DISCOUNTING FOR PUBLIC POLICY: THEORY AND RECENT EVIDENCE ON THE MERITS OF UPDATING THE DISCOUNT RATE

Weighing benefits and costs that take place over time requires discounting those amounts to present value equivalents. This necessitates selecting a discount rate which can adjust for the fact that resources are more valuable today than in the future if consumers prefer to consume today rather than wait, or if firms could be earning a positive return on invested resources. Current guidance from the office of management and budget requires using both a 7 percent and 3 percent real discount rate in regulatory benefit-cost analyses. This issue brief reassesses the current choice of discount rates and methodologies for selecting the 3 percent and 7 percent rates. Empirical evidence suggests that real interest rates around the world have come down since the last evaluation of the rates, and new theoretical advances considering future uncertainty likely suggest lower long term rates, as well. In general the evidence supports lowering these discount rates, with a plausible best guess based on the available information being that the lower discount rate should be at most 2 percent while the upper discount rate should also likely be reduced.

1. Introduction

Implementing benefit-cost analysis requires using specific numerical parameters for the discount rate used to convert costs and benefits that occur in the future into the equivalent values they would have if realized today. The specific numerical parameters used by the Federal government and others are not based on timeless truths but instead on actual economic opportunities and observed market behavior, which change over time. The discount rate guidance for Federal policies and projects was last revised in 2003. Since then a general reduction in interest rates along with a reduction in the forecast of long-run interest rates, warrants serious consideration for a reduction in the discount rates used for benefit-cost analysis. This issue brief explains the theory behind discount rates, the empirical derivation of these discount rates, and the argument that based on updated data they should be lowered going forward.

In benefit-cost analysis, discounting is used to compare benefits and costs of a project or regulation that occur in different time periods. There are two main rationales for discounting benefits and costs that occur in the future relative to the present. First, individuals generally prefer to consume goods and services sooner rather than later. Second, resources that are required to be invested by government regulations displace capital that would otherwise be earning a positive return elsewhere in the economy.

The discount rate is used in a wide range of government decisions, including project analysis and regulatory benefit-cost analysis. Under one theoretical model that is embodied in the current U.S. Federal guidance in Circular A-4 by the Office of Management and Budget (OMB) the appropriate discount rate to use in evaluating the net costs or benefits of a regulation depends on whether the regulation primarily and directly affects private consumption or private capital. Regulation may directly affect private consumption through channels such as raising consumer prices for goods and services. In contrast, regulation may also displace or alter the use of capital in the private sector. The opportunity cost of funds, and thus the appropriate discount rate, depends on which of these is the case.

Circular A-4 has been updated periodically, most recently in 1992 and 2003. It currently requires agencies to use both a 7 percent and 3 percent real discount rate in regulatory analyses. The 7 percent rate in Circular A-4 is aligned with the discount rate used for Federal spending programs, as outlined in Circular A-94. The 7 percent rate was based on the opportunity cost of capital, and thus is most appropriate when the project is displacing investment. The 3 percent rate was based on the rate that the average saver uses to discount future consumption. Since these rates were last updated both the economy and the theory of how to apply discount rates have evolved.

The 3 percent discount rate required in Circular A-4 was based on the real rate of return on long-term government debt. If we take the rate that the average saver uses to discount future consumption as our measure of the social rate of time preference, then the real rate of return on long-term government debt may provide a fair approximation. For the thirty years preceding the issuance of the current Circular A-4 discount rate guidance in 2003, this rate had averaged around 3 percent in real terms on a pre-tax basis. For example, the yield on 10-year Treasury notes averaged 8.1 percent between 1973 and 2003, while the average annual rate of change in the Consumer Price Index (CPI) over this period was 5.0 percent, implying a real 10-year rate of 3.1 percent. This was similar to the long-run real rates that economists were forecasting at the time.

Interest rates have fallen steadily for the last three decades, as have most economists' forecasts for future interest rates. For example, the Administration's most recent forecast for the long-run real interest rate on ten-year government bonds (which is very close to the consensus of a broader set of economist forecasts) is 1.4 percent, compared with a forecast of 3.5 percent in 1992 and 3.3 percent in 2003. Economic analysts—including the International Monetary Fund—expect interest rates to remain low worldwide going forward. These trends present an opportunity to revisit whether the 3 percent rate should be revised downward to reflect new interest rate forecasts.

The 7 percent discount rate required in Circular A-4 is an estimate of the average before-tax rate of return to private capital in the U.S. economy, sometimes referred to as the social opportunity cost of capital. It is a broad measure that reflects the returns to real estate and small business capital as well as corporate capital. It is intended to approximate the opportunity cost of capital, and it is the appropriate discount rate whenever the main effect of a regulation is to displace or alter the use of capital in the private sector.

This measure is based on National Income and Product Accounts data that is updated regularly and averaged 7.1 percent from 1947 to 2014, with no clear long run trend. Nonetheless, unlike the social rate of time preference which can be proxied by market interest rates, arriving at an estimate of the social opportunity cost of capital is a challenging empirical exercise. Parameters that must be estimated, with substantial uncertainty, include the size of the capital stock (residential and non-residential structures, machinery and equipment, and inventories) and substantial portions of the income flows on that stock. Estimated income flows, in particular, are based on imperfect data like tax returns, surveys and imputations. Moreover there are no regular private forecasts of the economywide rate of return. In addition, even if we did have a precise measure or forecast of the economywide rate of return it could differ from the true value of the social opportunity cost of capital— the concept underlying benefit-cost analysis—because of unpriced externalities, market power that leads to supernormal returns, the incorporation of market risk, and taxation.

Special ethical considerations arise when comparing benefits and costs across generations. Although most people demonstrate time preference in their own consumption behavior, it may not be appropriate for society to demonstrate a similar preference when deciding between the well-being of current and future generations. Future citizens who are affected by such choices cannot take part in making them, and today's society must act with some consideration of their interest. For these and other reasons, current guidance in A-4 advises that federal agencies consider sensitivity analysis for benefit and cost estimates using a positive discount rate lower than 3 percent, in addition to using the 3 and 7 percent rates.

The choice of discount rate can be consequential for public policy and project analysis. Consider a public project that would provide benefits of $100 million in 10 years. After discounting to determine the value of the benefits today, the benefits would be $74 million under a 3 percent discount rate, and $51 million under a 7 percent discount rate. For projects that provide benefits over an even longer time horizon, this discounting relative to the nominal $100 million in benefits will be even more dramatic: if the benefits accrue in 50 years, the present value would be $23 million under a 3 percent rate and $3.4 million under a 7 percent rate.

This issue brief reassesses the current choice of discount rates and methodologies for selecting the 3 percent and 7 percent rates. The assessment begins with a broad overview of the main discount rate approaches. Two subsequent sections then review the theoretical and empirical evidence surrounding potential adjustments to the lower (3 percent) and the upper (7 percent) rates in

Circular A-4. The purpose of the document is to highlight the theoretical and empirical questions that would be relevant to any reassessment of the discount rates in regulatory analysis, and to discounting for public policy more broadly. In general the evidence supports lowering these discount rates, with a plausible best guess based on the available information being that the lower discount rate should be at most 2 percent while the upper discount rate should also likely be reduced.

2. Broad description of the main discount rate approaches

In a perfect capital market with no distortions or uncertainty, the return to savings would equal the return on private sector investments, and there would be no need to specify different discount rates for the analysis of public policies and projects. The single market rate of interest would be the unambiguously correct choice to value costs and benefits in present-day terms in the same way as the individuals affected by a policy or project.

In practice, capital markets are not perfect, private sector returns are taxed (often at multiple levels), and market interest rates often reflect risks associated with capital investments. These factors create differences between the rate at which consumption can be traded over time and the rate of return to private sector investments. Under these circumstances, what rate or rates should the government use? A large body of economic research addresses this question. The two most common approaches consider the social rate of time preference (SRTP) and the social opportunity cost of capital (SOC).

2.1 Social rate of time preference

The use of the social rate of time preference (SRTP) in discounting is based on the idea that a policy's costs and benefits can be represented as changes in consumption profiles over time; in this case, the discount rate should be the rate at which society is willing to trade current for future consumption. Society discounts future consumption when the level of consumption is expected to increase and the marginal utility of consumption is expected to decline. Society may also exhibit a positive "pure time preference" even in the absence of changes in future consumption, perhaps due to risk of future mortality.

One common proxy for the SRTP is the tax-free rate of return on government bonds or other low-risk marketable securities. In the United States, for example, the after-tax real (inflation-adjusted) rate of return on fixed-rate Treasury bills is often used as an approximation of the SRTP. This is the approach behind Circular A-4's specification of the 3 percent discount rate, the current lower rate for federal regulatory impact analysis. The reasoning is straightforward, as noted above. If we think of this rate as equivalent to the earnings rate on personal savings, it is an indicator of the rate at which individuals affected by a policy may trade off consumption for investment (or current for future consumption) in their private choices. More broadly, it represents the rate at which society as a whole can trade consumption today for consumption in the future.

A benefit of using the interest rates on Treasury debt as an indicator of the social rate of time preference is that Treasury interest rates are readily observable and not vulnerable to measurement error, since they are priced in deep, liquid markets. If the Treasury interest rate is the appropriate proxy, then a policy maker need not be concerned about data quality when looking for the right rate.

However, there are drawbacks to using market rates as a proxy for the SRTP. The rate of time preference for society as a whole, the relevant rate for informing public decisions, may differ from that of individuals for many reasons. For example, the probability of death influences the rates at which individuals may trade consumption over time, whereas society can be presumed to have a longer planning horizon. Additionally, individuals routinely save and borrow at varying rates of return and interest, and a large fraction of individuals do not hold government bonds. Also, to the extent that Treasury interest rates are impacted by foreign demand for safe assets, then the Treasury interest rate incorporates information about the social rate of time preference in other countries as well as in the United States. Further, for some projects, the horizon over which costs and benefits might accrue is much longer than that of the longest-dated Treasury bond. In this case, the implicit assumption is that rates of time preference applied over 30 years are the same as those applied over 100 years or more, which may be an aggressive assumption. For these and other reasons, the SRTP is not directly observable and may not equal any particular market interest rate.

Another option is to rely on neoclassical growth theory and estimate the SRTP using a framework developed by Ramsey (1928). We consider this method further in Section 3.2.

2.2 Social opportunity cost of capital

Funds for public projects or policies, including those used to comply with government regulations, may displace other investments, and their associated future consumption. The social opportunity cost of capital (SOC) approach to discounting recognizes and works to quantify this opportunity cost, asking whether a policy's overall return is at least as large as the pre-tax return to the likely alternative use of the same resources by the private sector. Because the SRTP does not account for this capital displacement (the fact that society loses the higher, pre-tax rate of return on displaced private investments), SOC-based discount rate estimates are generally higher than SRTP-based estimates.

The social opportunity cost of capital can be estimated by the pre-tax marginal rate of return on private investments observed in the marketplace. Some have used only corporate debt or only equity (e.g., returns to stocks) to measure the social opportunity cost of capital, while others have used broad measures that capture virtually all private capital investments. In practice, it is not clear how to estimate marginal returns, and therefore average rates of returns are measured. Average returns could be higher than marginal returns because firms probably make the most profitable investments first. On the other hand, average returns could be lower than marginal returns if sunk investments experience shocks which render them less valuable, while new investments are made on the basis of better information. A common assumption in economic theory, based on assumptions of constant returns to scale in a perfectly competitive market, is that average returns are equal to marginal returns. Market rates also reflect risks faced in the private sector, which may not be relevant for public sector evaluation. In addition, private returns that involve unpriced externalities or monopoly rents will likely be higher than the true social return.

3. Revisiting the 3% rate in A-4

3.1 Current approach: Treasury rates

As previously noted, the 3 percent discount rate in Circular A-4 is based on the real rate of return on long-term government debt. This section examines how long-term interest rates have changed over time and forecasts for the future.

Long-term interest rates in the United States and many other advanced economies are at historically low levels. This is due, in part, to the global financial crisis and subsequent aggressive policy responses. But long-term rates had fallen worldwide for nearly 20 years prior to the crisis, so the decline is due to secular, as well as cyclical factors. Thus, even after the global economy has fully recovered from the Great Recession and economic policies normalize, underlying long-term interest rates will likely remain lower than they have been historically (CEA 2015).

Figure 1 provides a long-run perspective on U.S. nominal interest rates, plotting the annual yields on one- and 10-year Treasury notes since 1871.[1] The figure highlights successive eras in economic history (e.g., the gold standard era and the Bretton Woods era). Several things stand out in the figure. First, nominal interest rates follow long swings and can spend extensive periods of time away from their long-run historical averages. Second, both the 10- and the one-year nominal interest rates have declined fairly steadily from their highs in the early 1980s. A third observation is that since the onset of the Great Depression during the interwar period, the 10-year rate has tended to be—though is not always—above the one-year rate. The relatively higher 10-year rate reflects the compensation investors require for holding a longer-term asset. It can also represent a persistent incorrect assumption that rates will rise in the future. The 10-year rate also tends to be less volatile than

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[1] Bond yield data are taken from the website of Robert Shiller, at http://www.econ.yale.edu/~shiller/data.htm, under "long term stock, bond, interest rate and consumption data" (http://www.econ.yale.edu/~shiller/data/chapt26.xls). Historical bond yields are also available from the National

Bureau of Economic Research Macrohistory database, Chapter 13 (Interest Rates). For the pre-1953 period, Shiller uses yields on 10-year government bonds from Homer and Sylla (2005). The bond yield is the market yield at constant maturity, quoted on an investment basis.

the one-year rate because the 10-year rate reflects an average of expected future short-term rates, as discussed below, and averaging smooths much of the year-to-year fluctuation in the shorter rate. Finally, the figure shows that since 2010, the one-year nominal interest rate has been below 0.46 percent—a level not observed previously in these data, though from 1935-45, the rate hovered between 0.5 and 1.0 percent.

Figure 1

One-Year and 10-Year U.S. Nominal Interest Rates

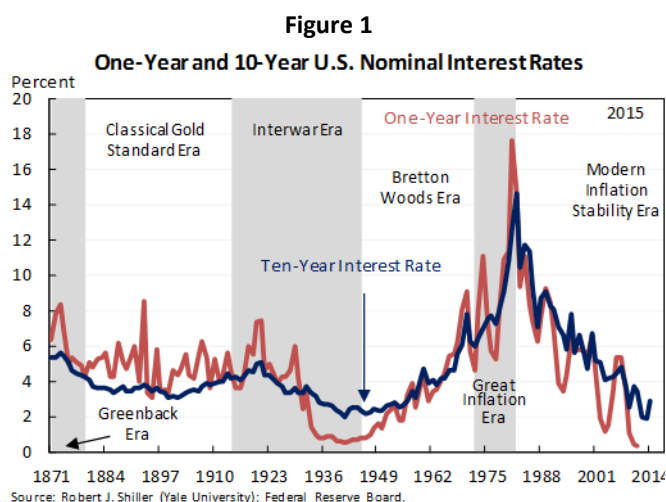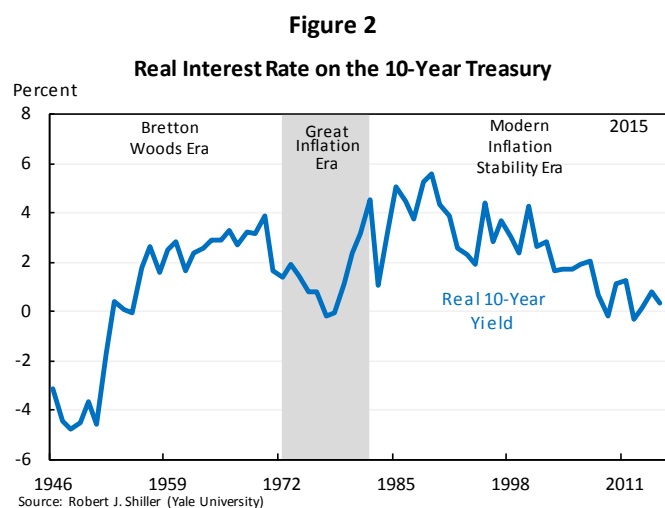Source: Robert J. Shiller (Yale University); Federal Reserve Board.

Figure 2 plots the real interest rate on the 10-year Treasury note since 1946, where the real interest rate is proxied by the difference between the nominal annual yield on the 10-year note less the five-year unweighted moving average of current and past annual inflation.[2] The real interest rate is the rate that influences economic activity—ultimately, market participants care about the returns to their saving and investment decisions net of inflation.[3] Like the nominal interest rates in Figure 1, the real 10-year interest rate has been on a steady decline since the mid-1980s, undergoing the longest sustained decline since 1876. In the post-war era, the 1980s stand as an aberration for the level of both nominal and even real interest rates.

Figure 2

Real Interest Rate on the 10-Year Treasury
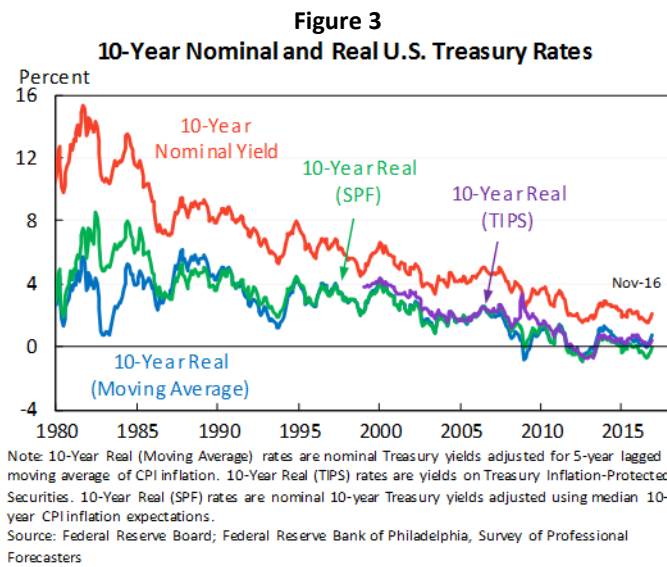

Source: Robert J. Shiller (Yale University)

The real interest rate has dipped into negative territory in recent years. Negative real interest rates have been observed previously in U.S. history and indeed have been much more negative—reaching almost negative 10 percent in the aftermath of World War I and negative 5 percent after World War II. In those episodes, the exceptionally negative real rate was a consequence of very high inflation. In recent years, it has been the low nominal interest rate and not high inflation that is behind a negative real interest rate.

Along with the nominal 10-year rate (in red) from 1980 on, Figure 3 shows the real interest rate as measured in Figure 2 (in blue) along with two additional proxy measures. The purple line is the interest rate on TIPS (the return on the 10-year Treasury note indexed to the consumer price index, or CPI), available only since 1997 when the security was first issued. In addition, the annual nominal yield less expected 10-year inflation as reported by the Survey of Professional Forecasters is shown in green.[4] Relatively low variance of inflation after the early 1980s has made inflation expectations more stable. Therefore, the real interest rate is highly correlated with the nominal interest rate. The two additional measures

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[2] Inflation expectations are not observable, and, moreover, can differ between individuals. As a result, measurement of the real interest rate based on nominal rates requires some assumption about "the" expected rate of inflation. In this report we therefore use alternative measures as a check on sensitivity.

[3] Because investors in nominal bonds are concerned about their future real purchasing power, the inflation rate relevant for pricing those bonds is the change in the PCE deflator, which is closer to an ideal index of money's purchasing power than is the fixed-weight Consumer Price

Index (CPI). In Figure 2, however, we use the year-over-year percent change in the annual CPI, because it is available back to 1871. The CPI-U (Consumer Price Index-All Urban Consumers) is reported by the U.S. Bureau of Labor Statistics from 1913.

[4] SPF expected inflation is the median expected 10-year inflation estimate of the Federal Reserve Bank of Philadelphia's Survey of Professional Forecasters. The median number of forecasters between 1981:Q3 and 1990:Q1 was 21. Since 1990:Q1, the median has been 37.

of the real interest rate shown in Figure 3 display the same declining path noted in Figure 2.

Figure 3
10-Year Nominal and Real U.S. Treasury Rates

Note: 10-Year Real (Moving Average) rates are nominal Treasury yields adjusted for 5-year lagged moving average of CPI inflation. 10-Year Real (TIPS) rates are yields on Treasury Inflation-Protected Securities. 10-Year Real (SPF) rates are nominal 10-year Treasury yields adjusted using median 10-year CPI inflation expectations.
Source: Federal Reserve Board; Federal Reserve Bank of Philadelphia, Survey of Professional Forecasters
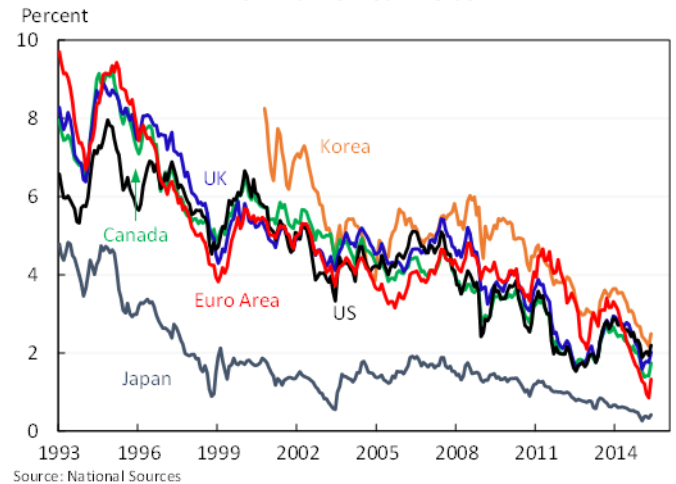
Similar trends have been observed in other advanced economies. Figure 4 shows the steady decline in long-term nominal rates for a sample of OECD economies. Japan's long-term nominal rate is notably lower than the rest over the period shown and the fall in its rate over time less sharp, but other countries' rates have moved closer to Japan's levels in recent years. Real long-term interest rates have fallen as well. Nominal interest rates on 10-year bonds currently fall short of inflation in Japan, France, Germany, and the United Kingdom.[5]

Figure 4
Nominal 10-Year Yields

Source: National Sources

An explanation for why long-term interest rates are so low, and whether low levels will persist, is one of the most difficult questions facing macroeconomists today. While it is difficult to make strong predictions, it is likely that equilibrium real interest rates will remain low. Models of economic growth imply a link between labor productivity growth, per capita consumption growth and the real (inflation-adjusted) interest rate. Historically periods of low real long-term interest rates (like the current period) have tended to coincide with low labor productivity growth. More broadly, changes in global saving and investment demand can shift global real interest rates, spilling into markets across the world. A variety of factors ranging from demographics to industrial composition could shift demand for saving or investment or both, contributing to the long run downward trend in global real interest rates.

Current forecasts suggest that rates will stay low for a considerable period of time. The Congressional Budget Office, the Blue Chip consensus forecasts, and the Administration forecasts all place the ten year treasury yield at less than 4 percent in the future, while at the same time forecasting CPI inflation of 2.3 or 2.4 percent per year.[6] The implied real ten year Treasury yield is thus below 2 percent in all these forecasts.[7] Markets suggest

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[5] The real rate is once again measured as the annual rate on the 10-year government bond less the lagged and current 5-year moving average of annual CPI inflation.
[6] The Congressional Budget Office in August 2016 forecasted long run 10-year real interest rates at 1.2 percent, and Blue Chip in October 2016 forecasted long run ten year real rates at 1.5 percent.

[7] The forecast of inflation is based on the assumption that the Federal Reserve meets its target of 2 percent inflation based on PCE prices. Because there has typically been a wedge where the CPI price index rises faster than the PCE price index, this would mean CPI inflation greater than 2 percent.

a similar interest rate a decade hence. Futures markets also suggest that 10 year nominal yields will be less than 4 percent in a decade, which would be consistent with real rates below 2 percent for the next decade. International Monetary Fund forecasts suggest that while average nominal interest rates in advanced economies are likely to rise moderately in the medium term, they will remain at historically low levels, and IMF projections have declined significantly over the past two years (IMF 2016).

3.2 Another standard economic approach: the Ramsey Equation

An alternative to the current approach of using Treasury rates as a proxy for the SRTP is estimating the SRTP using a framework developed by Ramsey (1928). The Ramsey model is a theory-based alternative to observed market rates; it can be used to help forecast future market rates, or as a framework for normative approaches that would seek to arrive at a discount rate from first principles, prescriptively. In the Ramsey model, a social planner maximizes the discounted sum of utility. This framework derives the discount rate under the optimal time path of investment. To derive the Ramsey equation, the framework requires the following assumptions (which we will maintain throughout the subsequent discussion): an increasing strictly concave utility function; additively separable utility; utility for a given level of consumption constant over time; a constant social rate of time preference; and isoelastic utility. These assumptions lead to the Ramsey equation (1):

$$(1) \qquad \rho_t = \delta + \gamma g_t$$

where ρ_t is the annual consumption rate of discount between time 0 and time t, δ is the pure rate of time preference (i.e., the rate at which the social planner discounts future utility), γ is the elasticity of marginal utility with respect to consumption (the inverse of the intertemporal substitution elasticity), and g_t is the annualized growth rate of per capita consumption between time 0 and time t (Arrow et al. 2014; Council of Economic Advisers 2015).[8] In an intergenerational

context, the parameter γ is also often interpreted as the degree of inequality aversion between different generations.

3.2.1. Parameter values in the Ramsey approach

The interpretation of this equation has fostered many debates. For example, methods to estimate γ vary widely and include estimates of consumption behavior based on consumer demand models, surveys of risk aversion, and revealed social desires for redistribution inferred from tax rates. These varying approaches lead to a wide range of estimates of γ, which can differ according to whether that parameter is conceptualized as the coefficient of relative risk aversion or the inverse of the intertemporal elasticity of substitution.

The parameter g is generally proxied by observed growth rates. These growth rates have come down around the world in recent years which stands as one possible explanation for lower observed and projected real interest rates (see CEA (2015) for a more extensive discussion).

Expert disagreement over the pure rate of time preference δ is especially fierce and this disagreement has led to a wide range of estimates. A first question is whether impatience – a strictly positive value δ – is even inevitable. Ramsey's (1928) own formulation of his eponymous model set $\delta = 0$. Koopmans (1960) suggested axioms that guarantee impatience, at least for optimization over infinite horizons. But if so, what specific value of δ is appropriate? A "descriptive" approach (e.g., Nordhaus 2007) posits that ρ_t is given by market rates and thus we can solve for the implied δ. A "normative" or "prescriptive" approach (e.g., Stern 2007) sets δ based on ethical considerations and uses this to determine what the social discount rate ρ_t should be. Ramsey's rationale for assuming $\delta = 0$ was his value judgment that differential treatment of different generations should be inadmissible. This is an important debate, although we will not come to grips with it in this document.[9]

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[8] The pure rate of time preference δ is the rate at which utility, not consumption, is discounted. The consumer adjusts her intertemporal consumption path until marginal utility, adjusted for discounting by the social rate

of time preference and return on assets, is constant over time.

[9] See Kaplow (2006) for an argument that the efficiency consideration should be separated from those of inter-generational equity; and Calvo and Obstfeld (1988) for a

Use of a market rate of discount implies, in principle, that the rate (whether measuring opportunity cost in terms of forgone consumption or investment) will be variable. The Ramsey equation (1) explains this variability through variation in the per capita consumption growth rate. In addition, however, the rate of utility discount δ in (1) need not be constant or even exogenous, nor is it evident that exogeneity is a reasonable assumption. The Ramsey equation (1) can still hold exactly under formulations, such as those surveyed in Obstfeld (1990), in which δ is endogenous.

A potential drawback of the Ramsey approach is that the rate of consumption growth is itself an endogenous variable, rather than an explanatory variable, except, perhaps, in the idealized steady states of certain models. So while (1) may be applicable to the very long-run given a reliable real long-run growth forecast, its usefulness for the medium term is less clear. As Harberger and Jenkins (2015) provocatively put it, rather than viewing (1) as a guide to the appropriate interest rate, one could view it as a guide to the appropriate consumption growth rate, and simply take market interest rates as the appropriate rates for project evaluation.

The variability of market interest rates does not imply that decisions will be dynamically inconsistent. The key requirement for a dynamically consistent solution of a maximization problem (under certainty) is that the marginal rate of substitution between consumption on two dates not change merely due to the passage of time. That requirement will be satisfied even if the term structure of interest rates is not flat (Gollier 2013, pp. 64-66).

Unfortunately, the general absence of very long-horizon securities makes market interest rates unavailable for evaluating projects with payoffs that continue far into the future. Thus, some other approach is necessary for evaluating such projects – either a forecasting framework based on theory, such as the Ramsey approach, or some type of empirically-based but more general forecasting setup (like a time-series model, assumed to be stable into the distant future, or even incorporating explicit learning dynamics). Interesting in this context is the recent work of Giglio, Maggiori, and

Stroebel (2015) on very long-term leaseholds, which suggests that far-future discount rates could be quite low. They examine 100 year or more leaseholds in property markets in the United Kingdom and Singapore, and find that households discount cash flows beyond 100 years at below a rate of 2.6 percent. This is consistent with a very long run discount rate of roughly 1 percent. Indeed, the problem of long term discounting bedevils *any* approach based on measured market returns. "Prescriptive" approaches to solving this long-horizon problem are discussed below. But even a "descriptive" approach will require theoretical assumptions and assumptions about empirical data-generating processes.

3.3 Dealing with uncertainty when discounting the far future

Some public policies and projects involve streams of benefits and costs that extend over such a long period of time that they will affect individuals across multiple generations, and even over centuries or millennia – for example securing waste from nuclear power plants. However, market rates of return give scant indication of the discount factors that might apply beyond the limited horizon of the standard traded securities that are available. Yet mechanical extrapolation of current rates of return places a negligible weight on the welfare of future generations, a practice that many researchers find hard to defend without any compelling empirical or theoretical guidance. Moreover, it seems hard to argue that historical trends in rates of return provide reliable guidance to likely developments centuries from now. Grappling with these problems forces policymakers to confront the considerable uncertainty about economic developments, including rates of return, far into the future.

In general, greater uncertainty about the far future implies rates lower than those observed in today's markets, regardless of how the estimated rates are measured. However, there is an active debate in the economics literature regarding the precise approach for discounting over very long time horizons.

A longer time horizon in an intergenerational policy context implies greater uncertainty about the

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model that operationalizes the general approach of treating time and generational discounting in a separable fashion.

investment environment and economic growth over time. Ideally, we would formally model this uncertainty. Weitzman (1998, 2001) showed theoretically and Newell and Pizer (2003) and Groom et al. (2007) confirm empirically that discount rate uncertainty can have a large effect on net present values. A main result from these studies is that if there is a persistent element to the uncertainty in the discount rate (e.g., the rate follows a random walk), then it will result in an effective (or certainty-equivalent) discount rate that declines over time. Consequently, lower discount rates tend to dominate over the very long term, regardless of whether the estimated investment effects are predominantly measured in private capital or consumption terms (see Weitzman 1998, 2001; Newell and Pizer 2003; Groom et al. 2005, 2007; Gollier 2008; Summers and Zeckhauser 2008; and Gollier and Weitzman 2010).

The proper way to model discount rate uncertainty remains an active area of research. Gollier (2002) extends the Ramsey framework, adding a third term that reduces the expected growth rate to account for an uncertain future; the impact is to reduce the discount rate, though the effect would likely be small in industrialized countries (Gollier and Hammitt 2014). Newell and Pizer (2003) employ a model of how long-term interest rates change over time to forecast future discount rates. Their model incorporates some of the basic features of how interest rates move over time, and its parameters are estimated based on historical observations of long-term rates. Subsequent work on this topic, most notably Groom et al. (2007), uses more general models of interest rate dynamics to allow for better forecasts. Specifically, the volatility of interest rates depends on whether rates are currently low or high and variation in the level of persistence over time.

Alternatively, while outcomes, especially over long horizons, are uncertain, this need not imply that the discount rate itself is uncertain. By integrating over the probability distribution of future outcomes, one can arrive at an expected value of future growth rates, to which a more conventional discount rate can be applied. This is akin to the proposal in Dasgupta (2008).

While Newell and Pizer (2003) and Groom et al. (2007) attempt formally to model uncertainty in the discount rate, two recent strands of argument suggest another way to incorporate uncertainty when discounting the benefits and costs of policies and projects that accrue in the far future – applying discount rates that decline over time. This approach uses a higher discount rate initially, but then applies a graduated schedule of lower discount rates further out in time.[10]

The first argument is based on the application of the Ramsey framework in a stochastic setting (Gollier 2013), and the second is based on Weitzman's "expected net present value" approach (Weitzman 1998, Gollier and Weitzman 2010). In light of these arguments, the governments of the United Kingdom and France apply declining discount rates to their official public project evaluations. [11] While promising, there are technical difficulties with the declining discount rate approach that have yet to be fully addressed by economists (Arrow et al. 2014, Newell and Pizer 2003). Another approach – and one of the options presented by the U.S. Interagency Working Group on the Social Cost of Carbon (2010) -- is to pick a flat but somewhat lower discount-rate schedule for projects involving distant costs and benefits where a declining discount rate might, in theory, be appropriate.[12]

4. Revisiting the 7% rate in A-4

As noted earlier, given distortions in the economy from taxation, imperfect capital markets, externalities, and other sources, the SRTP and the marginal product of capital need not coincide, and analysts face a choice between the appropriate opportunity cost of a project and the appropriate discount rate for its benefits. The social opportunity cost of capital (SOC) approach focuses

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[10] Gollier and Zeckhauser (2005) reach a similar result using a model with decreasing absolute risk aversion.
[11] The U.K. has adopted a real annual discount rate that declines in steps of 50 basis points from 3.5 percent (in years 0 through 30) to 1 percent for horizons greater than 300 years (H.M. Treasury 2003). The French government recommends a 4 percent discount rate up to 30 years, with the rate declining thereafter to reach a level "slightly above" 2 percent after 500 years (Commissariat Général du Plan 2005).
[12] While the IWG (2010) discusses this option and presents one set of estimates of the social cost of carbon using a discount rate of 2.5%, the estimates presented as "central" in all IWG documents use a discount rate of 3%, equivalent to the current SRTP-based lower rate in OMB Circular A-4.

on the investment that is displaced by government projects or regulations as its point of departure.

4.1 Overview of SOC and major considerations

The SOC approach, developed by Mishan (1967) and Baumol (1968), among others, is based on asking if the overall return on a project at least matches the benefits from the likely use of the same resources by the private sector. It does so by applying an appropriate discount rate to the stream of project returns. Conceptually, as noted above, discounting can be simple: when the economy is free of tax and other distortions, and under complete certainty, returns on all privately-held assets in the economy are equalized and any one of those returns furnishes the appropriate discount rate: the real interest rate on bonds, the marginal product of capital, etc.

In reality, taxes and other distortions drive a wedge between the private returns available to savers and the social marginal product of their saving. This means that a unit of resources allocated to consumption yields less marginal social value than a unit allocated to investment, contrary to the undistorted optimality condition, and in this case, evaluating a project that uses current resources depends on whether those resources are drawn from consumption or investment. In an open economy one must also consider the possibility of financing by foreign lenders.

Under a blended SOC approach, developed by Harberger (1972), Sandmo and Drèze (1971), Burgess (1988) and others, the discount rate depends on:

- The pre-tax marginal return to capital.
- The after-tax marginal return to capital.
- The marginal cost of foreign financing.

The weight on each component above roughly equals the respective share of each activity that funding the project displaces (Burgess and Zerbe 2011). Thus, if ρ is the return to capital, $r = \rho(1 - \tau)$ the return to savers (where τ is the tax rate on capital), f the marginal cost of foreign finance, and θ_i the share of financing from source i, then the appropriate discount rate will be $\theta_1\rho + \theta_2 r + \theta_3 f$.

As an example, imagine a project that will require investing K tomorrow and will yield benefits of B perpetually, also starting tomorrow. A fraction θ_1 of each investment dollar will displace capital with present-value

return ρ/r (in terms of current consumption) while a fraction θ_3 will entail a perpetual foreign exchange cost with present value of f/r. The remaining cost fraction $\theta_2 = 1 - \theta_1 - \theta_3$ comes out of current consumption. Thus, the project is socially worthwhile if
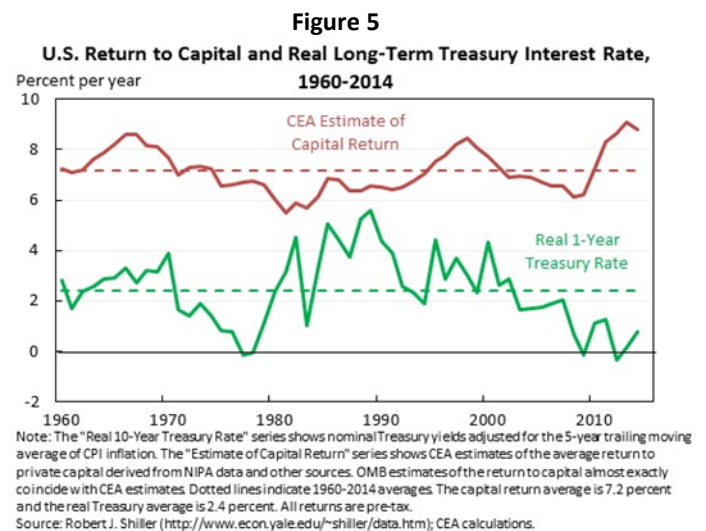
$$\frac{B}{r} > \left(\theta_1 \frac{\rho}{r} + \theta_2 + \theta_3 \frac{f}{r}\right) K$$

This is equivalent to using the weighted discount rate:

$$\frac{B}{\theta_1\rho + \theta_2 r + \theta_3 f} > K$$

4.2 Issues in SOC measurement and current practice

There are several issues to consider when using the SOC methodology. The first issue is finding empirical analogs for the rates of return. Burgess and Zerbe (2011) discuss alternatives. For the pre-tax return to capital, they write that (p. 6) "National Accounts data can be used to estimate annual rates of return on reproducible capital … as the ratio of the total income accruing to capital divided by the stock of capital." A number of studies use this method. It also corresponds roughly to current OMB practice in determining the 7 percent rate used in Circulars A-4 and A-94. OMB's estimates also include land, which is non-reproducible capital and therefore perhaps not relevant when estimating marginal returns. The approach uses data covering a broad swath of the economy and leads to fairly consistent and stable estimates, as Figure 5 shows, with the rate roughly moving around 7 percent.

Figure 5

U.S. Return to Capital and Real Long-Term Treasury Interest Rate, 1960-2014

Note: The "Real 10-Year Treasury Rate" series shows nominal Treasury yields adjusted for the 5-year trailing moving average of CPI inflation. The "Estimate of Capital Return" series shows CEA estimates of the average return to private capital derived from NIPA data and other sources. OMB estimates of the return to capital almost exactly coincide with CEA estimates. Dotted lines indicate 1960-2014 averages. The capital return average is 7.2 percent and the real Treasury average is 2.4 percent. All returns are pre-tax.
Source: Robert J. Shiller (http://www.econ.yale.edu/~shiller/data.htm); CEA calculations.

While estimating the SOC using National Accounts data, as is currently done for the Federal guidance, has many advantages – such as the fact that these data encompass all economic sectors and forms of reproducible capital – it also has drawbacks (Burgess and Zerbe 2011). The estimate divides the total income accruing to capital by the value of the capital stock; both the numerator and the denominator in this fraction are estimated with uncertainty. Challenges, according to Burgess and Zerbe (2011), include "how to separate the return to capital from the return to labor in unincorporated businesses; how to reliably separate payments to unimproved land from the return to capital; and how to determine appropriate rates of economic depreciation for the various capital types" (pp. 6-7). Contrast this with the estimate of the SRTP, which is readily observed and not subject to measurement error.

As an alternative, some authors point to the return on publicly traded equity (Weitzman 2007), though this covers a narrower portion of the capital stock and includes volatile capital gains, so it has not been favored as common practice. The real return on market equity indexes does appear to be declining. It is less clear how to approximate empirically the rate of return available to consumers. Some derive the rate of return to consumers by estimating and subtracting the taxes from the pre-tax return to capital (Burgess and Zerbe 2011; Harberger and Jenkins 2015). Empirically approximating the marginal cost of foreign finance is perhaps the most difficult task of all (see Curcuru, Thomas, and Warnock 2013).

A notable feature of figure 5 is that while the NIPA based calculation (in red) has been oscillating around 7 percent, the real rate of return on Treasuries has been falling, suggesting a growing divergence between the real safe return based on financial market data and the return based on the NIPA calculations.

One possibility for this divergence is simply that the NIPA measures of the rate of return on capital are mis-measured. Many experts believe that equity premiums and other measures of the return to more risky investments in capital, while cyclical, have not systematically risen over time (Graham and Harvey 2016, Duarte and Rosa 2015) . Then to the degree that the long term interest rate is well measured it is more plausible that at least part of the divergence between this and the estimated return to capital could reflect mismeasurement of the return to capital.

Moreover, there are extensive market- and survey based measures of expected future interest rates which make us more confident that the best guess for these should be substantially lower today than was the case in 2003. In contrast, there are no available market or regularly updated survey estimates of the economywide rate of return to capital. In the absence of these, it would suggest putting more weight on the better-estimated parameter—which is interest rates—and to the degree that is adjusted making a similar adjustment to the rate of return to capital.

Moreover, even to the degree it was measured and projected accurately the market return on capital such as that based on the NIPA calculations could differ from the social return for a variety of reasons. For example, some element of profit could reflect unpriced externalities (positive or negative). Dasgupta, Mäler, and Barrett (1999) give an example of a negative externality, in which the profit rate earned by polluting firms exceeds the social rate in the absence of an appropriate pollution tax. If some firms exercise market power, setting prices above marginal cost, then market rates of return include some monopoly rents and thus exceed the true market rate of return to capital, at least in cases where those rents are not related to fixed costs such as for innovation. Harberger and Jenkins (2015) note that the divergence from competitive rates of return due to monopoly rents should be considered in choosing the social discount rate, but that this divergence likely varies little over time. However, CEA analysis finds that several indicators suggest that competition has declined in recent decades, and that rents may have increased (CEA 2016). Unfortunately, it is not clear how to estimate the net effect of positive and negative externalities on the measured private return to capital, and the magnitude and trends in these net effects are unknown.

Third, market rates of return may also diverge from the SOC because private returns include both the pure time value of money and a risk premium, and some or all of that risk premium may not be relevant to government decisions. Since the 1960s economists have argued whether the social discount rate should be associated with a risk-free rate or one that reflects market risk. Diamond (1967) and Hirshleifer (1964, 1966) argued that under complete markets the government should incorporate a factor equal to the cost of risk into the discount rate it uses to evaluate its own activities. Others (Jorgensen et al. 1964, Samuelson and Vickrey 1964,

Arrow and Lind 1970, Harberger and Jenkins 2015) subsequently argued that the government can achieve greater diversification than private investors, and that individual policies and projects represent very small fractions of society's total wealth and are independent of other components or national income. Under those assumptions, a risk free rate would be the appropriate one for discounting. More recently analysts have advocated SOC-oriented discount rates that fully or partially incorporate market risk, since government investments and policies ultimately shift risk to current and future taxpayers (Lucas 2012, Harberger and Jenkins 2015).

A related strain of literature would look to market prices to arrive at the SOC, arguing that this approach better aligns the incentives facing policymakers with the public interest (Lucas 2012). For example, if one looked to equity returns, this could suggest a lower rate than the current method used to arrive at the SOC, while hurdle rates used by firms in private investment decisions could suggest a higher rate. In theory, the "true" SOC could be either higher or lower than observed market rates. While the concerns raised above about externalities, market power and incomplete markets are drawbacks to the use of private market indicators to estimate the SOC, proponents would note that such measures are widely observable over long periods of time, well understood, and possibly no worse than the alternatives (Lucas 2012). In addition, the fact that Treasury rates are market rates is seen as a particular strength of the common practice of using Treasury rates as a proxy for the SRTP.

An additional challenge for the SOC methodology is how to deal with taxation. The approach tends to assume that lump sum tax/subsidies are the marginal tax instrument, an unrealistic assumption but one that simplifies analysis considerably (Burgess 2013).

5. Conclusion

The discount rate is a key parameter in a wide range of government decisions, including project analysis and regulatory benefit-cost analysis. Following the guidance in OMB's Circular A-4, agencies are currently required to use both a 7 percent rate (representing the social opportunity cost of capital) and a 3 percent rate (representing the social rate of time preference) in benefit-cost analysis. Though the guidelines in A-4 are continually monitored, they have been updated

approximately once per decade in recent years. Given the passage of time and the continued evolution of the economy and our understanding of it, a review of the discount rate guidance in A-4 is overdue.

Since 2003, when the guidance in A-4 was last updated, the economy and the theory of how to apply discount rates have evolved. The most obvious such change, highlighted in this report, is the ongoing, significant decline in the long-term interest rates that undergird the choice of the SRTP-oriented lower rate (currently 3%). In the United States and other advanced economies, long-term equilibrium real interest rates are at historically low levels and are expected to remain low for a considerable period of time. Even if they rise some over the next decade – as most forecasts suggest – they are projected to be far below 3 percent. There has also been a significant debate in the economics literature regarding the appropriate approach to discounting costs and benefits over the very long run, using the Ramsey framework or other methods. Intergenerational ethical considerations and greater uncertainty about the investment environment and economic growth in the far future would tend to support lower discount rates in this context. This point is partially addressed in the current discounting guidance in A-4, but is worthy of additional study and public comment should the guidance be revisited—with plausible estimates based on past data and current market- and survey-based forecasts of at most 2 percent.

The potential reasons to revisit the SOC-oriented upper rate (currently 7%) in Circular A-4 are somewhat different. One potential reason to revisit the SOC-oriented rate would be based on the fact that long-term interest rates, which are not subject to mismeasurement, have come down, and that this provides some information (though not comprehensive information) about the SOC, as well. Thus, any downward adjustment in the lower rate could provide partial support for downward adjustment of the upper rate as well. This could be the case because the measures of and projections for the rate of return to capital are so much less certain than they are for market interest rates. In addition, while the current proxy for the SRTP (the long-term Treasury rate) has fallen significantly from the historical average, the measure currently used to estimate the SOC for the 7% rate has no clear long-run trend. However, there has been an active debate in the economics literature about the appropriate empirical

analogs for the SOC, with many alternatives proposed. Important issues to consider include unpriced externalities, rents associated with market power, the degree to which market risk should be incorporated, how to deal with taxation, and the possibility that observed market indicators may contain relevant information that is not incorporated in the current SOC estimate. Moreover in at least some of these cases, like market power, there is evidence that increases in monopoly returns would suggest that a constant measured rate of return to capital is consistent with a reduction in the relevant rate for use in social discounting.

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