

# Expensive emissions: Risk-adjustment generates high values for the social cost of carbon

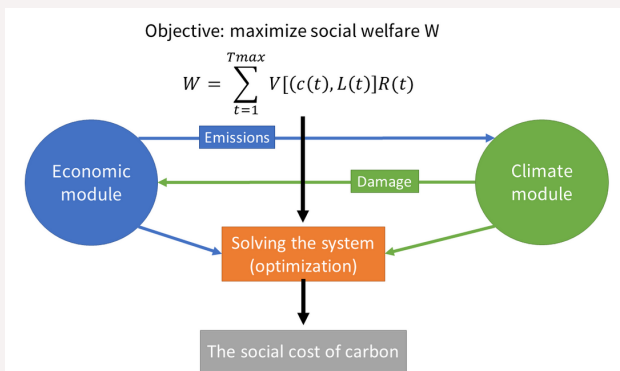
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**OVERVIEW:** The social cost of carbon is the economic cost of producing an additional ton of carbon dioxide emissions or its equivalent and it is one of the most important concepts in climate economics. This research poster investigates the effects of discount rates and risk of catastrophic climate events to the social cost of carbon and finds that vastly different values of social cost of carbon can be produced with different choice of parameters. Furthermore, if discounting is risk-adjusted, the value of social cost of carbon is almost always high, which implies that ambitious mitigation policy would be justified if climate risk is taken into account.

## Framework for the Dynamic Integrated Climate-Economy model = DICE

The social cost of carbon is often estimated with integrated assessment models (IAMs). I will use as the basis of my discussion the DICE model developed by Nobel-winner William Nordhaus. (2016, 2017)

- $W$  = social welfare function
- $V$  = instantaneous social welfare function
- $c(t)$  = per capita consumption
- $L(t)$  = population and labour inputs
- $R(t) = (1+p)^{-t}$  = discount factor



## The effect of discounting

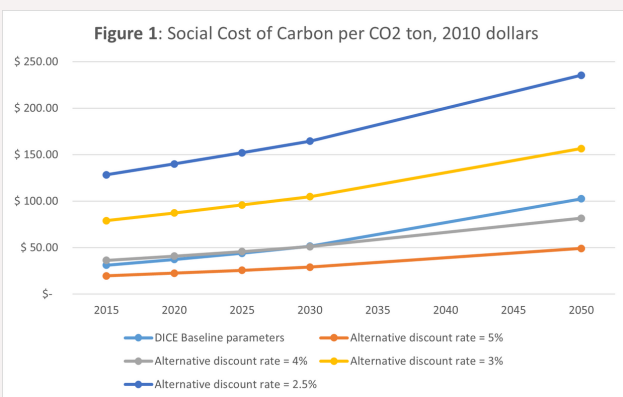


Figure 1 is calculated with the most recent DICE model (Nordhaus, 2017) and it demonstrates how alternative discount rates for future consumption can have a huge effect on the social cost of carbon, especially in the long run. The US Government has earlier used discount rates between 2.5 to 5 percent. However, after Joe Biden was elected the US president, the working group for social cost of carbon has done an initial review, which concludes that the discount rate is likely to be lower than 2.5 percent. (IWG, 2021) Several economists like Stern (2007) have been arguing for lower discount rates in favour of future generations.

## Sources

- Ackerman F. Stanton A. E., 2012. *Climate Risks and Carbon Prices: Revising the Social Cost of Carbon* Economics The E-Journal Vol. 6, 2012-10 <http://dx.doi.org/10.5018/economics-ejournal.ja.2012-10>
- IWG 2021. *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990* Interagency Working Group (IWG) on Social Cost of Greenhouse Gases, United States Government. [https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument\\_SocialCostofCarbonMethaneNitrousOxide.pdf](https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf)
- Nordhaus, D. W. 2016 *DICE 2013R: Introduction and User's Manual* <https://sites.google.com/site/williamnordhaus/dice-2013r>
- Nordhaus, D. W. 2017 *Revisiting the social cost of carbon* Proceedings of the National Academy of Sciences of the United States of America Vol. 114, No. 7 <https://www.jstor.org/stable/26479373>
- Pindyck S. R. 2019 *The social cost of carbon revisited* Journal of Environmental Economics and Management Volume 94, March 2019, pp. 140-160 <https://doi.org/10.1016/j.jeem.2019.02.003>
- Stern N. 2007 *The Economics of Climate Change - The Stern Review, Chapter 2A: Ethical Frameworks and Intertemporal Equity* Cambridge University Press. pp 46-62 <https://doi.org.libproxy.ucl.ac.uk/10.1017/CBO9780511817434.007>
- Weitzman M. 2010 *GHG Targets as Insurance Against Catastrophic Climate Damages*. Cambridge, MA: National Bureau of Economic Research, June. Available at: <http://www.nber.org/papers/w16136>.
- Weitzman M. 2013 *Tail-Hedge Discounting and the Social Cost of Carbon* Journal of Economic Literature, SEPTEMBER 2013, Vol. 51, No. 3 pp. 873-882 Available at: <https://www.jstor.org/stable/23644837>

## Adjusting for risk

Climate change includes a risk of catastrophic impacts and if people are risk-averse, the social cost of carbon is bound to be high. In the user manual for DICE 2013R Nordhaus states that the damage function in DICE has not been calibrated for large temperature increases of over 3 Celsius, which limits the usefulness of the model in the case of catastrophic climate change. In fact, all the most common IAMs – DICE, FUND and PAGE – can be criticized for almost neglecting the probability of catastrophic climate change. (Pindyck, 2019) Figure 2 has been drawn with the results from Weitzman (2013) for year 2010. His calculations are based on the report of the IWG, which used an average of three IAMs (DICE, FUND and PAGE). Weitzman's results are from 2013, but they are still applicable, because DICE, FUND and PAGE are still most common IAMs.

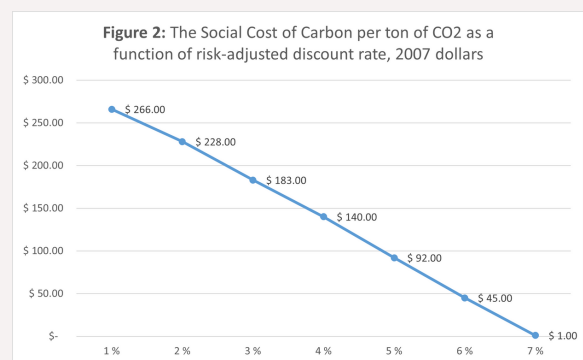
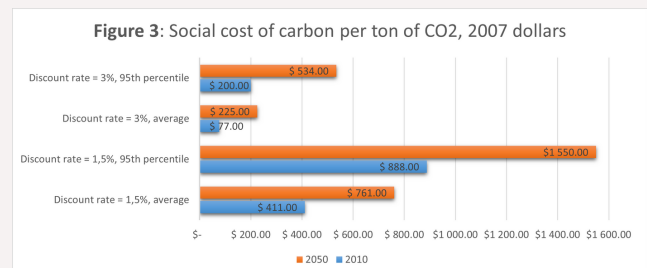


Figure 2 shows that if adjusting for risk, the price of social cost of carbon is almost always high, since even a discount rate of 5% - which many would argue to be unrealistically high – produces a value of 92\$ per CO2 ton already in 2007 dollars. However, even higher estimates can be developed.

Climate sensitivity parameter is the long-term temperature increase expected from a doubling of the concentration of carbon-dioxide in the atmosphere. DICE model uses an average of the likely value of the climate sensitivity, but Ackerman and Stanton (2012) argue that the 95th percentile value should be emphasized to account for the uncertainty regarding the climate change. Figure 3 has been drawn with the help of Ackerman and Stanton (2012) and it shows the DICE model with high-temperature damages calibrated according to Weitzman (2010) with different values of climate sensitivity. As we can see the value of social cost of carbon with high climate sensitivity can be in 2010 almost \$900 per ton of CO2 rising to over \$1500 per ton of CO2 in 2050.



## Concluding remarks

- Vastly different estimations of the social cost of carbon can be derived depending on the choice of discount-rate, risk-adjustment and climate sensitivity.
- If risk-adjustment for catastrophic climate events is considered, then the value of social cost is high even when combined with a high discount rate.
- With high climate sensitivity, low discount rate and high damages, the value of social cost of carbon can be almost \$900 per ton of CO2.
- **High evaluation of social cost of carbon justifies even aggressive climate change mitigation policies, because it shows that emissions are indeed expensive for the society.**