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PUBLIC INTEREST COMMENT

RECOMMENDATIONS TO IMPROVE CONSISTENCY AND TRANSPARENCY IN THE EPA'S CLEAN AIR ACT BENEFIT-COST ANALYSES

JAMES BROUGHEL
Senior Research Fellow, Mercatus Center at George Mason University

Increasing Consistency and Transparency in Considering Benefits and Costs in the Clean Air Act Rulemaking Process
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The Environmental Protection Agency (EPA) is seeking comments on its proposed rule, "Increasing Consistency and Transparency in Considering Benefits and Costs in the Clean Air Act Rulemaking Process" (hereafter referred to as the EPA benefit-cost rule).[1] If implemented, this proposed procedural regulation would commit the EPA to adhering to certain analytical practices when establishing regulations under the Clean Air Act. In general, the EPA should be applauded for embracing economic analysis in its rulemaking process and attempting to commit to some best practices, and many features of the EPA's proposal are praiseworthy. However, the regulation in its present form also has some shortcomings. To improve the regulation, this comment makes three broad recommendations:

1. The EPA should more clearly define any vague terminology in its proposed regulation, particularly terms such as "benefit-cost analysis," "social benefits," and "society."
2. The EPA should commit to presenting disaggregated benefits and costs in its analysis, specifically categorizing impacts in terms of whether they pertain to investment, mortality, and people in other countries.

1. Increasing Consistency and Transparency in Considering Benefits and Costs in the Clean Air Act Rulemaking Process, 85 Fed. Reg. 37057 (proposed June 11, 2020).

For more information, contact
Mercatus Outreach, 703-993-4930, mercatusoutreach@mercatus.gmu.edu
Mercatus Center at George Mason University
3434 Washington Blvd., 4th Floor, Arlington, VA 22201

3. The EPA should not adjust its $100 million threshold for economically significant regulations for inflation. Nor should it not commit to monetizing all costs and benefits in its regulatory analysis.

DEFINITIONS

The EPA consistently uses vague terminology throughout its rulemaking, especially with respect to terms such as "well-being," "society," "social welfare," "benefit-cost analysis," "social benefits," and "social costs." If such terms are not clearly defined, the EPA's analysis could suffer and may not measure anything particularly meaningful.[2] In general, the EPA should be clear that it intends its analysis to measure efficiency, specifically Kaldor-Hicks efficiency (since there are two types of efficiency—Pareto efficiency is the other).

The EPA should also clarify its definitions of benefits and costs. According to the Office of Management and Budget, "'Opportunity cost' is the appropriate concept for valuing both benefits and costs."[3] However, the EPA's proposed regulation seems to suggest that only costs are measured in terms of their opportunity cost (while benefits are measured in terms of changes in "societal well-being").[4] Moreover, it is the opportunity cost to *society* that is the relevant metric here,[5] where "society" refers to all individuals with standing in the analysis, now and in the future. The EPA should clearly define "society" to make clear exactly who gets standing in its regulatory analysis.

Finally, the EPA pays little attention to the "opportunity cost of capital" in its proposed regulation; i.e., the returns to invested capital created or displaced by its regulations. The EPA's proposed rulemaking should define the "opportunity cost of capital" and commit to measuring it, since this is a critical input in any benefit-cost analysis.

The following definitions would constitute substantial improvements if added or substituted in place of those definitions currently in the EPA's proposed rulemaking:

1. "Benefit-cost analysis" (BCA) means an evaluation of the positive and negative changes associated with the action. The normative foundation of BCA is the potential compensation test of Kaldor and Hicks. BCA answers the question of whether the benefits for those who gain from the action are sufficient to, in principle, compensate those burdened, such that everyone would be at least as well off as before the policy. The calculation of net benefits (benefits minus costs) measures the economic efficiency of a regulation, where economic

2. Benefit-cost analysis (BCA) is often of little value because it often lacks a meaningful measure of welfare. James Broughel, "Make Benefit-Cost Analysis Meaningful," *Regulatory Review*, January 7, 2019.
3. Office of Management and Budget, *Circular A-4*, 2003.
4. According to the EPA, "Social benefits, or benefits, means the positive changes in societal well-being incurred as a result of the regulation or policy action. Social costs, or costs, means the sum of all opportunity costs, or reductions in societal well-being, incurred as a result of the regulation or policy action." Increasing Consistency and Transparency in Considering Benefits and Costs in the Clean Air Act Rulemaking Process, 85 Fed. Reg. 37057, 35625 (proposed June 11, 2020).
5. The distinction between private and social opportunity costs can be critical. Individual willingness-to-pay (WTP) values in markets often do not correspond with social opportunity cost, even though they may correspond with private opportunity cost. If the EPA were to use, for example, a WTP value from a market where externalities prevent some who are impacted by the transactions in that market from trading in it, the value that corresponds with a marginal increase or decrease in output in the market would clearly be inappropriate, as it would represent the private, rather than social, value of the resource. The social value is the relevant value for BCA.

efficiency refers to Kaldor-Hicks efficiency, a situation whereby the dollar value of aggregate wealth in society is maximized.

2. "Social benefits," or "benefits," means the positive incremental changes accrued as a result of the regulation or policy action. Benefits are measured in terms of their social opportunity cost, which in practice usually refers to the maximum amount society is willing to pay for the benefit.
3. "Social costs," or "costs," means the negative incremental changes incurred as a result of the regulation or policy action. Costs are measured in terms of their social opportunity cost, which in practice usually refers to the minimum amount society is willing to accept as compensation for a loss.
4. "Society" refers to all individuals with standing in the analysis, now and in the future. By default, those with standing are typically citizens and residents within the United States. Standing can be granted to other individuals when impacts on other individuals are of concern.
5. "Opportunity cost" means the value of the next best alternative to a particular activity or resource. Willingness to pay captures the notion of opportunity cost by measuring what individuals are willing to forgo to enjoy a particular benefit.
6. "Social opportunity cost" is the value society is willing to forego to enjoy a particular benefit. It refers to what the market price of a resource would be in a perfectly competitive market, free of distortions such as externalities. If the market for a resource does not exist or substantial market failures are present in a market for a good, then the social opportunity cost of the resource is the price that would emerge if the market did exist and if affected third parties (including those in the future) could trade in the market at zero transaction costs.
7. "Opportunity cost of capital" means the returns to invested capital that are not reflected in a capital asset's price. It can be expressed as the marginal before-tax rate of return to private capital in the US economy. A base-case rate of 7 percent shall be used to account for the opportunity cost of capital in the EPA's regulatory analysis.[6]

DISAGGREGATING BENEFITS FOR SUMMARY TABLES

The EPA is requesting comment on whether and how it should present disaggregated benefits and costs within a table that summarizes conclusions of its BCAs.[7] In general, it would be helpful if the EPA would commit to doing this. Moreover, the following are examples of types of benefits and costs the EPA should take care to single out in such a table:

- The EPA should delineate between benefits and costs that are consumed and those that come in the form of investment.

6. Though Office of Management and Budget (OMB) guidelines conflate the two concepts, there is a critical distinction to be made between this opportunity cost of capital rate and the social discount rate. James Broughel, "The Social Discount Rate: A Primer for Policymakers" (Mercatus Policy Brief, Mercatus Center at George Mason University, Arlington, VA, June 2020) (see the attachment to this comment); James Broughel, "OIRA Should Stop Calling a Tail a Leg," *The Bridge,* August 26, 2019.
7. Increasing Consistency and Transparency in Considering Benefits and Costs in the Clean Air Act Rulemaking Process, 85 Fed. Reg. 37057, 35623–35624 (proposed June 11, 2020).

In general, the proper way to conduct BCA is to separate consumption and investment, since these different benefits and costs have different rates of return associated with them.[8] If an analyst doesn't discern which benefits and costs are invested and which are consumed, he or she can have little confidence that the opportunity cost of capital has been accounted for in analysis.

- The EPA should distinguish domestic benefits and costs from international benefits and costs, and it should use an international measure of willingness to pay when presenting benefits and costs from an international perspective.

  At the outset of an analysis, an analyst must decide who gets counted in the analysis (this is the issue of standing mentioned earlier). This can be determined by several factors. One is democracy. For example, US regulatory agencies might be responsible for considering the effects only on people within the borders of the United States, since these are the people within the agencies' jurisdiction. Or, standing might be determined by the distribution of policy impacts. For example, when individuals in other countries are affected, impacts on them might be included as well, but should be presented in a disaggregated manner such that it is clear which benefits accrue to people in the United States and which accrue to people in other countries.[9] Moreover, when the scope of analysis extends to individuals in other countries, the social opportunity cost of resources should be valued from an international perspective as well. For example, the EPA often uses a population average value of a statistical life to monetize mortality benefits in its analysis.[10] When analysis is conducted from an international perspective, the relevant average would be the global average value.[11]
- The EPA should present mortality benefits separately, including countervailing changes in mortality.

  The agency should clearly break down how many lives are expected to be saved from its rules and present this number unconcealed by factors such as discounting. It should also present the "gross" and "net" mortality reduction, where the net mortality reduction accounts for countervailing risk increases (or decreases) owing to income losses (or gains) induced by the regulation.[12]

8. See, for example, Liqun Liu, "A Marginal Cost of Funds Approach to Multi-Period Public Project Evaluation: Implications for the Social Discount Rate," *Journal of Public Economics* 87, no. 7 (2003): 1707–18. The shadow price of capital method, which OMB calls "the analytically preferred method" of accounting for the opportunity cost of capital, also distinguishes between benefits and costs that are invested and those that are consumed. See Office of Management and Budget, *Circular A-4*.
9. According to OMB Circular A-4, "Your analysis should focus on benefits and costs that accrue to citizens and residents of the United States. Where you choose to evaluate a regulation that is likely to have effects beyond the borders of the United States, these effects should be reported separately." Office of Management and Budget, *Circular A-4*, 15.
10. There are reasons to be skeptical of using the value of a statistical life (VSL) to value mortality risks. However, if the EPA continues with its current (imperfect) practices, consistency requires a global average VSL when the scope of analysis is global. For discussion of problems associated with the VSL, see James Broughel, "Rethinking the Value of Life: A Critical Appraisal of the Value of a Statistical Life" (policy paper no. 2020.002, Center for Growth and Opportunity at Utah State University, Logan, UT 2020); James Broughel and Michael Kotrous, "The Benefits of Coronavirus Suppression: A Cost-Benefit Analysis of the Response to the First Wave of COVID-19" (Mercatus Working Paper, Mercatus Center at George Mason University, Arlington, VA, June 2020).
11. The global average VSL is about $1.8 million for 2015. This value can be reproduced by taking a population-weighted average of the VSL values found in W. Kip Viscusi and Clayton J. Masterman, "Income Elasticities and Global Values of a Statistical Life," *Journal of Benefit-Cost Analysis* 8, no. 2 (2017): 226–50.
12. James Broughel and W. Kip Viscusi, "The Mortality Cost of Expenditures," *Contemporary Economic Policy* (published ahead of print, June 25, 2020), https://doi.org/10.1111/coep.12483.

$100 MILLION DESIGNATION: THE EPA SHOULD NOT ADJUST THIS THRESHOLD FOR INFLATION

The EPA is seeking comment as to whether it should adjust for inflation the $100 million "economically significant" designation for its rules,[13] resulting in a higher threshold to qualify for mandatory scrutiny. It should not. The $100 million threshold was always an arbitrary cutoff. All else equal, it is better for more regulations to be analyzed than fewer, unless the EPA can demonstrate that the burden imposed on the agency by doing so outweighs the benefits. At this point, so few regulations are analyzed,[14] let alone analyzed credibly, that it is hard to imagine why analyzing fewer regulations would be sensible.

THE EPA SHOULD DROP ITS COMMITMENT TO "MONETIZE ALL THE BENEFITS"

The EPA is proposing to commit to "monetize all the benefits" to the extent practicable.[15] However, monetizing all benefits in a BCA is not necessary, realistic, or even desirable in most cases.[16] This commitment may open up EPA rules unnecessarily to challenges. The EPA should drop this commitment.

CONCLUSION

This comment has made a number of recommendations to the EPA about ways to improve its proposed benefit-cost rule. While the nominal commitment of the agency to adhering to sound benefit-cost practices is noteworthy, there remain problems with the EPA's proposed rule as it now stands. However, a few simple but important changes could go a long way toward improving this rulemaking and improving future EPA regulatory analysis.

ATTACHMENT

James Broughel, "The Social Discount Rate: A Primer for Policymakers" (Mercatus Policy Brief)

13. Increasing Consistency and Transparency in Considering Benefits and Costs in the Clean Air Act Rulemaking Process, 85 Fed. Reg. 37057, 35623 (proposed June 11, 2020).
14. James Broughel and Richard Williams, "More Information Needed on the Benefits and Costs of Regulations," *The Bridge*, August 22, 2018.
15. Increasing Consistency and Transparency in Considering Benefits and Costs in the Clean Air Act Rulemaking Process, 85 Fed. Reg. 37057, 35626 (proposed June 11, 2020).
16. For practical purposes, investment benefits and costs are what determine the efficiency of policy actions, so monetizing nonpecuniary benefits and costs is usually unnecessary. The intuition for this is as follows: When the opportunity cost of capital rate exceeds the rate at which the future is discounted (the social discount rate), a marginal increment of investment is preferred to a marginal increment of consumption. Under such conditions (which can generally be expected to hold), invested resources are what determine the efficiency of a policy action. That is to say, investment should be increased until the rate of return to capital falls sufficiently to meet the social discount rate. At that point a dynamic optimum is achieved, and the focus of analysis will shift to static efficiency, at which time consumption benefits and costs help determine the efficiency of an action. James Broughel, "The Social Discount Rate: A Primer"; Tyler Cowen and Derek Parfit, "Against the Social Discount Rate," in *Justice Between Age Groups and Generations*, ed. Peter Laslett and James S. Fishkin (New Haven, CT: Yale University Press, 1992), 151.

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POLICY BRIEF

The Social Discount Rate: A Primer for Policymakers

James Broughel

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The social discount rate used in cost-benefit analysis (CBA) is an interest rate applied to benefits and costs that are expected to occur in the future in order to convert them into a present value. This conversion is done to ascertain what those benefits and costs are worth today. The social discount rate is widely considered to be one of the most important inputs in CBA in that small changes in this rate can result in large swings in present-value calculations, thereby having a major influence on whether a project passes or fails a cost-benefit test. However, the social discount rate is widely misunderstood for a variety of reasons. This primer explains the basic conceptual issues involved with the social discount rate and tries to clear up some common misunderstandings.

BASIC CONCEPTS

The two core discounting concepts in CBA are the "consumption rate of interest" and the "investment rate of interest."[1] The investment rate of interest accounts for the marginal social rate of return to capital in the economy. The intuition behind this rate is that investments earn positive, compounding rates of return. The consumption rate of interest, meanwhile, represents the rate at which a unit of consumption in the present is traded for a unit of consumption in the future. This interest rate reflects consumers' time preferences and, in certain circumstances, may be represented by the risk-free market interest rate.[2] The standard approaches to discounting in CBA all rely on these two interest rate concepts.[3] For the sake of clarity, when this article refers to "the social discount rate" in CBA, it is the consumption rate of interest for all of society that is being referenced.

The investment rate of interest will generally be higher than observable market interest rates (and by extension the consumption rate) because the minimum required rate of return demanded by

businesses will tend to exceed their costs of borrowing, owing to taxes. If the expected after-tax rate of return on a project falls below businesses' cost of borrowing, they will not undertake certain investments that might still be profitable from a societal point of view. In this way, taxes create allocative distortions in the economy that limit the amount of overall investment.

The risk-free market interest rate can deviate from the natural rate that reflects consumer time preferences, owing to factors such as inflation or market inefficiencies (e.g., externalities). Small adjustments can be made in an analysis to account for such factors. However, discounting consumption in CBA also becomes much more complicated in an intergenerational context, because while all human beings exhibit some degree of time preference, they only exhibit positive time preference during the time they are alive. No one is impatiently waiting to be born. So while there is a potential case to be made on *positive* grounds for discounting consumption for policies that only have impacts within a lifetime or perhaps a within a generation, it does not follow that this rationale extends to policies with *intergenerational* consequences. Most often, how much value society should place on consumption in the future is an ethical question.

THE POWER OF COMPOUND INTEREST

The consumption and investment rates of interest are different from a discount rate used in financial analysis in that they are applied to real resources, which are distinct from financial resources. The consumption rate of interest is used to discount resources that are consumed, and the investment rate of interest applies to resources that are invested. Any interest rate, be it applied to money or anything else, is important owing to the power of compound interest.

Tables 1 and 2 demonstrate the influence small changes in the discount rate have on present-value calculations. As is evident from table 1, an investment paying $1 million in 100 years is worth just $72.45 in present-value terms at a 10 percent discount rate, $1,152.45 at a 7 percent rate, and $52,032.84 at a 3 percent rate.

The primary reason for discounting cash flows is the time value of money. Since cash can be invested and earn interest, the sooner money is earned the better, otherwise interest and its subsequent returns are forgone. While the time value of money also applies to investment returns in CBA (when they come in a pecuniary form), the case for discounting nonpecuniary consumption is based on a different set of rationales than the time value of money.

Table 1. Present Value of $1 Million Earned 100 Years in the Future, at Various Rates of Interest

Investment rate of interest	0%	1%	3%	7%	10%
Present value	$1,000,000.00	$369,711.21	$52,032.84	$1,152.45	$72.57

Source: Author's calculations.

On the one hand, there is the observable fact that people tend to exhibit positive time preference. That is, they prefer consumption sooner rather than later. However, as discussed earlier, this provides little justification for discounting benefits and costs to those not yet born. Common arguments for using a positive social discount rate in an intergenerational context are that people in the future will be richer than those in the present, so, owing to the phenomenon of diminishing marginal utility, a unit of consumption—including a life—can be expected to generate less utility to future citizens than to present citizens. Or sometimes it is simply stated that the well-being of people in future should be discounted at compounding exponential rates since future utility matters less than present utility.

Table 2 highlights the importance of the discounting when comparing lives saved in the future to an equivalent number of lives saved in the present. For example, 10,000 lives saved in 100 years are worth 198 lives in the present at a 3 percent social discount rate and worth just 1 life using a 10 percent social discount rate.

Table 2. Present Value of 10,000 Lives Saved 100 Years in the Future, at Various Social Discount Rates

Social discount rate (society's consumption rate of interest)	0%	1%	3%	7%	10%
Present value (lives saved)	10,000	3,697	520	12	1

Note: Human lives are not divisible into parts. Hence, lives are rounded to nearest whole number.
Source: Author's calculations.

WHEN TO USE EACH RATE

When conducting a CBA, one must be careful to use appropriate rates in their appropriate contexts. Nonpecuniary aspects of life cannot be invested in an account, so they should never be treated as if they will compound in value at the marginal rate of return to capital. At the same time, returns to capital often *can* be reinvested, so it is entirely appropriate to treat capital investments as if their returns compound in value at the investment rate.

Guidelines from the federal government conflate these two discounting concepts by recommending that regulatory agencies apply a single social discount rate to all benefits and costs, irrespective of whether those benefits and costs are like capital investments or like consumption.[4] This is a problem because it means analysts are essentially treating all benefits and costs as if they are either consumption or investment,[5] when rarely is this the case. Treating consumption and investment equally gives too much weight to consumption relative to a comparable amount of investment because, in general, one dollar of investment is more valuable to society than one dollar of consumption.[6]

The way to resolve this issue is to use the two different rates in their different contexts, which means separating consumption and investment in the analysis. Positive and negative incremental investment can be kept on one side of the ledger (out of convention this is often the cost side), and consumption can be kept on the other side of the ledger (the benefits side).[7] Then the two different interest rates can be applied distinctly to their respective benefits or costs.[8]

SOME MISCONCEPTIONS ABOUT SOCIAL DISCOUNTING

Misconception #1: Analysts Are Discounting Money Rather Than Lives

Some commenters argue what is being discounting in CBA is money rather than lives saved.[9] This confusion arises because benefits and costs are valued in monetary terms in order to compare them to one another. The undiscounted dollar values in CBA refer to monetary equivalents; i.e., the value individuals place on certain resources in terms of what they are willing to spend for them. Using such a valuation technique does not convert those resources into something that can be invested, like money. Dollars are simply a convenient measuring stick to make comparisons in value.

Consider, for example, the similar practice of adjusting the value of resources for inflation when they occur in different years (which also occurs in CBA). After an inflation adjustment, resources have a dollar value assigned to them, but those dollars actually represent bundles of real resources, hence the use of the term "real" when referring to inflation-adjusted values. Lives are not literally being converted into money when they are expressed as monetary equivalents in CBA. Real resources are ultimately what is being valued.

Misconception #2: The Opportunity Cost of Capital Is the Basis for Social Discounting

Other observers assert that a social discount rate is necessary in CBA because of the opportunity cost of capital; i.e., because capital earns a rate of return in the future. For example, government guidelines recommend regulatory agencies use a 7 percent social discount rate that "approximates the opportunity cost of capital."[10]

Capital's rate of return cannot be the basis for social discounting, however, because the rate at which individuals discount future consumption shapes household savings patterns and by extension determines capital's rate of return.[11] Basing the social discount rate on the opportunity cost of capital rate involves circular reasoning. Moreover, an optimum is achieved when capital investment is increased to such an extent that the investment rate of interest falls to meet the social discount rate. At this point, the additional utility generated from an incremental unit of capital investment is zero, which, again, provides no particular basis for social discounting.[12]

Misconception #3: Only Regulatory Benefits Have Intergenerational Consequences

Social discounting often comes up in the context of climate change policy or other environmental contexts such as nuclear waste disposal, where society has to wait a long time for the benefits of a government regulation to pay off.[13] This can create an impression that the social discount rate matters most for environmental projects or only for projects with nonpecuniary *benefits* far in the future. In fact, costs often have intergenerational consequences as well, though these costs often go unaccounted for in analysis. Even small amounts of investment displaced by government projects today can have significant long-acting consequences, owing to the power of compound interest.

Moreover, people are continually being born and dying, so what constitutes a "generation" may in fact be a relatively short period of time. While deciding how much weight to give to the consumption of future generations is based on a value judgment, a commitment to assessing the benefits and costs of policy as they actually occur requires acknowledgment of the impacts of policies through this investment channel.

A NOTE ABOUT DECLINING DISCOUNT RATES

Some economists have suggested that, owing to uncertainty, the government should consider using a social discount rate that declines over time.[14] There are two rationales for declining discount rates that do not involve any suboptimal, or irrational, decision-making.[15] One rationale takes the perspective of a social planner that centrally plans the economy. The discount rate of the social planner may decline over the investment horizon owing to the combination of the social planner being risk averse and there being fluctuations in and uncertainty about the rate of economic growth in the future.[16]

A second rationale for declining discount rates is called the Expected Net Present Value approach, and it asserts that in the presence of uncertainty, a declining discount rate is equivalent to a constant rate under certainty.[17] Consider the possibility that there is a 50 percent chance that the social discount rate is 3 percent and a 50 percent chance that it is 7 percent. To account for this uncertainty, one could calculate the present value of the project at 3 percent, then at 7 percent, and then obtain the expected value; i.e., the average of these present values. It turns out that the implied certainty-equivalent discount rate consistent with this average present value is lower than 5 percent, the average of the two social discount rates. Furthermore, as the time horizon extends into the future, this implied discount rate gets closer and closer to 3 percent, the low end of possible discount rates. Therefore, accounting for uncertainty can entail use of a declining discount rate that is equivalent to a constant rate under certainty.

The first argument for declining discount rates, based on the preferences of a social planner, is explicitly normative. Whether to adopt this method or not is a value judgment because this rationale depends on ethical choices about the social planner's welfare function. The second argument

is more compelling because it is simply a mathematical property that follows from taking the expected value of a function, although aspects of this argument are normative as well.[18]

In either case, however, if an analyst uses a declining social discount rate owing to uncertainty, he or she must also adjust the estimation of the opportunity cost of capital over time in the analysis, since it will vary with the social discount rate. In general, a lower social discount rate means a higher estimated opportunity cost of capital and vice versa, which is why low and declining discount rates need not encourage more regulation. If the opportunity cost of capital is accounted for in analysis, regulatory costs can be very large when the social discount rate is low or declining. However, these costs often go overlooked, leading to the common view that a low social discount rate encourages more regulation.

CONCLUSION

This primer has sought to provide some clarity on the topic of the social discount rate and to clear up common misconceptions about this rate. Misunderstandings often stem from conflating the two main discounting concepts: the consumption and investment rates of interest. Indeed, even government guidelines on regulatory analysis seem to make, or at least encourage, such mistakes.

Moreover, some aspects of discounting are inherently normative; that is, they involve value judgments. Analysts should always be clear about what aspects of their analysis involve value judgments. For example, if the preferences of a hypothetical social planner are important determinants of present-value calculations, this fact should be made transparent in the analysis. Furthermore, the opportunity cost of capital should always be accounted for in any analysis, and analysts should understand that estimates of the opportunity cost of capital will tend to vary with the social discount rate used, rather than the other way around.

Adhering to these basic principles could potentially resolve many common problems found in modern CBA.

ABOUT THE AUTHOR

James Broughel is a senior research fellow at the Mercatus Center at George Mason University. Broughel has a PhD in economics from George Mason University. He is also an adjunct professor at the law school at George Mason University.

NOTES

1. These are sometimes referred to as the "net" and "gross" rates of interest, respectively.

2. Absent distortions, the risk-free rate can be thought to reflect a natural rate of interest that embodies current consumers' time preferences.

3. David F. Burgess, "The Appropriate Measure of the Social Discount Rate and Its Role in the Analysis of Policies with Long-Run Consequences" (Mercatus Symposium, Mercatus Center at George Mason University, Arlington, VA, 2018); Mark A. Moore and Aidan R. Vining, "The Social Rate of Time Preference and the Social Discount Rate" (Mercatus Symposium, Mercatus Center at George Mason University, Arlington, VA, 2018).

4. Office of Management and Budget, *Circular A-4*, 2003.

5. It could also mean the analyst is assuming that the economy has reached the optimal amount of investment, such that $1 of incremental investment will yield no more social utility than $1 of consumption.

6. Richard A. Williams and James Broughel, "Toward an Improved OMB Annual Report on Federal Regulations," *Regulation* 42, no. 4 (2019–2020): 20–24.

7. Capital also comes in different forms. The term often refers simply to physical capital—productive machines and equipment—but can also include human capital, social capital, and natural resources (which some call natural capital). Each will produce different rates of return depending on whether the returns are temporary or ongoing and whether some portion of the return can be reinvested.

8. It is sometimes argued that it is inappropriate to discount benefits occurring in the same year at different rates. For example, a 2017 report from the National Academies of Sciences states, "consistency requires that the same discount rate must be applied to all benefits and costs that occur in the same year." However, as Liqun Liu correctly notes, it is entirely appropriate to discount consumption and investment at different rates owing to their different rates of return. On the inappropriateness of using two discount rates, see Kenneth J. Arrow et al., "Determining Benefits and Costs for Future Generations," *Science* 341, no. 6144 (2013): 349–50; National Academies of Sciences, Engineering, and Medicine, *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide* (Washington, DC: National Academies Press, 2017). On the correctness of using two discount rates, see Liqun Liu, "A Marginal Cost of Funds Approach to Multi-Period Public Project Evaluation: Implications for the Social Discount Rate," *Journal of Public Economics* 87, no. 7(2003): 1707–18.

9. According to Arden Rowell and Cass Sunstein, "So long as monetary values are assigned to the relevant variables, it is only money, and not any variable, that is being discounted." Kip Viscusi, citing Rowell and Sunstein, similarly states, "What is being discounted is not the number of lives, but a monetary amount equal to the willingness to pay to reduce risks to life." Arden Rowell and Cass R. Sunstein, "On Discounting Regulatory Benefits: Risk, Money, and Intergenerational Equity," *University of Chicago Law Review* 74, no. 1 (2007): 171–208; W. Kip Viscusi, "Rational Discounting for Regulatory Analysis," *University of Chicago Law Review* 74, no. 1 (2007): 209–46.

10. Office of Management and Budget, *Circular A-4*.

11. Tyler Cowen and Derek Parfit, "Against the Social Discount Rate," in *Justice Between Age Groups and Generations*, ed. Peter Laslett and James S. Fishkin (New Haven, CT: Yale University Press, 1992), 151.

12. Cowen and Parfit, "Against the Social Discount Rate."

13. See the various Intergovernmental Panel on Climate Change reports or the 2006 Stern report on climate change. Nicholas Stern, *The Economics of Climate Change: The Stern Review* (London: Her Majesty's Treasury, 2006).

14. Kenneth J. Arrow et al., "Should Governments Use a Declining Discount Rate in Project Analysis?," *Review of Environmental Economics and Policy* 8, no. 8 (2014): 145–63.

15. At first glance, declining discount rates sound a lot like "hyperbolic discounting," which is a behavioral anomaly that can lead to suboptimal, or "time inconsistent," decisions, whereby a different decision would be made depending on the time in which the decision is made. The rationales for declining discount rates mentioned here do not suffer these problems. On hyperbolic discounting, see David Laibson, "Golden Eggs and Hyperbolic Discounting," *Quarterly Journal of Economics* 112, no. 2 (1997): 443–77.

16. For a detailed description of this social planner perspective, see Christian Gollier, *Pricing the Planet's Future: The Economics of Discounting in an Uncertain World* (Princeton, NJ: Princeton University Press, 2012).

17. Martin L. Weitzman, "Gamma Discounting," *American Economic Review* 91, no. 1 (2001): 260–71; Martin L. Weitzman, "Subjective Expectations and Asset-Return Puzzle," *American Economic Review* 97, no. 4 (2007): 1102–30; Richard Newell and William Pizer, "Discounting the Benefits of Climate Change Mitigation: How Much Do Uncertain Rates Increase Valuations?," *Journal of Environmental Economics and Management* 46, no. 1 (2003): 52–71.

18. For example, if one instead evaluates projects in future-value terms (rather than present-value terms), the phenomenon reverses. That is, the social discount rate rises toward its highest possible value. Resolving the paradox requires, again, assumptions about the social planner's welfare function, including assumptions about risk aversion and consumption smoothing. Martin L. Weitzman and Christian Gollier, "How Should the Distant Future Be Discounted When Discount Rates Are Uncertain?," *Economics Letters* 107, no. 3 (2010): 350–53.