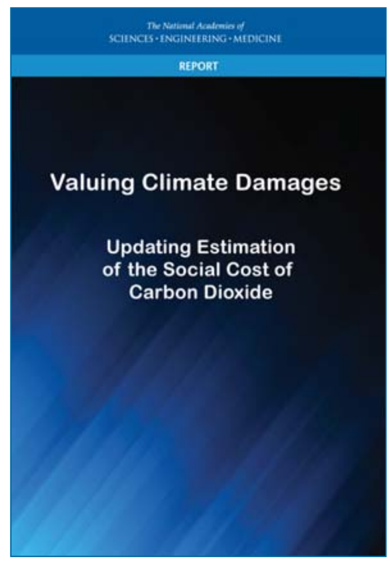
Report
HIGHLIGHTS

March 2017

Discounting Climate Impacts for Valuing the Social Cost of Carbon



When federal agencies are considering regulations that affect carbon dioxide emissions (CO_2), they are required to analyze the emissions' impact on climate change and the resulting net damage or cost to society. Such analyses rely on a measure known as the social cost of carbon.

The federal Interagency Working Group on the Social Cost of Greenhouse Gases (IWG) developed a method for estimating the social cost of carbon (SC-CO_2) that has been used by agencies since 2010. The group asked the National Academies of Sciences, Engineering, and Medicine to recommend potential approaches for a comprehensive update to the methodology to ensure the estimates reflect the best available science. An overarching recommendation is to "modularize" each of the four primary steps in SC-CO_2 estimation—socioeconomic, climate, damages, and discounting—to satisfy a set of scientific criteria and to draw more readily on expertise from the wide range of relevant scientific disciplines.

One focus of the resulting study committee's report, *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide* (2017), was updating the process by which climate damages that occur in the future are translated into their dollar value today—a process known as discounting.

Discounting is the process by which costs and benefits spread over current and future years can be compared in order to establish whether a particular choice leads to an overall net benefit. The discount rate refers to the reduction ("discount") in value per year as a future cost or benefit is adjusted to be comparable with a current cost or benefit.

The discount rate plays an important role in estimating the SC-CO_2 because the impacts of today's CO_2 emissions persist and accumulate far into the future.

Currently, the IWG uses three discount rates—(2.5%, 3%, and 5% per year)—to discount future climate damages. The central value of a 3.0 percent rate, consistent with the consumption rate of interest in the Office of Management and Budget's (OMB) Circular A-4 guidance, is meant to reflect the post-tax, risk-free interest rate. The 5.0 percent rate is included to represent the possibility that climate damages are positively correlated with consumption growth. And, the 2.5 percent rate is intended to reflect uncertainty in the discount rate itself.

This approach, does not incorporate, however, an explicit connection between discounting and consumption growth that arises under a more structural (e.g., Ramsey-like) approach to discounting. Such an explicit analytic connection is especially important when considering uncertain climate damages that are positively or negatively associated with the level of consumption. In that situation, both climate damages and the discount rate are related to the level of consumption, leading them to be correlated.

Under typical assumptions, they are positively correlated due to damages being directly related to economic activity and tied to the overall size of the future economy, and due to the value of impacts on human health and mortality being tied to future per capita consumption levels. Climate change impacts and discount rates could be negatively correlated, however, if the potential for catastrophic impacts raises the possibility that some uncertain outcomes may involve much lower rates of economic growth and higher incremental damages because of climate change.

The committee recommends use of a discounting module that explicitly recognizes the uncertainty surrounding discount rates over long time horizons, its connection to uncertainty in economic growth, and, in turn, to climate damages. This relationship should be modeled using the Ramsey formula for the discount rate (r),

$$r = \delta + \eta^* g,$$

where δ is the rate of "pure time preference" at which future welfare or utility is discounted; g is the growth rate of per capita consumption; and η represents the decline in the value of an additional dollar of consumption as society grows wealthier (i.e., the absolute value of the "elasticity of marginal utility of consumption").

A direct implication of the Ramsey formula is that the discount rate is inherently linked to the growth rate of the economy. This interdependence implies that the rate used to discount future climate damages needs to be consistent with assumptions about the rate of economic growth that underlie the calculation of climate damages in the damages module, as well as the emissions path in the socioeconomic module.

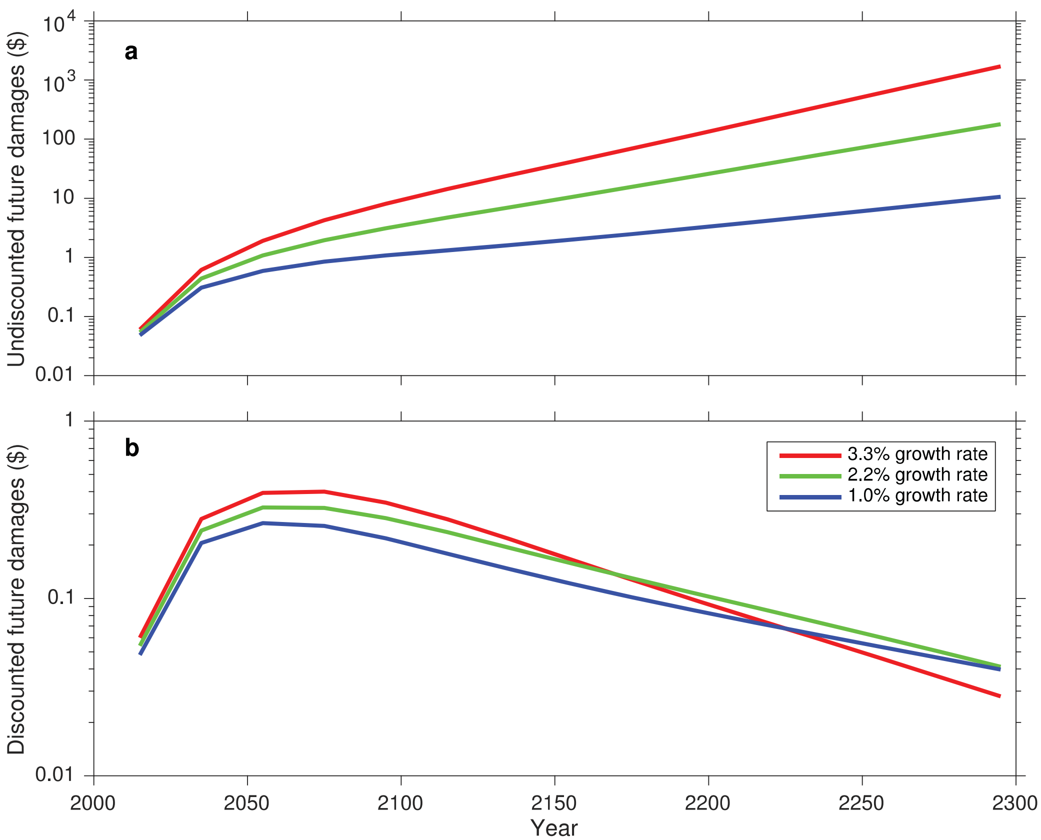


FIGURE 1 Illustrative example of undiscounted and discounted future damages from 1 incremental ton of CO_2 in 2015.

NOTES: The three growth scenarios are shown in undiscounted dollars in Figure 1a and in discounted dollars in Figure 1b. The population projection is fixed for simplicity. Ramsey parameter values of δ = 1.1% and η = 0.88 are assumed for illustration.

The committee recommended a procedure for the socioeconomics module that produces projections of per capita Gross Domestic Product (GDP) growth by drawing on statistical models of historical data in conjunction with elicitation of expert judgment. The resulting distribution of GDP per capita growth rates can be summarized by a small number of representative values (e.g., three equally likely representative growth rates). To capture the interconnection of uncertainty in economic growth, discount rates, and damages, these growth rates are then used to produce consistent discount rates using the Ramsey formula, as well as being used for projected damage estimates.

As an illustration, consider three per capita economic growth rate scenarios using 1 percent, 2.2 percent, and 3.3 percent growth rates, that are equally likely outcomes from the socioeconomics module. These growth rates are then used as inputs to the damages module to produce equally likely alternative futures of climate damages from one additional metric ton of carbon dioxide emitted in 2015. As shown in Figure 1a, a lower per capita economic growth rate implies a lower level of climate damages. Note, in this particular example, damages are assumed to be positively related to economic growth.

For purposes of illustration, assume Ramsey parameter values of δ = 1.1 percent and η = 0.88. The Ramsey formula implies that damages along the three growth paths will be discounted at rates of 2 percent (for g = 1%), 3 percent (for g = 2.2%) and 4 percent (for g = 3.3%). Applying growth rate-specific discount rates to the stream of climate damages yields a stream of internally consistent discounted damages that incorporate uncertainty in the rate of economic growth (see Figure 1b)[1]. The sum of discounted damages along each path yields an estimate of the SC-CO_2 for that path of damages. A central SC-CO_2 estimate would be constructed by averaging these values. The distribution of SC-CO_2 values would be used to describe uncertainty in the SC-CO_2.

Use of the Ramsey formula requires choosing values of the parameters δ and η. One could choose δ and η as normative welfare parameters, but this may not lead to rates that are comparable to observed discount rates. Alternatively, one could choose those parameters to match observed consumption rates of interest. For example, given an economic growth rate, it is possible to pick combinations of δ and η that match the 3 percent consumption rate of interest used by the OMB for near-term discounting.

The committee recommended that the parameters chosen for the Ramsey formula should be consistent with theory and evidence and should produce certainty-equivalent discount rates[2] consistent, over the next several decades, with consumption rates of interest. In the near term, the certainty-equivalent discount rate will equal the discount rate given by the Ramsey formula, with g replaced by the average rate of economic growth. In the example above, this implies a certainty equivalent discount rate of 3.3 percent (= 1.1% + 0.88 * 2.1666%). Additionally, three sets of Ramsey parameters should be used to generate a low, central, and high certainty-equivalent near-term discount rate, and three means and ranges of SC-CO_2 estimates.

Note that this discounting procedure does not necessarily lead to greater present values or a lower effective discount rate. The practical impact of the recommended approach on the present value of damages depends on the correlation of economic growth with climate damages. If, for example, damages and economic growth are positively correlated, as they are in most existing integrated assessment models, scenarios with low economic growth will have low discount rates, but they will also have low damages: in that case these two features tend to offset one another leading to a present value for damages that is more stable than if one does not account for this linkage. Thus the incorporation of this explicit discounting relationship will not itself lead to higher or lower present values. It will however provide an internally consistent treatment of uncertainty throughout the estimation framework and will avoid combining discount rate assumptions that are inconsistent with other assumption in the analysis.

[1] Note that damages in year t along each path will be discounted to the present (2015) using the discount factor = exp (- rt).

[2] The certainty equivalent discount rate is the rate used to discount damages in year t back to the present that yields a discount factor (see footnote 1) equal to the average of the discount factors based on the distribution of growth rates.

COMMITTEE ON ASSESSING APPROACHES TO UPDATING THE SOCIAL COST OF CARBON

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For More Information . . . This Report Highlights was prepared by the Board on Environmental Change and Society (BECS) based on the report *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon* (2017). The study was sponsored by the members of the Interagency Working Group on the Social Cost of Carbon, including the U.S. Department of Commerce, U.S. Department of Energy, U.S. Department of the Interior, U.S. Department of Transportation, and the Environmental Protection Agency. This Report Highlights was made possible through a grant from the Alfred P. Sloan Foundation. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the report are available from the National Academies Press, (800) 624-6242; http://www.nap.edu or via the BECS page at http://nas.edu/valuing-climate-damages.

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