



Discounting the Economic Impacts of Climate Change – Options and Viable Choices

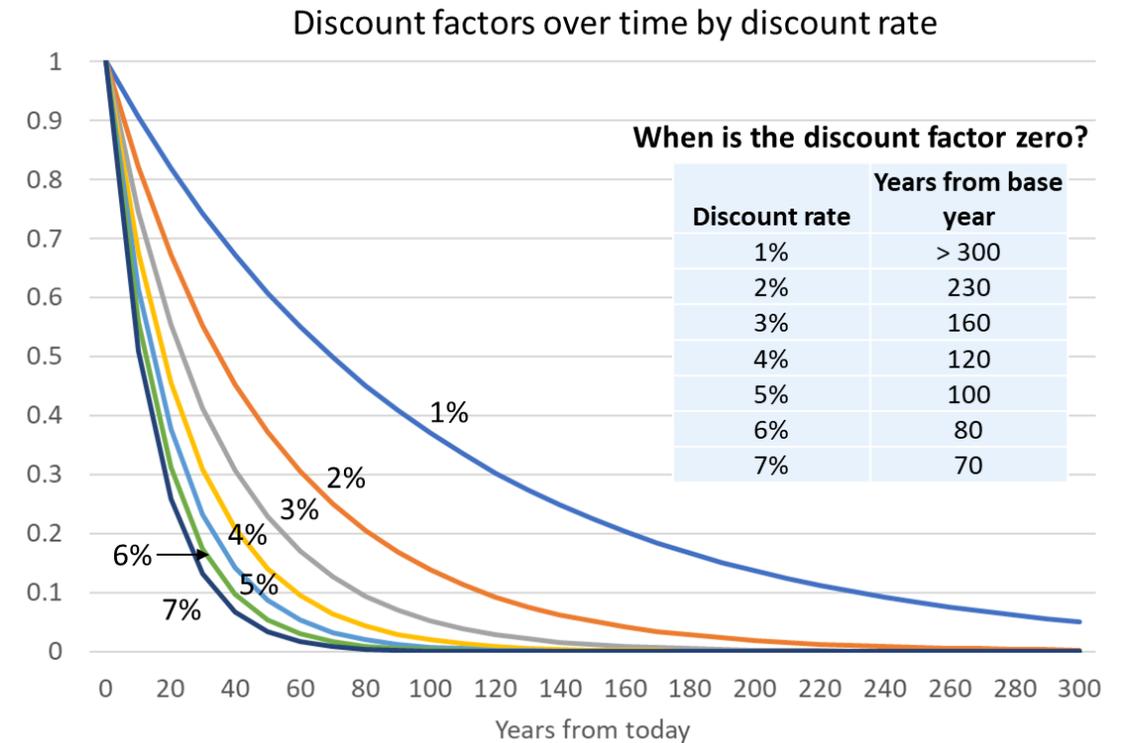
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The importance of discounting

- Conceptually,
 - Why discount? Evidence shows that current and future consumption are not equal
 - Should discounting be a policy lever (e.g., to address climate change or correct for market failure)?
 - No, we need objective information on how society is willing to make trade-offs over time
 - Furthermore, we need stability. Not discounting subject to political winds.
- Computationally,
 - Discounting has a significant impact on net present value calculations. For instance, Biden EPA SC-CO₂ values for 2020 w/ dynamic discounting (EPA, 2023):
 - Near-term 2.5% - \$120
 - Near-term 2.0% - \$190
 - Near-term 1.5% - \$340



Higher discount rates = lower discount factors

Discounting options

- **Zero**
- **Constant rates** – but what values?
 - e.g., 2.5%, 3%, and 5% (Obama/Biden Interim social cost of greenhouse gases, SC-GHG, estimates discounting approach)
- **Dynamic rates** (Ramsey formula) – but how to calibrate?
 - e.g., Biden EPA SC-GHG discounting approach (table to right, [Rennert et al, 2022](#)); near-term 4.5% “risk-adjusted rate of time preference” ([Barrage and Nordhaus, 2024](#))

Dynamic discounting Ramsey formula

$$r_{\tau} = \rho + \eta g_{\tau}$$

Discount rate in period tau = Pure rate of time preference (P RTP) + Elasticity of the marginal utility of consumption (absolute value) x Growth in per capita consumption in period tau

An example of calibration parameters (EPA, 2023)

| Near-Term Target Certainty-Equivalent Rate | ρ | η |
|---|--------|--------|
| 1.5% | 0.01% | 1.02 |
| 2.0% | 0.20% | 1.24 |
| 2.5% | 0.46% | 1.42 |

Source: Rennert et al. (2022b)

Discounting scientific considerations – constraints

- Discounting needs to be consistent with the following scientific considerations ([EPRI, 2023](#)):
 1. Duration of CO₂ investment,
 2. Observations (observed rates, observed economic growth),
 3. Very long-run observational record (b/c projecting 300 years),
 4. Type of economic trade-offs estimated (consumption vs. capital),
 5. Theory (projected economic growth, parameter constraints),
 6. Empirical evidence (parameter constraints),
 7. Economic projections,
 8. Modeling framework, and
 9. Other benefit-cost calculations (e.g., compliance costs, air quality benefits)

Evaluating the options in terms of the considerations

Consistency with each scientific consideration?

| Option | Duration of investment | Observations | Very long-run observational record | Type of economic values/trade-offs estimated | Theory (economic growth, behavior) | Empirical evidence | Economic projections | Methodology | Other benefit-cost calculations |
|----------|------------------------|--------------|------------------------------------|--|------------------------------------|--------------------|----------------------|-------------|---------------------------------|
| Zero | N | N | N | N | N | N | N | N | N |
| Constant | Possibly | Possibly | Possibly | Possibly | N | N | N | N | Possibly |
| Dynamic | Possibly | Possibly | Possibly | Possibly | Possibly | Possibly | Possibly | Possibly | Possibly |

“Possibly” = some value or calibration choices could be consistent

Key conclusion: Only dynamic discounting has the opportunity to be consistent with all the scientific considerations

Calibrating the dynamic discounting equation

$${}^1 r_T = {}^3 \rho + {}^3 \eta g_T {}^2$$

- Procedure: (1) choose near-term rate, (2) choose calibration economic growth assumption, (3) set parameter values
- However, there are constraints on the choices due to the scientific considerations
 - Near-term target discount rate selection – should be consistent with...
 - Duration of investment
 - Very-long run historical observations
 - Type of climate damage trade-offs modeled
 - Viable calibration combinations
 - Assumed calibration economic growth rate – should be consistent with...
 - Very-long run historical economic growth evidence
 - Parameter values rho (ρ) and eta(η) – should be consistent with...
 - Near-term target rates and assumed calibration economic growth
 - Theory (e.g., $\rho > 0$, $\eta > 1$)
 - Observations (e.g., $\rho > 0.01\%$)
 - Empirical evidence (e.g., $\eta \geq 1.45$)

Evaluating calibration choices – e.g., Biden EPA SC-GHG discounting calibration (EPA, 2023)

Table 2.4.2: Calibrated Ramsey Formula Parameters

| Near-Term Target Certainty-Equivalent Rate | ρ | η |
|---|--------|--------|
| 1.5% | 0.01% | 1.02 |
| 2.0% | 0.20% | 1.24 |
| 2.5% | 0.46% | 1.42 |

Implied assumed calibration economic growth rate

- 1.45%
- 1.45%
- 1.45%

Source: Rennert et al. (2022b)

(1) Inconsistent with the duration of investment (100+ yrs), very long-run historical observations (100+ yrs), type of damages trade-off modeled, and viable calibration choices (rho, eta, and assumed growth) – **rates of 3% to 5% are consistent (3% social security rate, 5% long-run projects, e.g., dams, and modeling trading-off costs & benefits)**

(3) Inconsistent with corrected near-term target rates and assumed economic growth (1 & 2), as well as theory, observations, and empirical evidence (e.g., $\eta \geq 1.45$)

(2) Inconsistent with very-long run historical economic growth evidence (> 50 yrs to centuries) – **rates of 1.9% to 2% are consistent**

Conclusion: The choices here need to be revised to be consistent with the scientific considerations

Calibration options consistent with scientific considerations

Some calibrations invalid (red) or questionable (orange).

| Near-term target discount rate | Assumed per capita consumption growth rate | Calibration 1 | | Calibration 2 | | Calibration 3 | | Calibration 4 | |
|--------------------------------|--|-----------------|-----------------------|-----------------|-----------------------|-----------------|-----------------------|-----------------|-----------------------|
| | | PRTP (ρ) | Elasticity (η) | PRTP (ρ) | Elasticity (η) | PRTP (ρ) | Elasticity (η) | PRTP (ρ) | Elasticity (η) |
| 1.0% | 2.0% | 0.1% | 0.45 | 0.5% | 0.25 | 1.0% | 0.00 | 2.0% | -0.50 |
| 1.5% | 2.0% | 0.1% | 0.70 | 0.5% | 0.50 | 1.0% | 0.25 | 2.0% | -0.25 |
| 2.0% | 2.0% | 0.1% | 0.95 | 0.5% | 0.75 | 1.0% | 0.50 | 2.0% | 0.00 |
| 2.5% | 2.0% | 0.1% | 1.20 | 0.5% | 1.00 | 1.0% | 0.75 | 2.0% | 0.25 |
| 3.0% | 2.0% | 0.1% | 1.45 | 0.5% | 1.25 | 1.0% | 1.00 | 2.0% | 0.50 |
| 4.0% | 2.0% | 0.1% | 1.95 | 0.5% | 1.75 | 1.0% | 1.50 | 2.0% | 1.00 |
| 5.0% | 2.0% | 0.1% | 2.45 | 0.5% | 2.25 | 1.0% | 2.00 | 2.0% | 1.50 |

Green box = includes some viable options

When calibrating assuming an economic growth rate of 2%, we find near-term target rates of 3% - 5% have viable calibration candidates.

Additional evidence needed to evaluate questionable (orange) options.

Concluding remarks

- **Discounting is important and the approach needs a strong grounding and proper scientific vetting**
- **The approach needs to be consistent with scientific considerations (to right)**
 - Zero and constant discounting are not
 - Dynamic discounting could be depending on the calibration
- **The Biden EPA dynamic discounting calibration is inconsistent with scientific considerations and should be revised! ([EPRI, 2023](#))**
 - With near-term rates of 3-5% and economic growth assumption of ~2%
 - With parameter choices consistent with near-term rates AND the growth assumption, theory, observations, and empirical evidence
 - Furthermore, impacts appear to be on aggregate consumption, and thus trade-offs with investment; and, question of whether discounting should be regional (not global)
- **What are others saying?**
 - Nordhaus (2023):* “The low discount rates that EPA has proposed as a default in general and for climate investments in particular are inappropriate for the kinds of investments that are being considered...the appropriate discount rate would be...4% to 5% a year.” (* *comments to EPA directly*)
 - [Fraas et al \(2023\)](#): “...recommend 3% and 5% as quite conservative estimates for the mid and upper bound consumption discount rates...For the social cost of capital in the nearer term, the appropriate values are likely to range from 5% to 10%.”
 - [Viscusi \(2007\)](#): “...the same discount rate should be used for benefits and costs...”

SC-GHG discounting scientific considerations

- Duration of investment
- Observations
- Very long-run historical record
- Type of trade-offs estimated
- Theory
- Empirical evidence
- Economic projections
- Modeling framework, and
- Other benefit-cost calculations



Thank you!

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MIT-EPRI analysis of global economic impacts estimates

Comment

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Reconciling widely varying estimates of the global economic impacts from climate change

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 Check for updates

Assessments of the aggregate impacts of climate change on the global economy are widely varying and diverge depending on the method employed. It is essential to understand the mechanisms behind the differing estimates and identify a robust range. Only then could these estimates meaningfully inform and guide climate actions.

Economists have been estimating the aggregate economic impacts of climate change on the global economy since the early 1990s. Such estimates, sometimes called ‘climate damage functions’, are meant to help guide decisions about climate change mitigation and adaptation. However, estimates of the global gross domestic product (GDP) loss due to a given level of global warming vary so widely – from negligible to catastrophic – that they are not helpful. For example, for a worst-case high global warming scenario (representative concentration pathway 8.5), the central estimate for global GDP loss in 2100 from climate change was 60% in one recent study¹ and 3% in another². This huge discrepancy in estimates is driven by the method employed and hinders meaningful use by decision-makers. As such, it is essential to reconcile estimates. To do so, several scientific challenges must be addressed, including improving our understanding of the various channels through which climate change could affect the economy as well as improving quantification of high-impact climate-driven events. Changes in the climate up to 2050 are largely unavoidable. However, better understanding of what and who is most at risk would provide guidance on how to reduce the economic and human costs of climate change.

Incomparability of methods

So far, the conventional approach to estimating the economic impacts of climate change has been to use structural or process-based modelling. This approach involves specifying structural relationships between climate change and the economy for different impact categories, and projecting responses to future climates. Another approach is to use historical data and statistical methods to directly estimate how the aggregate economy has changed with variations in weather and climate. A third approach is meta-analysis, which derives a statistical relationship between global temperature change and economic impacts using the estimates from the other methods as input data (Box 1).

Differences in estimates of the aggregate economic impacts of climate change from statistical approaches compared with structural approaches are striking³ (Fig. 1). A comparison⁴ of recent structural modelling estimates from the DICE (Dynamic Integrated

Climate-Economy), FUND (Climate Framework for Uncertainty, Negotiation and Distribution) and PAGE (Policy Analysis of the Greenhouse Effect) models found that for 3 °C of warming, the 5th to 95th percentile range of impacts (in terms of losses in global GDP) was –3% (net climate benefits) to 5% for FUND and 1% to 3% for PAGE, and deterministic impacts from DICE were 2%. For 2 °C of warming, the corresponding numbers were –3% to 2% for FUND, 0% to 1% for PAGE and 1% for DICE. Although there is some variation, the structural modelling estimates are all of the same order of magnitude; with more recent studies producing similar results.

The recent statistical modelling economic impact estimates, however, generally produce estimates that are an order of magnitude higher, reaching up to 55% and 38% annual global GDP losses for 3 °C and 2 °C of global average warming, respectively. These statistical approaches also estimate up to 10% global losses from the warming the world has experienced so far (1.08 °C)⁵, which is debatable. For context, the COVID-19 pandemic, which caused a global economic shutdown, is estimated to have caused a 2–6% annual loss in global GDP.

The statistical modelling results need deeper investigation. Specifically, evaluation is needed into the mechanisms that produce such large impacts on the macroeconomy that are completely eluding the structural models. The statistical modelling results suggest a potential catastrophic outcome, but there is no structural intuition or well-defined relationships, and it is therefore difficult to interpret, much less dispute, as the counterargument is simply that structural modelling must be missing something important. It is also difficult to make sense of the sensitivity of statistical estimates to alternative specifications. For instance, the variation is huge in the Burke et al.⁶ results across their four statistical specifications (Fig. 1). Most importantly, if these results are accurate, it is essential to know the mechanisms by which this impact occurs because we might then be able to design approaches to reduce the impact.

Differing perceptions across experts

Just as different modelling approaches lead to quantitative economic climate impact estimates of different magnitudes, so too does elicitation of estimates from different experts. In one expert elicitation study, both economists and physical climate scientists were surveyed, resulting in two completely different views⁷. The economists generally estimated impacts to be a few percentage points of the economy, whereas physical scientists’ estimates were generally an order of magnitude larger. This divergence of opinions appears to persist today, and at a minimum, highlights the difference between physical impacts and economic valuation of those impacts, which are distinct analytical parts of estimating economic impacts and involve separate uncertainties.

There is also disagreement about the appropriate discount rate to use for estimates of the net present value of economic impacts. This issue came to the fore when a study commissioned by the United

nature climate change

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- [Reconciling widely varying estimates of the global economic impacts from climate change](#)
- Morris, J*, SK Rose*, J Reilly, A Gurgel, S Paltsev, A Schlosser (*corresponding authors)
- *Nature Climate Change* 15: 124-127.
- February 2025
- Global economic impact estimates are relevant to evaluating the benefits of global climate goals, assess global economic climate risk, and SC-GHGs
- “Assessments of the aggregate impacts of climate change on the global economy are widely varying and diverge depending on the method employed. It is essential to understand the mechanisms behind the differing estimates and identify a robust range. Only then could these estimates meaningfully inform and guide climate actions.”

Resources

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