Testimony of
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to the
Technology and Innovation Subcommittee of the
Committee on Science and Technology
U.S. House of Representatives
March 24, 2010

Chairman Wu, Ranking Member Smith, and members of the Subcommittee, thank you for the opportunity to take part in this hearing. I was invited here to talk about innovation for economic growth, and what we can learn from the extensive efforts of other nations to excel in this domain so we can secure the long-term economic welfare of the American people.

There are some baseline points to be made when discussing innovation policy:

1. Spurring and promoting innovation is a critical role of government, and is a very different strategic exercise from promoting specific industries, sectors, or even skills.

2. Good innovation policy needs to allow experimentation and change as it, and the industries it helps to develop, evolve.

3. In order to promote innovation there is a need to balance the different interests of the public, represented by the elected government, and private companies and individuals that will be the major agents of innovation in our country.

Current US policy debates have been clouded by significant misunderstandings in relation to these principles. A careful analysis of other nations' efforts to use the tremendous forces of competition and entrepreneurship to spur innovation, can help us sort out these misunderstandings and improve our innovation policies.

In this testimony I will:

1. Lay out the challenges associated with government efforts to enable innovation.
2. Describe three roles a government can take on to support rapid innovation-based growth and illustrate how some other countries have implemented policies to fill these roles.
3. Discuss the lessons the US might take from international experiences in innovation policy.

Innovation, growth and the US

Innovation has been a tremendous force for good. Innovations in industry, health, and agriculture have advanced the quality of life of the American people to such a degree that today the average American child has a much better, more comfortable, luxurious, and healthy life than the Emperor of China had in the beginning of the 20th century. Thanks to innovation, the world no longer faces imminent hunger, diseases that were once both common and fatal are vanquished, and the sum set of appliances in an average American home gives its owner the ability to do things that were impossible with a regiment of workers and scholars just a few generations ago. We might forget, but what we now consider as low-tech traditional industries, were, only a few decades ago, the cutting edge of high-technology. Indeed, in the 1967 movie, *The Graduate,* Mr. McGuire famously said to Benjamin one word that embodied the future of industrial innovation: "Plastics." For this country to stay a world leader, our children will need to be able to react in the same bemused way we do to the idea of plastics as the future, when someone in circa 2050 would say: "Nano-technology."

The US has grown to prominence as *the* place where people with vision and drive can become educated, generate novel ideas, and secure specialized financing to transform their ideas into superior products and services. Furthermore, it was in the US where one could pursue that course without its being squashed in infancy by stronger corporations, the legal system, or the growing costs of doing business and staying independently employed. With each new innovation-based revolution – agriculture, steel, electricity, internal combustion engine, aviation, space, information technology, and biotechnology – the US has led the world, becoming richer and stronger as a result. This has been true not only with regard to novel technologies brought to the market for the first time, but with regard to new ideas all along the production chain. To accomplish this, the United States has developed the world's best centers of higher education and research and the world's most efficient system for transforming ideas into marketable realities. Today, however, in each and every part of this system we face increased international competition.

Choices matter

Contrary to commonly held belief, the current processes of intensified globalization give countries a larger number of rapid-innovation-based economic growth alternatives than they had in the past. A general truism today is that both the onslaught of international economic forces and the fragmentation of production limit the power of governments to set unique courses of successful economic growth. And yet, these same conditions have given countries more choices of action than ever before, for the increasing complexity and openness of the world allow nations that wish to engage with the international economic system a far larger number of entry points than in any other period. This does not mean that stimulating development has become an easier task for government, nor that success, if it is achieved, is without cost.

Rapid-Innovation-Based growth – the misunderstood strategic policy implication

The case of rapid-innovation-based growth presents a variety of problems for those who try to understand the role of government. Since the main aim is to bring to fruition novel ideas – ideas that cannot be known in advance – for products and services that are as yet unimagined, we cannot develop policies assuming that we know the markets, the products, the industries, the specific skills needed, or how they will be combined (Breznitz 2007b). This is not the case of developing or restructuring an existing industry, such as the car industry, where the products are well understood, and where we have a clear idea of how to make them, and a pretty good guess about the capabilities we would need to make better vehicles.

In the case of innovation, the aim of the government is to spur agents, some of whom are currently unknown or do not yet exist, to come up with novel ideas and transform them into products and services, which, as of now, cannot be defined. Accordingly, in its idealized form innovation policy aims to equip the economy with agents of change that are stimulated for actions in ways we cannot foresee. Furthermore, with globalization – that is, the growing fragmentation of production where products are produced in discreet stages across many locales – we at best have only a limited ability to predict the exact division of labor between the local agents and the international economy that would allow for the making and sale of these products and services for maximum profits. Hence, we need to develop agents (both individuals and organizations) that have the capacity to understand science and technology as well as the market, and the capability to generate novel ideas. In addition, we need to ensure that they work within a system that enables them, as smoothly as possible, to transform these ideas into products and services to be sold worldwide.

What we do know, however, is that the inherent characteristics of industrial research and development (R&D) would lead, under free competitive market conditions, to under-investment in innovation from a social optimum point of view (Arrow 1962; Nelson 1959). For this reason almost every nation on earth now engages in public funding of innovation in an attempt to lower the risk and stimulate more activity. Similarly, many nations now try to increase the rewards for innovation in the hope of making them more attractive. This is part of the logic behind systems, such as the patent system, that grant monopoly rights to inventors who come up with ideas that are deemed original. Consequently, in our era of globalization governments now need to actively engage in two critical domains: i) solutions to the industrial R&D market failure; ii) local-global relationships. My research has found that different countries successfully solve these issues in very different ways, leading to significantly varied outcomes both in the scope of activities and in the distribution of the economic fruits of success within their societies.

None of these issues are considered to be outside the mainstream of policy and theory. Most scholars and policy makers would fully agree that there is a need for public funding of industrial R&D. However, the common policy prescription urges government to go no further than minimal 'market-enhancing' intervention. It is here where the most common misunderstandings about innovation policy occur.

Three Challenges

Once governments commit to funding of industrial R&D, a host of issues that are not fully acknowledged in policy debates and theory comes into play. Specifically, nations that subsidize industrial R&D face three overlapping challenges (Breznitz and Zehavi 2010):

1. Trust: the need to establish trust both between public and private actors and among private actors.

2. Coordination: the need to coordinate R&D across institutional actors. Both the trust and coordination challenges are closely associated with the overarching goal of establishing cooperation among private and quasi-private actors.

3. Motivation: the need to motivate private actors to innovate in ways that contribute to the domestic economy – the prima facie reason for public funding in the first place.

Trust: The importance of trust for industrial R&D is manifested in two different types of relationships: trust between the government and private actors and trust among the private actors themselves. The 'trust' deficit with regard to 'government-private' relations is associated with the problem of information asymmetries. One of the government's main objectives in financing R&D is the creation of new industries and the introduction of new activities into the local economy. As a consequence, by definition, markets are either underdeveloped or not yet in existence. Under these circumstances, the government cannot rely on market signals to ensure that: a) its investments are used properly; and b) that its policies lead to the stated goal of creating new industries and capabilities within the national economy. Because governments cannot fully rely on the market for information, adherence to a pure financier/provider division might create significant information asymmetry problems between the government and private firms. Even in the private market it is assumed that these problems can never be optimally resolved, and hence, that financing of new R&D-based companies is, supposedly, best handled by specialized financiers, such as venture capitalists, who use a variety of instruments to negate, but can never fully eliminate, these information asymmetries.

Second, as we have learned from the multidisciplinary study of innovation in the last few decades, innovation is a collective endeavor that necessitates close cooperation among agents if it is to flourish and result in long-term economic growth (Antonelli 2000; Carlsson et al. 2002; Edquist 1997; Hagedoorn 2002; Kenney 2000; Lester and Piore 2004; Lundvall 1992; Nelson 1993; Powell et al. 1996). Therefore, for public investments in private R&D to deliver sustained

economic growth there is a need to accommodate close cooperation among firms. However, against the backdrop of fully competitive free markets it is to be expected that inter-firm collaborations would be laced with suspicion and distrust. Balancing cooperation and competition is no simple matter even when firms possess complementary knowledge and capabilities. Moreover, even in situations in which private firms do choose to cooperate, insufficient trust is likely to push partners to restrict the scope of cooperation (Li, Eden et al. 2008). Government-facilitated cooperation has, over time, successfully engendered trust among cooperating private actors. Closely related to this problem, countries that rely solely on public funding to stimulate R&D growth might well discover, to their dismay, that firms are underutilizing public funding because of capacity problems in the private sector (Justman and Teubal 1995). This problem is compounded by inter-firm competition that engenders distrust and discourages professional cooperation across firms. This is a major problem because R&D is a collaborative venture in which the interplay of different skills and ideas allows professionals to achieve together what would have been well nigh impossible on their own. Isolated professionals might well fail to make substantial breakthroughs, where the same professionals working in cooperation would have had a far better chance.

Coordination: Meaningful and sustained interaction among diverse actors that are separated organizationally, geographically, or both, is not a given regardless of concerns regarding trust. The system of innovation literature shows that private firms that engage in R&D activities cannot operate in an optimal manner without the support of an array of other institutions (Carlsson et al. 2002; Edquist 1997; Lundvall 1992; Nelson 1993). The development of a high technology industry does not happen in an institutional vacuum. Many locales must undergo a fair amount of industrial restructuring before the conditions are right for high technology growth. For example,

dynamic R&D-led industries lead to the need to have ever greater flexibility in the labor force. This flexibility must be achieved while preventing severe political backlash against innovation when it leads to deep crises in specific locales. Such a feat, however, can be accomplished only with close coordination between private market actors and public actors that work together to legitimize and facilitate flexibility-enhancing restructuring (McDermott 2007; Ornston and Rehn 2006; Traxler and Unger 1994).

Domestically-oriented Motivation: Governments would like private actors not only to be motivated to innovate, but to do so in ways that would benefit the local economy. Yet there is little assurance that this would be the case because private actors' prime need and interest is to maximize their personal utility regardless of effect on other domestic firms or the geographical locale in which their value-added activities take place. These different goals create two distinct conflicts of interests between the government, on the one hand, and private companies, on the other.

First, one of the main justifications for public support of industrial R&D is the expectation that private R&D would generate positive spillovers for the rest of the economy. The government therefore aims to maximize local spillovers from its industrial R&D investment. However, in their search for profits, companies prefer to maximize the appropriability of their R&D outcomes. Private firms do their best to create the most competitive R&D possible – certainly a public interest – but would also do their utmost to fully appropriate its benefits and limit the spillover effects – something that governments would like to prevent.

Second, governments prefer that individuals and firms contribute first and foremost locally. But what could motivate private domestic actors to stay, or for that matter return, home? While the government hopes to keep as much high value-added business at home, commercial

firms would relocate abroad if they deem such a move advantageous. The traditional economic viewpoint is that, even if commercial firms indeed choose to pick up and leave, it is all for the best because the reallocation of resources would be more efficient and benefit domestic consumers (Krugman and Obstfeld 1991). Nonetheless, the rationale for public investment in R&D is specifically to create positive spillover at home, and this will not occur if both the R&D and the diffusion of its results are conducted abroad as it is more and more the case in our globalizing world (Gomory and Baumol 2000).

The three related problems of trust, coordination and motivation are by no means unique to innovation. In the R&D field, however, these concerns are accentuated for at least three reasons. First, distrust – especially among private actors – is likely to be prevalent because of the nature of the product and also that of the firms involved. Where innovation is at the epicenter, then a firm's advantage is to be found primarily in its ability to create new know-how. Transfer of information and technology to other firms, and with it a firm's competitive advantage, is relatively easy (Lundvall 1999). Hence, firms have a strong incentive to limit the lines of communication with other firms so as not to suffer from unwelcome knowledge transfer. As a result, establishing trust between private firms is a challenging venture. Second, the R&D field is relatively internationalized compared to most other production domains. This means that coordination is likely to involve not only domestic but also international actors. Obviously, this implies an additional challenge for coordination. Finally, in R&D-intensive high-technology sectors, such as information- or bio-technology, both firms and professionals are comparatively far more footloose than in traditional industries or services (e.g., steel manufacture or healthcare). Therefore, the question of how to motivate private actors to contribute locally is more pertinent than in most other fields.

Three Government Roles, Many Games: What do other countries do?

There are three broad roles by which governments, using very different modes which are tailored to their specific conditions, support rapid-innovation-based growth:

i) public-financing of private-innovation, where the government supplies capital to private agents who use it to engage in R&D and innovation;

ii) public production of innovation, where public production is commonly understood to imply industrial R&D conducted in government research institutes, universities, and non-profit research institutes such as hospitals; and,

iii) the government acting as a facilitator, where the main emphasis here is on the government role in anchoring professional, inter-institutional networks, and more generally, on the government's role in fostering relations with – and among – private actors.

The importance of the third role, facilitating policies, cannot be over-emphasized, as government-sponsored networks have been shown to be one of the most important factors for the creation of a favorable environment for radical innovation (Godoe 2000; Kushida 2008; Kushida and Zysman 2008; O'Riain 2004). Actor interaction within these networks helps shape a common vision of the future, and R&D efforts, which are then channeled towards realizing this vision (Lester and Piore 2004). Indeed, some argue that DARPA's excellence in conducting this role in the American context is the base for its greatest successes (Fuchs, forthcoming).

Since public financing of private innovation activities is the best known and most discussed role of the three, let me briefly describe some international examples of successful usage of the two others. Taiwan has received much attention for its extremely successful

application of the public production strategy. The government had mitigated the market failure and information asymmetries problems by undertaking the core R&D itself. This created a unique division of labor between government and industry in the case of the IT industry. The specificity of this division of labor stems from the state's high level of participation in the development of the technological capabilities of the industry. In this division of labor, public research institutions do most of the R&D up to the level of a working prototype, and then disseminate the results to industry, which concentrates on final development and integrated design. It is this division of labor that is considered responsible for Taiwan's leading role in the global information technology industry, most famously in semiconductors. This strategy also allowed Taiwan to create a large number of jobs – not just jobs for the very high-skilled and educated, but jobs at many levels, thereby spreading the fruits of its innovation success more widely across the society (Amsden and Chu 2003; Berger and Lester 2005; Breznitz 2007b; Fuller et al. 2003; Hong 1997; Mathews and Cho 2000; Meany 1994; Park 2000).

This public production-anchored model also addresses the capacity problem. The government concentrates scarce capacities, and by so doing, overcomes the private non-cooperation obstacle. Arundel and Geuna contend that in Europe public research is an especially important resource for firms that lack the financial resources, or capabilities, to obtain knowledge abroad (Arundel and Geuna 2004). Therefore, a case can be made for more direct public intervention in R&D. However, for such interventions to work the incentives for public R&D production should be carefully aligned with the growth and creation of a local *privately-owned* industry and the government should set a premium on bureaucratic flexibility in its research institutions. Otherwise, the negative outcomes will outweigh the positive ones.

Israel is an example of a highly successful use of the facilitator strategy. A measure of the success of its innovation policies is the fact that in 1968, when the first government committee on R&D policy was convened, there were only 886 academy-trained R&D workers in the entire industrial sector. Within three decades of implementing its new innovation policies, Israel boasted the highest number of high-tech companies listed on NASDAQ after the United States. As part of these efforts, as early as 1975, the Israeli Office of the Chief Scientist of the Ministry of Trade, Industry and Employment (OCS), Israel's main industrial innovation agency, launched a joint program with the American Government that matched local companies with American multinational corporations (MNCs). This program, known as the Bi-national Industrial R&D foundation (BIRD), concentrated on fostering and financing cooperation between Israeli and US companies (BIRD 2000; Breznitz 2007a; Teubal 1997; Trajtenberg 2001; Yahalomi 1991). Its mode of operation has been to fund projects co-designed by American and Israeli companies, in which the R&D was done in Israel, and the marketing and product definition handled in the US. As a consequence, the Israeli government stimulated international cooperation that ensured R&D would commence in Israel, and mitigated the information asymmetries between itself and the private firms it sponsored by receiving high-quality "external" evaluation from world-leading American MNCs. In 1992 Israel went further in its network facilitating policies with the MAGNET program. MAGNET, which stands for Generic Non-Competitive R&D, addresses two problems related to the development and maintenance of the long-term innovative advantage of companies. The first problem is a large number of companies in the same technological space, all of them too small to compete on the basis of, or to advance, cutting-edge infrastructural research activities that are crucial to their survival. The second problem is the underutilization of academic research. MAGNET solves some of these issues by creating a consortium to develop

generic technologies. MAGNET consortiums are created for a period of up to three years. All IP outputs are shared among the consortium members, at least one of which must be a university. The consortium members also must agree to license this IP to local companies at a cost that does not reflect monopoly status. MAGNET has been critical in allowing Israeli firms to tap into otherwise inaccessible knowledge domains, and to develop new technologies and products for markets and niches whose needs they did not understand, using technologies they could not afford to develop alone. However, while Israel's sole focus on novel-product R&D and intimate ties with the American industry led it to great success, the economic gains of this success have been very narrowly distributed, and the success of the high-tech industry has resulted in only negligible spillovers to the rest of the business sector (Breznitz 2007a; Breznitz 2007b; Trajtenberg 2001).

Finland is a classic example for the government role as a facilitator using a very different strategy. In Finland, after the fall of the USSR, national employer and labor associations created long ago for collective bargaining and resolution of labor-capital conflicts were infused with a new mission as they morphed into institutions to regulate the transition from a traditional to a high-technology "new" economy (Ornston 2006; Ornston and Rehn 2006). Consensus among the old actors created a platform on which new dense inter-firm networks were built. A panoply of government actions established new public commissions, and agencies pushed the old partners towards agreement on new objectives for the economy and new channels for public expenditure, for example, the Science and Technology Policy Council, which subsequently gave rise to Tekes. These broad agreements legitimized the deep structural transformations involved and formed the bedrock of multi-polar networks on the local level. In the most successful cases of development of new technology industries in Finland, for example in the city of Tampere, new networks were

constructed by combinations of previously-developed skilled labor, university strengths, industrial commitment, and municipal leadership. However, Finland's inability to create new companies and its growing reliance on one – Nokia – is apparent even in the case of Tempere, where Nokia is by far the biggest employer (Juha and Sotarauta 2002).

Back to the home court – Lessons Learned

Successful innovation policies throughout the world have taught us a few valuable lessons:

i) innovation policy can significantly enhance economic growth and national competitiveness;
ii) innovation policy are context-specific and need to evolve in tandem with private industry;
iii) there are many different modes of devising and implementing innovation polices, each of which leads to different social and economic outcomes;
iv) to be successful in innovation policy implementation governments need to be able to engage in all three roles: financer, producer, and facilitator.

While far from ensuring success, these points lead to a few principles, which if applied, can increase the chances of success and induce a better policy learning curve. First, the federal government should sustain and enhance its important role as financier. While that by itself will not yield a qualitative change, it is necessary as the minimal first step. Second, the government needs to carefully evaluate its R&D production activities to decide which serve useful purposes and which should be restructured or cancelled, and to determine in which domains timely, and perhaps finite (that is limited in time-scope), public production could stimulate large-scale undertaking by private actors, which should always be the ultimate goal of innovation policy. Thirdly, and perhaps most importantly, the federal government needs to think more constructively and comprehensively on the role that the government can play as a facilitator of

innovation activities. Here scope for experimentation is needed, and while the ARPA/DARPA model has worked in the past it is far from being the only approach that should be pursued.

It is critical to note that in order to conduct the three roles, specifically the facilitating role, a nation must have deep knowledge of the technological domains, as well as a nuanced understanding of the current, and always changing, needs of private actors. This includes knowing and having access to individuals (such as leading researchers in specific labs) as well as organizations, and understanding business dynamics in multiple sectors.

In the case of a the US, a big federal democracy aiming to stimulate growth throughout its economy in all locales, a dual approach, local and federal, might be the key to success. Creating new federal-state partnerships could also have the benefit of stimulating states to compete in the development of different, experimental, and creative policies.

From many levels of analysis, American states, in terms of size, economic history and capacity, and unique contextual situation, are similar to many of the European and Asian countries that are widely viewed as the paragons of successful innovation policy experimentation and implementation. Many of these policies necessitate close collaboration among actors within a particular spatial unit, and hence, lend themselves much more easily to state rather than federal engagement. Furthermore, since many successful innovation policies need to be tailored to specific conditions, both the intimate knowledge essential for the development, and the capacities critical for their implementation, exist on the local and not federal level.

One way, certainly not the only one, of tapping this potential, creating a dynamic of innovative thinking among policymakers, and devising a working public-private partnership, is to allow for federal funding to be allocated on competitive basis for states and local governments that develop unique and comprehensive ten to fifteen-year programs that take into account local

needs and capabilities as well as the national innovation agenda. Winning proposals should get substantial federal funding (50-60%), and should be evaluated around the seventh year of the program, by which time the first signs of change should be evident. If successful, these programs should be funded for another finite period of time. In addition the federal agency responsible for these programs should arrange workshops that allow collaboration and learning among participating states, as well as replication of the more successful models across the country.

We need to recruit the tremendous forces of competition and ingenuity to help us seriously apply innovation to our innovation policies. We must think outside of conventional constraints as we seek to develop policies to enhance the innovativeness of the American business sector and secure our future economic growth.