



Congressional Budget Office

Background Paper

How CBO Projects the Real Rate of Interest on 10-Year Treasury Notes

December 2007

The logo for the Congressional Budget Office (CBO), consisting of the letters "CBO" in a white, serif font centered within a solid black square.

CBO

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Note

The figures in this background paper use shaded vertical bars to indicate periods of recession as well as dashed vertical lines to separate actual from projected data. (A recession extends from the peak of a business cycle to its trough.)

Preface

Twice a year, the Congressional Budget Office (CBO) makes 10-year projections of the budget that assume a continuation of current policies and laws. Those projections depend in part on the outlook for the economy. This background paper describes CBO's methodology for projecting the real (inflation-adjusted) rate of interest on 10-year Treasury notes—which is important because it not only affects (and is affected by) economic activity but also directly influences federal outlays, as interest payments on federal debt depend on it.

Angelo Mascaro and Steven Weinberg of CBO's Macroeconomic Analysis Division prepared this paper, with assistance from Adam Weber and under the supervision of Robert Dennis, John Peterson, and Kim Kowalewski. Larry Ozanne and Thomas Woodward of CBO's Tax Analysis Division helped with incorporating tax effects into the analysis. Douglas Hamilton, Arlene Holen, Mark Lasky, Donald Marron (formerly of CBO), Marvin Phaup, and Marika Santoro provided comments on a draft.

John Skeen edited the paper, and Christine Bogusz proofread it. Maureen Costantino prepared the paper for publication. Lenny Skutnik produced the printed copies, Linda Schimmel coordinated the distribution, and Simone Thomas prepared the electronic version for CBO's Web site (www.cbo.gov).



Peter R. Orszag
Director

December 2007

Contents

Introduction *1*

Estimating and Forecasting the Natural Rate of Interest *3*

The Return on Capital *3*

Adjustments for Equity and Credit Risk *7*

Projecting the Natural Rate of Interest *12*

Estimating and Forecasting the Real Rate on 10-Year

Treasury Notes *12*

Estimates of the Real Rate on 10-Year Treasury Notes over
History *15*

Forecasting the Real and the Nominal 10-Year Treasury Rates *18*

**Appendix A: Calculating the Long-Run Equilibrium Return on
Capital** *21*

Appendix B: Calculating the Risk-Adjusted Return on Capital *23*

Figures

1.	The Natural Rate of Interest and the Real Rate on 10-Year Treasury Notes	2
2.	Return on Capital from the Income Side of the National Income and Product Accounts	4
3.	The Income-Side and Product-Side Measures of the Return on Capital	6
4.	The Equity-Risk Premium Derived from the Difference Between the Real Return on Equity and the Real Rate on 10-Year Treasury Notes	10
5.	The Credit-Risk Premium Derived from the Difference Between the Rates on Moody's Baa Corporate Bonds and 10-Year Treasury Notes	11
6.	The Combined Risk Premium	13
7.	The Natural Rate of Interest and the Tax-Adjusted Return on Capital	14
8.	The Rate of Interest on 10-Year Treasury Inflation-Protected Securities	16
9.	The Real Rate on 10-Year Treasury Notes Using 10-Year and One-Year Expectations of Inflation	17
10.	Two Measures of the Real Rate on 10-Year Treasury Notes	20

How CBO Projects the Real Rate of Interest on 10-Year Treasury Notes

Introduction

As part of the economic forecast that underlies the Congressional Budget Office's (CBO's) baseline budget projections, the agency projects a number of interest rates for a 10-year horizon. Of those, the rate for the 10-year Treasury note is a particularly important one for the forecast because it is both one of the rates that are used to estimate federal debt-service payments and a reference point for forecasts of other interest rates. To anchor the medium-term projections of the 10-year rate, CBO uses the concept of the natural rate of interest, a rate that is based on estimates of the economy's underlying ability to produce output from its capital stock. That concept links the projection of the 10-year rate to CBO's projections of inflation and all of the factors (such as growth of the labor force, productivity, investment, and saving) that contribute to the potential output of the economy—helping to provide consistency within the projection framework.

The use of the natural rate is based on the theory that the real 10-year Treasury rate—the nominal 10-year rate minus expected inflation over the next 10 years—will be similar to the natural rate during periods in which inflation is relatively stable and the economy is operating near its potential. If the real rate is below the natural rate for an extended period, inflation will tend to rise because the demand for goods and services will tend to exceed the economy's potential to produce them. Conversely, inflation will tend to fall if the real rate is above the natural rate. Because CBO's projections assume that inflation will neither be trending up nor down in the medium term (the latter years of the 10-year horizon), the projections assume that the real rate will converge with the natural rate over the 10-year projection horizon (see Figure 1).

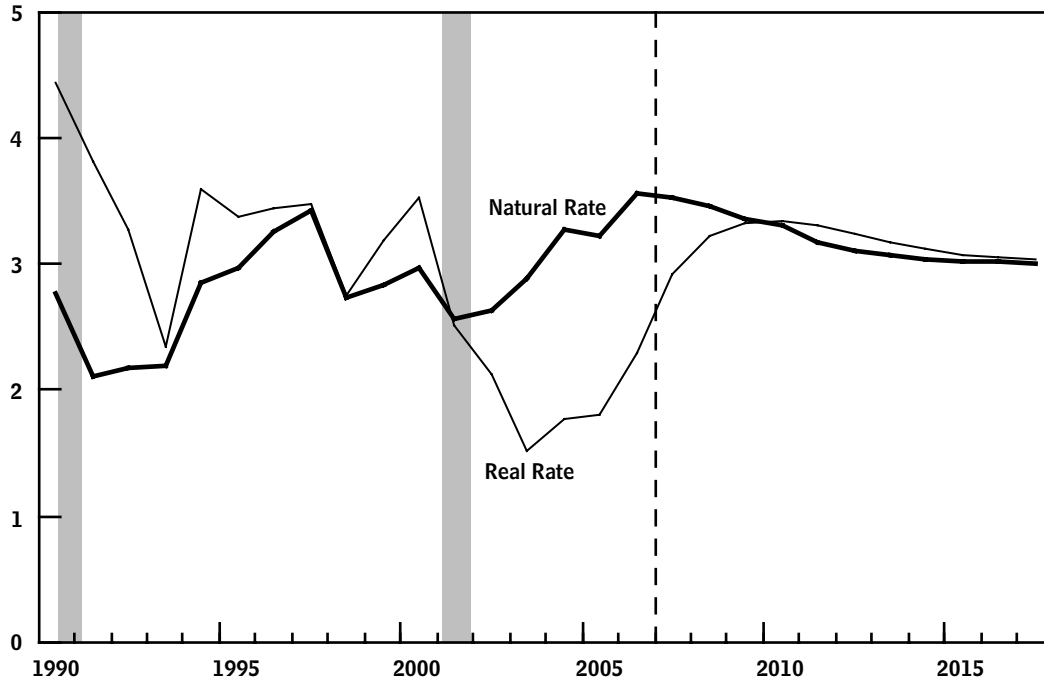
Although CBO's projection of the natural rate of interest anchors its projection of the real rate for the 10-year Treasury note over the medium term, CBO uses a variety of information to forecast that real rate for the first few years of the 10-year horizon. Important factors include CBO's forecast for growth and inflation, the demand for credit (including the federal deficit), and the supply of credit (including the foreign supply). Such information affects the pattern of convergence—how the projection of the real 10-year Treasury rate merges with the projection of the natural rate.

This background paper summarizes CBO's methods for calculating the natural rate of interest and applying it in projections of the real and nominal interest rates on 10-year Treasury notes.

Figure 1.

The Natural Rate of Interest and the Real Rate on 10-Year Treasury Notes

(Percent)



Sources: Congressional Budget Office; Federal Reserve Bank of Philadelphia; Federal Reserve Board; Department of Commerce, Bureau of Economic Analysis.

Notes: Projections are from CBO's August 2007 forecast, presented in *The Budget and Economic Outlook: An Update*.

Data are annual.

Estimating and Forecasting the Natural Rate of Interest

Estimating the natural rate of interest, either over history or for projections, is a two-step procedure. First, CBO estimates the real return on capital (adjusted for taxes on profits). That estimate is based on the agency's view of the economy's physical production process—how capital and labor are used to produce output and generate complementary income payments to capital and labor. Because all output simultaneously generates income, data from either the income side or the product (output) side of the national income and product accounts (NIPAs), compiled by the Bureau of Economic Analysis, can be used. Second, CBO estimates an adjustment for the risk in actually realizing the return on capital. Because part of the return on capital is compensation for the risk that some firms will default and inflict losses on investors, an estimate of the real rate based on income payments from capital is higher than the natural rate. Therefore, that risk premium must be removed to yield an estimate of the natural rate. That rate is comparable to the real rate on 10-year Treasury notes, which is also free of default risk. In particular, the risk premium is based on a weighted average of separate estimates of the risk of holding equity and debt claims on capital; it also includes an adjustment for the different tax treatment of profits and interest payments generated by businesses.

Over the next 10 years, CBO projects, the natural rate of interest will decline slightly, from an estimated level of about 3.6 percent in 2006 to about 3 percent. That decline stems from a projected decline in the return on capital, much of which reflects a projected slowdown in the growth of the labor force.

The Return on Capital

CBO uses two complementary approaches for estimating the return on capital, one from the income side and the other from the product, or production, side.¹ The income-based approach measures the rate of return on capital as the ratio of capital income to the capital stock. Its construction has the advantage of being independent of assumptions about production relationships or determinations of whether the economy is in or out of equilibrium. It provides a relatively smooth estimate of the return on capital over the historical and projection periods.

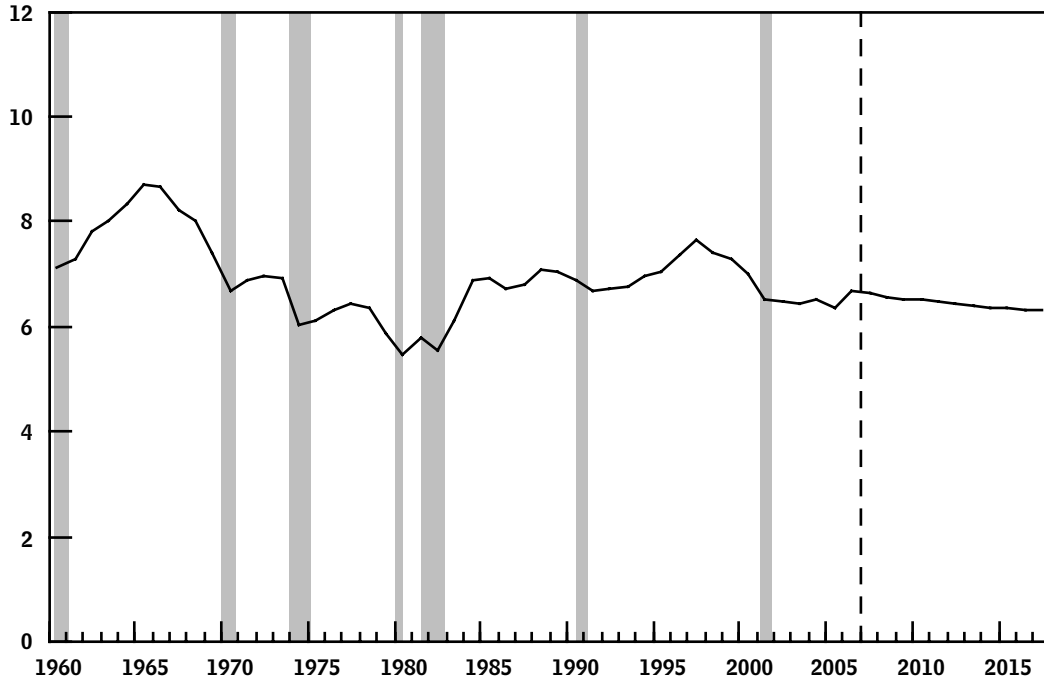
The second approach uses a standard production relationship to estimate a long-run equilibrium measure of the return on capital in terms of its fundamental determinants—the ratio of gross private domestic investment to gross domestic product (GDP), the depreciation rate for physical capital, and the growth rates of productivity and the labor force. In equilibrium, actual payments to capital (that is, the income measure of the return on capital) will be consistent with the marginal product of capital derived from the production measure. Thus, in CBO's projections—which, after the first two years, do not attempt to include cyclical factors—the income measure converges with the product measure.

1. For a discussion of the income and product measures in the context of models of economic growth, see Robert J. Barro and Xavier Sala-i-Martin, *Economic Growth* (New York: McGraw-Hill, 1995).

Figure 2.

**Return on Capital from the Income Side of the
National Income and Product Accounts**

(Percent)



Sources: Congressional Budget Office; Department of Commerce, Bureau of Economic Analysis;
Department of Labor, Bureau of Labor Statistics.

Note: Data are annual.

The Income-Side Estimate of the Return on Capital. The income-side measure is estimated as the ratio of capital income to the capital stock (see Figure 2). Capital income is a domestic private-sector concept estimated as the sum of domestic corporate profits, people's rental income, 35 percent of proprietors' income, and interest paid by domestic businesses, using data from the NIPAs^{2,3} The private-sector capital stock, valued at the prices of newly produced investment goods, consists of businesses' plant (that is, facilities) and equipment, software, inventories, housing, and land—all valued at current market prices.

The income-side measure of the return on capital has both cyclical and trend components. From 1960 to 1970 and from 1991 to 2001, the return rose during the recoveries from recessions and peaked during the expansions, before falling as the expansions matured. Across business cycles, the return has exhibited extended periods in which the underlying trend was falling (as from 1960 to 1980) and then rising (from 1980 to the late 1990s). The projection for 2007 to 2017 has a slight downward trend. The longer-term pattern stems from more fundamental factors, as described next.

The Product-Side Estimate of the Return on Capital. The long-run equilibrium return on capital can be expressed as a function of its basic determinants—the ratio of private-sector investment to GDP, the growth of the labor force, the growth of productivity, and the rate of depreciation of the capital stock (see Figure 3 and Appendix A).

In the long run, trend movements in the return on capital are traceable to its fundamental determinants. Higher investment (or, equivalently, higher national saving plus net inflows of saving from abroad) means higher levels of capital for a given labor force and a correspondingly lower return on capital. Alternatively, a higher rate of growth in the labor force means less capital per worker and a higher return on capital. Faster growth in overall productivity also raises the return on capital (and on labor as well). Faster depreciation of capital also requires a higher return on capital to compensate for the shorter life span for recovering past outlays for investment.

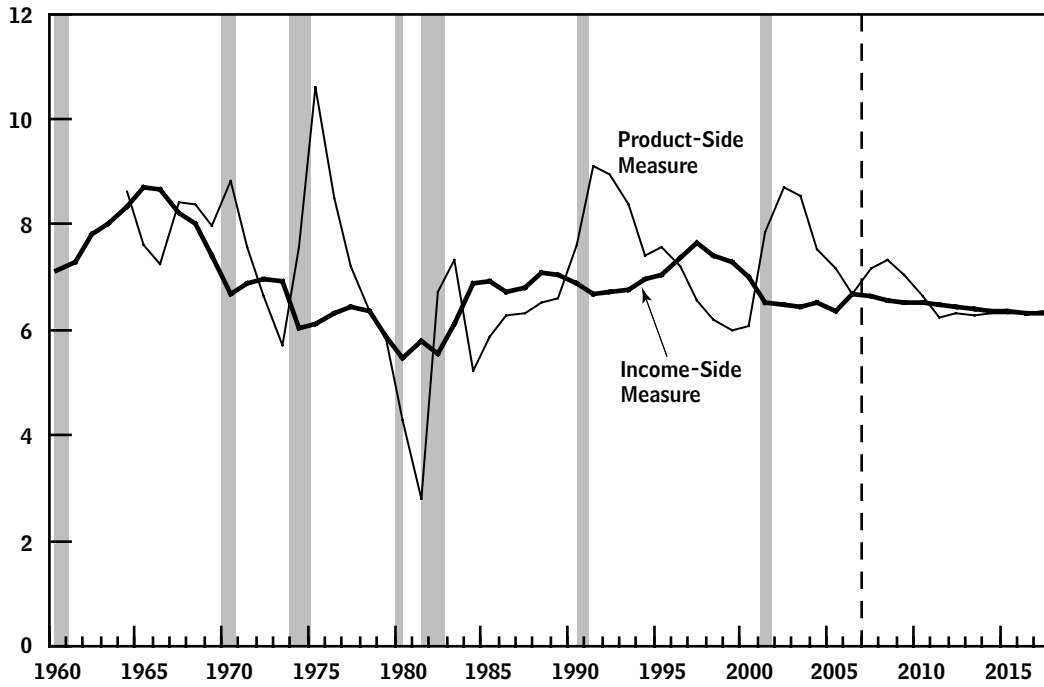
2. The exclusion of 65 percent of proprietors' income is an informally accepted practice among researchers. The excluded amount is considered wages and salaries that compensate proprietors for their labor, and the remaining 35 percent of proprietors' income is considered equity income of proprietorships (interest expenses of proprietorships are part of interest paid by domestic businesses). For an analysis of the appropriateness of the practice, based on data from the United States and 30 other countries (industrial and developing), see Douglas Gollin, "Getting Income Shares Right," *Journal of Political Economy*, vol. 110, no. 2 (April 2002), pp. 458–474. See also Congressional Budget Office, *How CBO Forecasts Income* (August 2006).

3. Another measure, using the concept of national income, can also be constructed by adding to domestic capital income the capital income earned abroad by U.S. residents and subtracting the capital income earned here by residents of other countries. The domestic and national measures differ somewhat, but CBO uses the domestic measure because it corresponds conceptually with GDP.

Figure 3.

The Income-Side and Product-Side Measures of the Return on Capital

(Percent)



Sources: Congressional Budget Office; Department of Commerce, Bureau of Economic Analysis; Department of Labor, Bureau of Labor Statistics.

Note: Data are annual.

From year to year, the product-side measure of the return on capital differs substantially from the income-side measure, although the measures tend to exhibit a common underlying trend. The product-side measure shows large swings that mostly reflect cyclical shifts in the rate of overall investment.

Projections of the Return on Capital. The projections for the product-side and income-side estimates of the return on capital differ significantly over the first two years of the projection span but converge over the remaining years. Cyclical patterns in growth of the labor force, investment, and GDP affect only the product-side measure for the first one and a half to two years or so of the projection. Beyond that period, the projections for real GDP converge to an estimate of its noncyclical potential, and projections of investment and labor supply converge to noncyclical values. With its determinants at their long-run values, the product-side measure becomes a measure of the long-run equilibrium return on capital. Projections of income shares also revert to long-term averages. In such an equilibrium, the income-side and product-side measures of the return on capital are equal.

Movements in the product-side measure in the projection span primarily reflect the pattern in the projected growth of the labor force, which generally slows because of retirement of the baby-boom generation. Slower growth of the labor force lowers the return on capital because it raises the stock of capital per worker (given investment). The product-side measure reflects current policy in two respects: The assumptions about investment incorporate projections of the government's deficit; and increases in marginal tax rates (especially when tax cuts expire in 2011) modestly reduce people's incentive to work, temporarily slowing the growth of the labor force.⁴ On the income side, capital income grows at a slower rate than the capital stock, because as the stock of capital per worker rises, the return on capital falls, slowing the growth of capital income as well. That process continues until the capital share of income and the labor share of income reach their long-run averages.⁵

Adjustments for Equity and Credit Risk

Capital income includes compensation for expected credit losses and for bearing risk in equity markets. Neither of those elements of compensation should be included in the estimate of the real rate on Treasury notes.

From the standpoint of a business, the premium paid to equityholders, or the equity-risk premium, is based on the difference between the real return on equity and the real return on an asset considered free of default risk, which is taken to be the 10-year Treasury note rate. The premium that the business pays to creditors, the credit-risk premium, is taken to be the difference between the rates on corporate bonds (with a

4. For a discussion of the effect of expiring taxes on employment, see Congressional Budget Office, *The Budget and Economic Outlook: Fiscal Years 2008 to 2017* (January 2007), pp. 40–41.

5. For a discussion of the relationship between capital income and labor income in CBO's projections, see Congressional Budget Office, *How CBO Forecasts Income*.

rating that roughly approximates the average credit rating of the business sector) and the 10-year Treasury note.

The overall risk premium is a weighted average of the premiums for equity risk and credit risk, with the weights determined by the relative amounts of equity and debt financing and by the way in which business income is taxed. By convention, the equity-risk premium paid by businesses is measured after taxes on profits, whereas the credit-risk premium is measured before taxes on profits. Both conventions depend on the fact that businesses' interest payments are deducted from capital income before computing the taxes on profits. (See Appendix B for a derivation of the natural rate of interest in the context of those conventions.)

The interaction between the desired mix of debt and equity used by businesses to finance production, and the desired mix of business debt and equity that investors wish to hold as assets, creates a link between the equity and credit premiums. Those premiums are also affected by the taxation of income from dividends, capital gains, and interest. CBO draws upon that link to make adjustments to the equity- and credit-risk premiums for the scheduled expiration of tax cuts.

Equity-Risk Premium. The equity-risk premium is the extra yield required by equity-holders to bear the risk of investing in a private business rather than in a risk-free asset such as a Treasury security. CBO measures that premium as the difference in the expected real return from a portfolio of Standard & Poor's index of 500 stocks and the Treasury 10-year note.⁶ According to the latest consensus among economists and participants in financial markets, the equity-risk premium, by that measure, will average about 3.4 percent over the years ahead.⁷ CBO uses that consensus estimate with a slight modification around 2011 to reflect the increase in tax rates scheduled under

6. According to recent research, the Standard & Poor's return on corporate equity and the return on noncorporate equity are quite similar. See Tobias Moskowitz and Annette Vissing-Jørgensen, "The Returns to Entrepreneurial Investment: A Private Equity Premium Puzzle?" *American Economic Review*, vol. 92, no. 4 (September 2002), pp. 745–778.

7. For an estimate based on a survey by the Chartered Financial Analysts Institute at its annual meeting (held from April 25 to May 2, 2007), see John Authers, "The Short View," *Financial Times*, May 2, 2007, p. 17. Also, in an analysis published in 2005, the Chief Actuary of the Social Security Administration assumed a real return on equity of 6.5 percent and an average real yield on long-term Treasury notes of 3 percent; the difference implies an equity premium of 3.5 percent. See Memorandum from Stephen C. Goss, Chief Actuary, Social Security Administration and Alice H. Wade, Deputy Chief Actuary, to Jeffrey Liebman, Maya MacGuineas, and Andrew Samwick, "Estimated Financial Effects of A Nonpartisan Approach to Reforming Social Security—A Proposal Developed by Jeffrey Liebman, Maya MacGuineas and Andrew Samwick" (November 17, 2005), available at www.ssa.gov/OACT/solvency/Liebman_20051117.pdf.

current law.⁸ Although the response to the scheduled increase is open to debate, CBO has adopted an assumption that the equity-risk premium will increase by 10 basis points, to 3.5 percent, as investors respond to higher personal tax rates on equity income by requiring a higher before-tax return (with a corresponding downward adjustment to the credit risk premium as detailed in the next section.⁹ An equity-risk premium on the order of 3.5 percent is about what would have been earned as of the end of 2006 by an investor who began investing in equities 45 years ago (see Figure 4).

Credit-Risk Premium. The credit-risk premium is the extra yield required by creditors for lending to businesses instead of to government. It is smaller than the equity-risk premium, partly reflecting the fact that creditors have a claim on capital income that is senior to the claim held by equity investors.¹⁰ It is estimated from the spread between rates on Moody's corporate Baa investments, the lowest investment grade rating and a rough measure of the average rating in the corporate sector, and the 10-year Treasury note, both as published daily by the Federal Reserve. The measure has fluctuated sharply in response to changes in the perceived risk of default by corporate issuers. In recent years, it has fallen from the high levels reached in the early 2000s in the wake of such notable defaults as those by Enron and WorldCom (see Figure 5).

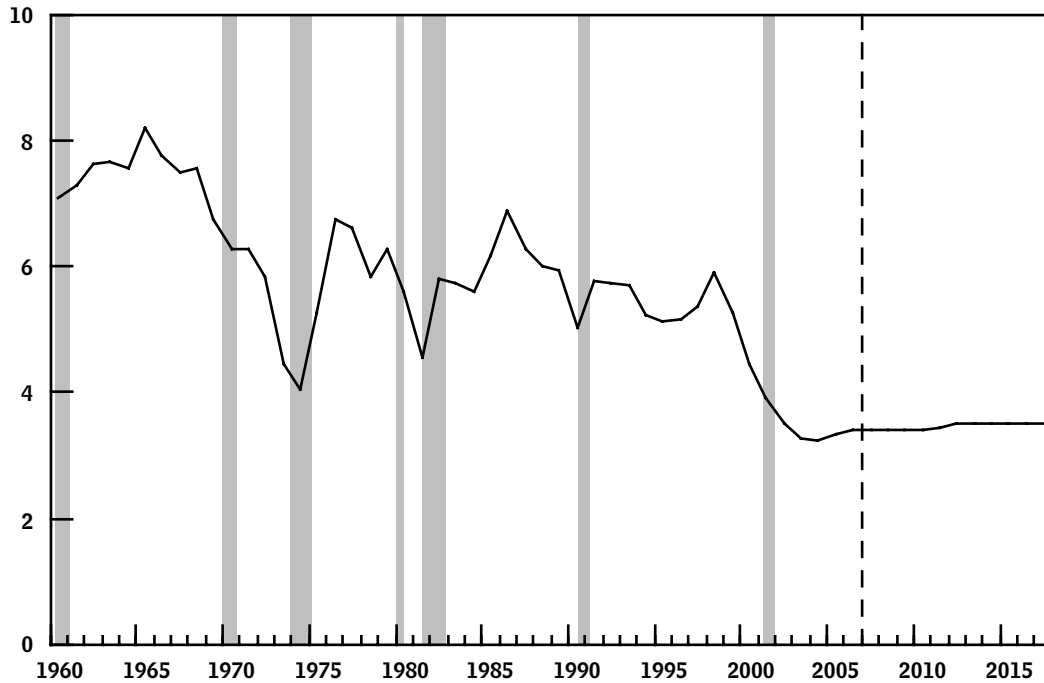
The projections assume that the credit-risk premium will increase from 1.6 percent in 2007 to about 1.9 percent—its average value of the past 40 years—during the initial years of the projection. The past four decades encompassed several business cycles in which a variety of domestic and international events have affected the quality of credit

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8. Although the assumptions adopted by CBO reflect the consensus estimate of the equity premium and how it is affected by tax rates, the volatile nature of stock markets creates substantial uncertainty in measuring the equity-risk premium and its reaction to changes in policy. For example, historical analyses using varying spans and ending or starting points can produce a wide range of estimates. Forward-looking measures are no less uncertain, not only because they involve forecasting a highly volatile value, but also because of the many long-standing difficulties in developing and testing theories of the stock market's behavior. For additional discussion of the equity-risk premium, see Eugene F. Fama and Kenneth R. French, "The Equity Premium," *Journal of Finance*, vol. 57, no. 2 (April 2002), pp. 637–659. For an investment analyst's view, see Richard Grinold and Kenneth Kroner, "The Equity Risk Premium," *Investment Insights*, Barclays Global Investors, vol. 5, no. 3 (July 2002), pp. 1–24. For a discussion on predicting the equity premium, see Amit Goyal and Ivo Welch, "A Comprehensive Look at the Empirical Performance of Equity Premium Prediction," Working Paper No. 10483 (Cambridge, Mass.: National Bureau of Economic Research, May 2004).
 9. Empirical estimates vary from little or no response of the risk premium to a change in tax rates on capital to a full response. CBO's estimate assumes a response that is about halfway between no response and a response that restores the after-tax risk premium to its level before the change in the tax rate.
 10. For a discussion of the determinants of the credit-risk premium, see Edwin J. Elton and others, "Explaining the Rate Spread on Corporate Bonds," *The Journal of Finance*, vol. 56, no. 1 (February 2001), pp. 247–277.

Figure 4.

**The Equity-Risk Premium Derived from the Difference
Between the Real Return on Equity and the Real Rate on
10-Year Treasury Notes**

(Percent)



Sources: Congressional Budget Office; Federal Reserve Board; Department of Commerce, Bureau of Economic Analysis; Department of Labor, Bureau of Labor Statistics; Professor Robert Shiller's equity data, available at www.econ.yale.edu/~shiller/data.htm.

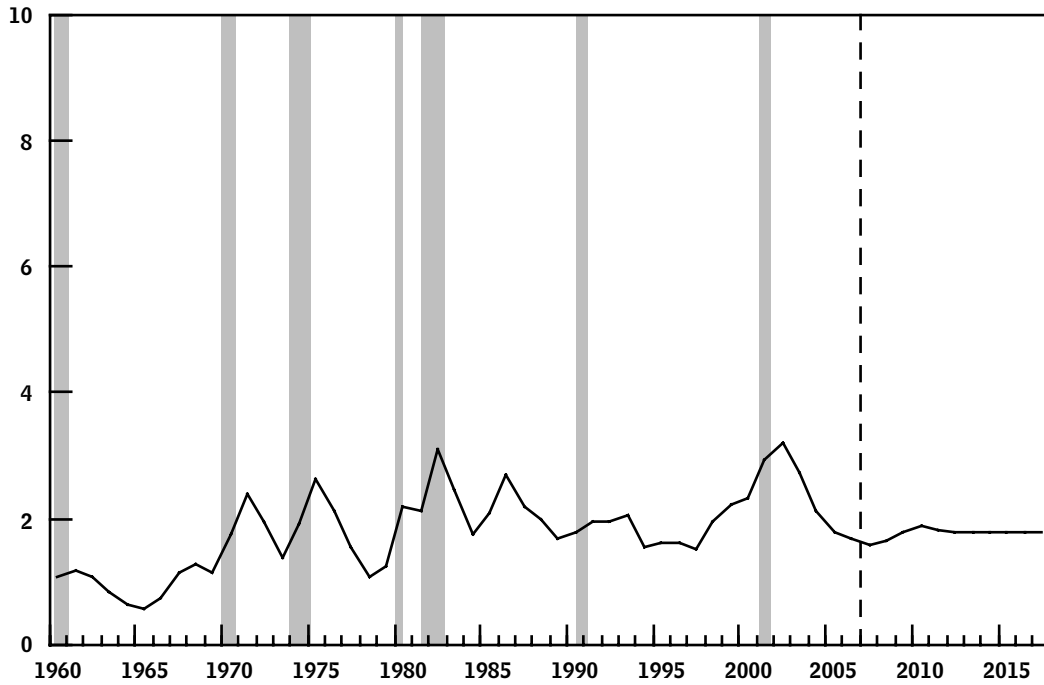
Notes: The equity-risk premium is based on the difference of geometric annualized returns for a rolling 45-year investment horizon. The final observation encompasses the span from 1961 to 2006, and the first observation encompasses the span from 1915 to 1960. Equity returns are adjusted using the consumer price index for all urban consumers. The interest rate before 1953 is series B72 in Department of Commerce, Bureau of Economic Analysis, *Long-Term Economic Growth, 1860-1970*.

Data are annual.

Figure 5.

**The Credit-Risk Premium Derived from the Difference
Between the Rates on Moody's Baa Corporate Bonds and
10-Year Treasury Notes**

(Percent)



Sources: Congressional Budget Office; Federal Reserve Board.

Note: Data are annual.

in the business sector. CBO also assumes that the credit-risk premium will decline by one-tenth of a percentage point after 2010 to 1.8 percent, as the scheduled increase of tax rates on dividends and capital gains induces a marginal shift by investors from equity income to interest income.¹¹

Combining the Equity- and Credit-Risk Premiums. The combined risk premium is a weighted sum of the equity-risk premium and the credit-risk premium (see Figure 6). The weights sum to one and reflect both the fraction of capital financed by equity and the tax rate on profits.¹²

Over the period between 1960 and 2006, the combined risk premium averaged 4 percent, with a range from about 2.6 percent to 5.0 percent. In the last five years of the span, it fell from about 3.5 percent to 2.6 percent. It is projected to stay near 2.6 percent during the initial years of the forecast, before moving slightly higher, to about 2.7 percent after 2011, on the basis of the expiration of tax cuts and the previously described projections of the credit- and equity-risk premiums.

Projecting the Natural Rate of Interest

The estimate of the natural rate of interest is obtained by adjusting the real return on capital (in this instance, the income-side measure) for both tax effects and the combined risk premium (see Figure 7).¹³

The trend of the natural rate of interest in the projection span mirrors the projection of its two components. The natural rate has a slight downward trend that settles to about 3 percent by the end of the period, mostly reflecting the projected decline in the return on capital as a result of the slowing growth of the labor force. The risk premium's upward climb during the first few years of the projection contributes additionally to the decline in the natural rate of interest.

Estimating and Forecasting the Real Rate on 10-Year Treasury Notes

The projection of the natural rate of interest described above provides an anchor for the latter years of the projection period for the real rate on 10-year Treasury notes. That projection of the real rate, in turn, guides CBO's projection of the nominal rate on such notes because CBO assumes that the average rate of inflation projected for the medium term is a good proxy for expectations of inflation for the long run. Adding the inflation rate in the medium-term projection to the projection of the real rate of interest gives the forecast for the nominal rate on 10-year Treasury notes.

11. That adjustment is paired with the adjustment estimated for the equity-risk premium.

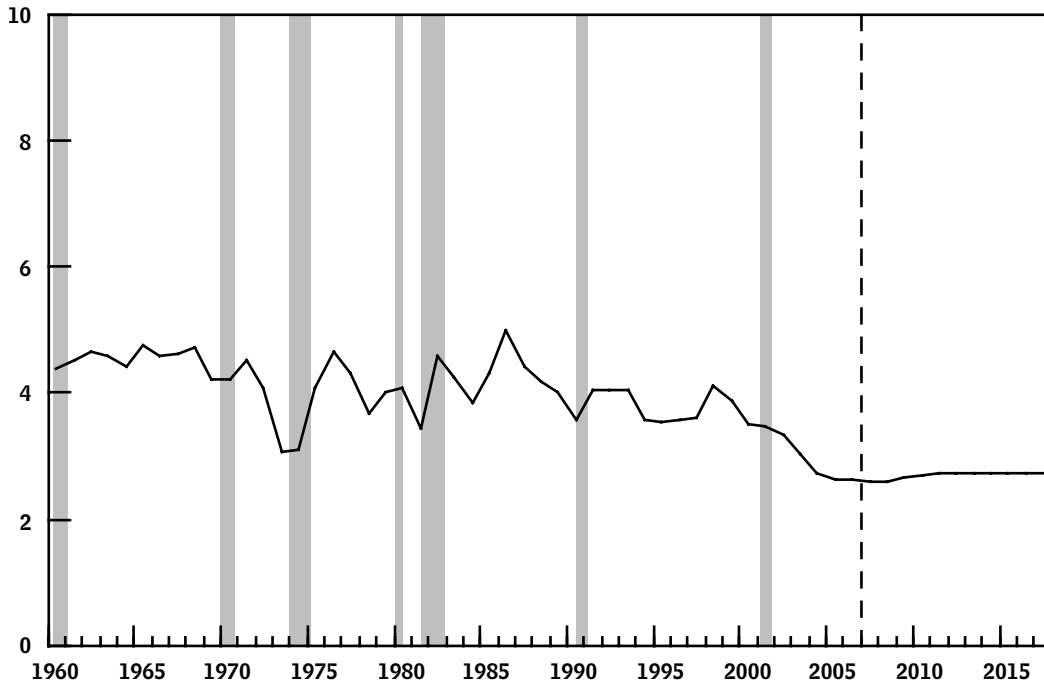
12. See the second term after the equal sign in equation 6 of Appendix B, and the accompanying text, for the specification and data sources of the weights and the combined risk premium.

13. Because those adjustments interact, the adjustment is not a simple subtraction; instead, it follows the formula given in equation 6 of Appendix B.

Figure 6.

The Combined Risk Premium

(Percent)



Sources: Congressional Budget Office; Federal Reserve Board; Department of Commerce, Bureau of Economic Analysis; Department of Labor, Bureau of Labor Statistics; Professor Robert Shiller's equity data, available at www.econ.yale.edu/~shiller/data.htm.

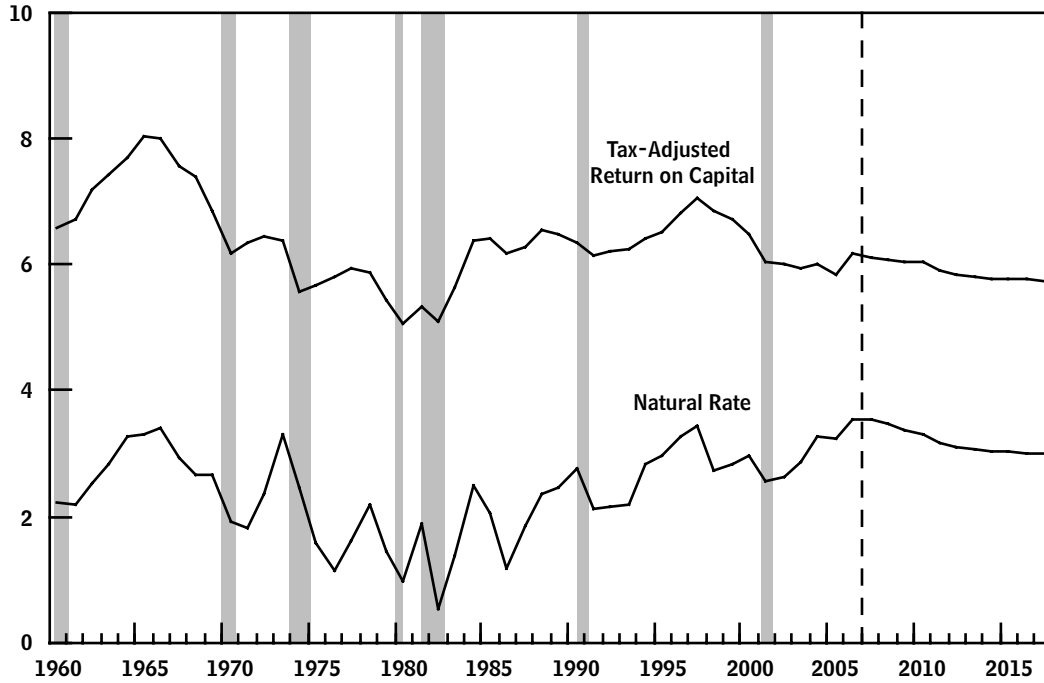
Notes: The combined risk premium is a weighted sum of the equity-risk premium and the credit-risk premium. The weights sum to one and reflect both the fraction of capital financed by equity and the tax rate on profits. See the second term after the equal sign in equation 6 of Appendix B, and the accompanying text, for the specification and data sources of the weights and the combined risk premium.

Data are annual.

Figure 7.

The Natural Rate of Interest and the Tax-Adjusted Return on Capital

(Percent)



Sources: Congressional Budget Office; Federal Reserve Board; Department of Commerce, Bureau of Economic Analysis; Department of Labor, Bureau of Labor Statistics; Professor Robert Shiller's equity data, available at www.econ.yale.edu/~shiller/data.htm.

Note: Data are annual.

Estimates of the Real Rate on 10-Year Treasury Notes over History

The real rate of interest on 10-year Treasury securities is the rate of return that investors expect to get after taking inflation, as measured by the growth in the consumer price index for all urban consumers (CPI-U), into account. The market for Treasury inflation-protected securities (TIPS) generates one estimate of the real rate, and a survey of inflation expectations along with the market for nominal Treasury securities generates another estimate. Both measures have provided similar indications of the real rate in recent years.

The first estimate of the real 10-year rate is the yield to maturity on 10-year TIPS.¹⁴ TIPS adjust the principal and coupon interest payments for changes in the CPI-U.¹⁵ They have been sold since January 1997, and the Treasury Department has computed constant-maturity yields back to January 2003 (see Figure 8).¹⁶ Data on TIPS are available daily from the market for Treasury securities.

The second estimate of the real 10-year rate is the difference between the yield to maturity on 10-year Treasury securities, which is a nominal yield (that is, not adjusted for inflation), and a survey forecast of 10-year inflation that is conducted quarterly by the Federal Reserve Bank of Philadelphia. Although that second measure is less timely than the TIPS measure, it has the advantage of being computable back to 1979, when the survey began. A rough measure of the real 10-year rate before 1979 can be constructed from a survey forecast of one-year inflation that goes back to the 1940s. The two measures have differed little over most of the period when both have been available, except in 1979 and 1980, when one-year and 10-year inflation expectations differed greatly as the Federal Reserve acted to end soaring inflation (see Figure 9).¹⁷

Initially, economic researchers judged the yield on 10-year TIPS to be too high to be the correct measure of the real rate of interest.¹⁸ Before 2004, their yield substantially

14. For a discussion of the inflation-protection feature of TIPS, see Jeffrey M. Wrase, "Inflation-Indexed Bonds: How Do They Work?" *Business Review*, Federal Reserve Bank of Philadelphia (July/August 1997), pp. 1–14, available at www.philadelphiafed.org/files/br/brja97jw.pdf.

15. Detailed information about TIPS is available at the Treasury Direct Web site: www.treasurydirect.gov/indiv/products/prod_tips_glance.htm.

16. For information about constant-maturity TIPS see www.treasury.gov/offices/domestic-finance/debt-management/interest-rate/real_yield.shtml.

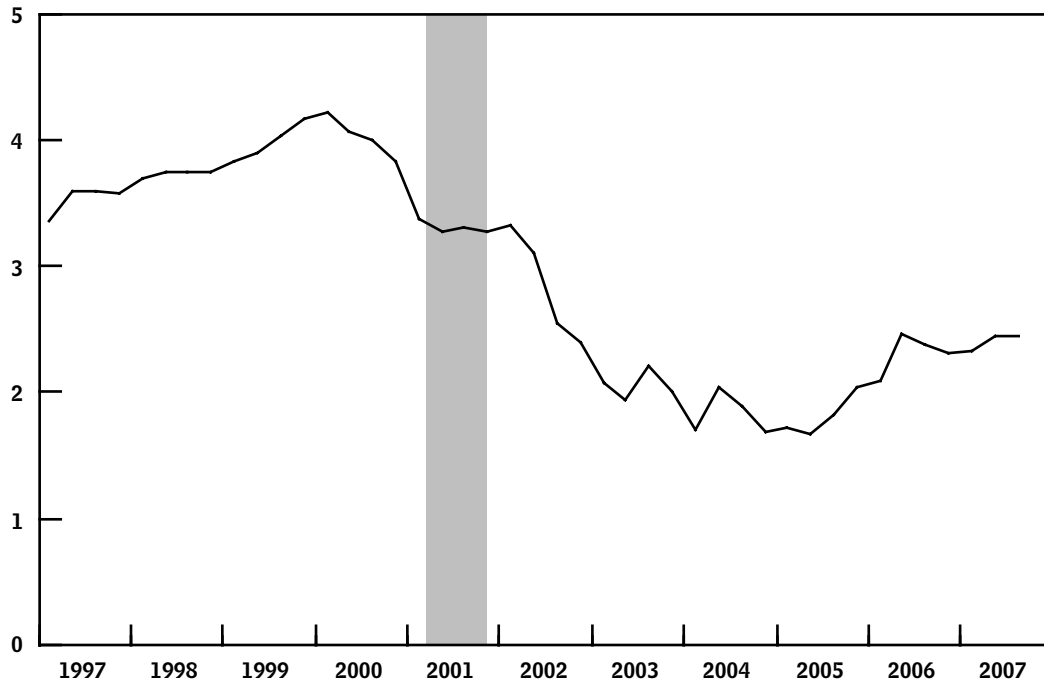
17. Data on both 10-year and one-year inflation forecasts are available at www.philadelphiafed.org/econ/spf/spfshortlong.html.

18. For a discussion of that judgment, see Brian Sack and Robert Elsasser, "Treasury Inflation-Indexed Debt: A Review of the U.S. Experience," Federal Reserve Board Finance and Economic Discussion Series, No. 2002-32 (June 4, 2002). Typically, the judgment was arrived at by observing that the inflation expectation implied by the difference between the nominal yield on 10-year securities and the yield on 10-year TIPS was much lower than that found in the survey forecast of ten-year inflation; that observation was assumed to imply that the TIPS yield must be too high to be correctly measuring the real interest rate.

Figure 8.

The Rate of Interest on 10-Year Treasury Inflation-Protected Securities

(Percent)



Sources: Congressional Budget Office; Federal Reserve Board; *Wall Street Journal*.

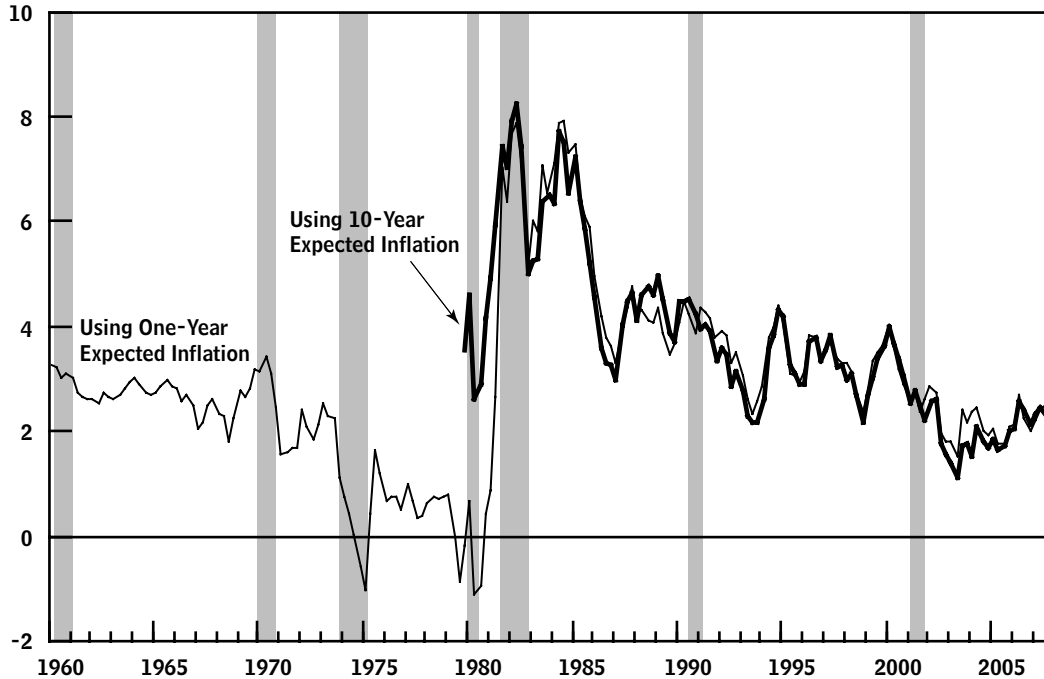
Notes: Rates before 2003 are those for on-the-run (that is, most recently issued) Treasury inflation-protected securities (TIPS). For 2003 onward, constant-maturity TIPS (as computed by the Treasury Department's Office of Domestic Finance and published by the Federal Reserve) are used.

Data are quarterly and are plotted from the first quarter of 1997 through the third quarter of 2007.

Figure 9.

The Real Rate on 10-Year Treasury Notes Using 10-Year and One-Year Expectations of Inflation

(Percent)



Sources: Congressional Budget Office; Federal Reserve Bank of Philadelphia; Federal Reserve Board.

Notes: The series for expectations of inflation for 10 years has a break in the fourth quarter of 1991. From that point onward, the series comes from the Federal Reserve Bank of Philadelphia's Survey of Professional Forecasters. Before then, the series is calculated on the basis of the Federal Reserve Bank of Philadelphia's semiannual Livingston Survey and the *Blue Chip's* economic indicators.

The series for expectations of inflation for one year has a break in the third quarter of 1981. From that point onward, the series comes from the Federal Reserve Bank of Philadelphia's Survey of Professional Forecasters. Before then, the series is calculated on the basis of the Federal Reserve Bank of Philadelphia's semiannual Livingston Survey.

Data are quarterly and are plotted from the first quarter of 1960 through the third quarter of 2007.

exceeded the inflation-adjusted yield on the 10-year Treasury notes: The quarterly difference averaged about 60 basis points and was as large as 160 basis points (see Figure 10).

The higher yield on TIPS might have been influenced by two transitory factors. One was the relatively small amount of TIPS sold by the Treasury Department and the correspondingly low level of trading activity compared with that of 10-year Treasury notes. Another was investors' limited familiarity with the new security. Both factors may have made the yield on TIPS a biased measure of investors' beliefs. But those factors have virtually disappeared. As of November 2007, the volume of TIPS outstanding had grown to \$471 billion, and TIPS constituted over 13 percent of the Treasury notes and bonds held by the public.¹⁹

Since early 2004, the difference between the two measures of the real 10-year rate has been small, and TIPS have gained acceptance as a measure of the real rate of interest and as a way to infer inflation expectations on a daily basis. The quarterly difference between the two measures of the real rate has averaged 3 basis points, and about 60 percent of the quarterly difference has been within 9 basis points. The Federal Reserve's monetary policy reports to the Congress now discuss measures of inflation expectations that use the difference between nominal rates on Treasury notes and the rates on TIPS.²⁰

Forecasting the Real and the Nominal 10-Year Treasury Rates

As previously mentioned, a wide variety of factors are taken into account for the near-term forecast of the real and nominal 10-year Treasury rates. In general, however, the real 10-year rate converges rather quickly to the projection of the natural rate in CBO's forecasts. Similarly, because CBO assumes that inflation is relatively steady in the medium term and that its projection of inflation reflects long-term expectations, the nominal 10-year rate also tends to converge quickly to the sum of the natural rate and the inflation rate.

The inflation rate that CBO uses for the nominal 10-year rate is the growth of the core CPI-U, which the agency has projected to average 2.2 percent growth in the medium term. (Core inflation excludes prices for food and energy.) That rate for the core CPI-U is consistent with the upper edge of the Federal Reserve's unofficial range for inflation. The Federal Reserve has indicated that it would prefer inflation within 1 percent to 2 percent, as measured by the growth of the core price index for personal

19. For additional discussion of the causes of the difference in observed yields between the two measures of the real rate, see Ben Craig, "Why Are TIPS Yields So High? The Case of the Missing Inflation-Risk Premium," *Economic Commentary*, Federal Reserve Bank of Cleveland (March 15, 2003).

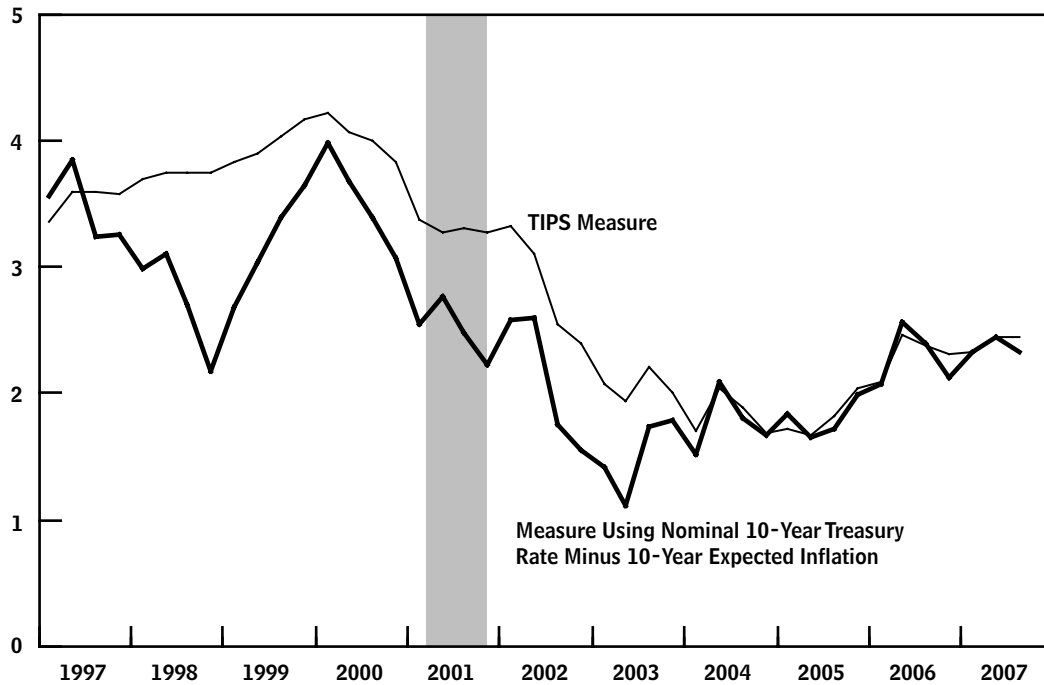
20. See Board of Governors of the Federal Reserve System, "Monetary Policy Report to the Congress" (February 14, 2007), p. 20, available at: www.federalreserve.gov/boarddocs/hh/2007/february/fullreport.pdf.

consumption expenditures, and growth in that price measure has averaged about 0.3 percentage points slower per year than the growth of the core CPI-U over the past 20 years. Therefore, CBO projects the nominal 10-year rate to average 5.2 percent in the medium term—a 3 percent real rate combined with 2.2 percent inflation.

Figure 10.

Two Measures of the Real Rate on 10-Year Treasury Notes

(Percent)



Sources: Congressional Budget Office; Federal Reserve Bank of Philadelphia; Federal Reserve Board; *Wall Street Journal*.

Notes: Rates before 2003 are those for on-the-run (that is, most recently issued) Treasury inflation-protected securities (TIPS). For 2003 onward, constant-maturity TIPS (as computed by the Treasury Department's Office of Domestic Finance and published by the Federal Reserve) are used.

Data are quarterly and are plotted from the first quarter of 1997 through the third quarter of 2007.

Appendix A: Calculating the Long-Run Equilibrium Return on Capital

The expression for measuring, from the product side of the national income and product accounts, the long-run equilibrium return on capital is:

$$\text{Return on Capital} = \frac{\alpha}{s} \left[\frac{g}{1 - \alpha} + n + \delta \right] - \delta \quad (1)$$

where α , g , n , δ , and s are, respectively, the capital-contribution coefficient in a Cobb-Douglas production function,¹ growth of total factor productivity,² growth of the labor force, depreciation rate for the capital stock, and the ratio of private domestic investment to output in the business sector. Investment is equal to national saving plus net saving that flows to the United States from abroad.

The Cobb-Douglas production function from which the return to capital is derived has the form:

$$\text{Output} = AK^\alpha L^{1-\alpha} \quad (2)$$

where A = total factor productivity, K = capital stock, and L = labor input. The value of the capital-contribution coefficient, α , is 0.32—which is typical for an economy-wide production function that includes residential housing, as this one does. It is also about the average of capital's share of total factor income (capital and labor income) over the past 25 years.

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1. The Cobb-Douglas production function, the form of which appears in the second equation of this appendix, estimates the contributions of capital and labor to the production of output. For further discussion, see Murray Brown, "Cobb-Douglas Functions," in John Eatwell, Murray Milgate, and Peter Newman, eds., *The New Palgrave: A Dictionary of Economics* (New York, NY: The MacMillan Press, 1987), vol. 1, pp. 460–461.
 2. Total factor productivity is average real output per unit of combined labor and capital inputs. The growth of total factor productivity is defined as the growth of real output that is not explained by the growth of labor and capital.

Appendix B: Calculating the Risk-Adjusted Return on Capital

The risk-adjusted return on capital depends on the proportions of capital financed by creditors and equityholders; the different tax treatment at the business level of taxation of capital income paid as interest rather than as profits; and the risk premiums associated with capital financed by creditors and equityholders.

The capital income of a business (receipts minus the cost of materials, labor, and depreciation) can be broken into three parts: interest payments to creditors; after-tax profits for equityholders; and the taxes on capital income minus interest payments (or the taxes on profits). Using that breakdown of capital income, the return on capital can be expressed in the following way:

$$R_K = \lambda R_E + (1 - \lambda)R_D + (T_E/K) \quad (1)$$

where R_K is the before-tax return on capital (before-tax capital income, as measured by the national income and product accounts (NIPAs), as a ratio of the capital stock), R_E is the after-tax return to equityholders (after-tax profits as a ratio of business net worth), R_D is the return on debt held by creditors (interest payments as a ratio of business debt), (T_E/K) is the ratio of the taxes on profits paid by owners of equity to the capital stock, and λ is the ratio of equity net worth to the sum of debt plus net worth.

Because the taxes on profits are computed on capital income minus the interest paid to creditors, the ratio T_E/K can be written as:

$$T_E/K = \tau[R_K - (1 - \lambda)R_D] \quad (2)$$

where τ is the tax rate on capital income net of interest.

Using the ratio from equation 2, the before-tax return on capital in equation 1 has this alternative form:

$$R_K = \lambda \frac{R_E}{1 - \tau} + (1 - \lambda)R_D \quad (3)$$

In equation 3, dividing the return on equity after taxes on profits by the factor 1 minus the tax rate on profits effectively expresses equity returns on a before-tax basis. As a result, the NIPA income from capital on a before-tax basis remains consistent with the sum of income from profits before taxes and interest income before taxes. (In the NIPAs, the income side of gross domestic product is a before-tax concept, and business profits are shown before taxes. Profits of the corporate sector are separated into after-tax profits plus the taxes on profits, but business profits of the noncorporate sector, including rental income of individuals not primarily engaged in real estate, are not broken out that way.)

The equity-risk premium, denoted by σ_E , is the difference between the real (inflation-adjusted) return on equity after the payment of the taxes on profits and the real return on the 10-year Treasury note (R_F), or:

$$\sigma_E = R_E - R_F \quad (4)$$

The credit-risk premium, denoted by σ_D , is the difference between the real returns on risky debt and the 10-year Treasury note, or:

$$\sigma_D = R_D - R_F \quad (5)$$

Combining equations 3, 4, and 5 by substituting into equation 3 the solution for R_E from equation 4, the solution for R_D from equation 5, and solving for R_F results in an equation for R_F as shown here:

$$R_F = \frac{(1 - \tau)}{1 - \tau(1 - \lambda)} R_K - \left[\frac{(1 - \lambda)(1 - \tau)\sigma_D + \lambda\sigma_E}{1 - \tau(1 - \lambda)} \right] \quad (6)$$

Equation 6 is a NIPA-based measure of the risk-adjusted return on capital, or the risk-free natural rate of interest, as used in this paper. The tax rate (τ) is computed as a weighted average of three rates of effective taxation on capital income under current law: the tax on equity-financed corporate capital; the tax on noncorporate businesses; and the tax on owner-occupied housing.¹ The weights are determined by the respec-

1. That rate was described in detail in a recent background paper, along with a companion spreadsheet. See Congressional Budget Office, *Computing Effective Tax Rates on Capital Income* (December 2006).

tive shares of the private domestic capital stock owned by corporations, noncorporate businesses, and households (including nonprofit organizations serving households), as reported for 2006 in the Federal Reserve's *Flow of Funds* report. The estimate for the ratio of net worth to the sum of debt plus net worth (λ) is approximated by the average of the ratio found in the *Flow of Funds* for the nonfinancial corporate sector, the sector which also is closely linked to estimates for the equity-risk and credit-risk premiums.

