Georgia Tech also has a research and education program, is more advanced in some aspects of transportation logistics than the United States is, and we can benefit from our partnership there. This program includes research and logistics funded by the Singapore government agencies, and the first Master's degree in the region in logistics and supply chain management.

In addition to the unique research opportunities provided through our foreign partnerships, our students also benefit from these relationships. As one of the Nation's top ten public universities, and its largest producer of engineers, we focus on educating graduates who understand technology in a global context. The nature of science and engineering curricula make study abroad difficult to accommodate, but our international platforms help us offer a wide array of opportunities. More than a third of our undergraduates study or work abroad. Seventeen of our undergraduate degree programs offer an international designator. This means special courses and overseas experience add a global context to their field of study, and that fact is noted on their diplomas. Our graduates are highly sought after by employers, and our alumni report that the international aspects of their education add value to their careers.

Georgia Tech also works closely with the State of Georgia in economic development, and our international programs provide a point of access for the State to develop international trade and investment relationships. For example, in 2005, the President of Lorraine and the Governor of Georgia signed a formal agreement, under which Georgia Tech Lorraine will serve as a facilitator for business to business contacts. Georgia Tech's international activities have also attracted foreign corporate research labs to Atlanta to locate adjacent to our campus.

In summary, our international platforms enable Georgia Tech to be a partner and collaborator in research discoveries happening in other parts of the world, and make our faculty and students citizens of the world.

Thank you for the opportunity to testify before the Committee. I would be happy to answer any questions.

[The prepared statement of Dr. Schuster follows:]

PREPARED STATEMENT OF GARY SCHUSTER

Chairman Gordon, Ranking Member Hall, Members of the House Committee on Science and Technology, it is an honor to be here today and have an opportunity to discuss the impact on American universities of the globalization of R&D and innovation, and the university response to it. I am provost of the Georgia Institute of Technology, and have been asked to speak to the experience of my own institution in creating and operating international campuses.

The Georgia Institute of Technology, familiarly known as Georgia Tech, is a 120-year-old technological university that is consistently ranked among the Nation's ten best public universities by *U.S. News & World Report.* The university is especially known for its engineering program, which is not only the Nation's largest, but is also ranked among its very best. Georgia Tech's selectivity is reflected in the SAT scores of its incoming freshmen, which average among the top five public universities in the Nation, and in the fact that the freshman class of 2006 contained a higher percentage of National Merit Scholars than any other public university in the United States. The quality of its faculty is demonstrated by the fact that Georgia Tech is among the Nation's top ten universities in National Academy of Engineering membership and recipients of the Presidential Early Career Awards in Science and Engineering (PECASE), and second in the Nation in recipients of National Science Foundation CAREER Awards. Among research universities with no medical school, Georgia Tech ranks among the Nation's top five in volume of research, both overall and federally funded. It is home to or partner in 20 federally funded national research centers of excellence. Recognized by numerous studies as a leader in technology transfer, Georgia Tech launches twice as many start-up companies as the norm for its volume of research and is home to the Nation's first university-based business incubator, which is also widely recognized as one of the Nation's best.

Like business and industry, research universities are faced with the challenge of competing in a new global environment. History shows us that the arts, sciences and technology have always advanced the fastest in trading centers. In an economy in which knowledge has emerged as the most valuable economic asset, universities are the knowledge trading centers. Historically viewed as ivory towers elevated above the workings of the everyday world, universities are now called upon to adapt to new roles and challenges as drivers of innovation, economic development, and prosperity in a global economy.

Georgia Tech's international activities fall under the rubric of its aspiration and mission, which is to define the technological research university of the 21st century and educate the leaders of a technologically driven world. In today's economy, this goal becomes a matter of defining a new academic paradigm that is effective in driving innovation and promoting economic well-being. How do we conduct research that generates innovation and educate our students in ways that enable our graduates to succeed and thrive in this environment? How do we as a public university of the State of Georgia serve the needs and efforts of our state and the United States to maintain and improve economic competitiveness? How do we contribute to solving seemingly intractable global problems that are critical to our well-being, from fresh water supplies to terrorism to global climate change? These are the motivating questions behind our efforts to develop a global university with a presence in strategic places around the world.

Like a number of American research universities, Georgia Tech engages in research on global problems and provides expanded opportunities and encouragement for its students to study abroad. Where Georgia Tech seeks to take a unique and more complex approach is with our international campuses. In short, we are shifting our mindset from a 20th century context focused exclusively on attracting the best talent to our home campus to a 21st century model of mutual exchange and partnership. Our goal is to build one of the world's few truly global universities.

The fundamental research that underlies innovation, which is conducted largely at research universities, thrives in an environment of openness and collaboration. Even researchers who are vying with each other to be the first to make a particular breakthrough discovery, often share information and are sometimes even collaborators. As developing nations establish world-class universities and research programs, breakthrough discoveries will occur in many locations around the world, rather than being concentrated in the United States and other developed nations. Georgia Tech's goal is to be present in those other locations—to be a partner and collaborator in discoveries that happen in other places, so that we here in the United States can leverage and benefit from the discoveries of others, just as others have and will leverage and benefit from discoveries made in the United States.

To achieve that goal, we are developing research and education platforms around the globe that are consistent with Georgia Tech's vision, mission, and strategic endeavors. In establishing these campuses, we look for a strategic advantage for Georgia Tech, a research-driven motive, and a clear educational benefit for our own students. We have been approached on numerous occasions by other nations looking primarily for a "provider" of engineering degrees to their citizens and have declined. While we believe that widespread educational opportunity is a good thing, we also recognize that there is a limit to the number of international initiatives that we as an institution can maintain, and we intend to be strategic and focused about what we undertake.

In selecting locations and developing formats for strategic international research and education platforms overseas, Georgia Tech observes a number of principles:

1. They are in the best interests of and to the benefit of Georgia Tech and our faculty and students, and they complement what we do in Atlanta.
2. They operate in accordance with the laws of the United States and the state of Georgia. This requirement is comprehensive, ranging from export controls to IRS rules, from the requirements of the *Bayh-Dole Act* to regulations regarding a drug-free workplace.
3. They operate within the laws and respect the culture of the host nation.
4. They operate in accordance with the rules governing Georgia Tech's accreditation.
5. They are consistent with Georgia Tech's charter, by-laws, policies, and academic and ethical standards. We will not sacrifice either quality or integrity.
6. They will operate in a self-supporting and revenue-neutral manner relative to our other operations. We do not undertake international activities to make money, nor do we invest any state or federal tax funds in the operation of these endeavors.

The Hearing Charter for this morning indicates that "Georgia Tech is building a campus in Andhra Pradesh, India, to offer Master's and Ph.D. programs." I assume that this statement is based on news accounts in the Indian press, and I would like to respond by noting that from Georgia Tech's perspective, the description by the Indian press of this project was somewhat premature. What we have actually agreed to is non-binding discussions that could culminate in a potential research and graduate education platform in Andhra Pradesh. However, as indicated above, we have a list of significant conditions that must be met, and we will not go forward until all of those conditions are met in Andhra Pradesh.

So, I would like to focus this discussion on the three international research and education platforms that we already have in operation: Georgia Tech Lorraine in Metz, France; Georgia Tech's program in Singapore; and Georgia Tech Ireland. Georgia Tech Lorraine is the oldest, established in 1990, and the most fully formed. It includes graduate and undergraduate education programs, research operations, and a "franchise" of Georgia Tech's business incubator. Our program in Singapore is younger and smaller, with research and graduate programs in conjunction with the National University of Singapore and Nanyang Technical University. Georgia Tech Ireland opened in June of 2006 in partnership with the Industrial Development Agency of Ireland and in collaboration with seven Irish research universities. This newest international site has begun as a research program and as yet has no educational component.

The research strengths and interests of each of these locations align well with Georgia Tech's research strengths and interests, and the primary driver for establishing these international platforms is enhanced research opportunities that provide a strategic complement to the major research thrusts on which Georgia Tech is focused. These campuses are mutually beneficial partnerships. In each case, we are there because we were invited based on our own strengths and interests. In each case, we are given indigenous support and have access to research funding from indigenous sources. In each case, we stand to gain from the research expertise represented by these locations.

For example, France has a high level of expertise in aspects of network security. Georgia Tech's campus in Metz, France, is a research partner with Centre National de la Recherche Scientifique, the French National Center for Scientific Research, which is the largest and most influential research agency in Europe. Our unique joint international research unit with CNRS is focused on secure and high-speed telecommunications and provides us with rapid access to French research and technology that would otherwise not be available to Americans. Georgia Tech Lorraine has strong research connections to the main campus in Atlanta, and we stand to gain from what we can learn there to the benefit of the state of Georgia and the United States.

Georgia Tech Lorraine is an "affiliate" of Georgia Tech rather than a branch campus. It is supported by the governments of Lorraine and Metz and has partnerships with several national research organizations, ten other European universities in France and elsewhere, and several French corporations. Its graduate enrollment approaches 175 students, and it has granted close to a thousand Master's degrees to date. The undergraduate program at Georgia Tech Lorraine began as a summer study program for our Atlanta-based students, offering engineering majors a unique opportunity to study abroad while keeping up with their curriculum. By summer of 2006, the program had more than 150 students and 14 professors teaching dozens of courses. In the fall of 2006, we began a very small year-round undergraduate program in electrical and mechanical engineering and computer science, which we hope to grow to more than 50 students by 2008.

Similarly, one of the world's premiere locations for experience and expertise in logistics is Singapore. Georgia Tech has long been recognized as the top university in the United States in systems engineering and logistics, which have become increasingly critical as the economy has grown increasingly global. However, there are aspects of logistics—transportation, for example—in which Singapore as the world's busiest port is more advanced than we are. Again, Georgia Tech's program in Singapore has a very strong research connection to the Atlanta campus, and we stand to gain from what we can learn there to the benefit of the state of Georgia and the United States.

Georgia Tech's Singapore platform has a comprehensive supply chain research program and the first Master's degree program in the region in logistics and supply chain management. In addition to research opportunities for Georgia Tech's faculty in systems engineering and logistics, it provides a critical component of Georgia Tech's executive Master's degree program in international logistics, which is based in Atlanta. In Singapore, Georgia Tech also offers a THINK Series, which includes seminars, workshops, and short courses designed to bring together logistics experts, business executives, and academic leaders for discussion, knowledge dissemination, and thought leadership positioning. Georgia Tech's Singapore program is supported by five agencies in the Singapore government, with its primary research support coming from the Singapore Agency for Science Technology and Research (A*STAR).

Georgia Tech's international platforms are directly involved in the international economic development activities of the State of Georgia. Georgia Tech was created in 1885 by State law to give the state an economic base and workforce in science and technology, and we have been actively involved in economic development activities since our inception. Georgia's State Department of Economic Development is located on the edge of the Georgia Tech campus in Atlanta, adjacent to Georgia Tech's own business and economic development outreach activities, and there is close collaboration. In particular, Georgia Tech has a full-time international specialist on its staff of economic development advisors whose job is to help the state take advantage of the economic development opportunities presented by Georgia Tech's international activities. For example, in September of 2005, Georgia Governor Sonny Perdue and Lorraine President Jean-Pierre Masseret signed a formal agreement that opened the way for technology companies from both places to develop business relationships with each other. The lynchpin of the agreement is Georgia Tech Lorraine, which will help French companies make business contacts in Georgia and give Georgia companies a platform to develop operations in Europe. Similarly, within a year of the opening of Georgia Tech Ireland in June of 2006, Ireland President Mary McAleese had visited Atlanta and the Georgia Tech campus, and Georgia Governor Sonny Perdue had made an economic development trip to Ireland. The City of Atlanta has always been a transportation hub, and a 2001 Clusters of Innovation study of the city by the Council on Competitiveness helped the local business community better understand the economic opportunities presented by logistics. The Metro Atlanta Chamber of Commerce has now launched a logistics initiative aimed at expanding this sector of the city's economy, which is benefiting from Georgia Tech's presence in Singapore.

It is very important for our faculty to have an international perspective on their area of expertise, and many of our Atlanta-based faculty spend time on our international campuses. Their time abroad allows them access to international opportunities without disrupting their research or career trajectories, and allows us to help ensure a positive experience for their spouses and children. It simultaneously enriches them professionally and helps to assure the consistency and quality of the Georgia Tech reputation at our international locations.

Georgia Tech's international campuses also represent an important opportunity for our students. As the Nation's largest producer of engineers and one of its best, we face the challenge of preparing our students to contribute to and compete in a global economy based on innovation. It is clear to us that it is in the best interests of the United States economy for our education programs to produce citizens of the world who are comfortable with diverse cultures, languages, and ways of thinking and solving problems. Although Georgia Tech is a global institution at both the graduate and undergraduate levels, most of the undergraduate experience is campus-based in Atlanta or Savannah, Georgia. The hands-on lab and practicum nature of science and engineering curricula make study abroad difficult to accommodate, but we have nevertheless developed a wide array of international opportunities for our undergraduate students. During the course of their studies, more than one-third of our undergraduate students study or work abroad, some of them more than once. Seventeen undergraduate degree programs offer an International Designator, in which a context of global economics, international affairs, and foreign language is added to the program of study. Almost 40 percent of Georgia Tech's undergraduates study foreign languages, despite their not being required for any major save one, modern languages. This level of international exposure for our students is sustained through our own study abroad and internship programs; through dual degree agreements with the Technical University of Munich in Germany, the Technical Institute of Monterrey in Mexico, Imperial College in England, and Shanghai Jiao Tong University in China; and through opportunities on our international campuses.

Feedback from alumni and strong employer interest in our students indicate the value of an international perspective to their education. In a 2005 survey, young alumni reported that the experience had helped them develop leadership skills, made them more comfortable in a culturally diverse environment, and enhanced their ability to resolve disagreements and mediate interpersonal conflict in teams or groups. We believe these are important skills for our graduates and increase their ability to thrive in a global economy. The value of our students' education is also reflected in the strong interest by the 550 corporate and government recruiters who came to campus to conduct nearly 10,000 job interviews during the past academic year. Some interviewed students as early as six months before they graduated in an effort to get a jump on the competition.

At Georgia Tech, we also believe that the technological research university of the 21st century will lead the way in improving the quality of life for all of the Earth's inhabitants, and our faculty and students are actively engaged in this endeavor. The nation of Liberia, struggling to recover from a devastating civil war, recently announced a new national information and communication technologies policy, developed with the assistance of Georgia Tech Public Policy Professor Michael Best and graduate students in public policy and computing. Civil and Environmental Engineering Professor Aris Georgakakos has worked with multiple nations to develop water management plans for many of the world's largest river systems. Civil and Environmental Engineering Professor Joseph Hughes and his students are helping the nation of Angola with water resource problems, while Research Scientist Kevin Caravati led a student team in the development of a solar-powered dry latrine that can be made from local materials to promote sanitation in Bolivia. City Planning Professor Michael Elliott has trained environmental experts from both Israel and Palestine in methods of resolving conflicts over water, a critical resource that plays a role in the political tensions of the Middle East. These are just a few examples of many faculty and students whose efforts are making a difference around the world. We believe that quality of life and economic opportunity promote political stability, which is to the advantage of the United States as well as the nations we assist.

Finally, it is important to understand that the process of establishing international platforms is a two-way street, and Georgia Tech's international character is an important factor in attracting foreign research labs to Atlanta. For example, in 2005 the Samsung Electro-Mechanics Company located a research lab adjacent to our campus that is working on the next-generation radio-frequency integrated circuit. This lab is expected to become the company's primary North American research location. Later the same year, Milan-based Pirelli located a North American branch of Pirelli Labs, the company's advanced research center, adjacent to our campus, and then consolidated the rest of its North American corporate staff activities to the same location. These undertakings are consistent with data reported by the National Science Foundation in the 2006 Science and Engineering Indicators. According to NSF, from 1997 to 2002, R&D investments made in the United States by foreign firms grew faster than R&D investments abroad by U.S.-based multinational corporations. In 2002, U.S. affiliates of foreign companies accounted for 5.7 percent of the total U.S. private industry value, but R&D conducted by U.S. affiliates of foreign companies accounted for 14.2 percent of the industry R&D conducted in the United States.

In summary and response to the specific questions posed:

1. *What was the general motivation for your institution to establish branch campuses overseas? What factors did you consider in making the decision to expand overseas, especially in terms of locations, costs, staffing, and the impact on the home campus?*

Georgia Tech's primary motivation in establishing overseas campuses is to enrich our research thrusts and leverage research expertise available in other parts of the world and prepare our students to thrive in the global economy. Our international platforms are mutually beneficial partnerships with high-quality international partners whose research interests align with ours. They benefit our university by enabling our faculty to operate in a global context and helping our students prepare to thrive in a global economy. They benefit the state of Georgia directly by serving as conduits for international economic development relationships. They are operated in accordance with the laws of the United States and the host country; accreditation standards; and Georgia Tech's own charter, by-laws, and policies. They are designed to be financially self-sustaining, so that tax revenues are not used nor are resources diverted away from other Georgia Tech programs. As a result, they are not technically "branch" campuses in the financial sense, because they will have no financial impact on the home campus.

2. *What do you anticipate the effects of these overseas branch campus programs will be on the overall global science and technology enterprise, especially in terms of jobs available to your home and branch campus graduates? What sorts of data and information are you collecting to determine if the effects are matching your original goals?*

Our overseas campuses offer us an opportunity to participate in research with partners whose expertise exceeds ours in particular areas and allows us access to international research opportunities and technologies that would otherwise be unavailable to Americans. Specifically in terms of our graduates, these campuses enrich our ability to produce citizens of the world, educated by professors who operate in an international context and presented with opportunities to study abroad that are not available to typical engineering and science students. The importance of these opportunities to our students is reflected in the strong interest by corporate and government recruiters in hiring them and in reports from our graduates themselves, who say that their international experiences as students contribute to their careers in significant ways.

3. *How are you adjusting your home campus science and engineering to better respond to the increasingly globalized economy?*

Georgia Tech aspires to be a truly global university that contributes to the economic competitiveness of Georgia and the United States through partnerships with other top international universities and research organizations that provide access to innovations and technology being developed in other parts of the world. The faculty and students of our home campus participate in these partnerships, and the knowledge and experience they gain enrich Georgia Tech's home campus and carry over into the relationships we have with American industries and with international partners who seek us out and create partnerships with us here in Atlanta. Georgia Tech is also committed to strengthening the international elements of the education we offer our students, and we have added an International Designator to many undergraduate majors, incorporating a global context into the course of study.

BIOGRAPHY FOR GARY SCHUSTER

Dr. Schuster is currently Provost and Executive Vice President for Academic Affairs and the Vasser Woolley Professor of Chemistry and Biochemistry at the Georgia Institute of Technology. Previously, he served as Dean of the College of Sciences.

Dr. Schuster holds a BS in Chemistry from Clarkson College of Technology (1968) and a Ph.D. in Chemistry from the University of Rochester (1971). After twenty years in the Chemistry Department at the University of Illinois, he became Dean of the College of Sciences and Professor of Chemistry and Biochemistry at Georgia Tech in 1994. He was a NIH Post Doctoral Fellow at Columbia University, a Fellow of the Sloan Foundation and a Guggenheim Fellow. He has been awarded the 2006 Charles Holmes Herty Medal recognizing his work and service contributions since his arrival at Georgia Tech.

Dr. Schuster has published more than 230 papers in peer reviewed scientific journals on topics ranging from biochemistry through physical chemistry. One of his best-known discoveries is called Chemically Initiated Electron Exchange Luminescence. It provides the mechanistic basis that allows the understanding of the bioluminescence of the North American Firefly. This discovery forms the basis for new clinical diagnostic procedures that have recently been commercialized.

His current research interests focus the interaction of light with matter and investigation of small molecules that bind and cut DNA selectively when irradiated with light. This work has application to understanding the origin of certain diseases, such as cancer, and aging.

Dr. Schuster and his wife, Anita, have two sons, a granddaughter, and grandson. Eric lives in Atlanta and Andrew lives in Chicago, Illinois. Their family enjoys downhill skiing and travel.

Mr. BAIRD. Dr. Schuster, thanks for your remarks. You will recognize, of course, you have been joined by a fellow Georgian on the dais here, Dr. Phil Gingrey. Thank you, Dr. Gingrey, for joining us.

Mr. Wessel, thank you.

STATEMENT OF MR. MARK G. WESSEL, DEAN, H. JOHN HEINZ III SCHOOL OF PUBLIC POLICY AND MANAGEMENT, CARNEGIE MELLON UNIVERSITY

Mr. WESSEL. Chairman Baird, Ranking Member Hall, Members of the Committee, thank you very much for this opportunity to submit my thoughts on the topic of the university role in the globalization of innovation, research, education, and development. It is a consuming issue for almost every major American university campus today.

One might legitimately wonder why a Dean of a policy school is testifying before a Committee on Science and Technology. I guess I have two answers to that question. One is, at Carnegie Mellon, we think of policy as a science as well as an art, but the other is probably half of what we do at the Heinz School involves information technology management, both in our research and education programs. And it is these programs, more than any other that we have, that are driving our globalization efforts at the Heinz School.

But this globalization, while I believe it to be a tremendously beneficial impact for our institutions and for the United States economy, it does challenge us to answer critical questions about the impact of our efforts, on the American economy, the effect on the generation of new technology and innovation for our citizens, and our obligations as institutions to people, culture, societies, and economic systems beyond our borders.

What is new, generally, in my opinion, about what is happening, is that American universities, while they have always had a strong international connection among faculty for research and in our student body, today universities are engaging the issue of becoming global institutions as part of our overall strategies.

There are many forces driving this, but I see three primary forces. One is, of course, the increasing globalization of economic and policy activity around the world. The second is that the American tertiary education system has been globally recognized as a driver of economic success, and increasingly, governments and businesses are coming to us from around the world to access that expertise. And finally, there are clearly competitive forces in our industry, which increasingly require us to be entrepreneurial to support the kind of quality and research and education which has been our hallmark for decades.

Beyond these general forces, what any university or college chooses to do on this front is a manifestation of that institution's particular circumstances, capabilities, and values. My university has made great strides in becoming a global institution. In 1997, other than study abroad programs, we offered only one academic program outside the United States. Today, we offer 12 different degree programs in 10 countries, and have institution building, joint degree program, and formal collaborative research activities in Singapore, Taiwan, India, China, and Portugal. Additionally, we have official presences, which can be characterized as branch campuses, in Greece, Qatar, Japan, and Australia. And that list is growing, and I expect it to grow in the future.

It is important, then, to point out that there is no single model that is optimal as an instrument to achieve our goals. We evaluate every global opportunity according to its ability to support us in achieving the following objectives: building alignment with the important organizations and individuals who are leaders in the global economy and policy environment; reaching new student markets that are unlikely to access our education by coming to Pittsburgh; create opportunities for our existing students to expand their professional education through integrated professional experiences abroad; improve our curriculum by broadening our exposure to global policy and business issues; build a globally aware faculty with an institutional environment capable of supporting intellectual inquiry into the emerging issues posed by globalization; and finally, to create new sources of revenue that can support our activities both abroad and at home.

You have rightly asked what outcomes we expect from our efforts to become global institutions. This is a new activity and a bold activity for institutions like mine. Nevertheless, we have some expectations. We expect increased recognition around the world of the potential constructive impact of our institution on the efforts of societies to fulfill the aspirations of their people, and a consequent increase in our brand equity. We expect increased financial support for our efforts from both public and private sector entities that are convinced of this value. We expect the ability to deliver education to highly qualified students whom we would not have been able to serve previously. We expect improved quality of education for all of our students, as we modify our curricula to reflect what we learn in partnerships around the world, and provide opportunities for true professional development in these contexts. We expect better research and innovation outcomes, as we expand our reach to include new intellectuals from around the globe, and we expect the ability to experiment with and learn from new models and modes for research and education in a highly decentralized and distributed environment.

I would now like to briefly take a moment to address an important issue, which I know has been of concern to the Committee. As universities become more global, we are effectively, if unintentionally, increasing the capacity of firms and individuals abroad, to do jobs currently done here in the United States. That is an arguable point, but it is my opinion that although this effect is likely to be quite small, it deserves an honest answer, and that honest answer is that it probably is so. Nevertheless, I think that it is also my opinion that in aggregate, the benefits to the U.S. economy and to American workers from our activity far exceeds the cost. Ultimately, our global efforts will create jobs in the United States through improved education and innovation in our institutions.

Without taking too much time, we believe the benefits will come in four primary forms: more innovation as a result of our ability to build more vibrant networks of intellectuals, drawing on high human capital individuals around the globe; graduates who are better trained to lead innovation in global business and policy enterprises of the future; more resources generated through our international efforts to support our institutions as a whole; and better, more outward-looking universities that are more connected to business and society, and have a greater ability to transfer knowledge outside their walls.

In my view, this globalization effort is simply a part of a broader movement in academia to reach out and become more engaged with companies, governments, and societies, and to be more directly concerned about the responsiveness of our efforts to the needs of society.

As evidence of this, Carnegie Mellon has not only gone abroad, it has gone to the West Coast. We now have a West Coast campus in the Bay Area that responds to that area's technology hotbed there. And my school, the Heinz School, has a new campus in Los Angeles to respond to the film industry, and will be opening a campus in Washington, D.C. within a year, to be more tied to our national policy mechanism.

Perhaps I have persuaded you, but perhaps not. Well, one thing I would like to say in closing is that Chairman Baird mentioned The Economist report that had 17 of the top 20 global universities coming from the United States.

But we are not immune to competition. If we ask what happens if we don't do this, I think the answer for us as institutions is actually quite grim. In 20 years, if we do not assiduously pursue globalization, I think you can easily expect half of the institutions that we see today in the top 20 to drop out. This would ultimately provide serious damage, both to the U.S. economy and to the U.S. political system.

Thank you very much.

[The prepared statement of Mr. Wessel follows:]

PREPARED STATEMENT OF MARK G. WESSEL

Chairman Gordon, Ranking Member Hall, Members of the Committee. Thank you for this opportunity to submit my thoughts on the topic of the university role in the globalization of innovation, research and development. It is a consuming issue on almost every major American university campus today.

I am Mark Wessel, Dean of the H. John Heinz III School of Public Policy and Management at Carnegie Mellon University. As many of you are aware, Carnegie

Mellon University is one of the Nation's leading private research universities. The university consists of seven schools and colleges with more than 10,000 students and more than 4,000 faculty and staff. Founded in 1968, the School of Urban and Public Affairs (SUPA) set as its purpose an aggressive effort to understand the causes of critical problems and to train individuals to use knowledge and technology to bring about positive change. In April of 1991, SUPA became the H. John Heinz III School of Public Policy and Management in honor of the late Pennsylvania Senator H. John Heinz III. The Heinz School is consistently rated as one of the premier public policy schools in the Nation.

The globalization of R&D and innovation is critical to the future not just of our institutions but of the economic success of the United States. It also challenges us to answer a critical question about our obligations as institutions to people, cultures, societies and economic systems beyond our borders.

To my knowledge, no university has "solved" this challenge. We each proceed in idiosyncratic ways based on our individual cultures, needs, capabilities and existing positions in the global marketplace. This is as it should be. Experimentation breeds innovation and the competition among these experiments will ultimately determine which models are most likely to be successful. Still, ultimately we must find ways to share information about our many individual experiments and gain a collective understanding on how to capitalize effectively on the opportunity globalization provides to enhance our capability to achieve our core mission—the advancement of knowledge and the training of citizens for productive roles in society. The efforts of this committee to understand this activity in universities can be critical in that process of coming to consensus.

The Heinz School and Carnegie Mellon have long been known for fostering practical problem-solving in an interdisciplinary environment that blends technology and the sciences with the arts, humanities, business and policy. Without question, innovation and collaboration characterize our success. Now more than ever, these strengths match up with important, emerging needs in our complex world.

I would like to specifically highlight the great strides the university has made globally. In 1997, the university offered just one academic program in three countries outside of the United States. Today, it offers 12 degree programs in 10 countries and has student exchange and joint-degree programs in Singapore, Taiwan, India, China, and Portugal. Additionally, we have an official presence in Athens, Qatar, Kobe, and Australia. My college participates directly in three of these four "branch campuses."

General Forces Influencing University Globalization Initiatives

You have asked us to comment on what is driving efforts by our universities in responding to globalization. Let me start by saying what is NOT driving this effort. Over the last 50 years there has been no lack of global collaboration in research. Particularly at the level of the individual researcher, international collaborations to advance knowledge and spur innovation have been profoundly important and often unnoticed components of the engine of the American university innovation machine. There has been no shortage of willingness of researchers across the globe to seek out others in their fields that can advance their understanding of problems of interests. In addition, particularly at the graduate level, major American universities have typically been open and welcoming environments for foreign students coming to seek the benefits of our educational system. In both these senses, American universities have always been intimately tied to a global system of innovation and knowledge transfer.

The difference today is that the institutions that are these researchers' and students' homes are deeply engaged in the process of globalizing as institutions. The process of engaging global economic and social systems is becoming part of the strategy for universities, not simply an outcome of what we do. This has taken many, many different forms. But the forces that are driving these efforts are reasonably clear.

Globalization of Economic Systems and the Public Good

One of the realities we face as universities is that the fundamental conditions around our value proposition have changed on several dimensions. For much of the latter part of the 20th Century governments at both the State and federal level accepted the proposition that universities were a "public good"—i.e., that the research and education output of American universities would make the society stronger in ways that would not be captured if not for the public subsidy. While this basic proposition is still accepted, the degree to which the public sector is willing to provide subsidy for this activity has declined—at least relative to the overall cost of providing these outcomes.

The implication is that (if we are smart) we must be far more conscious of the value added we generate that customers will pay for. And the nature of those customers' needs has changed fundamentally as a result of globalization. Every business of any scale has been transformed by technology-driven global supply chains, by the emergence of new competitors in every market and by the increased need for continuous process and product innovation—innovation that can now come from anywhere and anybody. Responding to the needs of these organizations requires us to change much about the way we do things. It is not sufficient that we just study the phenomena driving economic globalization. Because of the rapidity of change in this environment (often driven by rapid change in technology), we must partner with firms to determine the sources of potential innovation. Moreover, those firms are no longer North American or European firms. Being present (or at least more proximate) with these new players in the world economy is critical.

This new economic system has other important implications for our students. For our traditional base of international students the advantages of coming to the U.S. for a university education are diminishing—not because the quality of our education or employment opportunities are declining but because the quality of those options in their home countries are improving. As emerging economies generate globally competitive industries, the opportunity for students from those countries to build their careers in their home countries increases and the relative value of access to U.S. labor markets (a traditional motivation for international students) declines. As foreign countries invest increasingly in tertiary education of high quality, the difference in the value added of our education relative to theirs declines.

For U.S. students, the likelihood that you might spend your entire professional career in the United States has declined. Education MUST become more global to accommodate the demands of their careers. And this "globalization" of education is fundamentally different than the traditional mode of staying at home and studying international business (with a possible semester abroad). It requires, at least to some degree, the ability to actually study their professional fields in the contexts in which they will practice.

Finally, this new economic system and the rapidity of innovation and change that drive it require the ability for firms to upgrade the skills of their employees more or less continuously. And because the value in the marketplace of human capital is higher than ever, this requires universities to deliver this capacity where the employees are globally resident rather than requiring them to come to us exclusively. While distance learning can serve some of these needs, it cannot meet them all for any of a number of reasons.

The demand of our mission that we serve the public interest generates even more impetus for us to include globalization in our strategic objectives. For all intents and purposes, there are no domestic policy issues any longer. The interconnectedness of economies, societies and the welfare of individuals cannot and should not be undone. Understanding the ways in which this interconnectedness will change our view of how good policy is made is critical. Moreover, our society depends on the willingness and ability of emerging societies to develop modern systems of governance—systems that are responsive to their internal constituents, weigh alternatives rationally, are invested in the future of the global economic system and are informed of the collective as well as the parochial interests in policy-making. For universities to contribute to the emergence of rational governance we will need to view ourselves as partners with the individuals and institutions in theses societies that are moving in that direction. I believe that requires physical presence.

The World Has Come to Us

The second force influencing American universities' desires to "go abroad" is that the world is adopting our model of tertiary education. Many governments around the world have come to recognize the role the American tertiary education system has played in supporting the innovation and productivity that have generated the most powerful economic system ever known. Public and even private investment in what aim to be high quality university systems around the world is truly impressive. This creates both opportunities and threats for us. The opportunities come because many of these governments have come to our universities for assistance in establishing these systems. These new institutions will become increasingly effective, they will become centers of innovation and knowledge creation in their own rights and our faculty and students will increasingly benefit from connection to them. Moreover, these institutions will create cadres of individuals with significantly higher capabilities that we might then engage in our own pursuits. My view is that the more assiduously we pursue institutional relationship with these new entities, the more likely our faculty and students are to benefit from their emergence.

But, of course, these new institutions are or will be competitors. They will inevitably compete with us for the faculty, students and resources that support us. Our advantage is that if we can assist these societies in fulfilling the role they might otherwise fill by creating new competitors we will be better off. And to the extent that requires us to modify how we do things to accommodate the local demands of these societies, the richer we will become as institutions on every dimension.

Our Industry Structure Will Change

My provost and former dean of the Heinz School, Mark Kamlet, is fond of saying that higher education is the last service industry in the world to undergo major structural change—but it is coming. Arguably, there are simply too many universities in this country. To put it another way, if we were largely for-profit institutions one would likely see significant merger activity in our sector. What that means for our discussion, I believe, is that the emergence of new markets abroad—i.e., markets that can't easily be accessed in our traditional educational and research delivery models staying at home—offer opportunities to take advantage of inherent economies of scale without jeopardizing the branding and selection fundamentals of our business model at home. Thus, for many of us, going global is simply efficient.

These are, in my mind the three most important general factors in driving the push for American universities to seek opportunities abroad. Of course, this is all enabled by advances in communication technology that in innumerable ways have facilitated building global institutions in many endeavors of life.

Specifics of the My Institution's Efforts

Beyond those general principles, what any university or college chooses to do on this front is a manifestation of that institution's particular circumstances, capabilities and values. I will speak with respect to the goals, objectives and strategies of the Heinz School but will reference broader activities at Carnegie Mellon. The Heinz School is a graduate professional school with two major areas of emphasis: a) public policy analysis and implementation; and b) information systems management and strategy. Our core aspiration in pursuing our globalization effort is to have a significant impact on both the evolution of the global IT-driven economy and to influence the process and structure of governance in emerging societies that have and will become such an integral part of this global system. We believe our comparative advantages are a commitment to objective, empirically driven, interdisciplinary inquiry and education and a commitment to innovation to produce value added for our constituents.

It should also be said that there is no single model that we believe is optimal as an instrument to achieve our goals. In reality, the replication of the model represented by our home campus in anything like the scale of the original has so far proven impractical and far too risky for our tastes and resources. At Carnegie Mellon, we do have what might commonly be referred to as "branch campuses" but they are smaller and more specialized than our home campus. However, we have sought to build real presence in the other nations I previously mentioned through a very wide variety of other means.

We evaluate every global opportunity according to its ability to support us in achieving the following objectives:

1. Build alignment with the important organizations and individuals who are leaders in the global economy and policy environment;
2. Reach new student markets that are unlikely to access our education by coming to Pittsburgh;
3. Create opportunities for our existing students to expand their professional education through professional experiences abroad;
4. Improve our curriculum by broadening our exposure to global policy and business issues;
5. Build a globally aware faculty with an institutional environment capable of support the broadest possible intellectual inquiry.

Of course, this is not an unconstrained problem. The primary constraints we pay attention to are:

1. The constraints on the managerial capacity of a small institution to deal with issues generated by a globally distributed organization;
2. The absolute need for every global venture (and all ventures collectively) to exhibit a high probability of positive financial returns and very low downside financial risk;

3. The necessity of maintaining quality standards in research and education consistent with our home campus.

You have rightly asked what outcomes we expect from our efforts to become global institutions. Ultimately, I believe that this is a bold but necessary activity whose full dimensionality will not be known for some time. Nevertheless, we expect some or all of the following to result if we are successful:

1. Increased recognition around the world of the potential constructive impact of our institution on the efforts of societies to fulfill the aspirations of their people and a consequent increase in our "brand equity";
2. Increased financial support for our efforts from both public and private sector entities that are convinced of this value;
3. The ability to deliver education to highly qualified students whom we would not have been able to serve previously;
4. Improved quality of education for all our students as we modify our curricula to reflect what we learn in partnerships around the world and provide opportunities for true professional development in these contexts;
5. Better research outcomes as we expand our reach to include new intellectuals from around the globe;
6. The ability to experiment with and learn from new models and modes for research and education in a highly decentralized and distributed environment.

I believe that these outcomes that we expect as one institution reflect what we might hope to achieve collectively in this effort. We will produce citizens better equipped to deal with the changing economic environment that has accompanied globalization. We will build partnerships that will increase knowledge generation and facilitate its transfer to society. Our universities will be financially stronger and require less government subsidy. We will become more efficient individually as we leverage existing infrastructure. We will support innovation in firms that fuel global economic growth.

These outcomes are difficult to measure. It is even more difficult to prove conclusively causal connections between university globalization efforts and these types of generalized social welfare outcomes. However, at the institutional level I believe we will be able to determine if we are successful. Successful global universities will have the following characteristics:

1. The number of our students who are able to spend portions of their education at our facilities or partners abroad in gaining education and experience in curricula and practicums that are fully integrated across campuses will increase;
2. Revenues generated from activities abroad can be used to support education and research at home campuses;
3. Our graduates will be sought out because of their ability to translate what they have learned to solve global economic and policy challenges;
4. We will have built a network of research partners with multiple collaborations across faculty and institutions globally;
5. We will have many private sector partners for whom our educational offerings are an integral part of their training and development efforts and who provide us with access to data and intelligence about emerging issues in technology and business;
6. We will have government and other academic partners around the world who rely on our expertise in developing their institutions and tertiary education systems, with whom we share infrastructure for the benefit of our students and faculty, and from whom we learn how our organization and system can adapt to be more effective in their environments;
7. Our board of trustees and advisory committees will be increasingly populated by influential business people and policy leaders from around the world.

Carnegie Mellon's globalization efforts have been a remarkable experience and we have learned much, even at this early stage. Largely because we are inexperienced at this, there have also been surprises—particularly at how difficult this task proves to be. Some of the major challenges for our future efforts are predictable. Because we are generally not-for-profit organizations, we do not have access to the kinds of financial markets that are capable of providing risk capital to these kinds of ventures. Most of us can or will only tolerate a limited amount of financial risk in almost any venture. Hence we will be constrained in our ability to pursue many of our goals by the degree to which we can identify partners with philanthropic or public interest motivations willing to provide us with this kind of capital.

A second source of challenge for us is that we have built a model for research activities that is dependent on a highly idiosyncratic environment and culture that is not well adapted to the global enterprise. At a policy level, many of the public agencies that fund research at universities will not fund foreign-based faculty—making it difficult to structure an integrated global research environment. Tax treatment for foreign-based research enterprises is uncertain, at best. Locally, our systems of supporting, evaluating and promoting faculty have relied heavily on a high degree of personal interaction and mentoring that is difficult to replicate in a global environment. To a significant degree, our educational programs have relied on extracting students from their homes and other productive activity to educate them in fairly isolated environments. Our management systems from finance to human resources to student services are all largely structure on the assumption of a geographically proximate environment.

We are also challenged to adapt to a highly varied global regulatory environment. Each nation in which we consider operating has a different set of requirements with respect to the operation of tertiary education environment and in many of these countries the sector is completely closed to external entry. Even understanding the implications of these differing regulatory and policy environments is very challenging for us.

Finally, the management challenges of inherently small institutions achieving global scale are truly daunting for us. This is more than a question of management and efficiency. Ultimately it is a question of whether we can globalize and still maintain the quality standards in research and education that has been the core of the success of American universities.

Thank you for the opportunity to testify on this important topic. I would be happy to answer any questions the Committee might have.

Biography for Mark G. Wessel

Mark G. Wessel has been named Dean of Carnegie Mellon University's H. John Heinz III School of Public Policy and Management, where he has served as Acting Dean since February of 2003.

"I am very pleased that Mark Wessel will assume the deanship. He will provide strong leadership and superb management skills. I look forward to continuing to work with him," said Carnegie Mellon President Jared L. Cohon.

As Dean, Wessel will direct the school's academic programs in public policy and management, two university-wide information systems and technology management programs, and six research centers.

Wessel, who came to the Heinz School in 1993, has served in administrative capacities such as Director of Health Care Programs, Associate Dean, Senior Associate Dean, and Chief Operating Officer.

His responsibilities have included management of the operational functions of the Heinz School program development and management, development and oversight of the School's Master's programs in information technology management, and student advising.

"For more than a decade, Mark Wessel has provided consistent leadership and vision while serving the Heinz School in a wide variety of key posts," said Carnegie Mellon Provost Mark Kamlet, who was Dean of the Heinz School from 1994 to 2000. "He will continue to build upon the Heinz School's strengths, particularly at the intersection of policy, management and information technology."

Wessel is a former economist and financial analyst for the United States Department of Energy. Prior to coming to Carnegie Mellon, he was a development specialist with the Mon Valley Initiative, where he developed community-based regional economic and social development strategies and projects for distressed communities in Western Pennsylvania.

He served as Assistant to the Associate Dean and undergraduate economics advisor at the University of Wisconsin at Madison, where he earned his Master's degree in economics. Wessel earned a Bachelor of Science degree in Foreign Service from Georgetown University.

Wessel is married to Linda C. Babcock, the James M. Walton Professor of Economics at the Heinz School. Also a former Acting Dean, Babcock specializes in research conducted at the interface between economics and psychology and received the Heinz School's Emil Limbach Award for teaching excellence in 1991.

According to Wessel, "if they want another dean in our family they'll have to get our five-year-old daughter, Alexandra!"

An avid golfer, he is teaching his daughter the game and has been known to beat Mark Kamlet when they hit the links together. Wessel also loves sailing in the Caribbean, playing the classical guitar, and, according to his wife, has a passion for "big, ugly cars."

In *U.S. News and World Report Magazine*'s 2001 ranking of graduate schools in public affairs, the Heinz School ranked seventh overall and first in the specialty area of information technology. The Heinz School has built an international reputation for excellence in educational programs and faculty research.

Its programs in information technology, criminal justice policy, policy analysis, finance and environmental policy are respected across the Nation and internationally as among the elite. Programs in health care and medical management, educational technology and other areas continue to grow and take national prominence.

Heinz School graduates serve in key managerial positions across a wide range of government, business and non-profit organizations. The school still takes a flexible and interdisciplinary approach to teach students to look at societal problems from many different perspectives, using technology, quantitative and qualitative analysis and group dynamics to arrive at innovative solutions.

Mr. BAIRD. Thank you, Mr. Wessel. Dr. Altbach.

STATEMENT OF DR. PHILIP G. ALTBACH, DIRECTOR, THE CENTER FOR INTERNATIONAL HIGHER EDUCATION; J. DONALD MONAN SJ PROFESSOR OF HIGHER EDUCATION, BOSTON COLLEGE

Dr. ALTBACH. Thank you. Chairman Baird, Ranking Member Hall, and colleagues. My role this morning is to provide a bit of broader perspective. I am not here to talk about the efforts of my own university in internationalization, but to provide a broad perspective on what I think some of the key issues are.

As my colleagues have said, the future of universities, of the excellent universities around the world, is a global future. There is no question about that. And if we, as institutions, and if we, as States and the Nation, don't take this seriously, we are going to fail in the future. So, that is key. We need to be globally competitive in higher education.

Universities have always been international, indeed global, institutions. From the medieval universities, which used, we should remember, a common language of instruction, Latin, and which attracted foreign students and faculty, they didn't call them that in those days, they were truly global institutions.

The United States, in fact, if you look at our higher education system, we have imported models from all around the world. Our university system is based, really, on three ideas: the British Colonial college, the German research university of the 19th Century, and the truly American idea of university service to society. Those are the three key elements that have shaped American higher education, and I should say, shaped the world's higher education today, because the American university is the global model. If you look around the world, and we all see every day, not every day, but frequently, colleagues from different countries coming to our universities and finding out how we do it, because we, in our higher education industry, are the gold standard today. So, that is very important.

A few definitions which I think are important, because we bandy about globalization, internationalization, and so on, and we often don't define them carefully. What I mean, and what many scholars have talked about globalization to mean are the broad economic and social trends that affect the world environment, including, of course, information technology, the growing role and use of the English language, which I think gives us, in the U.S., a very significant advantage internationally in higher education, worldwide demand for access, and so on. These are factors over which we have little control, and which are part of the broader environment.

What I mean by internationalization, and my colleagues have talked about aspects of this this morning, are the specific policies of governments, universities, schools, colleges, and even people, to adapt, define, and contribute to this global environment. Academic institutions, as well as states and nations, have different ideas about adapting to the global environment, and I would say, as a comparative educator, that if you look around the world, our major national competitors, deeply engaged in an academic foreign policy, are ahead of us in the U.S., in terms of thinking about their approaches, national approaches to higher education, exports to higher education policy, in a global environment.

What is meant by multinationalization, and here is where branch campuses come in, multinationalization encompasses academic programs and institutions, including the branch campuses, that are offered by academic institutions in one country, in another. Some people have called this McDonald-ization, and part of is franchising, in truly McDonald's fashion. Now, that is not what the universities represented at this table do, but there is some of that around the world, and it is important to watch, because all of the global trends, the international trends, are not of tremendously high quality today.

Let me mention a few things, a few kind of, one particular case study that I know is of interest to this committee, and that is the interesting issue of branch campuses. There are, according to the rather incomplete research, at least 82 branch campuses that operate today around the world, and the number is probably significantly higher than that. The United States is the largest single country that contributes to the branch campus phenomenon, with approximately half. Branch campuses are largely a North to South phenomenon. That is, universities in rich countries are opening branch campuses in developing or middle income countries. Most branch campuses worldwide, with very few exceptions, operate in English overseas, even from countries like the Netherlands, which is not an English-speaking country. Their branch campuses operate largely in English. With the opening of China and India, both highly complicated regulatory environments today, the branch campus phenomenon is likely to become even more important.

What are the motivations, very briefly, to senders? To earn money? That is part of it. To build a brand image overseas. To help to recruit students from other countries to come to the home campus. To provide a destination for study abroad for our own students. And broadly, as part of an internationalization strategy.

And finally, a couple of problems. The failure to earn money is a problem. The University of New South Wales in Australia just recently closed its branch campus in Singapore, after less than a year, and the expenditure of a very large amount of Australian money, and by the way, Singapore money, too, because enrollments were not what they wanted. The failure to maintain the standards of the home campus abroad. Again, the institutions at this table would not be part of that phenomenon, but it is there. It is important. How do we get our own faculty to go abroad to teach for periods of time? Difficulties of dealing with host governments and institutions. Regulatory environments overseas are quite difficult. Managing quality control at this end of things, through our accrediting system, which is used and very effective in contributing to the quality assessment and control within the United States, is less able to do that abroad.

Well, these are some of the issues, and I hope I have provided at least a little bit of perspective to get our discussion going here this morning.

Thank you.

[The prepared statement of Dr. Altbach follows:]

PREPARED STATEMENT OF PHILIP G. ALTBACH

GLOBALIZATION AND THE UNIVERSITY: REALITIES IN AN UNEQUAL WORLD

Mr.Chairman, and Members of the Committee. Thank you for the opportunity to participate in this hearing. The broad theme of the internationalization of higher education has immense relevance for American colleges and universities and for U.S. leadership in higher education worldwide. It is the case that the United States has, overall, the best higher education system in the world, and that American ideas about higher education are influential worldwide. For this reason alone, we have a special responsibility to play a responsible role in international higher education. It is also the case that we cannot take our dominant position for granted—other countries are building higher education capacity and are aggressively moving into the global academic market.

The analysis here is intended to provide a broad overview of internationalization trends. I define key terms and then analyze how these trends affect higher education in the international context.

In the past two decades, globalization has come to be seen as a central force for both society and higher education. Some have argued that globalization, broadly defined as largely inevitable global economic and technological factors affecting every nation, will liberate higher education and foster needed change. Technological innovations such as the Internet, the forces of the market, and others will permit everyone to compete on the basis of equality. Knowledge interdependence, it is argued, will help everyone. Others claim that globalization strengthens worldwide inequality and fosters the McDonaldization of the university. All the contemporary pressures on higher education, from massification to the growth of the private sector are characterized as resulting from globalization. There is a grain of truth in each of these hypotheses—and a good deal of misinterpretation as well. This essay will seek to "unpack" the realities of globalization and the related concept of internationalization in higher education and to highlight some of the impact on the university. Academe around the world is affected differently by global trends. The countries of the European Union, for example, are adjusting to new common degree structures and other kinds of harmonization that are part of the Bologna process and related initiatives. Countries that use English benefit from the increasingly widespread use of that language for science and scholarship. Of special interest here is how globalization is affecting higher education in developing countries, which will experience the bulk of higher education expansion in the next two decades (Task Force on Higher Education and Development, 2000).

From the beginning, universities have been global institutions-in that they functioned in a common language, Latin, and served an international clientele of students. Professors, too, came from many countries, and the knowledge imparted reflected scholarly learning in the Western world at the time. Since universities have always figured in the global environment, they have been affected by circumstances beyond the campus and across national borders. This reality is all too often overlooked in analyses of 21st century globalization. A long-term perspective when considering the university reveals the deep historical roots of the ethos and governance of universities. As Clark Kerr has noted, of the institutions that had been established in the Western world by 1520, 85 still exist—the Roman Catholic Church, the

British Parliament, several Swiss cantons, and some 70 universities. The universities may have experienced the least change of these institutions (Kerr, 2001, p. 115).

Today's globalization, at least for higher education, does not lack precedents. From the beginning, universities have incorporated tensions between national conditions and international pressures. While English now dominates as the language of research and scholarship, in the 19th century German held sway, as did Latin in an earlier era. Students have always traveled abroad to study, and scholars have always worked outside their home countries. Globalization in the 21st century is truly worldwide in reach—few places can elude contemporary trends, and innovations and practices seem to spread ever faster due to modern technology. But, again, similar trends have occurred in other periods as well.

It is also the case that all of the universities in the world today, with the exception of the Al-Azhar in Cairo, stem from the same historical roots—the medieval European university and, especially, the faculty-dominated University of Paris. This means that the essential organizational pattern of the contemporary university worldwide stems from a common tradition—this is an important element of globalization. Much of the non-Western world had European university models imposed on them by colonial masters—academic systems in India, Indonesia, Ghana, and the rest of the developing world stem from common Western roots. Even those countries not colonized by Western powers—such as Japan, Thailand, Ethiopia, and a few others—adopted the Western academic model (Altbach & Selvaratnam, 1989). This is the case even where, as in China, well-established indigenous academic traditions already existed (Hayhoe, 1999).

The American university itself, so influential worldwide, constitutes an amalgam of international influences. The original colonial model, imported from England was combined with the concept of the German research university idea of the 19th century and the American ideal of service to society to produce the modern American university. Foreign models were adapted to domestic realities in creative ways. As the European Union moves toward the harmonization of national higher education systems in the "common European space," foreign influences again emerge—degree structures, the course-credit system, and other elements in modified form—to produce evolving academic patterns. Just as Japan adapted German academic models and some American traditions as it built its modern university system after 1868, the European Union is looking to "best practices" worldwide in 2004.

Given the centrality of the knowledge economy to 21st-century development, higher education has assumed a higher profile both within countries and internationally because of its roles in educating people for the new economy and in creating new knowledge (Altbach, 1998a). As evidence, the World Trade Organization is now focusing on higher education. Currently, a debate is under way concerning the General Agreement on Trade in Services (GATS). Multinational corporations and some government agencies in the rich countries are seeking to integrate higher education into the legal structures of world trade through the WTO. These developments indicate how important universities and knowledge have become in the contemporary world (Larsen, Martin, & Morris, 2002; Knight, 2002; Altbach, 2002).

Definitions

It will be useful to define some of the terms in the current debate about globalization. For some, globalization means everything—an inchoate catch-all for the external influences on society. For others, it includes only the negative side of contemporary reality. This essay examines the international environment of higher education and seeks to analyze how that environment affects national higher education systems and individual academic institutions. Thus, the focus is not on the detailed issues of the management of academic institutions—changing administrative structures or changes in the specific nature of academic appointments for example, although these may be influenced by global trends. Rather, we are concerned with how societies and universities have dealt with mass enrollments, privatization, and the new technologies, among others.

In this discussion, globalization is defined as the broad economic, technological, and scientific trends that directly affect higher education and are largely inevitable in the contemporary world. These phenomena include information technology in its various manifestations, the use of a common language for scientific communication, and the imperatives of society's mass demand for higher education (massification) and for highly educated personnel, and the 'private good' trend in thinking about the financing of higher education. Academe is affected by, for example, patterns in the ownership of multinational publishing and Internet companies, the investment in research and development worldwide, and international currents of cultural diffusion. These, and other, trends are part of globalization—they help to determine the nature of the 21st century economy and society. Although globalization is by no means a new phenomenon—the medieval universities were affected by the global trends of the period—it has increased salience in interdependent world of the 21st century. All are affected by these trends, and must take them into consideration as part of higher education policy and reality.

Internationalization refers to specific policies and programs undertaken by governments, academic systems and institutions, and even individual departments to undertake student or faculty exchanges, engaged in collaborative research overseas, set up joint teaching programs in other countries or a myriad of other initiatives. Internationalism is not a new phenomenon and indeed has been part of the work of many universities and academic systems for centuries. With much room for initiative, institutions and governments can choose the ways in which they deal with the new environment. Internationalism constitutes the ways that contemporary academe deals with globalization. While the forces of globalization cannot be held at bay, it is not inevitable that countries or institutions will necessarily be overwhelmed by them, or that the terms of the encounter must be dictated by others. Internationalization accommodates a significant degree of autonomy and initiative (Knight, 1997; Knight, 2005; Scott, 1998; De Wit, 2002).

Another new trend in higher education trend is multinationalization, which refers to academic programs or institutions located in one country offering degrees, courses, certificates, or other qualifications in other countries. The programs are often sponsored jointly with local institutions, but this is not always the case (Teather, 2004). A joint-degree sponsored by institutions in two or more countries, often called "twinning," is an example of a multinational academic enterprise. Offshore institutions constitute one variation of the trend—this may be carried out through franchising (sometimes referred to as "McDonaldization") or simply by opening a branch institution (Hayes & Wynyard, 2002). The American University of Bulgaria, offering U.S.-style academic programs in English in Bulgaria and accredited in the United States is an example. Increasingly, the Internet is used in the delivery of multinational academic programs.

Globalization cannot be completely avoided. History shows that when universities shut themselves off from economic and social trends they become moribund and irrelevant. European universities, for example, ignored both the Renaissance and the Industrial Revolution and ceased to be relevant. Indeed, the French Revolution swept away the universities entirely. Napoleon established the grandes ecoles in order to provide relevant training for the leaders of society and to contribute to science and technology. Von Humboldt had to reinvent the German university model in 1809 in order to make them relevant to the development of science and industry in Prussia (Ben-David and Zloczower, 1962). Institutions and systems possess great latitude in how they deal with globalization and other social influences—at times they have effectively coped with such changes. At other times, the innate conservatism of academe prevented this. Thus, those who argue that there is just one model for higher education in the 21st century are clearly wrong.

Centers and Peripheries

The world of globalized higher education is highly unequal.

Concentrating on developing countries and on smaller academic systems immediately reveals the specter of inequality. While the Internet and other manifestations of globalization are heralded as disseminating knowledge equally throughout the world, the evidence is mixed on the outcomes. In some ways, globalization does open access, making it easier for students and scholars to study and work. But in many respects, existing inequalities are only reinforced while new barriers are erected. The debate in higher education mirrors analyses of globalization generally. Economists Joseph Stiglitz and Dani Rodrik, among others, have argued that in some respects globalization works against the interests of developing countries, reinforcing international inequalities (Stiglitz, 2002; Rodrik, 1997; Rodrik, 1999). Neither is opposed to globalization—and both see it as inevitable—but their critiques reveal critical problems that tend to be overlooked in the dominant perspectives on the topic.

The powerful universities and academic systems—the centers—have always dominated the production and distribution of knowledge. Smaller and weaker institutions and systems with fewer resources and often lower academic standards—the peripheries—have tended to be dependent on them. Academic centers provide leadership in science and scholarship and in research and teaching. They are the leaders with regard to organizational structure and mission of universities, and in knowledge dissemination. The centers tend to be located in larger and wealthier countries, where the most prestigious institutions benefit from the full array of resources, including funding and infrastructures—such as libraries and laboratories to support research, academic staff with appropriate qualifications, strong traditions, and legislation that supports academic freedom. The academic culture fosters high achievement levels by individual professors and students, and by the institutions themselves. These top institutions often use one of the major international languages for teaching and research, and in general enjoy adequate support from the state.

The world of centers and peripheries is growing ever more complex (Altbach, 1998c). The international academic centers—namely the leading research-oriented universities in the North, especially those that use one of the key world languages (particularly English)—occupy the top tier. High quality universities do exist elsewhere—for example, in Japan and several smaller European countries. A number of universities in China, Singapore, and South Korea aspire to the status of top research institutions. Even within countries at the center of the world academic system in the early 21st century—the United States, Britain, Germany, France, and to some extent Australia and Canada—there are many peripheral institutions. For example, perhaps 100 of America's 3,200 postsecondary institutions can be considered research universities. These institutions receive more than 80 percent of government research funds and dominate most aspects of American higher education. The rest of the American higher education system lies on the periphery of the research centers—these segments, including the comprehensive universities, community colleges, and others play important roles in both the academic system and in society—but they are not considered to be leaders in the academic system. While hardly a new development, this stratification has probably become more pronounced in recent years. Countries that had relative equality among universities are fostering diversification—the U.K. has created a ranked system, and Germany is moving in that direction.

Other countries possess similarly stratified academic systems. There are also universities that play complex roles as regional centers, providing a conduit of knowledge and links to the top institutions. For example, the major universities in Egypt provide academic leadership for the Arabic-speaking world and are links to the major centers, while contributing relatively little themselves. China's key universities are significant producers of research, mainly for internal consumption, while at the same time serving as links to the wider world of higher education.

In many ways, it is now more difficult to become a major player in international higher education—to achieve "center" status (Altbach, 1998b). The price of entry has risen. Top-tier research universities require ever greater resources, and in many fields scientific research involves a large investment in laboratory facilities and equipment. Enabling institutions to remain fully networked for the Internet and information technology is also costly, as are library acquisitions—including access to relevant databases. Universities in countries without deep financial resources will find it virtually impossible to join the ranks of the top academic institutions. Indeed, any new institution, regardless of location, will face similar challenges.

Academic institutions at the periphery and the academic systems of developing and some small industrialized countries depend on the centers for research, the communication of knowledge, and advanced training. The major journals and databases are headquartered at the major universities—especially in the United States and the United Kingdom—since international scholarly and research journals are largely published in English. Most of the world's universities are mainly teaching institutions—in developing countries virtually all are in this category—that must look elsewhere to obtain new knowledge and analysis. Many smaller developing countries, for example, lack the facilities for research, do not provide degrees beyond the Bachelor's, and are unable to keep up with current journals and databases due to the expense. Structural dependency is endemic in much of the world's academic institutions.

A New Neocolonialism?

The era of the Cold War was characterized by the efforts of the major powers to dominate the "hearts and minds" of the peoples of the world. The Soviet Union, the United States, and others spent lavishly on student exchanges, textbook subsidies, book translations, institution building, and other activities to influence the world's academic leaders, intellectuals, and policy-makers. The goals were political and economic, and higher education was a key battlefield. The rationale was sometimes couched in the ideological jargon of the Cold War but was often obscured by rhetoric about cooperation (Altbach, 1971).

The programs included many that offered considerable benefit to the recipients—including scholarships to study abroad, high-quality textbooks, scientific equipment, and other resources. Participation in programs took place on an entirely voluntary basis, but in a context of scarcity assistance becomes difficult to decline. Acceptance meant increased ties to the donor countries and institutions and long-term dependence on the countries providing the aid. Installation of laboratory equipment or computers, for example, meant continuing reliance on the supplier for spare parts, training, and the like.

We are now in a new era of power and influence. Politics and ideology have taken a subordinate role to profits and market-driven policies. Now, multinational corporations, media conglomerates, and even a few leading universities can be seen as the new neocolonists—seeking to dominate not for ideological or political reasons but rather for commercial gain. Governments are not entirely out of the picture—they seek to assist companies in their countries and have a residual interest in maintaining influence as well. The role of the governments of such countries as the United States and Australia in advocating the interests of for-profit education providers and others in their countries in the World Trade Organization with regard to the General Agreement on Trade in Services (GATS) and other matters is but one example. As in the Cold War era, countries and universities are not compelled to yield to the terms of those providing aid, fostering exchanges, or offering Internet products, but the pressures in favor of participation tend to prevail. Involvement in the larger world of science and scholarship and obtaining perceived benefits not otherwise available present considerable inducements. The result is the same—the loss of intellectual and cultural autonomy by those who are less powerful.

The Role of English

English is the Latin of the 21st century. In the current period, the use of English is central for communicating knowledge worldwide, for instruction even in countries where English is not the language of higher education, and for cross-border degree arrangements and other programs. The dominance of English is a factor in globalization that deserves analysis if only because higher education worldwide must grapple with the role of English (Crystal, 1997).

English is the most widely studied foreign language in the world. In many countries, English is the required second language in schools, and the second language of choice in most places. English is the medium of most internationally circulated scientific journals. Universities in many countries stress the importance of their professors' publishing in internationally circulated scientific journals, almost by definition in English, placing a further premium on the language. Internet websites devoted to science and scholarship function predominantly in English. Indeed, English serves as the language of Internet academic and scientific transactions. The largest number of international students go to universities in English-speaking countries.

English is the medium of instruction in many of the most prominent academic systems—including those of the United States, the United Kingdom, Australia, Canada, and New Zealand—all of which enroll large numbers of overseas students. Singapore, Ethiopia, and much of Anglophone Africa use English as the primary language of instruction as well. English often functions as a medium of instruction in India, Pakistan, Bangladesh, and Sri Lanka. Other countries are increasingly offering academic programs in English—to attract international students unwilling to learn the local language and to improve the English-language skills of domestic students and thus enable them to work in an international arena. English-medium universities exist in many countries—from Azerbaijan and Bulgaria to Kyrgyzstan and Malaysia. In many countries—such as Japan, the Netherlands, Germany, Mexico, and so on—universities offer English-medium degree programs and courses at local universities. Many European Union nations offer study in English as a way of attracting students from elsewhere in the EU. English is clearly a ubiquitous language in higher education worldwide.

The role of English affects higher education policy and the work of individual students and scholars. Obviously, the place of English at the pinnacle of scientific communication gives a significant advantage to the United States and the United Kingdom and to the other wealthy English-speaking countries. Not surprisingly, many scientific journals are edited in the United States, which gives an advantage to American authors—not only are they writing in their mother tongue but the peer review system is dominated by people accustomed to both the language and methodology of U.S. scholars. Others must communicate in a foreign language and conform to unfamiliar academic norms. As mentioned earlier, in many places academics are pressured to publish in internationally circulated journals—the sense being that publication in the most prestigious scientific journals is a necessary validation of academic work. Increasingly, international and regional scientific meetings are exclusively in English, again placing a premium on fluency in the language.

English-language products of all kinds dominate the international academic marketplace, especially journals and books. For example, textbooks written from a U.S. or U.K. perspective are sold worldwide, influencing students and academics in many countries and providing profits for publishers who function in English. The English-language databases in the various disciplines are the most widely used internationally. Universities must pay for these resources, which are priced to sell to American or European buyers and are thus extraordinarily expensive to users in developing or middle-income countries. Nevertheless, English-language programs, testing materials, and all the other products find a ready market in these countries.

Countries that use "small languages" may be tempted to change the medium of instruction at their universities entirely to English. A debate took place in the Netherlands on this topic, and it was decided to keep Dutch as the main language of instruction largely out of concern for the long-term survival of the Dutch language and culture—although degree programs in English are flourishing in the country. Where collaborative degree programs are offered, such as in Malaysia, the language of instruction is almost always English and not the language of the country offering the joint degree.

English is supplanting such languages as French, German, and Spanish as the international medium of scholarship. These other languages are in no danger of disappearing in higher education, but their world role has shrunk. The use of English tends to orient those using it to the main English-speaking academic systems, and this further increases the influence of these countries. Regardless of the consequences, however, English will continue as the predominant academic language.

The Global Marketplace for Students and Scholars

Not since the medieval period have such a large proportion of the world's students been studying outside their home countries—more than 1.5 million students at any one time—and some estimate that the number of overseas students will grow to eight million by 2020. Large numbers of professors and other academics travel abroad temporarily for research or teaching, and substantial numbers of academics migrate abroad as well to pursue their careers. Aspects of globalization such as the use of English encourage these flows and will ensure that growth continues. As academic systems become more uniform and academic degrees more accepted internationally, immigration rules favor people with high skill levels, and universities look to hiring the best talent worldwide, the global marketplace will expand.

The flow of academic talent at all levels is directed largely from South to North—from the developing countries to the large metropolitan academic systems. Perhaps 80 percent of the world's international students come from developing countries, and virtually all of them study in the North. Most of these students pursue Master's, doctoral, and professional degrees. Many do not return to their countries of origin. Close to 80 percent of students from China and India, two of the largest sending countries to the United States, do not return home immediately after obtaining their degrees, taking jobs or post-doctoral appointments in the United States. The years since the collapse of the Soviet system has also seen a flow of scientists from Russia to Western Europe and North America. Students from industrialized countries who study abroad typically do not earn a degree but rather spend a year or two in the country to learn a language or gain knowledge that they could not acquire at home.

Most international students pay for their own studies, producing significant income for the host countries—and a drain on the economy of the developing world. According to estimates, the money spent abroad by students from some developing countries more than equals incoming foreign aid. These students not only acquire training in their fields but also absorb the norms and values of the academic systems in which they studied. They return home desiring to transform their universities in ways that often prove to be both unrealistic and ineffective. Foreign students serve as carriers of an international academic culture—a culture that reflects the major metropolitan universities, and may not be relevant for the developing world.

In 2002, universities in the United States hosted almost 85,000 visiting scholars. Although statistics are not available, it is estimated that visiting scholars number 250,000 worldwide. The predominant South-North flow notwithstanding, a significant movement of academics occurs among the industrialized countries and to some extent within other regions, such as Latin America. As part of the Bologna initiatives of the European Union, there is more movement within Europe. Most visiting scholars return home after their sojourns abroad, although a certain number use their assignments as springboards to permanent emigration.

The flow of highly educated talent from the developing countries to the West is large—and problematical for Third World development. For example, more Ethiopian holders of doctoral degrees work outside of Ethiopia than at home, and 30 percent of all highly educated Ghanaians and Sierra Leoneans live and work abroad (Outward Bound, 2002, p. 24). Many African countries experience this pattern. South Africa is losing many of its most talented academics to the North, while at the same time it is recruiting from elsewhere in Africa. This migration has seriously weakened academic institutions in many developing countries.

Migration does not affect only developing countries. Academics will go abroad to take jobs that offer more attractive opportunities, salaries, and working conditions, as illustrated by the ongoing small but significant exodus from the United Kingdom to North America. To combat this trend, U.K. authorities have provided funds to entice their best professors to remain at home. Being at the center of research activity and having access to the latest scientific equipment sometimes lures scholars from small but well-endowed academic systems, such as those in Denmark or Finland to the metropoles. In some fields, such as engineering specialties and computer science, the percentage of professors from other countries working at U.S. universities is very high—reflecting the fact that almost half the doctoral students in these fields are foreigners. Academic migration takes place throughout the academic system, especially in the sciences, engineering, information technology, and some management areas. Such migration occurs both at the top of the system, with some world-famous scholars attracted abroad by high salaries, and at the bottom, where modest salaries are able to draw foreigners to jobs that are unappealing to local applicants.

Academic migration follows complex routes. Many Egyptian, Jordanian, and Palestinian academics work at Arabian Gulf universities, attracted by better salaries and working conditions than are available at home. Indians and Pakistanis are similarly drawn to the Gulf as well as to Southeast Asia. Singapore and Hong Kong attract academics worldwide. Mexico and Brazil employ scholars from elsewhere in Latin America. South Africa, Namibia, and Botswana currently recruit Africans from elsewhere on the continent. Some of the best scholars and scientists from Russia and a number of Central European countries have taken positions in Western Europe and North America. The existing traffic among member states will likely grow once the EU implements policies to harmonize academic systems, a process now underway.

The most significant "pull" factors include better salaries and working conditions and the opportunity to be at the centers of world science and scholarship (Altbach, 2003, pp. 1–22). The discrepancies in salaries and conditions between North and South mean that in most developing countries academics cannot aspire to a middle-class lifestyle or have access to the necessary tools of research and scholarship.

One of the many "push" factors involves the limited extent of academic freedom in many developing countries. Academics can be subject to restrictions and even arrested if they stray from officially approved topics. Favoritism and corruption in academic appointments, promotions, and other areas further erode the environment of the university. In many higher education systems, job security or stability are unattainable. Conditions at Third World universities stem largely from the scarcity of resources and the pressure of increased student numbers on overburdened academic institutions. While the "pull" factors at the centers will retain their influence, the "push" factors can be moderated. Overall, however, the migration of academic talent will continue in the current globalized environment.

People have long equated the migration of talent with brain drain. The life stories of emigrants have changed (Choi, 1995). Many academics now keep in close contact with their countries of origin, maintaining scientific and academic relationships with colleagues and institutions at home. Growing numbers of academics have even gone back after establishing careers abroad as economic and political conditions at home have changed. Some academics from South Korea and Taiwan, for example, left United States to accept senior academic appointments in their home countries once academic working conditions, salaries and respect for academic freedom had improved. More commonly, expatriate academics return home for lecture tours or consulting, collaborate on research with colleagues in their country of origin, or accept visiting professorships. Facilitated by the Internet, these links are increasingly accepted as appropriate and useful. Such trends are especially strong in countries with well-developed academic systems, such as China, India, and South Africa, among others.

The migration of academic talent is in many ways promoted by the industrialized countries, which have much to gain. Immigration policies are in some cases designed to encourage talented personnel to migrate and establish residency—although at least in the United States security concerns in the aftermath of 9/11 have changed the equation to some extent. In many countries, academic institutions make it easy for foreigners to fit into the career structure. Countries that place barriers to foreign participation in academe, such as Japan and now perhaps the U.S. may find it more difficult to compete in the global knowledge sweepstakes. Industrialized countries benefit from a large pool of well-educated scientists and scholars—people educated by developing countries—who choose to take their talents and skills to the highest bidders. In this way, the developing world has supported the North's already overwhelming lead in science and scholarship. The renewal of links between academics who migrate and their countries of origin mitigate this situation somewhat, although developing countries, and some smaller industrialized nations, still find themselves at a disadvantage in the global academic labor market.

The Curriculum

The field of business administration exemplifies the global dominance of ideas by the major English-speaking academic systems. In most countries, business administration is a new field, established over the past several decades to prepare professionals for work in multinational corporations or in firms engaged in international commerce as well as in local business. The dominant pattern of professional studies is the M.B.A. degree—the American-style Master's of business administration. This degree originated as the way to prepare American students for work in U.S. business, based on American curriculum ideas and American business practices. A key part of many M.B.A. programs is the case study, again developed in the U.S. context. The M.B.A. model has been widely copied in other countries, in most cases by local institutions, but also by American academic institutions working with local partners or setting up their own campuses overseas. While the programs sometimes are modified in keeping with the local context, the basic degree structure and curriculum remain American.

Another example of the export of the curriculum is the proposed incorporation of some general education in the first-degree. Part of the U.S. undergraduate curriculum for two centuries, general education provides a broad background in the disciplines along with critical thinking skills. *Higher Education in Developing Countries: Peril and Promise,* an influential report sponsored by the World Bank and UNESCO, advocates general education as an alternative to the existing largely specialized undergraduate curriculum common in higher education worldwide (Task Force on Higher Education, 2000). The future of general education as a curriculum reform is not clear.

There is an increasing use of common textbooks, course materials, and syllabi worldwide, stimulated by the influence of multinational publishers, the Internet, and databases, as well as the growing number of professors who return home after their study abroad with ideas concerning curriculum and instructional materials. These materials originate mainly in the large academic systems of the North—especially the United States, the United Kingdom, and France.

Disciplines and fields vary in terms of how globally homogenous they have become. Such fields as business administration, information technology, and biotechnology are almost entirely dominated by the major academic centers. Other fields—such as history, language studies, and many areas in the humanities—are largely nationally based, although foreign influences are felt in methodology and approaches to research and interpretation. The internationalization of the curriculum, like other aspects of globalization, proceeds largely from North to South.

The Multinationalization of Higher Education

The emergence of a global education marketplace exhibits itself in the form of a variety of multinational higher education initiatives—ranging from "twinning" programs linking academic institutions or programs in one country with counterparts in another to universities in one country setting up branch campuses in another. Cross-border higher education ventures include many that use the Internet and other distance education means to deliver their programs. Many for-profit companies and institutions have invested in multinational educational initiatives, as have a range of traditional higher education institutions (Observatory on Borderless Higher Education, 2004).

History shows that the export of educational institutions and the linking of institutions from different countries generally represented a union of unequals. Earlier "export models" involved colonialism—the colonial power simply imposed its institutional model and curriculum, often diluted and designed to for intellectual subservience, on the colonized (Ashby, 1966). In almost all cases, the institution from the outside dominated the local institution, or the new institution was based on foreign ideas and nonindigenous values. Examples include the British in Africa and Asia, the Dutch in what is now Indonesia, and French initiatives in Africa and Asia. The Spanish monarchy asked the Roman Catholic Church to set up universities in Latin America and the Philippines; religious orders such as the Jesuits undertook what might now be referred to as multinational higher education. In the 19th century, American Protestant missionaries established universities based on the U.S. model in Lebanon, Egypt, Korea and Turkey, among other places—for example, the American University of Beirut. During the Cold War, both the United States and the Soviet Union exported their academic institutions and ideas, mainly to the developing world, generally tied to foreign aid, and in some cases set up universities reflecting their views—such as the University of Nigeria-Nsukka (Hanson, 1968).

The same inequality is characteristic of the 21st century, although neither colonialism nor Cold War politics impels policy. Now, market forces, demands for access, and monetary gain motivate multinational higher education initiatives. When institutions or programs are exported from one country to another, academic models, curricula, and programs from the more powerful academic system prevail. Thus, programs between Australian and Malaysian institutions aimed at setting up new academic institutions in Malaysia are always designed by Australian institutions. Rarely, if ever, do academic innovations emanate from the periphery out to the center.

The export of academic institutions from one country to another is a growing but not entirely new phenomenon. Of course, both traditional colonialism and the government-sponsored foreign assistance programs of the Cold War era exported institutional models, practices, and curriculum from the metropole to developing countries. In the past decade, the number of institutional exports based on non-governmental programs have risen, usually on the initiative of the exporting country. In the 1980s, for example, American colleges and universities directed their attention to Japan as a higher education market. Several hundred U.S. institutions explored the Japanese market, and more than a dozen established campuses—usually in cooperation with a Japanese institution or company (Chambers & Cummings, 1990). A small number of Japanese institutions looked into the feasibility of a U.S. connection, with a few even setting up branch campuses. However, most Japanese programs involved bringing Japanese students to the United States for study, while U.S. programs focused on educating Japanese students in Japan. Generally, the institutions engaging in export activities were not the most prestigious schools. By 2000, very few of the branches were still operating. In Japan, the difficulty of obtaining Ministry of Education certification for U.S. programs proved overwhelming, and the initiatives on both sides were affected by the protracted economic slowdown in Japan. The U.S.–Japan initiatives were unusual in that both sides were industrialized countries.

Some of the export initiatives taking place today are indicative of global trends. A small number of prestigious American universities are establishing campuses worldwide, usually in popular professional fields such as business administration. The University of Chicago's business school now has a campus in Spain that offers Chicago degrees to Spanish students and students from other European countries, using the standard Chicago curriculum—taught in English mostly by Chicago faculty members—with an international focus. It includes a period of study at the home campus as well. Some other U.S. universities have developed similar programs.

An unusual but interesting model of multinationalization is being undertaken by Singapore, which is inviting a number of prestigious foreign universities, such as the University of Pennsylvania's Wharton School, to start programs in Singapore. The government carefully selects the institutions and provides incentives to encourage them to come to Singapore. Another trend has been the establishment of U.S.-style universities in such countries as Kyrgyzstan, Qatar, and Bulgaria, among other places. These schools typically originate through local initiative, and many have strong links to American universities. Some are supervised by the U.S. partners and accredited in the United States. The language of instruction is English and the curriculum U.S. based. The quality of these American clones varies considerably, with some simply capitalizing on the cachet of an American-style education.

In keeping with the standard export model, a university in an industrialized country will set up a program abroad, often but not always in a developing country, at the invitation of a host institution. The host may be an educational institution or a corporation without any link to education, or some combination of the two. Many examples of these arrangements have been set up in Malaysia to satisfy unmet demand by local students. Universities from Australia and the United Kingdom are most active in Malaysia, but the new programs have generated complaints of low quality, poor supervision, or inadequate communication between the providers and the hosts. In Israel, a number of small American colleges and universities (some of lesser quality) began to offer academic degrees when the market was opened up in the 1990s by the Israeli government. After considerable criticism, restrictions were later placed on the programs—many of which have ceased to exist.

In another export model, foreign academic degree programs are “franchised” by local institutions. The foreign university lends its name provides the curriculum, some (often quite limited) supervision, and quality control to a local academic institution or perhaps business firm. The new institution is granted the right to award a degree or certificate of the foreign institution to local students. Unfortunately, these franchising arrangements have led to many abuses and much criticism. Many articles have appeared in the British press charging that some U.K. institutions, mostly the less prestigious ones, involved in overseas programs are damaging the "good name" of British higher education. Meanwhile, "buyers" (fee-paying students) overseas think that they are getting a standard British degree, when in reality they are receiving the degree but not the level of education provided in the United Kingdom.

There are a large number of "twinning" programs worldwide. This arrangement links an academic institution in one country with a partner school in another. Typically, the university in the North provides the basic curriculum and orientation for an institution in the South. In such arrangements, academic degrees are often jointly awarded. Twinning has the advantage of aiding institutions in the South in developing new curricular offerings, with the stamp of approval of an established foreign university. Again, the higher education 'products' come from the North, often with little adaptation to local needs.

As can be seen in this brief discussion, there are many facets to the 21st century multinationalization of higher education. However, some common perspectives and motivations can be identified. With few exceptions, a central goal for all of the stakeholders, especially those in the North, is to earn a profit. Institutions in the South that are attracted to multinational initiatives may also be interested in making money, but they also want to meet the growing demand for higher education and for new degree programs that may not be available in local schools. As with other aspects of globalization in higher education, multinational arrangements between institutions are marked by inequality.

Information Technology

The information age carries the potential of introducing significant change in higher education, although it is unlikely that the basic functions of traditional academic institutions will be transformed. The elements of the revolution in information technology (IT) that are to transforming higher education include the communication, storage, and retrieval of knowledge (Castells, 2000). Libraries, once the repositories of books and journals, are now equally involved in providing access to databases, websites, and a range of IT-based products (Hawkins & Battin, 1998). Scholars increasingly use the Internet to undertake research and analysis and to disseminate their own work. Academic institutions are beginning to use IT to deliver degree programs and other curricula to students outside the campus. Distance education is rapidly growing both within countries and internationally. IT is beginning to shape teaching and learning and is affecting the management of academic institutions.

IT and globalization go hand in hand. Indeed, the Internet serves as the primary vehicle for the globalization of knowledge and communications. As with the other aspects of globalization, significant inequalities exist. Inevitably, the information and knowledge base available through the Internet reflects the realities of the knowledge system worldwide. The databases and retrieval mechanisms probably make it easier to access well-archived and electronically sophisticated scientific systems of the advanced industrialized countries than the less networked academic communities of the developing countries.

For scholars and scientists at universities and other institutions that lack good libraries, the Internet simplifies the obtaining of information. This change has had a democratizing effect on scientific communication and access to information. At the same time, however, many people in developing countries have only limited access to the Internet (Teferra, 2003). Africa, for example, has only recently achieved full connectivity to the Internet.

The Internet and the databases on it are dominated by the major universities in the North. The dominance of English on the Internet also affect access and usage of information. Multinational publishers and other corporations have become key players, owning many of the databases, journals, and other sources of information. Academic institutions and countries unable to pay for access to these information sources find it difficult to participate fully in the networks. Tightening copyright and other ownership restrictions through international treaties and regulations will further consolidate ownership and limit access (Correa, 2000).

Distance education, while not a new phenomenon, comprises another element of higher education profoundly affected by IT. The University of South Africa, for example, has been offering academic degrees through correspondence for many decades. The Open University in the United Kingdom has effectively used a combination of distance methods to deliver its highly regarded programs. IT has greatly expanded the reach and methodological sophistication of distance education, contributing to the growth of distance education institutions. Of the 10 largest distance education institutions in the world, seven are located in developing countries, and all use IT for at least part of their programs. Universities and other providers in the industrialized nations are beginning to employ IT to offer academic programs around the world, a significant portion of which are aimed at developing countries. Entire degree programs in fields such as business administration are offered through distance education on the Internet, and many providers view the international market as critical for the success of their programs. These providers include corporations, such as some of the major multinational publishers, for-profit educational providers like Sylvan Learning Systems, and others. Some universities now offer degree and certificate programs through the Internet to international audiences. Firms such as Microsoft, Motorola, and others are offering competency certificates and other training programs in fields relating to their areas of expertise.

As with the other aspects of globalization discussed in this analysis-the leading providers of IT consist of multinational corporations, academic institutions, and other organizations in the industrialized nations. The Internet combines a public service—e-mail and the range of websites to which access is free—with a commercial enterprise. Many databases, electronic journals, e-books, and related knowledge products are owned by profit-making companies that market them, often at prices that preclude access by those in developing countries.

Nevertheless, developing countries have been able to take advantage of IT. For example, most of the largest universities using distance education are located in developing countries. The African Virtual University is an effort by a number of African nations to harness the Internet and other distance techniques to meet their needs. AVU's success so far has been limited, and many of the courses and programs are based on curriculum from the North. E-mail is widely used to improve communication among scientists and scholars and to create networks in the developing world. While the information revolution will neither transform higher education, nor is it a panacea for the higher education needs of developing countries, it is one of the central elements of globalization in higher education.

International Agreements and Frameworks

In the new era of globalization in higher education, new international agreements and arrangements have been drawn up to manage global interactions. The arrangements between countries range from bilateral agreements on student and faculty exchanges to the mutual recognition of degrees—for example, the many binational commissions governing the American Fulbright scholarship and change programs. Of the current international agreements in higher education, perhaps the most comprehensive are the European Union's: the comprehensive Bologna framework, designed to introduce changes to harmonize the higher education systems of all EU member states, and specific exchange and scholarship programs such as ERASMUS and SOCRATES. In contrast, NAFTA, the North American Free Trade Agreement, ASEAN (the Association of Southeast Asian Nations), and others have few implications for higher education.

An indication of the potential impact of globalization is the debate over the inclusion of higher education in particular and knowledge industries within the framework of the WTO through the GATS proposal. While GATS has not yet been fully formulated and is not part of the WTO framework, it is relevant not only because of its influence but also for what it reveals about the reality of globalization. GATS seeks to establish "open markets" for knowledge products of all kinds—including higher education. The idea behind GATS and, for that matter, the concept of globalization is that knowledge is a commodity like any other and should be freely traded around the world. The proponents argue that free trade will benefit everyone by permitting competition in the marketplace of ideas and knowledge products.

GATS and related arrangements also seek to provide a legally binding framework for the circulation of educational services and for the protection of intellectual property (Knight, 2004, pp. 3–38). Thus, GATS and the WTO are very much related to TRIPS (Trade Related Intellectual Property) arrangements and copyright regulations. The motivating force behind all of these regulatory frameworks is to rationalize the global trade in knowledge and to ensure open markets and protections for the owners of knowledge products. The WTO and its related agreements, as well as international copyright, have the force of law—they are international treaties supported by a legal enforcement regime. These arrangements were created to protect the sellers and the providers, not the buyers and users, and as a result they have negative implications for developing countries (Raikhy, 2002). For example, copyright laws have been further strengthened to protect the owners of knowledge, while failing to open access through "fair use" provisions or meaningful special arrangements for developing countries.

Those favoring GATS and the regulatory framework in general are the sellers and owners—multinational knowledge companies, governments focusing on exports, and others (OECD, 2002). Testing companies such as the U.S.-based Educational Testing Service, multinational publishers, information technology and computer firms, for-profit educational providers such as Sylvan Learning Systems, and others are examples of businesses involved in global education that see GATS as benefiting their interests. In many countries, government agencies most focused on GATS include not the ministries of education but rather departments concerned with trade and export promotion. In the United States, it is the Department of Commerce that has taken the lead and not the Department of Education. In the United Kingdom, the Department of Trade and Industry has been in the forefront. Education groups in the United States, Canada, and a number of other countries have been skeptical or opposed to the GATS proposal. The American Council on Education, which represents most university presidents in the United States, for example, has spoken out against GATS. Developing countries have generally not yet taken a position on the concept of free trade in education and knowledge products.

While the complicated details of a GATS treaty have not been worked out, the basic issues are straightforward. Should education in all of its manifestations be considered as a commodity to be traded in the marketplace, regulated in the same fashion as are automobiles or bananas? As Lawrence Summers, the former U.S. Treasury Secretary and current President of Harvard University put it in a recent interview, "I'm skeptical as to whether bringing educational issues under the auspices of trade negotiations would be helpful. . .. To start with, many educational institutions are nonprofit, their motivations are different from the motivations of commercial firms that we think of in a trade context. There may be some egregious practices that should be addressed, but I would be skeptical about treating education in a way that had any parallels with financial services, with insurance, or with foreign investments" (The World According to Larry, 2002, p. 38).

While GATS would bring developing countries into a global framework of commerce and exchange in higher education, it would remove aspects of autonomy from educational decision-making. Extending the principle of free trade to education would open national markets in signatory countries to testing companies, providers of distance education, and many other organizations. Regulation or control of these entities would prove difficult if not impossible to achieve. Institutions or companies could, in principle, count on having access to foreign education markets. Since developing countries typically import rather than export their educational products or institutions, it is unlikely that GATS would promote their exports. Developing countries represent the markets that sellers from the industrialized world are eager to target. Most developing countries, having few educational "products" to export, would be at the mercy of the multinational providers.

Current arrangements—in which all countries retain authority over educational imports and exports, subject to some regulatory arrangement such as international copyright, patent treaties, local accreditation and licensing arrangements, and the like—nonetheless permit a great deal of international higher education exchange, as this essay illustrates. It can be argued that international education markets are already appropriately open, and additional legal requirements to open them further are not needed. Cross-border educational transactions of all kinds are being actively pursued worldwide. At present, the developing countries are the main importers of products and services from abroad—and they would be most directly affected by GATS.

Conclusion

Globalization in higher education and science is inevitable. Historically, academe has always been international in scope and has always been characterized by inequalities. Modern technology, the Internet, the increasing ease of communication, and the flow of students and highly educated personnel across borders enhances globalization. No academic system can exist by itself in the world of the 21st century.

The challenge is recognize the complexities and nuances of the global higher education context—an academic world fraught with inequalities in which market and commercial forces increasingly dominate. The traditional domination of the North over the South remains largely intact. The task of ameliorating inequalities in the context of mass higher education is not an easy one. Yet, it is important to ensure that globalization does not turn into the neocolonialism of the 21st century.

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Appendix 1

Twinning and Branch Campuses: The Professorial Obstacle

PHILIP G. ALTBACH

Branch campuses, twinning arrangements, and other manifestations of cross-border higher education are booming. Universities in Europe, Australasia, and North America see a huge market by offering their degrees in other countries. At the same time, Singapore and several of the states in the Arabian Gulf have identified themselves as educational centers and are attracting international higher education providers. In the Gulf, there is even competition for attracting overseas universities. China has opened its doors to foreign institutions, and India is moving in this direction.

While there are no accurate numbers, more than 500 branch campuses exist worldwide—plus thousands of "twinned" programs. In addition, the phenomenon of the "American University of . . ." manifests another trend in cross-border higher education. There are a dozen or more such universities, some of which have a direct link with a U.S. university while many simply use the name "American" and offer a U.S.-style curriculum in English in a non-U.S. setting. If the General Agreement on Trade in Services (GATS) becomes part of the structure of international academic arrangements, the numbers of all kinds of cross-border institutions will increase even faster.

One significant problem exists with these arrangements. Who is teaching the students at these branch campuses? What does a degree from a university signify if the teaching staff are not from the university offering the degree? To use the McDonald's analogy—is the meal (degree) a true McDonald's hamburger if only the recipe (the curriculum) comes from McDonalds. The rest of the process—the ingredients (facilities) and the cooks (professors)—are local, rather than from the sponsoring institution. Should a university in the United Kingdom (or another country) claim to offer a degree overseas if only the curriculum is from the sponsoring school, perhaps along with an element of quality control?

With little data indicating the proportion of faculty members from the home universities teaching at branch or twinning campuses, anecdotal evidence shows that the numbers are small and most of the teaching is carried out by professors who are not faculty from the sponsoring institution. Even when they do come from the home university, faculty teaching at branch or twinned campuses are generally not the "star" research-active professors.

It is not known if some of the recent high-prestige universities that have entered the branch campus business—the University of Chicago, the Cornell University Medical School, the University of Nottingham, and others—have a different profile than the many more average institutions thus far engaged.

The Background of Teachers

Many faculty members are hired locally—some "moonlighting" from a local university. Other "local hires" are full-time staff, obtained from the local academic market or attracted away from local or regional institutions. Some faculty are natives of the country of the sponsoring university but not faculty members at that institution. For example, an American university in Singapore might hire an American working in Japan or Taiwan. Ph.D. holders who are teaching part time or on short-term assignments in the home country may also be attracted to work overseas. The sponsoring university generally tries to ensure that these faculty have a doctoral degree from a respectable institution—insofar as possible from the country where the sponsoring university is located.

Attracting Top-Quality Faculty

At branch campuses this task may not be easy, particularly on an assignment of a year or more. Except for a few specialists in the culture where the branch is located or professors committed to learning about foreign cultures, an overseas assignment as a full-time member of the academic staff at a university in Europe, North America, or Australia may not lure prominent faculty. In addition to the challenges of uprooting families, finding schools for children, and the like, an overseas assignment disrupts the rhythm of academic life. For younger professors seeking to obtain tenure and promotion, an overseas assignment is particularly dangerous. It will inevitably disrupt a research agenda and in the sciences may make research impossible given the lack of equivalent laboratory equipment and staff. Since branch campuses are always oriented toward teaching rather than research, teaching loads are often higher than at the home university. Libraries and other facilities are never the same either.

Many branch campuses offer faculty members from the home university additional perquisites—such as housing, transportation for families, payment of school fees, and others. In some cases, salary supplements are provided, and there is usually a tax advantage. But even these benefits may not produce a sufficient attraction.

As a result of these factors, the professors teaching at branch campuses are seldom full-time research-active faculty from the home university. If from the home institution, they are often senior staff close to retirement or those with fewer commitments at home. Most are not from the home university. Relevant academic departments at home often must approve the academic qualifications of these professors and offer them some kind of temporary appointment to legitimize their appointments.

Conclusion

Does an academic degree mean that a student has studied at the university offering the degree? Does it mean that he or she has been taught by the faculty of that institution? Does it mean that the curriculum and language of instruction of the home university have been used? Is it enough that the home institution has approved the qualifications of the teaching staff and that the general conditions of teaching are considered to be satisfactory? Should teaching be provided by faculty members who are actually on the home institution's staff, or is it acceptable that an itinerant but qualified collection of teachers do the work? Is it acceptable that the prestigious universities whose fame in their home countries is based on excellence in research as well as teaching provide an academic environment in the branch campus almost exclusively devoid of research? Cross-border academic cooperation and transnational higher education are characteristics of the 21st century, but it is necessary to carefully examine the realities in order to assess quality and effectiveness.

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Appendix 2

JULY 2007

International Branch Campus Issues

LAURA E. RUMBLEY AND PHILIP G. ALTBACH

This memorandum is intended to provide an introduction to some of the key issues relating to the phenomenon of branch campuses worldwide. We mainly summarize some of the key points made in L. Verbik and C. Merkley, (2006). *The International Branch Campus: Models and Trends,* published by the Observatory on Borderless Higher Education, London. Additional insights are added as well. This memo and the OBHE report provide an overview of branch campuses, with data from a variety of countries. A new report specifically on U.S. branch campuses abroad, Madeleine Green, et al., (2007). *Venturing Abroad: Delivering U.S. Degrees Through Overseas Branch Campuses and Programs,* published by the American Council on Education, provides some detail on the U.S. experience. The authors note that there is no comprehensive analysis of this theme anywhere and no reliable statistics concerning the extent of the phenomenon. The demise, just a month ago, of the Australian University of New South Wales' campus in Singapore after considerable investment and effort by UNSW, and problems with other Australian initiatives, is an indication of the volatility of this sector.

Overview

- Significant growth over past decade
- U.S. leads internationally with in terms of overseas branch campus activity but "more and more countries are engaging in branch campus development" (p. 2)
- Diverse geographic spread of initiatives, but "financial incentives" do seem to spur activity in particular countries/regions
- three main approaches to establishing/funding branch campus are identified:
    1. self-funding
    2. external funding-more common among newer initiatives
    3. provision of facilities-more common among newer initiatives

U.S. has had branch campuses overseas since at least the 1950s

- Originally designed for institutions' own study abroad students or locally based U.S. military personnel
- Since 1990s—much bigger operations (in terms of both academic activities and physical plant) catering to local and/or international students

Why?

- Concerns over quality and ed provision abroad in situations where the home institution didn't have total control
- Incentives—external support and/or regulatory environments favoring branch campus developments
- Interest in diversifying and becoming less dependent on international student recruitment to the home campus

Other issues driving/informing OBHE study

- No official, comprehensive list of international branch campuses appears to exist anywhere.
- Lack of global consensus on a definition of branch campuses.
- "little to suggest that branch campus development has peaked" (p. 24), although it may have reached a "saturation point" in some places, such as Singapore and Hong Kong.
- Growth driven by opportunities for external funding, increased competition in int'l ed and greater regulation of transnational ed around the world.
- However, nothing indicates that "fully-fledged branch campuses will become the dominant type of transnational education in the near future" (p. 24), given their resource intensiveness and the "significant financial and reputation risks" (p. 24) that accompany them.

Definitions

Some subjectivity involved in determining what exactly a branch campus is. The OBHE puts forth the following as a definition of a branch campus:

". . .an offshore operation of a higher ed institution which fulfils the following criteria:

- The unit should be operated by the institution or through a joint-venture in which the institution is a partner (some countries require foreign providers to partner with a local organization) in the name of the foreign institution.
- Upon successful completion of the study programme, students are awarded a degree from the foreign institution."

OBHE's report excludes

- joint degree programs
- institutions where one or more foreign or domestic institution's programs are offered
- programs offered through a partner institution
- branch campuses that have evolved into fairly independent institutions in their own right
- "foreign-backed" universities (p. 4)
- "international universities" modeled on a foreign country's higher ed system but without formal ties to a specific institution (American University of Beirut, of Cairo, etc.)

Opportunities

Rationales

- To diversify modes of delivery to international students and be less dependent on recruitment to the home campus
- To collaborate more easily with foreign academic institutions and industries
- To generate revenue
- For strategic internationalization
- To reach new markets and students
- To contribute to HE capacity building in countries with less developed HE sectors
- To enhance overall international profile and reputation
- To reclaim/reframe historical linkages to contemporary advantage

Benefits

- Control over ed provision and quality
- Simplicity—no need to enter into potentially complicated partnerships
- Establishment of "a full and distinctive corporate presence in another country"
- Brand name enhancement
- Competitive advantage over competitors' offerings

Risks

Info about risks appears to be more widely available, and more regularly accessed, now than in previous years.

Branch campus development must be understood as an entrepreneurial activity that (a) implies a certain amount of risk that must be understood and accepted going in, and (b) may not yield positive results (espec. financially) for some time, although "brand recognition" and reputation enhancement may come more quickly.

Risk areas include:

- Financial loss—these risks tend to be greatest
- Operational challenges
- Market fluctuations
- Damage to institutional reputation—these are also fairly considerable risks

Regulations:

- Complex and fast-changing landscape for national regulation of transnational provision

- Relatively few countries have specific regs in place for foreign providers, but this number is growing—South Africa's effort to tighten its regulatory framework has had a major impact on foreign providers there by demanding a much higher level of commitment to quality, planning, oversight, and transparency of operations (OBHE *Breaking News Article*—6th August 2002)
- Also growing are the numbers of countries seeking to regulate the export activities of their HE institutions (major examples being the UK and Australia)—trying to ensure that provision abroad is comparable in quality to provision at home

Major Players

Branch campus providers:

- OBHE's report identifies 82 international branch campuses.
- North to South trend dominates
- U.S. clearly dominates (50 percent), followed by Australia (12 percent—has been more active than the UK for a full decade), the UK (five percent—more recently pursuing branch campuses than Australia), and Ireland (five percent)
- South to South activity is rare (India and Pakistan the rare exporters to places like Dubai's Knowledge Village)

Why U.S. dominance?

- History—have been setting up overseas operations for several decades
- Invitations—have been actively courted by proactive hosts (Singapore, Qatar, etc.)
- Post-9/11 environment-perception is it may be easier to take the ed overseas than get the students into the U.S.

Branch campus hosts:

- UAE (20 percent)—almost all in its Knowledge Village
- Qatar (nine percent)
- Singapore (seven percent)
- Canada (six percent)
- Malaysia (six percent)—[good overview on situation in Malaysia in OBHE *Breaking News Article*—11th November 2004]
- China (five percent)
- Support, funding, and infrastructure make all the difference in terms of attracting branch campuses

Providers and hosts:

- UK
- Australia—[A lot going on here. On the one hand, Australia has had some highly public setbacks in terms of overseas failures in the last year and is seen to be reigning in this activity to some degree, shutting down some operations abroad (see OBHE *Breaking News Articles*—1st June and 10th July 2007) and applying tighter quality assurance controls (see Aussie govt's *Transnational Quality Strategy*). Meanwhile, the development of South Australia's 'University City' initiative raises Australia's profile as a branch campus host in its own right.]
- Canada
- Netherlands
- France

*"The only country which seems to be almost untouched by branch campus developments is the U.S., which in general exhibits very limited transnational activity." Interest by Latin American universities in the growing U.S. Hispanic community may change this reality over time. There is evidence that this situation has changed since the OBHE.

Branch campus interests, activities, and characteristics

Degrees and subjects

- 23 percent offer only Bachelor's degrees
- 58 percent up to Master's degrees

- five percent up to Ph.D. level
- five percent offer pre-Bachelor's only programming
- 66 percent teach more than one subject area
- 74 percent offer some courses in either business, IT, or both

Facilities, enrollment, and tuition

- Fairly incomplete for the 82 institutions included in the study (see p. 9)

Funding

- Model A—Fully funded by institution
  - May be a fading model, as more institutions seek collaborative arrangements, although the benefit of this model is autonomy of decision-making and quality control
- Model B—External funding
  - Funding may come from host government funds/support or private companies or other orgs, in the home or host countries, or elsewhere
  - This model has come on the scene mostly during the last decade
  - Often linked to a national strategy for internationalization by the host country
  - Obvious benefits, however institutions need to carefully consider issues of mission and whether they can cover costs not provided for by the host.
- Model C—Facilities provided
  - Newest model but quickly growing
  - Key examples are Knowledge Village (KV) (est. 2002, Dubai) and Education City (EC) (est. late 1990s, Qatar)
  - Most often found in economically advanced states of the Gulf due to availability of resources (public and private $), lack of local HE capacity (i.e., need and interest in developing this), and a concentrated strategy for reform of local economy (e.g., moving away from reliance on oil revenues)
  - South Korea and to some extent Japan seem to be moving toward "special zones" for foreign investment to facilitate developments along these lines but don't have the investment resources of KV and EC.

Underhill, W. (2006, August 21). Sowing seeds: From Cornell in Qatar to Monash in Malaysia, satellite campuses are a booming business. *Newsweek, International Edition.*

"When it comes to education, location isn't everything; provenance is." (Underhill, W.)

"A branch campus is about commitment—not just renting out your name" (Stéphan Vincent-Lancrin, OECD)

Number and diversity of players in international branch campus game are expanding:

- For the U.S., this means more competition in this area
- lesser-known (particularly non-U.S.) universities expanding abroad have less to lose and more to gain, whereas big-name U.S. universities have a lot on the line in terms of their already-established international reputations/"brand names"

Benefits of the branch campus movement are multi-faceted:

- Students get good educational options without the costs of travel
- Host countries get "top-rated schools to plug the gaps in their own educational systems"
- Local economies gain access to research facilities for economic development and income from students attracted from throughout the region
- Incoming institutions are able to internationalize their profiles and reputations, and can provide good overseas gigs for their faculty and students while exercising potentially better quality control than through distance education on franchising
- The U.S. can reap important public diplomacy benefits—"This is a good way for the United States to represent itself overseas, particularly in Arab coun-

tries where in the past most of the trae has been in guns and oil" (Antonio Gotto, dean of Weill Cornell Medical College in Qatar's Education City)

Challenges:

- Meeting host governments' expectations, including "performance targets" tied to ongoing financial support
- Potential exists for flat-out "bad fits" (LER's term), in the form of culture clashes and low enrollments, etc. (à la U.S. expansion into Japan in 1980s)

Imperatives:

- Government support for higher education in many countries (U.S., UK, Australia) is falling, making it important for institutions to generate new sources of income
- International student recruitment to home campuses is becoming increasingly more competitive globally
- More home-grown options for HE are cropping up around the world (good example being China), so it makes sense to start competing on that turf
- More English-language programs are available in more places around the world—U.S. can't expect students to continue coming here for that reason, and have new opportunities to compete in English-speaking environments in many more countries

Key Issues and Questions

Branch campuses seem to make good sense and have good potential for long-term success under the following conditions:

- Generalized economic growth and dynamism in the host country
- Unmet demand for higher education in the host country
- Widespread use of English in the host country
- Meaningful host country incentives to foreign providers, in the form of funding, facilities, favorable tax and/or regulatory arrangements, etc.
- Host country interest in curbing the outflow of domestic students and professionals through study abroad and brain drain
- Reasonable levels of competition among foreign providers in the host country or region
- Sound strategic planning to balance higher education imports and domestic capacity in ways that benefit both sides
- Stable, transparent, and appropriate regulatory environments for foreign providers (for accreditation, quality assurance, etc.)
- Host country-foreign provider relationships that are built on the concepts of partnership and commitment

Branch campus experiments can end disastrously:

- Closure of University of La Verne Athens in Fall 2004 (OBHE *Breaking News Article*—1st November 2004) provides example of a situation with multiple layers of problems
    - Questionable internal controls
    - Poor management of relationship with Greek partner
    - Insufficient oversight of foreign/private educational provision by Greek authorities
    - Very negative financial, political, legal, and public relations consequences
- UNSW Asia was launched in Singapore by Australia's University of New South Wales in an effort to establish Asia's first foreign comprehensive university. It closed its doors on 28 June 2007 after just a few months of operation, citing an unviable financial outlook, mostly due to poor enrollment levels—current and projected. Major issues: tuition (was very high, prompting the question "why not just go to nearby Australia itself at that cost?"); programming (does Singapore just lend itself more naturally to specialized foreign programming rather than a comprehensive university?); poor financial planning ("'You can' set up such a big venture without an established stream of income," claims Professor Simon Marginson. . . "because you can't subsidise the majority of your costs for very long.")

Host countries may have various rationales for seeking to import branch campuses:

- Qatar appears to have both foreign policy objectives and domestic educational and economic development goals: "Qatar, which is an ally of the American government and currently hosts the Pentagon's Middle Eastern headquarters for the war in Iraq, is aiming to improve the quality of education for its citizens, while increasing its ties with the United States" (OBHE *Breaking News Article*—2nd April 2003)
- Presence of competitive foreign branch campuses can be used to address unmet demand for higher ed in-country, and be a tool for improving domestic higher ed provision over time, as in Malyasia (OBHE *Breaking News Article*—11th November 2004)
- The planned "University City" in the state of South Australia seems to be the first example of a Western country actively courting international branch campuses. The goal seems to be to continue to attract large numbers of Asian-Pacific students to Australia; raise the level of research and overall competitive performance of Australian higher education, by placing high-quality foreign providers in the mix; and derive real economic benefits for the local economy hosting the institutions

Important tensions are revealed in the international branch campus movement in some contexts

- Taiwan, for example, appears to have authorized foreign provision of higher education "'in order to comply' with WTO negotiations, but did not necessarily reflect a desire to open up the market to foreign institutions" (OBHE *Breaking News Article*—10th May 2005), since it already has excess capacity. Along with Japan and Korea, Taiwan struggles "with wanting to both protect and challenge domestic higher education, and both internationalise and retain a strong national identity" (OBHE *Breaking News Article*—10th May 2005).
- In Greek Cyprus, the government's support of a branch of Harvard University's School of Public Health has prompted outcry from the local higher education sector, particularly private universities. Private colleges there have "long complained of second-class status" and are critical of the government's plan to "lavish millions on a prestigious foreign university rather than support domestic providers" (OBHE *Breaking News Article*—11th June 2004)
- In Vietnam, government and international donor agency support of foreign institutions (Australia's RMIT and U.S.'s Roger Williams University [whose branch campus in Vietnam is called American Pacific University] has been criticized by locals who argue that "the funding should have been invested in bolstering the research capabilities of existing universities." In addition, critics say that the high tuition charged and only modest scholarship programs offered by the foreign institutions do not serve national objectives to educate more underprivileged students, nor are the 'Western-oriented' curricula, ESL, and U.S.-based college prep courses relevant to Vietnam (OBHE *Breaking News Article*—14th January 2006).
- The India Institute of Management-Bangalore (IIM–B) was initially thwarted initially the government of India in its effort to accept Singapore's invitation to establish an operation there. "India's Human Resource Development Ministry did not express the necessary support for the venture (the current charter for the institutions reportedly does not permit offshore operations and would have to be amended) citing the need for all six IIMs to focus on meeting domestic demand for high quality education, rather than spending time and resources catering for students abroad" (OBHE *Breaking News Article*—6th February 2006).

  Beyond this specific example, it's interesting to note that "discussions about foreign provision [in India] seem to have been dominated by rhetoric emphasizing the negative aspects of transnational education. . .However, with significant unmet demand, higher education participation rates of less than 10 percent, problems of brain-drain and under-funding. . ., policy-makers may find it hard to employ or uphold a protectionist stance on the import of foreign education. In addition, with (an albeit limited number of) Indian institutions looking to offer courses abroad and a range of bilateral trade agreements with other countries in place, India will find it increasingly difficult to justify attempts to prevent foreign providers from entering the country" (OBHE *Breaking News Article*—6th February 2006)

Proactive host countries have different strategies for attracting foreign branch campuses:

- Qatar offers significant financial incentives (OBHE *Breaking News Article*—2nd April 2003)
- Singapore offers access to Asian markets and the opportunity for incoming institutions to raise their international reputations and profiles (OBHE *Breaking News Article*—2nd April 2003)
- South Korea (OBHE *Breaking News Article*—16th September 2005) and Japan (OBHE *Breaking News Article*—24th March 2006) are exploring special investment zones and other incentives to make themselves more attractive to high quality foreign providers (both are cited in the OBHE branch campus report)
- Thailand touts itself as a safe, central, cost-effective location for foreign providers, and is explicitly linking internationalization to widespread systemic reform of the higher ed sector. Interestingly, there was talk of the establishment of a branch of Al-Azhar university to serve the region's Muslim population, but LER can't find any evidence that that's happened yet as of 2007. . . Likewise, OBHE reported that Thailand had been selected to host China's first-ever foreign branch campus, affiliated with Jinan University, which focuses on educating China's non-mainland populations—but LER can't find any evidence that that's happened yet as of 2007. . . (OBHE *Breaking News Article*—12th March 2004)

Some countries present special challenges for foreign providers:

- Security questions in the Middle East (OBHE *Breaking News Article*—2nd April 2003)
- Repressive governments or societies, for example in the Middle East (OBHE *Breaking News Article*—2nd April 2003)
- Government interference in curricula, for example in Vietnam where Communist ideology course requirements have been instituted (*Chronicle of Higher Education,* 24 June 2005)
- National language and religious/moral education requirements, for example in Malyasia (OBHE *Breaking News Article*—11th November 2004)

Branch campuses can fulfill unique roles in some societies—consider the fact that such a large percentage of female students is enrolling in Qatar's Education City programs (Cornell's Medical School program there is 70 percent female). What are the longer-term ramifications of this? The unintended consequences, positive and negative?

Increasing geographic diversity for branch campus expansion:

- Netherlands Business School (NBS) in Nigeria (OBHE *Breaking News Article*—4th April 2004). Why Nigeria?
    - ○ Huge youth population—potential for market expansion
    - ○ Widespread use of English language in Nigeria—not a lot of use of Dutch around the world and the Netherlands already has a lot of experience providing high-quality academic programs in English!
    - ○ High unmet local demand for higher education in Nigeria
  - NBS is starting small and working with a local partner (African Leadership Forum, ALF) with whom it has a compatible mission
  - NBS is targeting individuals in senior positions—LER's thought: wisely taking a low-risk strategy to begin
  - Netherlands has already been "crowded out in the major Asian markets by universities from Australia, UK and USA" so they've decided to focus on "innovation and competitive advantage, whether in terms of subject niches [e.g., technical education in Singapore], cultural affiliations [in Indonesia and South Africa], or underdeveloped markets such as Nigeria"
  - Challenge for Netherlands in Nigeria is the sustainability of economic and democratic reforms on the ground.
- Chile in Ecuador (OBHE, *The International Branch Campus,* 2006 report)
- India in Singapore and UAE (OBHE, *The International Branch Campus,* 2006 report)
- Iran in UAE (OBHE, *The International Branch Campus,* 2006 report)

- Ireland in Bahrain, Malaysia, Pakistan, and UAE (OBHE, *The International Branch Campus,* 2006 report)
- Italy in Argentina (OBHE, *The International Branch Campus,* 2006 report)
- Pakistan in Kenya (OBHE, *The International Branch Campus,* 2006 report)
- Philippines in Vietnam (OBHE, *The International Branch Campus,* 2006 report)
- Mexico possibly in the U.S. (OBHE, *The International Branch Campus,* 2006 report)

Field of regional education hubs getting more crowded

- Now four Middle Eastern hubs for transnational education:
    - Knowledge Village (Dubai, UAE)
    - University City (Shar'jah, UAE)
    - Education City (Qatar)
    - Higher Education City (Bahrain, as of 2007), described in-depth in OBHE *Breaking News Article*—16th January 2007
  - and a 5th in planning stages:
    - Academic City, (Abu Dhabi, UAE)
- In Asia:
  - "Study Korea" project aims to raise number of international students studying in South Korea from 17,000 to 50,000 over the next five years,
  - Australia builds its "University City" in South Australia
  - Singapore consolidates its position
  - Malaysia aspires to more international students
  - Thailand trying to position itself as a friendly, lower-cost destination for the region's mobile students

This involves a lot of branch campus activity—are we reaching/will we reach a saturation point here? how many "regional education hubs" can any one region sustain?—question also raised by OBHE *Breaking News Article*—16th January 2007

Concluding Thoughts

- Commitment and long-term planning seem to be key when it comes to branch campus success. Rather than making the decision to establish a branch campus *strictly* for financial and branding reasons, it seems that institutions would be wise approach the establishment of a branch campus in almost the same way as they consider the establishment of a fully-fledged new college or university—**what role is this institution meant to play over time in a particular set of institutional, local, national, and international contexts? This is actually a very complex question!**
- In addition to the significant amount of real activity going on, there's also a lot of "vaporware" out there, i.e., there's a lot of talk about branch campuses that never materialize into anything. Branch campuses are big, shiny manifestations of internationalization, but they're not the only part of the phenomenon that matters.
- At the present time, branch campuses, like much else in the broad area of higher education internatinalization, is a "wild west" of unregulated, often ill thought out, initiatives by a host of players—governments, private enterprise, academic institutions (for profits and non-profits) and others.

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BIOGRAPHY FOR PHILIP G. ALTBACH

Philip G. Altbach is J. Donald Monan, S.J. Professor of Higher Education and Director of the Center for International Higher Education in the Lynch School of Education at Boston College. He has been a senior associate of the Carnegie Foundation for the Advancement of Teaching, and served as Editor of the *Review of Higher Education, Comparative Education Review,* and as an Editor of *Educational Policy.* He is author of *Comparative Higher Education, Student Politics in America,* and other books. He co-edited the *International Handbook of Higher Education.* Dr. Altbach holds the B.A., M.A. and Ph.D degrees from the University of Chicago. He has taught the University of Wisconsin–Madison and the State University of New York at Buffalo, where he directed the Comparative Education Center, and chaired the Department of Educational Organization, Administration and Policy, and was a post-doctoral fellow and lecturer on education at Harvard University. He is a Guest Professor at the Institute of Higher Education at Peking University in the Peoples Republic of China, and has been a Visiting Professor at Stanford University, the Institut de Sciences Politique in Paris, and at the University of Bombay in India. Dr. Altbach has been a Fulbright scholar in India, and in Malaysia and Singapore. He has had awards from the Japan Society for the Promotion of Science and the German Academic Exchange Service (DAAD), has been Onwell Fellow at the University of Hong Kong, and a senior scholar of the Taiwan Government. He was the 2004–2006 Distinguished Scholar Leader of the New Century Scholars initiative of the Fulbright program.

DISCUSSION

Mr. BAIRD. I really thank all the witnesses for just fascinating and stimulating discussion on a very intriguing topic.

Dr. Skorton, I especially share your commitment to the role of universities and academic environment to international collaboration and understanding. You know, one of my goals as Chair of the Subcommittee on Research and Science Education is the concept of science diplomacy, finding ways where we can bridge gaps that may emerge in politics, religion, culture, et cetera, and using the science and academic endeavor to bring people together.

Dr. Schuster, I also appreciated very much your insights. We tend to look at this as oh my goodness, American universities are giving something valuable, that is uniquely American, away to the other countries. I think you pointed out well that there are many countries that actually do things better than us, and we can learn from our presence there, and that, thereby, benefits us, because we are not just giving our vast superior knowledge in every universal field away. We actually can go to places where they are ahead of us, which we tend to forget sometimes here.

Mr. Wessel, I appreciated your comment that policy is both science and art. Hang around here long enough, you will learn it is more artifact than art. And Dr. Altbach, the historical insights are well taken. This is, indeed, not necessarily an immediately new phenomenon.

One of the questions I have is, I have come to appreciate the incredible value that has derived to our society from foreign students who have come here and gained their undergraduate or graduate degrees, and then go back to the home country with not only knowledge that they serve their own country with, but in many and most cases, I think a deep affection for our country.

As we establish branch campuses overseas, will we see a decline in the number of foreign students who come here, and hence, a potential indirect decline in that kind of emotional tie to our own Nation, that carries all sorts of benefits? Any thoughts on that?

Dr. SCHUSTER. Let me answer first. And that is something that is of interest and a little bit of concern to us as well, at Georgia Tech. In the programs that we are establishing abroad, particularly the graduate programs at the Master's and at the Ph.D. level, a part of the curriculum expects those students to spend a semester or a year on the Atlanta campus, for exactly the purpose that you identified, to give them an experience of the American research university and the American culture. And we believe that that will strengthen the ties, and expand our ability to build relationships, and use science as diplomacy around the world.

Mr. WESSEL. I agree with Dr. Schuster. It is hard to say at this stage, but the early evidence that we have is actually quite promising on this. We opened a campus in Kobe, Japan, about two years ago, and I have seen at my school applications from Japanese government officials and private sector folks actually increased as a result of the increased visibility that we have.

We never had Australian students at our campus, and because we have developed our campus in Pittsburgh, and because we have developed an integrated curriculum across our two campuses, we now have students going back and forth between those two campuses, and we have Australian students in Pittsburgh, and U.S. students taking part of their studies abroad.

So, I actually am cautiously optimistic about the impact on this in our home campus.

Dr. ALTBACH. Actually, I am highly optimistic that there will not be a decline in international student numbers coming to the U.S. If you look at the projections in the outyears, the demand for international higher education, be it from students who want to go to a different country, and there are many motivations for people who want to go to different countries, including immigration, which is going to continue, those numbers seem to be quite significant.

So, I think the establishment of branch campuses of American universities overseas will not affect overall students numbers coming here, and may, as my colleagues have said, actually improve the quality of students coming to this country, because they will know better what they are getting into, and have an exposure already to U.S. higher education.

I might point out one other thing slightly related to your question, and that is, if you look at overseas student enrollments over a long period of time in the U.S., you will find that very significant numbers have not gone home, and that has benefits to our country, and of course, you know, American policy-makers have been concerned about maintaining in some ways the numbers from overseas who contribute to S&T in this country. But the big sending countries, India and China, over time, 75 percent or so of their graduates, this is over 20 years, have remained in the United States after their graduation. So, this is a very significant number, and we need to examine what this means for our economy, and of course, what it means for their economies, as well.

And one final little point. That is, to me, the big determinant on numbers of foreign students is not branch campuses. It is U.S. policy welcoming, making possible for international students to come to this country. Visa restrictions and all that stuff that you are well aware of.

Thank you.

Dr. SKORTON. As Yogi Berra has said, or as attributed to him: "It is hard to predict, especially about the future." And I agree with my colleagues, in terms of the, we are about all of the same generation, in terms of how we grew up in higher education.

I want to sound a slightly dissonant note, though, with my colleagues. I think that thinking about American higher education as an economic sector, just for a moment, we consider it a calling, of course, but it is also a business, an economic sector. I am not complacent about our ability to continue to compete in the world. These are selective schools you see in front of you, who get many more applications than we can accept students, both domestic and international.

Overall, we have very, very serious competition from international institutions in the developed world, in Australia, the UK, Europe, and elsewhere, and a rising tide of competition coming from China and India. The Indian government has been advised to quadruple the number of universities in India over the next 15 years, quadruple. And the population changes, the foreign competition, and other matters may make the answer to this question different ten years from now than it is now. I am not sure what the effect will be.

There are two other factors. One, to repeat what Dr. Altbach said, the ease or lack of ease of getting in the country, staying in the country, leaving the country on a brief visit, is a very, very tough sweet spot to find. We are all concerned about this on this panel. We are also very concerned about national security.

And secondly, I think a very, very important final comment is that the ability of our universities to offer something unique and different at a cost that people can afford is another factor, and I would only speak for my own university, and of private universities in the country, that it is a very expensive proposition, and the ability of international students to find resources to meet those financial obligations are also a big challenge.

So, in summary, I agree that right now, we are not concerned that the branch campuses will directly impact our ability to share the American experience with people from overseas, but I think in the long run, we cannot be complacent about this aspect of the American economy, either.

Mr. BAIRD. Mr. Hall.

Mr. HALL. Thank you. Dr. Skorton, your testimony argues that the U.S. needs to continue attracting "the best and brightest students, staff, and faculty members to remain competitive." And in addition, you argue that we ought to invest in teaching and research abroad to "spur economic growth."

Are these two goals on the same level, mutually exclusive, and how can we provide both equal educational opportunities abroad, if we are seeking the benefits here?

Dr. SKORTON. Mr. Hall, this is the $64,000 Question. It is a balancing act that we have to deal with in this country. I call your attention to work by the Business Higher Education Forum over the last few years, including a Congressional hearing about five weeks ago, about the crisis in the pipeline for STEM graduates in the United States.

And not to take up more than my time, but I am glad later to give to the Committee staff abundant data from the Business Higher Education Forum and other sources that shows the tremendous work that we have to do to maintain a robust pipeline of teachers and students in STEM disciplines in this country.

So, I want to say, and I want to make this point very strongly, we do need the best and the brightest from overseas. Depending on the American university that one talks about and looks into, perhaps as much as 50 percent of the graduate student population in some mathematical, physical science, and engineering disciplines, and perhaps as much as 30 percent of the graduate student population in some life science disciplines, are international in focus. So, I need, and I would hasten to say we need the brightest international students for our programs.

By the same token, these clichés about the world being flat and so on are actually true, and just as multinational corporations do everything from R&D to marketing to product development around the world, so innovation is an international phenomenon. And so, in fact, I don't really see them as mutually exclusive. The question will be, as we build up the strength overseas, will we bump into each other going in the door? That is what you are asking me. Right now, the answer is no. Make no mistake about it. We accrue the main benefit in this country of international collaborations, but we have to keep an eye on it, and we do not collect data as robustly and crisply to answer many of the questions that you have raised.

Mr. HALL. And the cost, and the other question by the chairman here, are the costs equivalent to the U.S., campus costs for an attendee, are they equivalent to our cost here, that you charge them to attend?

Dr. SKORTON. I wouldn't want to speak broadly about all branch campuses, but we are, I believe it was Dr. Schuster who used the word revenue-neutral, and the idea would be whatever the costs are, and they are going to depend on the sort of operation that it is, it will cost a different kind of expense to train a physician or an engineer than it will cost to train someone in a humanities discipline or a social science discipline. But I think in general, we have to operate under the idea that it will be revenue-neutral. And so overall, whatever the cost of education is, we have to find a way to retire that.

I know you know this, Mr. Hall. I just want to remind you that the cost of paying for higher education in this country is a complicated crazy quilt of the tuition paid, which does not cover all the costs, philanthropy, and enormous public investment. At Cornell, a private university, we get nearly $1 billion of public money a year, in the form of research grants, student aid, money from the State of New York. And so, this combination of tuition, grants and contracts, philanthropy, and other procedures, all have to add up to a nonprofit bottom line. So, in general, the costs have to be borne, but the various weighting of those factors, how much will be from the different factors on different campuses, will depend on the discipline, the costs, and the overall capability of the institution.

Mr. HALL. I keep reading and hearing the media keeps shouting back at us, the escalating cost of sending your youngster to school, and how we better be saving for, you know, that when it is the fourth or fifth grade now and looking ahead for it.

Do you ever have any situations where some of us Americans send ours over to your school there, and could they attend there? Would that be one way of us cutting down on the escalating cost of graduating from, say, Cornell?

Dr. SKORTON. I am going to give you a firm yes and no answer to that one.

Mr. HALL. Okay. Okay.

Dr. SKORTON. Yes.

Mr. HALL. It is probably not a fair question.

Dr. SKORTON. Everything is fair. Yes, certainly, American students are eligible to go to many of these campuses, although the idea, of course, is to establish a footprint in another society. We do have work to do in higher education, on the balance between cost control and funding, and just because I have garnered the floor, and I will say very quickly in 30 seconds, it is a three part solution to the problem that you have raised.

We need a commitment from you and other Members of our elected officials to make sure that public money continues to go to student aid in this country. We cannot fail to do that, no matter what other economic challenges we have. Secondly, our own alumni have to help us with philanthropy, and thirdly, I know that I have to do a better job of cost containment going forward. I wouldn't say that about my colleagues, but I know I have to do a better job of cost containment.

Mr. HALL. And in closing, what better way can we spend our money? And my last question, and I don't expect an answer for it, is for a state institution overseas, who do you consider to be out of state? I will withdraw that, and I will yield back my time.

Mr. BAIRD. Mr. Lampson.

Mr. LAMPSON. Thank you. Thank you, Mr. Chairman. Mr. Hall always comes up with the hardest of the questions.

I happened to be in a meeting, and I stepped out for a minute. Last week, we were in a hearing, and I saw a group of college students sitting in the audience, talking or listening. On the panel, I decided to go out and listen to the kids. And I found it pretty fascinating, what their insight was. And the group of young folks that I met with are now sitting in the backroom over there, helping me design a program that will implement what their vision is, and hopefully, we will succeed. It really is about the students and what they can get out of that, and what we would like to see happen into the future, as far as I am concerned.

And I was wondering about, because what we see happening with other nations building their own universities, are there any that have built branches in the United States from their universities, that you are aware of?

Dr. ALTBACH. Very briefly, there are rumors that a couple of Mexican universities are opening, or planning to open branch campuses in Hispanic areas in the United States to serve Spanish speaking students in the U.S. But those are, so far, unconfirmed. The short answer to the question is no.

And this is an interesting broader policy issue, actually, because in my view, there isn't much potential. The higher education environment in the United States is so complex and so, generally speaking, good, and so varied across sectors, it would be difficult for an international, a foreign institution, to come here and make a success of it. The British Open University actually tried, a few years ago, using their brand of distance education, to come into the U.S., and failed.

So, I think broadly, the answer is no.

Mr. LAMPSON. I am hoping that the example that you said, or the rumor was, is not an example of North-South that you explained a minute ago. Do you have a comment, Mr. Wessel?

Mr. WESSEL. I don't know that they have actually set up branches here, but I know we have a relationship with Tecno Monterrey in Mexico, and they have very assiduously pursued student markets, particularly in the Southwest United States, for their programs, including in partnership with some U.S. institutions.

Mr. LAMPSON. Are you having the kinds of difficulties when students, when it comes to the time that a student who is in your branch needs to spend time here, on your main campus here in the United States, how difficult is it for them to receive the visas necessary, or the other visiting documents necessary for them to come? Anyone. Dr. Schuster.

Dr. SCHUSTER. Yeah. I can't speak directly to the specific cohort of students who would be coming from branch campuses, but I think everybody at this table, and I suspect that everybody in the room is aware of some of the challenges that higher education has faced, in being able to have visas issued in a timely way to appropriate students, and any assistance that you might be able to provide to us in resolving that problem, we would greatly appreciate.

Mr. LAMPSON. Well, I want your comment, but has it had an impact on the financing of our universities? Both of you may want to comment it, or anyone. Go ahead, Dr. Skorton.

Dr. SKORTON. First of all, I would like to separate the two questions. The overall question, as my colleagues have said, about the accessibility of the U.S. to international scholars and students continues to be an area of concern. I wouldn't want to be in your seat trying to decide exactly where to find that sweet spot, but I think the pendulum swung a certain distance before and immediately after 9/11. It has swung back. We have had a lot of terrific dialogue from the higher education community, with the Department of Homeland Security, and with the State Department.

I am honored to be in the National Security Higher Education Advisory Board, which was appointed by the Director of the FBI, and there is about 20 university presidents on that Board, and the whole point of that was to initiate better dialogue. So, I think that things are going in the right direction.

The branch campuses are a special case. It is a small number of students, relative to the large number of international students who come here, and we have it set up in advance as a prescribed program. So, for example, we have students right now in the summer, in Ithaca, New York, and in New York City at the Medical School of Cornell, Weill Cornell Medical College, from the medical school and premedical program in Qatar, international students, and we have been able to do that.

So, two separate questions. I think focused approaches to programs, where it is clear, the length of time the student is going to be staying. It is all worked out ahead of time. We have had a lot of cooperation. It has been more manageable. The overall issue of visas and so on, is still trying to find what the right balance is. It is difficult.

Mr. LAMPSON. There is talk that China has built a significant number of new universities. They are attracting a lot of the world's students, Australian, perhaps other countries. It is obviously something for us to worry about. Do you have any comments? Do you advise that we ought to be looking at it, as a Congress, to help change any aspect of that?

Dr. ALTBACH. If I can reflect on that. China, and India, too, are beginning to have strategies to attract students from other countries to those countries. My own view is that they will not be tremendously successful. The issues of quality of higher education, language questions, ease of study, the attractiveness of those cultures and so on, are such that it will be a bit difficult for them to attract the numbers that they seem to be thinking about. So far, there isn't much going on in that area, but there will be, and we should be careful to monitor it.

My own view is, so long as U.S. institutions maintain their quality, maintain their attractiveness, and maintain their sort of general excellence overall, we will do very well in international competition in higher education. We start with a huge advantage. Our issue here is to maintain that advantage. We are at a good place, if we continue to be aware of the issues, to support the institutions, to provide rational access, in terms of immigration and visas and that sort of thing, we will do well. I am pretty optimistic about that.

There is a lot of competition out there. The Australians, the British, the New Zealanders, they particularly, at the present time, are the big competition. They are doing pretty well. They have some problems. Australia, particularly, right now, which I think over-invested and didn't take the care that they needed to in establishing some of their overseas twining and branch campuses and franchising. So, it is coming back to bite them a little bit.

But so long as we maintain our excellence and attractiveness, we will do fine.

Mr. LAMPSON. Thank you, Mr. Chairman.

Mr. BAIRD. I am going to recognize Mr. Inglis.

Mr. INGLIS. Thank you, Mr. Chairman.

Several years ago, we had an exchange student at our house from Turkmenistan. While he was with us, the Turkmenbashi, the guy that ran Turkmenistan, closed all the hospitals in Turkmenistan, and said if they are sick, they can come to the capital. And that gives you an idea about where this guy comes from. And I said to him, Sadar, how long does it take to get from your town of Mari to the capital? He said two hours. So it gives you an idea of the conditions, maybe, in Turkmenistan, that if you are having a heart attack in Mari and you need to get the capital, it is two hours away.

And the last night that he was with us, he came into my little office at our house, and he said sir, I want to come back. He said it is possible, in this country, for ordinary people to send their children to college. In my country, it is not possible. So, will you help me come back?

Of course, it is quite a show stopper for me. Last night, I got a call from my wife, saying what are we going to do with Sadar, because we just got an email from him saying will you help me? It would cost me $2,600 a year, and $150 a month, to go to the American University of Central Asia, and we have got five kids, and one has finished college, one is in college, one is going next year. And so, my wife says, maybe we can help Sadar. I suppose that Sadar, in some ways, is somebody that fits some of this. It is a way of offering him an opportunity.

Is the goal to make it more cost effective for him, or to expand the reach of your universities, or both?

Dr. SCHUSTER. I think everybody is moved by the sort of stories that you just related, and the truth is, and I think most of us in this room know that there are thousands and thousands of those stories of qualified, ambitious individuals who are just looking for an opportunity to succeed. And part of our motivation is to provide those opportunities around the world.

I want to come back to this question of what it is that attracts foreign students to American universities, and what it is that we are trying to propagate by moving some of our operations offshore. And it comes down to two important issues, I believe, quality and culture. And it has been said by my colleagues here, and I thank you very much for the compliments, by characterizing American universities as the gold standard of the best in the world, and I think that is certainly true, and is well recognized.

And the question becomes, of course, well, what is it that drives that? What is it that makes the American universities recognized globally as the leader? And why is it that I think personally that universities established in India, whether they quadruple the number, or in China, will not become competitive quickly, and the answer is culture. And I think that the opportunity to succeed in a meritocracy, rather than a culture of hierarchy, is one of the great strengths of the American university. It is open. It is a competition of ideas, not of age or of birth or of status or of title, and I think that the examples of history inform us of that. American universities have been the entry point for immigrants to the United States, to gain an education, and to become successful and leading citizens.

And part of our objective in moving offshore is to provide that opportunity for students, like the one that you describe, in their home country.

Mr. INGLIS. And see, the challenge for somebody like Sadar, is getting the opportunity to come here. I think we can get the visa, right? It is relatively open, that is my impression. Is that correct? And coming here is obviously more expensive than being educated at the American University of Central Asia, if he has got the price right, at $2,600 a year plus $150 a month. But still, that is a large sum of money if you are in Turkmenistan.

Mr. WESSEL. So, I just wanted to make one connection on this issue of students coming here. One of the real primary reasons students come to universities in America is to access the U.S. labor market. They certainly come for the training that we offer, and the skills enhancement, but it is much easier for them to get jobs in U.S. companies through being in school here, than if they do their study abroad.

One of the problems on the visa side that I see is not so much student visas, although that can be an issue, but the reliability of our system to provide work visas for highly talented foreign nationals actually influences the choices people make when they decide where they are going to come to college. And that has been a much more highly variable phenomenon, particularly over the last few years, and I think it is a very difficult question, for reasons Dr. Skorton outlined, and others.

But I think it is a really important for us to pay attention to.

Mr. INGLIS. And Mr. Chairman, I would be happy to entertain any offers of grants and aid at this point. Just kidding.

Mr. BAIRD. Mr. Inglis, I appreciate it. I think we are all appreciative of your support for that student. I want to recognize Mr. McNerney.

Mr. MCNERNEY. Thank you, Mr. Chairman. I want to thank all of you for coming out here this morning. I know you all have busy schedules, and your testimony has been very interesting and enlightening.

Dr. Skorton, have you found a need to create private institutions or private entities to carry out creating overseas institutions, and to operate and own those institutions?

Dr. SKORTON. You mean entities separate from Cornell University?

Mr. MCNERNEY. Private institutions that could be associated in some way with Cornell, but yes, separate?

Dr. SKORTON. No. We haven't been, if you have a chance, or your staff, to look at a checklist, an appendix that I put in my prepared remarks, we have made public exactly what sort of due diligence we do when trying to figure this out. We have been quite open about it. We share it with other universities who have thought about going, for example, into Education City in Doha. We have been able to do that through the normal mechanisms of the corporate structure of Cornell.

But there is a lot of detailed due diligence that goes into that. If you have a chance, sir, I would be glad to respond, is laid out in that appendix.

Mr. MCNERNEY. Sure. Now, that we are talking about the due diligence, you indicate that there is a need to have a compelling, or you want a compelling reason to open up an institution. What sort of framework do you use to make that decision that something is compelling or not?

Dr. SKORTON. By compelling, I mean that there is a rationale in the local context, that is, we are filling a need, even if it is a competitive need, in the culture or society. So, for example, in the case of the Medical School in Qatar, there was a perceived need, a perceived market, if I can use that term, for an American medical degree in that part of the world. It is the first coed institution in Qatar, and as is indicated in the appendix, we have retained the right to utilize nondiscrimination policies, as we do in the United

States and the State of New York, to apply to hiring, and to admissions decisions in that culture.

So, part of it is, by compelling, I mean that there is a need or market or niche that looks like it would be important. Another compelling need would be on the research side, as Dr. Schuster has said, and I can't emphasize this too much, the ability to study certain problems that are best studied in a certain environment, or best studied jointly.

And so, that is what I meant by the idea of compelling.

Mr. MCNERNEY. Thank you, Dr. Skorton. Yes, Dr. Schuster.

Dr. SCHUSTER. Let me add to and amplify what Dr. Skorton has said. One of the first criteria is that we be invited. We want to be wanted by the government, by the structure that asks us to be a partner or a participant in the foreign country in which we plan to operate, and so, we don't want to look as though we are colonists or invaders. We want to be invited in.

Another criterion is that we want to make sure that we set up an operating environment and an operating structure in which we can maintain our quality and our ethics. As Dr. Skorton said, we will not operate in a way which will violate our principles. Quite important is the opportunity to take advantage of unique resources or challenges within a country. And so, for example, I suspect you are all aware of the challenges associated with water quality and water distribution. We have faculty working in Africa, in Central Africa, on water distribution, advising governments, advising governments in the Middle East on water quality and water distribution opportunities. And that turns into opportunities for our faculty members to participate in the solution of some of the most challenging problems the world faces.

Mr. MCNERNEY. So, there is a humanitarian aspect to this decision-making as well, then, it sounds like.

Dr. SCHUSTER. It is one of the components, sir, in which we weigh the opportunities. I think that many of us at this table, I suspect of all us at this table, will tell you that rarely does a week or a month go by where we don't get an inquiry from some entity in a foreign government, asking for a partnership at some level, and I like the phrase that Dr. Altbach used, McDonald-ization. That is not a role that we want to participate in.

Mr. MCNERNEY. Dr. Altbach, I wanted to ask you this. You mentioned regulation several times. Could you elaborate on what that means, or is that too specific to the country that you are locating in?

Dr. ALTBACH. Yes, it is specific to the countries in which you are locating. Each country has a different regulatory environment, or in some cases, no regulatory environment, or in other cases, they are thinking it through. And it becomes very complicated for U.S. or other foreign institutions, which are thinking of locating a branch campus in any given country.

India is a prime example right now. They are thinking through how they want to regulate, how they want to recognize, and how they want to permit foreign academic institutions coming into the country. China, for a long time, has had the policy of insisting, and I think it is not a bad policy, actually, insisting that foreign institutions that wish to come in to China must partner with a local Chinese institution. They can't do it on their own, and they are thinking of changing that, so as to make it possible for free-standing branches to come in.

But the point of my comment is that there is a range of different regulatory environments. They are changing. Some of them are not exactly uncorrupt, and institutions which are thinking of going into a country need to be concerned about these matters.

If I can make a couple of other reactions to points that have been——

Mr. MCNERNEY. I am going to ask you to refrain, Dr. Altbach.

Dr. ALTBACH. Okay.

Mr. BAIRD. If the opportunity arises in a second. I guess we are over Mr. McNerney's time.

Dr. ALTBACH. Sure.

Mr. BAIRD. And I want to give time to all the panelists today. So, Mr. Gingrey.

Mr. GINGREY. Mr. Chairman, thank you, and the chairman whispered in my ear when I came to the Ranking Member's seat, and he said, you are not going to try to out-anecdote Mr. Hall, are you? He was a little surprised when I told him I did have an anecdote. It is about Dr. Schuster. In fact, Dr. Schuster, I was reading in your bio, and I want to share this with everybody that is in the room, that Dr. Schuster has published more than 230 papers in peer reviewed scientific journals on many topics, but one of his best-known discoveries is called Chemically Initiated Electron Exchange Luminescence. It provides a mechanistic basis that allows the understanding of the bioluminescence of the North American firefly. This discovery forms the basis for new clinical diagnostic procedures that have recently been commercialized. Well, I want to, here is the anecdote.

Dr. Schuster, when I was 12 years old, I had a great idea. It was during the summertime, and my cousin and I were catching these fireflies. We called them lightning bugs. And my parents were going out that evening with his parents to dinner, and I knew when they got back they would enjoy a cocktail before going to bed, so me and my cousin decided that we would try to freeze these lightning bugs and put them in an ice tray. And our idea was, of course, to freeze them in the luminescent phase, and what a surprise that would be when they went to mix their drinks later on that night.

Unfortunately, all these fireflies went dark, and they were just dead bugs inside these ice cubes. Now, fortunately, I slept through that spanking, but I would just like to say that I think if you have cashed in on this, I would like for you to share some of those royalties with me, because that is the anecdote. Now, I do have a serious question, though, and this is a very serious, serious hearing, and——

Mr. BAIRD. I promised the witnesses this would be an erudite panel here today.

Mr. GINGREY. Well, we wanted to lighten it up a little bit, Mr. Chairman. No pun intended, of course.

But really, the question is, and of course, Dr. Altbach, I think, pointed to it when he said that 75 percent of the graduates, foreign nationals that come here on student visas, and in graduate programs, Master's or Ph.D. programs, have remained in the country after they have completed their studies.

And you know, there is good and bad in that, and my concern, and we have discussed this with other panels before this committee, and certainly, when I was on the education committee in a previous Congress, we talked about it, in dealing with the higher ed sections, the brain drain, and the fact that you know, they come and they stay and they compete, and maybe, they are possibly paid a little bit less, it is a disincentive, I am afraid, to some of our best and brightest in this country to proceed STEM education, maybe even when they need to be thinking about it in the middle of the high school level, because gee, you know, lawyers and doctors, and certainly not politicians, make more money than engineers and pure scientists and chemists and biochemists, and I would like any and all of the witnesses, in the time remaining, I took too long for the anecdote, but if you can respond to that, because it is a concern.

Dr. ALTBACH. Since I made the initial comment. First of all, I was talking about China and India specifically. It is not true overall. Many other countries have significantly higher rates of return, even developing countries, of students who get their degrees here and do go back.

I don't like to refer to, any more, to what used to be called the brain drain, because I think the situation now in the era of globalization, and I will try to be really brief, because this is a really big issue, is now much more complicated, and individuals who stay in the United States, especially from rapidly developing countries, increasingly have important relationships back home, and that benefits their economy, and it benefits our economy, and it greatly benefits them. There is much more going back and forth, so to be brief, although the stay rate is declining modestly, more are going home as there are opportunities in their home countries, but even those who remain are much more engaged in the global economy, and that benefits us and it benefits them.

Mr. WESSEL. I agree with that, and I would also say there are pieces of evidence from our experience, and this relates to our graduate programs in information technology management. There is no evidence that our international student graduates earn less money when they graduate than our domestic student graduates. They are treated quite similarly on that scale.

And we go out of our way, including additional financial support, to try and attract qualified U.S. citizens to these programs, and it is a serious, serious challenge. And that, despite the fact that we fund them more generously than we would, on average, an international student of the same caliber. It is a real challenge for us.

Mr. BAIRD. Very excellent question, and delightful anecdote as well. Mr. Wu.

Mr. WU. Well, since we seem to be in the anecdote business today, let me jump in with one of mine.

I don't know if this story is really true or not, but it is a story that Chinese kids are told, and I suppose there is a point to it. The story is that silk technology left China because of, depending on your point of view, a courageous or a treacherous Chinese princess, who carried the silk cocoons, the silkworm in their cocoons, in I don't know, a bouffant hairdo or something like that, and she snuck the cocoons in there, and carried them down the Silk Road, enabling other countries to start competing silk industries. And the reason why she so carefully hid those cocoons is because, so Chinese children are told, there was a death penalty imposed for exporting silk technology from China.

Now, whether that is true or not, I thought I would just share that story with you all, as you consider exporting American know-how to other countries. The world has progressed in many respects, but some of the old lessons, well, they are old lessons, because there may be a grain of wisdom, or not, as the case may be, and I just offer up that story. Well, the story kind of speaks for itself.

Before you all raise your hands to comment, I want to pitch something else to you all, which is a way to enhance student financial aid at no cost to the taxpayer, which is tied to bringing additionally qualified folks to the United States.

Chris Cox and I proposed this in 1999, and we almost got it passed, but we got caught in a three way squeeze at the plate, and it didn't quite pass, but we are running it back up the flagpole, and just wanted you all to be aware of it. The proposal is to grant an additional quantum of H1B visas, and as you all know, businesses petition for the visas on behalf of a beneficiary. The petitioner would be required to make a payment to an accredited college or university in the amount of the then-existing Pell Grant. Let us just call that, today, $5,000. As you know, petitioners today, recruiters pay $100,000, $200,000, to bring an employee in, to find a qualified employee, pay the moving costs, and all the other associated costs, so $5,000 a year is, on a comparative basis, chump change. And every high tech operating executive I know is strongly in favor of this proposal. Their lobbyists here in Washington sometimes sing a slightly different tune.

The way that this would work is that they would come to qualified universities and lay down their $5,000. You would certify that they had done so, and the immigration authorities would give expedited processing to their visa petition, and in this case, expedited processing would probably work, because most of the time, the folks that they are looking for are already at your institutions, and all the pre-clearances could have been done well in advance.

I continue to think that this is a good idea, and we are going to pitch it up as part of a broader immigration package, and I have brought this to the attention of various educators and high tech folks, back in 1999 and 2000, and the education community was very, very enthusiastic. The high tech community, at the operational level, was very enthusiastic. At the lobbying level, back in 1999, they called that an additional tax. We responded that it was not a tax, it was a voluntary payment. They seemed to have come around, because in 2007, no one is saying the "T" word anymore, but they do want a credit for prior donations made, and our response has been, well, actually, we would like to see fresh cash on the barrelhead, because we want to see that for college financial aid, and by the way, the legislation, as drafted, would require you all to pass that on, dollar for dollar, through to American students.

And just wanted to make you all aware of that. While not giving up my place in the queue of the anecdote business, either. And with that, Mr. Chairman, I yield back the balance of my time.

Mr. BAIRD. Mr. Rohrabacher.

Mr. ROHRABACHER. Thank you very much, Mr. Chairman. First, I would like to mention that, I know that Cornell University is very involved in Arecibo telescope project in Puerto Rico. I consider that a very good example of the type of positive impact that our major universities can have in really practical terms.

And I would alert the rest of our committee to the plight of that particular project, in terms of funding, and I believe that it is important for us to work with you to keep that project alive. So, that is the good part of my questions.

Now, the other shoe is going to drop in a minute here. I will have to tell you, Mr. Chairman, I find a lot of talk about globalization to be clichéd, and I am going to have to tell you, the testimony today hasn't changed my opinion of that. And you guys are from major universities. Frankly, I didn't find depth in your remarks at all about globalization.

Let me tell you, the people of the United States pay for our universities, by and large. This is not a public service to foreigners. Billions of dollars spent for higher education by the American people are meant, first and foremost, to educate our young people, to provide skills for American young people. We should have no apologies to make about that, and the sort of glancing over the negative impact of what is happening in some areas, in terms of having foreign students in the United States. The cliché about we live in the global world now just doesn't cut it with me.

But let me ask you this. First of all, before I, as I get into the last question, which focuses on the real problem here, what are these foreign students studying? Are they not, many of these students, from China, for example? Being trained to take basically, information and research information back, which we have spent billions of dollars to develop in the United States? Are we not, then, putting this into their, this human computer, so they can go home and utilize that, in some cases, in their military, in order to put the United States in jeopardy? Is this not something that we should be concerned about? Because what I understand is many of these foreign students at the graduate level are taking the hard sciences, which permit them, the information, that can help with their military and their war industries.

Please go right ahead.

Dr. SKORTON. First of all, Mr. Rohrabacher, I want to thank you for bringing up Arecibo, and I very much appreciate your support of that project.

At the risk of being impertinent, I want to disagree with the last comment that you made.

Mr. ROHRABACHER. Please disagree.

Dr. SKORTON. Okay. Okay.

Mr. ROHRABACHER. I am here for that.

Dr. SKORTON. And I am going to do it from the perspective of reassuring you, number one, and I hope this doesn't sound like a platitude, but I am proud to be on that National Security Higher Education Advisory Board. The whole point of that, appointed by the Director of the FBI, is for us to roll up our sleeves, so to speak, and work on these very problems that you are talking about. There is no question that what you have raised is a potential concern, no question about it. And there is no question that both industrial espionage and other kinds of espionage is a concern on both sides of the street.

Mr. ROHRABACHER. Well, this isn't espionage. I think we are handing people over things——

Dr. SKORTON. That is the part that we have to do a good job on our side of doing it, but what I, the part I want to disagree with you about is that I believe that the American public is putting money into universities certainly to educate Americans. Absolutely no question about it. But these kind of universities, research universities, you are, especially through this committee, thank goodness, putting hundreds of millions of dollars, billions of dollars, depending on the agency, for research that leads to innovation.

And we have a complex innovation network, and I am sorry to hit you with a cliché that seemed to upset you, but it is true that we are living in a global world, and that we need, it is true we need the best and the brightest to work on these complex problems.

Mr. ROHRABACHER. But don't we have a pool, a great pool of Americans? By the way, we are Americans of every race, every religion, that is what is great about America.

Dr. SKORTON. I am a first——

Mr. ROHRABACHER. They come from everywhere. Don't we have a large pool of Americans that could then be trained, rather than having to bring these people in from overseas, to take, to participate in this, and adding value to their existence?

Dr. SKORTON. Well, I think we are all facing the same direction you are trying to face. I am a first generation American, first generation through higher education. Unfortunately, we are not doing as good a job in the STEM pipeline in this country as we need to be. And I feel silly telling this committee about it, since you have been supportive of bills like H.R. 362, the *10,000 Teachers, 10 Million Minds Act,* in Title I, that if you keep doing what you are doing in this committee, you fund these federal agencies for research that will lead to innovation, you help us fill up the STEM pipeline, then what you are talking about may come to fruition some day. Right now, I need the brightest international students to fill out the programs that we have at our university, and no, I am sorry to say that we are not doing a good enough job in the STEM pipeline in this country, and I am glad afterwards to share with your staff the data that——

Mr. ROHRABACHER. Just so you know, I have been very supportive of our efforts to provide scholarships for graduate level students, provided to make sure we meet these scientific needs in our country, so that NOAA and NASA and the rest of these organizations could actually provide scholarships to make sure that our people are being trained.

And I think to the degree that we have to bring in students, foreign students, in to fill these slots, rather than training Americans, is a symbol of failure, not something that we should be bragging about.

Thank you.

Mr. BAIRD. I thank the gentleman.

One of the things I particularly value about Mr. Rohrabacher is a willingness to present other sides of the story that need to be presented. Very well said, and well responded to.

I think at this point, we have heard a number of important insights, and a fascinating, fascinating hearing on what is clearly going to be a growing trend, I think, and with important implications.

Unless there are any urgent final comments or questions from the panel, if other Members of the Committee wish to submit comments, or if the members of our panel wish to offer additional remarks, we appreciate very much your time and testimony and your work. And we look forward to seeing you again, hopefully down the road.

And at this point, the Committee stands adjourned. Thank you very much.

[Whereupon, at 11:35 a.m., the Committee was adjourned.]

Appendix:

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Gary Schuster, Provost and Vice President for Academic Affairs, Georgia Institute of Technology

Questions submitted by Chairman Bart Gordon

Q1. How do STEM programs offered at foreign campuses affect the offshoring of STEM jobs? Are we exporting one of the principal sources of our comparative advantage? What policy changes need to be made to ensure that the globalization of universities is in the national interest?

A1. The comparative advantage that the United States enjoys in innovation comes from many sources, including our culture of entrepreneurship and our ability to leverage discoveries made in the United States and elsewhere. Our country's key advantage is not having the knowledge itself, but in knowing how to use it. Georgia Tech's students and faculty also gain a comparative advantage from Georgia Tech's position as a national and international institution. As one of the nation's top ten public universities and its largest producer of engineers, we focus on educating graduates who understand technology in a global context. We hear from the corporate sector that they need graduates with both technical skills and experience and appreciation of global marketplaces and work environments. Our graduates are highly sought after by employers, and our alumni report that the international aspects of their education add value to their careers. Our researchers benefit from awareness of the international state of scientific advancement and from collaborations enabled by Georgia Tech's open and outward-looking approach. Producing these kinds of graduates and enabling our faculty to perform research at the cutting edge assists the State of Georgia and the U.S. in attracting companies to our region and driving U.S. competitiveness.

Q2. In Mr. Wessel's written testimony, he notes that "the degree to which the public sector is willing to provide subsidy for [universities'] activity has declined—at least relative to the overall cost of providing. . ..research and education output." Has this decline affected the way universities view their relationship to the society that those public-sector subsidizers represent? Who do today's universities regard as their stakeholders?

A2. Georgia Tech is proud to be considered one of the country's best public universities, and fluctuations in the level of public sector contributions do not affect the role played by the public sector as a key stakeholder. As a public institution, a central tenant of our strategic plan is that we will grow and adapt to new circumstances in order to continue to be an educational and economic driver for not only Georgia, but for the Nation and the world. To serve all of our stakeholders, we must constantly tune our educational and research strategies to reflect current realities. Successful universities of the future will be defined by their ability to build learning and research communities that are multi-disciplinary and multi-institutional and that cross their own traditional boundaries as well as those among industry, government, and academia throughout the world. Extending Georgia Tech into the global environment is therefore a natural step in providing service to our students, the State and the Nation.

Q3. Asserting that "there are too many universities in this country," Mr. Wessel stated in his prepared testimony that "the emergence of new markets abroad. . .offer[s] opportunities to take advantage of inherent economies of scale without jeopardizing the branding and selection fundamentals of our business model at home. Thus, for many of us, going global is simply efficient." Sloan Foundation President Ralph Gomory has pointed out that one of globalization's effects has been to drive a wedge between the fundamental interests of multinational corporations and those of the national economies in which they are based. Is the drive for efficiency described likely to lead to a similar split between major universities and their home societies?

A3. Georgia Tech's home society is primarily composed of local, State and federal stakeholders, students and alumni, and the private sector. This society is well served, in our view, by a strategy that expands educational and research opportunities internationally. As noted in my remarks at the hearing, as the Nation's largest producer of engineers and one of its best, we face the challenge of preparing our students to contribute to and compete in a global economy based on innovation. The State of Georgia does not exist in isolation to the world but constantly seeks international business and investments. While the United States is undoubtedly the world's leader in innovation, it is not the only place in the world creating new ideas and technologies. Accessing these ideas and innovations is also an important aspect of a global presence. Challenging our students and exposing them to broad experiences, as well as enabling researchers to be present at the global intersections of research and innovation, will bring benefits back to our "home society" by way of economic development and talent.

Corporate recruiters and research sponsors operate in a multi-cultural, multi-linguistic and multi-domestic environment. It is a reality for them and, increasingly, a reality for STEM graduates. Our graduates are asked by their employers to operate in global marketplaces and diverse cultures. Prospective employers seek Georgia Tech students who possess international experiences and skills. It is in the best interest of the United States economy for our education programs to produce citizens of the world who are comfortable with diverse cultures, languages, and ways of thinking and solving problems.

Q4. In Mr. Wessel's oral testimony he said, "As universities become more global, we are effectively, if unintentionally, increasing the capacity of firms and individuals abroad, to [do] jobs currently done here in the United States." Do you agree with this statement? If so, how do you weigh this cost to nation in your decision criteria? If not, why is he incorrect?

A4. Ideas and knowledge are now global. We have to be global to compete. The United States does not have a monopoly on brilliant ideas or intelligent people. International presence puts American universities on the front doorstep of the best talent and ideas in the world. International linkages expand access to ideas and generate opportunities for our faculty and students. While it is true that we are exposing others to our knowledge and ways of doing things, we are also creating capabilities for other societies to develop their own strengths and expertise, which allows them to tackle problems and create markets unique to their own societies. It also creates trading relationships and cultural understandings, which may help facilitate international stability. The grand challenges of today's world—clean air, clean water, enough food, enough energy—are so complex and important that they require expertise and collaborative effort from around the world.

Q5. What specific steps have you taken to ensure that your U.S. STEM students are benefiting from your globalization efforts? How do you measure the benefits to your U.S. students?

A5. As one of the Nation's top ten public universities and its largest producer of engineers, we focus on educating graduates who understand technology in a global context. More than a third of our undergraduates study or work abroad. Seventeen of our undergraduate degree programs offer an International Designator. This means special courses and overseas experiences that add a global context to their field of study, and that fact is noted on their diploma. Our graduates are highly sought after by employers, and our alumni report that the international aspects of their education add value to their careers. In addition, by participating in international research collaborations, based both in Georgia and overseas, our faculty and students learn what the state-of-the-art is and how research works in other countries and the private sector. This helps position U.S. researchers and companies to design effective global strategies. It is Georgia Tech's goal that all students, graduate and undergraduate, and across all disciplines will receive an education that would allow them to be globally competent upon graduation.

Q6. Would the cost of delivering a degree abroad have implications for the number or caliber of foreign students who come to the U.S. for their education? Might that, in turn, affect the available talent pool within the U.S.?

A6. We believe that creating a global presence will improve access to the best and brightest foreign talent. While the global educational marketplace is increasingly competitive, Georgia Tech's activities in the U.S. and abroad raise awareness of the capabilities and value of Georgia Tech's research and education programs and the attractiveness of studying at Georgia Tech and in the U.S. High quality students will still want to come to study in the U.S. for the same reasons U.S. students will continue to want to go abroad—the recognition that the world is a global marketplace and understanding how to work in multinational situations is key to a successful technical education and career.

Q7. You say that one of the benefits of being a transnational university is promoting cultural exchange and international understanding among your domestic students.

How much interaction do your domestic students have with international scholars, both academics and students? What if you only consider branch campuses—how much interaction is there between American students and foreign students enrolled at branch campuses?

A7. Foreign students and scholars on the Georgia Tech campus in Atlanta participate fully in campus life. American students interact in classroom, laboratory, and social settings with foreign classmates, professors, exchange students, and visitors. The Office of International Education serves foreign students enrolling on the Atlanta campus. In addition to assisting with administrative matters such as visas, insurance, and registration, the office has been proactive in helping students become part of the campus community. They offer a number of programs, e.g., International Coffee Hour: Coffee, Culture and Conversation, a seven-week non-credit course in accent reduction to enable students to communicate more effectively, and volunteer opportunities in the Atlanta metropolitan area.

More than a third of our undergraduates study or work abroad during the course of their education. At Georgia Tech's campus in France, foreign students interact with domestic students and scholars in a variety of ways both inside and outside the classroom. American and foreign students studying there work with professors from the Atlanta campus who have come to teach there temporarily and with faculty who live and work there full-time. Georgia Tech's campus in Lorraine has an active student government association and sports program open to all students.

Foreign students who enroll in Georgia Tech's programs overseas include time on the Atlanta campus as part of their studies. For example, there are currently 165 students registered at Georgia Tech Lorraine with an additional 35 students from that campus completing their studies in Atlanta. Students enrolled in the dual Master's degree program in Global Logistics and Supply Chain Management offered by Georgia Tech and the National University of Singapore are required to spend two semesters enrolled on Georgia Tech's Atlanta campus.

In addition to the sorts of face-to-face interaction described above, distance learning plays an increasingly important role in the delivery of course content in overseas collaborations. Students in campuses on more than one continent can be engaged in the same classroom activity through high-speed real-time connections.

Q8. What's the motivation for considering a campus in Andhra Pradesh? What degree programs are being proposed? What do your U.S. students gain from an MS/Ph.D. program established there? How does your planned campus in India differ from your current campuses in Ireland, Singapore and France? Could you elaborate on your efforts in China?

A8. Despite what has been reported in the Indian press, Georgia Tech has not agreed to build a campus in Andhra Pradesh, India. What we have actually agreed to is non-binding discussions that could culminate in a potential research and graduate education platform in Andhra Pradesh. However, we have a list of significant conditions that must be met, and we will not go forward until all of those conditions are met in Andhra Pradesh. These conditions are closely tied to a few core principles. A potential opportunity must provide a strategic advantage for Georgia Tech, have a research-driven motive, and a clear educational benefit for our own students. It must operate within the parameters of the laws of the United States and Georgia as well as the host nation. The activities must also preserve the quality and integrity of Georgia Tech's reputation. Finally, we strive to operate all international operations in a self-supporting and revenue-neutral manner relative to our other operations. These principles must be fulfilled by all our overseas activities. Each overseas opportunity is assessed on a case-by-case basis, and the structuring of each program is designed to take advantage of the unique capabilities of the country and partner institution.

In China, Georgia Tech is partnering with Shanghai Jiao Tong University (SJTU), located in Shanghai, China. Since May 2006, selected Georgia Tech graduate courses have been taught at SJTU by Georgia Tech faculty, and SJTU students can pursue dual Master's degrees from both institutions. In addition, since May 2005, a Georgia Tech Shanghai Summer Program has been offered for undergraduate students from all over the United States. Georgia Tech faculty members teach regular Georgia Tech courses in engineering, humanities, and social sciences. Students also enroll in complimentary non-credit courses offered by SJTU in Chinese cooking, Chinese painting, Chinese calligraphy, martial arts, and Tai Chi.

Questions submitted by Representative Eddie Bernice Johnson

Q1. What does it cost to deliver a degree in the U.S.? France? Singapore? China? India?

If it is cheaper to get a degree in the home country, why would a student decide to go to the U.S. for the same degree?

A1. Costs to deliver a degree are difficult to quantify because they are affected by not only location, but also area of study, costs of supporting faculty expertise, infrastructure expenses, and many other factors. Each overseas activity is assessed on a case-by-case basis, and the structuring of each program is designed to take advantage of the unique capabilities of the country and partner institution. Tuition is established in a manner that reflects the total resources available to the campus and Georgia Tech's intent to operate all international operations in a self-supporting and revenue-neutral manner relative to our other operations.

In general, foreign students choose to study in the U.S. for a variety of reasons, including access to unique expertise and facilities and the chance to experience a different culture. Georgia Tech continues to receive applications from very bright foreign students, and, in the end, high quality students will still want to come to study in the U.S. for the same reasons U.S. students will continue to want to go abroad—the recognition that the world is a global marketplace and understanding how to work in multinational situations is key to a successful technical education and career.

Q2. Of the countries you single out as locations of existing Georgia Tech programs, France and Ireland are OECD members and Singapore occupies a special and advanced place on the continuum of economic development.

Might different concerns surround undertakings in a country such as India that has not achieved such a high level of development, considering potential differences between that country and the U.S. in everything from salary levels to the significance of the indigenous research to which the U.S. institution would gain access?

A2. Each Georgia Tech overseas program is considered, evaluated, selected, and designed based on the unique opportunities and circumstances of the potential partner institution and country. There are certain core principles that are applied to all overseas activities, as outlined in my testimony to the Committee. However, the way in which each partnership contributes to the core principles, including assisting Georgia Tech in meeting its mission of defining the technological research university of the 21st century and educating the leaders of a technologically driven world, varies widely. The world is getting progressively "smaller," and Georgia Tech graduates and researchers will have responsibilities and opportunities throughout the globe. The value of and need for partnerships by U.S. universities with a variety of institutions in a variety of countries at a variety of stages of development should be defined broadly, and the implications of such partnerships should be explored thoroughly.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mark G. Wessel, Dean, H. John Heinz III School of Public Policy and Management, Carnegie Mellon University

Questions submitted by Chairman Bart Gordon

Q1. How do STEM programs offered at foreign campuses affect the offshoring of STEM jobs? Are we exporting one of the principal sources of our comparative advantage? What policy changes need to be made to ensure that the globalization of universities is in the national interest?

A1. Because there are competing forces around this issue it is a complicated question deserving of some empirical analysis. Given that caveat, though, my guess is that in the short run it is almost certainly true that as the quality of tertiary education improves in foreign countries foreign citizens gaining that training compete for jobs globally, some of which might otherwise have been done by U.S. workers. The long run issue is, of course, whether the increased efficiency generated by having work done by its lowest cost provider frees resources for use on higher value-added activities that will increase wealth in the United States. I believe it does and will. Many U.S. firms, in out-sourcing software development have become more focused on innovations around their core business whether those are manufacturing or IT enabled services. Ultimately, this is the dynamic source of progress markets offer societies.

I also think it important to note that our citizens absolutely have to come to a better sense of the way in which their professional lives and the value they create in society will change fundamentally as a result of globalization. If we do not "globalize" their education (and this means something fundamentally different than just providing some new curriculum in our old ways) it will be the greatest abdication of our responsibility to U.S. society in the history of American universities. That of course is an opinion and probably an extreme one relative to my colleagues. But I hold it firmly. Indeed, I extend this view to research as well although I admit that case is harder to make on evidentiary grounds. We know the people that employ are graduates at every level increasingly demand professionals with global skills and experience.

There are two or three primary policy initiatives required to take advantage of this dynamic process. We must be much better as a society at providing resources to those most directly negatively affected by the dislocations open trade in services can generate. The "winners" must compensate the "losers" in this process or the society will not be able to generate sufficient consensus to sustain the discipline of competition. We are notoriously bad as a society at this important process and it will only become more important in the future. This process WILL occur whether universities globalize or not.

It is self-serving, of course, but the other essential policy initiative is to continue and even increase investment in our educational system. While the tertiary system is important, relatively speaking we arguably have more work to do at the primary and secondary levels to create both the ability and predisposition for young Americans to pursue science and technology professions. Only by increasing our expectations with respect to the educational outcomes of our population as a whole (and our system leaves behind many) can we create and take advantage of the opportunities opened by innovation.

Q2. Has (the) decline (in public sector support for universities) affected the way universities view their relationship to the society that those public-sector subsidizers represent? Who do today's universities regard as their stakeholders?

A2. Another very provocative question! It's hard to imagine that it hasn't although my sense is that so far this has occurred at the margin rather than the core of our activities. And some of that change is actually positive (although some not). And some of that change may have occurred with or without the changes noted in support.

One indicator of this change is the relative size and frequency of fund-raising campaigns run by major universities. A $1 billion campaign was huge a very few years ago. We seemingly blew through $2, $3, and $4 billion as the normative goal without batting an eye.

Again, although the data needs to be analyzed, my guess is that over the last few decades we would also observe a significant increase in the proportion of almost any major university's resources spent on lobbying both state and federal representatives. This is a reflection, I believe, of the increased relative scarcity of non-politicized funding (e.g., the National Science Foundation) and the consequent effort to substitute politicized funding (e.g., earmarks).

Finally, of course, universities have become far cleverer at estimating elasticities of demand for their educational programs and pushing price to its optimal net revenue point. This is a very controversial development, I realize. It is not clear, though, that society is worse off as a result of this in that it tends to direct student support to the neediest segments of our population.

With a lesser degree of generality, many universities have focused more on building closer ties with corporate customers or expanding their suites of professional Master's programs as revenue generating activity.

And it is clearly the hope for the globalization process that it will generate net resources for any university engaged in the process.

In aggregate does this shifting constituency base for universities mean they are less connected to the goals of their society as a whole? Although it is a worthy question and there are clear examples of where this has happened (I think of the very few but notorious cases where funding from drug companies has influenced research on the effects of new drugs), my strong sense is that our connection to the fundamental social interest has not decayed. The core output at our great universities is the generating of new knowledge through research and the transfer of that knowledge to our graduates. My sense is that the barriers between the demands of funders and the research and education decisions that occur at universities are still very much intact and effective. But I equally would not be surprised to see erosion around the margin as research and education become more directed to the needs and aspirations of particular constituencies most able to fund them. While a certain amount of this is probably constructive, we must at all costs be on guard against this proceeding "too far" and I do worry that in the increasingly intense battle for resources this is a danger. I should note that there are increasing demands from the political constituency which are as much threat to the comparative advantage our universities generate as they are protective of that advantage.

Finally, I will repeat that I believe our society has a fundamental interest in its citizens being more globally capable and that the globalization of American universities is absolutely essential to achieve that goal.

Q3. Sloan Foundation President Ralph Gomory has pointed out that one of globalization's effects has been to drive a wedge between the fundamental interests of multinational corporations and those of the national economies in which they are based. Is the drive to efficiency described (in your testimony) likely to lead to a similar split between major universities and their home societies?

A3. I don't think so but it is another question worth evaluation. My argument would be that the highest socially value-added activity of major research universities has been to generate new knowledge. This is why we have been funded. Educating students has been a way to transfer that knowledge to society effectively and in doing so achieve other social goals of equality of opportunity (and maybe even the psychological and social maturation of our population). A core feature of basic science is that while the costs of generating it are very, very high—the marginal cost of its distribution is relatively low and decreasing as technology is rapidly changing. Thus, achieving scale in the distribution process (globalization) will not reduce the basic science available to our society—although it does decrease our "monopoly" control over that science. Moreover, although most universities have not figured out how to take advantage of it, the prospect exists that globalization will decrease the cost of generating new knowledge. Again, the solution to the problems this could generate is not to attempt to control the dissemination of knowledge to humankind. It is, rather, to continue apace the good work of this committee to support new students entering STEM fields so that our comparative advantage might rest in finding the economic and social applications of this new science with the highest value to our nation and species.

Q4. What specific steps have you taken to ensure that your U.S. STEM students are benefiting from your globalization efforts? How do you measure the benefits to your U.S. students?

A4. At levels of specificity I am only competent to speak for the Heinz College at Carnegie Mellon and not for the university as a whole. While our evaluation of global activities is broader than this there are three critical questions we ask ourselves. First, will the activity generate net resources that can support the "home" campus, its students and faculty. We try to make that analysis comprehensive and include both faculty and managerial time as well as the indirect costs of the activities. But it is a difficult measurement. Nevertheless, I believe that my college will have more faculty on site in Pittsburgh in the next five years as a result of the resources provided by these efforts than it would have otherwise and that our student/faculty ratio will be lower on-site. Not a perfect indicator of benefit but not a bad one.

Second, to date we have always found "partners" to work with abroad and one of our criteria in selecting both the partners themselves and the structure of our activities is whether it holds the potential to generate new knowledge or curriculum that can be imported back into our broader environment. So, as one example, we have an IT program that trains General Motors employees globally. As a result of that connection and the needs of our partner, we have been pushed to develop and deploy expertise in managing the global sourcing of IT enterprises. These classes have been imported back into our traditional curriculum, making our students in Pittsburgh better trained. It has also led to data collection and project based activities that have stimulated new research areas—not because GM wanted this research but because our faculty became stimulated by the interactions. We have tried to replicate this model in our other partnerships as well with some good success. These partners offer us the indirect benefit of helping expand our reputations and thereby help our students find new career opportunities.

Finally, we have invested significant resources in technology that allows us to integrate our activities across our global sites. Classes are now easily transmitted back and forth allowing students at all sites access to faculty and courses than none independently could replicate in full. Further, it allows connections between researchers across these sites that stimulate collaboration.

Measurement is a difficult task. Obviously the above implies a financial measure, measures of content exchange across physical space (e.g., transmission of courses) and measures based around research projects and curriculum development. None of these are easy and, frankly, we probably aren't doing as good a job as we might in being systematic about assessing this data.

Questions submitted by Representative Eddie Bernice Johnson

Q1. What does it cost to deliver a degree in the U.S.? France? Singapore? China? India? If it is cheaper to get a degree in their home country, why would a student decide to go to the U.S. for the same degree? Might this have implications for the number or caliber of foreign students who come to the U.S. for their education? Might that, in turn, effect the available talent pool within the U.S.?

A1. If your question is truly "what does it cost" I don't know with certainty and it depends on how you offer it. Fixed costs of starting up somewhere else are very high and in our experience require substantial subsidy from external partners. Marginal costs are likely to decline over time as we achieve scale in those other environments. There are lots of subtleties, though. For example, faculty in Australia are paid less than faculty in the U.S. However, other "costs of doing business" there are significantly higher. And "exporting" U.S. faculty to another location is extremely expensive.

If your question is "what do we charge" the answer at Carnegie Mellon is we charge the same for a degree anywhere in the world—at least to a first order approximation. Sometimes our partners will subsidize certain target audiences in paying that price but our price remains the same. I suspect this is the case for most major universities although I do not know this. However, there are pressures in these markets which could change this over time—although universities will resist that both on principle and because it poses difficult practical problems in markets.

There are three primary reasons international students come to the U.S. for their education. Elites from other countries come for knowledge and prestige. The majority of international students come for knowledge and for access to the U.S. labor market. This latter motivation is even more intense at the graduate level than the undergraduate level. The emergence of high quality tertiary education institutions abroad (which is happening quite independent of U.S. university efforts to globalize) will reduce the cost of education and begin to shift the cost-benefit analysis. What the net effect of that will be in terms of our supply of skilled labor from abroad will depend on U.S. universities' ability to maintain their edge in the creation and delivery of knowledge, the dynamism of the U.S. economy and the opportunities it creates, and very importantly whether we tackle the important policy problems around immigration in a more constructive way than we have so far.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Philip G. Altbach, Director, The Center for International Higher Education; J. Donald Monan SJ Professor of Higher Education, Boston College

Questions submitted by Chairman Bart Gordon

Q1. How do STEM programs offered at foreign campuses affect the offshoring of STEM jobs? Are we exporting one of the principal sources of our comparative advantage? What policy changes need to be made to ensure that the globalization of universities is in the national interest?

A1. Inevitably, as foreign academic systems develop and grow more sophisticated and improve their quality, bright students who might have chosen to come to the U.S. may choose to stay at home in China or elsewhere. This will expand the number of well-qualified S and T personnel abroad and may increase jobs in these fields outside of the U.S. This does not necessarily mean that there will be fewer such jobs in the U.S. but only the that the entire S and T field will be more diversified worldwide—the U.S. can grow along with others.

What can the U.S. do about this situation? The answer is easy—we can, and must, keep the quality of our universities high and ensure that we are providing "world class" preparation in S and T fields. This will mean that qualified foreigners will continue to choose to study in the U.S., and some will choose to remain after completing their degrees. It will also mean that Americans can get a world class education in S and T in this country and more will be lured to these top universities.

Q2. In Mr. Wessel's written testimony, he notes that "the degree to which the public sector is willing to provide subsidy for [universities'] activity has declined—at least relative to the overall cost of providing. . .research and education output." Has this decline affected the way universities view their relationship to the society that those public-sector subsidizers represent? Who do today's universities regard as their stakeholders?

A2. Cutbacks in state funding to higher education and especially to the public research universities has affected how academe looks at society and government. More and more, universities are forced to look out for the "bottom line" and this is often at the expense of basic research and top quality S and T training. Universities are forced to do short-term research for the private sector. While such research is often useful, it cannot be at the expense of basic training of doctoral students or producing basic research that leads to longer term discoveries—as well as Nobel Prizes.

One public university president once said—"at one time we were a state university, then we became a state supported university, and now we are a state located university"—meaning that the university had to generate its own funds, through high tuition, selling products and services, and the like. This is not good for science.

Q3. Asserting that "there are too many universities in this country," Mr. Wessel stated in his prepared testimony that "the emergence of new markets abroad. . .offer[s] opportunities to take advantage of inherent economies of scale without jeopardizing the branding and selection fundamentals of our business model at home. Thus, for many of us, going global is simply efficient." Sloan Foundation President Ralph Gomory has pointed out that one of globalization's effects has been to drive a wedge between the fundamental interests of multinational corporations and those of the national economies in which they are based. Is the drive for efficiency described likely to lead to a similar split between major universities and their home societies?

A3. I do not believe that there are too many universities in the U.S. Our research universities are quintessential "public good" institutions. American society needs to support these institutions to perform their essential missions of teaching and research, and to some extent service. If we do this, the activities of multinational corporations will not affect higher education in a basic way. It is simple—we need to keep aware of the basic mission of our research universities. These universities are not servants of multinational corporations but rather teaching and research institutions that deserve public funding and support. We cannot leave this support to the private sector, especially in a globalized economy!

Q4. What are the primary drivers of university globalization? How do universities factor in America's national interest when determining whether and how to globalize?

A4. Universities are moved toward globalization by trends in science and scholarship, and to a small extent by the need to enroll foreign students to earn money. Universities also internationalize in an effort to provide an international perspective for American students. One can look at Australia to see how an excellent university system has been forced to recruit overseas students and establish branch campuses just to make money because of government cutbacks. So far, American internationalization has been mainly for sound academic reasons, especially at the top colleges and universities. Because the U.S. has no clearly articulated national higher education policy in the international, or for that matter, in other areas, U.S. universities have no sense of what is in the national interest really.

Q5. In your opinion, what are the potential risks that American universities face in establishing international campuses, and are they adequately considering these risks? What types of data and information do you believe universities need to make an informed decision?

A5. Relatively few U.S. universities have established overseas campuses so far, although the number is growing. Universities need to look at the big picture of what establishing campuses will do to their domestic mission, whether such campuses can be sustained over time, and they need to ensure that they are maintaining high academic standards overseas. I do not believe that many are doing their "due diligence" when considering overseas expansion.

Q6. What is the extent of the globalization of U.S. universities now? How extensive will it become? What are the barriers to the internationalization of U.S. universities?

A6. This question would require a long and complex answer. My own opinion is that U.S. universities are not much globalized—we send only modest numbers of students overseas for international study, we have limited relationships with foreign universities and so on. There are some leaders in internationalization, but by and large the system is fairly insular. A key barrier is, of course, funding. The Lincoln scholarship program would help a lot, as would greater attention at the State level to internationalization—essentially no U.S. state really has an active agenda in this field.

THE GLOBALIZATION OF R&D AND INNOVATION, PART III: HOW DO COMPANIES CHOOSE WHERE TO BUILD R&D FACILITIES?

Thursday, October 4, 2007

House of Representatives,
Subcommittee on Technology and Innovation,
Committee on Science and Technology,
Washington, D.C.

The Subcommittee met, pursuant to call, at 10:08 a.m. in Room 2318 of the Rayburn House Office Building, Hon. David Wu [Chairman of the Subcommittee] presiding.

The Subcommittee on Technology and Innovation

Hearing on:

The Globalization of R&D and Innovation, Pt. III: How do Companies Choose Where to Build R&D Facilities?

October 4, 2007
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building
Washington D.C.

WITNESS LIST

Dr. Martin Kenney
Professor of Human and Community Development
University of California, Davis

Dr. Robert D. Atkinson
President
Information Technology and Innovation Foundation

Mr. Steve Morris
Executive Director
Open Technology Business Center

Mr. Mark M. Sweeney
Senior Principal
McCallum Sweeney Consulting

Dr. Jerry Thursby
Ernest Scheller, Jr. Chair in Innovation, Entrepreneurship, and Commercialization
Georgia Institute of Technology

HEARING CHARTER

SUBCOMMITTEE ON TECHNOLOGY AND INNOVATION
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

The Globalization of R&D and Innovation, Part III: How Do Companies Choose Where to Build R&D Facilities?

THURSDAY, OCTOBER 4, 2007
10:00 A.M.–12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose

On Thursday, October 4, 2007, the Subcommittee on Technology and Innovation of the Committee on Science and Technology will hold a hearing to consider the factors companies use to locate their research & development (R&D) and science, technology, and engineering intensive facilities. Witnesses will discuss the policies other countries use to attract such facilities, and how to make the U.S. more attractive to companies. Firms now have many options around the globe when deciding where to locate R&D, design, and production facilities. This hearing—the third in a series of hearings examining the impact of globalization on innovation—will explore the trends in, and factors for, site selections for science, technology, and engineering intensive facilities and the policies needed to ensure that the U.S. remains attractive for these investments.

2. Witnesses

Dr. Martin Kenney is Professor of Human and Community Development at University of California, Davis, and Senior Project Director at the Berkeley Roundtable on the International Economy, University of California, Berkeley.

Mr. Mark M. Sweeney is senior principal in McCallum Sweeney Consulting, a site selection consulting firm.

Dr. Robert D. Atkinson is President of the Information Technology and Innovation Foundation (ITIF).

Mr. Steve Morris is the Executive Director of the Open Technology Business Center (OTBC).

Dr. Jerry Thursby is Ernest Scheller, Jr. Chair in Innovation, Entrepreneurship, and Commercialization at Georgia Institute of Technology.

3. Brief Overview

- Firms weigh many factors when deciding where to site R&D and science, technology, and engineering intensive facilities including market access, costs, intellectual property regimes, customizing products for the local market, proximity to university labs, co-location with production facilities, quality of R&D personnel, and tax and other incentives provided by the host locality.
- Other countries, industrialized and developing, are courting high-technology facilities to spur innovation, job creation, and economic growth. Offshoring began with lower-skill, labor-intensive tasks, such as call centers, but the practice is moving up the value chain to include R&D and other science, technology, and engineering intensive facilities. And low-cost countries, like India and China, are using targeted industrial policies to attract an increasing share of high-technology facilities and jobs.[1]

[1] See, for example, "China Rushes Upmarket: In the face of scandals, Beijing shifts incentives to higher quality exports," *BusinessWeek,* September 17, 2007.

- Many analysts believe that America's comparative advantage is derived in large part from its ability to stay on the cutting edge of innovation and R&D. They argue that maintaining technological leadership has become even more important as an increasing scope of jobs become offshorable to low cost countries.
- Trends in R&D site selection are not well tracked but recent announcements show that many facilities are being placed outside the U.S. According to *Site Selection* magazine, 22 of the 25 largest facility investments in semiconductor plants since January 2006 have occurred in Asia, including nine of the top 10.

4. Issues and Concerns

What are the trends in site selections for R&D facilities? Is the U.S. continuing to get its proportionate share of new R&D investments? Trends in R&D site selection are not well tracked but recent announcements show that many are being placed outside the U.S. For example, Applied Materials announced the opening of a major R&D complex in China in March 2007. According to *Site Selection* magazine, 22 of the 25 largest facility investments in semiconductor plants since January 2006 have occurred in Asia, including nine of the top 10. A University of Texas study recently found that of the 57 major global telecom R&D announcements in the past year, more than sixty percent (35) were located in Asia, whereas, a meager nine percent (5) were located in the U.S.

An OECD study found that China recently passed Japan as the number two R&D performing country. China's ascent has been very rapid and is driven in part by multinational corporation investments in R&D. The National Science Foundation found that, as of 2002, there are net inflows of R&D into the U.S. by multinational firms. The largest surplus is with Europe, where European-based multinationals spent $20.7 billion to perform R&D in the U.S., whereas, American-based multinationals only spent $12.6 billion to perform R&D in Europe.

What factors do site selection managers consider when locating R&D, design, and production facilities? Studies show that many factors are weighed by firms when deciding to site an R&D facility including market access, costs, intellectual property regimes, customizing products for the local market, proximity to university labs, co-location with production facilities, and quality of R&D personnel. The importance of each factor varies across industries—e.g., site selection for pharmaceutical drug discovery is different from semiconductor R&D. Some analysts also believe there is an emerging division of labor where work on incremental improvements to existing products is done in lower-cost countries, but work on new products stays in developed countries.

A recent study by Drs. Jerry and Marie Thursby found that labor costs were not the main reason for locating R&D; market factors, proximity to universities, and quality of R&D personnel were all at least important. Other analysts have pointed out that labor costs are the critical differentiator between countries since high quality personnel is a prerequisite for any R&D facility. Low-cost countries, like India and China, are rapidly building the capacity and quality of their R&D and research universities. As a result, those analysts expect that low-cost countries will capture an increasing proportion of R&D and engineering services.

What role do government policies play in site selection? How do tax relief, training support, intellectual property laws, and other policies affect site decision-making? Countries use a variety of incentives to attract and retain STEM intensive investments, including special economic zones, tax holidays, and in some cases requiring it for market access. As low cost countries are targeting more innovation, tax holidays have played a critical role in spurring information technology investments, especially in countries such as India. As low-cost countries move higher up the value chain, other developed countries are offering even greater incentives to attract and retain R&D investments.

What strategies can local governments use to make their cities and counties more attractive to companies looking for facility locations? Cities, states, and counties are sometimes able to provide financial incentives to companies interested in locating facilities in their area. However, due to limited budgets, many local economic development agencies must rely on more creative strategies for attracting companies. Local governments often tout proximity to complementary markets, highly skilled local populations, affordable housing, low state taxes, or other features companies might find favorable. However, as competition increases with international locations, local governments must be more proactive in demonstrating the suitability of their states, towns, and counties to companies.

Chairman WU. Good morning. The hearing will now come to order.

I want to thank everyone for attending today's hearing on *The Globalization of Research and Development and Innovation, Part III: How Do Companies Choose Where to Build R&D Facilities?*

This is a third in the Science and Technology Committee's series of hearings on the topic and the first to explore the phenomenon from the point of view of businesses looking for the optimal location for R&D facilities. More importantly, and most relevant to this committee, we are interested in hearing what our country can do to attract business R&D facilities and keep them here in the United States.

The Science and Technology Committee just led the Congress in passing the *America COMPETES Act,* which strengthened R&D in education programs that will make our country more innovative and our students more successful in science, math, and engineering.

As we will hear from our witnesses today, competitiveness, especially on the regional level, depends on far more than a well-prepared technical workforce and first-class R&D facilities. For a business looking to locate an R&D facility, other factors matter also, like access to transportation, favorable government policies, good local universities, and employee necessities, such as affordable housing and access to quality health care.

In 1993, the Oregon legislature created the Strategic Investment Program, or SIP. The goal was to attract high tech companies to Oregon, specifically the semiconductor industry. The program allows for a 15-year property tax abatement, among other factors. Most importantly, the program is administered by local government, so that they can use it as they please. Washington County, in my Congressional district, has actively used this to attract companies. Intel, Sun Microsystems, Genentech, and a number of other high tech companies have located facilities in the region, providing quality jobs to local communities.

SIP is not the only factor that makes Oregon competitive for recruiting high tech firms, but it is one example of a government policy designed to attract companies to stay in the United States. To understand the challenges facing our country, we need a better understanding of who we are competing against for R&D facilities.

While trends in R&D site selection are not well tracked, recent announcements show that many R&D facilities are being placed outside the United States. According to Site Selection Magazine, 22 of the 25 largest facility investments in semiconductor plants since January of 2006 have occurred in Asia, including nine of the top ten. While this is not a complete one-on-one track with R&D, R&D frequently follows such investments, and vice versa. Of course, we need far more data and information to truly quantify the extent to which companies are building facilities overseas, and even more information to understand why.

Some of our witnesses today will discuss the extent to which low cost countries have been able to attract the offshoring of high tech work. Because this is an emerging challenge, there are differing viewpoints on the scale of the globalization of R&D and innovation. I am sure we will have a lively debate on this topic, which will hopefully give us a better background on the competition among countries and regions.

Two of our witnesses come from the practitioner end of the site selection field, and will be able to address more of the why. I am interesting in hearing both how companies make decisions on where to locate, and what we can do to entice them to locate in America, because America would be better off if we could find ways to maximize a company's economic success while creating good jobs here in the United States. It is my home that we will be able to strike this balance between the interests of multinationals, and creating jobs and R&D facilities here in the United States.

The Chair now recognizes Dr. Gingrey, our Ranking Member of this subcommittee, for his opening statement.

[The prepared statement of Chairman Wu follows:]

PREPARED STATEMENT OF CHAIRMAN DAVID WU

I want to thank everyone for attending today's hearing on *The Globalization of R&D and Innovation, Part III: How do Companies Choose Where to Build R&D Facilities?* This is the third in the S&T Committee's series of hearings on the topic of the globalization of R&D, and the first to explore the phenomenon from the point of view of businesses looking for the optimal location for the R&D facilities.

On the flip side, and most relevant to this committee, we are also interested in hearing what we can do to make sure that our states and our country can do to attract those businesses.

The Science and Technology Committee just led the Congress in passing the *America COMPETES Act,* which strengthened R&D and education programs that will help make our country more innovative and our students more successful in science, math, and engineering.

But as we'll hear from our witnesses today, competitiveness, especially on the regional level, depends on far more than a well-prepared technical workforce and first class R&D facilities. Don't get me wrong: those are the basis for our country's economic success.

But for a business looking to locate an R&D facility, other factors matter too: like access to transportation, favorable government policies, local universities, and worker amenities like affordable housing and access to quality health care.

In 1993, the Oregon legislature created the Strategic Investment Program. The goal was to attract hi-tech companies to Oregon, specifically the semiconductor industry. The program allows for a 15-year property tax abatement.

Most importantly, the program is administered by local governments, so they can utilize it as they please. Washington County in my district has actively used this to attract companies. Intel, Sun Microsystems, Genentech, and a number of other high-tech companies have located facilities in Oregon, providing quality jobs to local communities. SIP is not the only factor that makes Oregon competitive for recruiting high-tech firms, but it is one example of a government policy designed to attract companies to stay in the U.S.

To understand the challenges facing our country, we need a better understanding of who we're competing against for R&D facilities. While trends in R&D site selection are not well tracked, recent announcements show that many R&D facilities are being placed outside the U.S.

According to *Site Selection* magazine, 22 of the 25 largest facility investments in semiconductor plants since January 2006, have occurred in Asia, including nine of the top ten. Of course, we need far more data and information to truly quantify the extent to which companies are building facilities overseas, and even far more information to understand why.

Some of our witnesses today will discuss the extent to which low cost countries have been able to attract the offshoring of high-tech work. Because this is an emerging challenge, there are differing viewpoints on the scale of the globalization of R&D and innovation.

I am sure we will have a lively debate on this topic which will hopefully give us a better background on the competition among countries and regions.

Two of our witnesses come from the practitioner end of the site selection field, and will be able to address more of the "why."

I am interested to hear both how companies make decisions on where to locate, and what we can do to entice them to locate here in the U.S. Obviously the main motivation of any company is to make a profit, and there's nothing wrong with that.

But everyone would be better off if we could find ways to maximize a company's economic success while creating good jobs here in the U.S. It is my hope that this hearing helps us strike that balance.

Mr. GINGREY. Mr. Chairman, thank you for holding these hearings, as you said, the third in our series, and certainly, on an incredibly important issue, the location of research and development, science, technology, and engineering intensive facilities of private companies.

In the technology-based economy of the twenty-first century, it is vital that we enact policies that continue to make the United States a viable and attractive option for companies when they decide where they will place these essential facilities. Our panel this morning will provide us with a wealth of information on this issue, both from academia and the private sector. It will help us shape future policies that will inevitably affect our economy for generations to come. I want to thank each of the witnesses for being here today, and I am looking forward to hearing each of you.

For companies, there are a multitude of factors that are considered when choosing to locate R&D facilities, whether that location is in the United States or elsewhere in the world. Our country is seen as being on the cutting edge of R&D, yet we continue to see the emergence of companies choosing offshore locations as an alternative to the United States.

Other countries are using the United States as a model for economic prosperity, through attracting investment in available resources, including human capital. These countries have invested in their own intellectual infrastructure, by placing an extra emphasis on science and engineering, to the point where a large percentage of graduates are in these fields. According to a recent study, 50 percent of students in China receive their undergraduate degrees in natural science or engineering. In Singapore, that number is 67 percent, and 38 percent of South Korea graduates fall into these fields.

Unfortunately, the United States is lagging behind, with a staggering 15 percent of graduates in natural science or engineering. So I am glad that the work of this committee, through the *America COMPETES Act,* begins to address this shortcoming. We still have a large gap, of course, to close in this area.

Furthermore, we have seen that China has made some of the most aggressive steps in advancing R&D, while we have chosen to place our fellow priorities elsewhere. China has founded the China Science Foundation that is modeled after the United States, and China is increasing its investment in science. R&D activities rose 500 percent in China between 1991 and 2002, from $14 billion to $54 billion, while during that same period, domestic R&D spending only increased by 140 percent, from $177 billion to $244 billion.

Mr. Chairman, if imitation is the sincerest form of flattery, we should be very flattered when it comes to R&D. Unfortunately, all of this flattery has had a profoundly negative effect for our economy. For example, according to Site Selection Magazine, 22 of the 25 largest facility investments in semiconductor plants, the Chairman has mentioned that, since January of 2006, occurred in Asia, including nine of the top ten. These are jobs that very easily could be held by hard-working Americans and stimulating our domestic economy. Instead, we are watching these jobs go overseas, and the United States falls further behind in an area of such importance to the future of our Nation.

The United States has historically been a leader in high tech, cutting edge innovation. Through a combination of increased domestic STEM education, which this committee has worked so diligently on, facilitation of domestic investment R&D, and collaboration on R&D policy, the United States can reclaim this leadership role.

So, I await the testimony of our witnesses on how we can address these critical issues facing our committee. And with that, Mr. Chairman, I yield back.

[The prepared statement of Mr. Gingrey follows:]

PREPARED STATEMENT OF REPRESENTATIVE PHIL GINGREY

Mr. Chairman, thank you for holding this hearing—the third in this series—on the incredibly important issue of the locations of research & development, science, technology, and engineering intensive facilities of private companies. In the technology-based economy of the 21st Century, it is vital that we enact policies that continue to make the United States a viable and attractive option for companies when they decide where they place these essential facilities. Our panel this morning will provide us with a wealth of information on this issue—both from academia and the private sector—to help us shape future policies that will inevitably affect our economy for generations to come. I want to thank each of the witnesses for being here, and I am looking forward to hearing from you.

For companies, there are a multitude of factors that are considered when choosing to locate R&D facilities, whether that location is in the United States or elsewhere in the world. Our country is seen as being on the cutting edge of R&D, yet we continue to see the emergence of companies choosing offshore locations as an alternative to the United States.

Other countries have used the U.S. as a model for economic prosperity through attracting investment in available resources, including human capital. These countries have invested in their own intellectual infrastructure by placing an extra emphasis on science and engineering to the point where a large percentage of graduates are in these fields.

According to a recent study, 50 percent of students in China receive their undergraduate degrees in natural science or engineering; in Singapore, that number is 67 percent, and 38 percent of South Korea's graduates fall into these fields. Unfortunately, the United States is lagging behind with a staggering 15 percent of graduates in natural science or engineering. I am glad that the work of this committee, through the *America COMPETES Act,* begins to address this shortcoming, but we still have a large gap to close in this area.

Furthermore, we have seen that China has made some of the most aggressive steps in advancing R&D while we have chosen to place our federal priorities elsewhere. China has founded the Chinese Science Foundation that is modeled after the United States, and China is increasing its investment in science. R&D activities rose 500 percent in China between 1991 and 2002, from $14 billion to $54 billion; while, during that same period, domestic R&D spending only increased by 140 percent from $177 billion to $245 billion.

Additionally, countries have also mimicked our technology transfer programs. A number of companies that locate their facilities abroad place them near universities so that they can work in collaboration with those laboratories. Many companies report that overseas universities are more cooperative than their U.S. counterparts and much more willing to seek common ground on intellectual properties rights. At the same time, companies are finding current Bayh-Dole laws overly burdensome on facilitating domestic investment.

Unfortunately, we have seen that a company can move its operation abroad in a short time period and end up with a much more generous contract. As we move forward, this committee must address these problems and find ways to provide the proper incentives for R&D investment to remain in the United States.

Mr. Chairman, if imitation is the sincerest form of flattery, we should be very flattered when it comes to R&D. Unfortunately, all of this flattery has had a profoundly negative affect for our economy. For example, according to *Site Selection* magazine, 22 of the 25 largest facility investments in semiconductor plants since January 2006 occurred in Asia, including nine of the top ten. These are jobs that very easily could be held by hard-working Americans and stimulating the domestic economy. Instead, we are watching these jobs go overseas and United States fall behind in an area of such importance to the future of our nation.

The United States has historically been a leader in high-tech, cutting edge innovation. Through a combination of increased domestic STEM education, facilitation of domestic investment in R&D and collaboration on R&D policy, the U.S. can reclaim its leadership role. I await the testimony of our witnesses on how we can address these critical issues facing our committee. With that Mr. Chairman, I yield back.

Chairman WU. Thank you, Dr. Gingrey.

If there are other Members who wish to submit opening statements, your statements will be added to the record at this point.

[The prepared statement of Mr. Mitchell follows:]

PREPARED STATEMENT OF REPRESENTATIVE HARRY E. MITCHELL

Thank you, Mr. Chairman.

Today's hearing raises important questions about the impact of globalization on the technical job market in the United States.

As the economies of the world become more intertwined, we need to ensure that America's participation in the global economy does not lower the standard of living for American workers.

While there is a consensus that the number of jobs available will not change, it is essential that we understand how globalization may impact the type of jobs available. This means that we must continue to educate workers with the necessary skills to perform STEM jobs.

Offshoring is increasing at a rapid rate in certain industries and is this trend is expected to continue. It is our job as lawmakers to carefully assess the current situation and hear from experts in the field to consider what our future actions should be.

I look forward to today's testimony, and I yield back the balance of my time.

[The prepared statement of Ms. Richardson follows:]

PREPARED STATEMENT OF REPRESENTATIVE LAURA RICHARDSON

Thank you Chairman Wu, for holding this important hearing today. As the newest Member to this committee, I have been very impressed thus far, by the apparent bipartisan manner in which this committee operates. From the USFA reauthorization hearing that we held this past Tuesday, to the hearing that we held last week on inter-operability in Health Information Technology, it is obvious to me that this subcommittee, and the Full Science & Technology Committee is dedicated to ensuring that our country remains competitive, and a leader in the fields of Science, Technology, Engineering, & Math (STEM).

Along those same lines the purpose of today's hearing is to discuss the factors that companies use to locate their research and development (R&D) and science, technology, and engineering intensive facilities.

I am proud to say that my home State of California has routinely led the Nation in the number of R&D facilities, and hence R&D funding. In addition to the numerous foreign companies like Honda which have at least four R&D facilities in California, numerous government agencies like the Department of Defense (DOD), NASA, Human Health and Services (HHS), the Department of Energy (DOE), the National Science Foundation (NSF) and the United States Department of Agriculture (USDA) all have their R&D facilities in the great State of California. These agencies, along with our great research universities have forged an outstanding working relationship over the years, and continue to do excellent work in the fields of physics, life sciences, environmental sciences, and energy sciences. In fact I am proud to say that California's R&D facilities on its own, could rival most foreign countries, in terms of funds received and overall performance. In fiscal year 2004 California received $19.9 billion dollars in federal R&D funding.

California's ability to lead the Nation in the field of R&D can be attributed to many factors that I am sure today's witnesses will expand upon in their testimony today, but allow me to mention a few. Typically the State of California leads the

Nation in the number of doctoral scientists, doctoral engineers, and science & engineering post-doctorate degrees conferred. Not to mention the fact that California residents typically lead the Nation in the number of utility patents held.

Therefore, I believe that our witnesses will agree that amongst other factors, the key components to locating R&D facilities are innovation and entrepreneurship. Innovation obviously comes in the form of an educated populous that is motivated in the field of Science, Technology, Engineering, and Math (STEM). This requires amongst other things a commitment that starts at the grade school level, continues through high-school, and culminates with the world class research facilities that our universities are known for not only in California, but around the Nation.

In terms of entrepreneurship, it is important that we continue to support venture capitalists that create the small businesses that are the backbone of the American economy. Google and Yahoo! are just two examples of American small business success stories. Along those same lines I was happy to support H.R. 3567, the *Small Business Investment Expansion Act,* last week which increases the investment opportunities for angel investors and other venture capitalist.

Allow me to end by stating that the State of California, and I believe that our witnesses would agree, is a perfect example of the type of location that inspire companies to place R&D firms at various locations. We have the human capital in the form of a highly educated workforce, the necessary infrastructure in places like Silicon Valley, strong Intellectual Property laws to protect a company's investment, a strong university system, and a great quality of life. Coupled with an effort to address the lack of necessary H–1B visas to meet the needs of the tech industry, we can continue to be the world's leaders in R&D.

Mr. Chairman, I yield back my time.

Chairman WU. At this point, I would like to introduce our witnesses. Dr. Martin Kenney is Professor of Human and Community Development at the University of California, Davis, and Senior Project Director at the Berkeley Roundtable on the International Economy at the University of California, Berkeley.

Dr. Robert Atkinson is the President of the Information Technology and Innovation Foundation. Mr. Steve Morris is the Executive Director of the Open Technology Business Center in Beaverton, Oregon. Mr. Mark Sweeney is a Senior Principal at McCallum Sweeney Consulting.

Dr. Jerry Thursby will be introduced by Dr. Gingrey in a moment, and as our witnesses should know, spoken testimony is limited to five minutes. Your written testimony will be submitted in full, and after your testimony, the Committee will have five minutes each to ask questions.

And Dr. Gingrey, if you would care to introduce our witness.

Mr. GINGREY. Mr. Chairman, thank you for giving me the opportunity.

Of course, it is always a great pleasure to have someone from my alma mater, the Georgia Institute of Technology in Atlanta, Georgia, to be with us as a witness, as they do such a great job, and we are looking forward today, Mr. Chairman, to hearing from all of the witnesses, including my colleague from Georgia Tech, Dr. Jerry Thursby.

He is a member of the Strategic Management Faculty. Dr. Thursby holds the Ernest Scheller Jr. Chair at Georgia Tech in Innovation, Entrepreneurship, and Commercialization. He has been published extensively in the areas of econometrics, international trade, and the commercialization of early stage technologies, with a particular interest in the role of university science in national innovation systems.

His work, Mr. Chairman, has appeared in such prestigious publications as the *American Economic Review,* the *Journal of the American Statistical Association, Management Science,* and *Science,* and he currently serves on the editorial board of the *Journal of Technology Transfer,* and is an associate editor of the *Journal of Productivity Analysis.*

I am disappointed that his wife, Dr. Marie Thursby, is not with us today. I had some stellar things to say about her, as well. Dr. Thursby informed me before we started the hearing, Mr. Chairman, that she is in the classroom teaching, and I think that is fantastic because some of the students, particularly those freshmen and sophomores, really need the very best and the brightest that we have to offer, and Dr. Marie Thursby is certainly a part of that effort, and we are proud to have him with us today.

Thank you, Mr. Chairman.

Chairman WU. Thank you very much, Dr. Gingrey, and we will now start with our witness testimony, and we will start with Dr. Kenney. Please proceed.

STATEMENT OF DR. MARTIN KENNEY, PROFESSOR, DEPARTMENT OF HUMAN AND COMMUNITY DEVELOPMENT, UNIVERSITY OF CALIFORNIA, DAVIS

Dr. KENNEY. Mr. Chairman and Members of the Committee, thank you for the opportunity to take part in this important hearing.

For the past five years, with Rafiq Dossani at Stanford University, and funded by the Alfred P. Sloan Foundation Industry Studies Grants, I have been studying services offshoring to lower wage economies. Today my remarks will focus on India and China.

R&D globalization is not new. Large U.S. firms have had laboratories in high labor cost foreign nations for decades. Conversely, most large foreign firms have U.S. R&D operations. The new phenomenon is the rapid expansion of R&D facilities operated by U.S. firms in China and India. The main reasons for R&D offshoring to China are a combination of product localization, government pressure, proximity to key customers, but cost is an important factor. In the case of India, cost and decreasing the time to market are the primary motivations. All assume that there are skilled persons available.

The Indian and Chinese R&D workforces are growing rapidly. Today there are approximately 140,000 R&D engineering services and software products workers in the Indian export sector. It is growing at about 20 percent per annum, and sales will be approximately $8 billion in 2007. Overall, in 2006, India exported $31.9 billion of services. Total employment was 1.25 million. A recent OECD report, using Chinese government statistics, estimated that China has 1.1 million S&T researchers. There are no statistics regarding how many are exporting R&D services, but it is surely very small, though they may be exporting their services embodied in physical goods.

As a comparison, the NSF data for 2003 finds that approximately 1.16 million U.S. workers are engaged in private sector R&D. An increasing number of U.S. IT firms have their largest foreign workforce in India. To illustrate, as of 2007, Adobe India had 1,000 employees, filed for 50 patents, and had global responsibility for producing software upgrades for two key products, PageMaker and FrameMaker. Today, IBM has in excess of 60,000 Indian employees and over 100 Ph.D. researchers. With IBM setting the pace, other U.S. IT service providers are expanding in India. This is not surprising, since competition with the Indian service providers, with their far lower cost bases, is heated.

Firms in other industries are offshoring. The GM R&D laboratory in Bangalore employs 500 professionals. GE has four R&D locations globally. GE's New York research headquarters employs approximately 1,900. The new Munich center employs 150, and the Shanghai center employs approximately 150. The Bangalore center has nearly 3,000 researchers. Also, the Indian service providers have large contract R&D arms. For example, Wipro, with 15,000 engineering professionals, claims to be the world's largest contract engineering firm.

Less is known about the extent and type of MNC R&D in China. For 2004, the OECD found that 166 firms had R&D facilities. The largest employer, Motorola, had 1,600 engineers in China. These MNCs were most likely to be developing new products or modifying existing products for the Chinese market.

Less prevalent was the expiration of new products for the global market or basic research. There is significant concern about intellectual property protection in China, and yet, despite the IP protection situation, MNCs are increasing their R&D commitment.

There are clear differences between the two nations. Much of the R&D in China is localization work or developing products for the domestic market. In India the focus is cost reduction and reducing time to market for products intended for the global market. The conceptualization and architecting of new products, strategic research planning, and product roadmapping will, for the most part, remain in the United States.

In terms of industry, R&D globalization is furthest advanced in the IT sector. In traditional manufacturing firms, R&D globalization is less advanced, but growing rapidly. The pharmaceutical and biotechnology industries are offshoring drug R&D more slowly.

Many nations have tax, cash, and in-kind incentives to attract R&D. China has schemes to encourage R&D by both domestic firms and MNCs. Also, informal pressure is used on the MNCs. As a generalization, India has no specific incentives. In India, R&D, like most other exported services, operates in technology parks where firms are exempt from all corporate income tax until 2010.

One vital U.S. research strength is our research universities that remain the finest in the world. Congress has done a remarkable job in providing research funds that have kept us at the cutting edge. With the *America COMPETES Act,* more moneys are to be appropriated to the physical sciences and engineering.

What might we do to ensure our continuing supremacy? First, we need to find ways to address the spiraling cost of graduate education. Second, to ensure the continuing supremacy of U.S. research universities in the information sciences, Congress might consider creating a National Institute of Information Sciences. The operation of the 1980 *Bayh-Dole Act* has, in many cases, spawned university bureaucracies that retard technology transfer.

Four, with understanding that innovation requires information, it is vital to reestablish the balance between patent protection and increasing the stock of freely usable knowledge. The lowering of technological, legal, and political barriers to trade has made R&D globalization a natural outcome. It is impossible, in the current political and economic environment, to see how this trend can be reversed.

However, the implications of offshoring may be felt most acutely in the next recession, when firms must decide whether and where to eliminate excess employees. For high wage nations, success in the global economy is ever more dependent on the ability to grow new industries. Innovation, entrepreneurship, technology and science, are keys to continuing prosperity. There are enormous opportunities for the U.S. economy, which is the most diverse and creative in the world.

Success will be based on increasing the capabilities within our workforce, even as large numbers of capable workers, paid far less than ours, enter the global labor market. Fashioning policies to meet this new challenge will be difficult, but as a nation, we have no choice.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Kenney follows:]

PREPARED STATEMENT OF MARTIN KENNEY[1]

Mr. Chairman and Members of the Committee, thank you for the opportunity to take part in this important hearing. I was asked to speak about the criteria firms use for locating their R&D sites in a globalizing world. For the past five years, with Rafiq Dossani of Stanford University and funded by Alfred P. Sloan Foundation Industry Studies grants, I have been studying services offshoring to lower wage economies. Today, my remarks will focus on R&D offshoring to India and China.

R&D globalization is not new. For example, IBM and many large pharmaceutical firms have had laboratories in high labor-cost foreign nations for decades. Nearly every major European or Japanese firm has R&D operations in the U.S. (see, e.g., Serapio et al., 2004). Recently, though, a new phenomenon has emerged, namely the rapid expansion of R&D facilities operated by firms from high labor cost nations in lower labor cost developing nations, in particular, China and India, along with Russia, Eastern Europe, and Brazil. My testimony focuses upon China and India because they have been the most important lower-wage nation recipients of R&D investment.

During the last two decades the work of what Robert Reich termed “symbolic analysts” has been digitized. With the advent of digitization the information has been freed from its physical media, and, as a result, can be shipped anywhere in the world (or, more correctly, workers from anywhere in the world can log into a database housing this information). The implications are profound. Not only might personnel in disparate locations collaborate on the same database or software programs, but R&D personnel might collaborate on designing the same artifact, be it an aircraft wing or an insulin pump.

R&D is a broad category of business activities including everything from relatively mundane product improvement and product localization work to the most sophisticated Ph.D.-level research conducted at the cutting edge of science or engineering. As a generalization, most R&D offshored to India and China is mundane, but some cutting edge work is being done, particularly in the research laboratories of firms such as Google, IBM, Microsoft, and Yahoo!. I was asked to limit my remarks to the R&D operations of MNC firms, though I will extend this mandate to encompass the Indian IT service providers that are now providing development work to global firms on an outsourcing basis. I would suggest that there is one other important missing variable in this discussion and that is the pattern of venture capital invest-

[1] Martin Kenney thanks the Alfred P. Sloan Foundation Industry Studies Program for funding the micro-level, field-based Industry Studies research that informs this presentation. The work on India was done with long-time collaborator Rafiq Dossani. I also thank my colleagues Martin Haemmig and Donald Patton with whom much of the work underlying this testimony was conducted. I also thank Kaley Lyons for research support in the preparation of this testimony.

ing in these two emerging economic giants, but I shall not discuss this important phenomenon.

To answer the questions posed by the Subcommittee, my testimony is structured in the following manner. First, I discuss the different reasons for offshoring R&D and provide real world examples throughout. I suggest that, in many cases, as, for example, product localization and developing new products for the foreign market creates only minimal competition for U.S. workers. Other types of R&D globalization may create greater competition and thereby have more significant implications for the U.S. In the second section, I discuss the trends in R&D offshoring with respect to India and, to a lesser degree, China. The third section briefly discusses governmental policies adopted by India and China to attract MNC R&D. In the conclusion, I suggest some policies that might help bolster U.S. leadership in commercializing the fruits of R&D.

Factors Influencing Site Selection for Offshore R&D Facilities

There is an ample literature on R&D globalization, in general. It can provide some insight into the site selection decision, but, generally it has not dealt with situations where there are very large wage differentials. Table One is a list of some of the more important reasons for offshoring. Prior to discussing the various reasons for site selection, it is important to state that only in cases of extreme compulsion will a private firm place an R&D site in a location that does not have at least some suitable personnel that can be employed.[2] In other words, the statement that firms are locating somewhere to access the local "talent" is trivial.

In Table One, each reason is presented as separate and dichotomous; despite the fact that almost always the decision to establish an R&D facility either domestically or abroad is due to a combination of factors. To illustrate, a cell phone manufacturer with large market share in China might experience significant pressure to undertake R&D in China. The manufacturer might also feel that future success is dependent upon customizing its phones for the Chinese market. Here, having a design and development team in China would be desirable in and of itself. So the pressure combined with the opportunity would be sufficient to overcome opposition for other reasons, such as concern about intellectual property (IP). Another example would be a firm with a significant manufacturing operation in a nation, it might find it helpful to have a small laboratory in proximity to its factory. These decisions would be even easier if the R&D personnel were less expensive than in the firm's home nation, all other things being equal.

Academic research suggests that understanding R&D facilities through observations at single points in time is hazardous, because there are almost always changes, as a firm's strategy, market position, and the external market evolve. An assumption that the evolution of an R&D facility moves unilinearly from say a government-mandated investment to one based on access to skilled personnel is unfounded. R&D facilities may evolve from having one objective to having multiple objectives or vice versa. Finally, firms may completely abandon an R&D facility if market conditions change dramatically.

Government Compulsion

Government compulsion, as a motivation for offshoring, comes in a wide variety of forms. For example, it can be mandated that foreign firms selling in the domestic market must invest a certain percentage of profits and sales in local R&D. More subtly, there may be a informal "pressure" applied by local officials. These forms of attracting R&D are unlikely to be captured through firm surveys. Anecdotally, it is widely reported that Chinese government officials apply considerable pressure to MNCs to upgrade their sales or manufacturing operations to include R&D. For example, the Danish firm Novo Nordisk, which has 70 percent of the Chinese diabetes market, established its first R&D laboratory outside of Denmark in Beijing, in part due to informal pressure from the Chinese government (Kjersem, 2006). Firms such as Cisco, Intel, and IBM having significant market shares in China are almost certain to experience significant informal pressure from government officials to establish local R&D operations.

In the case of India, Boeing, as part of a deal to sell aircraft to Air India, agreed to $1.8 billion in offsets that had to be invested in India. To fulfill its offset obligations, Boeing is purchasing engineering services from Indian firms and considering establishing its own engineering subsidiary in India (*The Economic Times,* 2007). In this case, the Indian government is, in effect, forcing Boeing to open facilities, which will include engineering, in India. In this case, it is simply quid pro quo.

[2] An example of this is the difficulty the Chinese government has had despite many schemes and subsidies in getting Chinese or foreign firms to locate in Western China.

These illustrations show that sovereign governments can impact the decision to establish an R&D facility abroad.

Localization and Access to Dynamic Markets

Very often foreign markets differ in substantial ways from a firm's home markets. Market entry may require localization, a process that may necessitate product reengineering or other substantial revisions. For example, to sell software in China, code must be rewritten to ensure that software is usable for Chinese-language speakers. This is considered development and is done in an R&D facility, very often in the country where the sales will take place. Similarly, foreign cell phone manufacturers must either transfer the specifications and schematics of their phone models to a Chinese development facility or do localization in some other usually higher cost location. Employing local engineers lowers costs. The local engineers can go a step further, redesigning and de-featuring the model to further lower cost and make the phone accessible to even more consumers. Sometimes this lower cost phone can then be exported to other markets.

In the case of localization, the establishment of an offshore R&D facility may relocate employment from the developed nation to a developing nation, but it also allows the model developed in the home nation to have a longer life and be more profitable. In effect, it creates a division of labor. For the MNC, the ability to localize effectively may be critical to capturing new markets. In the case of India, the market is smaller and since the language problem is not as prominent, there is less localization of R&D. But there are examples, such as Texas Instruments India that designed a single chip that combines all the functions of the multiple chips in a cell phone, thereby dramatically reducing the cost of cell phones and thus allowing market expansion to lower-income groups (Mitra, 2006).

Proximity to Key Customers

For suppliers, proximity to a key customer's facilities may be an important marketing advantage. So, for example, Intel has an enormous and increasing number of customers in China and proximity to their operations is important both in terms of a show of commitment, but also to be able to rapidly respond to their needs/issues. Similarly, the Chinese telecommunications equipment market is growing rapidly, therefore firms such as Cisco and Juniper Networks require an R&D presence to satisfy their customer's desires. The establishment of such R&D facilities is driven by a headquarters' estimation of the current and future importance of its customers, and is not directly driven by a desire to access qualified personnel or cost concerns.

Access to Highly Qualified Personnel

For certain types of R&D, access to qualified personnel can be the most important factor governing R&D location. For example, nearly every major information technology firm in the world has some sort of R&D operation in Silicon Valley. In the past many saw this as a problem. Their reasoning was that foreign firms were accessing technology to transfer it abroad. What was not understood was that having these firms in Silicon Valley REINFORCED its primacy in the global IT economy. By being in the region and communicating, while accessing information, these firms transmitted information into the ecosystem and, of course, hired or transferred skilled persons into the ecosystem, thereby increasing Silicon Valley's global salience. In this case, despite wage rates, which many consider exorbitant, the specialized personnel and unique information dominate cost considerations. The U.S. has been an enormous beneficiary of these investments.

Around the Clock Engineering

Having global R&D operations allows a firm to take advantage of the fact that normal operating hours differ by time zones. Here, the savings is in development time. Such a strategy does not imply that lower-cost offshore personnel should be used. However, the ability to use lower-cost personnel would, of course, be an attractive added bonus. There are a variety of ways in which this natural phenomenon can be utilized.

The most obvious, but often relatively difficult to manage, strategy is to undertake work in say, North America, and then electronically transfer the project to another location, say India or Europe, where they continue the work. Though simple in concept, this can become unmanageable when there are difficulties requiring immediate communication with the offshore team that has already gone home. Another strategy entails having the lower-cost foreign engineers do the less desirable debugging and testing for the U.S. programmers overnight. Here, the foreign engineers are given the low-skill, more routinized tasks while the U.S. programmers do the more challenging work. Over time, this strategy can have problems as the most skilled engineers in any nation want to work on the hottest projects.

Another strategy has been to take a development project and divide the work into various modules, allowing autonomous progress until various benchmarks are met then the modules are integrated. Here, there is the advantage of a division of labor, but it need not be hierarchical. The foreign modules may be just as sophisticated as those done in the U.S. In this case, there is no explicit time-saving, as the foreign team could just as easily sit in the U.S. The motivation is cost-saving, as the work could be done in the home nation, but for a much higher price.

Access to a Lower-Cost Labor Force

In market economies lower cost labor forces have always held an attraction, particularly if the quality of their production is roughly comparable to that of an existing work force. This is at the heart of Richard Freeman's (2005) observation about the doubling of the world's workforce through increased access. For firms of all sorts, the ability to access adequately trained, college-educated personnel at a cost of between 40–60 percent less than those in their developed home nations is an ample attraction. It is, of course, not easy managing across borders, but for many U.S. firms efficiently utilizing their offshore and, particularly, Indian work force is of vital importance in ensuring their profitability. In the last month, EDS, which has in the past two years hired and acquired in excess of 20,000 Indian employees for its global operations, announced that 12,000 U.S. employees will be terminated. Unless these 12,000 were unskilled, cost must have been a consideration. Thus, in the same ways manufacturing was offshored in the past, certain service and R&D functions are being offshored today.

Consider the cost differences. The VC-financed Indian firm Tejas Networks designs sophisticated telecommunications switches (i.e., its products compete with those of Cisco, Huawei, and Alcatel/Lucent). Were the firm to have been established in Silicon Valley, it would have cost between $100–150 million, whereas Tejas, which is now on the verge of positive cash flow, cost between $30–50 million—a dramatic difference (Tejas Network executive, 2006). In the case of a software/ASIC design firm, the cost comparison for 50 engineers in India, with an average cost of $40,000 per year in Bangalore, yields a burn rate of $2 million per year versus in Silicon Valley where the average salary would be $180,000 per year for a burn rate, in wages alone, of $9 million per year (Indian startup firm executive, 2006). There are, of course, many disadvantages to locating in India rather than Silicon Valley, but the cost equation is quite compelling. Similar cost advantages would be true for any other firms locating R&D operations in India.

Nearly all firms are under cost pressure from rivals or stockholders intent upon increasing their returns. The existence of an accessible lower cost labor force is a natural attractant. For commodity-style work it may be difficult to resist the "India price" for a service. Today, U.S. service workers are being introduced to offshore competition from lower-wage workers from around the world, but especially from India.

Section Summary

This section has briefly summarized a variety of reasons that a firm might want to offshore its R&D to a low-cost nation. Cost emphatically is not the only reason for offshoring. For many operations in China, some combination of product localization, government pressure, and proximity to key customers help explain the corporate decisions. Low-cost engineering personnel are also significant. There is also an elite strata of brilliant global-class science and technology talent that MNCs will pursue where ever they are located—and with their huge numbers of people it is not surprising that some of them are located in India and China. R&D facilities are established in various locations to access different qualities in the labor force. The next section examines offshore R&D operations and provides illustrations of MNC strategies in globalizing their R&D operations to India and China.

Trends in R&D Offshoring

Measurement of R&D offshoring is difficult for the following reasons: First, firms are not required to report on their R&D in any uniform manner. Second, it is difficult to precisely define R&D. Many activities, such as porting a software platform from say the Microsoft operating system to Linux, are relatively routine and are considered development. On the other hand, upgrading a proprietary banking software application is usually not considered development.

Today, the dominant destination nations for R&D offshoring are India and China. Their importance is, perhaps, best illustrated by a survey of 300 executives conducted by the *Economist* (2007) asking which nations were the best overall overseas location for R&D investment (excluding their home nation). Approximately 28 percent answered India, approximately 23 percent answered the U.S., and another 14 percent answered China. The remaining answers were scattered among various nations with Canada a distant fourth place (seven percent). Many non-U.S. executives saw the U.S. as the most important location. If we believe that U.S. executives consider the U.S. the most important location, India is still the second most important location. In 2007, it is not an exaggeration to suggest that for U.S. R&D managers, the three most important nations are the U.S., India, and China (the European Union as a whole would be of similar importance).

The Indian and Chinese R&D work forces are still smaller than that of the U.S. The latest NSF data suggests that in 2003 approximately 1.16 million U.S. workers were engaged in private sector R&D (NSF 2005; 2007) and that four million U.S. workers with Bachelor's degrees were employed in science and technology occupations. Despite the rapid and continuing annual growth rates of 20 percent per year, the 140,000 private sector R&D workers in India is small when compared to the U.S. The OECD (2007), using Chinese government statistics, estimates that China has 1.1 million science and technology researchers of all types. By the U.S. standard, India and China are still laggards.

India[3]

The Indian GDP of $805 billion in 2006 is significantly smaller than the $2,527 billion Chinese economy. However, India exported $31.9 billion of services (Nasscom, 2007), there are no comparable statistics for China, but its service exports are significantly less. Of particular importance is the increase of the R&D, engineering services, and software products category to $6.5 billion. It is estimated that this will increase by a further 22 percent to approximately $8 billion in 2008. In 2006 total employment in the services export sector was approximately 1.25 million. Employment growth is expected to continue at in excess of 20 percent per year. As a gauge of the importance of the entire industry to India, in 2007 the IT service industry generated 5.2 percent of national GDP (Nasscom, 2007).

Indian wages are indicative of the cost savings that can be achieved. According to one source, for fresh bachelor degrees there are roughly three tiers with different wages. In the first tier, Google, Yahoo, Microsoft, and eBay will pay $30,000 to $35,000 for IIT's best graduates. The second tier of firms are Cisco, TI, and the Silicon Valley startups that pay between $15,000 to $20,000 and primarily recruit from the top tier of the best regional colleges and the middle rung of the IITs. The Indian outsourcers such as TCS and Infosys employ the third tier and pay approximately $10,000 per year.

To understand the growth in Indian service provision and the rise of significant R&D potential, illustrations from various MNCs are useful. Table Two provides the employment in India by various non-Indian software and software services firms. What is most remarkable is the scale of the operations. In India an increasing number of U.S. software firms have their largest foreign workforce. To illustrate, as of 2007, Adobe had 1,000 employees in India and had already filed for 50 patents developed by its Indian employees (Gupta, 2007). Adobe India has been given global responsibility for producing software upgrades for two key products, PageMaker and FrameMaker.

Among the software services firms, growth has been organic through hiring and inorganic through the purchase of Indian firms (see Table Two). It is important to note that the vast majority of this employment is NOT in R&D, but rather more mundane service provision. The largest of these MNCs, IBM, only reestablished its operation in India in 1992, but the preponderance of its growth has been since 1999. Today, IBM has approximately 60,000 Indian employees and expects this to grow to 100,000 by 2010. To speed its growth, in 1994 IBM acquired a leading Indian business process firm, Daksh, with 6,000 employees. In 2004, it acquired the 1,400-employee Network Solutions, which specialized in IT infrastructure services. In terms of R&D, IBM has research laboratories in both Delhi and Bangalore and, according to a recent New York Times article, employed 100 Ph.D. researchers in India in 2006 (Rai, 2006).

With IBM setting the pace, other U.S. IT service providers are also rapidly expanding. For example, EDS, which entered India in 1996 as a GM subsidiary, began its expansion even later, and as of 2005 it had only 3,000 employees in India. In 2006, EDS management decided that it had to rapidly build its offshore operations, so it acquired the 11,000 person Indian business process firm MphasiS, and in 2007 acquired the 700-person firm RelQ. Simultaneously, it accelerated hiring at its existing Indian facilities. To be sure, it is not only U.S. domiciled organizations that are

[3] This section draws heavily upon Dossani and Kenney (2007a, 2007b).

responding, as Table Two shows, the largest European outsourcing firms are rapidly increasing their presence in India.[4]

The reason these MNC service providers are expanding their presence is not surprising, since competition with the Indian service providers, with their far lower cost basis, is heated. In the 2006 EDS Annual Report, its Chairman and CEO reporting improved results observed, "We continued to realign our work force with strong offshore capabilities, making us more price competitive and responsive to client needs. We more than doubled our presence in high-quality, lower cost locations to 32,000 employees. While India was the primary beneficiary, we also are migrating our work force to other regions such as Latin America, China, Hungary and Poland." Each of the major MNC service providers faces a similar conundrum, namely a cost structure that is difficult to sustain in a globally competitive environment.

The MNC service providers establishing facilities in India have been joined by firms from a wide variety of other industries. For example, major retailers, such as Target Corporation, have large Indian subsidiaries. According to Robert Kupbens, the Vice President for Technology in Technology at Target Corporation (2007), in August 2006 Target Corporation opened its Bangalore subsidiary, and in mid 2007 employed 500 persons, but expected the Indian operation to grow to 3,000 by 2009. The types of work to be performed in India are indicative of the evolution of these offshore subsidiaries. By the end of 2007, operational responsibility for Target.com will be in India. The spectrum of work will also expand, as a financial team is being formed to do analysis. The India team even does photo retouching and newspaper circular layouts for the U.S.

In traditional manufacturing sectors such as automobiles, the McKinsey Global Institute (2005) identified R&D and engineering as most vulnerable to offshoring and found that 44 to 45 percent could theoretically be relocated. Moreover, this included not only simple low skilled engineering. For example, General Motors (GM) is a leader in relocating R&D and certain elements of design. Its offshore centerpiece is a laboratory in Bangalore employing approximately 240 professionals in 2004, 400 in 2006, and has announced that it is expanding employment to 800 persons by 2008. The skills being recruited are fascinating. In July 2005, the laboratory advertised jobs for individuals with Master's degrees or, preferably, Ph.D.s, in aerospace, computer, industrial, mechanical, and software engineering and computer and materials science. In the materials laboratory, GM sought candidates with Master's degrees and Ph.D.s in metallurgy, polymer science, materials science, materials processing, and math-based analysis of materials. In the material process modeling group, the work included validating microstructural models, designing high-performance materials, and molecular modeling of nanocomposite/TPO exfoliation and fuel cell membranes (General Motors, 2005). These job descriptions illustrate the engineering activities being offshored by industrial corporations. Moreover, GM is not alone, as Caterpillar, Delphi, and others build their Indian R&D operations.

The case of Agilent Technologies India (AGI) illustrates the rapidity with which an Indian operation can mature. AGI was established in 2001 to undertake both back office and engineering services. Its initial engineering services work was simple data entry. However, the operation rapidly matured and began doing CAD support the next year. The next task it undertook was QA for product development. In 2003, electronic design automation software development commenced in India. Success in these initial projects encouraged the addition of an ASIC design center in India, only the fourth one that Agilent operated globally (Dossani and Manwani, 2005). In April 2006, AGI announced that it had purchased 10 acres of land in the Delhi area to build its own campus. Employment growth was rapid, as it had no employees prior to November 2001, and by November 2004 had 1,200 employees with plans to increase to 2,000 by 2006. Agilent India is expanding in three ways: First, its engineering capabilities are growing rapidly. Second, more of the firm's global back office operations are being relocated to India. Finally, the Indian market for its test and measurement equipment is burgeoning.

Yahoo! has rapidly expanded its Indian operation. In 2003 Yahoo! established its Indian Development Center (IDC) and hired 150 engineers (Seth, 2006). It has since grown to nearly 1,000 employees in December 2006. But, from our perspective, what is more interesting is how its work has evolved. Initially, the IDC operated as a low-end engineering back office for Yahoo! Palo Alto. In general, the work transferred to India was low value-added and mundane. One result was high rates of attrition sapping the cost savings. To address this problem, in 2004 Yahoo! moved first-level project management to India, a step that gave the Indian operation greater owner-

[4] In fact, in recent months there have been a spate of articles in the industry press suggesting that the relative tardiness on the part of European software services firms to offshore to India has put them at significant disadvantage when compared to their U.S. and Indian rivals.

ship, but created conflicts with U.S.-based managers. The solution was relocating complete responsibility for major activities such as datamining. Now the Indian functional manager reports directly to a SVP in Palo Alto. With the increasing success of the Indian operation, functional responsibility not only for datamining, but also for mobile applications and iPod broadcasting, has been transferred to India (Seth, 2006).

These are indicators of learning and maturation. These anecdotes indicate that at certain MNCs, their Indian operations have matured sufficiently to receive global mandates—a powerful indication of an ability to mobilize talented persons and ascend the value ladder. Possibly the most interesting case is General Electric (2007), which has only four research locations globally. Its New York Research Center headquarters employs approximately 1,900 persons, at the new Munich center approximately 150 persons are employed, and in the Shanghai center another 150 persons are employed. The Bangalore center employs nearly 3,000 researchers, i.e., more than the other three centers combined (General Electric, 2007). When measured by the sheer number of employees, the size of the GE commitment is remarkable.

Despite this growth, the Indian operations are not comparable to those in the U.S. In market understanding and global project management the Indian operations still lag behind those in the U.S. As the manager of a large MNC noted, "It is easy to do cutting-edge work in India and to manage large projects. The difficulty is in launching products from India, especially the last stage between putting it all together and going live. There is also a gap in capability in conceptualizing projects from India." It takes time to build sophisticated capabilities. And yet, these subsidiaries are becoming important.

The final important group of firms are the large Indian service providers such as Infosys, HCL, Satyam, TCS, and Wipro, and smaller service providers such as Sasken. The large Indian service providers are evolving rapidly and a number of them are developing powerful contract engineering/R&D arms. For example, Wipro, with 15,000 professionals, claims to be the largest contract engineering firm in the world. Wipro also does contract semiconductor chip design. Only three years ago, Wipro was largely confined to the two lower value-added steps of Verification and Physical Design and Production and Silicon Production Engineering. Today, overseas customers contract them to provide higher value-added services in digital/analog design and even architecture. The benefit for the Indian vendor is that it can receive improved rates for the project and its Indian employees can develop new capabilities satisfying their desire to improve their skills (Personal interviews, 2006).

The Indian service providers are broadening their businesses by offering ever more engineering services. For example, in 2006 TCS announced an alliance with Boeing to work closely with its customers to design the interiors of new aircraft they had purchased. This alliance led to TCS establishing a aircraft interior design "laboratory" in Chennai (Kurup, 2006). HCL claims to have 1,500 person-years of experience designing medical devices such as blood glucose meters for foreign customers. Often the role of the Indian firms is linked to their expertise in software systems, which are a rising portion of the cost and value-added in instruments of nearly every sort. There has also been a proliferation of smaller specialty engineering firms. For example, Sasken provides IC design and silicon platform software services to the world's mobile device manufacturers. To improve service to its U.S. customers, it recently established a subsidiary in Monterrey, Mexico.

The proliferation of MNCs and Indian service firms is creating a powerful ecosystem that is proving attractive to yet more firms and also encouraging firms to undertake more ambitious and sophisticated activities there, including R&D (Dossani and Kenney, 2007b). Absent an unforeseen event, Indian service and R&D employment can be expected to continue to increase by 20 percent per annum at least for the next three years. By 2010 there will be approximately 175,000 Indians working on R&D and engineering services for the global economy. Firms such as Wipro will be the largest engineering services firms in the world. By then India will be a recognizable force on the world R&D scene.

China

Less is known about the extent and type of MNC R&D in China. For example, a recent OECD report on the Chinese innovation system provides no employment data for the MNC R&D facilities. Even the number of laboratories varies widely by report. For example, in the most comprehensive survey of the Global Business Week 1000 and Fortune 500 MNCs in China through 2004, the OECD (2007) found that 166 firms had R&D facilities. Of which, 26 were in software, 20 were in telecommunications, and 15 were in semiconductors. In contrast, Zedtwitz (2004) found that in 2005 there were 750 R&D laboratories in China.[5] The largest employer was Motorola (2007a), which had 1,600 engineers scattered across a number of cities.[6] In summation, every major MNC IT firm has R&D operations of some sort in China.

Given the wide disparity in counts of the number of MNC R&D laboratories in China, it is not surprising that there is even less known about their operations. In one of the few quantitative studies, the OECD found that the MNCs were most likely to be exploring products for the Chinese market and this was closely followed by modifying existing products for Chinese markets. Somewhat less prevalent was exploring new products for the world market (which would be the politically correct answer). Even less mentioned was exploring unknown science and technology fields, something that would most closely resemble basic research. The final category was R&D to support production and operations in China (more than one answer was possible).[7] These results suggest that MNC R&D facilities in China tend to be domestically oriented.

There is significant concern on the part of MNCs about the protection of their intellectual property and know-how. The enforceability of IP rules is indicative of a bigger societal issue relating to the laws and social norms about appropriating or transferring the knowledge generated while working for an employer. Since acceptance of IP rules is more than just enforcement-driven, simply passing laws and then trying to enforce them is unlikely to rapidly change the larger social environment. Though there can be little doubt that Indian IP enforcement is superior to China, few would state that it is equal to the U.S. or Western Europe. Despite IP protection weaknesses, MNCs are increasing their research commitment in China. To take advantage of the large and rapidly growing market and low-cost capable workers, MNCs are careful to undertake R&D in areas in which there would be minimal damage from leakage to the external market.

China is rapidly becoming an important location for R&D. Chinese domestic firms such as Huawei, ZTE, Lenovo, and Haier are investing significant sums in R&D and expanding their global R&D reach. They already have some R&D operations in the U.S. that they established or, as in the case of Lenovo, inherited through acquisition. Given the build-up of capital in China, it is only natural that they will buy U.S. assets—and technology is an important attractant. Simultaneously, MNCs will (indeed feel they must) increase their R&D activities in China regardless of the IP environment.

Summary

There is a global competition for R&D facilities, but today the two most important destinations for R&D offshoring are India and China. And yet, they differ markedly in terms of the character of R&D being offshored to them. The greatest beneficiary, India, outside some areas of offsets, largely in the aerospace sector, has done little beyond providing a free trade zone. The Chinese government has pursued a more aggressive policy of encouraging MNCs to establish R&D facilities. And yet, India is receiving more R&D employment. From their behavior, it appears as though MNCs are less concerned about the potential loss of IP in India and thus undertake R&D there that they might not consider in China.

There are other differences between the types of MNC R&D in the two nations. First, much of the R&D in China is localization work or developing products for the Chinese market. In India, until very recently the domestic market was of minimal interest. Second, in China there is large and increasing, but thus far not well-quantified, R&D production engineering investment by Taiwanese firms.[8] This type of R&D is largely non-existent in India because it has not been an important manufacturing site nor are there leading customers, though this may be changing, particularly in telecommunications as market expansion is torrid.

The salient differences between the two nations is that MNCs are reluctant to undertake R&D in China whose results might be easily copied by domestic rivals. This need not necessarily affect the sophistication of the R&D. For example, Microsoft undertakes extremely sophisticated basic research in both nations. However, firms carefully distinguish the types of work to be done in the two nations. To illustrate, Intel China's R&D is concentrated on research for system-level software and Intel-

[5] The reasons for this wide discrepancy may be a decision to count each of Motorola's 19 labs in China separately and/or the capture of the R&D operations of smaller firms such as those of smaller Taiwanese firms.

[6] It is worth noting that Motorola India employed 3,000 engineers in 2007 and 40 percent of the software in its phones worldwide was developed in India (Motorola 2007b).

[7] OECD (2007) found far fewer MNC R&D facilities than other surveys such as Zedtwitz (2004).

[8] For a discussion of the spatial division of labor in the notebook computer industry, see Dedrick and Kraemer (2006).

specific projects whose disclosure would not put it at a disadvantage. It also has its Channel Systems Laboratory whose purpose is to help vendors design PCs for other environments. This laboratory manages five other laboratories outside of China. The strategy for the Chinese laboratories is to undertake projects whose results are either meant for the public or would be of little use to a competitor. In contrast, in Intel's Indian operations 50 percent of the employees are involved in integrated circuit development, the heart of Intel's business. In the future, Intel Bangalore will design server chips. Broadcom, another important U.S. semiconductor firm, designs some of its most important chips in India, where it has over 200 designers. In contrast, its R&D facility in China was established to support Chinese customers, while its major design operations are located in Taiwan. As a generalization, in most cases among MNCs, and in particular IT MNCs, their more globally oriented R&D is located in India. While, as a rule, their Chinese R&D facilities are smaller and have more of a domestic focus.

Types of Facilities Sited in Low Cost Regions

Facilities localizing an MNC's product or developing specialized local products are likely to be located in the low-cost country. The lower cost nations are far more likely to do development work, rather than product conceptualization. Given their superior infrastructure, the conceptualization and architecting of new products is likely to continue to be concentrated in developed nations. Strategic research planning and product road mapping is almost certain to remain in the firm's home country, though as a foreign R&D operation matures it might be given responsibility for designing products for its domestic market or be given full responsibility for product upgrades.

Sectors

The available evidence suggests that R&D globalization is most advanced in the IT sector. Established firms such as IBM, HP, Motorola, and Texas Instruments have long had overseas R&D facilities, and newer firms, such as Intel, Microsoft, and Adobe, began their international R&D expansion in the 1990s. For the younger, but research-intensive VC-financed firms, such as Google and Yahoo!, overseas R&D commenced even earlier in their development. Conversely, all major European and Asian IT firms have made significant investments in U.S. R&D facilities. What is new is the decision by nearly all of these firms to build significant R&D capability in India and China.

In traditional manufacturing firms, R&D globalization is less advanced, but both nations are experiencing an increase in the number of R&D facilities (OECD, 2007). For example, according to OECD (2007), seven foreign auto manufacturers have research facilities in China. Unfortunately, there is no information regarding the types of research. This contrasts with the General Motors Indian facility, which describes the advanced research underway. Firms in the traditional manufacturing industries will increase the size and scope of their offshore R&D facilities.

The human health care industries, though smaller than IT and traditional manufacturing, encompass many of the most research-intensive firms in the OECD nations. Recent research suggests that there is only limited investment by the major pharmaceutical firms in developing nation R&D facilities (Cockburn, 2007). For example, the OECD identified six MNC biotechnology and pharmaceutical R&D operations in China. According to Yuan (2007), of the six pharmaceutical R&D operations in China, only two, Lilly and Pfizer, were U.S. firms. At this time, the pharmaceutical investments in China appear to be complementary rather than substitutes for R&D in the developed nations. Interestingly, none of the large pharmaceutical MNCs had R&D operations in India. Given the critical importance of intellectual property protection and the extreme secrecy in which human health R&D takes place, it is unlikely that there will be a rapid relocation of R&D operations to low-wage environments. And yet, given the growing pressure to increase profits, a plethora of organic chemists in developing nations, and the rising importance of developing nation markets, particularly, China and increasingly India, it is likely that pharmaceutical MNCs will gradually increase their offshore R&D. As a caveat to this conclusion, a significant amount of clinical trials and data analysis are already conducted offshore and more can be expected to be relocated.

In summation, there are sectoral differences in terms of the globalization of R&D. IT R&D has globalized most rapidly, while pharmaceutical R&D is diffusing more slowly. Traditional manufacturing firms have only recently begun making major R&D investments in the lower-cost nations, but it is likely to increase.

Policies among Foreign Nations to Attract R&D Facilities

R&D facilities are considered desirable by politicians and economic development professionals. Many nations have tax, cash, and in-kind incentive schemes to attract

R&D. Some nations, such as Singapore, Ireland, and Israel have utilized policy to upgrade their economies. Of course, many nations offering similar incentives have experienced only minimal success. In the U.S. the Federal government has ceded such recruitment efforts to the state and local governments, and a number of them provide significant incentives to attract R&D investment. And yet, the most successful state in attracting such R&D investment, California, has few incentives, leading to the conclusion that their efficacy is suspect. For R&D investment there can be little doubt that the most effective attractor is the quality and price of the labor force. For example, Silicon Valley, an extremely expensive business location, has had great success in attracting R&D investment. What is obvious is that absent a capable work force, only enormous incentives will attract R&D investment.

China has various tax incentive schemes to encourage R&D by both domestic firms and MNCs. There are many science parks willing to provide low-cost office space and often they have free trade zone protection providing tax holidays. In its desire to attract foreign R&D operations, some charge that Chinese government officials coerce MNCs into locating in China and then pressure them to share their IP. However, there are also dissenting Chinese voices suggesting that these foreign R&D operations retard the development of technology by domestic firms because the foreign firms charge unduly high license fees for their patents, "crowd out" domestic firms in the market for highly skilled labor, monopolize technology standards, and thwart technology transfer and knowledge spillovers (OECD, 2007).[9] Provincial and city policy-makers often supplement national government policies. For example, Shanghai has aggressively pursued MNC R&D facility investment. And yet, absent a stronger legal and social environment protecting the fruits of their R&D, it is unlikely that MNCs will move large portions of their R&D to China.

India has no specific incentives to attract foreign R&D investment. The Software and Technology Parks of India regulate R&D, like all other exported services. STPI operates like a free trade zone and all firms registered under it are exempt from corporate income tax until 2010. These are substantial incentives, however, they are not specifically targeted at R&D as opposed to other services, such as call centers and data entry.

China has more actively pursued R&D investment than has India. However, neither of them has gone after R&D investment as single-mindedly as nations such as Singapore, Ireland, and Israel. Interestingly, in China there is some dissent regarding the wisdom of encouraging foreign R&D operations. In contrast, Indian and MNC firms are treated equally by STPI and there has been little dissent by domestic firms. This suggests that other variables, such as a superior IP protection environment, English-language capability, and management skills, are as important as a larger market and more active government involvement.

Conclusion and Policy Opportunities

The current globalization of R&D is an outcome of the increasingly globalized and intertwined sinews of economic activity. It is impossible in the current economic environment to see how this trend could be reversed. The result of the technological, legal, and political lowering of barriers to trade has made R&D globalization a natural outcome. Absent a national consensus, for which none exists or is likely to ever exist, that the import of such services should be outlawed or taxed severely, the current trends in the globalization of services including R&D will continue.

The wage gap between India and China and the U.S. is so great that even with wage increases of 10–15 percent per annum, it will remain substantial for at least the next decade. Moreover, both governments are expanding their higher educational systems in a bid to increase their supply of trained labor. Should the Indian or Chinese labor markets become too expensive, Russia, the Ukraine, and others also have significant supplies of capable engineers. Certain occupations, such as routine engineering, accounting, and finance are being commoditized and globalized. The full import of this movement by firms to access the skills of the global labor force has not yet been felt. The effect is most likely to be experienced in the next recession when firms are faced with the decision as to whether and where to eliminate excess personnel. I believe this will fall most heavily on the high-cost employees who have only globally available skills.

For high-wage nations success in the global economy become ever more dependent on the ability to envision and grow new markets. This means there are enormous opportunities for the U.S. economy, which is the most diverse and creative in the world. It suggests our educational institutions must train young persons regardless of the discipline to be creative and entrepreneurial. The engineering and science dis-

[9] Obviously, MNCs have no interest in allowing the know-how and intellectual property that is the key to their competitiveness to leak to local rivals.

ciplines are absolutely crucial as they provide the new knowledge that is an input to the creation of new wants and needs. For example, who would have guessed that Internet search and online auctions would become multibillion-dollar global businesses centered in the U.S.?

The strengths of the U.S. political economy are well known. First, our research universities remain the finest in the world. The U.S. government and Congress have done a remarkable job in providing the research funds that have kept us at the cutting edge. With the *America COMPETES Act,* more monies are meant to be allocated to the physical sciences and engineering. Despite this major new initiative, the vitally important areas of computer science and electrical engineering require more targeted investment. To ensure the continuing supremacy of U.S. research universities in the information sciences, Congress might consider whether a National Institute of Information Sciences should be created along the lines of the fabulously successful National Institutes of Health. At this moment, the National Research Council is conducting a study of the health of the U.S. IT R&D ecosystem and the report will be available shortly.

Many of the most important new venture capital-financed firms such as Yahoo! and Google came directly from university graduate students. Unfortunately, the spiraling cost of graduate education is creating an increasing burden on universities and departments wishing to fund these bright young students. Having the finest research universities in the world provides the U.S. with a reservoir of the most highly technically trained persons in the world. To allow this resource to deteriorate would be an incalculable and unforgivable disaster.

A second area that the Committee may wish to explore is the operation of the 1980 *Bayh-Dole Act,* which ceded rights to federally funded inventions to universities. In retrospect, this was important for removing obstacles to the transfer and commercialization of university innovations. In the intervening years, every research university has established a Technology Transfer Office. However, as Robert Litan et al. (2007) conclude, university bureaucracies have arisen that often frustrate technology transfer. Horror stories about university bureaucracies frustrating technology transfer and researcher entrepreneurship are widespread. Well-drafted legislation vesting the patent rights to federally-funded research in the inventor would likely accelerate transfer and encourage entrepreneurship. If there is concern that the meager income the universities derive from licensing would be lost, it could be mandated that they receive a five percent stake in any revenues from the invention. In cases in which university researchers do not want to commercialize their inventions, they could assign the patent to the university, a third-party, or place it in the public domain. For certain inventions, such as techniques for gene splicing, stem cell creation, software inventions, or improved manufacturing processes, a public domain strategy would increase the public benefit, as adoption is likely to be even faster and more widespread. In other cases, assigning the patent to the university or a third party would be most effective. The inventor is likely to have better insight than any university licensing manager who cannot possibly know the nuances of every technology.

The increasingly restrictive patent regime particularly in software may also be retarding technological development. With the growing emphasis on Open Source software and recombinant innovations,[10] it is vital to establish the right balance between patent protection and increasing the stock of freely accessible knowledge. In an innovation-based economy, in which our nation's success depends upon the value-creating creativity of its citizens,[11] any obstacles to the circulation of information, be it a too restrictive intellectual property regime or unnecessary secrecy, will retard the ability to create new value.

Technology, innovation, entrepreneurship, and science are four keys to the continuing prosperity of the U.S. economy. Success will be based on increasing the capabilities within our workforce even as large numbers of capable foreign workers paid far less than ours enter the global labor market. The U.S. won the Cold War, succeeded in breaking down trade barriers, and opening markets around the world. Now, we must compete in this more open world. Responding to the challenges will require increased investment in our work force, a rethinking of our educational system, and strategies for increasing the creativity of the American people in engineering, manufacturing, design, and the arts.

[10] On recombinant innovation, see Hargadon (2003).
[11] On the importance of creativity to competitiveness, see Florida (2003).

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Table 1. The Motivation for Offshoring and Key Calculation

Motivation for Offshoring	Key Calculation(s)
Foreign government requirement	Is market sufficiently large to compel compliance?
Need to localize product or service	Is market sufficiently lucrative to undertake localization. Cost/benefit calculation
Proximity to key customers	Is customer sufficiently significant to warrant the expense
Access to extremely specialized or high-quality talent	How necessary is access? If critical, then costs can be extraordinarily high and the firm must still bear it.
Around the clock engineering	The goal is to shorten development times by having work ongoing in different time zones. Personnel costs are not the key motivation.
Lower cost workers	This is directly driven by the relative cost of undertaking the work in the home market or in the lower-cost market. Of course, the availability of skilled personnel is necessary, as few firms are willing to be shoulder a significant training cost.

Source: Compiled by Martin Kenney

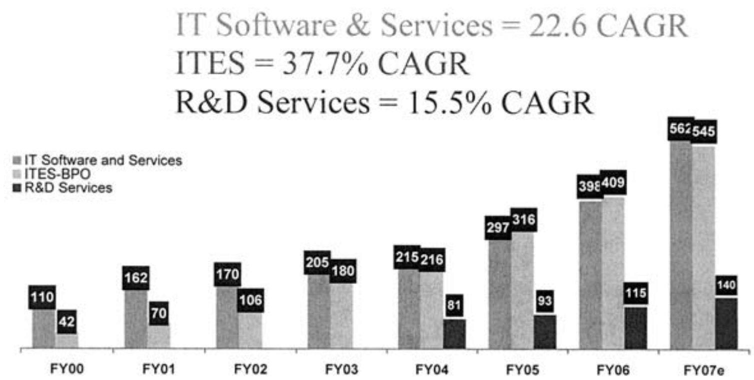
Table Two: Employment in India by Selected Large Non-Indian Systems Integration and Software Firms

Firm	Date of Entry	Nationality	Employment in India (date)	Global Employment 2006	Percent Employed in India	Acquisitions (Name, Date, # of employees
Systems Integrators						
Accenture (2)	1987	U.S.	35,000	129,000	27	
CapGemini	2003	France	12,000 (2006)	75,000	16	Kanbay, 2006, 5,000
CSC		U.S.				
EDS (3)	1996	U.S.	17,000 (2007)	117,000	15	MphasiS, 2006, 11,000 RelQ, 2007, 700
IBM (1)	1992	U.S.	60,000 (2006)	369,277	18	Daksh, 2004, 6,000 Net. Sol., 2005, 1,400
Siemens IT Solutions and Services	1992	Germany	4,000 (2006)	43,000	9	
Software Producers						
Adobe	1997	U.S.	1,000 (2007)	5,879	17	
Microsoft	1998	U.S.	4,000 (2006)	57,000	7	
Oracle	1994	U.S.	8,600 (2006)	55,000	16	I-Flex, 2006
SAP	1996	Germany	3,500 (2006)	38,400	9	
Yahoo!	2000	U.S.	1,000 (2007)	10,000	10	

1. Reentered India 1992 for domestic market and includes total employment not just IBM Global Services.
2. In 2007, Accenture employed more persons in India than anywhere else in the world.
3. In 1996 served GM India from India.

Source: Compiled from various news reports and corporate Securities and Exchange Commission filings.

Figure 1: The Number of Employees in Thousands and Compound Annual Growth Rate (CAGR) for Different Service Sector Employment from 99-00 to 06-07e



Source: Nasscom 2007

BIOGRAPHY FOR MARTIN KENNEY

Martin Kenney is a Professor at the University of California, Davis and a Senior Project Director at the Berkeley Roundtable on the International Economy. He is a fellow at the Center for Entrepreneurship at UC Davis. He has authored or edited five books and over 120 scholarly articles on the globalization of services, the history of venture capital, university-industry relations, and the development of Silicon Valley. His two recent edited books *Understanding Silicon Valley* and *Locating Global Advantage* (with Richard Florida) were published by Stanford University Press where he is the editor of a book series in innovation and globalization. Currently, he is preparing a book on the history and globalization of the venture capital industry. He was a visiting professor at the Copenhagen Business School, Cambridge University, Hitotsubashi University, Kobe University, and Tokyo University. He has consulted for or presented to various organizations including the InterAmerican Development Bank, the World Bank, Presidential Council of Advisors on Science and Technology, National Academy of Engineering, National Academy of Sciences, National Research Council, Association of Computing Machinery, and the OECD and consulted for various firms. His research is currently supported by the NSF, the Sloan Foundation, and the Kauffman Foundation.

Chairman WU. Thank you, Dr. Kenney. Dr. Atkinson, please proceed.

STATEMENT OF DR. ROBERT D. ATKINSON, PRESIDENT, INFORMATION TECHNOLOGY AND INNOVATION FOUNDATION

Dr. ATKINSON. Thank you, Mr. Chairman, Dr. Gingrey, and Members of the Committee. I appreciate the opportunity to appear before you.

I have focused on this issue of both economic development and site location, particularly in the R&D area, for a long time, including when I was a Project Director at the former Congressional Office of Technology Assessment. And I think there is a lot of—one of the issues that is hard to understand about this particular challenge is that it is relatively new. There isn't as much research on it as we would like, but even given that, I think, there are some things that we can say somewhat definitely about what is happening—why it is happening.

I don't think there is any doubt that there has been a significant increase in U.S. offshoring of R&D in the last decade. In the last decade, the share of U.S. firms' R&D sites went from 59 percent of them being here in the U.S. to 52 percent being in the U.S. The share in China and India increased from eight to 18 percent. So decline in the U.S.—and the increase is largely in China and India.

According to a recent survey by the Industrial Research Institute, which is a trade association of R&D managers, the U.S. R&D managers, over 60 percent of U.S. companies are investing R&D in China, 50 percent in India, and 20 percent in Eastern Europe, and that is growing faster than their R&D investments in other places.

I think if you look at the effect of that, there is some debate about that, is this a complement, or a substitute? I think the evidence is pretty clear it is a substitute. According to BEA numbers, between 1998 and 2003, which was the latest data that they provide, investment in R&D by U.S. majority owned affiliates increased outside of the U.S. by 52 percent. Total R&D, corporate R&D in the U.S., by U.S. and non-U.S. firms that would include insourcing of R&D increased by just 26 percent, so at half the rate. And that trend has gone, they recently, just in 2005 and 2007, U.S. rates increased about half of the rest of the world.

What is driving this? I think there is—you will hear a debate, I think probably today, and there is a debate somewhat in the literature, but I would agree with Dr. Kenney. I think at the end of the day, while there are multiple factors that determine particular types of R&D outsourcing or offshoring, by the type of R&D, by the type of firm, by the type of country, costs, I would argue, is the major driver. That is not to say that access to market and access to talent aren't a factor, but I think cost is the major driver. You have got salaries for R&D personnel in China that are one-sixth of the U.S., and very good talent over there. So, for example, the recent Booz Allen Hamilton study showed that when it comes to moving R&D to developing nations, low cost skills base was the predominant factor.

And I would differentiate between developing and developed. The cost is not a big factor, really, or the major factor in going to a developed country, because the cost differential is not that great. It is, I would argue, the major factor in going to a developing country. And again, an IRI study showed that the two biggest factors for going offshore anywhere, combined were: number one, lower cost talent, and number two, lower cost facility and materials.

And I think one of the reasons why some studies have shown that access to talent is an important factor is akin somewhat to, and Mr. Chairman, you can appreciate this, I use the analogy, you are not going to have a lumber and wood products firm located in the desert. They have to locate where there is timber. And you are not going to have an R&D facility locate where there are no R&D scientists and engineers. So that is kind of the baseline. You have to have that. Once you have that, then the question of cost comes into play and, I think, plays a very important role. So China has a lot of skilled R&D engineers and scientists, as does India and the fact that the low cost is important.

I would just add a point on incentives. I think incentives sometimes don't get picked up as much in the survey instruments, because they are not the driver, but the way firms make these decisions is they don't just look at incentives and then labor costs and facilities costs. They combine them all together into a cost estimate. When you do that, I actually think incentives play an important role.

The U.S., for example, was number one in 1990, had the most generous research and development tax credit of any of the OECD nations, the 30 OECD nations. In 2005, we were 17th most generous, and that is partly because our credit has gone down, mostly because other countries have looked at this, and said we want to be an attractive location for R&D. We are going to put in place these incentives. So Mexico has a more generous incentive than we do. China has a very aggressive incentive. So does India.

The last point on this, as Dr. Kenney mentioned, government pressure. I think forced technology transfer is an important issue, particularly in China, where the government pressures U.S. companies to get access to their market, to move R&D facilities over there. It is a direct violation of the WTO, and it is something that we don't really, frankly, as a country do very much about.

Three quick things I think we can do. We recently issued two reports on the R&D tax credit, the first one showing, I think, very clear economic studies showing it is an effective tax tool. We think we need to significantly increase the credit, and I would be happy to share that report with you.

Our specific recommendation is that we need to do more on supporting R&D at the federal level. The *America COMPETES Act* went a long way towards that. We have got a new report coming out, proposing the creation of a National Innovation Foundation.

Third, while skills, I think, are not the driver, it is important that we have good skills here. And we need to do that at two levels. One is domestically, so again, the *America COMPETES Act,* it took important steps there, but also in terms of making sure that we are open towards the best and the brightest from the rest of the world coming, including H–1B visas, and letting people with a graduate degree stay here.

And lastly, and I think it is again, an area we haven't looked at enough, but we need to more aggressively combat these foreign practices. I don't think there is a problem with countries investing in science or skills or R&D credit. It is very different, though, when they use unfair practices to force U.S. companies to put R&D there. I would argue our trade policy hasn't done enough there, and that is something that we should do more of.

So thank you very much.

[The prepared statement of Dr. Atkinson follows:]

PREPARED STATEMENT OF ROBERT D. ATKINSON

Mr. Chairman, Mr. Gingrey, and Members of the Committee, I appreciate the opportunity to appear before you today to discuss the issue of globalization of R&D and the factors that influence the location of U.S. R&D investments.

I am President of the Information Technology and Innovation Foundation. ITIF is a nonpartisan research and educational institute whose mission is to formulate and promote public policies to advance technological innovation and productivity. Recognizing the vital role of technology in ensuring American prosperity, ITIF focuses on innovation, productivity, and digital economy issues. I have studied and written extensively about the issues of offshoring, U.S. technology competitiveness, and the location decisions of technology-based firms.

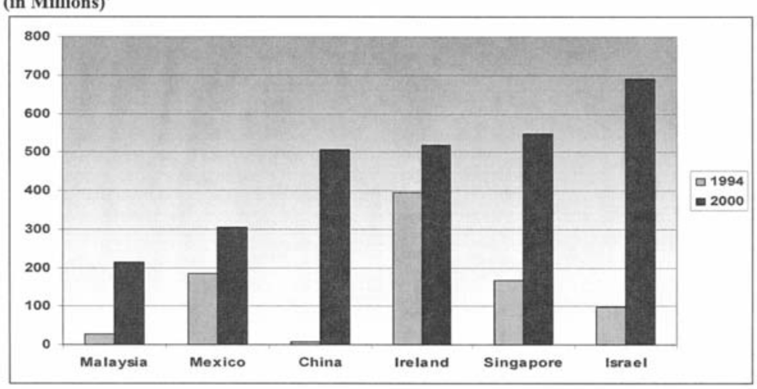
How Much R&D Is Being Offshored?

Until recently corporate R&D was generally not very mobile, certainly not in comparison to manufacturing. But in a "flat world" companies can increasingly locate R&D activities anywhere skilled researchers are located. Estimating the current and future magnitude of R&D offshoring, however, is difficult, in part because it is a relatively new process that is undergoing significant change.[1] Indeed, while the internationalization of R&D activities by U.S. multinational firms has been a growing phenomenon for the last two decades, the process appears to have accelerated in the last decade and shifted its locational focus from Western Europe to some lower cost nations, including Eastern Europe and Russia, China, and India. For example, most of the over 700 independent foreign R&D facilities in China have been established since 2000.[2] Eight of the top ten R&D-spending companies in the world have established R&D facilities in China.[3]

Yet, notwithstanding the newness of these trends, the evidence is fairly conclusive that R&D offshoring is increasing substantially. In the last decade the share of U.S. firms' R&D sites located in the United States declined from 59 percent to 52 percent, while the share in China and India increased from eight to 18 percent.[4] According to a recent survey of U.S. R&D managers, over 60 percent of U.S. companies surveyed are investing in R&D in China, 50 percent in India, and 20 percent in Eastern Europe. Although 65 percent of U.S. companies are increasing their R&D investments in Asia, just 29 percent are doing so in higher-cost Western Europe—the traditional destination for U.S. corporate R&D.[5] From 1994 to 2003, R&D performed by U.S. firms outside the United States increased significantly in low-wage nations like Mexico, China, and Malaysia, and also in mid-wage nations like Ireland, Israel, and Singapore (see Figure 1).

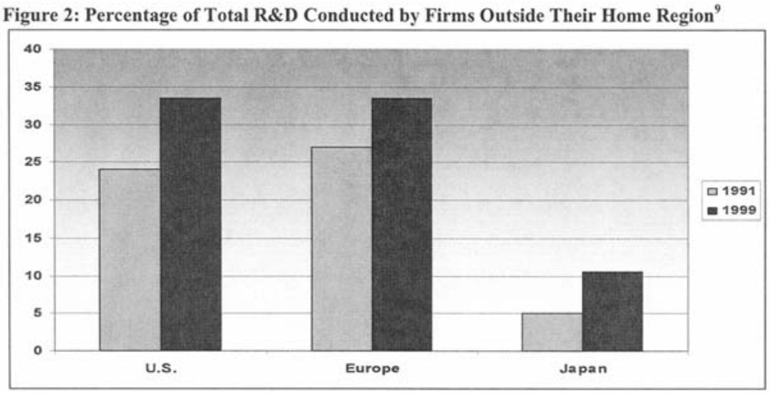
But it's not just large multinational firms that are offshoring R&D; small and mid-sized technology firms are as well. One study of California-based technology firms (80 percent of which had less than 500 employees) found that R&D was actually the most common activity offshored, with around 60 percent of firms reporting that they offshore R&D, which is about twice the rate of manufacturing offshoring and three times the rate of back office offshoring.[6]

Figure 1: R&D Performed Overseas by Majority-Owned Foreign Affiliates of U.S. Companies (in Millions)[7]



Moreover, not only are U.S. firms offshoring more R&D, but European and Japanese firms are as well. As Figure 2 demonstrates, the percentage of R&D conducted outside firms' home countries increased throughout the 1990s, even before the rapid increase in R&D offshoring to developing nations after 2000. The United Nations Conference on Trade and Development (UNCTAD) reports that of 1,773 greenfield R&D projects set up between 2002 and 2004, projects in developing nations by companies based in developed countries accounted for over half (953) of total projects, 70 percent of which were in China and India.[8]

Figure 2: Percentage of Total R&D Conducted by Firms Outside Their Home Region[9]

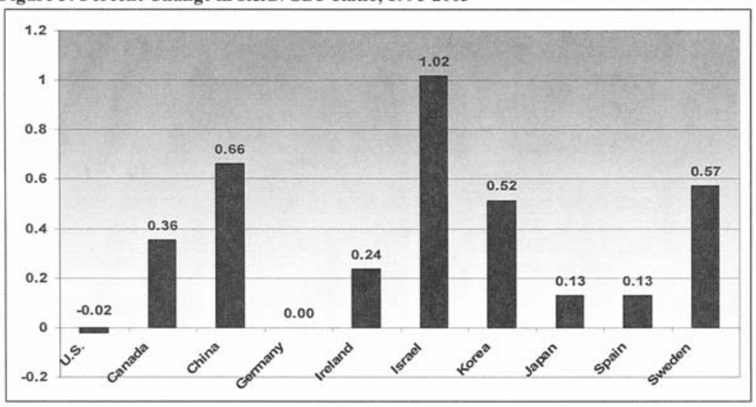


The Effects on Domestic R&D

There is considerable disagreement about the effect within the United States of these trends in R&D investments. It is certainly possible that offshoring of U.S. R&D will not affect the growth rate of R&D in the United States. If firms in most other nations are also globalizing their R&D they might in turn expand their R&D investments in the United States. To some extent this has happened, as multinational firms around the world have offshored a growing share of their R&D, some of it has come to the United States. But on net, however, it appears that in recent years more R&D has been offshored from the United States than has been insourced to us. One indicator of this trend is the fact that, between 1998 and 2003, investment in R&D by U.S. majority-owned affiliates increased twice as fast overseas as did total corporate R&D (U.S. firm and foreign firm) in the United States (52 percent vs. 26 percent).[10]

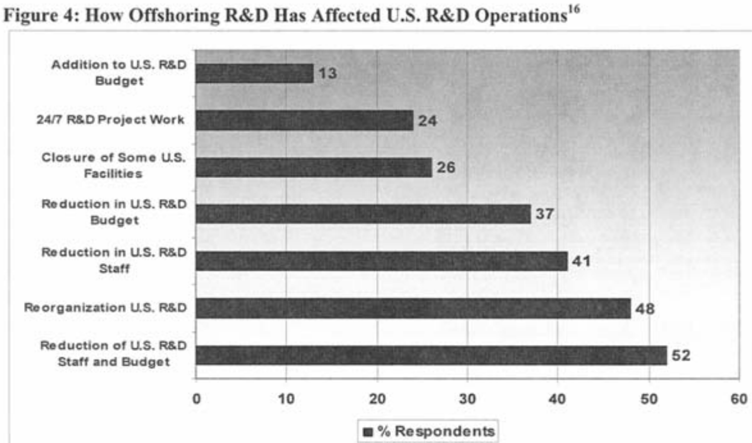
It's also possible that the expansion of offshored R&D by U.S. firms has no detrimental effect on the amount of their domestic R&D investments. U.S. firms that take advantage of lower cost R&D abroad may simply be expanding their overall R&D beyond what they would have done otherwise. However, it appears that this is not the case. Corporate-funded R&D as a share of GDP fell by seven percent in the United States from 1999 to 2003, while in Europe it grew by three percent and in Japan by nine percent and even faster growth rates in China and India. From 2005 to 2007, R&D investment in the U.S. increased by 4.9 percent (PPP constant dollars) but increased in the rest of the world by almost twice that rate (8.7 percent).[11] Moreover, U.S. share of global R&D fell from 46 percent in 1986 to 37 percent in 2003.[12] Overall, while investments in R&D as a share of GDP actually fell for the United States from 1992 to 2002, they increased in most other nations, including Japan, Ireland, Canada, Korea, Sweden, China, and Israel. (See Figure 3.)

Figure 3: Percent Change in R&D/GDP Ratio, 1991-2003[13]



As the macro-level R&D investment data point to the substitution of foreign R&D for domestic, or at minimum to the fact that foreign R&D comes at the expense of a more robust expansion of domestic R&D. Survey data suggests similar conclusions. A survey of corporate research managers conducted by the Industrial Research Institute (IRI), the leading professional organization for corporate R&D managers, concluded that, "It is not surprising that two of the interrelated changes most often noted with respect to the effect on domestic [R&D] operations [from expansion of offshored R&D] are (1) a reduction in staff levels in domestic facilities, and (2) a reduction in domestic funding of R&D."[14] Indeed, IRI found that 52 percent of respondents reported that offshored R&D led to reductions in domestic R&D spending or staff, with just 13 percent reporting that it led to increased U.S. staff (see Figure 4). Likewise, a 2005 survey of multinational firms conducted for the National Academy of Sciences found that 15 respondents expect to increase R&D employment in the United States over the next three years, whereas 23 expected a decrease. Almost 70 respondents expected an increase in R&D employment in China and over 40 in India, with no respondent expecting a decline in these countries.[15]

Figure 4: How Offshoring R&D Has Affected U.S. R&D Operations[16]



What Is Driving the Movement of R&D Offshore?

There appear to be a number of factors driving increased R&D offshoring. First, technology has made it possible for more work to be done at a distance. Researchers can be in close contact with others around the world through e-mail, the Internet, and video teleconferencing. Second, other nations have woken up to the opportunities of attracting internationally mobile investment, including R&D facilities. Many developing nations have established the infrastructure, skilled workforce and business climate to become attractive locations for this kind of work. Indeed, many foreign governments, and their sub-national governmental units, are implementing exactly the same kinds of economic strategies that U.S. states have long practiced, including providing direct grants and tax waivers for establishing R&D facilities.

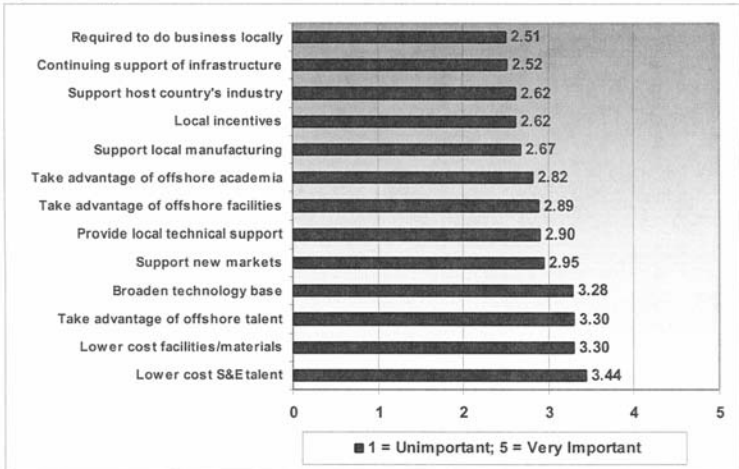
Most researchers agree that there are a number of motivations for U.S. firms to offshore R&D, including access to local markets, access to talent, and cost reduction. There is less consensus on which factors are the most important. Because R&D offshoring, particularly to developing nations such as China, India, and Russia, is new, there is relatively little research on the subject. However, some research has been done, but it yields conflicting answers. In part this is because the reasons firms offshore R&D vary according to a number of different factors, including the location, the type of R&D (e.g., more routine product development vs. more exploratory basic research), and the organizational form (in existing facilities; establishment of facilities that are specifically developed for the purpose of conducting R&D; or contracting with independent organizations for R&D). Moreover, the motivation for conducting R&D in other nations is changing. Traditionally, much overseas R&D was conducted to adapt products to foreign markets.[17] However, in the last decade, an increasing share of offshored R&D has been for the purpose of developing technology that can be used in the firm's global markets.

So what factors are most important in offshoring R&D from the United States? As might be expected, costs do not appear to be the driving factor for offshoring R&D to other developed nations. After all, R&D costs are generally not lower in Western Europe and Japan. There, factors such as access to markets, linkages to existing production facilities, and access to talent are the most important factors.

However, when it comes to offshoring to developing nations, it appears that cost reduction is the major driver. Indeed, this is what we would expect, given that salaries for R&D personnel in a nation like China are as low as one-sixth of those in the United States. In India the annual salary of an electronic circuit designer with a Master's degree and five years of experience is about $18,000, compared to $84,000 in the United States. Moreover, Indian engineers work about 450 hours a year more than their U.S. counterparts.[18]

A number of studies and surveys point to costs as the main driver. Booz Allen Hamilton found that when it comes to moving R&D to developing nations, access to a "low cost skills base" is a key driver for establishing new R&D sites.[19] A survey by the Industrial Research Institute agreed, finding that cost reduction is the most important factor in the decision to offshore R&D, with almost 39 percent of U.S. corporate respondents citing it as their most important consideration. Moreover, another 31 percent cited increased competitiveness, which could include cost reduction factors. When asked to assess the importance of individual factors important to the decision to offshore, lower cost S&E talent and lower cost facilities/materials were the two most important factors (see Figure 5).

Figure 5: Why U.S. Firms Outsource R&D[20]



A survey of California technology companies found a similar pattern. For foreign outsourcing (unaffiliated offshoring), cost reduction was the most important factor. For affiliated offshoring, costs and access to skilled labor were both important.[21] It appears that these factors are at work in other nations as well. A survey of Danish firms found that cost reduction was the major factor leading them to offshore R&D.[22]

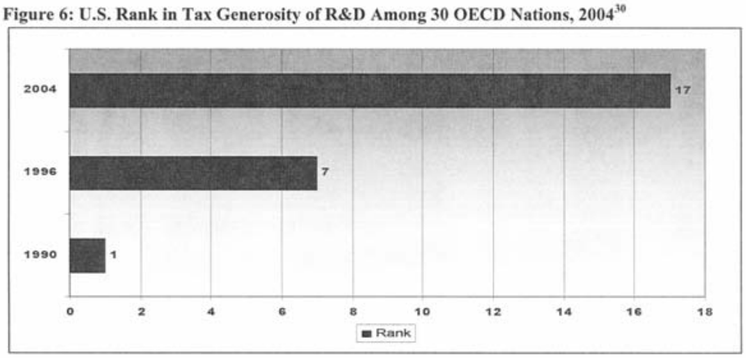
While most studies cite cost reduction as the most important driver in the decision to offshore R&D, particularly to developing nations, one widely cited and reported survey by Thursby and Thursby conducted for the National Academy of Sciences concluded that market growth potential and availability of skilled R&D workers, and not cost, are the top two factors that drive multinationals to offshore R&D to other nations.[23] Yet, there are several reasons to believe that this research study significantly underestimates the importance of cost. First, the study shows that low costs are more important to the location decisions for emerging countries than developed nations or relocation in the home nation. Second, the study asks firms to assess the importance of tax breaks and costs separately. But when making location decisions most firms consider these factors together. If the survey instrument had instead asked respondents to assess the importance of total costs, including tax breaks, it is likely that costs would have been reported as a more important driver.

Finally, and perhaps most importantly, it is not clear that availability of skills is the major driver of R&D offshoring. It seems more accurate to view the availability of R&D talent as a basic requirement of a site in order to be considered, but not a driver per se. In other words, firms will not move an R&D facility to a location where there is no technical talent, any more than a lumber and wood products firm would move to a region where there are no trees. Access to talent, as well as other basic necessities like electricity, water and telephone, is a requirement. Places with little or no access to these factors are simply not in the running. It doesn't matter how cheap the labor is or how big the incentives are, if a place doesn't have skilled researchers, R&D facilities will not locate there. So in a narrow sense, respondents may cite the availability of skills as an important factor. However, this is very different than saying that the availability of technical skills is the driver of the decision to offshore R&D. This is not to deny that sometimes firms locate R&D in particular regions because there is a concentration of particular types of scientific and technical talent there. But it's not clear that the major driver of firms going to China or India is the availability of skills.

Given that costs are the most important driver in offshoring R&D, particularly to developing nations, what role do incentives play? Costs are determined both by overall costs of doing business and by specific incentives. Generally, incentives are not listed as the most important factor in determining R&D location decisions. However, because they do contribute to the overall cost estimation firms undertake, they are a factor involved in decision-making. This is one reason why within the last decade many nations, including most of Southeast Asia and Europe, have made attracting and growing R&D a centerpiece of their national economic strategies. Their aggressive use of R&D tax incentives is just one indicator of that commitment. In 1990, the United States enjoyed the distinction of having the world's most generous tax treatment for research and development. However, because the generosity of the credit has been whittled away over the years, and other nations have forged ahead, by 2004 we had dropped to 17th most generous (see Figure 6).[24] For example, China provides a 150 percent deduction on R&D expenses (provided that R&D spending increased 10 percent over the prior year). Mexico offers a tax credit of 30 percent not only for all R&D expenses but also for equipment (which is not eligible for the credit in the United States). India provides a tax deduction of 125 percent of certain R&D expenses.[25] But nations use more targeted incentives as well. For example, China has established a large number of research parks and many advertise tax breaks for foreign companies locating there. Other R&D incentives include tax breaks on R&D labor, exemption from VAT taxes on equipment purchases, and subsidized research facilities.[26]

Many nations aggressively market their R&D tax policies to attract global research investments. Australia touts its generous R&D tax incentives in order to persuade multinational companies to invest there.[27] Ireland places ads in U.S. business magazines to market its attractiveness as a location for R&D facilities.[28] Not surprisingly the growth rate of R&D of U.S. foreign affiliates was higher in countries with tax-based R&D incentives than those without.[29]

Figure 6: U.S. Rank in Tax Generosity of R&D Among 30 OECD Nations, 2004[30]



There is one other factor that may lead firms to offshore R&D. In some nations, pressure from the national government for "technology transfer" have led some firms to establish R&D facilities there, in order to be able to access the domestic market to sell goods and services.[31] For example, China sometimes requires companies to establish a research institution, center, or lab for joint R&D in order to get approval for joint ventures. Since the WTO prohibits forced technology transfer, nations that have joined the WTO have discovered that they can avoid a WTO violation by "encouraging" technology transfer without formally requiring it. One way is for local government officials reviewing investment applications to make it clear that a quid-pro-quo deal is required for approval. Burying these deals in the fog of bureaucracy lets "mercantilist" countries hide their WTO violations that bring in more offshored R&D than they would otherwise receive.

Is R&D Offshoring Good or Bad for the U.S. Economy?

Not only is the extent and cause of R&D offshoring debated, so too is whether it is good or bad for the U.S. economy. There is a general consensus that R&D offshoring is beneficial to U.S. firms. Otherwise, why would they engage in it? Nonetheless, it is important to note that unless firms manage this process effectively, it's possible that they could lose valuable intellectual property to competitors. This could happen if other companies are able to gain access to the knowledge and then commercialize in direct competition. R&D offshoring could also benefits the U.S. economy if U.S. firms end up doing more R&D because of offshoring and are able to be more innovative and competitive than their rivals in other nations.

Yet, offsetting these potential gains are the potential losses to the U.S. economy of the direct and indirect economic activity related to R&D. There is no doubt that while offshoring, like trade in general, benefits the United States by lowering prices on a wide array of services, it is also true that it threatens particular workers and communities. It is hard to make a strong case that losing low-wage jobs to offshoring hurts the U.S. economy, since many laid-off workers are likely to move up to higher wage, higher-skilled jobs, especially if they receive the necessary support and retraining. However, if the jobs are higher wage—as are R&D jobs—then it is less clear how offshoring these jobs benefits the economy. It is unlikely that most of the laid off workers, or the workers not hired because the firm did not expand R&D in the United States, would find jobs at comparable incomes.

Moreover, the decline or otherwise slower growth of R&D investments is likely to mean fewer (or slower growth in) jobs for scientists and engineers.[32] This in turn could lead to fewer individuals choosing science, technology, engineering and math (STEM) careers, thereby exacerbating the trend toward more offshoring of R&D, until a new lower equilibrium is established. Moreover, R&D jobs appear to be linked to production jobs. Indeed, there is a correlation between a nation's investment in R&D and the share of its total manufacturing exports that are high-tech.[33] As a result, offshored R&D could lead to less high-tech production.

Finally, there is considerable evidence that R&D activities generate positive spillovers and that these spillovers are geographically limited in scope.[34] For example, there is evidence that offshored R&D spurs domestic companies in the receiving nations to increase their R&D, thereby increasing the competitive challenge to U.S. firms.[35] This is one of the reasons for the renewed interest around the world in regional "clusters" of economic activity, particularly innovation-based economic activity. As a result, losing R&D means more than the loss of the actual R&D activities.

What Should Congress Do?

Congress has a key role to play in responding to this new challenge to the innovative position of the U.S. economy. However, one role it should not play is engaging in a debate about whether U.S. companies "should" be offshoring R&D or whether CEO's that offshore R&D are "Benedict Arnolds."[36] In the new global economy with hyper-competitive product and financial markets, companies that do not take advantage of appropriate offshore R&D opportunities will suffer in the marketplace and in equity markets. But going to the other extreme and doing little in response, hoping that "the market" will solve the problem is likely to be equally as unproductive.

Rather, Congress should focus on adopting the kinds of policies that will make the United States a place where companies—U.S. and foreign—want to increase their R&D investments. Making the environment and "ecosystem" for R&D the most vibrant and attractive in the world is a goal everyone should be able to agree on. There are four key steps Congress should consider:

• **Expand the R&D tax credit:** Perhaps the most straightforward and effective way to make the United States more attractive to internationally mobile R&D investment is to expand the R&D credit. Congress could start by doubling the credit's rate to 40 percent.[37] Doubling the credit would make an important statement that the United States is serious about keeping and growing research-based economic activities. In addition, Congress should also expand the Alternative Simplified Credit. Moreover, in order to spur more research partnerships between companies and American universities and federal laboratories, Congress should allow firms to take a flat credit of 40 percent for collaborative research conducted at universities, federal laboratories, and research consortia.

• **Create a National Innovation Foundation:** The Federal Government's traditional focus on basic science (principally through the National Science Foundation), agency-specific mission-oriented research, and managing a patent system is no longer sufficient to ensure that the United States remains the world leader in R&D and innovation. If the United States is going to meet the economic challenges of the future, the Federal Government will need to make the promotion of innovation a larger part of its national economic policy framework. Congress took an important step in that direction with the passage of the 2007 *America COMPETES Act.* But the challenge is neither modest nor fleeting and more needs to be done.

Other nations have come to that conclusion. In recent years many nations, including Finland, France, Iceland, Ireland, Japan, the Netherlands, New Zealand, Norway, South Korea, Sweden, Switzerland, and the United Kingdom have either established or significantly expanded separate technology- and innovation-promotion agencies. They realized that if they were to prosper in the highly competitive, technology-driven global economy they needed specifically to promote technological innovation, particularly in small and mid-sized firms and in firms in partnership with universities.

It is time for the United States to do the same and create and fund a new National Innovation Foundation (NIF), with a core mission to boost innovation in businesses.[38] The NIF would work with businesses, State governments, universities, and other partners to help spur innovation. The NIF would operate a competitive Industry Research Alliance Challenge Grant program to match funding from consortia of businesses, businesses and universities, or businesses and national labs. The NIF would also operate a competitive grant program to increase state investments in innovation-based economic development activities. States would submit proposals to the NIF laying out their technology-based economic development (TBED) strategies and explaining how NIF support would enable them to do more and better. Qualifying projects would include a host of TBED activities, including technology commercialization centers, industry-university research centers, regional cluster development programs, regional skills alliances, and entrepreneurial support programs.

• **Ensure an Adequate Supply of Skilled Researchers:** While costs are a key driver in offshoring to developing nations, ensuring an adequate supply of STEM talent is an important factor in helping ensure that companies conduct more R&D in the United States. For if companies have difficulty in hiring skilled STEM workers, it will be that much more of a spur to look overseas. As a result, we need to not only work to expand the domestic supply of STEM talent but also expand the opportunities for talented foreigners to come to the United States and contribute their expertise. Congress took several steps toward the first goal in the recent *America COMPETE Act,* but these efforts need to be expanded and fully funded, including providing more funding for specialty math and high schools.[39]

But even with these efforts, it's important to note that at least for the short term, we won't be able to rely only on domestic supply alone. Policy-makers around the world are also waking up to the fact that a key component of increasing domestic R&D is expanding the supply of individuals with STEM degrees. Yet at a time when many other nations are making it easier for talented immigrants to enter their country, either as students or workers, the United States is struggling to decide what to do.[40] We have sent out mixed messages to the rest of the world since September 11, 2001, and in the immigration debate of the past year, pragmatic discussion of skills was drowned out by heated rhetoric about other aspects of immigration. As a result, Congress should expand and reform the H–1B visa program. In particular, tighter oversight of the program may be required to ensure that employers, particularly foreign ones, are paying prevailing wages. Finally, immigration policy should make it easier for foreign students studying in STEM fields to attend school here and to gain a path to citizenship once they obtain their graduate degrees.

• **More Vigorously Combat other Nations' Efforts to Force U.S. Companies to Move R&D Offshore:** As noted above, some nations tie access to their markets to company investments in R&D in their nation. Even though these practices violate the letter or spirit of the WTO, they are popular tactics with some mercantilist countries to gain valuable technological know-how. Yet, it is one thing if a company wants to invest in R&D in other nations as part of its business strategy. It is quite another for it to be coerced into doing so in order to gain access to the market. The United States government, and in particular the United States Trade Representative (USTR), needs to be much more proactive in fighting these kind of high-tech mercantilist actions and ensure that governments do not pressure U.S. firms to move R&D offshore.

Conclusion

The U.S. economy still possesses enormous strengths and advantages in technology and innovation. However, the rise of offshore R&D threatens our technology leadership, particularly as there are few signs that, absent new public policies, this trend is not likely to abate any time soon. Ensuring continued technology leadership will require bold new policies to spur domestic R&D and innovation.

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Robert Atkinson is President of the Information Technology and Innovation Foundation, a Washington, DC-based technology policy think tank. He is also author of the book, *The Past and Future of America's Economy: Long Waves of Innovation that Power Cycles of Growth* (Edward Elgar, 2005). He has an extensive background in technology policy, he has conducted ground-breaking research projects on technology and innovation, is a valued adviser to state and national policy-makers, and a popular speaker on innovation policy nationally and internationally.

Before coming to ITIF, Dr. Atkinson was Vice President of the Progressive Policy Institute and Director of PPI's Technology & New Economy Project. While at PPI he wrote numerous research reports on technology and innovation policy, including on issues such as broadband telecommunications, Internet telephony, universal service, e-commerce, e-government, middleman opposition to e-commerce, privacy, copyright, RFID and smart cards, Internet telephony, the role of IT in homeland security, the R&D tax credit, offshoring, and growth economics.

Previously Dr. Atkinson served as the first Executive Director of the Rhode Island Economic Policy Council, a public-private partnership including as members the Governor, legislative leaders, and corporate and labor leaders. As head of RIEPC, he was responsible for drafting a comprehensive economic strategic development plan for the state, developing a ten-point economic development plan, and working to successfully implement all ten proposals through the legislative and administrative branches. Prior to that he was Project Director at the former Congressional Office of Technology Assessment. While at OTA, he directed "The Technological Reshaping of Metropolitan America," a seminal report examining the impact of the information technology revolution on America's urban areas.

He is a board member or advisory council member of the Alliance for Public Technology, Information Policy Institute, Internet Education Foundation, NanoBusiness Alliance, NetChoice Coalition, the Pacific Institute for Workforce Innovation, and the University of Oregon Institute for Policy Research and Innovation. He also serves on the advisory panel to Americans for Computer Privacy, is an affiliated expert for the New Millennium Research Council, a member of the editorial board of the Journal of Electronic Government, a member of the Reason Foundation's Mobility Project Advisory Board, and a Nonresident Senior Fellow at the Brookings Institution. Dr. Atkinson was appointed by President Clinton to the Commission on Workers, Communities, and Economic Change in the New Economy. He is also a member of the Task Force on National Security in the Information Age, co-chaired by Markle Foundation President Zoe Baird and former Netscape Communications chairman James Barksdale. In 1999, he was featured in "Who's Who in America: Finance and Industry." In 2002, he was awarded the Wharton Infosys Business Transformation Award Silver Medal. In addition, *Government Technology Magazine* and the Center for Digital Government named him one of the 25 top "Doers, Dreamers and Drivers of Information Technology." In 2006, *Inc. Magazine* listed Atkinson as one of "19 Friends" of small business in Washington. He received his Ph.D. in City and Regional Planning from the University of North Carolina at Chapel Hill in 1989.

ITIF is a 501(c)(3) nonprofit organization founded in 2006. Created in partnership with the Information Technology Industry Council, it is governed by a board of distinguished IT and innovation policy leaders and experts.

Chairman WU. Thank you very much, Dr. Atkinson. Mr. Morris, please proceed.

STATEMENT OF MR. STEVE MORRIS, EXECUTIVE DIRECTOR, OPEN TECHNOLOGY BUSINESS CENTER (OTBC); MANAGING DIRECTOR, OREGONSTARTUPS.COM

Mr. MORRIS. Thank you, Mr. Chairman, and thank you to the Committee for the opportunity to just talk before you today.

I would like to, I guess, bring sort of a technology business background approach to this, and more recently, my focus really has been on startups, although I have been at larger companies, too. I would like to, I guess, talk about some of my observations, at least, as to what is important.

Many of the factors that have already been talked about are clearly key in deciding where you are going to locate an R&D facility. If you don't have the workforce and the infrastructure that is required for that technology, it isn't going to happen. If you don't have IP protection, it is less likely to happen. If it is not an attractive place to recruit employees and retain employees, it makes it more difficult. Access to technology, if you don't have the universities, you don't have the strategic partners you want to work with, again, it is not as likely to happen. I guess, my thing would be you have to build on your strengths. We are not going to lead in every possible aspect of R&D. Not even the U.S. can do that. We can pick our battles, you know. What technologies are we strong in? Let us invest in the existing clusters in those areas best in the R&D universities in those areas.

Certainly work on the K–12 system in this country, because that is important, not only for recruiting employees. Employees care about the education of their kids. But clearly, that creates the future workforce. But, I guess, the area I would like to talk about a little more, which is more uniquely my focus, is what I think is our big advantage, which is entrepreneurship and entrepreneurial innovation. That is a very strong thing for this country.

It is relatively easy to start a company in the U.S. compared to other areas. Culturally, entrepreneurship is an okay thing to do. It is encouraged. It is not frowned upon, the way it is in some other countries, and a lot of innovations happen in this country, because of our entrepreneurial flair.

I think there are some important things we can do to strengthen that, which will relate directly to attracting more R&D operations to this country. A couple of examples from Oregon, we have an IBM facility for open source software in Beaverton. The reason that is there is because they have bought a startup company called Sequent Computers, excuse me, in Beaverton, and that brought IBM to the area. They saw, then, that there was a great workforce, and a lot of other advantages for an open source software group. It ended up getting located there. That is an example where what started as a very small startup actually attracted a very large R&D organization into the area.

A second example, more on the smaller end, because of our strength in entrepreneurship and because of our strengths in specific markets and technologies, we have an opportunity to attract more entrepreneurs to come to the U.S. from offshore to start their startups here.

Again, a recent example in Oregon, a company called Lunarr, with two Rs, started by an entrepreneur from Japan, who had a very successful company there, sold it, came to the U.S. to start Lunarr, because number one, it is a Web 2.0 company, and he looked at the U.S. as being a better market, so we had an advantage there. Two, the strategic partners in Web 2.0, they were here. And number three, he found the workforce that he needed, which was hard to find in Japan. He decided on Portland, as opposed to California, mainly because of quality of life for his employees. So, now, yes, it is a small company, but of course, Google was a small company once, and clearly, that is the bet you make when you invest in startups is that some of them will be home runs.

The third example I wanted to mention is something we are beginning to have success with at OTBC, the incubator in Beaverton for technology startups, where we have realized that small software, open source software companies in Japan, are having a hard time recruiting the engineers they need. We have explained to them that we have a lot of those things here, and we are making it very easy for small companies, who normally wouldn't be opening an R&D operation in the U.S. at this stage, say with 20 or 30 people. Well, as an incubator, we can make that very easy for them. So we just signed our first lease with a software company from Japan, to open up an R&D office at OTBC. We have got a verbal commitment from a second one, and I know of at least ten more companies that look like good prospects over the next one to two years. So, again, these are small, but they all have very good growth potential, and some of them will be growing into big companies.

So I would really like to suggest that a part of a strategy for attracting R&D investments from big and small companies, the whole strategy really should include a focus on entrepreneurship, because it is such a strength, and there are some things we need to address to make that even stronger. Like a specific issue we have right now is the migration of venture capital to much later stage companies. It is very difficult these days to raise seed level money, absolutely something that could be improved with some government policies. So I would urge the Committee to consider those, more startup oriented packages. Some of them will grow to be big.

Thank you very much.

[The prepared statement of Mr. Morris follows:]

PREPARED STATEMENT OF STEVEN MORRIS

Introduction

As the Manager for an incubator for high-technology startups in Beaverton, Oregon, and a startup entrepreneur myself, much of my focus the past few years has been on startups and entrepreneurship, although in 25 years in high-technology business, I have worked for and with a number of very large technology companies. Below, I have tried to share with the Subcommittee my understanding of the major factors technology companies consider when deciding where to locate a Research and Development (R&D) facility.

One theme in my remarks is "build on your strengths." One of our strengths in the United States is that we are very good at innovation and entrepreneurship. The two frequently go hand-in-hand, with a new innovation (e.g., a new technology for more effective web searches) resulting in a startup (Google, for example) which grows into an industry leader.

The Subcommittee's focus is probably on convincing larger technology companies in the U.S. to keep their R&D operations in the U.S. and on convincing larger foreign companies to locate their R&D operations here. I'd like to argue that the U.S. strengths in innovation and entrepreneurship are by themselves advantages in keeping and/or attracting R&D operations in the U.S.

And, it's possible to leverage our innovation and entrepreneurship strengths to attract foreign entrepreneurs to open R&D operations here and even to start their companies here. I only have anecdotal evidence to offer—but we're seeing such relocations happen in Oregon. Some of those transplanted operations will grow into large, successful companies, yielding a very high return-on-investment for any governmental programs that facilitate the process. I believe that investing in our entrepreneurial strengths, and attracting startup-level R&D operations should a key component of a U.S. R&D competitiveness strategy.

Factors

> *What are the factors that influence companies when selecting sites for facilities, especially for research and development? Has competition for locating R&D intensive facilities increased?*

There is a long list of factors that a high-technology company will consider in deciding on the location of a new R&D facility. In my experience, some of the more important factors are:

Workforce

Human capital is the most critical resource for an R&D facility. Companies will consider locating an R&D facility in a region only if that region provides a highly educated workforce with expertise relevant to the type of R&D in question (or at least with a well educated, trainable workforce, and a location that is so attractive that the company is confident that they can recruit the specialized skills and knowledge that are required). This is certainly one good reason that states are beginning to adopt a "cluster" strategy of leveraging their existing strengths (or "clusters") of technologies. (I think of this as a "build on your existing strengths" strategy.) The existence of a cluster implies existence of a skilled workforce to support that cluster. And it also implies that other required infrastructure is already in place. . .

Availability of required infrastructure

Although human capital is critical, there are often other aspects of infrastructure that must also be available to support R&D activities. A semiconductor facility, for example, requires access to a broad range of chemicals, machinery, analytical equipment, and very specific raw materials that are processed in particular ways by skilled vendors. For R&D work, there are advantages in having local vendors supplying infrastructure pieces so collaboration is easier. Working with a local vendor to make adjustments to equipment on make modifications to the way some chemical or component is processed is much easier if the vendor is across town rather than on the other side of the continent. (Even in a “flat world,” face-to-face teamwork still has problem-solving advantages!) Again, this is another reason for a “cluster” strategy.

Quality of Intellectual Property (IP) protection

R&D might be defined as the process of creating technology-based intellectual property, or IP, so protecting that IP is extremely important. The U.S. has very strong IP protection laws, which reduces the likelihood that an employee will take IP learned at one company to a competing company. Not all countries have such strong protections. However, one key segment of the U.S. IP protection infrastructure is very bogged-down right now—and that is the patent process. Obtaining a patent can take (and usually does take) multiple years.

Attractiveness to Employees

No R&D facility can rely exclusively on the workforce that is available locally. Growth and specialized needs will require recruiting employees from outside of the area. And, of course, it's important to retain the employees you have. That makes attractiveness of the R&D location to employees a very important factor. It's no surprise that this reduces to considerations such as:

Quality of life

Quality of K–12 school system (highly educated workers care about the education of their children)

Cost of living

K–12 and University Education

As suggested above, available of a high-quality K–12 education system is important for attracting and retaining employees. But a second reason that K–12 is important is that it is developing the company's long-term workforce. And availability of high-quality higher education options is important for employee development and retention. A highly-educated workforce needs access to ongoing educational opportunities. This is especially critical in an R&D workforce where technology skills must be continually improved and extended.

Access to technology

In addition to having access to a highly-trained workforce, R&D operations benefit from access to university research that is relevant to their R&D and access to strategic partners that cooperate in or contribute to technology R&D.

Tax Climate and Tax/Financial Incentives

These cover a wide range of possible strategies from property tax and income tax breaks to very good real estate deals, government-funded employee training programs, etc. All other things being equal, clearly the lower-cost location has significant advantages. However, if some of requirements mentioned above are not in place, then no level of financial or tax incentive will win the day.

Strategies

What strategies have the City of Beaverton and Portland metro area employed to try to attract companies to build facilities there? Which strategies were successful, and which were not? Why?

For Beaverton, with relatively little land available for incorporation into the city, creating new office parks to accommodate a large corporate R&D center is simply not an option. So with respect to technology companies, Beaverton has focused on encouraging the formation of new companies, and helping existing companies grow. This dual strategy is reflected in two of the City's economic development tactics: creating a high-tech incubator and implementing an “economic gardening” program to help existing Beaverton companies grow. Of the two programs, the incubator (OTBC) is very relevant to attracting R&D operations to the U.S.

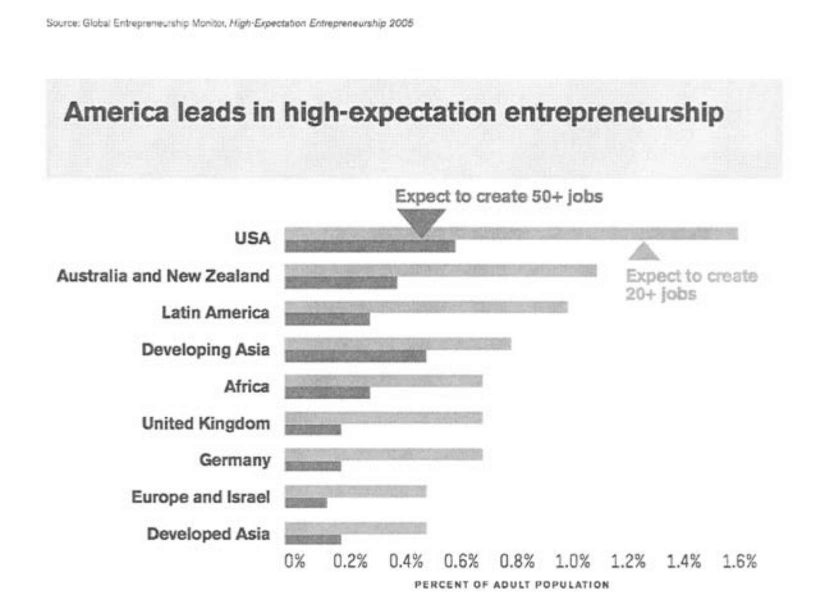
OTBC provides office space and coaching/advising services to high-tech startup companies to increase the odds of their success. The program is relatively new (we started adding startup in 2006) but is already starting to show results. For example, OTBC companies attracted $8 million in private (angel and venture capital) investments in the past three months—already showing a good return on the $1.3 million investment Beaverton made to kick off the program.

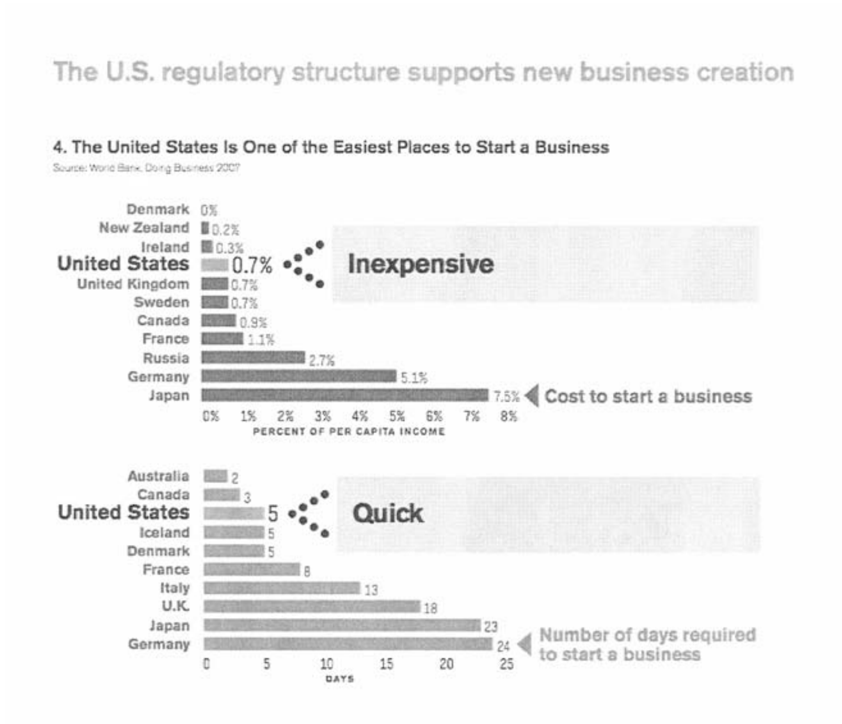
The more relevant result for the Subcommittee is that OTBC is beginning to see success in attracting offshore startups to establish a U.S. R&D beachhead at the incubator. I discuss this in more detail in the next section.

The Importance of Entrepreneurial Innovation

As I suggested earlier, I believe that entrepreneurial innovation and a healthy high-tech startup environment are significant U.S. strengths which are important to attracting R&D operations to the United States.

There is considerable evidence as to the U.S. strength in entrepreneurship:





As shown by the above charts, in the U.S., entrepreneurial expectations are high, and the regulatory environment makes it inexpensive and quick to start a venture.

Oregon is particularly strong in entrepreneurship and new-venture creation. In 2005, Oregon was #7 of all states in the level of small business ownership, with 19.5 employer firms and self-employed individuals per 100 people in the labor force. (Source: U.S. Small Business Administration, Office of Advocacy, 2005, Small Business Economic Indicators.)

One weakness in the U.S. entrepreneurship ecosystem is funding of early-stage (seed) companies. As venture capital funds have increased in size over the past decade, the total amount of venture capital available has grown significantly. But as fund size increases, venture capital firms have been forced to make larger investments in later stage companies. A $300M fund simply can't make small investments (say, under $1M or $2M) because they can't manage that many investments. This has created a funding gap for startups. Angel investors (high net worth individuals who invest in startup companies) are partially filling that gap with seed-level investments, but that is only a partial solution. This country's startup economy is in critical need of improved access to seed-stage capital.

A strong entrepreneurship environment is important in attracting R&D operations for at least three reasons:

1. One mechanism for attracting R&D relocation is through acquisition of a startup.

   Example: IBM now has an R&D facility in Beaverton. That came about because IBM purchased Sequent Corporation, a local startup and Intel spin-off. Having a presence and office space in Beaverton, IBM subsequently decided that because of the region's strength in open technologies, and Oregon's quality of life advantages, Beaverton made an excellent location for an IBM open-source software development operation. You can argue that acquisition of a U.S. startup by an offshore company is moving technology out of the U.S.—but if the company reinvests, building more local R&D infrastructure, then it's certainly a net win for the U.S.

2. The U.S. can leverage the countries entrepreneurship advantages and strengths in specific high-tech markets to attract startups that might otherwise locate in their home countries.

   Example: Lunarr is a startup in Tigard, Oregon that was started by a successful Japanese entrepreneur. After one startup success in Japan, he decided to start Lunarr (a web 2.0 collaboration service) in the U.S. because it provided easier access to web 2.0 technologists and partners in the U.S., and because of U.S. is a good place to start and grow a business. He selected the Portland area (after considering several west-coast sites) primarily due to the high quality software-engineering workforce, and the quality of life in Oregon.

3. Entrepreneurship strengths, quality of life, and highly educated workforces can all be leveraged to attract R&D operations of offshore startup companies to the U.S. Although these companies are small, many of them have excellent growth potential, and a few will no doubt become "home runs" generating considerable economic benefits.

   Example: In June of 2006, I visited Japan as part of a Governor Kulongoski trade mission. I met with four open-source startup companies in Japan. All four were having trouble recruiting the open source software engineers they needed. Oregon has a strong open source workforce, and OTBC provided an easy was for a small Japanese software company to start up an R&D operation in Beaverton (in the incubator world, this is called providing a "soft landing" for offshore companies). Since that trip, OTBC has signed a lease with one Japanese software company—Blueleaf—and received a verbal commitment from a 2nd Japanese software company to sign a lease by the end of the year. That's a 50 percent success rate! Both companies have the goal of recruiting open source software engineers, and building an R&D center in Beaverton.

   Building on this early success, I visited a major open source software exposition in Tokyo last June and met with 40 open source software companies, 10 of which look to be good prospects for opening an open source R&D operation in Oregon within the next one to two years.

   A strong entrepreneurship/startup ecosystem is also a factor in attracting a larger company's R&D operation. A strong entrepreneurial environment, combined with a highly educated workforce (as part of a technology cluster, so the workforce is trained in technology relevant to the company) combined with university technology and technology from other local (cluster) technology companies creates an energized environment that generates innovative technology spin-offs—often creating attractive acquisition targets for larger R&D operations. Even for a larger R&D operation, access to innovation is as important as access to technology.

Recommendations

What types of incentives most influence companies searching for a facility site? What recommendations would you provide to the Federal Government to aid local governments working to make their areas more attractive to companies?

IP protection: Streamline the Patent Process

The U.S. likely has the most effective intellectual property protection in the world—but it can move very slowly. We need to speed the patent process. Five to six years to get a patent is simply too long in the fast-moving high-tech world. Either the process needs to be simplified, or more resources need to be applied.

Innovation and Entrepreneurship: Build on our strength—and merchandise it

We can build on our strength in startup innovation by

Investing in technology startup incubators and "soft landing" programs

Investing in University technology transfer programs

Improve the Seed-Level Investment Situation

Countering the decrease in seed-level investment from the U.S. venture capital industry is critically important for maintaining a healthy entrepreneurial environment in the U.S. I would suggest:

- Reduce the capital gains tax for angel investments in early stage startups
- Perhaps create a "U.S. Innovation Accelerator" fund (as a time-limited experiment) that would add a 15 percent "kicker" to angel investments be-

tween $50K and $250K. Such a kicker would be a great help to entrepreneurs raising seed capital from angel investors. Even something as small as a 15 percent kicker would provide angels with significant leverage on their investments. Not only would this improve the seed-level funding environment, but managed correctly, it would make money. (The fund would receive stock in the companies.) This is an investment, not an expense!

Invest in University Research, but Choose the Right Technologies

Not even the U.S. can be #1 in all areas of technology. We should proactively choose the technologies the U.S. intends to dominate, and invest in University research in those areas. Perhaps leverage existing state investments and state technology clusters by adding to or matching state investments in R&D (the States know best what clusters are their areas of strength.)

Tax incentives: Choose our battles

As mentioned above for University research, the U.S. can be #1 in all areas of technology. We should proactively choose the technologies the U.S. intends to dominate, and create tax incentives targeting those areas.

Invest in K–12 Education

This is critical for developing, recruiting, and retaining a quality workforce. We need to significantly improve science and math education in elementary, middle and high schools and also should start to teach students about innovation and invention before they go to college.

Immigration: we need Access to the International Talent Pool

The U.S. educational system cannot supply all of the advanced degree professionals that U.S.-based R&D operations will need to employ. U.S. based operations—whether owned by U.S. firms or foreign firms—need to be able to recruit foreign workers. Security concerns have made it more difficult for people from abroad to attend U.S. university programs and join U.S. companies, just when rapid development in their own economies make it more attractive for them to return there. We need to make it easier for highly-educated foreign individuals to attend U.S. schools and work for U.S. firms.

Promote the Value of Quality of Life

A major strength we have in Washington County and in Oregon in general is the exceptional quality of life. And while I'm a biased Oregonian, there are certainly many other parts of the country that offer excellent quality of life. This is an advantage we should promote. Any corporation considering a new location is interested in recruiting quality employees—and excellent quality of life makes that job much easier. So let's figure out how to market that!

BIOGRAPHY FOR STEVE MORRIS

Steve Morris is the Executive Director of OTBC and the Managing Director of OregonStartups.com. He has more than 25 years of management experience in the software, service, and semiconductor test industries at companies such as Hewlett Packard, Integrated Measurement Systems, Cadence Design Systems, Mentor Graphics, and Credence Corporation. Prior to joining OTBC, he founded OregonStartups.com, providing consulting and web-based advice and information or startup companies. He founded Teseda Corporation and served as CEO from 2001 to 2005, and prior to that founded two internal startups in larger companies. He has extensive experience in strategic marketing, business plan development, strategic partnerships, and venture capital fund raising. He holds a B.A. in mathematics from Reed College and a Masters of Science degree from Carnegie-Mellon University Graduate School of Industrial Administration(now The Tepper School of Business).

Chairman WU. Thank you very much, Steve. Mr. Sweeney, please proceed.

STATEMENT OF MR. MARK M. SWEENEY, FOUNDER, CO–OWNER AND SENIOR PRINCIPAL, MCCALLUM SWEENEY CONSULTING

Mr. SWEENEY. Thank you, Mr. Chairman and the Committee. Pleased to be here today.

I am going to speak to you from the trenches. My firm is a site selection firm. We help companies decide where to build their facilities, so we work with them directly on the types of location decisions this committee is interested in. Our firm does help all kinds of companies, from all over the world, look all over the world, and we do support all types of activities, office, including R&D, manufacturing, and distribution.

The site selection process can be seen from a lot of different perspectives. Perhaps the most helpful is to see it as bringing geography issues into a company's capital investment decision. When a company sees an opportunity, whether it is for a new product or a new market, or demand for enhanced research and development or customer service, once they have that opportunity in front of them, they need to decide where, because where they do something has a very large impact on how successful they will be. The factors that go into the where question cover a lot of the same bases, but in their details, will be different for each type of project, for each type of company, and even change over the life of the decision.

In the early stages of our projects, it is important for us to understand our clients' strategic drivers, what this investment is all about, what this opportunity is all about, as well as the operational drivers. What are the specific things associated with this project that are going to be impacted and different, depending on where they actually locate?

In general, we examine three broad areas of factors: physical factors, operating factors, and living factors. Physical factors can include things like sites, buildings, and all types of infrastructure, and as you might imagine, the demands for those will vary greatly from project to project. Operating factors are factors that influence the decision and the location over the life of the project.

A big component of that is labor, and all the issues that go into labor evaluations, availability, quality, cost, et cetera, utilities, utility effectiveness, reliability, and utility cost. For industrial projects, transportation is usually very important, and then, taxes and incentives are a factor in every site selection. On the living conditions side, that gets into quality-of-life issues. The community assets in a company, in a community, the housing market, medical services, the security of the company, and cultural and recreational assets. Again, the various weights on these factors will depend on the particular project, and on the stage of the project, but we generally deal with all of those factors on all projects.

When we get to a final stage, the way we manage our projects, when we get to the final phase, having done both desktop and field work analysis on all the factors I mentioned, we will have finalists that are generally acceptable locations for our client's project. What that means is the final decision is being made being strong, viable candidates. Incentive negotiations tend to become most intense at the end of the project, and as a result, do have significant influence, because at that point, you are trying to make distinctions among viable locations, and incentives can help accentuate the strengths, mitigate the weaknesses, and sharpen the differences between your finalist locations.

Now, for research and development facilities, let me back up a moment, projects at the very beginning can often be seen as, in a very broad sense, either being driven by site and physical factors, or being driven by people and human resource factors. Now, all of those factors get involved in all projects, but that is sort of where the general tone starts. Research and development projects will be people-driven projects. All of the factors are important, but perhaps, the primary most important factor is access to quality talent. That can be talent that is currently available in a location, but just as important, the ability to recruit and retain that talent into your candidate location. For R&D, that recruitment is going to take place on a global level, so your ability to attract talented people from around the world into your community is going to have a big influence on our final decision.

You have heard a lot from my esteemed fellows here on the panel about the trends in research and development. Those offshore trends are impacting all types of activities. Countries have recognized that R&D is a great basis for future competitive economic activity, and by establishing advantages in R&D, they are positioning themselves not only to win that battle, but positioning to win future economic development battles as R&D efforts get commercialized.

Countries outside of the obvious ones like China and India, countries like Singapore, and even our neighbors in North America, Canada and Mexico, have taken very aggressive stances to recruit research and development.

In the U.S. there are some opportunities for us to re-compete and reestablish our leadership. Some of those would include the big science project or the big vision, something along the lines of NASA that will not only energize the country, but create great types of research and potential spinoffs, and at the same time, hopefully energize younger Americans to find science and engineering career paths more attractive.

In tax and finance policies, the U.S., as has been shown here, has fallen way behind on tax policy, and has very little, in terms of capital-oriented grants, and therefore, finds itself, even if it is competing as a finalist for a project, being outspent and out-incented in the final stages of a project. Legal issues include intellectual property rights. We have a strong patent system. It makes it easy to get patents, but it is difficult to move that out into commercialization by other firms.

Growing and retaining an entrepreneurial base, which is what takes R&D activities and bridges it to commercialization. There is a lot of efforts there. Those can be improved considerably.

And then, finally, an area where the U.S. has a natural advantage is that a lot of companies in advanced manufacturing would like their research and development to be in relatively close proximity to their key, cutting edge manufacturing locations. They would like to put R&D in this country, but when you can do it in a neighboring country, or a different country around the world for a fraction of the cost, that overcomes the natural tendency to be close. So, there is some low hanging fruit that the U.S. could grab to help stem this tide of R&D, but it is a wide range of policies that would take that.

Thank you.

[The prepared statement of Mr. Sweeney follows:]

PREPARED STATEMENT OF MARK M. SWEENEY

Thank you for the opportunity to testify before your subcommittee at the hearing entitled *"The Globalization of R&D and Innovation, Part III: How Do Companies Choose Where to Build R&D Facilities?"*

Introduction

I am a founder, co-owner and Senior Principal with the firm McCallum Sweeney Consulting, Inc. (MSC) of Greenville, SC. We are a site selection consulting firm; we help companies decide where to build their new facilities. We help companies from all over the world look all over the world, although the vast majority of our search activity is in North America. We help all types of companies with all types of projects, including headquarters, back office, research & development, manufacturing and logistics/distribution. Additional information about our company, our services and our recent clients can be found at our web site: *www.mccallumsweeney.com.*

Site selection can be seen from many perspectives, but it perhaps most clearly seen as bringing geography to the capital investment decisions of companies. Companies identify an opportunity—it may be for a new product, or new markets, or for increased R&D, or to meet growing customer service demands. Whatever the opportunity or need may be, a lot goes into the decision to spend capital to establish and operate a new facility. One important question in this decision is "Where?" Many of the factors that are important to a facility project will be different in different locations, so where a company decides to build and operate impacts the success of the investment and enterprise.

The Site Selection Process

The approach our firm takes with clients is a rational, phased approach. It starts with understanding the company's investment project and its strategic and operational drivers. These will vary with each project by project type (e.g., R&D vs. manufacturing). From these indicators we will help the firm establish a search region. For industrial projects, this is typically a contiguous region defined largely by inbound and out-bound transportation costs. For office-oriented projects, the search "region" may be a discreet set of locations typically defined by key labor characteristics. The search region is screened against various statistics that measure the project decision criteria, using geographic information systems (GIS data). This determines our Areas of Interest. These are further investigated to narrow the search to a set of Candidate Communities.

Candidate Communities have met the basic needs of the project and will be the focus of field investigations. In the field we thoroughly investigate Physical Conditions (sites, buildings, infrastructure), Operating Conditions (labor, utilities, transportation, taxes), and Living Conditions (quality of life issues including community assets, housing, medical, education, security, cultural and recreational assets, etc.). After considerable comparative analysis, this phase concludes with selection of Finalist Communities.

For MSC, only locations that are viable will move to the Finalist group. The Finalists will likely present different strengths and weaknesses but will all be understood at that point to be locations in which the project could operate successfully. The final phase is final due diligence on key factors (sites, labor markets, etc.) as well as final negotiations, including incentive negotiations. Detailed financial modeling is completed as well as final risk assessments, and a final location is selected in which to site the facility.

Key Decision Factors

A lot of factors go into a site selection decision. The relative importance of various factors will vary with i) the nature of the project and ii) the stage of the project. For a broad generalization, projects can usually be understood to fall into one of two groups: those whose initial and primary drivers are "people-driven" (for example, R&D facilities) and those whose initial drivers are "site-driven" (for example, large manufacturing facilities). All projects will deal with site issues, and all projects will deal with human resource issues, but this distinction shows the primary driver and influences on various projects.

Research and development facilities are people-driven. The most important factor in locating such facilities is the availability of high quality skilled labor. This will include availability of such human resources in the community as well as the ability to effectively recruit and retain such talent to the new location. And for R&D facilities in particular, this recruitment will likely take place on a global scale.

So, detailed criteria evaluations for R&D facilities will focus on a wide range of human resource issues. On a broad level such things as education attainment statistics, the presence of graduate degreed individuals, the presence of other R&D activities, the presence of strong colleges and universities, even the community's local education system will be assessed. The ability to recruit and retain talent from around the world will focus the decision-makers on community characteristics, including support for diversity, a wide variety of strong cultural and recreational assets (often favoring urban amenities), adequate housing at various levels, strong medical infrastructure, comfort with the security of the location, and excellent transportation and communication infrastructure.

Final decisions will come from comparing the strongest candidates against each other on these factors and the overall cost of the project. Costs can vary significantly from one location to the next, and these include both up-front investment oriented costs as well as on-going operational costs over years. Incentive negotiations are typically very important in these final stages of the decision.

Incentives do influence location decisions. Generally, projects drive incentives, not the other way around, and incentive become more important as the project proceeds. Incentives cannot make a bad location good, but can create or accentuate differences between the final candidates. Incentives typically provide a company with i) lower costs, and ii) lower risks. Incentives can take the form of grants, access to capital, lower cost capital, infrastructure support, recruitment, screening and training support, utility cost reductions, and a wide variety of tax advantages from exemption to credits to abatements.

While many factors have brought a company to its final decision, the final financial comparisons have a major influence on the final decision. For R&D facilities, all finalist locations should be ones where the "people" issues are found to be acceptable, so incentives help create distinctions among a set of acceptable alternative locations.

Competition for R&D

The geographic expansion of location decisions to a global perspective is well documented. Site searches for all types of activities (manufacturing of all types, back office operations, and even research and development projects) are now conducted on a global basis.

The countries and regions that understand the R&D location decision have positioned themselves to meet the needs and be particularly attractive to this business sector. Countries like Singapore and Canada have been very aggressive in supporting education, university activity, research funding, and research and development rules and regulations, all of which attract the attention of R&D location decision-makers. Communities such as Singapore and Montreal are very international in scope and so represent a strong location for the global recruitment of key talent. As the source of supply of Ph.D.s and high quality talent grows outside the U.S., the ability to recruit and retain non-native talent is critical.

Competition and Incentives

The U.S. can do a lot to enhance its competitiveness for R&D facilities. The U.S. can build on its current success and base of existing advanced manufacturing by leveraging a common desire to keep R&D and manufacturing in close proximity. There are a number of state efforts to establish a strong primary-level research and development base through recruitment of key "stars" in a particular field and building up the R&D and entrepreneurial infrastructure around them; federal support could leverage these efforts with great success. Related to this are efforts to enhance the entrepreneurial sector including licensing policies (especially for joint government-business research and development projects) and access to capital at various stages of development. The Federal Government could have immediate impacts on this factor with enhancements of development activities associated with the federal laboratories across the country.

There is a lot on the books for research and development tax credits, but the successful countries are going way beyond that with capital-oriented incentives (grants, very large investment tax credits).

The U.S. must find a way to balance enhanced security concerns with the need to allow recruitment of talent (and lots of it) from around the world.

A "Manhattan-Project" style commitment to key areas of research and development (for example energy) could provide an economic stimulus that could last for years (if not generations).

BIOGRAPHY FOR MARK M. SWEENEY

Mark Sweeney is a senior principal in McCallum Sweeney Consulting (MSC), providing site selection services and economic development consulting to companies and organizations worldwide. Recent MSC clients include Boeing, Nissan, Dollar General, Michelin, and Trex.

With more than seventeen years of experience in site selection and economic development, Mr. Sweeney assists companies by identifying, evaluating, and selecting the optimal location for their capital investments. Such projects cover a wide array of related factors, including sites, infrastructure, transportation, labor and demographics, state and local taxes, utility services, incentives, etc.

Mr. Sweeney also provides consulting services to leading economic development organizations across the United States in such areas as strategic planning and organizational design, site certification, adaptive reuse, target industry programs, incentive strategies, and sustainable development.

Mr. Sweeney has assisted clients in a wide variety of industries, from automotive manufacturing to software development and Internet services. Recent clients include Nissan (headquarters; auto assembly; engine; warehouse), Michelin (tire and rubber mfg; warehouse), Dollar General (distribution); and Trex (composite lumber). Of particular note are the Nissan headquarters project (announced their relocation to Nashville, TN in November 2006) and the Nissan automotive assembly plant (announced for Canton, MS in November 2000). He has conducted siting projects in Europe and Asia as well as most regions of the United States. Economic development clients include TVA, Duke Power, and the States of Oklahoma and Tennessee.

Mr. Sweeney spent more than five years at the South Carolina Department of Commerce, serving as Director of Research and Communication. There, he directed departments providing project management support, information management (including world's leading economic development application of Geographic Information Systems), and communications. Mr. Sweeney was also one of the authors of *Approaching 2000—An Economic Development Vision for South Carolina,* a state strategic plan for economic development.

Mr. Sweeney has a Master's in Business Administration from Clemson University and a Bachelor of Science from Appalachian State University. In addition, Mr. Sweeney was a recipient of a Murphy Fellowship for graduate work in economics at Tulane University.

Mr. Sweeney is married with three children and lives in Greenville, SC. He is active in the community and currently serves on the Board of Directors for the Carolina Youth Symphony.

Chairman WU. Thank you very much, Mr. Sweeney. Dr. Thursby, please proceed.

STATEMENT OF DR. JERRY G. THURSBY, PROFESSOR AND ERNEST SCHELLER, JR. CHAIR OF INNOVATION, ENTREPRENEURSHIP, AND COMMERCIALIZATION, GEORGIA INSTITUTE OF TECHNOLOGY

Dr. THURSBY. Thank you, Mr. Chairman, and thank you, Dr. Gingrey. I am going to be high tech today, and so, we are going to go to PowerPoint.

I am going to be talking about results of a survey that Marie Thursby and I conducted in 2005. It was of R&D intensive firms, about half of them in the U.S. and half of them in Western Europe.

Now, we were asked to talk about recent trends in R&D activity, and in our survey, we actually asked that of our respondents. We said do you anticipate a substantial change of worldwide distribution of R&D employment in the next three years. Two hundred and nine respondents answered the question, 62 percent said no, we are not anticipating a change. Of those anticipating a change, we said is it going to be an increase or a decrease. Well, you can see up here that the primary increases, indeed, are going to be India and China, and there is going to be a net decrease in the United States and Western Europe. To give a little bit of perspective there, that is 23 firms in both U.S. and Western Europe who are anticipating a decrease in R&D employment in the United States, 15 anticipating an increase or net change of eight firms, which is less than four percent of our sample. But you see a lot is going to China and India.

Now, let me go to the next panel. Well, we asked them if they could identify a recently established or planned facility outside the home country. If they could, we asked them questions about the facility. We asked them, can you think of a recently established or planned R&D facility within the home country. If you can, we are going to ask you questions about that. Two hundred and thirty-five sites were identified. We get a slightly different picture here when we look at realizations versus their expectations. Realizations here, the bulk of these facilities have been in the U.S. and Western Europe.

Now, 80 percent of these facilities, more than 80 percent, were actually established since the year 2000 or were in a planning phase at the time that we did it. So, the evidence here is mixed. They are saying one thing about anticipation, but when you look at the realizations of the recent past, you are getting a slightly different picture.

How about factors, and what drives them to go into these particular locations. And notice, we are asking about factors involved with specific locations, not what do you think is a reason about why you want to go to a location. What really led you to that? If you look at facilities in emerging countries, and facilities in developed countries, you get a very different picture. So the most important factors for going into an emerging economy—the most important factor is output markets, and we have heard quite a bit of that today. That is growth potential of those countries.

Second most important to these particular firms, for the facilities they establish in emerging markets, second most is quality of R&D personnel. Tied for third is costs, which were equally important university factors; detractors, weak IP protection in emerging markets. Now, if you go to developed countries, when the sites are actually in developed countries, the bulk of these are in the U.S. and Western Europe, the most important factor is the quality of people that they can hire, and strong IP protection. And those were equally important for these firms in establishing these particular facilities.

Next, access to high quality university faculty and being able to collaborate with those universities, then output markets. And there were no detractors identified for going into developed markets. Notice that cost is not there as a detractor for developed market.

Also, notice what is not up there, and we did ask about, one of which is legal requirements to enter markets. They said no, that was not influencing decisions. We asked them about tax breaks and direct government support as a reason for going to those countries. On average, that was not important. For a few firms, that was important, but on average, it was not important. And we asked them about regulatory restrictions, fewer regulatory restrictions, which might attract them to particular markets. No, that was not important.

We also asked them about type of science, a question that was proposed to us. What are they doing when they actually go there? So we broke science into two categories. One, we called familiar science or familiar technology. It is sort of routine science, versus new technology, or sort of cutting edge science. So we like to think of it as new science versus familiar science, and as you see here, the vast majority of the effort in emerging economies is in routine science. The new stuff, the important stuff, the cutting edge stuff, is all taking place in developed economies.

By the way, the most important factor determining whether or not new science versus routine science is taking place, universities. Finally, to sort of sum up the major conclusions, there is some indication of movement of R&D from developed to emerging, but there is some—the recent and strategically important facilities are in developed economies. Location decisions are complex and vary according to whether the site is an emerging economy or developed economy. The most important factor for emerging economies, market factors, for developed economies, R&D personnel and IP protection. Universities are always important.

Costs are not important in developed economy sites. They are tied with universities, of importance in emerging economy sites, and the relative importance of factors for new science versus familiar science. Universities are very, very important in this, and very little new science is being conducted in emerging economies.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Thursby follows:]

PREPARED STATEMENT OF JERRY G. THURSBY AND MARIE THURSBY

Factors in International Location and Type of Corporate R&D[1]

I. Introduction

The idea that the United States dominates cutting edge science and technology is increasingly challenged as the U.S. share of patents and scientific awards declines and the media reports increasing corporate reliance on offshore research and development (R&D).[2] R&D globalization is also center stage in policy circles as questions are raised as to how the U.S. and Western Europe can provide environments conducive to innovation.[3] Over a concern that policy discussions be informed by data,

[1] This project was conducted with generous support from the Ewing Marion Kauffman Foundation, as well as the industry partners of GUIRR, the Georgia Institute of Technology, and Emory University. Numerous individuals have aided in the design and implementation of this survey, but the authors are particularly indebted to Merrilea Mayo of GUIRR, Ross Armbrecht, former President of the Industrial Research Institute, Andrew Dearing of the European Industrial Research Management Association, Harold Schmitz of Mars, Inc., Jean-Lou Chameau of California Institute of Technology, Tim Ryan of GFK Custom Research, Inc. and Peter Kelly of the American Chemical Society.

[2] A search of the archives of the *Wall Street Journal* and the *New York Times* over the period 2002–2005 showed 61 articles focused on the offshoring of R&D. Thirty-eight of these articles mentioned costs as a factor in offshoring decisions while 29 noted the quality of R&D personnel as a factor. Other factors were mentioned as well, though none as prominently as costs and quality of R&D personnel. Ten noted the role of output markets while four mentioned intellectual property regimes and three discussed the role of universities in the process.

[3] See, for example, the Council on Competitiveness, 2004, *Innovate America: Thriving in a World of Challenges and Change,* and the Committee on Science, Engineering, and Public Policy

Continued

rather than case studies or anecdote, the Government University Industry Research Roundtable (GUIRR) of the National Academies asked the authors to undertake a study of the factors behind R&D site location with particular attention paid to the decision to locate in the home country versus other countries.[4] A survey was conducted in the summer and fall of 2005 and results can be found in Thursby and Thursby (2006a, 2006b).[5] The target firms were R&D intensive firms and large enough to feasibly have R&D facilities in multiple locations. The majority are firms whose home country is either the U.S. or a country in Western Europe. For most of what follows we aggregate the responses of the U.S. with those from Europe given that there are few differences based on the home country of the firm. Additional background on the survey is found in the appendices.

In this testimony we review and expand upon the findings of the earlier studies to address a series of questions posed to us by the Subcommittee on Technology and Innovation of the U.S. House of Representatives. We were provided with a list of questions. All of the questions pertain to the factors that influence R&D location, the types of R&D conducted in the U.S. versus lower cost emerging countries, and the potential for government policies to attract and retain R&D in the U.S. Our survey evidence provides direct evidence on the relative importance of various factors, including policies, in both R&D location and the types of R&D conducted. Our results point to important differences in the factors that influence the decision to conduct R&D in developed economies versus emerging economies. Section II identifies trends in the distribution of R&D employment worldwide. Section III describes the factors considered in the survey and their relative importance for companies responding to the survey. Section IV addresses the types of R&D conducted in various locations and shows not only that there are clear differences in the types of R&D conducted in developed and emerging country sites, but the factors that are most important for the type of R&D conducted are somewhat different than those that influence site selection. The combined evidence is striking. As discussed in the conclusions in Section V, while cost is a factor it takes a back seat behind market and other input supply factors such as quality of personnel. Perhaps the most striking result is the importance of expertise in universities and an environment that facilitates collaboration with universities in both site location and type of R&D.

II. Current and Expected Future Distribution of R&D Employment

The firms who responded to the survey are generally multinational in their R&D efforts. Only about 15 percent of the 248 respondents currently have all R&D personnel in the home country whereas about one in five have more than half of R&D employees outside the home country.

While the primary focus of the survey was factors behind the respondents' recent R&D location decisions, some questions addressed whether the distribution of R&D employment is changing or is expected to change. Two hundred and nine respondents answered a question on whether they "anticipate the worldwide distribution of technical staff will change substantially" over the next three years. Thirty-eight percent indicated a substantial change was anticipated.

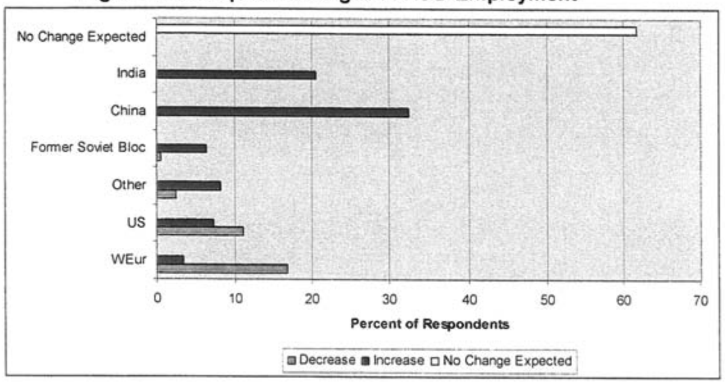
The firms expecting a change were asked for the region(s) where employment was expected to grow and for the region(s) in which it was expected to decline. Respondents were given five choices (they could choose multiple locations): *United States, Western Europe, Former Soviet bloc countries, China, India, Other.* Results are in Figure 1.

2006, *Rising Above the Gathering Storm: Energizing and Employing American for a Brighter Economic Future.*

[4] Note that this study is a peer reviewed report to the National Academies rather than a report by the National Academies.

[5] Jerry Thursby & Marie Thursby, "Here or There? A Survey on the Factors in Multinational R&D Location," National Academies Press, 2006a. Jerry Thursby & Marie Thursby, "Where is the New Science in Corporate R&D?," *Science,* Vol. 314, December 2006b.

Figure 1. Anticipated Changes in R&D Employment



China and India are the regions where most growth is expected. The "other" category consists largely of targets in Asia. Net decreases are expected for the U.S. and Western Europe. For the U.S., 23 respondents anticipate a decrease while 15 anticipate an increase. Fifteen of those anticipating a decrease are U.S. firms and two of the 13 anticipating an increase are U.S. firms. Thus 11 percent of the 209 firms expect to decrease employment in the U.S. while 7.2 percent expect to increase technical employment in the U.S.; the net change is 3.8 percent. A larger net change is expected for Western European countries. Seven firms (3.3 percent) anticipate an increase in technical employment in Western Europe and 35 (16.7 percent) anticipate a decrease.

III. Factors in Location Decisions

III.1 New or Planned R&D Sites

Unlike a number of prior surveys on factors behind R&D site locations, this survey did not ask respondents for their general perceptions about issues in globalization.[6] Rather, the survey linked factors to specific locations. Respondents were asked whether or not their firm had recently established, or was planning to establish, a facility outside of the home country. If the answer was "no" the respondent was not asked further about R&D site locations outside the home country. This strategy was used in order to minimize noise in the data. Focusing on an actual site decision should, in principle, minimize responses driven by what respondents think the factors ought to be. In a real sense, the survey solicited responses from those who had "done their homework" or were "doing their homework" about site locations outside the home country. The specific survey statement and question was:

> *Think about some of the more recent R&D facilities established by your firm. This can include facilities you are in the process of building or staffing or which are only in the planning phase. Choose one of these that is OUTSIDE the home country and that is both considered to be central to your firm's current R&D strategy and about which you are familiar.*
>
> *Does such a facility come to mind?*

If the answer was "yes" the respondent was asked a series of questions about the identified facility. This exercise was repeated substituting "INSIDE the home country" for "OUTSIDE the home country." Respondents could answer for a) an outside facility, b) an inside facility, c) both an inside and an outside facility, or d) they would not answer questions about location decisions.

For identified facilities, respondents were asked for the destination country, the year the facility was established (or expected to be established) and number (or expected number) of technical employees. Ninety-two facilities were identified in the

[6] See, for example, the Economist Intelligence Unit 2004, *Scattering the Seeds of Innovation: the Globalization of R&D* and the Council on Competitiveness 2005, *National Innovation Survey.*

home country and 143 outside the home country. Table 1 gives the locations (both inside and outside the home country) identified. Facilities are broken down by the country location of the facility (the leftmost column) and home country of the respondent.

Given the attention that has been drawn to the establishment of R&D facilities in China and India, it is interesting to note that a substantial number of respondents were able to identify sites in developed economies. There are more sites identified in the U.S. and Western Europe (128) than in China and India combined (73). Recall, however, that these responses are not for all recent or planned sites. Our question was about sites that are both considered central to overall R&D strategy and about which the respondent is familiar.

Table 1. Site Locations of Recent or Planned Facilities

	Respondent's Home Country			
Site Location	**US**	**Western Europe**	**Other**	**Total Sites**
US	34	14	0	48
Western Europe	19	61	0	80
China	30	23	2	55
India	9	9	0	18
Other	13	12	9	34
Total Sites	105	119	11	235

III.2 Size and Age of Selected Sites

As a measure of the importance of the site, respondents were asked both for the number of technical employees employed or expected to be employed in the facility and for the number of technical employees worldwide. Employment by facility and worldwide employment are highly skewed so both the means and medians are reported in Table 2.

Table 2. Number of Technical Employees

	Median Number of Technical Employees	**Mean Number of Technical Employees**
Outside/Emerging	50	205
Outside/Developed	44.5	127
Inside	90	219
Worldwide employment	700	3788

For each R&D site, the survey asked for the year it was established or, if it was a planned facility, the length of time before it would be operational. More than 80 percent of the facilities were established after 2000 or are planned facilities.

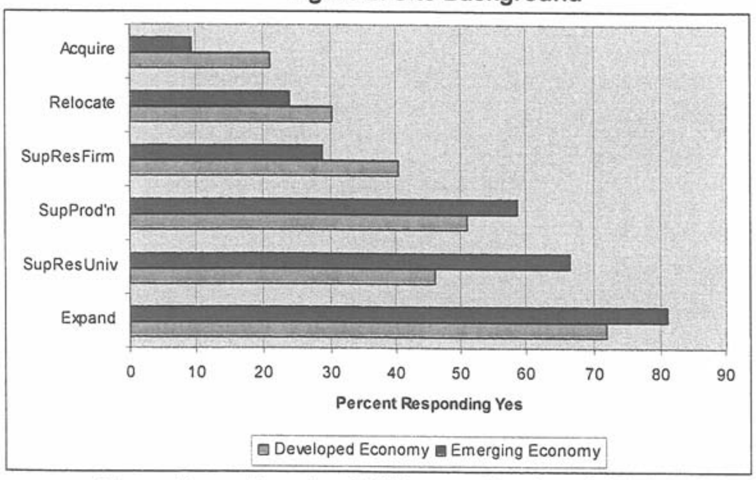
III.3 Site Background

We asked whether a series of statements were or were not correct about the site. The statements made were

1. *This was part of an overall expansion of my firm's R&D effort*
2. *This was an acquisition of an existing R&D site.*
3. *This was to establish or support research relationships with other firms.*
4. *This was to establish or support research relationships with local universities or research institutes.*
5. *This was to support needs of existing production facilities.*
6. *This was a relocation of my firm's R&D effort.*

The Yes/No responses to these statements were aggregated into responses for sites in a developed economy *versus* sites in emerging economies (responses for home versus other developed sites are not significantly different). The percent who indicated yes to each statement is in Figure 2. Developed versus emerging country responses are significantly different at a 10 percent level or smaller for all cases except supporting production and relocation. The most important feature of the sites is the fact that they are generally expansions of R&D effort. In contrast sites are less likely to be relocations of effort or the product of acquisitions. Emerging economy sites are more likely to be for the purpose of supporting university research relationships. While perhaps surprising it likely stems from firms having already established extensive research networks with universities in developed economies, whereas they may only now be in the process of establishing these networks in emerging economies.

Figure 2. Site Background



Observations: Emerging 86-90 Developed 142-147

III.4 Factors in the Selection of R&D Sites

This Section deals with the factors involved in the decision to locate. The approach was as follows. A list of potential factors involved in site selection was provided for each site that a respondent had identified as a recent or currently planned facility. Respondents were first asked whether they agreed or disagreed that the factor was correct about the location. They were then asked how important or central the factor was in the deliberations on whether to locate in the country. For sites outside the home country the statements were:

> *We want to know the factors that you considered in locating R&D in this country. First, we will ask if you agree or disagree with a statement about this location as it affects your firm. We use a five point scale where five indicates that you strongly agree and one indicates that you strongly disagree. Three will indicate that you neither agree nor disagree. Second, we will ask how important or central the factor was in deliberations on whether to locate in this country. Use a scale of one to five where five is very important and one is not important at all.*

The following statements about factors were provided (shorthand used for each is in parentheses).

1. *There are highly qualified R&D personnel in this country. (QualR&D)*
2. *There are university faculty with special scientific or engineering expertise in this country. (UnivFac)*
3. *We were offered tax breaks and/or direct government assistance. (TaxBreaks)*
4. *In this country it is easy to negotiate ownership of intellectual property from research relationships. (Ownership)*
5. *Exclusive of tax breaks and direct government assistance, the costs of R&D are low in this country. (Costs)*

6. *The cultural and regulatory environment in this country is conducive to spinning off or spinning in new businesses. (Spin)*
7. *It is easy to collaborate with universities in this country. (CollabUniv)*
8. *There is good protection of intellectual property in this country. (IPProtect)*
9. *There are few regulatory and/or research restrictions in this country. (FewRestrict)*
10. *The R&D facility was established to support sales to foreign customers. (SupSales)*
11. *This country has high growth potential. (Growth)*
12. *The R&D facility was established to support production for export to other countries. (SupExport)*
13. *The establishment of an R&D facility was a regulatory or legal prerequisite for access to the local market. (LegalReq)*

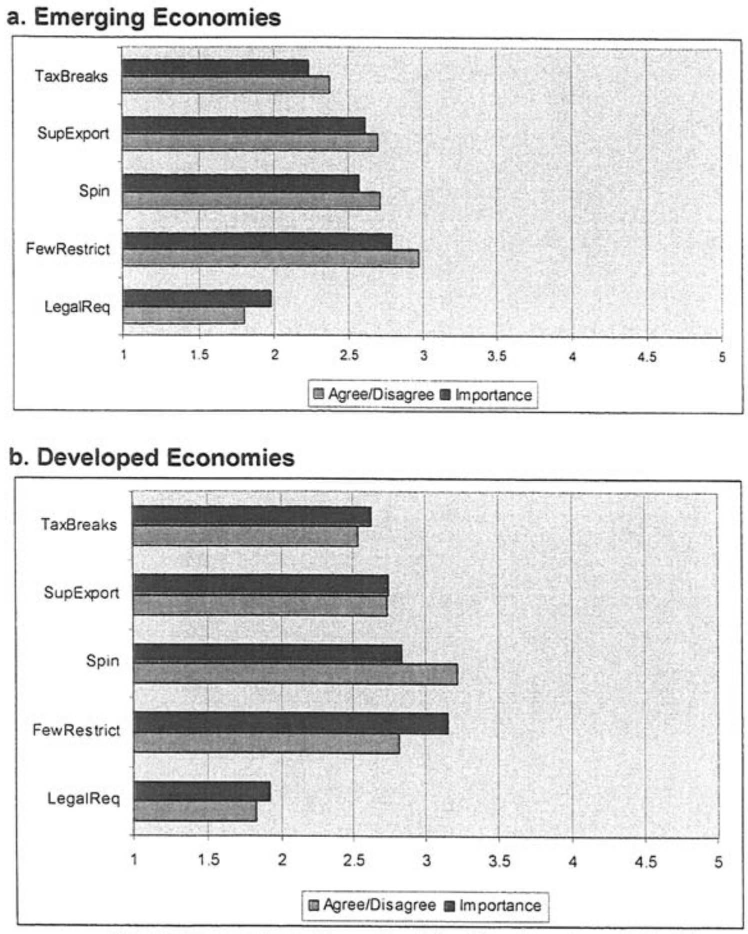
Note that each statement was worded is such a way that agreement indicates that, from the standpoint of the firm, the factor is favorable for location at that site. If the level of agreement is a four or five then the factor is correct about the site and that factor is a potential attraction for the site. If a one or two is given then the respondent disagrees that the factor is correct and that factor is a potential push away from the site. It is then the level of importance that indicates whether the factor was actually an attraction or not.

A similarly worded question was asked about facilities inside the home country. Results for sites in the home country are, with few exceptions, not significantly different from results for sites in other developed countries. For that reason we aggregate home and other developed country responses.

III.5 Unimportant Factors

Five of the 13 factors appear unimportant regardless of site location. These five factors have average or mean importance scores of less than three (that is, the average of the one to five scale on how important or central a factor was in deliberations on the site decision was less than three) or only slightly greater than three no matter where the site is located. The factors are legal or regulatory requirement for market access, tax breaks and/or direct government assistance, spinning off or spinning in new businesses, supporting production for export to other countries and few research restrictions. Results for these factors are in the panels of Figure 3.

Figure 3. Unimportant Factors



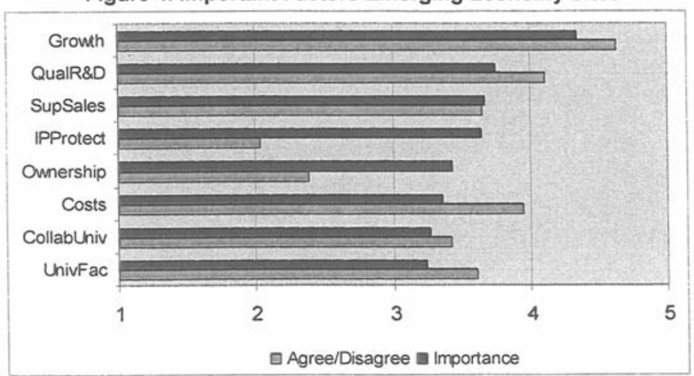
No of observations: Emerging 81 – 88 Developed 88-144

The result on tax breaks and/or other government assistance is perhaps surprising given their (apparent) popularity in attracting manufacturing. Mean values can mask whether tax breaks and/or direct government assistance were offered to some firms (but not others) and for those firms TaxBreaks could have been important. For emerging economy responses it is the case that only three of 80 respondents (3.8 percent) both agreed or strongly agreed (i.e., a score of four or five) that they had been offered tax breaks and/or direct government assistance and had noted the importance of TaxBreaks as either a four or five. In developed economies 26 of 140 respondents (18.6 percent) either agreed or strongly agreed and also noted that tax breaks were important (score of four or five).

III.6 Important Factors: Emerging Economy Sites

Results for the remaining eight factors for sites in developing or emerging economies are in Figure 4; factors are ordered by level of importance. Eighty-one percent of these sites are in China or India.

Figure 4. Important Factors Emerging Economy Sites



Number of Observations 81-87. Statistical Tests of Importance (5% level):
UnivFac=CollabUniv=Costs=Ownership
Costs=Ownership=IPProtect=SupSales
Ownership=IPProtect=Supsales=QualR&D

All factors with the exception of growth are similar in their levels of importance. Only the growth potential of the country is significantly different from all other factors. The decision to locate in an emerging economy is a complex one in which only growth potential of the output market stands out as significantly more important than all others.

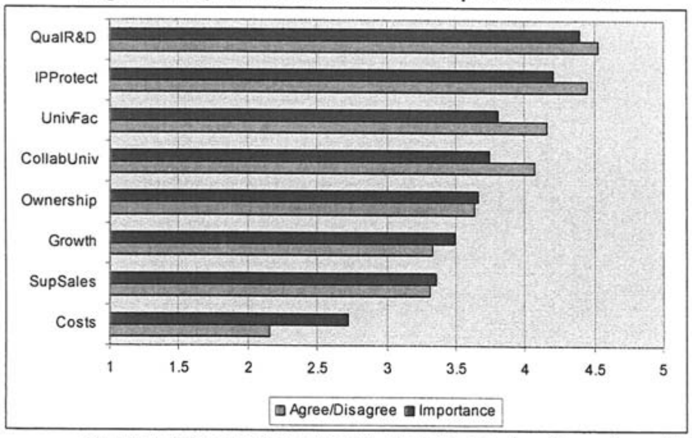
The results on costs are noteworthy as they conflict with more anecdotal reports (see Footnote 2). Respondents agree that costs (net of tax breaks and direct government assistance) are low, but they attach significantly less importance to them in deliberations on selection of sites (one percent level of significance). Costs are lower in emerging economies, but they do not stand out as being particularly important or central in location decisions as compared to other factors. In particular, five factors are higher in importance—and two of the five are significantly higher.

For the two intellectual property factors (ease of ownership of intellectual property from research relationships and good protection of intellectual property), there is disagreement with the factor statements. Nonetheless, both factors were important or central in the location deliberations. That is, the IP environment is not good for sites in emerging economies, the companies consider this in their deliberations, but they nonetheless establish sites there. Clearly, the positive factors in these economies outweigh the negative IP factors, an issue addressed later in more detail.

III.7 Important Factors: Developed Economics

Figure 5 gives the results for factors in developed economies; factors are ordered by the level of importance. While costs are not important, they are included in this Figure for comparison with emerging economies.

Figure 5. Important Factors in Developed Economies



Number of Observations 52-144. Statistical Tests of Importance (5% level):
SupSales=Ownership=Growth=CollabUniv
Ownership=Growth=CollabUniv=UnivFac
IPProtect=QualR&D

The most important factors in the deliberations to place a site in a developed economy are intellectual property protection and the quality of R&D personnel (which are not significantly different). This contrasts sharply with emerging economy sites in which growth potential is the most important factor (followed by the quality of R&D personnel). The next five factors ("university faculty with special expertise" to "supporting sales") are all important with each having a mean importance score greater than three, but they are not statistically significantly different from each other in importance.

III.8 Summary of the Importance of Factors in Site Selection

The importance of factors in selecting R&D sites varies according to whether the facility is in a developed or in an emerging economy. To summarize, we categorize factors by whether they can be viewed as attractions to a site or whether they detract from the site. An "attractor" is defined as a factor with a mean agree/disagree score greater than three and a mean importance score greater than three. All statements about factors are made in such a way that, if true, the statement would be positive from the standpoint of the firm. A "detractor" is defined as a factor receiving a mean agree/disagree score of less than three and a mean importance score greater than three.

Table 3. Attractor and Detractor Definitions

	Agree/Disagree Score	Importance Score
Attractor	> 3	> 3
Detractor	< 3	> 3

Results on attractors and detractors are in Table 4. The factors are presented separately for sites in developed *versus* emerging economies. They are rank ordered by importance; the first factors in a list are the most important. An "equal" sign signifies no significant difference in the factors. For example, the quality of R&D personnel and IP protection are equal in importance for locating in a developed economy and they are the most important factors in that decision; this is followed by university factors, etc.

Table 4. Attractors and Detractors

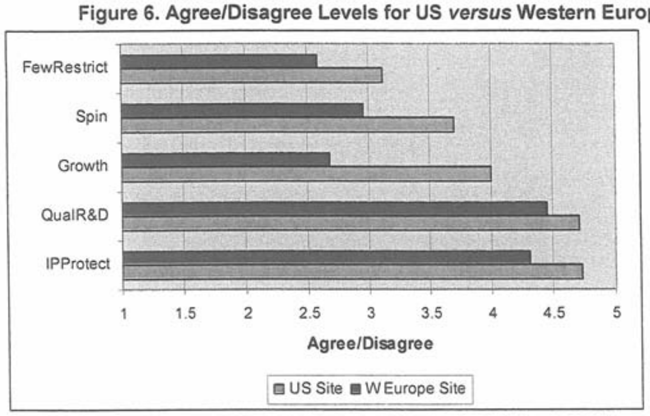
	Attractors	Detractors
Developed Economies	Quality of R&D Personnel = IP Protection University Factors Output Markets	*No Detractors*
Emerging	Output Markets Quality of R&D Personnel Costs = University Factors	IP Factors

Output Markets are Growth & SupSales
University Factors are CollabUniv and UnivFac
IP Factors are IPProtect and Ownership

III.9 U.S. versus Western Europe

Figure 6 gives the levels of agreement only for those factors where there is a significantly different (five percent level) response for sites in the U.S. versus Western Europe.[7] Their level of importance is given in Figure 7.

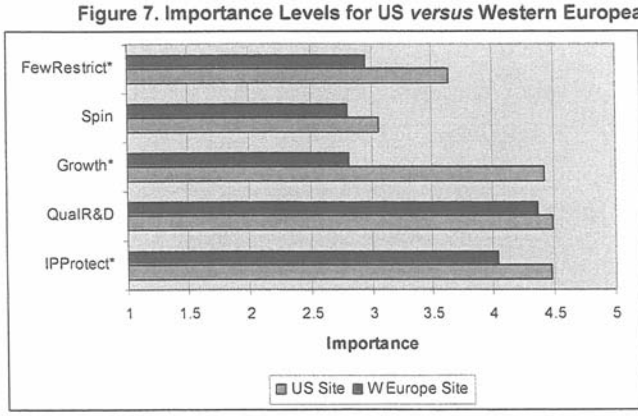
Figure 6. Agree/Disagree Levels for US *versus* Western European Sites



No. Observations: US 47-49 (except Growth at 15) WEur 75-79 (Except Growth at 28)

[7] There are significantly different levels of agreement for SupExport but we do not include it in the figure. Western European sites are significantly more likely to support exports. However, this is almost certainly due to the fact that many European respondents are based in small countries that tend to be more exported oriented.

Figure 7. Importance Levels for US *versus* Western European Sites



**Indicates that the difference is significant at the 5% level*

While the quality of R&D personnel and IP protection are significantly higher in the U.S. the differences do not appear to be qualitatively large and the importance of the quality of R&D personnel is not significantly different. On the other hand, the differences in the levels of agreement for growth potential, the ability to spin companies in or out, and few restrictions are not only statistically significant, but the differences are qualitatively large. Additionally, the importance in the location decision of growth potential and few restrictions are significantly different.

IV. Types of Research Conducted in Developed versus Emerging Countries

A series of questions were asked regarding the type of research conducted at various sites. Rather than use the standard categories of development, applied research and basic research, the survey focused on whether the purpose of the R&D is to create products and services that are new to the firm and whether the R&D involves a novel application of science. The following definitions were used:

A NEW TECHNOLOGY is a novel application of science as an output of the R&D. It may be patentable or not.

Improving FAMILIAR TECHNOLOGY refers to an application of science currently used by you and/or your competitors.

R&D for NEW MARKETS is designed to create products or services that are new to your firm.

R&D for FAMILIAR MARKETS refers to improvement of products or services that you already offer your customers or where you have a good understanding of the end use.

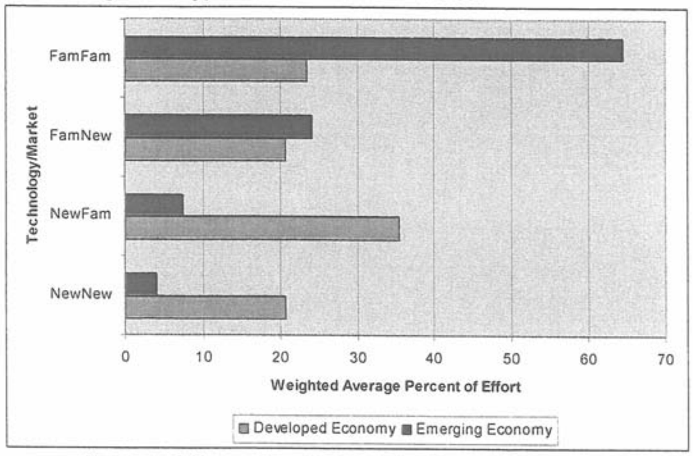
This gives four possible types of R&D:

1) *Improving familiar technologies for familiar markets*
2) *Improving familiar technologies for new markets*
3) *Creating new technologies for familiar markets*
4) *Creating new technologies for new markets.*

The survey's use of "New" *versus* "Familiar" markets does not refer to geographical markets; the question is whether the firm is currently selling such a product or service. Respondents were then asked for the percent of the technical staff employed in each of the above four activities.

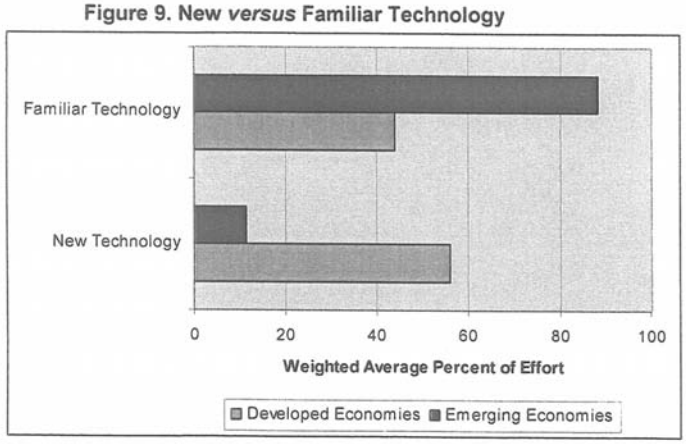
Results do not vary significantly between responses for the home country and other developed economies hence the results are aggregated. In addition, we have used weighted averages where the weights are the number of technical employees at a facility; thus, facilities are treated differently according to their size. Results are in Figure 8. Results for new science *versus* familiar science are aggregated in Figure 9.

Figure 8. Types of Research Conducted



Number of Observations: Developed Economy 133 Emerging Economy 85

Figure 9. New *versus* Familiar Technology



When comparing types of R&D across sites, work at emerging economy sites is always significantly different from effort at other sites.

It is striking that very little new science is conducted in emerging economies. Thus, while companies are conducting R&D in economies despite weak IP protection (as shown in Table 4), their cutting edge science tends not to be done in those locations.

In Thursby and Thursby (2006b) we related the responses on agreement and importance of the various factors affecting site location to the percentage of effort devoted to new science in the sites. The primary results are given In Table 5. The first column lists each factor considered important in site selection and the second column gives the importance rank attached to the amount of new science conducted. Note that the importance of factors for the type of science conducted is different from the importance of factors in site selection. Of particular note is the fact that university characteristics are the most important factors in determining where new or cutting edge science is conducted.

Table 5. Relative Factor Importance in Determining where New Science is Conducted

Factor	Rank
University collaboration	1
Faculty expertise	2
Cost	3
Growth	3
Support sales	5
IP Protection	Not important
Ease of ownership	Not important
Quality R&D personnel	Not important

Rank is from most important (rank=1) to factors not important in type of science.

V. Conclusion

Our survey evidence directly addresses several of the Subcommittee questions. First, we explored the role of a variety of factors in R&D site location. We included thirteen factors, including demand factors such as market growth potential, resource supply factors such as cost or quality of technical personnel, as well as a number of policies such as taxes, IP protection, and regulatory environments.

Several results are striking. First, as shown in Table 4, the relative importance of factors for sites located in emerging economies is quite different than those in developed economies. Quality of R&D personnel and IP protection are the most important attractions for companies locating in developed countries, while output market potential is the most important attraction of emerging economies. Second, university expertise and the ease of collaborating with universities is the third most important factor in developed countries and they are tied with cost as the third most important factor in emerging countries. Third, as shown in Figures 5 and 6, when sites in the United States and Western Europe are compared, the United States appears to be more conducive to location when the growth potential of the market is considered important.

We also explored the type of R&D conducted in different locations and in our Science publication. An important result from our combined studies is that the factors that are the most important in determining location are somewhat different that those that determine the type of R&D conducted. While universities, and an environment conducive to collaboration, are among the top three factors in attracting a facility, they are the most important factors in determining where the cutting edge science is conducted. IP protection is a significant detractor to locating in emerging economies (see Table 4), but notice in Table 5 that IP protection does not determine the type of science. Our interpretation, explored more fully in Thursby and Thursby (2006b) is that IP protection is important for conducting both cutting edge and routine R&D.

From a policy perspective, then, these results emphasize the importance of policies that support the conduct of R&D. These include policies to support the training of a highly qualified technical workforce as well as good IP protection which provides incentives not only to conduct R&D but facilitates the exchange of ideas emerging from research. According to the firms in our sample, both the quality of R&D personnel and IP protection are highest in the United States. The results on ease of university collaboration further emphasize the need for policies that facilitate the exchange of ideas. Finally, it should be noted that while on average tax breaks were not important, for companies locating in developed countries almost 19 percent said they were important.

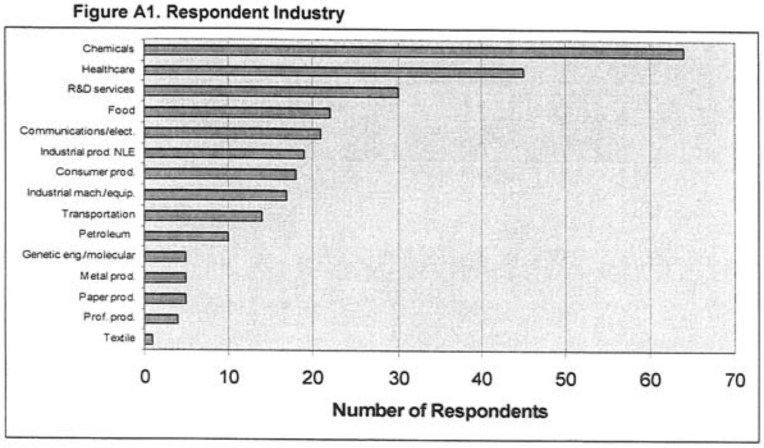
Appendix A:

Survey Design and Respondent Characteristics

The survey has benefited not only from the input of GUIRR but also from the input of the Industrial Research Institute, the European Industrial Research Management Association and the American Chemical Society's Committee on Corporate Associates. R&D managers from ten firms were interviewed about R&D site locations and the design of the survey. Based on those discussions the most relevant issues on R&D location strategies and factors in the location decision were identified. Discussions also covered mechanisms for capitalizing and protecting intellectual property. Survey responses were obtained over the period May 2005 to February 2006.

The industry of the respondent is given in Figure A1. Note that respondents were permitted to specify more than one industry. Two hundred and eighty industrial selections were made.

Figure A1. Respondent Industry



Appendix B: Definitions

R&D effort can be defined in a variety of ways. Here effort is defined in terms of employment. Questions regarding expenditures are subject to greater potential measurement error than are questions regarding employment. First, there are the usual problems with exchange rate conversions and issues of purchasing power across economies (e.g., is $1mil spent on R&D in the U.S. comparable to the same amount spent in, say, China). Second, it is clear from interviews with R&D managers that they were more likely to have a clear notion of employment in various locations than they would expenditures. It is also noted that employment effects generally translate directly into policy issues of interest.

The survey began with a set of definitions:

For the purpose of this survey, we consider research and development, that is, R&D, to encompass the following: 1) R&D that entails new applications of science to develop new technologies, 2) R&D to improve technologies currently used by you, 3) R&D to create new products or services, and 4) R&D to improve existing products or services sold or licensed by you.

Whenever we use the phrase "technical staff" we mean employees who conduct or support R&D. These include researchers, research assistants, lab technicians and engineers involved in any of these types of R&D.

Whenever we use the word production we mean either manufacturing of a good or provision of a service.

Product means either a good or provision of a service.

BIOGRAPHIES FOR JERRY G. THURSBY AND MARIE THURSBY

JERRY THURSBY

Dr. Jerry G. Thursby is a member of the strategic management faculty of Georgia Institute of Technology and holds the Ernest Scheller, Jr. Chair in Innovation, Entrepreneurship, and Commercialization. Prior to joining the College of Management in 2007 Professor Thursby was Goodrich C. White Professor of Economics and Chair, Department of Economics, at Emory University.

Professor Thursby has received several teaching awards and has published extensively in the areas of econometrics, international trade, and the commercialization of early stage technologies with a particular interest in the role of university science in national innovation systems. His work has appeared in such prestigious outlets as *American Economic Review, Journal of the American Statistical Association, Management Science* and *Science.* He has received research funding from the Alan and Mildred Peterson Foundation, the National Science Foundation, the Sloan Foundation, National Bureau of Economic Research through the NBER Project on Industrial Technology and Productivity, the Ewing Marion Kauffman Foundation, the National Institutes of Health, the Georgia Research Alliance, and the U.S. Department of Agriculture. He currently serves on the editorial board of the *Journal of Technology Transfer* and is an associate editor of the *Journal of Productivity Analysis.*

Professor Thursby has held faculty appointments with Emory University, The Ohio State University, Purdue University and Syracuse University.

MARIE THURSBY

Dr. Marie Thursby is currently a Professor of Strategic Management and holds the Hal and John Smith Chair in Entrepreneurship at the College of Management, Georgia Institute of Technology, as well as an adjunct professorship in Economics at Emory University. She has been a research associate of the National Bureau of Economic Research for twenty years and serves on several major journal editorial boards, including *Management Science* and the *Journal of Technology Transfer.*

Thursby has published extensively on the economics of innovation, with particular emphasis on role of universities in innovation systems, multinational R&D decisions, and the role of contracts in effective technology transfer. Other research interests include international economics and industrial organization, with a focus on how government policies and industry interact to determine competitiveness. Her work has been published in top-ranked peer-review journals such as *Science, Management Science,* the *American Economic Review,* and her most recent research on multinational R&D has been published by the National Academies Press. She has received research funding from the Alan and Mildred Peterson Foundation, the Alfred P. Sloan Foundation, the Ewing Marion Kauffman Foundation, the Ford Foundation, General Motors Corporation, the National Institutes of Health, the National Science Foundation, and the U.S. Department of Agriculture.

Prior to joining Georgia Tech in 2002, Professor Thursby held the Burton D. Morgan Chair of International Policy and Management at Purdue University, with prior faculty appointments at the University of Michigan, Ohio State University, Syracuse University, and North Carolina State University. She received her A.B., *cum laude,* in Economics from Mount Holyoke College and her Ph.D. from the University of North Carolina at Chapel Hill.

DISCUSSION

Chairman WU. Thank you, Dr. Thursby.

Now, we move to the question phase of our proceedings, and the Chair recognizes himself for five minutes. These five minute periods, as you all have already experienced, go very, very quickly. I would like to get in at least two questions, the first one narrowly cast, and then the second one a broader question to the entire panel.

Dr. Atkinson, you referred to some incentives or some inducements to locate R&D facilities as close to, if not unfair trade practices. Can you elucidate what some of those practices might be that border or cross the line as unfair trade practices?

Dr. ATKINSON. Clearly, one is tying market access to putting a facility in the country. I am aware of a major U.S. firm that was told if it wanted to access the Chinese market, it had to establish an R&D facility in Beijing, which it did, and it put 500 researchers there.

It was not planning to do that. It wanted to do the R&D domestically here in the U.S. Now, you can argue, well, some of the surveys don't quite pick that up. Actually, some of the surveys that I have seen actually do pick that up, particularly in the IRI survey. And anecdotally, you hear it a lot.

One of the reasons surveys may not pick that up as much is companies are in a bind. They have no market, they have no bargaining power, really, you know. The only bargaining power will be, again, the U.S. Government versus foreign governments on this, because companies are not going to say, we are going to blow the whistle on this, because then they don't get market access. So some other company will get that market access.

That is the principal, that is, I think, one of the principal things. You can make an argument that, at least under some of the EU rules, for example, that some of these very, very large subsidies are a violation of the WTO. And we just issued a report called *The Rise of the New Mercantilist Unfair Trade Practices in the Innovation Economy,* which I would be happy to submit, but it listed a wide array of these practices: standards manipulation, intellectual property theft. Another problem is that companies will move facilities there, and then the IP will be stolen, frankly, and the government will do almost nothing. In fact, sometimes turning a blind eye to it, and then that IP goes to U.S. competitors, who then produce product as well, so——

Chairman WU. If you could submit that to the Committee, I would deeply appreciate it. And now, more broadly, to the panel. In my personal experience in Oregon, we began by attracting manufacturing facilities for the semiconductor industry, and then, a lot of R&D facilities followed. And sometimes, R&D facilities follow manufacturing, sometimes manufacturing follows R&D.

Could you all address for me, please, the factors that you see that drive either one, and particularly, how manufacturing might follow R&D overseas, and R&D might follow manufacturing overseas?

Dr. THURSBY. Well, I think probably it depends on the country. At this point, and I will speak about India and China, and I won't speak about any other countries.

At this point, I think you are getting R&D following manufacturing to China, but that is also mixed, of course, with this exploding Chinese market that you want to access. So, in that particular case, R&D is following manufacturing, though there is other R&D in China that is very high end R&D. I have to caveat, or disagree a little bit with the previous presentation. You have extremely high end R&D in China, in the Microsoft Research Lab in Beijing. Also in the Google lab in Bangalore. I have been there. These are Ph.D.s from only the Stanfords, Berkeleys, and MITs, not from second tier institutions. This is absolute cutting edge research, at the finest level in the world.

In the case of India, where R&D and services are what the Indians are doing, there hasn't thus far been that much movement of manufacturing following R&D, and, I think, if it does move to India, it will probably be for the domestic market, like the new Nokia operation there. So in certain cases there is a linkage. In many others, I would say we don't see that linkage.

Dr. ATKINSON. Historically, in the regional science literature, what has been the predominant view is that you have this product cycle, and you start off with innovation and creation of new product through the R&D process, and then, the sort of first stage production usually is proximate to that, because you are working out the bugs and all that, and then, eventually, as production matures, it becomes more commoditized, it becomes locationally free, and goes to offshore.

I think one of the dangerous views, though, I think, that is emerging out in the U.S., is that that model no longer holds and that we don't really need to worry about R&D. It is manufacturing that is important, and R&D no longer is tied to manufacturing. And, I think, I would agree with Dr. Kenney. I think there are occasions where that is true, where R&D follows manufacturing, and there are also just as many, if not more cases, where R&D leads to manufacturing. We have seen that in Israel, for example, which by the way, has of all the countries in the world, has the biggest R&D and GDP ratio increase. I mean, they have just gone gangbusters, and they have been able to, out of that R&D, create production that still stays in Israel.

So I do think that it is a complex issue. I don't think it is one where we can just say R&D doesn't lead to manufacturing. I think it does in many cases.

Dr. THURSBY. I think the reason why we found so much familiar science in emerging markets is because that science is actually following sales in those markets. It is following manufacturing. A lot of that is product localization. Yes, there is some cutting edge science being done in China, but it is not a lot of it. In fact, where you really find it is in things like Microsoft, or a permutation, apparently the Chinese are excellent in.

So I think that panel shows that what is going there is, by and large, supporting sales, which in the earlier panel, I showed that was the most important reason for going into, setting up R&D in emerging markets, which because of the growth potential in those markets, and because they want to support the sales, support sales in those markets. When you talk to business executives who have set up R&D labs, what you continually hear is that our company is afraid not to be in China and India, because that is a huge growth market. If we are not there now, we are sort of behind the eight ball ultimately. And one way they enter those markets is R&D. And I think it is probably true some of the R&D may precede manufacturing, but I think a lot of it is following. So, we are just going to put manufacturing into China, we are going to put manufacturing into India, and it is natural to have R&D follow that manufacturing.

Thank you.

Chairman WU. Thank you. Any other member of the panel?

Dr. KENNEY. I would just like to interject something. China is manufacturing. The R&D in India has not followed manufacturing. That is just a fact. I just want to be very clear that those two countries are very different countries, and the way they are being inserted into the global economic system is quite different.

So, when you talk about R&D following manufacturing, I think in the case of China, that is quite correct. In the case of India, there just isn't that much multinational manufacturing there. It is now starting to come in. So, I think we need to be very careful that we look at different countries.

Dr. Atkinson referred to Israel, again, a very different insertion into the global economy. Very much at the very highest end of global research. I mean, what is going on in Israel is, for all intents and purposes, equivalent to Silicon Valley, and you can see it. I do a lot of work on the globalization of the venture capital industry. You can see it in the investments that are made in each of those geographies by the VCs, and I'm talking about Sequoia, I mean the elite U.S. VCs, and of course, the domestic VCs.

You have to be very careful. They look at the world, as all firms do, and think about what are the assets there and what will be the assets there. And I think that is a better way to look at it, if you want to be very granular. At the more general scale, then, one can have different kinds of answers, but I am pretty granular on this.

Chairman WU. If I may, just take advantage of my position as Chair here to drill down one further step. In looking at this difference between India, China, and Israel, are those market forces driving this, human talent forces driving this, or government policy forces driving this? What is the combination of things that are driving these differences between those three different developmental patterns?

Mr. Sweeney.

Mr. SWEENEY. And I think it might have been brought up earlier, the first and foremost factor is going to be the availability of talent, so all the other factors won't matter too much, if these locations didn't have the presence of the type of talent that is needed. Now, once that talent is established, then the other factors can make a difference, and I think cost, for some types of activities, is going to be very important, particularly if the cost differences for accessing that talent are dramatic.

So I think it is a combination of market forces forcing companies to look where they can do this best, finding where the talent is, and then finding among that smaller set of locations the location that presents the best cost and benefit profile within that picture.

Chairman WU. Perhaps we could return to this in a moment. Let me recognize the Ranking Member of the Subcommittee, Dr. Gingrey.

Mr. GINGREY. Mr. Chairman, thank you.

And Mr. Sweeney's comments about talent, I think, are very appropriate, and of course, as all of you know, this committee, the Science and Technology Committee, and particularly, the Subcommittee on Technology and Innovation, we have really done a lot of work in the *America COMPETES Act* in regard to trying to solve that talent problem. And I think 10,000 Minds, or whatever the title was, it is important work and we have done a good job on that, and I think we are addressing this disparity and will continue to do that. Obviously, more needs to be done.

But as Mr. Sweeney just said, if talent is not here, and the talent is there, whether you are talking about China or India or Israel or wherever, that is first and foremost. And if the talent is here, in equal quantity and quality, then I think the cost factor really raises its ugly head if I can say ugly, not being too pejorative about cost, because I think it is important. My question then is, we will continue to work on this, on the talent factor, and indeed, maybe even the cost factor.

But Dr. Atkinson, in your testimony, you talked a little bit about this, the National Innovation Foundation. And I would particularly like to pursue that question with you and the other witnesses, in regard to that, if this is the direction that you and maybe the other witnesses think we need to go in, or is there some difference of opinion about that?

Dr. ATKINSON. Well, thank you.

As I said, this is a new report that we will be issuing jointly with the Brookings Institution, I believe in early 2008. And one of the spurs of looking at this issue was initial research that we had done that showed that many, many countries now, particularly in the last decade, have established analogues to their science agencies, and have also established these innovation or technology agencies. So, for example, the UK just established theirs earlier this year. Korea just established theirs in 2002. Finland has a premier entity called Tekes, which, I am not advocating we would fund it at this level, but if they were funding it at the level of per capita, if we funded it at that level, we would be investing $33 billion a year. I mean, that is the level of commitment that they have made to this.

What I would envision this doing is certainly not industrial policies, certainly not picking winners and losers, but really doing two main kinds of things. One is—there is a program that you may be aware of called MARCO, the Microelectronics Advanced Research Corporation, which is a DARPA-funded initiative with the semiconductor industry, and it funds, I think, I don't remember the number, six or seven focus centers at universities around the country.

And what they have done is, the semiconductor industry realized they can't invest in R&D that is six to ten years out. It is just too risky for them in this global, competitive market. So by partnering with DARPA and industry money and putting together a roadmap of where they see these real, technical, and scientific challenges, they then have worked with universities to do that. I think that is a very, very good model, and I think I would see this National Innovation Foundation as supporting more of that.

The second key issue, and we alluded to it a little bit, is the states are a very important player here. I ran a State Economic Development for the Governor of Rhode Island, and one of the things that states do is they invest in a lot of the kinds of things that it is really inappropriate for the Federal Government to do, or the Federal Government is too large, it is too distant, but the states, Oregon being a good example, they have a nanotechnology initiative, a biotech initiative, but the states underinvest in those, because—and I worked for a Governor. I understand that you have got a term, and those benefits oftentimes accrue after your term of office is over, or they may spill over to the next state.

So I think a federal/state partnership to help states do this kind of technology-led economic development, do more of it, would be an important role.

Thank you.

Mr. GINGREY. Any others want to comment on that as well? We have a little more time. Dr. Kenney.

Dr. KENNEY. I think that there—each of this nations you mention, Israel, China, and India, have different strategies. India's is basically tax rebates for call centers, R&D, whatever you would like, very straightforward, sort of, almost a vanilla envelope type of benefits. China, of course, has R&D, subsidizes R&D, or gives tax benefits, for both domestic and multinational firms. I think the real, and of course, some property, real estate, that is often not the national government, but the various provincial, Shanghai, Beijing, give real estate rebates. And the other thing that Dr. Atkinson said is, there is pressure. Most of it, you are not actually going to be able to see. It is informal pressure from bureaucrats, saying you know, hey, you have got a nice market here. We would love to see an R&D facility, not a mandated, you must have an R&D facility. So it is going to be very hard to pick, and it is subtle pressure. So I think that is pretty clear.

Israel is very interesting. Israel invested in R&D, first of all, attracted American manufacturing and R&D facilities, Motorola, Intel, a number, this was back in the '80s, then developed a very sophisticated subsidy program for its venture capital industry. And it is sort of a case study of brilliance and good management, and I think we could learn something from how Israel organized the attraction of R&D, the movement upstream of the marketplace, but you have to understand that is both a small country, and a country that makes investments in R&D and educating its workforce on a probably unparalleled scale, except, perhaps, Northern Europe.

So I think there is a lot to learn from the way the Israelis built an entrepreneurial economy, built their venture capital industry. And I think Steve Morris is absolutely right. The United States is going to compete through entrepreneurship in the future, and we have to continue to figure out ways to incentivize venture capital, to incentivize entrepreneurship. We need to look at the university technology licensing offices, as to whether they are transferring the technology out there quickly or they are becoming bureaucratic fetters to the transfer of technology.

And I don't think we have really looked at that very seriously in our research. So that is one area that I would really put my finger on, and say we might continue to think about that.

Mr. GINGREY. Mr. Chairman, I see that my time has expired. In the second round, I would like, maybe, for Dr. Thursby to address that point that Dr. Kenney just made at the end.

Thank you.

Chairman WU. Thank you very much, Dr. Gingrey. And now, the gentlelady from California, Ms. Richardson.

Ms. RICHARDSON. Yes. Thank you, Mr. Chairman. First of all, I would like to acknowledge our Ranking Republican Member, Dr.

Gingrey. I am happy to hear you say—Dr. Gingrey, I am happy to hear you say that you are willing to look at the cost. That is very encouraging to me.

Mr. GINGREY. Absolutely.

Ms. RICHARDSON. So the fact that I think we all realize we need to be competitive, but at some point, we realize there is going to have to be a cost associated to it.

Mr. GINGREY. Absolutely.

Ms. RICHARDSON. And your leadership—of being willing to get that, and say yeah, that is something we might need to look at, I think, is very encouraging, so I wanted to compliment you before you make your mad dash.

The second thing, going specifically into the questions that I had, Dr. Kenney, and I think Dr. Gingrey was going down that pathway. Can you elaborate specifically on how university technology licensing rules affect our competitiveness? Can you give us more specifics?

Dr. KENNEY. I think Bob Litan from the Kauffman Foundation has recently put out a report on the role of university licensing offices in frustrating the technology. Most of what I know is anecdotal from my university and others, about how difficult it is to work through a university bureaucracy that doesn't know the technology often as well as the inventor herself or himself. And therefore, actually becomes an unknowledgeable intermediary between either the venture capitalist, if we are talking about a spinout sort of situation, for those of us in California, is quite important, or the large firm. And this, particularly the IT firms, have been very upset about how the tech licensing offices are controlling IT technology. And Intel and IBM, I know, have actually started a consortium to create a set of new rules for tech transfer from IT and CS departments.

So, it also probably depends on the particular technology, as I outlined in my statement, the particular industrial linkages. Is it an entrepreneurial situation, versus a licensing to a large firm? I think it is across that spectrum of industries and departments. There hasn't been that much research that has looked at that.

Most of the research that is being done right now on tech transfer comes out of the AUTM data, the Association for University Technology Managers Database. That database is actually, and I have done some research looking at all entrepreneurial firm coming out of universities like UC–Davis, Wisconsin, Illinois, and that is just a subset of all of the technology that comes out. So, AUTM itself, the research, has not looked at the full spectrum of firms that are coming out. So, I would say that right now, we don't have the research to really know this. So, I have mostly anecdotes that I hear from people around the country, scientists who are trying to move tech out and are having difficulties with their tech licensing office.

Ms. RICHARDSON. As you find specific information, if you could supply it to this committee, that would be helpful. My second question, more to Mr. Sweeney, but I think it applies to most of those on the panel. Could you provide this committee specific examples of China, India, and Israel, of policies that they implemented? We talked about them fairly broadly. I mean, you alluded to Israel, you know, we said well, China does this, India does that, but nothing specific.

And I think really, hopefully, the power of this committee is that, at some point, we could bring forward some legislative proposals that might mirror and help us to be more competitive. So, if we could get some specific language of what some of these countries have done, that would, I think, enable us to better consider economically if it is something that we can do as well.

Mr. SWEENEY. Yes, I would be glad to address that.

I will defer the India/China/Israel comments to my colleagues here, and I do want to remind everybody that it is not just those three countries for which we compete with R&D. The developed countries are more than just the U.S. I am assuming that is not a fire alarm. Is that correct?

Just on this continent, Canada has an aggressive federal tax credit for R&D throughout the country that is complemented by provincial policies, and that varies from province to province. Some provinces are very aggressive. Part of the value of those tax credits, for one of our clients in particular, is that they were refundable credits. So, you get a credit for the amount of capital that you invest in research and development. If you do not have a tax liability early on, and typically, you don't, to capture that credit, it will be refunded as cash, so it is a very capital favorable type of credit that has an immediate high impact on the location decision, because it addresses an upfront cost.

Away from specific company policies, like tax credits and grants, Canada also has invested in research institutes. The oil sands area of Northwest Canada is one of the biggest booming areas in the world right now with activity. Most of that started with government funded research, with hundreds of researchers in government research labs developing the ability to economically extract energy from the oil sands and shales of Northern Canada.

So, it is a combination of spending money on research institutes at a government level, or a public/private partnership level, as well as tax credits, and other types of benefits to influence specific companies.

Those types of things have worked very, very well for Canada. They are working, starting to work well even in Europe. Overall, that chart may show Western Europe having a declining amount of R&D, but the EU has focused on that as something they need to address, and even a country like France, that has now largely dramatically increased their tax credits for R&D.

There are very specific tax credits and expenditure programs out there.

Ms. RICHARDSON. Okay.

Chairman WU. Thank you, Mr. Sweeney. And I thank the gentlelady. We have just gotten notice of six votes upcoming on the floor, and if it is acceptable to the members of the panel, what I would like to do is to try to get through one round of questions for everyone, and perhaps a followup for Dr. Gingrey for Dr. Thursby.

And if the gentlelady would yield, I would like to proceed with the gentleman from Utah, Mr. Matheson.

Ms. RICHARDSON. I am sorry, Chairman. I would like to clarify that I made a specific request. Could each of you who have information about specific policies, because it did make up a majority of the conversation that we had today, that you could supply us with those specifics of those various policies, whether it is companies or countries, so we could have some specific things to review. Okay. Thank you.

Chairman WU. That request will be made, and I am sure the witnesses will be happy to supply that in writing.

Mr. Matheson.

Mr. MATHESON. Well, thank you, Mr. Chairman. I will just ask one question at this point.

An issue that has gotten a lot of discussion in the political dialogue of our country recently, in general, has been our country's immigration policy. But it seems to me one aspect of immigration policy that has not received much attention is the impact of our current immigration policy, with respect to highly skilled workers in this country. And I think that this discussion today about how this country positions itself, in terms of being competitive in the R&D world, it is relevant to at least ask the Committee about their opinions about how our current immigration policy is affecting both our academic centers in this country, and also, the private sector, in attracting bright people that can encourage development of solid R&D within our country? And I would just throw that question out to the panel.

Dr. ATKINSON. I would like to take the first comment on that, if I may. As we have said, I think, pretty consistently here, the ability to attract talent is the primary driver in the initial stages of location decisions for R&D. When you look for attracting talent, you want to see if the talent is where you are looking, but in addition, you want to be able to recruit and retain that talent to the community that you are considering.

That gets into a lot of quality of life issues, but even before that, because the production of this talent is no longer the dominant domain of the U.S., in terms of producing Ph.D.s, R&D firms recognize that their recruitment is going to be on a global basis. So, their question is, how effectively can I recruit globally the talent that I need to staff and develop my facility?

The U.S. is no longer the primary source of internally grown talent, and is no longer the easiest location in which to recruit that talent. Somehow, the U.S. policy has to balance the security concerns with the need to recognize that the talent that this country needs to succeed is available throughout the world. Other communities and countries, Singapore and Montreal are both very, very effective at not only growing the talent, but especially, in recruiting globally the talent that they need, and both of them have become very strong R&D centers.

Mr. SWEENEY. I don't think anybody on this panel would disagree that it is very, very important to have high quality people coming into the U.S., but I want to go a step beyond that, and I think there is a looming problem with keeping them in the United States. It is because the opportunities for them back in their home country is much, much greater. I give that, this is anecdotal evidence, incidentally, which I typically don't like. I would rather be systematic, but I know of one professor at Georgia Tech had been there for 23 years. He was Indian, and he returned home, because he had, now, better opportunities in India than he would have had 23 years ago.

Another firm in our survey established a facility in China, simply because they had Chinese scientists who they valued greatly, who wanted to go home to China. So, the only way the firm was going to keep them was to put a facility in China, and put that fellow in charge of that.

So I think the issue is a little broader than just bringing them in. It is keeping them here once they get here, because it is becoming very—they can maintain the same lifestyle now, in many areas of China and India, that they could maintain in the U.S. and they could be home.

Mr. MATHESON. I yield back, Mr. Chairman.

Chairman WU. Thank you very much. And Mr. Mitchell? No questions, then. Dr. Gingrey, you had a followup question.

Mr. GINGREY. Mr. Chairman, yes, and if Dr. Thursby will follow up to the question that maybe Dr. Kenney asked rhetorically in regard to the universities and licensing and transferring technology.

Dr. THURSBY. I need that on, don't I? What I would really like to talk about here is the importance of federal funding for R&D facilities. We have pulled out health care from other industries, and of course, federal funding of health care has been pretty dramatic in the last 20 years, and if you look at where the target for R&D in health care happens to be, it is the U.S.

Now, there are a number of reasons for this, but I think the primary reason that the U.S. is a target is because for so many years, there has been substantial funding in health care, which has created a base of high quality people that these firms can hire, as well as labs within universities, where knowledge can spill over into these firms.

And that was simply all I wanted to add to that.

Chairman WU. Thank you very much, and I want to thank the entire panel. And before we bring the hearing to a close, I want to thank all of you and all the participants.

The record will remain open for additional statements from Members, and for answers to follow-up questions, and I will have at least several written questions that I did not get an opportunity to ask from the dais today.

The witnesses are excused, and the hearing is now adjourned. Thank you all very, very much.

[Whereupon, at 11:22 a.m., the Subcommittee was adjourned.]

THE GLOBALIZATION OF R&D AND INNOVATION, PART IV: IMPLICATIONS FOR THE SCIENCE AND ENGINEERING WORKFORCE

TUESDAY, NOVEMBER 6, 2007

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON TECHNOLOGY AND INNOVATION,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The Subcommittee met, pursuant to call, at 2:30 p.m., in Room 2318 of the Rayburn House Office Building, Hon. David Wu [Chairman of the Subcommittee] presiding.

BART GORDON, TENNESSEE
CHAIRMAN

RALPH M. HALL, TEXAS
RANKING MEMBER

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE AND TECHNOLOGY

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The Subcommittee on Technology and Innovation

Hearing on:

The Globalization of R&D and Innovation, Pt. IV: Implications for the Science and Engineering Workforce

November 6, 2007
2:30 p.m. – 4:30 p.m.
2318 Rayburn House Office Building
Washington D.C.

WITNESS LIST

Dr. Michael S. Teitelbaum
Vice President
Alfred P. Sloan Foundation

Dr. Charles McMillion
President and Chief Economist
MBG Information Services

Dr. Harold Salzman
Senior Research Associate
Urban Institute

Mr. Paul J. Kostek
Vice President
Career Activities
Institute for Electrical and Electronics Engineers—USA (IEEE-USA)

Mr. Henry Becker
President
Qimonda North America

HEARING CHARTER

SUBCOMMITTEE ON TECHNOLOGY AND INNOVATION
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

The Globalization of R&D and Innovation, Part IV: Implications for the Science and Engineering Workforce

TUESDAY, NOVEMBER 6, 2007
2:30 P.M.–4:30 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose

On Tuesday, November 6, 2007, the Committee on Science and Technology's Subcommittee on Technology & Innovation will hold a hearing to consider the implications of the globalization of research & development (R&D) and innovation for the American science, technology, engineering and mathematics (STEM) workforce. This hearing—the fourth in a series of hearings examining the impact of globalization on innovation—will explore the impact of high-technology offshoring on American STEM workers and students. Witnesses will discuss the new opportunities and challenges for workers created by globalization, including how globalization is reshaping the demand for STEM workers and skills. The witnesses will also address how offshoring is affecting the STEM workforce pipeline and how incumbent workers are responding to globalization.

2. Witnesses

Dr. Michael S. Teitelbaum is Vice President of the Alfred P. Sloan Foundation. He is a demographer who has studied the supply and demand science and engineering labor market.

Dr. Harold Salzman is Senior Research Associate at the Urban Institute. He is a sociologist who has a recent study on the STEM workforce pipeline and offshoring.[1]

Dr. Charles McMillion is President and Chief Economist of MBG Information Services. He is an expert in evaluating economic trade data, particularly trade in advanced technology with China.

Mr. Paul J. Kostek is Vice President for Career Activities of the Institute for Electrical and Electronics Engineers-USA. IEEE–USA is the largest professional engineering society in America. The Career Activities Committee focuses on promoting the career-related policy interests of electrical, electronics and computer engineers and related information technology professionals, with a special focus on U.S. members.

Mr. Henry Becker is President of Qimonda North America, a supplier of memory products with facilities and offices in North America, Europe, and Asia.

3. Brief Overview

- Most analysts believe that globalization will not affect the aggregate number of jobs in the U.S. However, they believe it will change the mix of occupations. Certain occupations will experience net losses while others will increase, and the skills demanded will shift.

[1] *Into the Eye of the Storm: Assessing the Evidence on Science and Engineering Education, Quality, and Workforce Demand.* Available at *http://www.urban.org/UploadedPDF/411562_Salzman_Science.pdf*

- Some analysts estimate that between 30 and 40 percent of all U.S. jobs will be vulnerable to offshoring. This vulnerability reflects the fact that a large share of previously non-tradable jobs has become tradable, putting downward pressures on wages for U.S. workers in those occupations.
- High-wage jobs requiring advanced STEM education and skills are also offshorable, and some analysts estimate they are among the most vulnerable to offshoring with computer programming topping the list of all occupations. According to a study conducted by Alan Blinder, director of Princeton University's Center for Economic Policy Studies, 35 of 39 STEM occupations are offshorable, including 10 of 12 engineering disciplines.
- Other analysts highlight the opportunities created by globalization. With emerging markets growing rapidly, demand for STEM-intensive products and services will grow. The transfer of complementary activities to lower-cost countries will spur greater demand for STEM workers.
- Offshoring is affecting the pipeline of STEM workers. Undergraduate enrollments in some STEM fields, particularly computer sciences, are down significantly over the past few years in part because students believe these jobs are vulnerable to offshoring.
- Analysts also believe that globalization may inject greater volatility in the STEM job market and workers need to be prepared to re-tool their skills on an ongoing basis.

4. Issues and Concerns

How will the globalization of R&D and innovation affect the supply of, and demand for, the STEM workers in America? Most analysts believe that globalization will not affect the aggregate number of jobs in the U.S. However, it will change the mix of occupations. Certain occupations will experience net losses while others will increase and the skills demanded will shift. Most analysts believe that the globalization will affect the number and mix of STEM workers needed. What do we know about the effects so far? Will workers in low-cost countries complement American STEM workers thus spurring demand? Or will those workers be substitutes for American STEM workers? How will these trends affect the STEM-workforce pipeline?

What are the numbers and types of jobs that will face increased competition from low-cost countries? Some jobs will move overseas and others will stay. What do we know about the types of jobs that are likely to be geographically sticky and those that are more footloose? Do the economic and trade data provide us an indication of the division of labor between America and low-cost countries? What skills will be in demand?

Is an inadequate supply of American STEM workers with specific skills causing companies to move offshore? Will producing more workers with specific skills prevent work from moving offshore?

What kinds of challenges do American STEM workers face in the wake of globalization, and what resources do they have to ensure they have careers that are both durable and resilient? Many analysts believe that globalization will cause greater volatility in the job market. Do STEM workers have the right set of tools and the right support to ensure they are able to keep their jobs? If they do get displaced are they able to quickly re-enter the job market? Do STEM workers face different challenges given their specialized knowledge? Incumbent workers face increased competition and potentially job and wage loss. What happens to those who are displaced?

How has offshoring changed the risks and rewards, costs and benefits, of a STEM career? How do we ensure that the next generation of workers gets the right kinds of education? What types of skills will be needed in the future? Globalization is expected to change the types of work in demand in the United States. A number of universities are responding to globalization by emphasizing innovation and creativity and de-emphasizing more technical work, with the expectation that the latter can be codified and therefore easier to offshore.

How are countries that are receiving high-skill jobs responding to the new opportunities? Can we predict what types of jobs they are actively pursuing now and will pursue in the next few years? A common narrative of globalization is that lower-skill, labor-intensive jobs will move offshore while higher level work will remain in the U.S. Is this narrative accurate? Are workers receiving clear labor market signals about jobs and skills that will be in demand and those that will be rendered obsolete by globalization?

Chairman WU. The Committee will come to order, and I want to thank everyone for attending this afternoon's hearing on The Globalization of Research and Development and Innovation, Part IV: Implications for the Science and Engineering Workforce. This is the final hearing in a series that the Science and Technology Committee launched in June to learn more about how the trend toward moving research and development jobs and facilities overseas is affecting our nation's economy and competitiveness.

So far this year, we have heard from economists, university presidents, industry representatives, and scholars who have presented a variety of interesting and sometimes contentious views about the topic of globalization of R&D. Next month, the Committee staff will release a report summarizing the Committee's findings and providing us with some ideas for next steps to address the challenges our witnesses have presented.

Today's hearing focuses on the impact of globalization on the American science and engineering workforce. This can sometimes be a heated issue. No one wants to think about losing their job, and today's science and engineering graduates face an uncertain future.

I am sure everyone here today will agree that we must find a way to help our current and future science and engineering workers better understand the challenges and opportunities facing them in the 21st century. They want to know which jobs will stay in the United States, which are likely to move overseas, and what types of new opportunities will be created through globalization.

Having to adjust to realities in the labor market is nothing new. The information age has made the workforce more efficient overall, but also rendered any number of jobs obsolete through automation or consolidation or the possibility of moving it a far, far distance, offshore.

Today, some science and engineering jobs are moving offshore, and workers here in the United States need to adjust or have assistance in that adjustment. Sometimes, that means finding a new field or a new company. Other times, it simply means learning new skills to remain qualified for those positions that stay in the United States.

The problem is that many workers are often surprised by changing job availability, whether those workers are experienced professionals approaching retirement or students contemplating a science or engineering career. That unpredictability hampers decision-making at the individual worker level and at the government level. Our witnesses today will help answer some of these questions about the scope of offshoring, which workers offshoring is most likely to affect, and how current science and engineering workers are responding to the challenges and opportunities of globalization.

I am glad that we have a representative of industry with us today to help us understand the business perspective on these workforce issues. Businesses today often are not simply employers. They provide education, training, and influence the types of education that tomorrow's innovative scientists and engineers receive at our universities today. I am hoping to learn more about the types of skills that industry will expect the next generation of workers to have so that we can make policy decisions that make students more competitive in a global economy.

The United States' science and engineering workforce is the best in the world. Today's hearing will help us better understand how to match workers' skills and abilities with employers' needs, thereby ensuring that it remains that way for years to come.

[The prepared statement of Chairman Wu follows:]

PREPARED STATEMENT OF CHAIRMAN DAVID WU

I want to thank everyone for attending this afternoon's hearing on *The Globalization of R&D and Innovation, Part IV: Implications for the Science and Engineering Workforce.* This is the final hearing in a series that the S&T Committee launched in June to learn more about how the trend towards moving R&D jobs and facilities overseas is affecting our nation's economy and competitiveness.

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Today's hearing focuses on the impacts of globalization on the American science and engineering workforce. This can sometimes be a heated issue. No one wants to think about losing their job, and today's science and engineering graduates face an uncertain future.

I'm sure everyone here today will agree that we must find a way to help our current and future science and engineering workers better understand the challenges and opportunities facing them in the twenty-first century. They want to know which jobs will stay in the U.S., which are likely to move overseas, and what types of new opportunities will be created through globalization.

Having to adjust to realities in the labor market is nothing new. The information age has made the workforce more efficient overall, but also rendered any number of jobs obsolete through automation or consolidation or offshoring.

Today, some science and engineering jobs are moving offshore, and workers here in the United States need to adjust. Sometimes, that means finding a new field or a new company. Other times, it simply means learning new skills to remain qualified for those positions that stay in the U.S.

The problem is that many workers are often surprised by changing job availability, whether those workers are experienced professionals approaching retirement or students contemplating a science or engineering career. That unpredictability hampers decision-making at the individual worker level and at the government level. Our witnesses today will help answer some of these questions about the scope of offshoring, which workers offshoring is most likely to affect, and how current science and engineering workers are responding to the challenges and opportunities of globalization.

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The U.S. science and engineering workforce is the best in the world. Today's hearing will help us better understand how to match workers' skills and abilities with employers' needs, thereby ensuring it remains that way for years to come.

Chairman WU. And with that, I would like to recognize my friend and colleague, Dr. Gingrey, for his opening statement.

Mr. GINGREY. Good afternoon, Chairman Wu. I want to first thank you indeed for holding this fourth hearing on the issue of offshoring that will address the implications for the science and engineering workforce.

It is well-documented that the United States has a very extensive history of scientific innovation that has benefited engineers and scientists as well as our nation's economy. Over the years, engineers and scientists have developed products and technologies that have raised the standard of living in our nation. In return, engineers and scientists have been rewarded for their efforts with abundant employment opportunities, excellent salaries, and a quality of life and substantial public respect, I might add.

The advent of globalization is in part jeopardizing this mutually beneficial relationship. A 2003 McKenzie Global Institute report estimates that 52 percent of engineering jobs are amenable to offshoring. This, along with the 2003 spike in unemployment among engineers and computer scientists, have led to feelings of widespread anxiety in these professions. For example, electrical engineers have become so concerned about their careers, that a 2006 IEEE survey showed only 13 percent of the engineers responded that prospects for long-term demand for engineers in the United States were excellent, and 18 percent responded that the prospects were poor. What is even more alarming, Mr. Chairman, is the same survey showed that only 37 percent, let me repeat only 37 percent of these engineers would recommend engineering as a profession to their children, and a staggering 35 percent would not recommend engineering at all. As a physician of 31 years, I can't say I enthusiastically encouraged my four children to enter the practice and profession of medicine. I didn't discourage them, but I didn't encourage them either. And by the way, none of them followed in my footsteps.

While there is certainly some disillusionment among today's engineers and scientists on the prospects of the innovation industry in the United States, our country has also had the benefit for the past several years of foreign companies in-sourcing jobs here in the United States. This phenomenon occurs when a foreign-based company establishes a subsidiary here in our country that provide jobs for hardworking American citizens, good jobs.

Mr. Chairman, in a 15-year window, from 1987 to 2002, jobs created as a result of in-sourcing have jumped from 2.6 million to 5.4 million and continued to increase. In-sourcing has also provided an infusion in our economy by accounting for 20 percent of the United States' exports. In 2003 alone, foreign companies reinvested $38.6 billion in their American operations. That is a substantial number. United States subsidiaries also serve as an important component to domestic R&D activities. According to Dartmouth College President, Matthew Slaughter, United States subsidiaries have spent $27.5 billion on domestic R&D, increasing its share of R&D activities to 14 percent.

Mr. Chairman, in my own State of Georgia, foreign-owned subsidiaries provide more than 190,000 high-paying jobs to our residents of the great State of Georgia. They provide the livelihood for 5.7 percent of Georgia's private sector workforce. This is an increase of over 18 percent in just five years. Additionally, over one-third of the jobs subsidiaries bring to Georgia are in the manufacturing sector. This is so important. I have a lot of textile and other manufacturing activities in the 11th District of Georgia.

Columbia University Professor Jeffrey Sachs goes so far as to say, and this is a quote, "there is no other fundamental mover of economic development than science and technology."

Chairman Wu, I could not agree more with that statement, and I am proud of the progress that this committee has made through the *America COMPETES Act* to increase STEM education, science, technology, engineering, and math, for America's youth as a way to provide incentives for domestic companies to stay here, right here at home. At the same time, though, we need to explore what can be done to bring more foreign-owned companies to our country to provide these high-paying jobs to hardworking Americans.

Mr. Chairman, I look forward to hearing today's testimony from our esteemed panel on the solutions that they have that will enable us to maintain and grow an engineering and scientific workforce that will indeed keep us the world leader in technology and innovation; and with that, Mr. Chairman, I yield back to you.

[The prepared statement of Mr. Gingrey follows:]

PREPARED STATEMENT OF REPRESENTATIVE PHIL GINGREY

Good Afternoon Mr. Chairman. I want to first thank you for holding this fourth hearing on the issue of offshoring that will address the "Implications for the Science and Engineering Workforce." It is well documented that the United States has a very extensive history of scientific innovation that has benefited engineers and scientists—as well as the Nation's economy. Over the years, engineers and scientists have developed products and technologies that have raised the standard of living in our nation. In return, engineers and scientists have been rewarded for their efforts with abundant employment opportunities, excellent salaries and quality of life, and substantial public respect.

The advent of globalization is—in part—eopardizing this mutually beneficial relationship. A 2003 McKinsey Global Institute report estimates that 52 percent of engineering jobs are amenable to offshoring. This, along with the 2003 spike in unemployment among engineers and computer scientists have led to feelings of widespread anxiety in these professions. For example, electrical engineers have become so concerned about their careers that a 2006 IEEE survey showed only 13 percent of the engineers responded that prospects for long-term demand for engineers in the U.S. were excellent—and 18 percent responded that the prospects were poor. What's even more alarming Mr. Chairman is the same survey showed that only 37 percent would recommend engineering as a profession to their children—and a staggering 35 percent would *not* recommend engineering at all.

While there is certainly some disillusionment among today's engineers and scientists on the prospects of the innovation industry in the United States, our country has also had the benefit for the past several years of foreign companies "in-sourcing" jobs here in the U.S. This phenomenon occurs when foreign-based companies establish subsidiaries in our country that provide jobs for hardworking American citizens.

Mr. Chairman, in a fifteen year window from 1987 to 2002, jobs created as the result of in-sourcing have jumped from 2.6 million to 5.4 million. In-sourcing has also provided an infusion in our economy by accounting for 20 percent of U.S. exports. In 2003 alone, foreign companies reinvested $38.6 billion in their American operations.

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Columbia University professor Jeffrey Sachs goes so far as to say "There is no other fundamental mover of economic development than science and technology." Mr. Chairman, I could not agree more with that statement, and I am proud of the progress that this committee has made through the *America COMPETES Act* to increase STEM education for America's youth as a way to provide incentives for domestic companies to stay here at home. At the same time, we need to explore what can be done to bring more foreign-owned companies to our country to provide these high paying jobs to hardworking Americans.

Mr. Chairman, I look forward to hearing today's testimony from our esteemed panel on the solutions they have that will enable us to maintain and grow an engineering and scientific workforce that will keep us the world leader in technological innovation. With that Mr. Chairman, I yield back.

Chairman WU. Thank you very much, Dr. Gingrey. I can report to you that the grass is always greener. I was riding in an elevator with a colleague in a law firm, this feels like decades ago now, but he said he wouldn't encourage any of his kids to become an attorney; and I thought, boy, that is kind of sad. And as you may know, Dr. Gingrey, I was a failure at your profession. I went to one year of medical school and then as far as I know, I am still on a leave of absence from that medical school and then trained as an attorney. And you know, the only thing that prevented me from switching from law school to medical school is that I had been there before. So the grass always is greener, and I suppose that——

Mr. GINGREY. Mr. Chairman, when you said the grass is greener, I thought for sure you were referring to Oregon versus Georgia. You guys are getting all the rain these days. But what you didn't know is I actually took the LSAT, and I scored really high on it; and I thought about going to law school just for maybe 30 seconds.

Chairman WU. Well, you know, we are in story-telling time now, and you know, I took the LSATs purely to prepare for the MCATs. And little did I know that I was actually going to use the score some day. So life is uncertain which I think is the theme of this hearing. Life is uncertain and preparation for the future is very, very important; and I think that is what many of our witnesses will address.

[The prepared statement of Mr. Mitchell follows:]

PREPARED STATEMENT OF REPRESENTATIVE HARRY E. MITCHELL

Thank you, Mr. Chairman.

Today's hearing raises important questions about the impact of globalization on the technical job market in the United States.

As the economies of the world become more intertwined, we need to ensure that America's participation in the global economy does not lower the standard of living for American workers.

While there is a consensus that the number of jobs available will not change, it is essential that we understand how globalization may impact the type of jobs available. This means that we must continue to educate workers with the necessary skills to perform STEM jobs.

Offshoring is increasing at a rapid rate in certain industries and is this trend is expected to continue. It is our job as lawmakers to carefully assess the current situation and hear from experts in the field to consider what our future actions should be.

I look forward to today's testimony, and I yield back the balance of my time.

[The prepared statement of Mr. Smith follows:]

PREPARED STATEMENT OF REPRESENTATIVE ADRIAN SMITH

Thank you, Mr. Chairman. Globalization affects Americans and Nebraskans every day, and I am pleased we are holding this hearing to learn more about its impacts on research and development.

As we well know, thanks to author Thomas Friedman, the world is indeed flat. The playing field around the world is increasingly level—and research and development is no exception. American innovations and advances in technology have played a major role in the flattening of the world. Now, we must work hard to maintain our edge in science and engineering.

Countries around the world, from Brazil to China, from India to Estonia, are gearing up to become keen competitors in research and development. Many of the scientists they seek to attract are trained right here in the United States of America. As Americans, we can, and should, work together with the international community of scientists and engineers. But it is vital to our nation's economy, not to mention our national security, that we ourselves remain a world leader in science and technology.

Earlier this year, Congress passed the *American COMPETES Act,* a first step toward ensuring our nation's competitiveness in the fields of science, technology, engineering, and mathematics. I am a co-sponsor of the *Investment in American Act of 2007,* which would increase from 12 to 20 percent the rate of the alternative simplified tax credit for research expenses; make permanent the tax credit for increasing research activities; and repeal the alternative incremental tax credit for research expenses. We need to take further action to ensure that top science and engineering talent remains in the U.S. in the future.

I look forward to hearing the testimony of our witnesses.

Thank you, Mr. Chairman, and I look forward to working with you in the future.

Chairman WU. I would like to introduce our witnesses today.

First, Dr. Michael S. Teitelbaum who is Vice President of the Alfred P. Sloan Foundation; Dr. Charles McMillion who is President and Chief Economist of MBG Information Services; Dr. Harold Salzman is Senior Research Associate at the Urban Institute; Mr. Paul Kostek is Vice President for Career Activities at the Institute for Electrical and Electronics Engineers; and Mr. Henry Becker is President of Qimonda North America.

As our witnesses know, please try to keep your oral testimony to five minutes and your written testimony will be entered fully into the record; and before we start with Dr. Teitelbaum, let me say that I think we are about to be interrupted by a series of floor votes which may take 30 minutes or so, and let me apologize to the panel and the attendees, but these interruptions just can't be helped. Let me apologize in advance. When votes are called, we will pause at that point and resume as quickly as possible. And with that, Dr. Teitelbaum, please begin.

STATEMENT OF DR. MICHAEL S. TEITELBAUM, VICE PRESIDENT, ALFRED P. SLOAN FOUNDATION

Mr. TEITELBAUM. Well, thank you, Mr. Chairman, Congressman Gingrey, Members of the Committee, Committee staff, ladies and gentlemen, thank you for holding this hearing and thank you for inviting me to appear before you. It is nice to be back on the Hill; and your comment, Mr. Chairman, about roll call votes is very reminiscent of my experience for two years on the Hill as Staff Director of the House Select Committee on Population. Unpredictable, uncontrollable, but real.

I should start by saying that my testimony is my own professional opinion, not necessarily the opinions of the Alfred P. Sloan Foundation; so you should understand these are my personal evaluations of the questions that your staff have posed to the panel.

Given the short time available for oral testimony, I am going to limit myself to five points. There is a good deal more in the written testimony you received. And I am going to have to be declarative and uncomplicated in making these five points because these are all very complicated issues, and they each deserve five minutes or more, but I can't do that.

My first point is that it is only fair to say up front that we actually do not know how much of U.S. origin R&D has been globalized so far, much less do we know how this will change in the future. The offshoring of these services is itself quite new, and it is very difficult to measure. The quantitative data we have are remarkably weak, and even worse in a way, they lag well behind what seems to be a rapidly changing scene.

U.S.-based companies that, at least according to press reports are energetically offshoring R&D investments to countries such as China and India seem to be very cautious about talking publicly about what they are doing. Now, most observers believe that the globalization of R&D are increasing and increasing fairly rapidly. But again, we don't have good quantitative data on this, and the trend is attributed to numerous incentives including some obvious ones: lower remuneration rates for scientists and engineers; heavy marketing of offshoring services by international consulting firms; the desire of U.S.-based firms to tailor product development to non-U.S. markets; U.S. tax provisions—that is something that Congress does actually have some leverage on provisions that allegedly perversely favor offshore investment of accrued profits in attractive capital and other subsidies offered by overseas governments for R&D; and even mandates to locate R&D operations therefore imposed by governments of some major countries such as China. And then there is federal support of both U.S.-trained foreign students and temporary work visas that facilitate offshore outsourcing of R&D and other high-skill services. These are all plausible but we can't really dissect them and tell you 12.34 of the trend is due to this one and .27 to that.

As is always the case, we know even less about the future than about the present and the recent past. So will the apparent rapid growth of R&D offshoring continue, or even accelerate? We don't know. Will firms decide that payoffs they had anticipated were overstated or that the risks they had planned for were underestimated? To what extent might R&D funding originating outside the United States provide career opportunities for U.S. scientists and engineers? We don't have answers to that. They are critically important topics for this committee, and I sincerely hope that you will pay a lot of attention to them over the coming years.

My second point is that although I know that you are routinely told by corporate lobbyists that their R&D is being globalized in part due to shortages of scientists and engineers or it will be if they continue to experience such shortage, no one who has studied this matter with an open mind has been able to find any objective data showing such general shortages of scientists and engineers. And here I include many academic researchers as well as several studies by the RAND Corporation and other think tanks commissioned by federal funds. That is point two. You have a vote.

Point three. The best evidence is that large fractions of U.S. college freshmen continue to be interested in pursuing majors in science and engineering. However, more than one-half of these change their minds once they begin their degrees, and move towards other studies and careers.

Fourth, we need to face that there is a serious disconnect between labor market demand for science professionals and the way federal funding is used to subsidize graduate science education and post-doctoral positions. This disconnect——

Chairman WU. I am sorry, Dr. Teitelbaum, but we had an old system of bells which I found charming. These new horns are terribly offensive, and I lost your last sentence which I think——

Mr. TEITELBAUM. Okay. I will say it again.

Chairman WU. Thank you.

Mr. TEITELBAUM. We need to face that there is a serious disconnect between labor market demand for science professionals—I am not speaking now about engineers—and the way federal funding is used to subsidize graduate science education and post-doctoral positions. This disconnect between demand and supply means that we are subsidizing substantially more science Ph.D.s, in my judgment—Ph.D. students, and post-docs—than can find attractive real job openings and future careers in these fields.

Our current model works roughly like this. If you vote in this committee and elsewhere in the Congress to substantially increase federal funding for basic research, one side-effect not intended by you is substantial growth in the number of "slots" for Ph.D. students and post-docs supported by the additional research funding you voted. Yet this increased research funding does not result in commensurate increases in career pathways for scientists once they finish their post-docs.

So this is a recipe for self-defeating instability, for enthusiastic booms followed by depressing busts. Some of the most rapid growth in the federally-subsidized science workforce has been in the category of post-doc. If the truth be told, only a very small percentage of the current post-doc pool seems to have realistic prospects of gaining the regular academic positions that they aspire to.

Does this mean that I believe it was unwise for this committee and the Congress to authorize increased federal support for K–12 science and math teaching, or for basic research in the physical sciences? To the contrary. My own view is that K–12 success in science and mathematics has become as important for both economic success and an educated citizenry as were basic reading and writing skills in the 19th and 20th centuries. And for basic research, my view is that such research produces valuable "public goods" that contribute powerfully to human welfare. Most corporate leaders say openly they cannot invest very much in basic research because it's difficult to capture the profits from it, and this alone makes basic research a very appropriate role for government. This leads me to my fifth and final point.

We need much more thoughtful attention to how the current federal funding system for graduate education might be gradually adjusted to better connect to the labor market demands for science professionals. There is strikingly little federal support for such analyses, and some small funding could go a long way to improve our understanding.

Now, I am going to skip over this because of time, and say one important adjustment would be to find practical ways to improve the fit between graduate science education and employment paths for science professionals outside academe. With this goal in mind, the Alfred P. Sloan Foundation has been investing millions of dollars of our money to assist you and U.S. universities in creating innovative Professional Science Master's degrees, known as PSM degrees. These are graduate-level science degrees designed in consultation with employers who provide guidance to the faculty on both the scientific and the business skills they consider critical for their new hires. They are designed to produce sophisticated science-trained professionals who are interested in non-academic careers in science and whose skills are of interest to non-academic employers, both corporate and governmental. There are now over 100 such degree programs offered by over 50 universities in 25 states, and there is a website I cite in my testimony that will give you a lot more information on them.

I just want to close by saying, Mr. Chairman, that I was pleased to see that in the *America COMPETES Act* the Congress provided the first authorization of federal funds to support these Professional Science Master's initiatives through the National Science Foundation. Of course, I understand, having been here for two years, that these authorized funds still need to be appropriated. Still, it is my hope that the National Science Foundation right now is actively planning how to move forward energetically building this and other promising graduate pathways that will improve the fit of U.S. graduate science education to the needs of the U.S. economy.

That is really all I can discuss in the short time available. I am ready to respond to Members' questions to the best of my ability, and I will be happy to provide you any further information subsequently. Thank you very much.

[The prepared statement of Dr. Teitelbaum follows:]

PREPARED STATEMENT OF MICHAEL S. TEITELBAUM

Mr. Chairman, Members of the Subcommittee, Ladies and Gentlemen:

Thank you for inviting me to share with you my thoughts on the fascinating questions you and your staff have raised regarding the U.S. science and engineering workforce, and the implications of globalizing R&D for its future dynamism and productivity.

By way of introduction, I am Vice President of the Alfred P. Sloan Foundation in New York, a philanthropic foundation created in the 1930s that has long devoted substantial funding to improving the health of U.S. science, engineering, and economic performance. Over the past few years, the Sloan Foundation has supported a number of research projects and data collections by leading analysts that address your questions. At a personal level, I should add that I am myself a demographer who has spent a good deal of time in recent years examining some of the questions you are raising. Twenty-five years ago I served as the Staff Director of the Select Committee on Population of this House. Today I am appearing before you in my personal professional capacity. The Sloan Foundation as an institution takes no positions on these issues.

Others on the panel will address the forces underlying globalization and possible future trends. In the short time available to me, I will focus on what we are *often told*—as distinct from what we *actually know*—about the sufficiency of the U.S. science and engineering workforce for the current and future R&D enterprise, and I will also offer some more speculative comments on the possible impacts of globalization trends.

The Conventional Portrait

Let me first, very briefly, summarize what I would call the Conventional Portrait. It will be very familiar to Members of this subcommittee; I know you have had many witnesses before you who have put forward such views. The Conventional Portrait may be summarized briefly as follows:

First, there are serious *shortages* or *shortfalls* in the U.S. of scientists and engineers—either current shortages/shortfalls, or "looming" ones—that bode ill for the creativity and competitiveness of the U.S. economy.

Second, the numbers of newly-educated scientists and engineers graduating from U.S. universities are reported to be insufficient for the needs of U.S. employers, even though the science careers they are offering are growing rapidly and are attractive and well-remunerated. Some argue that it is this insufficiency that really compels U.S. high-tech firms to offshore increasing fractions of their R&D work, and to hire increasing numbers of scientists and engineers from abroad to "fill the gaps."

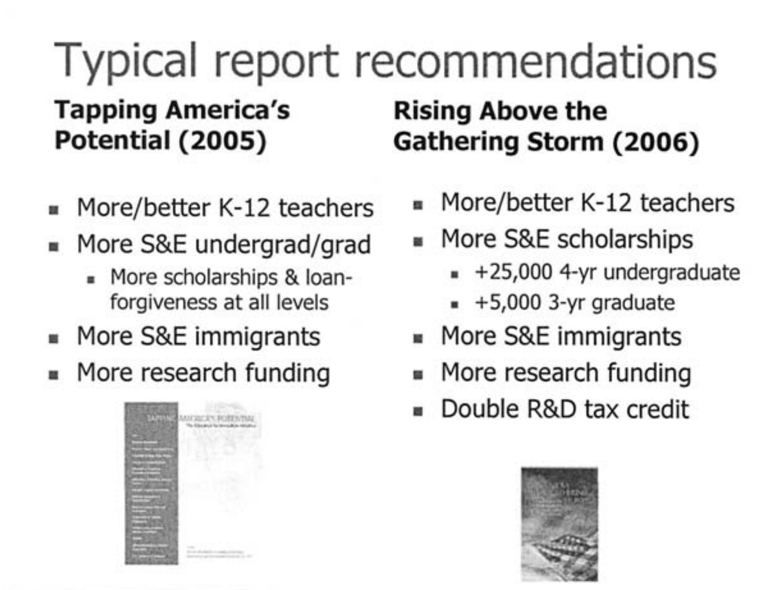
Third, the argued insufficiencies of supply are due to the weakness (or even "failure") of U.S. K–12 education in science and math.

Fourth, U.S. students are showing declining interest in science and engineering careers, even though these are growing strongly.

Fifth, the "postdoc" status found in growing numbers in most U.S. research universities offers an excellent training opportunity for young scientists before they enter into the promising academic research careers that lie before them.

Sixth, the Congress should respond to these realities by providing large government investments to increase the number of students completing majors in science and engineering fields, and in increasing the flow of federal research dollars to these fields.

Two prominent examples of such portraits can easily be found in the 2005 report *Tapping America's Potential,* led by the Business Roundtable and signed onto by 14 other business associations; and by the 2006 National Academies report *Rising Above the Gathering Storm,* which was the basis for substantial parts of what eventually evolved into the *American COMPETES Act.* The 2005 *Tapping America's Potential* report called for an array of policies and expenditures to "double the number of science, technology, engineering, and mathematic graduates by 2015," i.e., a 100 percent increase in 10 years. They were very forthright about this; this core goal appeared right on the report's cover.



The Realities

I have described such views as "Conventional," but unfortunately that does not mean they are correct. *To the contrary, they are largely inconsistent with the facts.* The realities—highlighted by the findings of most researchers who have addressed this subject with an open mind—are very different from the Conventional Portrait; indeed in important ways they are almost the opposite. Here is a similarly brief summary of the findings from such research:

First, no one who has come to the question with an open mind has been able to find any objective data suggesting general "shortages" of scientists and engineers. The RAND Corporation has conducted several studies of this subject; its conclusions go further than my summary above, saying that not only could they not find any evidence of shortages, but that instead the evidence is more suggestive of surpluses. I would add here that these findings of no general shortage are entirely consistent with isolated shortages of skilled people in narrow fields or in specific technologies that are quite new or growing explosively.

Second, there are substantially more scientists and engineers graduating from U.S. universities that can find attractive career openings in the U.S. workforce. Indeed science and engineering careers in the U.S. appear to be relatively *un*attractive—relative that is to alternative professional career paths available to students with strong capabilities in science and math.[1]

Third, students emerging from the oft-criticized K–12 system appear to be studying science and math subjects more, and performing better in them, over time. Nor are U.S. secondary school students lagging far behind comparable students in economically-competitive countries, as is oft-asserted.

Fourth, large and remarkably stable percentages of entering freshmen continue to report that they plan to complete majors in science and engineering fields; however, only about half of these ultimately do so.

Fifth, the postdoc population, which has grown very rapidly in U.S. universities and is recruited increasingly from abroad, looks more like a pool of low-cost research lab workers with limited career prospects than a high-quality training program for soon-to-be academic researchers. Indeed, if the truth be told—only a very small percentage of those in the current postdoc pool have any realistic prospects of gaining a regular faculty position.

Sixth, rapid increases in federal funding for scientific research and education is more likely than not to further destabilize career paths for junior scientists. Under the current structure, the effect is substantial growth in "slots" for Ph.D. students and postdocs to conduct the supported research, but only limited increases in the numbers of career positions (I will give you a concrete and large example in a moment).

There are many researchers and organizations that have developed this set of understandings of what is actually happening—for example: leading researchers at the RAND Corporation; Harvard University; National Bureau of Economic Research; Urban Institute; Georgetown University; Georgia State University; Stanford University; etc. I'll be happy to provide your staff with a bibliography of the now-substantial body of research and analysis that comes broadly to this set of conclusions.

Why is the Conventional Portrait a Washington Perennial?

So why, you might ask, do you continue to hear energetic re-assertions of the Conventional Portrait of "shortages," shortfalls, failures of K–12 science and math teaching, declining interest among U.S. students, and the necessity of importing more foreign scientists and engineers?

In my judgment, what you are hearing is simply the expressions of interests by interest groups and their lobbyists. This phenomenon is, of course, very familiar to everyone on the Hill. Interest groups that are well organized and funded have the capacity to make their claims heard by you, either directly or via echoes in the mass press. Meanwhile those who are not well-organized and funded can express their views, but only as individuals.

The interest groups that continue to make the Conventional case include:

- Some employers of scientists and engineers, and their industry associations [ample pools of qualified hires, without need to raise wages and benefits?]
- Some universities and university associations [graduate student enrollments and postdocs to conduct funded lab research?]
- Some funding agencies [credible argument for increased funding?]
- Some immigration lawyers and their associations [high-volume visas, with legal fees paid by employers?]

I want to emphasize that in making this case, none of these interest groups intend any harm to anyone. There is no evil intent, nor malevolence, nor exploitation. They are simply promoting their interests, as interest groups should be expected to do.

Yet there are few (if any) organized groups that represent the career interests of professional scientists or engineers—not to mention the future interests of people who are still students and who might, or might not, choose to pursue such careers.

So when you hear from interest groups about this range of subjects, you pretty much hear only from employers and their associations, universities and their associations, funding agencies, and immigration lawyers and their associations. There are exceptions to this, but they are few in number and often tightly constrained about lobbying you.

The Perverse Funding Structure for Science Graduate Education

Let me turn now to one of the perverse aspects of the way funding for science is currently structured. Given the short time available, I must simplify (I hope I do

[1] There are many journalistic reports of senior scientists and engineers advising students, including their own children, not to pursue careers in these fields. . ..

not *over*-simplify). Put simply, the way we currently fund graduate education in science is a recipe for instability, for enthusiastic booms followed by dispiriting busts. Let me illustrate by reference to NIH and the biomedical sciences.

Many of you may be aware that a large majority of biomedical Ph.D. students and postdocs supported by NIH are financed by *research* grant funds, rather than by "training" or education funds. This was not the case 25 years ago, but it is now. This means that if NIH research funding is increased in response to too-low success rates for grant applicants, one effect is funding for more Ph.D. students and postdocs who are recruited by NIH grant recipients to do the bench research work. This means that, after a lag of several years, there will be more recent Ph.D.s and postdocs seeking research employment, and applying for NIH research grants. This in turn tends to *reduce* the grants success rate going forward.

Something exactly like this is now underway—with a vengeance—in the biomedical research sector. In part due to low and declining success rates, and special concern about the especially difficult experiences of younger scientists, Congress increased the NIH research budget by 100 percent in only the five years from 1998–2003—on the order of 14–15 percent annual increases. The absolute increase was also large: from $13.6 billion to $27.3 billion. If inflation is taken into account, the "real" percent and absolute increases were of course lower, but still very large.

Following the promised doubling, NIH budget growth has stagnated since 2003. The result is what many in the biomedical field are calling a "hard landing," and what others call a "funding crisis." Researchers are spending more and more of their time writing proposals, the stability of research careers is imperiled, and some labs face the prospect of closing down.

Much of what is now happening was not only foreseeable, but was actually foreseen. Dynamic modeling of the U.S. Ph.D. and research funding systems undertaken by Goldman and Massy[2] at Stanford and RAND during the 1990s demonstrated (for all who cared to see) that:

- University departmental needs drive intake of Ph.D.s (p. 20)
- Ph.D. admissions are insensitive to external labor market conditions (p. 22)
- Simulations of five years of research funding growth at two percent per year followed by stable funding produces a short-term increase in employment for recent Ph.D.s, followed within a few years by declines in employment for recent Ph.D.s (pp. 42ff).

An unrelated but prescient article by prominent observers of the biomedical research scene, published by *Science* magazine in 2002, anticipated correctly what was to take place several years later, following the final 14 percent budget increase in 2003. The authors estimated that given the nature of the NIH biomedical research funding structure, continuous annual budget increases of at least six to eight percent would be required to maintain stability and avoid serious negative consequences.[3]

One way to describe the system we have evolved is one with "positive feedback loops" built right into it—unintentionally, to be sure—a bit like a cockeyed thermostat that responds to rising temperatures not by shutting off the furnace but instead by calling for more heat. In all systems analyses of which I am aware, positive feedback loops like this *tend toward unstable equilibria*—if funding growth is rapid enough, one can readily foresee there will be boom first, followed by bust, unless rapid budget increases can be continued indefinitely.

One important lesson from the recent NIH case is that one of the fundamental goals of doubling the budget—to increase success rate of proposals, especially for younger scientists—was frustrated by the positive feedback loops inherent in the current funding structure. Funding success rates and career prospects did improve somewhat during the five years of rapid budget increases, but once the doubling had been completed proposal success rates quickly declined—to levels even lower than before the budget doubling began. And the largest negative effects seem to have

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[2] Charles A. Goldman and William F. Massy, *The PhD Factory: Training and Employment of Science and Engineering Doctorates in the United States* (Boston: Anker Publishing, 2001). The research on which this book was based was supported by a peer-reviewed grant from the Alfred P. Sloan Foundation.

[3] David Korn, et al., "The NIH Budget in the "Postdoubling" Era, *Science,* Vol. 296, 24 May 2002, pp. 1401–1402.

been concentrated among younger biomedical scientists, who represent the future of the research enterprise.[4]

What Should NOT Be Done?

The NIH case may not tell us what should be done now, but it does offer valuable insights into what should NOT be done. It also points to (again) foreseeable problems if the current structure remains unchanged and Congress carries through with the increased appropriations for NSF, Department of Energy and NIST foreshadowed in recent authorizations. I do hope this Committee will give some scrutiny to how repeats of the current rebound crisis from the NIH budget doubling can be avoided if the science funding budgets of these other agencies are doubled in the coming years.

What should NOT be done is to take actions that will increase the *supply* of scientists and engineers that are not intimately coupled with serious measures to ensure that comparable increases occur in the *demand* for scientists and engineers. A supply-side-only focus—various advocates are lobbying for sharply increased research funding, more incentives for science and engineering students, more temporary or permanent visas for scientists and engineers, etc.—might satisfy the demands of influential interest groups over the short-term. But if the overall structure currently in place is not modified, one can reasonably anticipate that the positive feedback loops in the current system will produce destructive effects over the medium-term—deteriorating grant success rates, and declining interest in science and engineering studies and careers among domestic students.

Implications of R&D Globalization

What can we say about the implications of quite recent trends toward globalization of R&D activities by U.S.-based employers? The first thing is to acknowledge that we don't really know in any detail what is happening now, and certainly not what is going to happen over the next five to ten years. Only a decade ago, no one would have forecast the rapidity with which it has become feasible and financially attractive for U.S. firms to out-source their R&D activities to low-wage offshore settings such as India and China. The general assumption then was that low-skill, low-wage manufacturing could and would be offshored, but that high-value-added R&D functions would remain in the U.S.

Clearly such confidently-asserted assumptions have proven to be false. However, the data as to the actual magnitudes and growth of such offshoring are very limited indeed, and the information we do have lags well behind the rapid pace at which such change seems to be occurring.

It has long been the case that no one has been able to accurately forecast future labor market demand for highly-educated scientists and engineers more than a few years into the future—as an outstanding National Academies report on the topic concluded forcefully in 2000.[5] Such forecasting efforts have become far more difficult as a result of the quite-recent movement toward offshoring of high-level R&D activities, led by many U.S.-based companies and consulting firms.

One result is that the risks and uncertainties of pursuing a STEM career in the U.S. are rising. If one combines the erratic paths and future uncertainties of R&D funding flows from the Federal Government, the boom/bust cycles that characterize many important high-tech industries, the uncertainties of federal visa legislation, and the apparent rising trend in offshore out-sourcing of R&D, it is very hard indeed to offer useful advice about the future prospects for a STEM career to a student with strong abilities and real interest in math and science. Certainly we can offer no assurances that they will find a "durable and resilient career path" in such fields.

What Should Be Done?

One thing that could and should be done is to dramatically improve the "signals" about such careers that are publicly available to prospective students. In particular, doctoral programs in many U.S. universities provide far less information to prospective and entering students about the career experiences of their recent graduates than do the law schools and business schools on the very same campuses. This should certainly change; students need to be provided with far better if they are to

[4] An excellent presentation on the NIH situation, presented at Harvard University last February by Dr. Paula Stephan of Georgia State University can be found at: *http://nber15.nber.org/sewp/Early%20Careers%20for%20Biomedical%20Scientists.pdf*

[5] National Research Council, Office of Scientific and Engineering Personnel, *Forecasting Demand and Supply of Doctoral Scientists and Engineers: Report of a Workshop on Methodology* (Washington: National Academies Press, 2000).

have realistic expectations as they embark upon a course of graduate study and postdoc research that often can stretch out over most of their 20s.

A second promising approach is to improve the direct connections between science employers and universities offering graduate science degrees. This is one of the fundamental elements of the *Professional Science Master's* degree programs that the Sloan Foundation has been supporting around the country. Typically these degrees involve two years of intensive graduate-level course work in relevant scientific fields, combined with courses in so-called "plus" skills that employers routinely report they seek in new hires: skills in communication, management, teamwork, leadership, entrepreneurship, along with on-the-job experience via internships with interested employers.

I am attaching to this testimony a one-page flyer that summarizes the Professional Science Master's. Much more information can be found easily at *www.sciencemasters.com*

I want to add in closing that it was personally encouraging to me that the Congress provided the first authorization of federal funding in support of Professional Science Master's programs, via the National Science Foundation, as part of the *America COMPETES Act* passed a few months ago and signed into law. It will now be interesting to see if these authorized funds are appropriated, and if so whether the National Science Foundation will move energetically to build this promising graduate pathway toward strengthening the U.S. science workforce.

Thank you for your kind attention. I stand ready to answer any questions you may have to the best of my ability.

Professional Science Master's Programs

IN TODAY'S COMPETITIVE GLOBAL MARKETPLACE, THE U.S. WORKFORCE NEEDS SKILLED PROFESSIONALS WHO COMBINE ADVANCED SCIENCE OR MATHEMATICS KNOWLEDGE WITH EXPERTISE IN COMMUNICATIONS, PROJECT MANAGEMENT, AND OTHER BUSINESS FUNDAMENTALS. THE PROFESSIONAL SCIENCE MASTER'S (PSM) DEGREE PREPARES GRADUATES WITH THOSE SKILLS AND MORE.

What is a Professional Science Master's Degree?

The Professional Science Master's (PSM) is an innovative, new graduate degree designed to allow students to pursue advanced training in science, while simultaneously developing workplace skills highly valued by employers. PSM programs prepare graduates for careers in business, government, or nonprofit organizations, combining rigorous study in science or mathematics with coursework in management, policy, law or related fields. Along with an emphasis on writing, leadership and communication skills, most PSM programs require a final project or team experience, as well as a "real-world" internship in a business or public sector enterprise.

QUICK FACTS:

- PSMs are currently offered by:
  - Over **100** programs
  - Over **50** institutions
- **1,300+** students enrolled annually
- PSM Graduates:
  - **1,300+** since 1997
  - About **85%** are U.S. citizens
  - About **54%** are women

Program Examples

PSM Degree	Science/Technology Courses	+	Professional Skills
Forensic Science	Drug Chemistry/Toxicology, Molecular Biology, Quantum Chemistry	+	Case Law, Expert Witness Testimony, Formal Reports, Library Skills, Rules of Evidence
Applied Industrial Mathematics	Differential Equations, Linear Algebra, Matrix Theory	+	Leadership, Organizational Decision Making, Strategic Human Resources Management
Bio/Pharmaceutical Discovery and Development	Clinical Biostatistics, Clinical Trial Design, Gene Expression Systems, Proteomics	+	Applied Entrepreneurship, Bioscience Business Strategy, Intellectual Property and Licensing, U.S. Regulatory Affairs
Applied Computing	Modeling, Network Design, Network Security, Simulation	+	Conflict Resolution, Negotiation, Presentation Skills, Project Management, Writing

How Does the PSM Enhance U.S. Competitiveness?

- **National Scope.** PSM programs directly respond to the national need for a stronger scientific workforce by preparing individuals with expertise in science and mathematics in combination with professional skills including communication and project management that are highly valued in the marketplace.
- **Regional Strength.** Partnerships with local employers are integral to PSM programs, ensuring that they remain responsive and adaptive to current and future workforce needs.
- **Institutional Innovation.** The interdisciplinary nature of the PSM program fosters collaboration between multiple departments, schools, and fields within colleges and universities.
- **Student Benefit.** With competitive salaries and exciting opportunities awaiting them upon completion of their degrees, students find the PSM program a compelling reason to remain in science, math, and technology fields.

Where can I find additional information?

PSM PROFESSIONAL SCIENCE MASTER'S

Search for PSM programs in your state at www.sciencemasters.com and learn about the PSM initiative at www.cgsnet.org.

COUNCIL OF GRADUATE SCHOOLS

BIOGRAPHY FOR MICHAEL S. TEITELBAUM

Michael S. Teitelbaum is Vice President of the Alfred P. Sloan Foundation in New York, where he is responsible for a wide range of program areas including the Sloan Research Fellowships, Science and Engineering Workforce, Professional Science Masters, Federal Statistics, and the Sloan Public Service Awards.

During academic year 2006–2007 he served as the Edward P. Bass Distinguished Visiting Scholar at Yale. His research interests include the causes and implications (economic, social, geopolitical) of very low fertility rates; the complex processes and implications of international migration; and patterns and trends in science and engineering labor markets in the U.S. and elsewhere. He has written extensively on these topics, as well as on the historical demography of Europe and on the intellectual history of debates about demographic trends. He is the author or editor of 10 books and a large number of articles on these subjects, and is presently at work on a new book focused on the rapidly spreading phenomena of very low fertility and rising international migration around the world.

Previously he was a faculty member at Princeton and Oxford Universities, and for two years was the Staff Director of the Select Committee on Population, U.S. House of Representatives. For much of the 1990s he served as Vice Chair and Acting Chair of the U.S. Commission on International Migration. He currently serves on the boards of the Center for Migration Studies in New York, the Population Resource Center in Washington, Americans for Generational Equity in Washington, and the Population-Environment Research Network; and as a Member of the Global Commission on Aging.

He was educated at Reed College and at Oxford University, where he was a Rhodes Scholar.

Chairman WU. Thank you very much, Dr. Teitelbaum. And Dr. McMillion, if you stay close to the five minutes of oral testimony, although we very much enjoyed Dr. Teitelbaum's 10-minute testimony, we will have time for your testimony at which point we will have to take a break to go vote on the Floor. Please proceed.

STATEMENT OF DR. CHARLES W. MCMILLION, PRESIDENT AND CHIEF ECONOMIST, MBG INFORMATION SERVICES

Dr. MCMILLION. Thank you for inviting me here today. I need to tell you I am from Texas, and so I speak very slowly. So five minutes goes quickly for me, but I will do my best.

You have heard about challenges from the ample supply of STEM workers, and you will hear more on the supply issues. I will focus on three key challenges likely to weaken demand for STEM workers.

This is the first of my three points. The rich U.S. marketplace for goods and services that sustains the STEM workforce has been maintained for a generation by soaring levels of debt. Since 1981, the ratio of federal and household debt to GDP has rocketed, breaking the World War II record in 2002, and is now in uncharted territory. Over the last seven years, federal and household debt combined, increased by over $10 trillion by GDP grew just over $4 trillion. Without this debt, there would be far fewer STEM jobs. No one knows how much longer this unprecedented borrowing can last, but it is a major vulnerability for STEM workers and indeed for the U.S. economy.

Second, massive U.S. losses in global trade have shifted our economy to activities that are non-globally traded, unraveling the technology supply chains that are essential to our STEM workforce and to our economy. For a generation, the United States has produced and earned far less than it spends borrowing and importing to make up for the shortfall, piling up record future obligations. The United States has accumulated $4.3 trillion in current account trade deficits just in the last seven years. Some economic theorists claim that importing what others can produce more cheaply allows a country to automatically concentrate on what it makes best, and the sales of this will pay for imports raising living standards for all. It is a nice story. The massive U.S. trade deficits over almost 30 years now including technology show that the world has become a far more complex place.

All manufacturing industries lost jobs since 2001. Most suffered trade deficits producing less than we ourselves needed for the U.S. economy. This process is unraveling or hollowing out the once tightly integrated and dynamic U.S. production and innovation system. Indeed, the United States lost its traditional global surplus and advanced technology products in 2002, and that deficit is worsening by another 45 percent this year. Since 2003, the U.S.'s global earnings on intellectual property, royalties, and fees were not enough even to cover global payments for imported advanced tech products, much less for any of the non-ATP products from autos to oil.

In the past seven years, of the 6.1 million total jobs created in the United States, all are accounted for in less productive, but globally protected, public and private education, health care, food services, and bars—some lawyers, too. During this time, more productive manufacturing jobs lost 3.2 million jobs. Professional and technical firms did add some jobs, but most of these appear to be related to the debt financed and globally protected boon in construction, education, health, and national security.

You heard testimony in June claiming as a success story that the United States no longer makes television sets because the United States must constantly innovate and move on. This now generation-old emphasis only on the nimble portion of the production and innovation system has worked very well for some individuals and for some global firms, but overall, it has failed STEM workers and the U.S. economy.

Finally, thirdly, China and other competitors are modernizing and integrating their production and innovation systems posing urgent, new threats to the STEM workforce and to the continued U.S. prosperity. China's former processing trade has rapidly transformed, integrating its modernizing industries into dynamic, efficient clusters. China's global trade surplus in manufacturing was only $31 billion in 2001, but it is near $400 billion this year. For example, in the massive and very important parts-dominated machinery and computer industry grouping, HS–84, China has rocketed from a $7 billion global deficit in 2001 to a surplus that will blow past $100 billion just this year. China's global current account surplus is over 13 percent of its GDP, and it this GDP of course is growing at over 11 percent a year.

The world's leading technology firms now need to be in China, and they must have good relations with China's tech-savvy and tech-hungry authorities. This need is not only because of very low production costs in China, but now also to be near their customers, the world's top producers of goods and services and the world's most rapidly growing domestic markets. This gives China's authorities enormous new power to require key tech transfers, R&D facilities, massive training, and a lot more. The OECD reports that China already spends more in purchasing power on R&D in Japan, and if current trends continue for just five more years, more will be spent on R&D in China than in the United States.

A U.N. survey finds China the overwhelming choice for new R&D facilities. Difficult economic times present fire-sale opportunities to those with money to spend, and China now has unprecedented amounts of money in its fast-growing, now $1.5 trillion official reserves and in its cash-rich firms fresh from wildly successful initial public offerings. This competition for the favor of China's authorities is ever more fierce, further weakening the demand for STEM workers in the United States. The STEM workforce and the U.S. economy face big challenges right now, not at some comfortably far-off point in the future. The United States cannot continue to rely on borrowing growth, channeling that growth to non-globally competing industries, and ignoring the rapid competitive emergence of China and others.

I hope that Congress will urgently organize itself to develop this strong, comprehensive development strategy that the scale of this new challenge requires. Thank you very much, and I look forward to discussion.

[The prepared statement of Dr. McMillion follows:]

PREPARED STATEMENT OF CHARLES W. MCMILLION

Thank you Chairman Wu and the other Members of this committee for your work in this vitally important area and for inviting me to appear before you today.

I believe the topic of these hearings is among the most important facing our country. The reason is simple: the U.S. can compete against vastly cheaper producers in China and elsewhere but only to the extent that producers of goods and services here in the U.S. make vastly superior products using vastly superior process technologies.

Misleading "competitiveness" indexes now invented for global firms notwithstanding, the U.S. economy has not been competitive for a generation. Rather, our economy has worked-off the vastly superior wealth, infrastructure and production systems that it enjoyed at the end of World War II when much of the rest of the world lay in rubble.

You heard from excellent witnesses in previous hearings and you have an outstanding panel of other witnesses today. So I will emphasize just three key, but often neglected points:

1. The U.S. economy and the scientific and engineering workforce has been sustained by an unprecedented and unsustainable level of debt for a generation;
2. Massive and chronic U.S. losses in global trade, a key cause of the debt explosion, have now produced enormous and unsustainable *foreign* debts and is rapidly undermining the vast technology superiority that is essential to our STEM workforce and to our economy;
3. China and other competitors are quickly creating remarkable dynamism, modernizing and integrating their innovation and production systems, posing very severe and urgent threats to the scientific and engineering workforce and to the U.S. economy.

There is a convention in economics, often useful for theoretical work, that assumes full employment. Unfortunately this purely theoretical convention has come to be adopted as reality by many analysts in the U.S.—although rarely anywhere else. This often unconscious assumption leads many analysts and policy-makers to complacency, focusing exclusively on shifts within a fully employed workforce rather than on job losses and the wage and other effects of significant unemployment.

Sustaining the U.S. workforce and the economy

Congress recently was forced to raise the $9 trillion federal debt ceiling. I hope all of you recall that the federal debt first reached $1 trillion only in 1981—after 200 years of world wars, a civil war, many other wars, depressions, recessions, wars on poverty, runaway inflation, rocketing oil prices, ambitious space missions and so much more.

It was an enormous economic and political issue at the time and in many ways a turning point in public policies.

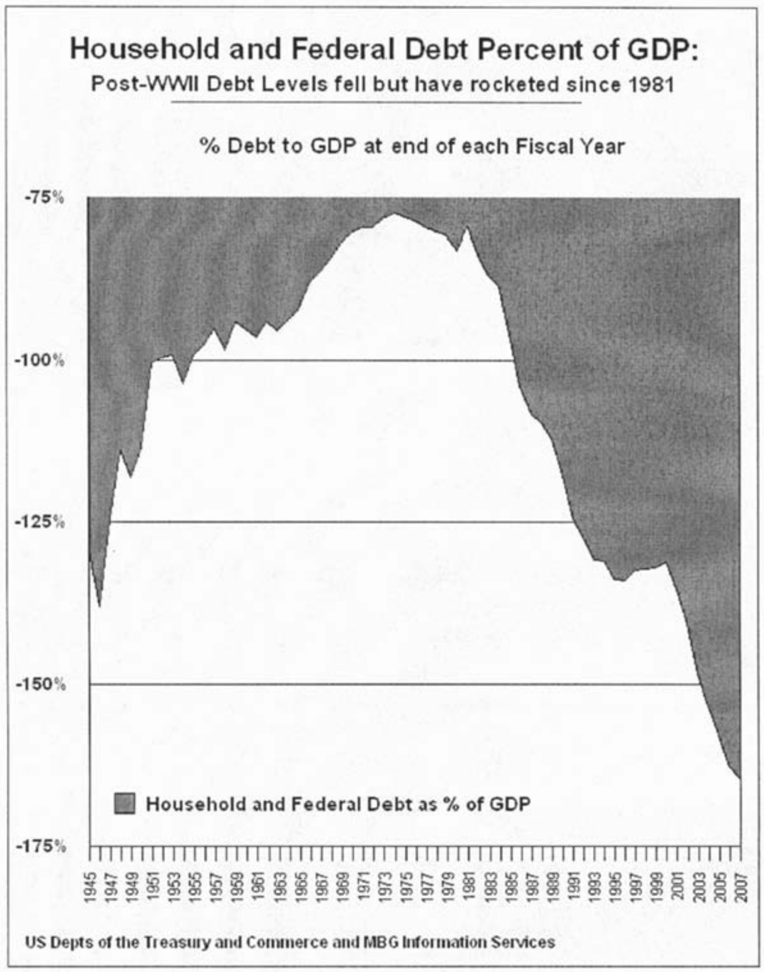
The federal deficit now stands at $9.1 trillion, up $3.3 trillion over just the last seven years.

Household debt is up even more, from $1.5 trillion in 1981 to $14 trillion today—creasing $6.8 trillion in just the last seven years. That is, federal and household debt increased by $10.1 trillion in just seven years. For comparison, nominal GDP grew by $4.1 trillion—just 41 percent as much as the growth of debt.

As a share of GDP, federal and household debt fell from the end of World War II until the 1970s. Since 1981 the debt-to-GDP ratio has soared, breaking the WWII record of 138 percent of GDP in 2002 and is now in uncharted territory, reaching 165 percent of GDP at the end of FY 2007.

Over the past seven years the U.S. created just 6.1 million total jobs with private sector jobs accounting for only 4.5 million of these with local public schools adding most of the public sector job growth. Even ignoring the multiplier effects of credit and job growth, this works out to over $1.6 million in tax cuts, government contracts, credit card and other debt stimulus for each new job; over $2.2 million for each new private sector job over the past seven years.

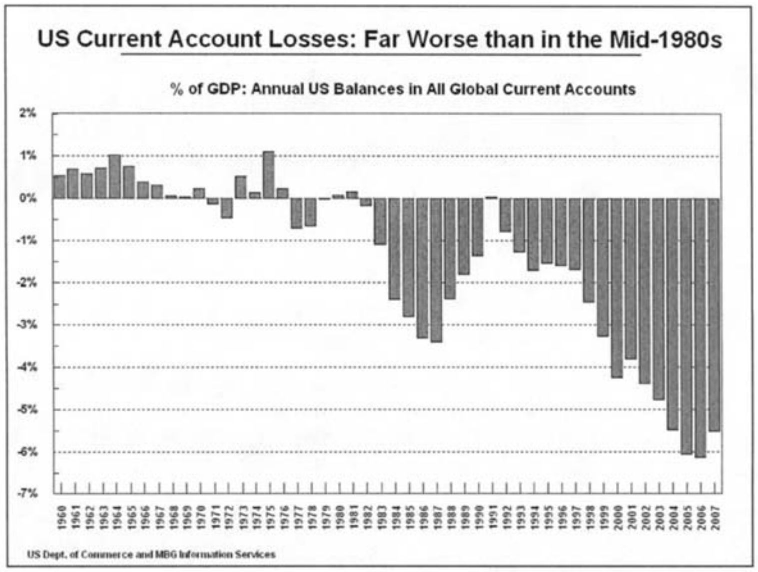
Even if debt had grown only at the rate of nominal GDP (and ignoring the depressing effect this would clearly have on GDP) over the last seven years, this still works out to over $1 million per new private sector job. (A table of historical debt and GDP data is below.)



Financial innovation and the ability to accumulate debt has been the strength of the U.S. economy. This distorts the economy in ways discussed below. Many find it unsustainable.

Global Commerce

Economic theorists often claim that importing what others can produce more cheaply automatically allows a country to concentrate on what it makes best, the sales of which will pay for imports, raising living standards for all. But chronic and massive U.S. deficits—now including for technology—and borrowing show that the world is now more complex.

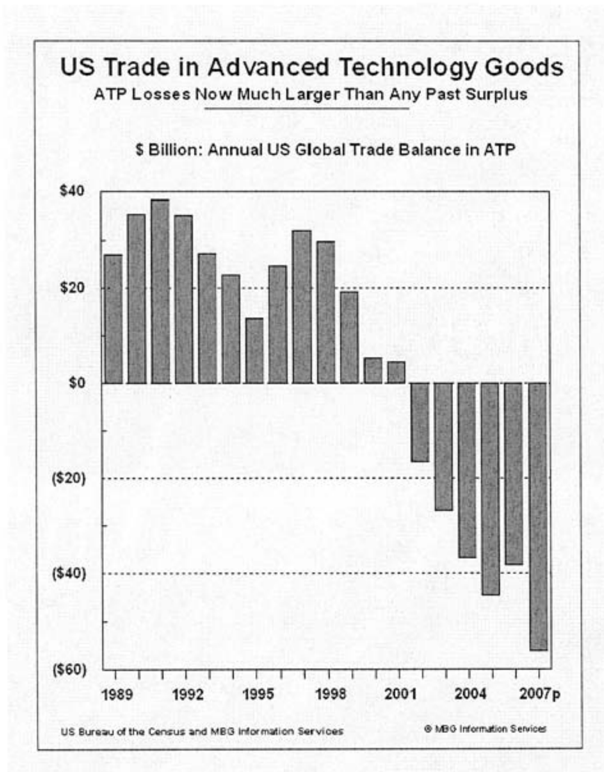


For a generation the U.S. has produced and earned far less than it spends, importing to make up for the production shortfall and piling up worsening record levels of asset sales and debt obligations. Worsening record trade deficits for goods and services reduced U.S. GDP in every year from 1995 to 2006 although the overall deficit is improving somewhat in 2007. U.S. GDP growth has long been far slower than world growth—including in each of the past eight years—but the U.S. will nonetheless accumulated over -$4.3 trillion in Current Account trade deficits just between 2001 and the end of 2007.

At the worst of the "competitiveness" crisis in 1987, the U.S. Current Account deficit briefly peaked at -3.4 percent of GDP. This deficit set a new record of -6.2 percent of GDP in 2006 and has now been worse than the mid-1980s' peak of -3.4 percent of GDP in each of the past eight years. On cue, the World Economic Forum of global banking and commercial firms just named the U.S. economy the world's *MOST* competitive; China and India rank 34th and 48th, respectively.

Over the past seven years, 65 of the 98 U.S. goods-producing industries in the International Harmonized Code suffered trade deficits, producing *less* than was needed for the U.S. economy. In total, U.S. goods producing industries suffered a cumulative -$4.4 trillion in net imports and production shortfalls over the past seven years.

The worst industry shortfall, of course, is mineral fuels. But next comes vehicles and parts, electrical machinery and parts, non-electrical machinery and parts, textile and apparel, furniture and almost all manufacturing industries that employ our science and engineering workforce. The only three large manufacturing industries with net exports and surplus production are aircraft and parts, medical and optical equipment and plastics—and the surplus in plastics is mostly for crude chemicals. Most of the goods-producing industries in which the U.S. has global net exports are agricultural and other commodities. (See table following.)



Indeed, the U.S. lost its traditional global surplus in Advanced Technology Products in 2002 with deficits now in a majority of the more than 700 products. Even with the overall deficit in goods trade improving by six percent yr/yr through August 2007, the ATP deficit is worsening by -45 percent and could reach a new annual record loss of -$56 billion. The ATP deficit is set to again exceed the net U.S. earnings on all Intellectual Property Royalties and Fees (including franchise fees) that appears headed for a total of about $42 billion in 2007. This will be the worst deficit in the now fourth consecutive year that the U.S. has suffered a global trade deficit in combined tech goods and services.

That is, for the past four years—and increasingly—U.S. global net earnings on Intellectual Property are not enough even to cover the net U.S. global payments for imported advanced technology products much less for any of the non-ATP products from autos to oil.

Labor market effects, current and future

Jobs, businesses and tax revenues lost to net imports are not automatically replaced but rather rely on various forms of debt stimulus noted above. BLS' jobs data and re-employment surveys also make clear that in the U.S., contrary to conventional theory, unemployed labor does not typically find more productive, higher wage employment. For a generation, new job growth in the U.S. has been almost entirely in *less productive* but non-globally traded industries and occupations that are not easily out-sourced.

In the past seven years of soaring debt, of the 6.1 million total jobs created, ALL were in non-traded, still-difficult-to-out-source public and private education and health care, and in food services and bars. During this time generally higher-wage, far more productive manufacturing firms were not adding but cutting -3.2 million jobs. Professional and technical firms did add 909,000 jobs during the period, many related to the non-globally competing boom in construction and national security.

Adjusted for inflation, wages and salaries no longer rise three to four percent per year as they did in the previous generation but have been stagnant or falling for *this* generation. The BLS reported again last week that *average*—not just median—real wages rose slightly in the past year but after falling sharply in 2005 this brings real wages back only to levels in 2002. As other panelists will discuss, the science and engineering workforce also has faced stagnant or declining real wages for a generation as the supply and price of talent in the U.S. has outstripped demand.

U.S. public policies and institutions have not kept up with fabulous technological advances, with the enormous and dynamic new capabilities of global firms or with the sophisticated and massive industrial policies of a few low cost countries, particularly China. Although China has long enjoyed a large surplus in trade with the U.S., China imported most of the component parts from other countries, mostly in Asia, with its economy focused on "processing" these parts into final goods. This "process trade" left China with a relatively small percentage of value-added in many modern products and only a small surplus in its global trade.

This has changed dramatically. China's global surplus in manufacturing trade was only $31 billion in 2001 but soared to $277 billion in 2006 and is on track to approach $400 billion for all of 2007. In the large, parts dominated, non-electrical machinery and computer industry grouping (HS–84,) China has rocketed from a -$7 billion global deficit in 2001 to a surplus of $77 billion in 2006 and the surplus is on track to far exceed $100 billion in 2007. China's global Current Account surplus reached $249 billion in 2006, 9.4 percent of GDP, and will also approach $400 billion in 2007—near 14 percent of a GDP that is growing by a price-adjusted 11.5 percent yr/yr.

Still, because of world-leading productivity growth, China reports that 1,440,000 (one-third) of this year's five million new university graduates were still without jobs in October. Cisco announced last week that they will expand their technology training centers in China that trained 90,000 since 2003 to train 100,000 more over the next three years. Comparable salaries for science and engineering jobs in China are reported between 10 percent and 30 percent of U.S. salaries.

The world's leading technology firms now must be in China and must have good relations with China's authorities. This necessity is now not only because of competitive production costs but also in order to be near their customers—the world's top producers of goods and, increasingly, services.

This gives China's authorities enormous power. For example, China requires global auto producers to have only a minority interest in any auto assembly plant in China, unless it is exclusively for export, and to provide an R&D facility. All major global auto firms are currently accelerating the amount, the scope and the quality of their R&D investments in China. Global firms in other industries are "strongly encouraged" to provide R&D before production permits are approved.

A recent UN survey of global firms found China the overwhelming choice for new R&D facilities. Controlling for purchasing power, the OECD found that China already spends more on R&D than Japan, and if current trends continue there could be more spent on R&D in China than in the U.S. within the next FIVE years. If China's spending continues to accelerate as it is doing now and/or if U.S. spending slows, R&D spending in China could pass that in the U.S. even sooner.

Of course, most R&D in China remains for now a variation on the theme of reverse engineering and most global innovations remain within foreign, global firms—although this is changing. China's vastly lower production costs allow "fast followers" and "cherry pickers" to reap much of the financial benefit from the innovations of others. With $1.5 trillion in foreign currency reserves, growing by $10 billion each week, China's authorities have vastly more power to access or acquire technologies than they had a decade ago when the House's bipartisan "Cox Commission" last investigated these matters. Indeed, one of the more urgent commercial and military technology issues today is the security of safeguards for trade and technology secrets within the Chinese joint ventures of global technology firms.

The current prospect of a U.S. economic slowdown or recession adds urgency to concerns for the science and engineering workforce. Along with the usual concerns for public and private R&D budget cutbacks, an economic squeeze often accelerates out-sourcing to lower-wage areas. Countries that depend on exports to the U.S. for growth would be affected, of course, but middle-range countries like Mexico would likely be most adversely affected by their own out-sourcing to lower-cost countries like China.

Also, difficult economic times present many fire sale opportunities to those with money to spend. China has unprecedented amounts of money to spend, both in it's official $1.5 trillion in foreign currencies, and in its often state-owned, cash-rich firms that recently issued wildly successful initial public equity offerings. The already intense and pervasive competition for the favor of China's very savvy authorities and their retainers is likely to get far more ferocious further weakening the scientific and engineering workforce in the U.S.

The U.S. faces enormous economic challenges ahead. I hope that the Congress will urgently organize itself to begin to develop the type of strong, comprehensive strategy that the scale of this challenge requires.

I would be very happy to discuss.

$ Billions	Nominal GDP (FY)	Gross Fed Debt (FY)	Personal Debts (FY)	Federal + Personal Debt	Annual Current Account Balance	Current Account Balance Since 1960	Total Disposable Income (FY)
1945	$223.1	-$258.7	-$30.3	-$289.0	N/A	N/A	N/A
1946	222.3	-269.4	-37.1	-306.5	N/A	N/A	161.1
1947	244.2	-258.3	-46.1	-304.4	N/A	N/A	171.2
1948	269.2	-252.3	-54.7	-307.0	N/A	N/A	190.6
1949	267.3	-252.8	-63.0	-315.8	N/A	N/A	190.4
1950	293.8	-257.4	-76.3	-333.7	N/A	N/A	210.1
1951	339.3	-255.2	-85.3	-340.5	N/A	N/A	231.0
1952	358.3	-259.1	-97.6	-356.7	N/A	N/A	243.4
1953	379.4	-266.1	-110.4	-376.5	N/A	N/A	258.6
1954	380.4	-271.3	-122.6	-393.9	N/A	N/A	264.3
1955	410.9	-274.4	-132.9	-407.2	N/A	N/A	280.7
1956	434.2	-272.8	-151.0	-423.7	N/A	N/A	300.4
1957	459.2	-270.5	-165.3	-435.9	N/A	N/A	318.9
1958	458.1	-276.3	-174.4	-450.7	N/A	N/A	326.6
1959	508.4	-284.7	-193.2	-477.9	N/A	N/A	350.5
1960	526.1	-286.3	-213.9	-500.2	2.8	2.8	365.2
1961	539.0	-289.0	-230.7	-519.6	3.8	6.6	377.9
1962	583.2	-298.2	-250.3	-548.5	3.4	10.0	403.8
1963	611.2	-305.9	-276.3	-582.2	4.4	14.4	420.7
1964	658.8	-311.7	-306.4	-618.1	6.8	21.3	460.3
1965	708.1	-317.3	-335.3	-652.5	5.4	26.7	489.4
1966	779.9	-319.9	-364.3	-684.2	3.0	29.7	530.9
1967	822.5	-326.2	-381.9	-708.2	2.6	32.3	569.5
1968	904.2	-347.6	-413.1	-760.7	0.6	32.9	622.5
1969	976.3	-353.7	-444.0	-797.7	0.4	33.3	663.5
1970	1,033.2	-370.9	-460.2	-831.1	2.3	35.7	730.6
1971	1,119.1	-398.1	-492.8	-890.9	-1.4	34.2	797.9
1972	1,225.9	-427.3	-548.8	-976.0	-5.8	28.4	848.9
1973	1,371.9	-458.1	-613.8	-1,072.0	7.1	35.6	965.4
1974	1,485.3	-475.1	-674.0	-1,149.0	2.0	37.5	1,055.0
1975	1,605.6	-533.2	-718.2	-1,251.3	18.1	55.6	1,193.2
1976	1,804.9	-620.4	-797.1	-1,417.5	4.3	59.9	1,284.5
1977	2,066.8	-698.8	-943.9	-1,642.8	-14.3	45.6	1,454.3
1978	2,336.2	-771.5	-1,102.4	-1,874.0	-15.1	30.5	1,630.5
1979	2,600.7	-826.5	-1,271.9	-2,098.4	-0.3	30.2	1,813.9
1980	2,786.6	-907.7	-1,403.7	-2,311.4	2.3	32.5	2,021.2
1981	3,178.7	-997.9	-1,527.1	-2,525.0	5.0	37.5	2,289.6
1982	3,276.2	-1,142.0	-1,597.9	-2,739.9	-5.5	32.0	2,447.2
1983	3,589.3	-1,377.2	-1,739.4	-3,116.6	-38.7	-6.7	2,635.1
1984	3,978.2	-1,572.3	-1,942.9	-3,515.2	-94.3	-101.0	2,955.0
1985	4,261.3	-1,823.1	-2,254.6	-4,077.7	-118.2	-219.2	3,115.4
1986	4,493.9	-2,125.3	-2,547.2	-4,672.5	-147.2	-366.4	3,307.2
1987	4,767.8	-2,350.3	-2,809.5	-5,159.8	-160.7	-527.0	3,484.5
1988	5,146.6	-2,602.3	-3,046.0	-5,648.4	-121.2	-648.2	3,786.9
1989	5,531.9	-2,857.4	-3,351.2	-6,208.6	-99.5	-747.7	4,038.8
1990	5,849.4	-3,233.3	-3,654.1	-6,887.4	-79.0	-826.6	4,325.7
1991	6,035.6	-3,665.3	-3,851.0	-7,516.3	2.9	-823.7	4,483.7
1992	6,380.5	-4,064.6	-4,059.1	-8,123.8	-50.1	-873.8	4,768.6
1993	6,674.6	-4,411.5	-4,306.1	-8,717.6	-84.8	-958.6	4,924.3
1994	7,115.1	-4,692.7	-4,610.3	-9,303.1	-121.6	-1,080.2	5,197.5
1995	7,432.1	-4,974.0	-4,960.2	-9,934.2	-113.6	-1,193.8	5,427.1
1996	7,866.2	-5,224.8	-5,306.2	-10,531.0	-124.8	-1,318.6	5,727.5
1997	8,381.9	-5,413.1	-5,670.2	-11,083.3	-140.7	-1,459.3	6,020.8
1998	8,789.5	-5,526.2	-6,073.7	-11,599.9	-215.1	-1,674.4	6,448.1
1999	9,313.5	-5,656.3	-6,619.2	-12,275.5	-301.6	-1,976.0	6,708.2
2000	9,862.1	-5,674.2	-7,255.9	-12,930.1	-417.4	-2,393.4	7,266.4
2001	10,135.1	-5,807.5	-7,900.6	-13,708.1	-384.7	-2,778.1	7,622.8
2002	10,527.4	-6,228.2	-8,565.9	-14,794.1	-459.6	-3,237.8	7,845.4
2003	11,086.1	-6,783.2	-9,660.2	-16,443.5	-522.1	-3,759.9	8,261.0
2004	11,779.4	-7,379.1	-10,668.7	-18,047.8	-640.1	-4,400.0	8,708.9
2005	12,558.8	-7,932.7	-11,860.3	-19,793.0	-754.8	-5,154.9	9,105.1
2006	13,266.9	-8,507.0	-13,052.1	-21,559.1	-811.5	-5,966.3	9,675.8
2007	13,926.7	-9,007.7	-14,025.0	-23,032.7	-760.0	-6,726.3	10,284.8
1955 to '81	$2,767.8	-$723.5	-$1,394.2	-$2,117.7	N/A	N/A	$2,008.9
1981 to '07	10,748.0	-8,009.8	-12,497.9	-20,507.7	-765.0	-6,763.9	7,995.2
2000 to '07	4,064.6	-3,333.5	-6,769.1	-10,102.5	-342.6	-4,332.9	3,018.4

US Department of Commerce, Federal Reserve and MBG Information Services

US Balance in Global Trade of Goods: -$4.4 Trillion in losses from 2001-2007

Deficits in 65 of 98 goods-producing industries led by fuels, vehicles, electrical and non-electrical machines

HS Industries: $Millions	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007p	Totals 2001-'07
Merchandise Totals....................	-$182,615	-$233,411	-$331,945	-$436,469	-$411,899	-$468,263	-$532,350	-$650,930	-$767,477	-$817,304	-$772,253	-$4,420,475
27 Mineral Fuel, Oil Etc..............	-65,632	-47,632	-65,345	-120,346	-109,264	-104,152	-139,173	-187,662	-263,071	-297,696	-287,866	-1,388,883
87 Vehicles, Not Railway...........	-54,365	-64,690	-89,566	-101,927	-100,201	-107,660	-109,633	-117,220	-115,975	-123,266	-108,620	-782,575
85 Electrical Machinery...............	-11,154	-18,573	-24,300	-37,812	-32,005	-41,379	-44,918	-59,802	-77,767	-83,293	-104,002	-443,167
84 Machinery/Computers...........	-3,289	-17,942	-28,254	-21,989	-16,565	-31,444	-39,621	-50,843	-55,388	-61,549	-53,348	-308,758
62 Woven Apparel......................	-21,447	-23,495	-25,009	-29,253	-29,104	-28,513	-31,107	-33,409	-35,695	-36,118	-37,033	-230,980
61 Knit Apparel..........................	-15,080	-17,980	-19,592	-21,825	-22,976	-24,600	-26,692	-28,880	-30,707	-33,022	-37,034	-203,910
94 Furniture And Bedding...........	-8,524	-10,836	-14,468	-17,290	-17,122	-20,995	-24,070	-27,485	-30,357	-32,227	-32,598	-184,854
95 Toys, Video Games, Sports E	-12,362	-13,934	-14,324	-15,116	-16,403	-17,810	-17,086	-17,721	-19,764	-20,361	-26,277	-135,422
O Specl Impr Provisions	-5,968	-8,526	-11,788	-13,818	-13,237	-13,045	-14,067	-16,194	-18,226	-20,190	-20,927	-115,886
64 Footwear..............................	-13,097	-13,029	-13,229	-13,987	-14,427	-14,685	-14,908	-15,852	-17,202	-18,330	-18,928	-114,332
44 Wood....................................	-5,676	-7,391	-9,934	-9,110	-9,709	-10,624	-11,381	-17,019	-17,655	-16,368	-11,467	-94,224
71 Precious Stones,Metals.........	-7,321	-10,609	-11,883	-14,570	-11,503	-13,014	-13,000	-15,329	-15,183	-12,512	-6,151	-86,692
30 Pharmaceutical Products.......	-352	-1,363	-2,326	-1,645	-3,475	-8,474	-11,842	-11,621	-13,725	-16,860	-19,641	-85,639
98 Special..................................	-2,438	-5,625	-10,389	-11,121	-11,985	-13,734	-11,548	-10,328	-11,451	-10,236	-5,887	-75,169
29 Organic Chemicals................	-513	-2,991	-6,009	-9,472	-12,704	-13,556	-12,826	-8,002	-9,940	-9,710	-7,633	-74,370
73 Iron/Steel Products................	-2,321	-3,396	-3,829	-5,001	-5,547	-6,347	-6,988	-10,337	-12,890	-14,906	-17,149	-74,163
22 Beverages.............................	-4,325	-4,958	-5,904	-6,633	-6,939	-7,934	-8,945	-9,515	-10,747	-13,504	-14,187	-71,772
72 Iron And Steel.......................	-8,622	-11,927	-8,664	-9,438	-5,501	-6,562	-3,586	-13,512	-10,825	-16,292	-9,706	-65,985
42 Leathr Art;Saddlry;Bags.........	-5,165	-5,239	-5,402	-6,428	-6,458	-6,488	-6,822	-7,404	-7,648	-8,336	-9,059	-52,214
63 Misc Textile Articles..............	-1,767	-2,377	-2,968	-3,482	-3,895	-4,733	-5,692	-6,824	-7,884	-8,686	-9,134	-46,848
76 Aluminum..............................	-1,859	-2,443	-3,048	-3,596	-3,505	-4,071	-4,633	-6,618	-7,955	-8,885	-7,486	-43,153
03 Fish And Seafood..................	-4,008	-4,715	-4,743	-5,490	-5,019	-5,166	-5,737	-5,398	-5,602	-6,356	-7,174	-40,452
40 Rubber..................................	-2,313	-2,999	-3,322	-3,243	-2,665	-3,742	-4,771	-5,913	-7,313	-7,912	-7,897	-40,213
48 Paper,Paperboard..................	-1,090	-2,501	-3,089	-3,782	-4,127	-4,315	-4,454	-5,334	-5,449	-5,554	-3,954	-33,187
74 Copper+Articles Thereof........	-1,624	-1,702	-2,183	-1,698	-2,574	-2,052	-1,328	-2,145	-4,113	-7,644	-6,227	-26,083
69 Ceramic Products..................	-2,148	-2,426	-2,711	-3,030	-2,734	-3,014	-3,387	-3,682	-3,983	-4,296	-3,823	-24,920
83 Misc Art Of Base Metal..........	-982	-1,298	-1,503	-1,481	-1,571	-2,050	-2,356	-3,145	-4,011	-4,486	-4,774	-22,393
91 Clocks And Watches.............	-2,377	-2,753	-2,738	-2,968	-2,601	-2,786	-3,134	-3,231	-3,415	-3,408	-3,581	-22,156
68 Stone,Plastr,Cement,Etc........	-1,001	-1,373	-1,830	-2,117	-2,232	-2,504	-2,716	-3,200	-3,659	-3,986	-3,835	-22,133
09 Spices,Coffee And Tea..........	-3,851	-3,361	-2,951	-2,809	-1,799	-1,847	-2,194	-2,379	-2,961	-3,243	-3,784	-18,207
82 Tool,Cutlry, Of Base Mtls.......	-974	-1,291	-1,427	-1,546	-1,440	-1,873	-2,307	-2,542	-2,521	-2,836	-2,801	-16,319
16 Prepared Meat,Fish,Etc.........	-796	-1,041	-1,310	-1,411	-1,397	-1,622	-1,824	-2,149	-2,189	-2,554	-2,408	-14,142
96 Misc. Manufacturing...............	-1,084	-1,196	-1,563	-1,634	-1,663	-1,744	-1,826	-2,073	-2,173	-2,253	-2,366	-14,097
07 Vegetables............................	-306	-698	-741	-759	-1,092	-1,210	-1,562	-1,872	-1,885	-2,111	-2,335	-12,067
97 Art And Antiques...................	-1,529	-1,228	-2,605	-2,433	-1,379	-2,630	-1,641	-1,782	-1,177	-1,048	-2,095	-11,752
28 Inorg Chem;Rare Erth Mt.......	-126	-666	-841	-975	-645	-620	-1,743	-1,848	-2,055	-2,004	-2,675	-11,589
18 Cocoa....................................	-979	-1,205	-1,033	-825	-808	-1,107	-1,716	-1,697	-1,929	-1,768	-1,661	-10,687
75 Nickel+Articles Thereof..........	-749	-420	-483	-956	-478	-395	-704	-1,341	-1,379	-2,122	-3,989	-10,408
01 Live Animals..........................	-960	-1,035	-984	-1,065	-1,342	-1,449	-828	-921	-1,417	-1,840	-2,095	-9,892
79 Zinc+Articles Thereof............	-1,242	-1,046	-1,181	-1,224	-994	-991	-841	-970	-989	-1,974	-3,067	-9,826
65 Headgear...............................	-747	-859	-963	-1,126	-1,156	-1,167	-1,249	-1,398	-1,364	-1,466	-1,445	-9,244
20 Preserved Food......................	-261	-156	-452	-461	-534	-671	-1,125	-1,329	-1,484	-1,578	-2,358	-9,080
17 Sugars....................................	-1,085	-944	-906	-797	-811	-1,065	-1,244	-1,255	-1,541	-1,864	-916	-8,695

US Balance in Global Trade of Goods: -$4.4 Trillion in losses from 2001-2007

Deficits in 65 of 98 goods-producing industries led by fuels, vehicles, electrical and non-electrical machines

HS Industries: $Millions	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007p	Totals 2001-'07
67 Artif Flowers,Feathers	-830	-905	-978	-1,042	-1,069	-1,147	-1,183	-1,198	-1,233	-1,311	-1,370	-8,511
19 Baking Related	-56	-155	-326	-354	-429	-756	-949	-1,008	-1,086	-1,298	-1,535	-7,061
06 Live Trees And Plants	-720	-774	-797	-869	-871	-862	-960	-1,064	-1,041	-1,068	-1,135	-7,002
70 Glass And Glassware	-151	-477	-871	-578	-350	-812	-919	-1,197	-1,348	-1,257	-1,053	-6,936
57 Textile Floor Coverings	-80	-255	-445	-658	-683	-825	-956	-1,027	-1,067	-1,117	-1,061	-6,736
92 Musical Instruments	-626	-774	-865	-1,007	-859	-881	-912	-971	-931	-785	-709	-6,047
25 Salt;Sulfur;Earth,Stone	-203	-388	-606	-445	-400	-438	-518	-692	-1,324	-1,404	-792	-5,569
46 Straw,Esparto	-229	-248	-256	-278	-307	-349	-382	-404	-427	-412	-425	-2,704
66 Umbrella,Wlk-Sticks,Etc	-220	-238	-233	-270	-279	-264	-300	-329	-357	-369	-416	-2,314
80 Tin + Articles Thereof	-207	-208	-213	-232	-210	-169	-184	-413	-293	-377	-541	-2,187
04 Dairy,Eggs,Honey,Etc	-90	-258	-406	-255	-295	-555	-632	-342	-288	-121	420	-1,813
13 Lac;Vegetabl Sap,Extrct	-298	-409	-325	-238	-203	-174	-219	-195	-286	-337	-270	-1,685
50 Silk;Silk Yarn,Fabric	-286	-269	-248	-269	-209	-207	-216	-261	-269	-236	-241	-1,640
43 Furskin+Artificial Fur	29	13	-22	-118	-146	-129	-192	-226	-196	-106	-526	-1,521
51 Animal Hair+Yarn,Fabrc	-382	-341	-249	-280	-237	-169	-184	-235	-231	-206	-219	-1,480
54 Manmade Filament,Fabric	26	11	103	409	175	53	-77	-101	-492	-408	-525	-1,375
45 Cork	-89	-100	-89	-107	-146	-146	-154	-168	-160	-153	-204	-1,130
78 Lead	-15	-30	-45	-41	-84	-71	5	-82	-200	-308	-373	-1,114
53 Other Veg Textile Fiber	-189	-185	-176	-148	-110	-98	-119	-161	-168	-184	-228	-1,068
15 Fats And Oils	610	1,257	560	75	229	604	483	-216	-485	-675	-358	-417
14 Other Vegetable	-24	-20	-22	-16	-44	-23	-23	-13	-34	-36	-131	-303
31 Fertilizers	1,672	1,690	1,590	772	329	633	382	250	-461	-291	-948	-106
36 Explosives	73	59	12	71	-3	1	70	84	48	45	125	370
05 Other Of Animal Origin	-47	-67	-98	-102	69	39	97	-57	22	78	151	400
58 Spcl Woven Fabric,Etc	92	90	230	216	295	334	89	137	26	-12	-62	806
81 Other Base Metals, Etc	-368	-312	-204	-67	-56	159	257	-85	214	520	21	1,028
33 Perfumery,Cosmetic,Etc	1,546	1,242	1,081	1,221	1,439	1,158	291	-321	-673	-288	-63	1,542
59 Impregnatd Text Fabrics	548	484	486	421	506	355	410	233	56	-8	12	1,564
56 Wadding,Felt,Twine,Rope	379	298	218	222	152	138	220	172	286	489	267	1,724
11 Milling;Malt;Starch	249	195	252	150	201	260	207	144	215	340	502	1,870
08 Edible Fruit And Nuts	895	394	-349	61	159	13	174	217	588	517	250	1,918
35 Albumins;Mod Strch;Glue	467	83	336	319	598	538	173	163	219	384	507	2,581
55 Manmade Staple Fibers	383	242	270	387	399	384	428	432	377	334	248	2,603
60 Knit,Crocheted Fabrics	-167	-190	-300	-199	-66	21	389	678	785	670	717	3,193
89 Ships And Boats	527	639	545	-65	685	-86	-568	-298	275	1,158	2,490	3,656
86 Railway;Trf Sign Eq	-126	-430	-702	-416	69	54	406	452	724	971	1,197	3,874
49 Book+Newspapr,Manuscrpt	1,666	1,511	1,159	1,017	1,022	497	512	452	535	649	704	4,372
37 Photographic/Cinematogr	379	199	151	717	248	598	711	544	522	871	1,005	4,500
26 Ores,Slag,Ash	-421	-928	-596	-486	-364	-383	-111	-28	815	2,086	3,224	5,239
93 Arms And Ammunition	1,839	1,901	1,477	1,333	1,321	1,123	693	954	826	1,032	1,159	7,108
21 Miscellaneous Food	1,570	1,278	1,333	1,317	1,365	1,237	1,360	1,247	1,380	1,592	1,674	9,854
34 Soap,Wax,Et;Dental Prep	997	836	791	836	950	895	1,086	1,435	1,564	1,892	2,168	9,991
24 Tobacco	4,961	5,046	3,988	4,142	2,801	1,718	1,625	1,368	1,025	1,196	915	10,648
41 Hides And Skins	1,226	868	868	1,274	1,668	1,510	1,716	1,893	1,816	2,020	2,281	12,904

US Balance in Global Trade of Goods: -$4.4 Trillion in losses from 2001-2007

Deficits in 65 of 98 goods-producing industries led by fuels, vehicles, electrical and non-electrical machines

HS Industries: $Millions	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007p	Totals 2001-'07
47 Woodpulp, Etc.	1,261	1,042	1,019	1,333	1,131	1,583	1,612	1,662	2,153	2,682	2,928	13,751
02 Meat	4,160	3,517	3,135	3,670	2,998	2,123	2,893	-318	980	2,066	3,569	14,309
32 Tanning,Dye,Paint,Putty	941	1,112	1,129	1,590	1,486	1,695	1,866	2,086	2,115	2,470	2,857	14,575
23 Food Waste; Animal Feed	3,844	3,350	2,712	3,073	3,516	2,983	2,948	2,664	2,948	3,284	3,772	22,115
52 Cotton+Yarn,Fabric	2,025	1,876	409	1,671	2,219	2,008	3,394	4,449	4,249	4,945	4,401	25,666
38 Misc. Chemical Products	5,997	5,938	5,716	6,290	5,977	5,748	6,051	6,361	6,721	8,069	9,250	48,178
12 Soy & Misc Grain,Seed,Fruit	7,990	5,477	5,164	5,977	6,095	6,764	8,922	7,742	7,355	8,003	10,895	55,777
39 Plastic	8,682	7,617	7,108	9,060	7,414	6,844	6,087	7,274	6,540	8,445	14,614	57,217
90 Optic,Nt 8544;Med Instr	8,515	7,434	7,302	8,399	9,390	6,392	5,308	6,782	8,457	11,546	12,580	60,456
10 Cereals	10,318	9,323	9,480	8,928	8,749	9,420	9,869	12,334	10,652	12,331	16,905	80,259
88 Aircraft,Spacecraft	30,856	39,398	34,641	22,809	23,450	26,236	23,898	25,451	33,753	49,432	55,209	237,429

US Department of Commerce, Bureau of the Census and MBG Information Services   2007 data are projected from yr-to-August actual:

Job Growth In Industries Not Facing Outsourcing or Imports

ALL net Job growth from Public/Private Education & Health Care, Restaurants/Bars

Industry: Nonfarm Jobs (1,000)	September 2000	September 2007	Change: 2007-2000 #	Change: 2007-2000 %
Total nonfarm	132,122	138,265	6,143	4.6%
Total private	111,387	115,961	4,574	4.1%
Total private supervisory	20,747	20,511	-236	-1.1%
Total private non-supervisory	90,640	95,450	4,810	5.3%
Goods-producing	24,644	22,324	-2,320	-9.4%
Goods-producing supervisory	6,500	5,837	-663	-10.2%
Goods-producing non-supervisory	18,144	16,487	-1,657	-9.1%
Service-providing	107,478	115,941	8,463	7.9%
Private Service-providing	86,743	93,637	6,894	7.9%
Private Services supervisory	14,247	14,674	427	3.0%
Private Services non-supervisory	72,496	78,963	6,467	8.9%
Natural resources and mining	605	728	123	20.3%
Logging	78.9	62.5	-16	-20.8%
Mining	525.8	665.2	139	26.5%
Oil and gas extraction	124.3	151.8	28	22.1%
Mining, except oil and gas	225.3	230.5	5	2.3%
Coal mining	75.6	81.0	5	7.1%
Support activities for mining	176.2	282.9	107	60.6%
Construction	6,807	7,613	806	11.8%
Construction of buildings	1,630.4	1,774.2	144	8.8%
Residential building	818.2	981.0	163	19.9%
Nonresidential building	812.2	793.2	-19	-2.3%
Heavy & civil engineering construction	941.9	988.8	47	5.0%
Specialty trade contractors	4,234.8	4,849.6	615	14.5%
Manufacturing	17,232	13,983	-3,249	-18.9%
Supervisory workers	4,848	3,924	-924	-19.1%
Non-supervisory workers	12,384	10,059	-2,325	-18.8%
Durable goods	10,874	8,863	-2,011	-18.5%
Supervisory workers	3,227	2,573	-654	-20.3%
Non-supervisory workers	7,647	6,290	-1,357	-17.7%
Wood products	607.6	520.3	-87	-14.4%
Nonmetallic mineral products	554	497	-57	-10.3%
Primary metals	617.8	449.1	-169	-27.3%
Fabricated metal products	1760.6	1,570.2	-190	-10.8%
Machinery	1456.6	1,220.1	-237	-16.2%
Computer and electronic products	1846.4	1,298.0	-548	-29.7%
Computer and peripheral equipment	303.1	197.2	-106	-34.9%
Communications equipment	251.3	142.6	-109	-43.3%
Semiconductors and electronic compone	697.1	457.3	-240	-34.4%
Electronic instruments	478.5	433.2	-45	-9.5%
Electrical equipment and appliances	591.6	435.5	-156	-26.4%
Transportation equipment	2024.7	1,699.5	-325	-16.1%
Motor vehicles and parts	1295.2	996.4	-299	-23.1%
Furniture and related products	681.4	523.5	-158	-23.2%
Miscellaneous manufacturing	733.5	649.6	-84	-11.4%
Nondurable goods	6358	5,120	-1,238	-19.5%
Supervisory workers	1,621	1,351	-270	-16.7%
Non-supervisory workers	4737	3,769	-968	-20.4%
Food manufacturing	1548.8	1,496.4	-52	-3.4%
Beverages and tobacco products	206.3	198.2	-8	-3.9%
Textile mills	376.2	164.9	-211	-56.2%
Textile product mills	215.6	152.0	-64	-29.5%
Apparel	485.2	212.2	-273	-56.3%
Leather and allied products	67.5	36.4	-31	-46.1%
Paper and paper products	602.6	454.3	-148	-24.6%

Job Growth In Industries Not Facing Outsourcing or Imports

ALL net Job growth from Public/Private Education & Health Care, Restaurants/Bars

Industry: Nonfarm Jobs (1,000)	September 2000	September 2007	Change: 2007-2000 #	Change: 2007-2000 %
Printing and related support activities	806.9	628.3	-179	-22.1%
Petroleum and coal products	122.8	116.9	-6	-4.8%
Chemicals	978.2	874.8	-103	-10.6%
Plastics and rubber products	947.8	785.2	-163	-17.2%
Trade, transportation, and utilities	26240	26,520	280	1.1%
Wholesale trade	5,909.9	6,028.5	119	2.0%
Durable goods	3,239.0	3,148.4	-91	-2.8%
Nondurable goods	2,055.5	2,070.7	15	0.7%
Electronic markets; agents/brokers	615.4	809.4	194	31.5%
Retail trade	15,315.7	15,393.3	78	0.5%
Motor vehicle and parts dealers	1,854.4	1,914.7	60	3.3%
Automobile dealers	1,221.7	1,247.6	26	2.1%
Furniture and home furnishings stores	545.6	585.3	40	7.3%
Electronics and appliance stores	570.6	533.7	-37	-6.5%
Building material/garden supply stores	1,144.5	1,290.1	146	12.7%
Food and beverage stores	2,989.1	2,878.4	-111	-3.7%
Health and personal care stores	936.3	968.7	32	3.5%
Gasoline stations	931.1	855.0	-76	-8.2%
Clothing and accessories stores	1,329.4	1,461.1	132	9.9%
Sporting goods, hobby, book, music store	679.4	671.6	-8	-1.1%
General merchandise stores	2,830.4	2,906.1	76	2.7%
Department stores	1,766.5	1,550.7	-216	-12.2%
Miscellaneous store retailers	1,011.6	886.0	-126	-12.4%
Nonstore retailers	493.3	442.6	-51	-10.3%
Transportation and warehousing	4,416.1	4,542.3	126	2.9%
Air transportation	616.9	493.5	-123	-20.0%
Rail transportation	232.4	229.1	-3	-1.4%
Water transportation	56.9	71.5	15	25.7%
Truck transportation	1,402.2	1,448.6	46	3.3%
Transit & ground passenger transport	371.2	395.9	25	6.7%
Pipeline transportation	45.7	40.7	-5	-10.9%
Scenic and sightseeing transport	26.9	27.8	1	3.3%
Support activities for transport	539.4	584.6	45	8.4%
Couriers and messengers	606.4	591.1	-15	-2.5%
Warehousing and storage	518.1	659.5	141	27.3%
Utilities	598.4	555.4	-43	-7.2%
Information	3,673.0	3,099.0	-574	-15.6%
Publishing industries, except Internet	1,042.1	903.4	-139	-13.3%
Motion picture and sound recording	381.4	389.8	8	2.2%
Broadcasting, except Internet	346.9	338.9	-8	-2.3%
Internet publishing and broadcast	51.1	44.2	-7	-13.5%
Telecommunications	1,292.9	972.2	-321	-24.8%
ISPs, search portals, data processing	512.4	398.5	-114	-22.2%
Other information services	46.4	52.0	6	12.1%
Financial activities	7,699.0	8,448.0	749	9.7%
Finance and insurance	5,690.1	6,245.6	556	9.8%
Monetary authorities - central bank	22.7	21.6	-1	-4.8%
Credit intermediation and related	2,543.0	2,916.8	374	14.7%
Depository credit intermediation	1,675.6	1,845.9	170	10.2%
Commercial banking	1,245.0	1,346.5	102	8.2%
Securities, commodity, investments	824.1	844.9	21	2.5%
Insurance carriers, related activities	2,215.4	2,367.0	152	6.8%
Funds, trusts, other financial vehicles	84.9	95.3	10	12.2%
Real estate and rental/leasing	2,009.1	2,202.1	193	9.6%
Real estate	1,314.4	1,524.5	210	16.0%
Rental and leasing services	667.0	644.9	-22	-3.3%

Job Growth In Industries Not Facing Outsourcing or Imports

ALL net Job growth from Public/Private Education & Health Care, Restaurants/Bars

Industry: Nonfarm Jobs (1,000)	September 2000	September 2007	Change: 2007-2000 #	Change: 2007-2000 %
Lessors of nonfinancial intangibles...........	27.7	32.7	5	18.1%
Professional and business services...........	16,800.0	17,950.0	1,150	6.8%
Professional and technical services.........	6,815.1	7,723.6	909	13.3%
Legal services..	1,068.6	1,180.0	111	10.4%
Accounting and bookkeeping.................	876.1	966.6	91	10.3%
Architectural and engineering................	1,253.5	1,441.8	188	15.0%
Computer systems design and related...	1,277.6	1,362.2	85	6.6%
Management and technical consulting....	720.8	1,011.2	290	40.3%
Management of companies and enterpris	1,800.7	1,854.7	54	3.0%
Administrative and waste services...........	8,183.7	8,371.9	188	2.3%
Administrative and support services.......	7,868.6	8,014.8	146	1.9%
Employment services............................	3,848.5	3,471.3	-377	-9.8%
Temporary help services.....................	2,645.4	2,548.8	-97	-3.7%
Business support services....................	793.9	809.5	16	2.0%
Services to buildings and dwellings......	1,568.0	1,860.8	293	18.7%
Waste management and remediation.....	315.1	357.1	42	13.3%
Education and health services..................	15,209.0	18,531.0	3,322	21.8%
Educational services..............................	2,425.8	3,040.1	614	25.3%
Health care and social assistance...........	12,783.3	15,490.7	2,707	21.2%
Health care..	10,909.6	13,075.7	2,166	19.9%
Ambulatory health care services.........	4,349.2	5,516.3	1,167	26.8%
Offices of physicians........................	1,853.2	2,236.4	383	20.7%
Outpatient care centers....................	389.4	500.6	111	28.6%
Home health care services.............	633.5	933.8	300	47.4%
Hospitals..	3,963.9	4,565.4	602	15.2%
Nursing and residential care facilitie	2,596.5	2,994.0	398	15.3%
Nursing care facilities.......................	1,517.4	1,614.3	97	6.4%
Social assistance..................................	1,873.7	2,415.0	541	28.9%
Child day care services....................	698.5	820.8	122	17.5%
Leisure and hospitality...............................	11,940.0	13,612.0	1,672	14.0%
Arts, entertainment, and recreation..........	1,799.3	1,959.6	160	8.9%
Performing arts and spectator sports.......	386.4	409.8	23	6.1%
Museums, historical sites, zoos & parks..	111.5	131.3	20	17.8%
Amusements, gambling, & recreation......	1,301.4	1,418.5	117	9.0%
Accommodations and food services........	10,140.6	11,652.5	1,512	14.9%
Accommodations..................................	1,899.2	1,859.6	-40	-2.1%
Food services and drinking places.........	8,241.4	9,792.9	1,552	18.8%
Other services...	5,182.0	5,477.0	295	5.7%
Repair and maintenance...........................	1,244.7	1,263.6	19	1.5%
Personal and laundry services..................	1,252.8	1,289.2	36	2.9%
Membership assocs & organizations........	2,684.1	2,924.6	241	9.0%
Government...	20,735.0	22,304.0	1,569	7.6%
Federal..	2,745.0	2,708.0	-37	-1.3%
Federal, except U.S. Postal Service.........	1,867.9	1,947.7	80	4.3%
U.S. Postal Service..................................	877.4	760.3	-117	-13.3%
State government......................................	4,804.0	5,175.0	371	7.7%
State government education....................	2,034.4	2,352.8	318	15.7%
State government, ex education...............	2,769.4	2,822.5	53	1.9%
Local government.....................................	13,186.0	14,421.0	1,235	9.4%
Local government education.....................	7,311.8	8,069.6	758	10.4%
Local government, ex education...............	5,873.8	6,351.6	478	8.1%

U.S. Department of Labor, BLS and MBG Information Services

BIOGRAPHY FOR CHARLES W. MCMILLION

President and Chief Economist of MBG Information Services, a consultancy based in Washington, D.C. providing timely business information, analysis and forecasting to a small, diverse national client base. Dr. McMillion combines more than 35 years of business and economic analysis, strategic planning and project management for industry, government and academia.

Dr. McMillion is a former Associate Director and Associate Professor in the Johns Hopkins University Policy Institute where he researched and managed business and economic policy issues and projects in the U.S. and abroad. He has held Staff Director and Chief Economist positions in the U.S. House and Senate and is a founder and former Executive Director of the bipartisan United States Congressional Economic Leadership Institute, where he worked with the Speaker of the House to conduct the major opening activity of the 100th Congress. He is associated with 12 successful legislative initiatives on economic and business policy.

He is the author or editor of four books and over 150 scholarly and popular articles and reports. A former Contributing Editor of *The Harvard Business Review,* McMillion wrote a regular column on key business and financial trends. He has also written a regular column on business for *The Washington Business Times.* A featured speaker in former President Clinton's December, 1992 Little Rock Economic Summit, McMillion often testifies on business issue before the U.S. Senate and House, and to state legislatures. He frequently lectures in the US, Europe and Asia including four tours sponsored by the United States Information Agency. A Returned Peace Corps Volunteer in Ethiopia, he is active in civic organizations.

Born in Fort Worth Texas, Dr. McMillion received his BA degree in government at the University of Texas, an MA degree at Southern Methodist University, and MA and Ph.D. degrees in political economy at Rutgers University. His dissertation, written in Europe in the 1970s, is one of the first thorough examinations of the effects of global trade and finance on national and regional markets and industries.

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Chairman WU. Thank you very much, Dr. McMillion. At this point, we will recess this hearing. There are four votes, so it will be a decent period of time before we reconvene, and again, my apologies to the panel.

[Recess]

Chairman WU. Here in the Science Committee we sometimes do demonstrations of—is it general relativity or special relativity—where time stretches out. My apologies to the witnesses. Dr. Salzman, please proceed.

STATEMENT OF DR. HAROLD SALZMAN, SENIOR RESEARCH ASSOCIATE, THE URBAN INSTITUTE

Dr. SALZMAN. Thank you. My analysis draws on research conducted with my colleagues and based on fuel work at some 74 sites, 38 firms in the United States, Europe, Asia, Latin America, and additional analysis of educational and workforce data, just to precede your findings.

First, firms and universities are globalizing due to changes in competitive strategies and that innovation and knowledge are flowing across borders with few constraints. Second, globalization is not occurring because of a lack of U.S. STEM workforce supply or quality; and finally, technology policies, kind of referred to as techno-nationalist policies of the past, are not well-suited for meeting these kind of structural changes and challenges before us.

So what do we observe about globalization of R&D? First, that firms are fundamentally restructuring their organization of innovation, engineering, and technology work by establishing centers of excellence around the globe, and these centers are, you know, all at the top end of leading edge innovation. It is initially driven by cost but it has since evolved into a much broader competitive strategy and focusing on cost misses what is behind this competitive strategy as it is evolving for R&D. They want to locate innovation centers in growing markets in emerging economies. They want to take advantage of labor there, both for cost and talent; and they are finding new types of innovation in those countries that is different from the types of innovation in United States, Europe, and other kinds of countries.

So in IT, for example, companies have pioneered a lot of systematic software development in order to do offshore work. So there is necessity of crossing distance. As the technology becomes a mature technology, this process improvement becomes an important innovation in quality, security, reliability of software, and gives them an advantage very similar to what the Japanese brought to new levels of quality in auto design and manufacturing. I think we know what the rest of the IT story is, which is that the United States has not captured any large share, if any at all, of global growth in IT services. At the same time, the United States has maintained a stable workforce in IT, even without capturing a growing share of it, albeit with layoffs and adjustments.

Other areas beyond IT are also developing in the emerging economies, often U.S. firms but often in their offshore sites; and we think the likely trajectory is the same as is happened in there. So what we find is that the institutional structure is vastly different than it was just a decade ago. Firms are globalized, U.S. human capital and universities and U.S. workforce is internationalized; and there is innovation advantages in offshore locations. These transformations mean that jobs that today look like they will stay in the United States because they require face-to-face interaction may not actually stay here in the near future. We visited firms that are doing KPO, knowledge process outsourcing, legal services, financial analysis, and other areas. It is just remarkable the things that they are looking at to see how they can decompose it, change it, routinize it so they can take most service work and conduct a large portion of it offshore.

So based on these findings, I conclude that very few jobs are inherently not in competition with jobs offshore. Within a decade offshore science and engineering capabilities rival those in the United States in many areas, perhaps not the breadth of innovation and not the depth of technology in certain areas, but certainly there will be strong innovation centers in many areas offshore, both in the United States and non-U.S. firms.

Last, we cannot assume the historical advantages that the United States will keep STEM jobs here indefinitely. Further, the strategy built on the assumption that the United States will have an exclusive hold on any particular type of work or occupation is in error. The approach in producing more scientists or engineers, at least those in the traditional disciplines, would seem to be misdirected.

So the part that answers the question of are we producing enough at the right times and whether STEM jobs are attractive is perhaps the more important question. The data I think as Michael Teitelbaum reviewed suggests that we are providing more than adequate supply of college and post-graduate scientists and engineers. We estimate it is something on the order of two to three times the number of job openings. This doesn't mean that there is an excess supply, but just the pool is adequate to draw from if there were a shortage which we don't find much evidence of. Whatever the numbers about career openings and the prospects of the future, from engineers and managers we have interviewed have a widespread perception that career prospects in these fields are rather dim. And I think we need to point out fewer engineers or managers say they counsel their sons, daughters, nieces, and nephews to go into engineering. It had a great ride, but the ride is over in their view.

You know, while I think that is disheartening to hear, what is even more disturbing in some of our interviews is exemplified by an engineering professor who told me that he would counsel an American student not to go to graduate school in engineering because of the poor career prospects. He said for a foreign student, it is a better career than their other options. For an American who had the ability to get into a graduate engineering program, he or she would have much better options elsewhere. Even within, it seems like, counseling is that there are not a lot of great opportunities. It is not true in all fields. There are some that are still very promising. So from what I can tell, there does not seem to be any real evidence of shortages or hiring difficulties. We have the person looking for a java programmer with 10 years' java experience. Well, java has been around 12 years. I am likely to find that. I am not sure that is a shortage. Or the company president who is quoted as saying there was a shortage that was so bad he had to start hiring people with just average skills. I think we would all like to hire at the top end of the distribution. That is probably not a realistic way to base policy.

So to conclude the fundamental problem facing the United States is that the institutional structure of knowledge and innovation development have changed. Firms and universities are now globalized as our knowledge in human capital flows. The goal of sequestering innovation, knowledge, or skills within national borders can no longer be achieved, whether desirable or not. In the past, GM's progress returned a benefit to the United States. Today, it is less clear whether the United States benefit where at least the workforce benefits more from GM or Toyota. So the future home country advantage firms will diminish further when the vast bulk of profit and marker are outside of the United States Thee strategies built on thinking that we have borders that contain it or built on trying to increase the workforce supply and the idea of holding it here is just unworkable and suggest alternative policy strategies and models are needed to capture value in the new global system. Thank you.

[The prepared statement of Dr. Salzman follows:]

PREPARED STATEMENT OF HAROLD SALZMAN

Mr. Chairman and Members of the Committee, thank you for inviting me to speak on the topic of globalization, the offshoring of research and development (R&D), and the science, technology, engineering, and mathematics (STEM) workforce. My testimony will address questions about the impact of offshoring and whether the United States has enough scientists and engineers (STEM workers), whether they are getting the education they need, and whether STEM careers are attractive. My analysis draws on research conducted with my colleagues Leonard Lynn at Case Western Reserve University and Lindsay Lowell at Georgetown University and is funded by the National Science Foundation and the Sloan Foundation.[1]

We are examining how multinational firms are globalizing their engineering and innovation and changes in the science and engineering education pipeline. The offshoring of science and engineering (S&E), high-end technology, and innovation work is the outcome of firms' strategy and organization, global human capital development and flows, and the nature of innovation activity in emerging economies. Our findings about these three changes are the basis for analyzing which jobs in the United States are affected by the development of offshore work, skill and education requirements for STEM work in the United States, and STEM workforce supply, and for a set of policy recommendations.

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The Urban Institute is a nonprofit, nonpartisan policy research and educational organization that examines the social, economic, and governance problems facing the Nation. The views expressed are those of the author and should not be attributed to the Urban Institute, its trustees, or its funders.

Summary

The following findings and policy implications are developed from my research on the globalization of innovation and engineering, and the U.S. STEM workforce education and supply.

Which STEM Jobs Face the Greatest Competition from Offshore Sites?

- Nearly all STEM jobs in the United States are already or potentially in "competition" with offshore STEM jobs. The historical advantages of advanced industrial nations may not last because of the rising capabilities of offshore workforces, changes in work process and communications, the potential transformation of product and service development and delivery, and innovation advantages in emerging economies.
- The impact of globalization on the U.S. workforce is not just determined by the increasing amounts of work done offshore. Although few jobs can only be done in the United States or other advanced industrial countries, STEM job growth in the United States can occur if the country can maintain a sufficient share of overall global market growth. This, in turn, depends on science and technology policy as well as other "competitiveness" factors.

Supply and Demand for STEM Workers

- The available data indicate that the United States' education system produces a supply of qualified STEM graduates in much greater numbers than jobs available. If there are shortages, it is most likely a demand-side problem of STEM career opportunities that are less attractive than career opportunities in other fields. However, standard labor market indicators do not indicate any shortages.
- Although there have been steady increases in the numbers of U.S. citizens and permanent residents pursuing a STEM education at both the undergraduate and graduate levels, the number of graduate students on temporary visas has also grown. It is unknown whether this indicates students on temporary visas are filling a demand for graduate students that U.S. undergraduate colleges cannot meet (serving as a complement to the domestic supply) or whether universities and companies are substituting temporary visa students for academically qualified U.S. students. Most likely, it is some of both, and there is a need for further research to determine the extent to which different immigration flows are complements versus substitutes.

Implications for Science and Engineering Education

- The standard education measures indicate there are enough students with the requisite skills to succeed in science and engineering courses of study, and managers we have interviewed rarely if ever note a lack of technical skills among their STEM workers.
- The skills STEM job applicants and workers lack are communication skills that enable employees to work across boundaries, coordinate and integrate technical activities, and navigate the multi-disciplinary nature of today's technical work. While solid math, science, and technology education is necessary to form the foundation for skills required by STEM workers, globally competitive education must go far beyond training technically competent graduates. A broad education that incorporates a range of technical and social science and humanities knowledge is important for developing a globally competitive workforce. In this, the United States currently has an advantage over the emerging economies.

A New Framework for Economic Growth

It is necessary to develop a new framework for achieving economic growth and prosperity based on a "collaborative advantage" policy framework. In brief, it is an approach that builds strength through participating in the global supply of human capital and innovation in collaboration with other nations. In addition, rather than taking a zero-sum approach to innovation, economic growth, and prosperity, this approach is based on mutual-gain strategies in which the growth in global markets provides expanding economic and job opportunities in all countries.

The United States is currently the best positioned country, I would argue, to lead this effort to establish a "global commons" of mutually beneficial global innovation and STEM workforces because of its history of openness, diversity, and free flow of knowledge, and because it is home to companies that are now leaders in developing globally distributed innovation systems (Lynn and Salzman, 2005). Learning how to maintain economic strength in this new world order, however, requires new policy approaches.

Background

Before examining these findings and policy implications in more detail, it is useful to understand the background to current globalization patterns. The important structural changes in the globalization of innovation involve changes in human capital flows and firms' organizational form, structure, and functioning. Additionally, there has been an "innovation shift" in which pioneering technology development is occurring in emerging economies. This leads us to question the longstanding views about the inherent innovation advantages of advanced industrial nations and particular regions, such as Silicon Valley. Theories of "geographical stickiness" propose that some regions have a unique mix of firms, capital, culture, and talent that makes them spawning grounds for innovation. Although these regions are likely to remain strong, the emerging economies are developing regional innovation clusters and industries that will be on par with those in the advanced industrial nations.

Internationalization of the Workforce

U.S. graduate schools and the workforce have become internationalized over at least the past 20 years. Students on temporary visas (recent immigrants) have generally made up between 20 and 50 percent of graduates of science and engineering graduate programs (with a few exceptions, such as petroleum engineers, of whom over 75 percent are foreign student graduates[2]) since the late 1980s (see Figure 1 for 1995 and 2005). Some programs, such as IT-related programs, experienced sharp spikes in the number of foreign student graduates in the late 1990s, but for most programs, there has been a slow increase or constant rate of foreign student enrollments over the past 20 years. Over this period, these graduates have entered U.S.-based firms and now make up a significant proportion of the science and engineering workforce, concentrated in particular occupations and industries (Table 1). A number of these scientists and engineers have now moved into senior technical and middle- and upper-level management positions. These workers, now in decision-making positions within firms, have the experience, familiarity, and linkages to facilitate the location of science and engineering work globally.

De-integration of the Firm

Historically, firms tended toward ever-greater integration of all parts of their production and services systems. This led to growth in organizational size and the scope of activities and functions. Firms also were firmly rooted in their "home" geographies, which aligned a firm's economic performance with that of the Nation in which it was based. Another structural shift that led to the current globalization of innovation began during the late 1980s. Out-sourcing began as large firms started buying rather than making commodity parts in manufacturing enterprises. Firms then expanded the scope of out-sourcing to the external acquisition of innovation and high value-added functions. This change in innovation strategy occurred throughout many industries and, in a remarkable shift, Wall Street now considers firms to be weak if they rely on strong internal R&D rather than external acquisitions of companies, innovations, or technologies. This change in organizational form is the foundation for the globalization of science and engineering work we are now witnessing. An international workforce facilitates this globalization by providing the cross-cultural experience and knowledge (it is argued that the more integrated organizational form and less international workforces of European and Japanese firms slowed their globalization, especially of high-level activities).

Innovation Shift

The third structural change is in the nature of innovation activity. There are at least three types of innovation shifts that provide advantages to emerging economies. First, in such areas as IT products and services, the initial offshoring of low-level activity (e.g., Y2K remediation) led to offshore companies implementing highly structured and systematized methods of developing software. As IT technologies mature, the innovation shifts from product development to process, which can lead to more reliable software.

[2] Throughout this paper, "foreign students" refers to students on temporary visas (generally indicating students immigrating to attend school); "U.S. students" refers to both U.S. citizens and permanent residents. "Immigrant workers" is based on country of birth as identified in Census surveys.

The second innovation change is in the types of innovation that come from the local context of the emerging economies. In previous stages of globalization, local innovation was confined to adapting existing products to local conditions. Now, the emergence of local innovation for local environments has not only global applications but can be a leading-edge innovation.

Third, innovation is occurring in both high-end and low-end technology. In the past, typically only high-end innovation pushed the technology frontier. Now, low-end innovation may provide opportunities for new technology development and high profit. For example, the high-end iPhone is predicted to capture something less than one percent of the global market (under 10 million units), whereas developing an innovative, cheap cell phone has potential sales in the hundreds of millions (China Telecom is already the largest cell phone company in the world with an estimated 300 million subscribers).

Importantly, innovation in emerging economy sites may be conducted in local or foreign-owned firms. Conversely, innovation developed in a company's home country in advanced industrial nations may be transferred to locations elsewhere in the world. Leading innovation in a U.S.-based company does not necessarily mean the innovation activity or its benefits will accrue to the United States—it doesn't mean that it won't, but the inherent or taken-for-granted advantage to the United States of U.S. company innovation is increasingly uncertain.

This analysis of the changes in the globalization of science and technology sets the background for considering the workforce implications.

Which STEM Jobs Face the Greatest Competition From Offshore Sites?

Little can be predicted about the inherent qualities of STEM jobs that make them more or less competitive vis-á-vis workers in low-cost countries. A number of analysts argue that certain types of work are unlikely to be offshored, such as very high-end science and engineering work or jobs that require face-to-face interaction. An analysis of the relative growth of industries and employment opportunities for the U.S. workforce may be more important than an analysis of which jobs are inherently limited to the United States. That is, overall market growth is more likely to sustain U.S. workforce growth than is an attempt to maintain an exclusive share of certain jobs. The current U.S. IT workforce, for example, is certainly smaller than if all the global IT work were being done here. Yet, the U.S. IT workforce is not appreciably smaller now than it was in the past because of the global growth in demand for software services. At the same time, large numbers of IT workers have been laid off or forced to change jobs as a result of global shifts in the location of different types of IT work.

Job Offshoring

As the supply of skilled workers develops across the globe, firms will not decide to locate work in the United States just because there is a large supply of skilled labor here. If the supply is already adequate elsewhere, as all indicators suggest, then increasing the supply here will not make the United States more attractive to firms. If, as we find, there is not a problem of supply of STEM workers in the United States, then what about the cost of STEM labor? Although cost is certainly important, particularly in the initial phases of offshoring, over time it becomes less important, particularly for high-end work. The wage-cost differential is declining, and when we include the coordination costs of travel and communications, we estimate the *net* cost savings of offshore STEM work is under 30 percent and shrinking. Further, for the *highest* levels of work, firms are not likely to jeopardize their innovative capabilities for marginal cost savings on a comparatively small portion of their workforce and wage bill. Now this is not always true, and it is not true for lower-level S&E work, but for high-level work, cost often becomes a secondary factor, as I will explain.

In our research examining case studies at 67 sites of multinational and entrepreneurial firms, several technology and innovation patterns emerged (Lynn and Salzman, 2007). First, firms typically begin by locating lower-level work in their offshore site, but as these sites develop their capacity—hiring and training more educated and skilled workers, attracting emigrants to return—they engage in "engineering creep," that is, the firms expand the range of work the offshore STEM workers do, sometimes as a complement to what is being done in the firm's home country sites, other times substituting for it. The progression up the "innovation value chain" is a new developing phenomenon, and we do not see any indication there are inherent limits to the level of activity that can occur in emerging countries. Human capital is becoming ever-more available, and financial capital is available as well.

The large markets in China, India, Brazil, and elsewhere lead firms to make the investments even for expensive labs and development facilities in these countries.

Some argue that the path for the United States is to move to the top of the value chain with highly skilled work, or creative work, and to abandon low-skilled work (e.g., NCEE, 2007). Others identify jobs that can't be offshored as personal services work (jobs that require face-to-face interaction) (Blinder, 2007). This proposition fails to account for the transformation that can occur in the structure of jobs requiring face-to-face interaction. For example, we visited a firm that does patent filings, financial analyst work, and other types of highly skilled professional services. Their approach is to restructure high-end work so that only the bare minimum of face-to-face interaction is necessary. Thus, they claim many professional services can be reduced to 10 or 15 percent direct contact in the United States, while the vast bulk of the work is done offshore. Alternatively, the rise of medical vacations, for instance, transports the customer to the offshore site for personal service.

These examples illustrate that firms are examining a range of STEM jobs that can be globalized. Recall that fewer than ten years ago, the consensus was that software could not be developed by teams separated over long distances. Microsoft was known for consolidating nearly all development in one physical location to facilitate knowledge transfer, typically transferring staff of acquired companies to their Redmond campus.[3] Even more recently, a number of high-tech executives said they wanted to keep their work located in the United States because "it helps to have a concentration of researchers in the same place, where they can interact over the water cooler and at the baseball game, as well as on the computer screen" (*Wall Street Journal,* 2006).

From our research, it is difficult to draw any firm conclusions about the types of STEM jobs or activities that will necessarily stay in the United States. Multiple factors drive the development of offshore capabilities, and the global strategies of firms go far beyond cost factors. Although some types of work may be difficult to conduct over long distances or asynchronous work shifts, firms respond to these limitations by restructuring how the work is done and by moving the work to offshore sites.

However, this does not indicate an imminent threat to higher-level S&E jobs: although globalization may limit the expansion of a firm's U.S. workforce, firms are unlikely to immediately abandon their U.S. sites due to their workforce's deep skill and experience. Firms' large investments in facilities and people are not easily replicated elsewhere. Moreover, the United States still has knowledge and capacities within its universities and organizations that are not available in the emerging economies. At the same time, there are impending shortages of workers offshore with the necessary skills and experience, so we should expect emerging economies will develop these capabilities at levels approaching those of the United States. Although there may not be precipitous declines in U.S.-based S&E work, growth is likely to be faster offshore, and some types of work may have faster offshore growth in the short-term, such as IT work.

For these reasons, current policy proposals that focus on skill development or increasing the size of the STEM workforce may be counterproductive. Without evidence of the corresponding demand for these workers, merely increasing the supply will potentially reduce the quality of jobs and discourage the next generation of students from pursuing STEM careers.

Supply and Demand for STEM workers

Common to many policy reports is a call for large increases in the STEM workforce, and K–12 improvement in math and science as the means of achieving this increase.[4] The data do not reflect the claim that U.S. students show declining interest in science and engineering fields, either in college or in entering the workforce. There was a one-time dramatic "Sputnik Spike" of students entering STEM fields in the early 1960s, followed by a sharp decline and then a gradual increase beginning in the mid-1970s and continuing until today (see Figure 3). The actual numbers of STEM college graduates has increased over the past three decades and held steady in recent years (Figure 4). The "continuation rate" of S&E Bachelor's graduates going on to graduate school, following the early 1960s spike and then decline, has also remained at a steady rate for the past two decades (Figure 5). The major change since the 1960s, of course, has been the large increase in foreign-born stu-

[3] In an analysis of Microsoft by Cusamano and Selby (1995, 12, 105, 244), the company's strategy is to "learn by doing" rather than have formal training programs, supposedly a necessity in "a fast moving industry."

[4] The following sections draw on, and are excerpted from, an analysis by Lowell and Salzman (2007).

dents (on temporary visas) entering graduate school (Figure 6) and the workforce (Figure 2).

From 1993 to 2002, U.S. colleges produced on average about 380,000 STEM Bachelor's degree graduates, over 70,000 Master's degree graduates, and nearly 20,000 doctoral graduates. Is that enough? The answer is not straightforward. We need to know what the employment demand is, whether the overall supply of graduates interested in entering STEM employment is equal to or greater than the number of openings (demand), and whether individuals not entering STEM employment are pursuing other careers because they are not interested in a STEM career, or could not find a job, or are not qualified for the STEM jobs that are available.

Are There Enough S&E Graduates?

To begin, it is important to know whether the production of domestic STEM college students is anywhere near the apparent demand for STEM workers. Looking at graduates and workforce growth, we can estimate an order of magnitude but not a precise calculation. Net workforce growth does not account for replacement needs due to retirement or to workers changing careers, and the supply of college graduates doesn't account for workers entering the workforce without a college degree or without a STEM degree (e.g., in IT occupations, up to 40 percent of workers do not have a four-year college degree).

The overall STEM workforce totals about 4.8 million, which is less than a third of the 15.7 million workers who hold at least one STEM degree. STEM employment is also a fairly consistent one-third of STEM graduates each year. From 1985 to 2000, the United States graduated about 435,000 S&E students annually with Bachelor's, Master's, and doctoral degrees—that total includes only U.S. citizens and permanent residents (about 72 percent of STEM workers hold a Bachelor's, 20 percent a Master's, and seven percent a doctorate degree). Over the same period, the net change in STEM occupational employment ran about 150,000 annually, such that the average ratio of all STEM graduates to net employment change was about three to one.[5] Of course, net employment growth is not a direct measure of employment demand or total job openings, since net growth does not include replacement for retirements or occupational quits, nor do these aggregate numbers indicate the types of workers sought (education level, experience, etc.). Moreover, it does not address future changes in supply or demand. But it certainly is suggestive that plenty of STEM students have been graduating relative to employment growth in STEM occupations.[6]

Naturally, not all STEM graduates will enter a STEM job, whether because of a change in interest, because their qualifications are not adequate, or because they never intended to enter a STEM career in the first place. However, there is a surprisingly low rate of STEM retention for the 1993 to 2001 cohorts of STEM graduates. One to two years after graduation, 20 percent of STEM Bachelor's are in school but not in STEM studies, while another 45 percent are working but in non-STEM employment (total attrition of 65 percent). One to two years after graduation, seven percent of STEM Master's graduates are enrolled in school but not in STEM studies, while another 31 percent are in non-STEM jobs (total attrition of 38 percent) (NSF, 2006, Table 3).

The STEM Job Market: What Is the Nature of the Demand?

The pathway from high school student to college graduate has a number of transition points that are the primary focus of current policy initiatives. The goal of these initiatives is to increase the flow into, and retention within, the STEM education pipeline. However, the data we have reviewed suggest that secondary and higher education systems are providing a more than adequate supply for industry's hiring needs. Of course, these are aggregate numbers, so there still could be shortages for particular occupations or industries. Also, targeted initiatives to increase the flow

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[5] Calculations made by the authors based on data on graduates and S&E employment for every second year from 1985 through 2000; the ratio is based on three-year moving averages of net employment growth.

[6] This simple calculation appears not to square with a comparison of the annualized growth rate of STEM graduates and jobs from 1980 to 2000. That calculation finds that the annual growth rate of STEM graduates at all degree levels is about a third of STEM employment growth (1.5 versus 4.2 percent annually). But the rate of growth argument is somewhat misleading, as the slower growth rate of STEM graduates is, as noted here, based on a far larger number than the smaller but more rapidly growing number of STEM jobs. At first blush, one might assume the number of graduates and jobs does not converge for about 20 years (see Science and Engineering Indicators, Appendix Table 3–2, *http://www.nsf.gov/statistics/seind06/pdf_v2.htm*).

of under-represented demographic and income groups are warranted to increase workforce opportunity and workforce diversity. But overall, addressing the presumed labor-market problems through a broad-based focus on the education system seems a misplaced effort. Whether increasing the supply of STEM-educated workforce entrants would have any significant impact on workforce supply (given a graduate pool already 50 percent larger than annual openings) is a question that requires a better understanding of the labor market for these graduates. Moreover, increasing the education supply with such low yields seems a highly inefficient approach without a better understanding of the factors involved in the transition rates at all points along the pathway.[7]

A few labor market studies, notably by Richard Freeman and colleagues (2004, 2006), have focused on the quality of STEM jobs. These studies conclude that the decline in the native STEM worker pool may reflect a weakening demand, a comparative decline in STEM wages, and labor-market signals to students about low relative wages in STEM occupations. Indeed, research finds that the real wages in STEM occupations declined over the past two decades and labor-market indicators suggest little shortage (Espenshade, 1999). Some researchers see these demand-side market forces causing highly qualified students to pursue other careers. A well-accepted model of cyclical patterns of student and worker supply is the cobweb model (Freeman, 1976). This research finds, in accordance with market mechanisms, that an increase in wages leads to an increase in job seekers but, in turn, a large supply of job seekers can depress wages. Declining wages will result in reduced student enrollments, although there is a lag in enrollment response. For example, research finds that a previous decline in mathematics enrollments through 1996 corresponded to this cycle (Davis, 1997). For this reason, caution is needed in increasing the supply of STEM graduates, particularly at the graduate degree level, without considering the level of demand and impact on future supply.

Where's the Problem? Hiring Difficulties Versus Labor Market Shortages and Perceptions About the Future of Science and Engineering

It is generally asserted, without much evidence, that education deficits are responsible for the difficulty employers experience in hiring. It is important to distinguish between the problems an employer may have hiring the people he or she wants and an actual shortage of workers or potential workers. Although there may, in fact, be a labor market shortage, all the evidence cited in various policy reports is entirely individual employer accounts of problems in hiring. The industries most vocal about labor market shortages and the need to import workers may be voicing unrealistic expectations of desired work experience more than deficiencies in the skills or education of a new hire, or just dissatisfaction with the cost of labor.

In previous research (Lynn and Salzman, 2002), we found that managers in engineering and technology firms do not claim a shortage of applicants, nor do they complain about applicants with poor math and science skills or education. They do often note difficulty in finding workers with desired experience, specific technical skills, or a sufficient number of "brilliant" workers in the pool.[8] The complaint, quite often, appears to be one of unrealistic expectations, as unwittingly illustrated in a recent *BusinessWeek* (2007) article on labor shortages. In this article, a company president described the current labor shortage as follows: "There are certain professions where skills are in such demand that even average or below-average people can get hired." It is difficult to consider an inability to only hire above-average workers a labor market shortage. Complaints also reflect firms' dissatisfaction about the need to train new entrants; often at issue is whether firms or education institutions should shoulder the costs of training new hires.

Other than frustration at not having an applicant pool at the tail-end of the skill distribution, the skills deficits most likely to be mentioned are the "soft skills" of communication and the ease of working across organizational, cultural, and disciplinary boundaries (Lynn and Salzman, 2002; Salzman, 2000). Science and engineering

[7] There is little comprehensive, systematic research on how college students choose a STEM career, either on the process or the factors that influence those choices. Standard labor-market economics theory focuses on the marginal impact of wage rate differentials. Research on career counseling is focused on matching interests and occupations, based on the assumption that interests are more or less fixed. The science and engineering communities have launched education and outreach programs to high school students to increase interest in those fields. And some observers focus on the overall appeal of an occupation based on its job quality and content of work as important factors influencing its attraction to potential entrants. There is some research that sheds light on the role of these different factors in labor supply.

[8] Employers may complain of difficulties in hiring experienced workers with specific skills, such as JAVA programmers with 10 years experience, but these "shortages" are not the result of insufficiencies in the education system.

firms most often complain about schools failing to provide students with the non-technical skills needed in today's firm.

It is also worth noting that, more generally, employers do not complain about the math and science skills of employees hired for professional positions. In a study of engineering skills, managers did not identify technical qualifications as a concern. Employers' complaints about math skills typically involve examples of retail workers who can't count change or clerical applicants who lack basic literacy. And even for these levels, the need is for a broad array of academic, social, and communication skills (Murnane and Levy, 1996).

If, as we argue, there is a sufficient potential workforce and any shortages are due to the inability of firms to induce more of those who are STEM qualified into STEM careers, then it is important to examine other factors that influence career decisions and hiring difficulties. In addition to wages, there is also the impact of perceived career opportunities and uncertainty. The current heated debate about the offshoring of engineering and other high-skill work should be expected to affect students' career choices. Although some analyses find relatively small numbers of jobs lost to offshoring, the *perception* about *future* opportunity is likely to affect a student's assessment of future opportunities as much as, or more than, tallies of current jobs available. These perceptions are not just the result of inflamed media commentators; even the business community appears to be undecided about the future course of its job location decisions. For example, in a bid to increase visa caps, a number of high-tech CEOs discussed the demand their companies had for U.S.-based science and engineering workers to a *Wall Street Journal* reporter in June, 2006:

> Mr. McNealy says Sun does 75 percent to 80 percent of its research and development in the U.S. Craig Barrett, Chairman of Intel Corp., says his company also employs most of its researchers in the U.S. and wants to keep it that way. The reasons? . . . "If engineering is happening here in the U.S., I think my children will have a richer work environment." (*Wall Street Journal,* 2006)

However, college graduates might have been influenced by an announcement Sun made to Wall Street analysts in May 2005:

> Sun Microsystems Inc. has chosen four of its facilities around the world *to take the place of its Silicon Valley office as the research and development hub*. . . .. "We are over-invested in high-cost geographies like the U.S., and under-invested in low-cost geographies like India," . . . the company's Senior Vice President of Global Engineering told reporters in Bangalore. [He] said the company will not lay off programmers in the U.S.—but won't hire many, either. . . . The company has reduced its staff to about 30,000, from roughly 43,000 four years ago. (Associated Press, 2005; emphasis added)

One can imagine that companies who are offshoring would have hiring problems even with an adequate labor market supply in the United States. Similarly, IT executives calling for greatly increasing, or even completely removing, numerical caps on foreign worker visas (e.g., the H–1B) may be sending strong signals to students and current workers about diminished career opportunities. Human capital is a long-term investment and potential STEM students read all the tea leaves before investing. We have conducted interviews with current managers and engineers who believe that there is little future in entry-level engineering jobs in many industries, and IT in particular. Not only will it be difficult to fill mid-level and higher-level positions from an inexperienced workforce that never had an entry-level position, but several future generations of workers, currently in school, are developing their work interests and career aspirations based on their perceptions about the future state of labor markets. A range of public policies, such as immigration policy and corporate practices such as offshoring R&D, affect the current workforce and future generations as well.

Content of Engineering Work

There is also some evidence that the content of engineering work, and the overall working conditions are less appealing today than in the past. From our current study of engineering, we often heard engineers and managers noting the lack of motivating science and engineering "problems" or challenges, like those of the early days of IT, and the lack of national purpose that was evident during the heyday of the space program. Engineers and managers interviewed also pointed to changes in both the substance and process of engineering. Projects are larger, team efforts, and require more coordination and management (whether because of out-sourcing, systems integration, or increased scale of the technology, such as large enterprise resource planning systems). Developing and building many types of technology may be more routinized and less challenging or interesting than before. As one colleague expressed it, "How many 'real' engineers does it take to build a bridge?"[9] These are attributes of both the intrinsic interest of the field and the cultural milieu, or zeitgeist, of science and engineering. Although these factors are difficult to measure, they were noted by interviewees as often as diminished job prospects in explaining why they would not enter the field today.

Some STEM graduates simply leave the field because they lose interest in the application of their training or, more prosaically yet, they find that the labor market pays more for them to take other jobs (e.g., Freeman, 2006). It is thus important to examine the full spectrum of labor market signals that can influence student and worker career choices.

Finally, it is important to understand the different STEM labor markets by industry, occupation, geography, and demographic. The labor market studies examine market conditions that may influence career choice in the aggregate. Less often do these studies examine choices by different demographic groups on entering specific STEM occupations or industries. For example, some STEM occupations appear to attract large numbers of traditional STEM students—U.S. native white males—but in others females outnumber males, and other occupations are disproportionately filled by immigrants. It is important also to understand specific industry dynamics. The IT industry labor market may be different from that of biotechnology or mechanical engineering (e.g., 40 percent of the IT workforce does not have a four-year degree; biotechnology has one of the largest concentrations of Ph.D.s in industry; engineers predominantly have only Bachelor's degrees). Although the labor market analyses examine changes in relative wages for STEM jobs and non-STEM jobs with similar education requirements (e.g., other professional jobs), they have not so far determined what affects the industry and occupation decisions of today's young people who could potentially enter STEM careers.

Implications for Science and Engineering Education

This analysis of globalization has implications for both the specific educational needs of scientists and engineers and broader educational directions. First, I review the types of skills and education that businesses need as reported by managers in technology firms (Lynn and Salzman, 2002). Second, I discuss the broader educational needs and goals implied by our analysis of global shifts in innovation and technology development and by an economic strategy based on collaborative advantage. Finally, I raise questions about the policy recommendations that the U.S. workforce skill and education efforts can or should be focused on "top of the value chain" jobs and the implications for the U.S. position in the global economy.

Skill Requirements

Over at least the past ten to fifteen years, organizational, technological, and business strategy changes have led to new skill requirements for engineers and other technical workers. The de-integration of technology activity requires engineers to work across organizational boundaries with suppliers. Products that incorporate or have tightly integrated technology of different types, such as electronics and machines, or different materials, require engineers to work across disciplines, both within and outside of engineering. Business strategy that places more emphasis on market-driven technology development also requires engineers to understand the business drivers as well as the technical drivers of product or service development.

These different boundary-spanning skills and abilities are increasingly important, especially in firms that are systems integrators or are at the higher value-added part of the development chain. Managers typically said that technical skills were fairly easy to find and not a distinguishing criterion between candidates. Setting good employees apart were their ability to communicate their ideas, to work with others on a team and with non-engineers, and other related social skills. These skills reflect the changes in the nature of engineering work, ranging from greater teamwork, working across disciplines, with customers, and interacting with customers and suppliers in developing and acquiring technology (Lynn and Salzman, 2002).

[9] Michael Horrigan, an economist at the Bureau of Labor Statistics, suggests that between the advances in knowledge for many engineering undertakings and technology shifts, say in using more engineering software, the role of engineering has likely changed and it may be that fewer jobs involve the engineering challenge of yesteryear (Personal communication, January 13, 2006). In our studies of engineering, we find that out-sourcing and offshoring lead to new engineering management layers and engineers comment that they now manage engineering projects rather than engage in "real" engineering. Others have commented that engineering is less central to "innovation" or at least product development than design, marketing, and other areas.

More recently, the global distribution of engineering has added another layer of technically adept but non-technical positions. Increasingly the ability to span cultures and nations is a key attribute. In this respect, we found global engineers and managers were often not born in the U.S. though educated here. Their experience across cultures and mixed national identities allowed them to move easily between and manage across global sites of the company.

In summary, we consistently find employers in technology firms most valuing the boundary-spanning skills that require adroit communication and an ease at working outside of a narrow field of expertise or technical training. In nearly all cases managers found a plentiful supply of technically qualified applicants and hiring decisions were made on the basis of their non-technical skills. While many of these skills can be provided through broad-based, multi-disciplinary education, some of the skills appear to come from cross-national experiences. In most cases, although these people were educated in the United States they were not born here and had lived in more than one culture. Perhaps this can be taught, but it may also require educators to incorporate cross-national experiences as part of technical training.

Implications for Education Policy

Solid math, science, and technology education is necessary to form the foundation of skills required by STEM workers. However, globally competitive education must go far beyond training technically competent graduates. A broad education that incorporates a range of technical and social science and humanities knowledge is important for developing a globally competitive workforce (e.g., see Hill, 2007). In this, the United States may have an advantage over the emerging economies. Trying to compete on the basis of sheer numbers of technically competent scientists and engineers is untenable and probably not the basis for achieving sustainable economic growth. Further, it is unlikely that a deficit of technical skills in the U.S. is leading to global diffusion of S&E work and innovation.

Importantly, although small numbers of individuals are credited with creating breakthrough innovations, it may be a mistake to focus so keenly on education targeting the upper reaches of the technical workforce. Under-estimated in many analyses is the role of lower-level workers in achieving high productivity and economic growth. For example, although innovating a better computer network server is important, it is the legions of network administrators and technicians that affect how much of the potential productivity gains are realized from the technology. Similarly, throughout many types of work, the skills and aptitudes of lower level workers have individually small but cumulatively large impacts on the economy.

A common but mistaken view of the future U.S. competitiveness focuses on maintaining a position at the "top of the value chain." Some of these scenarios imply that in ten or so years most of the U.S. workforce will be employed in "creative work" with low-skilled jobs located in emerging economies or done by machine. This prescription errs in two respects. First, the workforce is unlikely to undergo a shift in its skill/job distribution of the magnitude implied by this prescription. The vast majority of the workforce currently are in jobs far from the level of "creative" and highly skilled work that is predicted to characterize the future U.S. economy. Wal-mart alone employs 1.2 million workers, with most earning less than $10 an hour. Restaurant and retail workers combined constitute the largest employment grouping in the U.S. labor force. Science and engineering jobs make up only five percent of all occupations, and even in highly technology-based industries, such as electronics or aerospace, the S&E workforce is well under 50 percent. Only in computer systems design and architectural and engineering services does it exceed half of their total workforces (57 percent and 58 percent, respectively; see Tables 2–4).

Secondly, this scenario assumes that the United States can dominate innovation and creative work globally. Every indication from our field work and review of current trends suggests it is highly unlikely that this work will be as geographically contained as it once was. As discussed above, firms have largely abandoned this old model and are globally distributing all types of work. It is not clear how the U.S. could achieve the dominance of global STEM work advocated in many policy reports when firms increasingly have "top of the value chain" work globally distributed.

The global position of the U.S. may be changing but the data do not suggest a precipitous decline in science, math, and engineering performance or an inability to educate large numbers of qualified scientists or engineers is the cause. At the same time, the large numbers of low academic performers should be a cause for concern and should be the focus of competitiveness policy.

Conclusion and Policy Discussion

Current policy is driven by the twin perceptions of a labor market shortage of scientists and engineers and of a pool of qualified students that is small in number and declining in quality. Math and science education are viewed as the primary policy levers to increase labor market supply, supplemented by increased immigration. But the data show little evidence to support those positions, and, in fact, indicate an ample supply of students whose preparation and performance has been increasing over the past decades. We are concerned that the consensus prescriptions are based on some misperceptions about efficient strategies for economic and social prosperity.

Assessing the claims of labor market shortages is crucial. Purported labor market shortages for scientists and engineers are anecdotal and not supported by the available evidence. Little analysis has been conducted of firms' hiring difficulties and the supply of workers. A particular employer's or industry's experiences in hiring could be the result of any number of factors. The assumption that difficulties in hiring are due just to supply can have counterproductive consequences: an increase in supply that leads to high unemployment, lowered wages, and a decline in working conditions will have the long-term effect of weakening future supply by discouraging current students. Moreover, by bringing immigrants directly into the STEM workforce but without the attachments immigrants develop through longer residency and schooling in the United States, there is likely to be greater geographical workforce mobility. As the physical infrastructure of emerging nations improves and they retain more of their skilled STEM workers, the location of innovation and R&D is likely to follow.

Investing in domestic human capital can provide longer-term benefits to the United States, and a collaborative approach with other countries will capture the benefits of their human capital development rather than trying to absorb it through short-term immigration to address short-term hiring needs (Lynn and Salzman, 2006, 2007). The characteristics of human capital development and employment are qualitatively different from that of prior periods, and we should not fall back on past approaches to policy. Instead, evidence-based policy is necessary for developing effective programs for the emerging global economy.

Policies to Strengthen U.S. Science and Engineering Capabilities

Our analysis suggests several education and policy recommendations that will strengthen U.S. science, technology, and innovation.

1. Emphasize a broad education rather than a narrow technical education. Math and science skills are not what employers report being in short supply among their professional and technical workforce. An over-emphasis on math and science could lead to the exclusion of the skills employers report most needing among their STEM workers. At the same time, it is important to broaden the content and improve the pedagogy of science and math throughout the education system, at primary, secondary and college levels. There are a number of efforts under way to improve science, math, and engineering education; additional support and diffusion of new curricula would be beneficial.

2. Expand the opportunities to enter a STEM career to populations currently under-represented. A number of programs encourage under-represented and minority high school and college students to enter STEM study and careers, such as those developed by the National Science Foundation. Improving the education of low-performing students and schools can expand the pool of qualified students motivated to enter a STEM career because of their intrinsic interest in these areas and because these fields offer attractive career opportunities. Increasing workforce diversity and equity also serve broader social and economic goals that strengthen the United States.

3. Encourage complements rather than substitutes in the labor market through immigration policy. The H–1B program is cited repeatedly by technology workers as a factor in their perceptions of diminished opportunity. Instead, visas offered after completing a U.S. graduate education would expand the STEM workforce with workers who are likely to have more attachment to the United States and stronger ties to U.S. colleagues even if they return home. It could also serve as a means of attracting higher skilled and more academically talented workers.

4. Evaluate the STEM supply and production by colleges. Government funding of STEM graduate program (e.g., via fellowships and research assistantships) should be adjusted to reflect market demand. Perhaps larger fellowships for a smaller number of recipients would improve quality and not depress wages. It may be better to control supply at the point of graduate school entry than after graduation and after a great deal of public and private educational investment. Discouraged graduates send negative signals to students further down the pipeline. Increased competition for fewer graduate slots would increase the value of the degree. As long as the supply of workers is far in excess of demand, as it currently appears to be, reducing the number of STEM graduates will not create a shortage and will increase the desirability of these careers as well as the quality of the graduate pool. Since it is not just wages but also longer-term employment prospects that affect STEM career decisions, this is one means of improving career opportunities.

5. Establish international labs, similar to the model of the U.S. national labs. Taking the lead in developing the structure and terms of participation in the global commons will provide the United States continued access to innovation and knowledge around the globe. It will also create new and exciting opportunities for U.S. STEM workers as well as integrate global STEM workers into networks in which the United States participates. This is one means of benefiting from global human capital development without substituting it for domestic STEM workers.

6. Focus innovation and technology policies on pressing global problems and technology that meets global needs. Understanding the innovation frontiers—not just high-end technology—and addressing global problems should be a key aspect of R&D policy. In particular, a focus on innovation under resource constraint, such as limited energy, will lead to innovations applicable to emerging markets. Many firms are doing this, but in other countries. Developing leading expertise in the U.S. will keep the United States engaged in global technology development.

7. Develop policy frameworks based on collaborative advantage and participation in the global commons of innovation. Trying to develop dominance or supremacy will not garner the support of other countries or the large segment of the U.S. STEM workforce that has some interest in seeing the development of their countries of origin.

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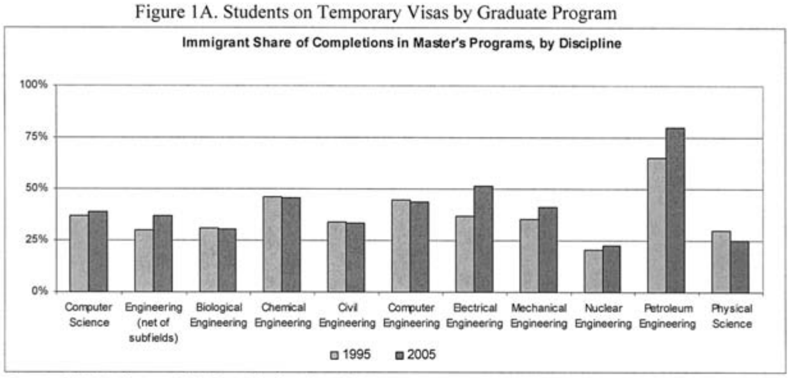
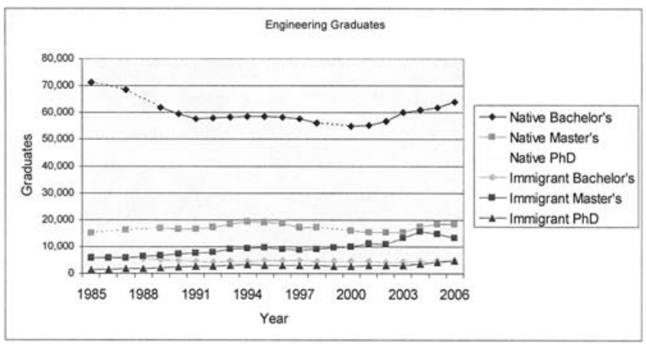
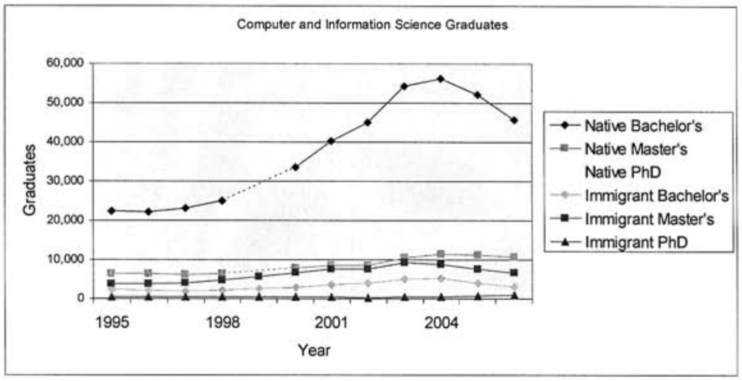
Figure 1A. Students on Temporary Visas by Graduate Program

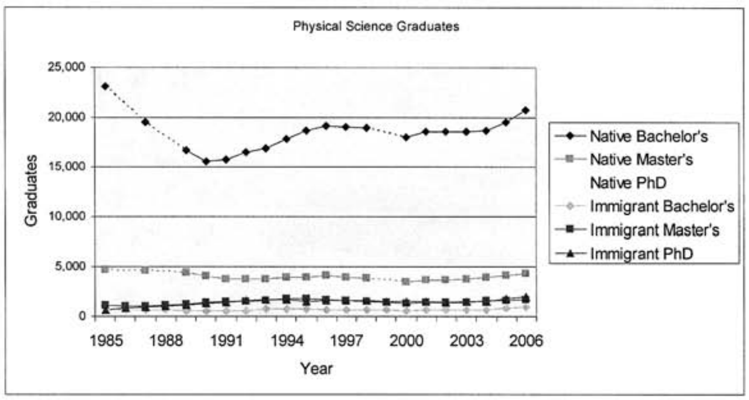


Sources: NSF, Indicators; IPEDS, tabulations by authors

Figures 1B–1D. Enrollment for Selected STEM Fields by U.S. and Temporary Visa Students




Computer and Information Science Graduates
60,000
50,000
40,000
30,000
20,000
10,000
0
Graduates
1995
1998
2001
2004
Year
Native Bachelor's
Native Master's
Native PhD
Immigrant Bachelor's
Immigrant Master's
Immigrant PhD


Physical Science Graduates
25,000
20,000
15,000
10,000
5,000
0
Graduates
1985
1988
1991
1994
1997
2000
2003
2006
Year
Native Bachelor's
Native Master's
Native PhD
Immigrant Bachelor's
Immigrant Master's
Immigrant PhD

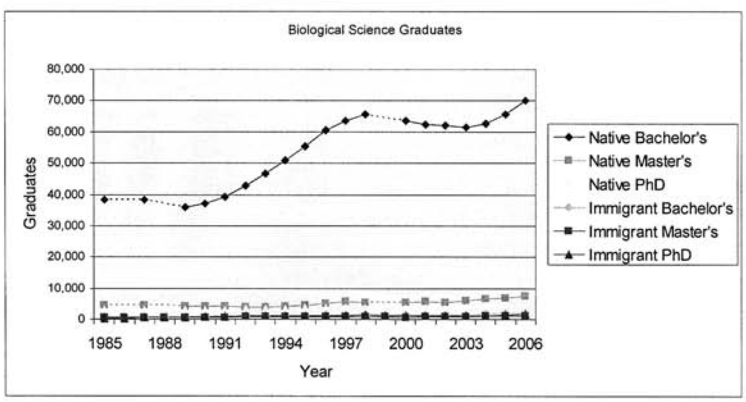

Biological Science Graduates
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Graduates
1985
1988
1991
1994
1997
2000
2003
2006
Year
Native Bachelor's
Native Master's
Native PhD
Immigrant Bachelor's
Immigrant Master's
Immigrant PhD

Table 1. Immigrants in Workforce, Occupation by Industry (percent)

Selected Core S&E Occupations with Large Workforce and/or High Immigrant Percentage

Cells with above all industry mean (> 19%) immigrant percent	Computer scientists and systems analysts	Computer program-mers	Computer software engineers	Civil engineers	Computer hardware engineers	Electrical and electronics engineers	Industrial engineers, including health and safety	Mechanical engineers	Medical scientists	Astronomers and physicists	Chemists and materials scientists
Electric power generation, transmission, and distribution	–	23	20	–	–	–	–	–	–	–	–
Pharmaceutical and medicine manufacturing	22	35	24	–	–	20	–	–	40	–	32
Industrial and miscellaneous chemicals	–	19	–	–	–	–	–	–	–	32	20
Computer and peripheral equipment manufacturing	30	29	39	37	40	22	29	37	–	45	63
Communications, audio, and video equipment manufacturing	24	35	41	29	41	29	19	37	–	25	–
Navigational, measuring, electromedical, and control instr.	–	–	23	24	22	–	–	–	–	27	44
Electronic component and product manufacturing, n.e.c.	29	35	41	25	50	35	28	26	–	–	29
Aircraft and parts manufacturing	–	–	–	–	–	–	–	–	–	–	–
Aerospace product and parts manufacturing	–	–	–	–	31	–	–	–	–	23	–
Medical equipment and supplies manufacturing	–	24	31	–	63	–	–	19	24	24	32
Radio, TV, and computer stores	29	27	32	–	36	24	37	42	–	–	–
Wired telecommunications carriers	21	31	40	31	50	23	27	–	–	–	–
Other telecommunication services	19	35	43	–	64	34	34	25	–	–	–
Other information services	21	27	41	–	57	42	–	47	–	–	–

Data processing services	–	23	29	–	–	–	–	31	–	–	71
Banking and related activities	22	32	37	–	40	–	–	–	–	–	–
Securities, commodities, funds, trusts, and other financial	26	42	41	–	62	–	–	.	–	–	–
Architectural, engineering, and related services	–	19	19	–	22	20	21	20	–	21	–
Computer systems design and related services	28	30	39	33	37	30	35	29	74	–	–
Management, scientific, and technical consulting services	25	36	36	25	27	25	20	19	23	–	–
Scientific research and development services	–	25	25	–	–	21	–	–	49	29	25
Colleges and universities, including junior colleges	22	25	24	20	24	29	–	31	51	41	43

Source: 2000 U.S. Census; tabulations by authors

Figure 2.

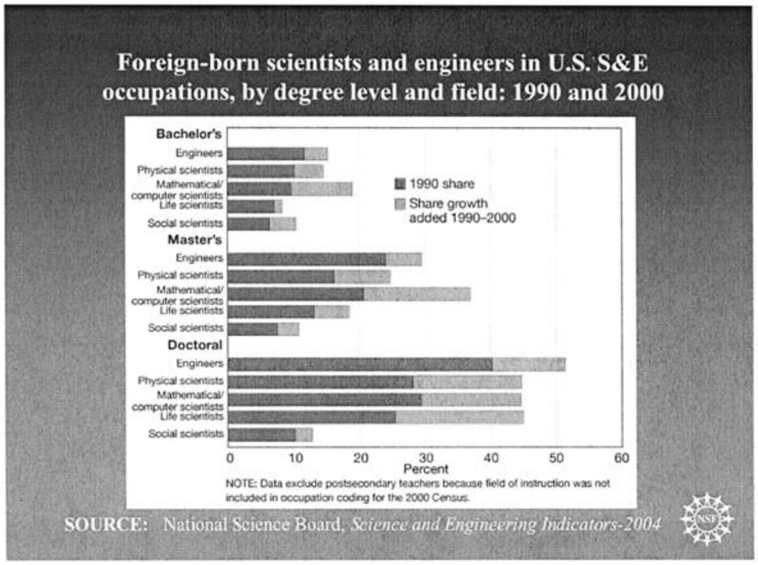
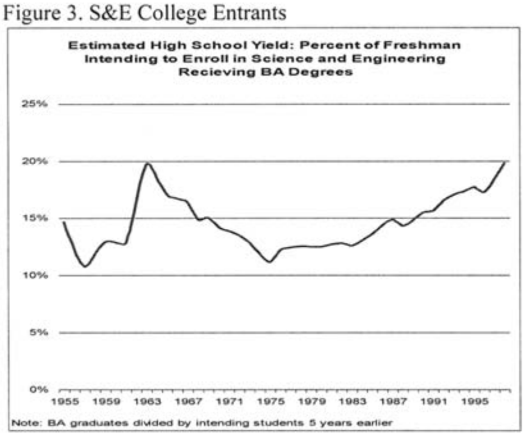
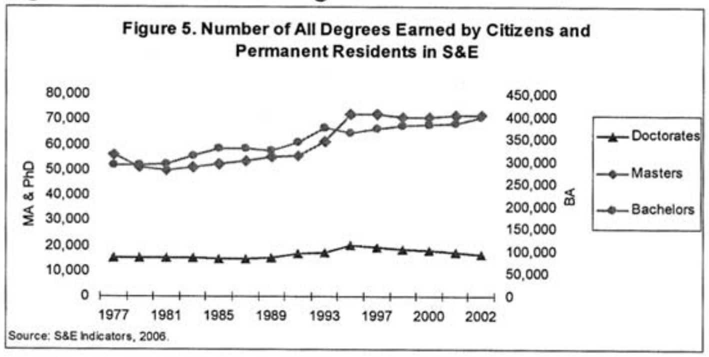
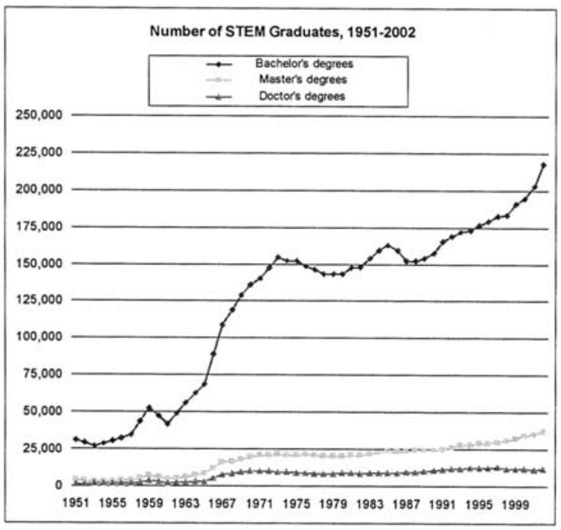


Figure 3. S&E College Entrants

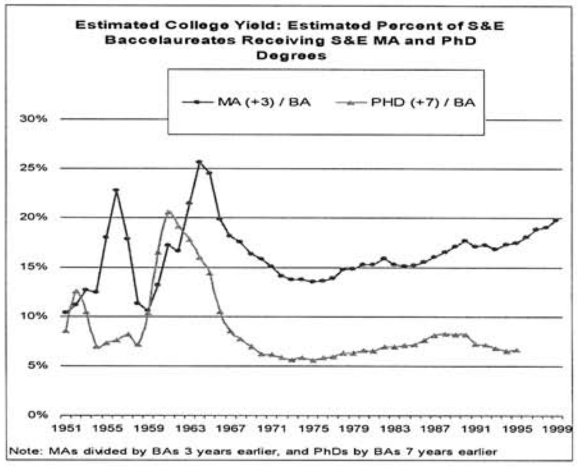


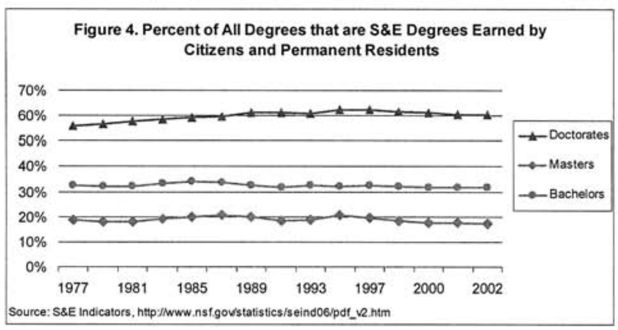
Figures 4A–B. S&E College Grads





Figures 5A–5C. S&E Bachelor Graduate Matriculation to S&E Graduate School and the S&E Workforce





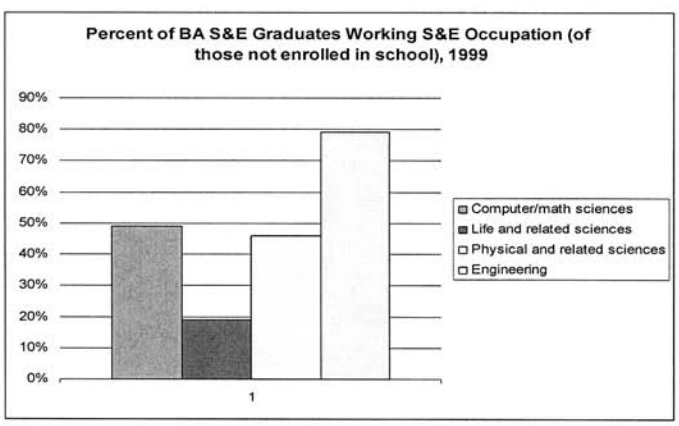


Figure 6. Temporary Visa Grad Students

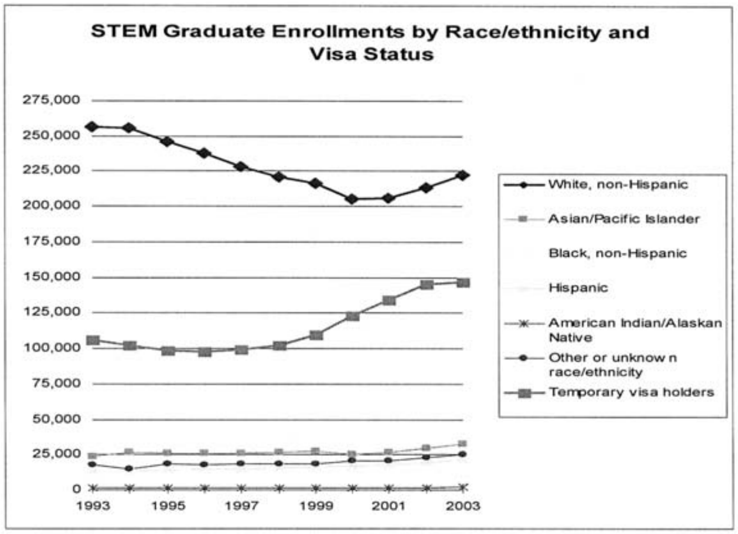


Table 2. Industry and S&E Employment by Size of Industry (> 750,000 Employees)

Code	Industry	Workforce Counts: Total Workforce	Workforce Counts: S&E Workforce, Total	Workforce Counts: S&E Workforce, Core S&E	S&E % of Total
	Totals / Average	167,996,851	8,102,712	5,113,526	5%
77	Construction	11,466,171	202,786	131,355	2%
786	Elementary and secondary schools	9,451,464	83,589	21,067	1%
868	Restaurants and other food services	9,351,427	7,833	4,306	0%
819	Hospitals	6,406,524	145,829	81,014	2%
497	Grocery stores	3,889,970	11,096	6,896	0%
787	Colleges and universities, including junior colleges	3,812,024	364,728	206,544	10%
538	Department stores	3,161,238	14,566	9,139	0%
947	Justice, public order, and safety activities	2,956,466	46,684	22,761	2%
699	Insurance carriers and related activities	2,924,894	164,195	122,387	6%
707	Real estate	2,473,782	22,443	10,319	1%
687	Banking and related activities	2,300,110	96,411	64,033	4%
859	Other amusement, gambling, and recreation industries	2,245,480	19,235	11,400	1%
847	Child day care services	2,163,328	1,897	637	0%
827	Nursing care facilities	2,122,146	4,139	1,759	0%
617	Truck transportation	2,110,791	9,997	7,197	0%
797	Offices of physicians	1,923,162	25,763	13,760	1%
866	Traveler accommodation	1,864,141	8,805	4,612	0%
357	Motor vehicles and motor vehicle equipment manufacturing	1,825,811	160,153	129,860	9%
727	Legal services	1,764,109	17,234	6,560	1%
877	Automotive repair and maintenance	1,672,318	2,727	1,221	0%
17	Crop production	1,518,346	6,500	2,974	0%
729	Architectural, engineering, and related services	1,429,041	835,095	433,909	58%
738	Computer systems design and related services	1,411,884	811,234	617,137	57%
467	Automobile dealers	1,393,185	3,525	1,541	0%
758	Employment services	1,341,742	34,975	18,738	3%
769	Services to buildings and dwellings	1,268,063	2,575	1,369	0%
697	Securities, commodities, funds, trusts, and other financial	1,267,650	82,396	55,829	6%
916	Religious organizations	1,263,280	5,997	2,396	0%
739	Management, scientific and technical consulting services	1,160,149	182,653	128,603	16%
339	Electronic component and product manufacturing, n.e.c.	1,155,562	287,082	197,320	25%
777	Landscaping services	1,142,979	17,518	6,175	2%
668	Wired telecommunications carriers	1,132,428	176,315	101,597	16%
939	Other general government and support	1,087,191	112,280	68,870	10%

637	Postal Service	1,080,002	12,977	3,460	1%
447	Groceries and related product wholesalers	1,074,737	10,588	6,263	1%
728	Accounting, tax preparation, bookkeeping and payroll service	1,056,771	23,745	15,223	2%
199	Printing and related support activities	1,053,559	24,380	14,879	2%
517	Clothing and accessories, except shoe stores	1,017,322	5,242	3,401	1%
689	Non-depository credit and related activities	1,012,234	49,234	32,156	5%
399	Not specified manufacturing industries	1,010,854	47,323	30,689	5%
898	Beauty salons	985,635	639	221	0%
487	Building material and supplies dealers	948,560	6,780	3,379	1%
479	Radio, TV, and computer stores	939,492	160,138	112,381	17%
507	Pharmacies and drug stores	869,676	6,204	3,906	1%
929	Private households	867,453	331	199	0%
818	Other health care services	864,344	34,630	22,536	4%
817	Home health care services	861,330	2,778	1,283	0%
917	Civic, social, advocacy organizations, and grantmaking and g	851,591	23,278	9,768	3%
837	Individual and family services	845,282	12,619	3,531	1%
389	Furniture and related products manufacturing	844,984	17,088	9,986	2%
798	Offices of dentists	819,974	1,120	680	0%
237	Plastics product manufacturing	810,652	37,451	21,558	5%
759	Business support services	810,092	24,063	12,443	3%
948	Administration of human resource programs	808,612	49,083	33,763	6%
856	Independent artists, performing arts, spectator sports, and	797,461	6,141	2,676	1%
607	Air transportation	782,879	16,335	11,944	2%
18	Animal production	780,289	3,761	1,311	0%
477	Furniture and home furnishings stores	779,128	3,080	1,581	0%
319	Machinery manufacturing, n.e.c.	774,521	79,649	56,387	10%
57	Electric power generation, transmission and distribution	772,758	116,756	83,205	15%
959	National security and international affairs	767,066	133,120	92,746	17%
629	Services incidental to transportation	751,034	18,442	11,829	2%

Table 3. Industry and S&E Employment by S&E Employment Size (> 25,000 S&E Employees)

Code	Industry	Workforce Counts			
		Total Workforce	S&E Workforce, Total	S&E Workforce, Core S&E	S&E % of Total
	Totals / Average	167,996,851	8,102,712	5,113,526	5%
729	Architectural, engineering, and related services	1,429,041	835,095	433,909	58%
738	Computer systems design and related services	1,411,884	811,234	617,137	57%
787	Colleges and universities, including junior colleges	3,812,024	364,728	206,544	10%
339	Electronic component and product manufacturing, n.e.c.	1,155,562	287,082	197,320	25%
746	Scientific research and development services	554,243	268,418	176,878	48%
77	Construction	11,466,171	202,786	131,355	2%
739	Management, scientific and technical consulting services	1,160,149	182,653	128,603	16%
668	Wired telecommunications carriers	1,132,428	176,315	101,597	16%
336	Computer and peripheral equipment manufacturing	510,732	168,502	133,118	33%
699	Insurance carriers and related activities	2,924,894	164,195	122,387	6%
357	Motor vehicles and motor vehicle equipment manufacturing	1,825,811	160,153	129,860	9%
479	Radio, TV, and computer stores	939,492	160,138	112,381	17%
819	Hospitals	6,406,524	145,829	81,014	2%
959	National security and international affairs	767,066	133,120	92,746	17%
358	Aircraft and parts manufacturing	536,821	122,688	102,428	23%
57	Electric power generation, transmission and distribution	772,758	116,756	83,205	15%
229	Industrial and miscellaneous chemicals	584,012	116,640	72,419	20%
957	Administration of economic programs and space research	733,908	115,144	77,652	16%
939	Other general government and support	1,087,191	112,280	68,870	10%
359	Aerospace product and parts manufacturing	283,463	109,780	94,542	39%
219	Pharmaceutical and medicine manufacturing	423,909	105,768	76,632	25%
949	Administration of environmental quality and housing programs	283,547	100,757	75,246	36%
678	Other information services	300,349	96,922	39,288	32%
687	Banking and related activities	2,300,110	96,411	64,033	4%

337	Communications, audio, and video equipment manufacturing	321,151	87,224	63,937	27%
669	Other telecommunication services	479,710	84,338	51,276	18%
786	Elementary and secondary schools	9,451,464	83,589	21,067	1%
697	Securities, commodities, funds, trusts, and other financial	1,267,650	82,396	55,829	6%
319	Machinery manufacturing, n.e.c.	774,521	79,649	56,387	10%
338	Navigational, measuring, electromedical, and control instrum	295,356	78,432	58,065	27%
808	Offices of other health practitioners	315,326	72,895	1,449	23%
679	Data processing services	246,177	70,538	43,929	29%
396	Medical equipment and supplies manufacturing	529,772	68,539	43,543	13%
349	Electrical lighting, equipment, and supplies manufacturing,	576,117	65,974	43,898	11%
667	Radio and television broadcasting and cable	699,813	51,432	25,565	7%
689	Non-depository credit and related activities	1,012,234	49,234	32,156	5%
948	Administration of human resource programs	808,612	49,083	33,763	6%
399	Not specified manufacturing industries	1,010,854	47,323	30,689	5%
947	Justice, public order, and safety activities	2,956,466	46,684	22,761	2%
417	Professional and commercial equipment and supplies	485,893	46,180	30,084	10%
749	Other professional, scientific and technical services	382,116	46,118	17,653	12%
937	Executive offices and legislative bodies	480,808	38,558	24,185	8%
237	Plastics product manufacturing	810,652	37,451	21,558	5%
758	Employment services	1,341,742	34,975	18,738	3%
818	Other health care services	864,344	34,630	22,536	4%
49	Support activities for mining	278,442	34,044	25,336	12%

Table 4. S&E Occupations and Employment

Occupation	Workforce, weighted count
Total	8,102,712
Computer Software Engineers	766,563
Computer Scientists and Systems Analysts	764,917
Computer Programmers	741,048
Engineering Technicians, Except Drafters	526,075
Computer Support Specialists	448,295
Miscellaneous Engineers, Including Agricultural and Biomedical	364,736
Network Systems and Data Communication Analysts	360,556
Electrical and Electronics Engineers	349,026
Civil Engineers	311,228
Mechanical Engineers	306,807
Drafters	270,016
Industrial Engineers, Including Health and Safety	218,132
Network and Computer Systems Administrators	217,879
Architects, Except Naval	216,867
Misc. Life, Physical, and Social Science Technicians, Including Social Science Research	199,625
Psychologists	186,635
Physical Scientists, All Other	166,891
Aerospace Engineers	130,329
Operations Research Analysts	120,390
Chemists and Materials Scientists	119,609
Market and Survey Researchers	105,804
Chemical Technicians	103,891
Surveying and Mapping Technicians	97,234
Biological Scientists	95,162
Environmental Scientists and Geoscientists	93,807
Medical Scientists	88,542
Database Administrators	85,114
Chemical Engineers	73,793
Computer Hardware Engineers	73,422
Miscellaneous Social Scientists, Including Sociologists	44,735
Materials Engineers	41,441
Surveyors, Cartographers, and Photogrammetrists	41,322
Environmental Engineers	38,759
Agricultural and Food Scientists	33,665
Miscellaneous Mathematical Science Occupations	33,378
Agricultural and Food Science Technicians	31,927
Conservation Scientists and Foresters	31,524
Economists	30,404
Petroleum, Mining and Geological Engineers, Including Mining	25,567
Biological Technicians	24,558
Urban and Regional Planners	24,455
Actuaries	23,214
Astronomers and Physicists	22,926
Geological and Petroleum Technicians	15,116
Marine Engineers	13,272
Atmospheric and Space Scientists	12,512
Nuclear Engineers	11,544

BIOGRAPHY FOR HAROLD SALZMAN

Hal Salzman is a sociologist and Senior Research Associate at The Urban Institute, a national, nonprofit, nonpartisan, research and policy organization. Dr. Salzman's research focuses on labor markets, workplace restructuring, skill requirements, and globalization of innovation, engineering and technology design. He is currently Principal Investigator of a National Science Foundation-funded project on globalization, innovation, and human capital; this continues his research on "collaborative advantage" in globalization, engineering, technology entrepreneurship (research funded by the National Science Foundation and Kauffman Foundation, with Leonard Lynn of Case Western Reserve University and conducted with colleagues in the U.S., Germany, Japan, China, India, and Latin America). Dr. Salzman is also examining the science and engineering education and labor supply in research supported by the Sloan Foundation. He has conducted a number of studies of the IT industry, on both software design and work practices and on labor force issues in the IT industry. Currently he is completing, with colleagues, a project on corporate restructuring and the impact on jobs and training. His publications include *Software By Design: Shaping Technology and the Workplace* (Oxford University Press) and articles on issues of technology, skills, and the workplace, including "Collaborative Advantage" (in *Issues in Science and Technology*), and forthcoming, *Technology Entrepreneurs in the Emerging Economies: The new shape of global innovation.*

Chairman WU. Thank you, Dr. Salzman. Mr. Kostek.

STATEMENT OF MR. PAUL J. KOSTEK, VICE PRESIDENT, CAREER ACTIVITIES, THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS–UNITED STATES OF AMERICA

Mr. KOSTEK. Thank you and thanks to Mr. Wu and to Mr. Gingery for the opportunity to testify this afternoon. I am here actually probably as the odd person on this panel since I am a working engineer by day and a volunteer for the IEEE–USA serving as the Vice President for Career Activities. In that role over almost 30 years, I have had the opportunity to communicate with engineers, computer scientists, in a wide variety of roles around the country. Historically the engineering profession has been one that has dealt with a cyclical pattern where there have been booms and busts of opportunities. If you lived in my hometown in Seattle in 1972, there was a very famous billboard that said the last person out of Seattle please turn out the lights as the Boeing company had a massive downturn. In the '90s we also saw a period of high unemployment as the United States went through a transition after the fall of the Berlin wall and the peace dividend kicked in and resulted in defense cuts and a big transition taking place for engineers going from the defense industry to new industries. And of course, we also saw just a few years ago the .com implosion that had a dramatic impact on engineering and computer scientists forcing people from their jobs.

Historically though, people have had the perspective that things would return to normal, that the marketplace would return and things would be better; and of course, now, with the emergence of India, China, we are seeing a very different marketplace where the competition for engineering, the competition for talent, isn't just here in the United States and that jobs that go away may not return in the future. So our members are now going through the challenge of trying to redefine themselves and identify what skills they need to compete. The most frequent question I am asked is what skills do I need to get that won't be outsourced? And frequently most people are disappointed when I tell them there is no guarantee of any skill I can tell you that can't be outsourced, and the expectation has to be that you have to constantly be assessing the marketplace, understanding what changes are taking place, and how that is going to impact how you work.

For some of our members, essentially they have given up. People will tell you that they have given up on engineering and given up on computer science careers, that they just felt that they have hit a certain age and going back to school to try again for a few years just isn't worth it for them. And there are a lot of sensors, and when we look at the question of supply and demand and of STEM talent, especially engineering talent, frequently I think the question that isn't always addressed is the question of utilization of the talent we do have in this country right now. There is a lot of emphasis placed on increasing the numbers of people who go into science and math at university level, but we don't do a lot of looking at what happens to the million-plus electrical engineers for example who are in the marketplace today. How do we utilize their skills? How do we help these people to reskill themselves, potentially even relocate themselves to the places where opportunities are. So those are the types of things that we are concerned about as people move forward with their careers and as we have these discussions on STEM and development, not just looking at where is the future coming from, but we also have a future pool of people that are present today who range from their 20's, 30's, 40's into their 60's. I mean, with the constant dialogue that goes on today about retirement age moving up, we will have a resource of people that we can use much longer if we are careful and if we keep them properly trained and utilized. And I think that is going to be one of the key elements that we as an organization look at as we meet with our partner organizations, as we talk to companies and industry is the question of how do we properly utilize the people that are there today? I think what you'll find frequently when you talk to some of the engineers who talk about giving up is that they feel like they've been forgotten, left behind, in terms of the changes that have taken place in the marketplace, in terms of just even the perception of whether some gray hairs means someone can compete in the technical marketplace as efficiently as somebody else who is much younger.

So I guess I would leave you with the challenges that we see going forward isn't just the question of developing a STEM workforce for the future, but it is also utilizing the current workforce because I believe if the current workforce, begins to fade away, feel there is no opportunities, that will also have a big impact on our abilities to attract the future generation. As any parent would advise their child, look at the career path. And unlike those few people who do get lucky with stock options at a Microsoft or a Google, the majority of engineers are not getting to a point where they can happily retire at 35 or 40, but are looking for careers that move them through their 50's and into their 60's. So with that, I'll close and again ask you all to consider those things as you look at the question of engineering in the future that it is also utilizing the current workforce.

[The prepared statement of Mr. Kostek follows:]

PREPARED STATEMENT OF PAUL J. KOSTEK

The Implications of the Globalization of R&D and Innovation for America's Science and Engineering Workforce

I want to thank Subcommittee Chairman Wu and Ranking Member Gingrey for inviting me to testify on the implications of the globalization of research, development and innovation for the people who work in science, technology, engineering and math-based occupations in the United States—all of whom are important contributors to the Nation's technological leadership, its economic prosperity and its military and homeland security.

Introductions

My name is Paul Kostek and I do hardware and software systems integration work on manned and unmanned aircraft for the Boeing Company in Seattle, WA. Since earning my degree in 1979, I have worked for large, mid-sized and small manufacturing and engineering service firms as a full-time salaried employee, an independent contractor and a part-time consultant. I've also been a partner in a start-up company and an officer in a professional engineering union.

Today, I speak on behalf of the Institute of Electrical and Electronics Engineers–United States of America (IEEE–USA) where I am Vice President for Career Activities. My perspectives are based on my own experience as an engineer and three decades of involvement with other engineers and scientists at work and in professional society activities at the local, State, regional and national levels.

The Institute of Electrical and Electronics Engineers (IEEE) is a transnational technical and professional society made up of more than 370,000 individual members in 150 countries. IEEE's purposes are to advance the theory and practice of electrical, electronics, computer and software engineering and to improve the ability of its members to innovate and create wealth that benefits the countries in which they live and work. IEEE–USA promotes the professional careers and technology policy interests of IEEE's 215,000 U.S. members.

Seventy percent of IEEE's U.S. members work in the private sector, primarily in the aerospace and defense, biomedical technology, computers and communications, electronics equipment and electric power industries. Thirty percent work for firms with 500 or fewer employees. Ten percent are employed by Federal, State and local government agencies. Ten percent teach at U.S. engineering schools or work at non-profit research organizations. Most of the remaining ten percent are self-employed and work as consultants to businesses and government.

Globalization and the "Dis-integration" of America's Engineering Enterprise (Cite 1)

Three decades ago, America's engineering enterprise was vertically integrated and hierarchically organized. Most research, design, development and even manufacturing functions were performed in the United States by American companies or at wholly owned subsidiaries in Canada, Japan and Western Europe. The engineering work being done in the rest of the world had little impact on the profitability of U.S. firms or the well-being of American workers.

Since then the integrated nature of engineering work has undergone profound organizational and locational shifts. The hierarchical business model that once conferred unassailable competitive advantage on U.S. firms based in Massachusetts, California's Silicon Valley and the Pacific Northwest has been turned on its head. U.S. firms have become multi-national and are racing to shift engineering research and design functions—not just routine development and production work—to subsidiaries and partners all over the world. Major breakthroughs in cellular telephony are being made in China, advances in software development, information technology and pharmaceutical research are taking place in India and cutting edge improvements in automobile power trains and aircraft control systems are emerging in Brazil.

This disintegration and redistribution of engineering work is an inevitable result of the growing competition between firms and countries in an increasingly technology driven global economy.

It is driven by underlying market imperatives, including the need to increase shareholder value, improve productivity and efficiency and promote unfettered flows of capital and labor. And it is enabled by the very technologies that scientists and engineers help to create, adapt and improve.

Lower labor costs in developing economies are undoubtedly a major contributing factor, but the new globalization of the engineering enterprise is also motivated by other factors including proximity to emerging markets, access to capable people as well as by cultural, social and regulatory environments that incentivize invention, innovation and entrepreneurship.

Impact on STEM Labor Markets and Professionals in the United States

Although there are no reliable figures on exactly how many jobs in STEM fields have moved offshore in recent years, the adverse impact of workforce globalization on high technology labor markets in the United States is becoming increasingly apparent. While unemployment rates for engineers and computer scientists—which reached historically high levels between 2001 and 2004—fell back to less than two percent in 2005, statistics on recent employment and compensation trends across most science and engineering fields are troubling, to say the least.

According to a just-released report from unbiased analysts at the STEM Workforce Data Project—based on data compiled by the Bureau of Labor Statistics at the U.S. Department of Labor—the decades long *growth in employment opportunities for scientists and engineers* in the United States *appears to have ended* in 2001. (**Cite 2**). Even more troubling is the Project's finding that *real salary growth for most STEM professionals has been flat or declining* for at least 10 years.

[Employment and salary growth for aerospace engineers (where increasing demand and improved financial incentives since the late 1990's)—and medical scientists (who are benefiting from strong upward growth in demand for health professionals in general) are the only notable exceptions to reported labor market conditions across STEM occupations.]

One very likely contributor to reduced rates of growth for domestic jobs in STEM fields—and flat or declining real wages for STEM professionals—are continuing increases in the offshore out-sourcing of engineering work.

If these trends continue—and knowledgeable observers think that they will—their impact on the health of America's high tech workforce could be devastating. The one/two punch of reduced demand (fewer job opportunities) and wage depression (flat or declining real wages) will encourage incumbent mid-career and older STEM workers to leave for better job opportunities in other fields and discourage talented students from pursuing science and engineering careers.

High Tech Specific Concerns, Issues and Questions

While most economists doubt that globalization will reduce the aggregate number of jobs in the U.S. economy, they all agree that the ongoing geographic redistribution of work—including engineering work—will alter the mix of jobs performed in the United States.

In order to maximize profits from the design, development, production, marketing and distribution of essential goods and services, employers must make the best possible use of all available factors of production.

1. *What types of jobs will face increased competition from low-cost countries?*

The transfer of high end engineering work, including increasingly sophisticated research, design and development jobs, from the United States, Western Europe and Japan to lower-cost locations in the former Soviet republics, China, India, the Middle East and South America is growing and will continue to grow in the foreseeable future. As the technical knowledge and skills base of workers in the developing world expands, the lure of lower costs—for labor, capital, plant and office space, equipment and infrastructure—proximity to emerging markets and promises of relief from burdensome environmental, labor and tax policies are likely to make off-shoring even more important for the competitiveness of U.S. firms.

2. *What kinds of jobs will go and what kinds are likely to stay?*

The sophisticated "high tech" knowledge worker/transactional analyst jobs popularized by former Labor Secretary Robert Reich are and will continue to be fair game for geographic relocation. Stickier "high touch" jobs that require continuing face-to-face communications with clients or customers in the United States are less likely to be shipped to other countries.

Problem-solving skills in such sectors as critical infrastructure protection; electric power generation, transmission and storage; cyber security and environmentally friendly building and transportation systems will continue to be marketable here and overseas.

3. *What kinds of knowledge and skills will be needed as the off-shoring of STEM jobs increases in scale and scope?*

Softer technical and people systems integration as well as process and program management skills and experience will become increasingly important in the United

States and elsewhere as workers in other parts of the world master increasingly sophisticated technical skills.

4. *How can we ensure that future generations of Americans get the knowledge and skills they will need to become and remain competitive in an increasingly technology-driven global economy?*

Parents, teachers, employers, family members and friends must emphasize the critical importance of making a life-long commitment to learning how to learn; and how to use technology including computer-based data collection, processing and storage devices to access, organize, evaluate and apply information to the solution of environmental, physical, social and political problems.

5. *Is an inadequate supply of American STEM workers with specific skills causing companies to move offshore?*

Although employers contend that an inadequate supply of appropriately skilled and properly motivated workers in the United States is forcing them to move jobs and facilities overseas, there is no credible economic evidence to support such claims. From the perspective of employers, in markets that reward firms that produce and deliver more, better, faster and cheaper, there are never enough good engineers. When it comes to workers, more is always better and cheaper is best.

6. *What kinds of challenges is globalization creating for American STEM workers and what kinds of resources do they need to ensure that their careers are durable and resilient?*

The successful application of new technologies can improve productivity by increasing efficiencies and/or reducing costs. Flexibility, adaptability, resourcefulness and determination are critical for continuing success in increasingly competitive global markets.

Individual engineers must be prepared to assume full responsibility for maintaining their employability. Employers and professional organizations can encourage and enable entry-level, mid-career and older engineers to develop the necessary knowledge, skills and capabilities.

Governments can help by establishing tax incentives for lifelong learning and providing short-term transitional assistance for displaced manufacturing and service sector workers, including scientists and engineers.

7. *How has globalization changed the risks and rewards, costs and benefits of careers in STEM fields?*

Globalization has significantly increased the risks and raised the potential returns/rewards for STEM professionals who are able to maintain/increase their employability.

8. *What are countries doing to create and retain high wage/high value added jobs and to send clear signals to their citizens about high demand job opportunities in today's increasingly competitive, technology driven global economy?*

The United States needs a coordinated national strategy—like the one that have been adopted by its principal competitors—to help American companies and citizens develop and maintain their technological competitiveness. Employers are understandably reluctant—for competitive and public relation reasons—to provide very much in the way of advance notice about their intentions to redistribute, consolidate or eliminate work at domestic and overseas locations.

IEEE–USA Policy Recommendations

The economic and employment challenges associated with globalization of science and engineering work are complex and consensus policy responses extremely difficult to formulate, let alone implement, in the midst of bitterly contested and extremely partisan Presidential and Congressional election campaigns. There are no easy answers or silver bullets, but there are some practical and immediate steps that can and should be taken:

- The Federal Government must collect and publish reliable statistics on the volume, nature and value of manufacturing, R&D and service sector jobs that are moving offshore and those being created in the United States by foreign direct investments.
- New and improved transitional assistance programs are needed to help displaced STEM professionals regain productive employment.
- Practical incentives, including targeted tax credits, paid internships and individualized instructional programs, should be established in the public and

private sectors to enable mid-career and older STEM professionals to maintain their employability.

- Stakeholders from business, educational institutions, government agencies, labor organizations and professional societies should work together to develop strategies and identify best practices that STEM professionals can use to differentiate themselves from their foreign competitors.
- Public and private sector employers must make post-graduate STEM education more affordable for U.S. citizens and legal permanent residents by offering financially competitive scholarships, fellowships and assistantships in exchange for extended service commitments.
- Congress must enact balanced reforms in the Nation's educational and employment-based admissions (immigration) programs. Such reforms should increase permanent employment-based admissions, facilitate the transition of foreign students with advanced degrees from U.S. schools to legal permanent resident status and reform the badly broken H–1B temporary work visa program.
- Congress should take affirmative steps to ensure that the U.S. retains the human talent and production capabilities needed to develop and utilize technologies deemed critical to U.S. national defense and homeland security.
- Public and private sector stakeholders must take steps to address barriers to overseas employment by U.S. STEM professionals and better enable such individuals to find work at foreign-owned companies, international agencies and non-governmental organizations.

Attachment A

Sources of Additional Information

1. Leonard Lynn and Hal Salzman, "The New Globalization of Engineering: How the Offshoring of Advanced Engineering Affects Competitiveness and Development," (Paper presented at the 21st European Group for Organizational Studies (EGOS) Colloquium, Berlin, Germany—June 2005)
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2. STEM Workforce Report No. 8, "Is U.S. Science and Technology Adrift?" (Washington; Commission on Professionals in Science and Technology, October 2007)
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3. B. Lindsay Lowell and Harold Salzman, "Into the Eye of the Storm: Assessing the Evidence on Science and Engineering Education, Quality and Workforce Demand" (Washington, The Urban Institute, October 2007)
http://www.urban.org/UploadedPDF/411562_Salzman_Science.pdf

Related IEEE–USA Policy Statements

1. U.S. Competitiveness and Innovation Policy—February 2006
http://www.ieeeusa.org/policy/positions/competitiveness.html
2. Offshore Outsourcing—March 2004
http://www.ieeeusa.org/policy/positions/competitiveness.html
3. Tax Incentives for Continuing Education—November 2004
http://www.ieeeusa.org/policy/positions/continuingeducation.asp
4. Ensuring a Strong High Tech Workforce Through Educational and Employment-Based Immigration Reform—June 2007
http://www.ieeeusa.org/policy/positions/Immigration0607.pdf

Attachment B

Commission on Professionals in Science and Technology

STEM WORKFORCE DATA PROJECT REPORTS[1]

1. Twenty Years of Scientific and Technical Employment

[1] *http://www.cpst.org/STEM_Report.cfm*

Report No. 1 (Jun 2004)
https://www.cpst.org/STEM/STEM1_Report.pdf

2. **Women in Science and Technology: the Sisyphean Challenge of Change**
   Report No. 2 (Oct 2004)
   https://www.cpst.org/STEM/STEM2_Report.pdf
3. **Participation by Minorities in STEM Occupations**
   Report No. 3 (May 2005)
   https://www.cpst.org/STEM/STEM3_Report.pdf
4. **The Foreign Born in Science and Technology**
   Report No. 4 (Nov 2005)
   https://www.cpst.org/STEM/STEM4_Report.pdf
5. **Science and Technology Salaries: Trends and Details**
   Report No. 5 (Aug 2006)
   https://www.cpst.org/STEM/STEM5_Report.pdf
6. **Four Decades of STEM Degrees, 1966–2004: The Devil is in the Details**
   Report No. 6 (Sep 2006)
   https://www.cpst.org/STEM/STEM6_Report.pdf
7. **STEM Employment Forecasts and Distributions Among Employment Sectors**
   Report No. 7 (Sep 2006)
   https://www.cpst.org/STEM/STEM7_Report.pdf
8. **Is U.S. Science and Technology Adrift?**
   Report No. 8 (Oct 2007)
   https://www.cpst.org/STEM/STEM8_Report.pdf
9. **Policy and the STEM Workforce System**
   Report No. 9 (Oct 2007)
   https://www.cpst.org/STEM/STEM9_Report.pdf

BIOGRAPHY FOR PAUL J. KOSTEK

Paul J. Kostek is a systems engineer with the Boeing Co., in Seattle and a senior member of the Institute of Electrical and Electronics Engineers (IEEE). He is a former IEEE–USA President and is now the organization's Vice President for Career Activities. He has been active in IEEE technical activities and U.S. engineering workforce issues for many years.

While Chair of the IEEE–USA Career & Workforce Policy Committee in 2005–06, Kostek met with high-tech executives and engineers across the country to get a sense of their concerns in today's job market. Under his leadership, IEEE–USA has offered career-management seminars throughout the United States, and he has counseled numerous engineers on optimal career paths.

Kostek was IEEE–USA President in 1999 and served on the IEEE Board of Directors. He was President of the IEEE Aerospace & Electronics Systems Society in 2000–01 and Chair of the American Association of Engineering Societies in 2003. He chairs the IEEE–USA Communications Committee and is a member of the IEEE's Member Benefits and Services Committee.

At Boeing, Kostek leads a hardware/software systems-integration team and oversees the design, modeling, installation and testing of computer systems on anti-submarine aircraft. He was previously assigned to a program-requirements management group that integrated controls and communications systems on unmanned military ground vehicles.

Kostek also chairs the American Institute of Aeronautics and Astronautics' (AIAA) Career Enhancement Committee and is a member of the Project Management Institute's Aerospace and Defense Specific Interest Group Board. He was General Chairman of the IEEE's Intelligent Transportation Systems Conference in 2004 and Chairman of a joint AIAA/IEEE Digital Avionics Systems Conference in 2006.

Kostek received his Bachelor's degree in electrical engineering technology from the University of Massachusetts, Dartmouth; completed graduate studies at the Polytechnic Institute of New York and Long Island University; and earned a certificate in project management from the University of Washington.

Kostek is an associate fellow of the AIAA and a member of the International Council on Systems Engineering, the Society of Automotive Engineers and the Project Management Institute. He and his wife, Leann, live in Seattle.

About IEEE–USA

IEEE–USA advances the public good and promotes the careers and public policy interests of more than 215,000 engineers, scientists and allied professionals who are U.S. members of the IEEE. With 370,000 members in 160 countries, the IEEE is the world's largest technical professional society. See *http://www.ieeeusa.org*

Chairman WU. Thank you very much, Mr. Kostek. Mr. Becker, please proceed.

STATEMENT OF MR. HENRY S. BECKER, PRESIDENT, QIMONDA NORTH AMERICA CORP.

Mr. BECKER. Thank you, Chairman Wu, Ranking Member Gingrey. It is a pleasure to be here. My background and experience spans 23 years with the semiconductor industry in total. I don't have any studies to cite. My testimony is empirical in nature and based on those 23 years.

First, I would like to start with a little bit of background on Quimonda. We are a global semiconductor company that designs, manufactures, and sells memory products, specifically D–RAMS, Dynamic Random Access Memories, for use in your computers, your laptops, gaming consoles, networks, a large array of consumer and mobile applications. We employ about 13,000 people worldwide, and last year we had revenue of about $4.9 billion. Since 1996, we have invested more than $3 billion in our manufacturing site near Richmond, Virginia, that houses two state-of-the art advanced production lines for wafer processing. We also have two design centers in the United States, one in Burlington, Vermont, one in Raleigh, North Carolina; and we also have sales, marketing, and support organizations throughout the United States. We employ some 3,000 people focused heavily on science and math backgrounds, focused towards engineering degrees for those 3,000 positions. Our chips are used by companies like Cisco, Dell, HP, IBM, Microsoft, Motorola, just to name a few. Today, 40 percent of our revenue comes out of the United States. And so our investment in manufacturing and design has grown significantly over the past 10 years.

More importantly, some of our industry key enablers call the United States home. Intel and MD for computing chip sets, for computers and laptops, and video for graphics in gaming applications; Apple and Motorola for wireless and hand-held applications, as well as some of the largest server farm users such as Google, that my colleague just mentioned.

Finally, the United States is home to JEDEC where the industry debates and adopts standards for global standards for the marketplace.

We selected Virginia for our manufacturing base partly because the State and local governments' strong commitment to partner with us to develop a stilled workforce, one tailored to our needs in manufacturing of semiconductors. We are proud to say that over the past 12 years, semiconductors went from being non-existent in that state to the number one export today.

Qimonda is a global company. Our headquarters are in Germany. We are traded on the New York Stock Exchange solely, and my boss, the CEO, is of Malaysian descent. We design, manufacture, and ship chips around the world to support the changing supply chains that our customers have and to gain access to skilled workers.

[Slide]

We do not have a geographic division of labor by worker roles, as you can see by the chart behind me. We have got manufacturing and R&D operation basically around the world. We have manufacturing on three continents—R&D on three continents for those specific reasons.

That said, most competitiveness and talent availability are issues for our manufacturing and design operations in the United States. Our primary competitors are located in Asia where labor rates are significantly lower and the education and skills are constantly on the rise. Additionally, we face critical shortages of workers with adequate science and math skills. The United States is just not producing enough skilled workers to support the semiconductor industry. Many of our new hires come from other semiconductor companies where they have been trained or they come through visa programs through other countries. We would hire more immigrants if there were more visas available. However, more visas are not the permanent answer.

It is our strong preference to see a larger pool of skilled U.S. workers. In the meantime, we have developed home-grown programs like many companies to meet the needs of our skilled workforce demands. As an example, in Virginia Henrico County, just outside of Richmond, Qimonda and Virginia Commonwealth University and the Henrico County Public School District have partnered together to create an education opportunity that we call the High Tech Academy. It is a two-year science and technology study program in the public school for juniors and seniors. At the end of the process they gain 32 credit hours that are fully transferable to any university in science and math. They are able to internship at Qimonda, and all the while they are being exposed to career opportunities in science and technology, not specifically for semiconductors, as they go through that educational experience.

But our efforts are not enough. Unless the United States actively develops more home-grown engineering talent, it is just a matter of time until development, high-tech manufacturing design work shifts from our country. It seems to us that producing more qualified U.S. engineering and science graduates is a better medium and long-term solution to the skill shortage we face than just increasing the number of visas to maintain the skilled data pool. The United States is competing with countries that offer significant incentives to attract both manufacturing of high-tech and design and development of new products. And they have also adopted strategic plans to increase their pool of skilled work forces. Most of these nations treat technology in general and semiconductors specifically on the level of the national strategic interest and as such have embraced it in the full extent they can, sometimes beyond the World Trade Organization norms. We have seen some of this directly, not only in the area of building skilled labor pools but also in the direct subsidies to companies. The need for stronger enforcement of those uncompetitive behaviors is something that we see as a threat to the U.S. technical worker as well.

The United States needs the fundamental investment in science and math, one that encourages ongoing education. One such program out there is FIRST Robotics. I don't know if you are familiar with it, but FIRST meaning For Inspiration and Recognition of Science and Technology. We are a strong supporter of that and believer in that approach. Students in high school build robots and are introduced to a world where science and technology are celebrated, not put off to the side as, you know, just the geeks do that—but it becomes mainstream. And if you have ever been to a competition or if you haven't I would encourage you to, because the level of enthusiasm is right up there with any sporting event you have ever been to. Kids begin dreaming of becoming science and technology heroes, and you are able to plant that seed and maybe grab onto that spark in their life.

We need to find additional methods to attract the most talented students into engineering and technology professions to produce the workforce that that keeps manufacturing and design here in the United States.

Thank you for the opportunity to offer my testimony, and I look forward to answering any and all your questions.

[The prepared statement of Mr. Becker follows:]

PREPARED STATEMENT OF HENRY S. BECKER

Good afternoon Committee Chairman Wu, Ranking Member Gingrey and the other distinguished Members of the Committee. Thank you for the opportunity to offer the views of Qimonda on the globalization of the technology sector and the consequent impact on the U.S. science and engineering workforce.

Qimonda is a global semiconductor company that designs, manufactures and sells memory products—D–RAM for use in computing, graphics, networking and mobile applications. We employ about 13,000 people worldwide, and had revenue of $4.9 billion in fiscal year 2006. We made our initial investments in the United States in 1996 when we were Siemens Semiconductor. To date we have invested more than $3 billion in two advanced manufacturing lines, two design centers, and a sales/marketing operation. In total we employ about 3,000 people in the U.S. with a range of skills but tilted heavily toward those with strong science and math skills, and degrees in engineering.

Our manufacturing operations are located in the White Oak technology park in Sandston, Virginia, just outside of Richmond, where we employ 2,400 people in the production or wafer fabrication of D–RAM. We have a design center in Burlington, Vermont employing approximately 125 professionals to develop products for mobile applications, and a second design center in Cary, North Carolina employing 200 plus to develop products for server and graphics applications. We employ an additional approximately 75 professionals focused on supporting the North American region in such areas of information technology, logistics and general administration. Finally, we have 85 plus professionals in sales and marketing in San Jose, California, as well as smaller groups of employees in Texas and elsewhere in the U.S. to serve our customer's operations.

Qimonda's North American operations support our U.S. and worldwide customer base, including companies like AMD, Cisco, Sony, Dell, HP, IBM, Microsoft, Motorola, Nvidia, Scientific Atlanta and Sun Microsystems to mention a few. We also participate in several R&D consortiums here in the U.S. working with other companies to develop advanced technology.

Our initial investment in 1996 was a result of our seeking a manufacturing presence close to many of our customers' operations. Today, forty percent of our revenues continue to come from the U.S. market for D–RAM memory, and so our investment in manufacturing and design has grown significantly in the past ten years. More importantly some our of industry's key enablers call the U.S. home. Intel and AMD for computing chip sets, Nvidia for graphics, Apple and Motorola for wireless and hand-held applications, as well as some of the largest server farm users such as Google. Finally the U.S. is home to JEDEC, where our industry debates and adopts standards for our marketplace.

When we looked at possible locations across the United States to set up our fabrication plant, we selected Virginia because of its positive business climate and the State and local government's strong commitment to partner with us to develop a skilled workforce to support our business. This commitment included financial incentives for the worker training we provided, cooperation on developing more technical training in community colleges, and establishing a Microelectronics Center and an advanced degree program at the Virginia Commonwealth University School of Engineering. We are proud to say that in the past 12 years, semiconductors in Virginia went from literally non-existent to the state's largest export item today.

Our design centers were located in Vermont and North Carolina because that is where we found the properly trained resources. In Vermont, we had a research partnership with IBM that ultimately led to us establishing, and then significantly growing, our own design center. In North Carolina, our presence was established first by a small team of engineers already doing D–RAM designs in the Research Triangle Park supporting the many customers that were also located there. The combination of access to skilled workers followed by customer location, quality of life and reasonable cost of living in Vermont and North Carolina has produced significant growth in both of these research operations.

Qimonda is a classic example of a global company: our headquarters and roots are in Germany, we are publicly traded on the New York Stock Exchange, and our CEO is Malaysian. If you refer to Figure 1, you will see our globally based manufacturing and design footprint. We design, manufacture and ship products around the world. We do not have a geographic division of labor by worker roles, but have manufacturing, design and sales in each major global region (North America, Europe and Asia) to support the changing supply chain needs of our customers as well as to gain access to workers and better serve markets in all regions of the world.

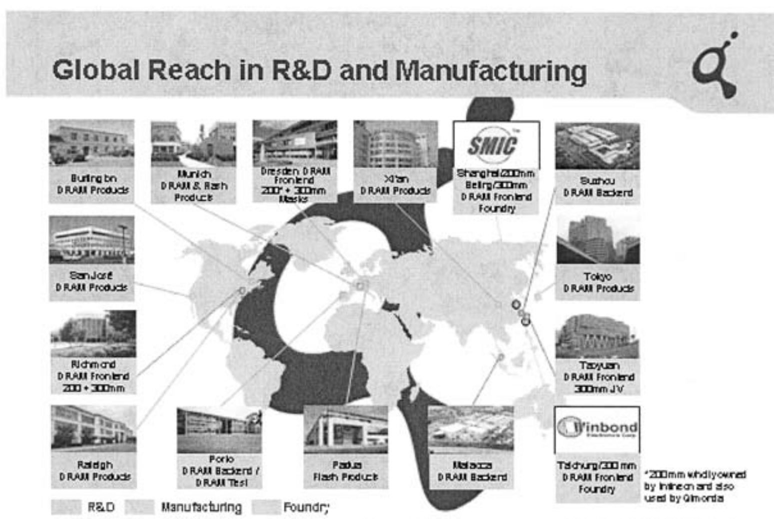

Figure 1

That said, cost competitiveness and talent availability are ever growing issues for our manufacturing and design operations in the United States. Aside from U.S.-based Micron Technologies, our primary competitors in the market are located in Asia where labor rates are significantly lower and the education and skill level is constantly improving. Labor is a key element of our cost structure in the U.S., and we remain competitive here only with constant increases in productivity. Pressure to shift more of our investment resources from the U.S. and into Asian-based fabrication plants and design centers is acute. D–RAM is a commodity product that is very cost sensitive and demands a 30 percent cost reduction or productivity improvement annually to remain competitive. Constant investment in new technology and equipment are required to continue competing.

In addition to higher costs for labor, we face a continuing shortage of workers with adequate science and math education to be able to support our manufacturing and design operations in the United States. A true skill shortage exists in both engineers for design work, and manufacturing associates with the adequate education foundation to work in the highly automated technical environment of our fabs. The United States is just not producing enough workers skilled to support the semiconductor industry. Many of our new hires come from other semiconductor companies or are immigrants to the United States. We are currently sponsoring more than 175 workers for visas and we would hire more immigrants if we were able to get more visas.

However more visas are not the answer. It would be our strong preference to see a larger pool of skilled workers here in the United States. We work continually to develop our own workforce, but that is not enough. Since we originally established our fab in Virginia, we have invested constantly in building technology education partnerships and initiatives region-wide. In cooperation with the Virginia Community College System, we supported the curriculum development for a two-year associate degree in microelectronics technology. Together with the state, we worked to mold the Virginia Microelectronics Consortia to develop engineering graduates for the semiconductor industry throughout Virginia's engineering colleges, and at Virginia Commonwealth University, we have supported curriculum development, funded professorships and student scholarships as well as provided operational expertise to start the Microelectronics Center in the beginning.

Following are just a few good examples of how we work with localities to develop the regional workforce to support our operational needs. Specific community education programs have grown from these advanced education investments. Henrico County's High Tech Academy is a science and technology based study program that showcases what can be done when the public and private sectors decide to cooperate on a critical need. The program sponsored by Qimonda and VCU exposes students to science and technology hoping to capture that area for further study and a profession someday. It is a two-year program for Henrico County Public School juniors and seniors that provide 32 transferable college credits for course work, and an internship at Qimonda.

Another notable program, our Technician Academy, is an internal education program that in partnership with the community college system brings instructors onsite to train our associates and allow them to earn a semiconductor associate degree. In addition to these formal programs, Qimonda sponsors the First Robotics competition by offering mentors, resources and financial support to help local teams participate in this national program that also exposes students to science and technology through the building of robots that compete in regional and national cooperative competitions or "co-opititions."

In Vermont, we have partnered with the Engineering School at the University of Vermont to sponsor a Senior Design Project in microelectronics.

I believe that most technology companies have their own home-grown programs primarily to meet their need for technology-based skilled workers.

However, unless the United States actively develops more home-grown engineering talent, it is just a matter of time until development, high tech manufacturing and design work shifts away from this country. It seems to us that producing more qualified U.S. engineering and science graduates is a better medium and long-term solution to the skill shortage we face than increasing the number of visas needed to maintain the skilled data pool supporting the technology industry here. And, for companies like ours, it costs thousands of dollars per worker in fees and human resources to obtain visas.

The United States is competing with countries that offer significant incentives for technology based manufacturing and product development, and have adopted strategies to produce a growing pool of talented labor. Most of these competitor nations treat technology in general, and semiconductors specifically, on the level of a national strategic interest and as such, have embraced it to the full extent they can—sometimes beyond World Trade Organization norms. My company and I believe that the United States needs a fundamental investment in science and math education, starting at a young age, to produce a workforce that keeps manufacturing and design work here in the United States. In addition, we need to find a way to attract the most talented students into engineering schools and technology professions.

Thank you for the opportunity to offer testimony to this committee and I look forward to answering your questions.

BIOGRAPHY FOR HENRY S. BECKER

Henry S. Becker is the President of the North American operations of Qimonda, the new memory products company that Infineon Technologies carved out on May 1, 2006. Previously he was Vice President and Managing Director of Infineon Technologies Richmond, located in Richmond, Virginia, a wholly-owned manufacturing subsidiary of Infineon Technologies, AG, located in Munich, Germany. In this position, he was responsible for all aspects of this high-volume 200mm and 300mm state-of-the-art D–RAM manufacturing site. Becker, who has been with Qimonda since the 1996 startup of the Richmond manufacturing site, has held many positions within Qimonda, including engineering, manufacturing and facilities management and Vice President of Wafer FAB operations.

He began his 23-year semiconductor career as a device engineer at Motorola, later moving into process and equipment engineering, and eventually into manufacturing management. Becker is a graduate of Ohio State University with a BS degree in electrical engineering.

DISCUSSION

Chairman WU. Thank you very much, Mr. Becker, and at this point we will open for our first round of questions. And the Chair recognizes himself for five minutes. Several of the witnesses, both before the break and afterwards, referred to mandatory technology transfer, that other countries sometimes require as a condition of doing business in that country or selling products in that country that there be a certain amount of technology transfer, and I think I am just going to start my questions with the most incendiary suggestion first, and that is why don't we respond to these mandatory requirements with a federal statute forbidding United States companies from complying with mandatory transfer. And I am throwing this out for thought purposes, not to actually prohibit technology transfer, but to give our companies leverage in their negotiations. There is a model for this. For a long time, Arab countries have had not an embargo, but a boycott of Israel; and I believe it is against American law to comply with that boycott. And many organizations find work-arounds where they can have activities in both Israel and in other places. The anti-boycott statutes basically encourage folks to kind of move in the right direction, and an anti-mandatory tech transfer statute might give American companies the opportunity to say, boy, I sure would like to do that, but I have got this U.S. Federal law that I have got to comply with; so let us talk about what we can do on a voluntary basis so it doesn't have to be mandatory so that we can comply. And that would at least change the weight of tech transfer, and that is where I am going to go with my questions later on about rate. What would you all think about the workability of an anti-mandatory tech transfer law?

Dr. MCMILLION. Mr. Chairman, we have some laws that restrict the transfer of technology. In fact, it is one of the things right now that Intel is relying on to limit the transfer of technology to their new Daleon $2.5 billion facility.

So the tech transfer laws that we have now I think do serve a very useful purpose. I think that additional laws, additional restrictions would be extremely helpful, and as you indicate, not necessarily because they would actually in all cases or many cases restrict the technology, but that they would give the company the ability to——

Chairman WU. Push back.

Dr. MCMILLION.—have a little bit more leverage than they have now. And if I could say also that one of the things to just suggest a way to think about these issues is that for many years, multinational firms were able to play countries against one another for good reasons and bad. They were able to move around resources to where they could be most efficiently utilized. There were very good things. There are very good things about multinational companies, and for many years they had done that. China poses I think for the first time, in my experience, an example of a country which has now created such dynamism that it is playing companies against one another and it is playing all of the major companies. In Intel's case, it is ADM and Intel in particular, but really all the semiconductor players. In automobiles, all of the major players—in the auto sector, there is an actual explicit requirement to locate R&D facilities in China in order to produce in these joint ventures by the way in which foreign companies are limited to a minority share. So when you read about General Motors or Toyota or Ford or whatever producing in China, they are all minority partners of those operations but they are required to move R&D facilities to China. And more restrictions I think would be very helpful for these companies.

Chairman WU. To get to that rate issue, and I think I want to announce that it will be the policy of the Chair to have a soft gavel on time limitations here. I just want to move to that rate issue, because I think several of you have referred to nimbleness and quickness of adjustment. And one of my observations anecdotally is that sometimes our organizations, our companies, can move much more quickly than individuals can retool, that is, either an organization doesn't survive and a new organization is founded in a new business line or an organization changes with business needs and retools, but that an individual has frequently invested years and years of education and a professional career and that it is tougher for the individual—say that, you know, it is hard, for example, to turn a hardware person into a software person overnight. What can we do to help individual workers or individual researchers to catch up with the rate of change, this nimbleness challenge that new markets seem to impose on us?

Dr. TEITELBAUM. I'll take a shot at that.

Chairman WU. Please, go ahead.

Mr. BECKER. I was going to maybe comment on the previous question and figure out how to wheel that into your second question. You know, the Taiwanese tried to slow down the export of their semiconductor business to China. They told the companies in Taiwan that you weren't allowed to build a 300 millimeter or 12-inch factory until you build one in Taiwan. Well, all that did was force them to go find partners and accelerate their partnership so that they could build one in China because they were chasing a market, they were chasing a lower skilled labor rate and availability of engineers. I think my colleague, Mr. Kostek here, talked a little bit more about how do we reuse the resources that we have at hand. And I think we have to look very diligently for those people. I mean, are they on the market? Are they looking for jobs? I think that they have the right skill sets, not necessarily are they in the right place because innovation is innovation and it takes creative thinking from my perspective. And somebody who has got experience brings with them the ability to take blinders off and answer questions from a different perspective.

So I don't know that you have to go out there and retrain those people. I think you have to have managers that are willing and have the vision to be able to hire those people into those jobs and to mentor the younger engineers on how to solve those problems in a more creative way.

Chairman WU. Dr. Teitelbaum.

Dr. TEITELBAUM. Mr. Chair, what I was just going to add—it is a different point, really, something that we at the Sloan Foundation have invested a lot of money over the last 12, 14 years—encouraging the availability of high-quality advanced education online to people who are working and can't really go back for a degree or a certificate, take six months or a year off. They need to earn an income. But they also need to keep their skills up to date in a rapidly changing set of science and technology sectors. I think the evidence is clear now that it is entirely possible—in fact it is very popular with students to provide high-quality education online, not at fixed times, so that people can do it when they are at home or traveling or sitting at an airport because the plane was delayed or whatever. These kinds of online education provisions have grown extremely rapidly. They are growing at about 20 percent per year among student populations in all fields, and I think it is something worth looking at seriously with respect to your nimbleness question. The nimbleness of the individual technical expert as compared to the nimbleness of the company.

Chairman WU. Anybody else want to take a shot at this nimbleness issue?

Mr. KOSTEK. I guess the only thing I would add, I think people addressed most of it, is I think in most cases—first off, very few people are going to make the dramatic switch from a hardware person to a software person. Some will, some will want to make a total transition. So in most cases it is using resources that Dr. Teitlebaum just touched on saying here are the skills I need to add to make myself employable. Then we need some level of flexibility from the employers to say, okay, here is somebody coming along who has picked up these new skills. They have not applied these skills yet but their history tells us they are proficient engineers and we should be utilizing these people to fill this position, even though they are not an exact match because they don't have the 10 years of job experience, but they have a 20-year history doing programming and they have just learned java so they should be able to apply. So in most cases I think what we are looking at from both groups, employers and the engineers, is really flexibility on both sides. People begin to communicate more effectively on what they are bringing to the table and what the expectations are of an employer in terms of filling a position.

Chairman WU. Thank you very much. Dr. Gingrey.

Mr. GINGREY. Thank you, Mr. Chairman. Mr. Becker, I was particularly interested in your testimony in regard to your company, Qimonda. And I am pleased of course to hear that a foreign-based company like yours are making investments in the United States, particularly in the engineering field, boosting as you pointed out domestic trade and the overall American economy. I think that is a very good thing. But you know, earlier this summer, back in July in fact, we were voting on the Farm Bill in the House; and the Democratic majority emphasized how important it was that we enhance our food stamp program, and other opportunities and a lot of the increased spending in the Farm Bill went to the food program. But unfortunately, in the pay-go rule, not a bad rule, Mr. Becker, and I am sure you are aware of this, $4 billion in new taxes on foreign-owned subsidiaries, like your company were passed. And of course, as you point out, you employ a lot of U.S. workers and good jobs. It might not have a great effect on companies that are already located in the United States that have established bricks and mortar and infrastructure and now all of a sudden they have got this additional tax burden; but it would be more costly for them to pick up and move offshore. So, they sort of bite the bullet and unfortunately have that burden. But my question is and my concern is I would like for you to address this, would not this be a tremendous disincentive for a company like your own that was thinking about establishing a subsidiary in the United States and all of a sudden, you know, this tax burden is there, and this to me it may very well be a disincentive. What do tax increases like this, what effect do they have on companies that we need? And I want to just add that my district, the 11th of Georgia, northwest Georgia, we have I think something like 272 companies like yours and they create 23,000 jobs in the 11th District of Georgia. That is nine counties. So we are not talking about small potatoes here. In my opening remarks I talked about the $5 billion I think it was. But respond to that for me, if you will, please. And I would like, Mr. Chairman, since you have a soft gavel, that some of the other witnesses may want to respond to that as well.

Mr. BECKER. In particularly the D–RAM business, D–RAMs are very much a commodity. The price that we get for a D–RAM is strictly driven almost 100 percent by supply and demand. More supply, less demand, the price goes down, and vice versa. Over the long haul, say the last 30 years, when we apply Moore's Law, if you have heard of Gordon Moore's Law from Intel, it talks about the doubling of a microprocessor's capability every 18 months, when we apply that to D–RAMs it translates into I have to produce a piece of memory or a bit of D–RAM memory each and every year. I have to reduce the cost of that by 30 percent. So any increase that I get hit with, whether it be tax, whether it be the cost of a consumable, whether it be my labor rate going up or whatever it is, my healthcare benefits, I have got to squeeze that out somewhere else or I am no longer competitive. So not only could it be potentially a disincentive to start there, it makes your job much tougher to stay there.

Mr. GINGREY. And I am not surprised at all of that response. Dr. Teitelbaum, the Chairman is going to be generous with my time. Maybe we can just start with you and go right down.

Dr. TEITELBAUM. Congressman, I don't have any great expertise in tax policy and tax law, so I don't know the details of the tax increase that you are describing. But generally speaking, if you raise taxes, you will have some effect in the market. I mean, that is the nature of economic behavior. I mentioned in my own testimony some of the other tax provisions that you might also want to think about, having to do with U.S.-based firms that have incentives not to bring their global profitability and invest it in the United States but rather invest it abroad. If you combine this with some of the mandatory and other incentives offered by other governments for investing in R&D abroad, it seems like a pretty good deal to me, a pretty good offer of, well, if you bring it back, invest it in R&D in the United States, we are going to tax the profits. But if you invest it abroad, we won't tax them and you will get incentives, very substantial incentives, from other governments.

Mr. GINGREY. In other words, it is a double hit really, as you pointed out. Dr. McMillion.

Dr. MCMILLION. Certainly the D–RAM business is a very low margin business, and so I can certainly sympathize with the effect of any tax rise or any increase in prices of any kind. I am not familiar with the tradeoff in the Agriculture Bill, so I can't really speak to the issue directly. I just remind Members, of course, I referred to it briefly in my oral testimony that federal debt, you recently had to raise the debt ceiling above $9 trillion. I would just remind everybody that it first reached $1 trillion in 1981. It was $5.5 trillion about seven years ago, so we have added close to $3.5 trillion over the last seven or eight years.

So we do need to have revenue for the Federal Government. Nobody likes to pay taxes, and certainly D–RAM business is an awful business to try to increase taxes on. But we do have to worry about our federal deficit.

Dr. SALZMAN. Sir, not my area of expertise. I think I will pass on that question.

Mr. KOSTEK. Well, I am an engineer, but as any engineer I have an opinion on everything, and I think a lot of our members would find——

Mr. GINGREY. Kind of like an MD?

Mr. KOSTEK. Yeah.

Mr. GINGREY. Or a lawyer.

Mr. KOSTEK. Or a lawyer. That is true. I think what I have found is most of our members are now learning the importance of understanding not just technology and how it is applied but also how, I'll call it the law of unintended consequences can hit you that what someone thinks is a really good piece of legislation can actually end up having a negative impact on employment and opportunities for people. So I would say in most cases, our members are looking now at the question of working for a foreign country. In-sourcing is creating a lot of great opportunities for people, and we may not want to be harming those opportunities because that is really the growth in many cases people are seeing.

Mr. GINGREY. Mr. Chairman, thank you for your patience. I appreciate that.

Chairman WU. Thank you very much, Dr. Gingrey. Ms. Richardson.

Ms. RICHARDSON. Yes, thank you, Mr. Chairman. My first two questions are for Mr. Becker. You mentioned in your written testimony and of the little bit that I got here today that you have seen a shortage of capable technical workers in the U.S. among which the educational level such as the associate, bachelors, and masters degree programs. What percentage of your workers hold degrees, you know, two-year, four-year, and graduate?

Mr. BECKER. If I look at the manufacturing facility that I have in Richmond, engineering degrees, four-year degrees, or maybe advanced degrees or probably—I should do the math in my head real quickly. I should be able to do that as an engineer, right? Probably 35 percent, 40 percent. Many of those people, you know, rise into the management ranks. People with associate's degrees typically are those who perform maintenance on our equipment. They also do the day-to-day process sustaining in our factory, deal with SPC, statistical process control, making sure things are performing, the processes are performing like they are supposed to. And high-school degrees are required for all of our manufacturing associates or our people who actually run the wafers on the manufacturing floor. As a percentage, manufacturing associates probably make up about half.

Ms. RICHARDSON. And what would you say are the fastest wage growth positions and does it differ in terms of the location of the facility where the job is performed?

Mr. BECKER. The fastest-growing wage? I can quote some wage statistics from the Richmond Wafer Fab facility. The local area wage average is somewhere around $35,000 plus or minus a year, you know, it changes from year to year. We pay on average about $65,000 at that facility. Obviously with more advanced degree or management you make more, but you know, the starting salary for a manufacturing associate is on the order of $40,000 because we ask them to be proficient in math in science to be able to deal with computer systems and to be able to read statistical charts and to be able to make decisions as to how to tweak the equipment so it continues to process the wafers as they should be processed.

Ms. RICHARDSON. Do you have a specific process locally with your colleges about your positions or do you do the traditional outreach or how do you let people know that these jobs are available?

Mr. BECKER. We obviously advertise for jobs, but when we first came to town in Richmond, Virginia didn't have a semiconductor industry per se. We worked very closely with the community colleges, put in place an associates degree in microelectronics that was geared toward our needs. We worked very closely with Virginia Commonwealth University. As luck would have it, Motorola negotiated a microelectronics center there. They are in our backyard. We do a lot of work with them. We spend a lot of time talking about curriculum development and modifications and changes so that their product, the undergraduate and the graduate student, are tailored to what we need to be successful.

Ms. RICHARDSON. And do you find the community college receptive to your needs?

Mr. BECKER. Absolutely, to the point where we have had more than one community college come together and put together a joint proposals and joint efforts to try and address that need.

Ms. RICHARDSON. Thank you, sir. I yield back the balance of my time.

Chairman WU. Thank you very much, Ms. Richardson. Dr. Ehlers.

Mr. EHLERS. Thank you, Mr. Chairman. It is a very interesting hearing. I would like to make several comments before asking questions based on the comments that I heard and some that I heard were said before I got here.

First of all, let me emphasize, I spent an immense amount of time on this, first throughout my life, but, especially through the last 12 years here; and I have spent a lot of my time just trying to improve math and science at the K–12 level. The question is why K–12? My opinion is that is where the biggest problem is for a couple of reasons. First of all, if students don't get an adequate math and science education in the elementary and secondary schools, they are not likely to choose engineering or science as a career at the university level simply because they will have a lot of makeup work to do and it will be at least five years if not six. So, I think it is important to give them that base.

Secondly, I believe that the jobs of the future, in fact many of the jobs of the present, require a good understanding of the basic principles of math and science. If you go into almost any factory today, it is worlds different from years ago, particularly a machine shop. Years ago when I would visit one, you would see lines of lathes, people standing at the lathes, turning the little screws, measuring with micrometers. Today it is huge milling machines, computer operated. The operators are paid very well, $70,000 to $80,000 a year but they have to understand how to run a complex machine. They are hired as high-school graduates. If they haven't developed the skills in math and science needed for that job, they simply won't get the job. I think the jobs of the future are all going to move in that direction requiring that skill, even some that are not highly technical.

One of my favorite stories was when I was in the State Senate in Michigan. One of the convenience store owners in that area discovered that he was losing about $100,000 cash per year in wrong change. Now that seems excessively large, but he had a chain and so it wasn't that much in each shop. But at the same time, you are all engineers. You know how diodes work. Giving change is a diode. If you get it wrong, the money just flows out. If the error is in the benefit of the customer, the money flows out. If it is a benefit of the store, it doesn't come back, it flows out.

Anyway, there are a host of reasons that I have for believing science and math at elementary and secondary schools are important. If nothing else, to be good citizens. In today's world, if you want to try to read the label of contents on something, you better have a little background. Or if you live in California and want to vote with the many environmental propositions they have every year, you had better know something about math and science if you are going to vote intelligently.

Having said that, what about higher education? There are a lot of engineers being prepared in the world. Last year alone China graduated more English-speaking engineers than the United States. In addition to that, they graduated a considerably larger number who are non-English-speaking. These engineers are going to get jobs somewhere, and I think it is better to have an oversupply of something like this. Also I happen to think that people who are trained in the sciences and engineering are very versatile employees in a number of fields. When I received my Ph.D., one of my brightest colleagues went off to Wall Street for a job. I am sure he has done much better than I have, but his analytical skills, his mathematical skills that he has developed are very valuable in that profession.

Engineering I think has particular problems, and Mr. Kostek, I think you zeroed in on those. People have given up, as you said, and I think that is true. I have a son who is an electronics engineer. He designs flight management computers for aviation and does a lot of other avionics work. He is adamantly opposed to the H–1B visa program because there are so many unemployed engineers already in this country. And in almost every case, you now, I checked through that, they are good people. They have done good engineering work in their life, but they never kept up with their field or for that case with other fields. And that is the key, and perhaps that is where the distance learning you mentioned, Dr. Teitelbaum, is most effective. Some don't want to go back to school, and that may be true; but then again, distance learning isn't that bad. And employers also have a responsibility to help them in that situation. As you say, they do feel left behind, and that is because they have been left behind, and it is partly their fault, perhaps partly their employer's fault by simply not keeping up with the field. I think everyone in the scientific field has to keep up with the times or they are soon going to be out of a job. I don't know if we can bring that through to them, but I sincerely believe that.

I am sorry, but I am a son of a minister; and I always tend to give sermons, but I would appreciate comments that any of you might wish to make, particularly if you disagree with them.

Mr. KOSTEK. Well, I guess the only thing I would maybe disagree with when you talked about an oversupply of engineers and scientists can't hurt, the question would be what do we do with the oversupply? I grant that people can go into other fields and other areas for employment, but think the message that may send to people following them in the pipeline is, well, I would like to study engineering but all these people who graduated before me never became engineers. They became other things. So I am going to go off and study business because that is where this person ended up.

So I think the risk we always face is that the oversupply may lead to an undersupply at some point in time as the system responds to what people see around them. In terms of the continuing education, that is something that we, you know, constantly talk to our members about, the necessary to upgrade their skills, watch the marketplace, and understand the changes that are taking place in terms of competition, that history has changed. And so the time of saying, well, there is a downside right now but we will be recovering soon is gone; and now what ends of happening is inexpensive, commodity-type components can be replaced and built somewhere else. And so people have to now constantly look at what am I adding to the business? How am I helping this business to make additional money?

Mr. EHLERS. Yes, and I don't disagree with any of that. I come from a liberal arts background. I happen to think that if you have a good liberal arts background, you are incredibly versatile in the marketplace; and it would be very disappointing for a new engineer to discover he has trouble finding a job in that. But there are many jobs in society that can use those skills that that person has, whether it is math or science. It has been very effective. I am a good example of that. As a physicist, I did research for 12 years. I ended up here. Now that may have been a waste of a scientist, but I think I have been able to accomplish something here simply because I am a scientist and the first research physicist ever elected. I would love to see more engineers and scientists. Hey, it is a pretty lonely world here. Other comments?

Dr. SALZMAN. Yeah, I think in general nobody is going to argue against more math, science, better education, it is a question of tradeoffs, and you know, particular concern is what are the tradeoffs inherent in policies that have been focusing on the K–12 math, particularly with the direction or the orientation of producing more scientists and engineers. And the concerns I would have are that—[inaudible] without unlimited dollars. Does it assess the [inaudible] of the top and the bottom? You know, for great concerns and the great deficits that we find are the bottom 30 percent, those who can't count change, those who can't do basic math. I have yet to hear an employer say that the professional staff are not skilled, educated enough in math and science. I have yet to hear an employer say their engineers don't have math/science skills. I do hear managers complain that their engineering and professional and technical staff don't have communication skills, don't have the broad-based education, business, marketing, liberal arts. And so in some ways, the over-emphasis on math and science does not create the kinds of scientists and engineers we need and doesn't direct the resources to those who are most deficient.

So that is my concern within the broad-based, you know, supportive more, better education, is that we need to look at what tradeoffs are in math. You know, science, it is [inaudible] to some sense if you increase the quantity of that, you are decreasing the quantity of something else.

Mr. EHLERS. My point on the K–12 is I think it is viable for them. My principal goal of having them learn math and science at K–12 is not to have them become scientists and engineers, but to become useful citizens in our democracy.

I think that is—one can show that that is essential. Now, if they happen to go on to science and engineering if they can't find a job, there are lots of other jobs that are available with that bill program. I taught at a liberal arts college as well as teaching at Berkeley, and I am convinced the liberal arts education is very good for engineers. When we followed up, our engineering graduates, a vastly disproportionate number of them ended up in management because they had picked up the other skills that you mentioned and were better needed for management. I think I have gone past my limit, Mr. Chairman.

Chairman WU. In a very useful way, Dr. Ehlers.

Mr. EHLERS. Unless someone else agrees with me then we——

Chairman WU. We have just been beeped for another set of votes. I think the only humane thing to do is to release the witnesses when we do have to go, but it is my intention to ask questions quickly so that members can as questions f they have them in the 10 or 12 minutes or so that we have left.

Back to the nimbleness issue, and anyone who wants to address this—so that students can, if you will, make the right moves between different types of training and also so that current workers can get the training or prepare for the next move if or when necessary. What market signals can we more effectively send, both students and current workers, so that they can choose among the available fields for either the first-time education or continuing education? Dr. Teitelbaum.

Dr. TEITELBAUM. Congressman, Mr. Chairman, I think it would be highly desirable in response to your question if graduate science programs made available to prospective students what have been the career outcomes of their recent graduates and if they are post-docs what they have been for post-docs in their program. This is raw material that all prospective students should be able to find easily. How have the chemistry Ph.D.s from the University of X done in their careers in the last few years? It is sometimes quite difficult to find, particularly in the biomedical sciences. And that would be a basic metric I would say. We ought to be providing those signals to the smart students who are thinking about what they want to do with their next five or 10 years.

Chairman WU. Mr. Becker.

Mr. BECKER. I think most progressive companies that are in the science and technology marketplace if you will do two things for their existing employees. They provide the opportunity, generally paid for, to go back to school, get an advanced degree, go to seminars, go to certificate classes. I heard an earlier testimony that may be difficult working a full-time job, but I think most employers want their employees to grow, okay? We have invested up front, and to get them to a certain point, we want to get them to the next level, to the next level, to the next level. When we talk about technical resources, not management resources but technical resources, I think most companies that are in those fields have what they call technical matter, which allows individuals not to hit a glass ceiling if you will, because they won't go into management, but to be able to progress in their careers, be compensated as they grow themselves technically and become a much more valuable asset to the company.

Chairman WU. Dr. Ehlers, I understand you have a——

Mr. EHLERS. Just very briefly in response to Dr. Teitelbaum. Not to disagree with you, but your example of a Ph.D. in chemistry reminded me that sitting in this room is Julia Juster who is my aid, Ph.D. in chemistry. I don't think she ever intended to come to the Congress to work, but she got a one-year fellowship at ACS in town, and she liked science policy and she is here and doing an outstanding job. I would be lost without her. But if she would have gotten discouraged by looking at the statistics, not getting jobs as chemists, she might have done that. Thank you very much.

Dr. TEITELBAUM. Actually, chemistry does pretty well. I think she would have been encouraged if those data had been available.

Chairman WU. Mr. Becker, do you have something to continue with or does anyone else on the panel have something to say on that?

Mr. BECKER. I am done my comment. Thank you.

Chairman WU. Thank you, Mr. Becker. Mr. Kostek.

Mr. KOSTEK. I think the only thing I would add is it is also an interesting time and several people on this panel heard me say this last week, no one would have thought a few years ago that someone would have created a business called Linden Labs that created something called second life where you now have people making thousands of dollars a year selling virtual products to virtual people on line. And so some of the opportunities that we talked about for our members and for our future engineers haven't been identified yet. And it is almost a question of encouraging people to be open to what may sounds like an absolutely crazy idea when it is first proposed, may turn out to be the ideal solution. And we are not necessarily talking about having special skills or adding new skills. It is more having the openness to say let us go try this thing. I am sure the father of the young man who created Facebook who, when he sold $240 million worth of his company to Microsoft last week was probably still sitting there shaking his head thinking, I can't believe he made a business out of this. So I think there are lots of times when—we talk about the skills. It is not just the skills, it is also the openness to take the risk in a vastly, quickly changing marketplace.

Chairman WU. Anyone else before we return to Dr. Gingrey?

Mr. GINGREY. Mr. Chairman, thank you. Picking up on what Dr. Ehlers said, I want to recognize also Dr. Dan Deckler who is my fellow. Raise your hand, Dan. Dan is a Ph.D. in electrical engineering. I think his basic undergraduate degree was in mechanical engineering, and I am very fortunate that he is with the Committee as a fellow for a year.

But you know, this whole issue of the thinking, and Dr. Teitelbaum, you mentioned I think you made a statement that in regard to engineers, we can offer no assurance that they will find a durable and resilient career path in such fields. Compared with other career paths, the question is, is a career in science and engineering more or less likely to guarantee a high-paying job? And what I notice, I was on the school board when I was first starting in politics, the high school, school board. And you know, it seems like a lot of my children's contemporaries when we went off to college, they wanted to be broadcast journalists. They wanted to be the next Lauri Dhu or Tony Snow or some of them with athletic ability, you know, hoped that they would be the next—I forget the coach's name at Alabama that is making $4 million a year. But you know, I think if there was some way we could educate young people in regard to when the economy is good, and it mostly is, that an engineering career is not a bad life and not a bad income. And I think a lot of our young people get a false sense of celebrities, I guess, because of our pop culture and television and that sort of thing. And so they think, well, engineering, I kind of like that, I like math, I like science, I like chemistry, I like physics, but you know, what are my chances of ending up making as much as a member of the United States Congress? Well, I would say darned good. All they have to do is make about $150,000 a year, and they are there. I really do believe that a lot of young people think that, you know, it is just not glamorous enough. But here five of you are testifying before Congress. That is pretty good. And your communication skills are good, and I think Dr. Ehlers or somebody else mentioned the importance of developing these other skills, other than just having a great brain for science and technology. So I don't know, maybe you want to comment on that a little bit? Dr. Ehlers I guess had to step out, maybe went to vote. But we just need to incentivize our young people in some way and get them turned on to the excitement of STEM education.

Dr. TEITELBAUM. Congressman, I couldn't agree more with that, and the only caveat I would add is that erratic boom/bust kinds of occupations are not the kinds of things you want to see if a lot of preparation and study is required to enter the occupation or the profession.

So booms and busts and oscillations with big hiring booms, and then five or seven years later big layoffs, send messages that you don't want to see sent; cover stories in major magazines during the last Silicon Valley bust, saying things like "Finished at 40?" and showing an electrical engineer or an IT professional. That is not a good sequence for occupations that really do require a lot of talent, a lot of hard work, and a lot of years to prepare for and to become proficient in.

So you want to not see these booms and busts. That is why I mentioned it in my testimony that we do have a tendency in our funding to encourage booms and busts in these sectors which are not healthy for the long-term enterprise.

Dr. SALZMAN. I would add maybe misperception about lack of interest. I mean, when you look at the amount of math, science taking, the majors students are entering, we don't see any drop-off but in fact, just gradual, you know, slight increase in the rate in percent of students that do elect for science and engineering majors in college. So there is not a lot of great evidence of decline of interest and the extent that it does vary as Michael Teitelbaum pointed out does seem to go with the employment cycle.

Mr. BECKER. Just a last comment about engineers in general. Part of the educational process to become an engineer is technical in nature, but another part of an engineer's education is how to solve problems, how to attack problems, how to logically work your way through those things. And I don't know if you want to see a show of hands, how many people in here have engineering degrees, but I personally believe that the skill that allows you to solve problem is transferable to almost anything you want to do.

Mr. GINGREY. And I will just kind of conclude. I know my time is expired, and we do have a vote but as I watched my children go through middle school and even into high school, especially middle school, they would have homework and they would have to do the rote kind of stuff. But at the end, there was always the word problems which were the most exciting, you know, how you apply what you learned and problem solving as you're talking about, Mr. Becker. And they would say, well, the teacher said we don't have to do those. That's just optional. When really to me it was the most important thing to work those word problems so that you become a problem-solver. Thank you.

Chairman WU. Mr. Becker, working for the organization that you do, you may have more knowledge of how Germany or Europe may do things differently than we do here in the United States, and I would welcome comments from the rest of the panel also. How does your company and how does Germany differ from say mainstream American practices or laws in sending signals to workers about what to prepare for or what happens if there are layoffs. You know, again, this is trying to get at the nimbleness issue of when organizations move. What is the best way to have people adjust to the organizational moves?

Mr. BECKER. It would be hard for me to characterize. The German workforce is a nimble workforce. I think it is one that is managed heavily and legally bound to the union process. There is heavy negotiations between companies and representatives for workers and workers councils. And we have Boards of Directors that govern our publicly held companies. They also have boards of directors that are 50 percent made up of representatives that represent the employees.

Chairman WU. My apologies, but if any of the other panelists have a comment on this question, I will take your answer in writing. The clock is at zero, but there are still about 150 Members who haven't voted, but I think that there may be a couple further inquiries which we will send your way in writing, and I am now going to bring the hearing to a close and thank our witnesses for testifying and for your forbearance—I—this broken-up set of sessions here. And the record will remain open for additional statements from Members and for questions and answers that any Committee Members may ask. The witnesses are now excused, and the hearing is adjourned. Thank you very much.

[Whereupon, at 6:08 p.m., the Subcommittee was adjourned.]