Relevant parameters for the determination of the social cost of carbon

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The debate about the value of the social cost of carbon has prominently featured the question of the discount rate. In this brief we highlight other parameters which have comparable importance and have received less attention. The quantitative values cited below have been produced with NICE, a variant of Nordhaus's RICE model which additionally includes inequalities (by quintiles) within regions of the world. The computations are made under the assumption of a 1.5% rate of pure time preference and an inequality aversion coefficient (elasticity of marginal utility) of 1.5.

The parameters discussed below can be influenced by policy, and therefore, in some cases, policy-makers may want to consider acting on them directly in order to reduce the need to mitigate emissions promptly. Here we only discuss what happens to the optimal carbon price under various exogenous assumptions about these parameters.

The distribution of damages

It is generally admitted that the poor will suffer more from climate change impacts (reduced crop yields, morbidity and mortality), although the rich may lose capital (see the Shock Waves report).

The typical computations are roughly replicated in NICE by assuming that damages due to climate change are proportional to income, within every region. Assuming instead that damages will be, in absolute equivalent monetary amounts, equal across quintiles (shifting the damages onto the poorer segment of the population), implies an optimal carbon price that is greater by 188% in 2035, and a full mitigation that comes 50 years earlier.

The distribution of mitigation costs

Policy choices can shift the cost of mitigation efforts across the distribution of income.

The typical computations are roughly replicated in NICE by assuming that costs are proportional to income. Assuming instead that costs will be, in absolute monetary amounts, equal across quintiles (shifting the cost to the poorer segment of the population), implies an optimal carbon price that is smaller by 57% in 2035, and a full mitigation that comes 50 years later. Conversely, shifting the cost to the richer segment of the population would raise optimal mitigation.

The scale of climate change impacts

There is great uncertainty not only about the distribution of damages but also about their magnitude.

The typical computations assume that damages are quadratic in temperatures and impose a rather moderate reduction in GDP (e.g., only 20% when temperatures rise to 12°C above preindustrial levels). Assuming instead that damages additionally involve a term that in the 7th power of temperature (following Weitzman 2012) and remains very small until 3.5°C but would reduce GDP by 50% at 6°C above preindustrial levels implies an optimal carbon price that is greater by 16% in 2035,

without altering the date at which full mitigation occurs. The small effect is due to the fact that temperature remains far below the levels triggering catastrophic impacts.

Population scenarios

There is great uncertainty about the future growth of the population, especially in Africa. If population grows more than in the central scenarios, this has two effects. First, there are relatively more people in future generations, therefore justifying greater efforts immediately (in similar fashion as a lower discount rate). Second, a larger population entails more emissions and more damages, further justifying additional mitigation.

The typical computations are roughly replicated in NICE by assuming the medium UN population scenario (which is higher than in earlier DICE and RICE computations). Assuming instead that the "high" UN scenario for the population will prevail (in particular with many more people in Africa), implies an optimal carbon price that is greater by 34% in 2035, and a full mitigation that comes 20 years earlier.

Convergence speed

Models like RICE assume that regions of the world grow and converge to (a fraction of) the level of the US GDP. There is great uncertainty both about the target level and about the speed of convergence.

Assuming that the convergence rate is half of what it is in RICE implies an optimal carbon price that is greater by 2.4% in 2035, and no change in full mitigation date.

Differential carbon prices

While a unique carbon price in the world would be optimal in a first best Pigouvian correction of the climate problem, the fact that the allocation of resources is far from socially optimal would actually recommend differential prices shifting the bulk of the mitigation effort to the rich and the emerging economies, especially in the first decades.

Assuming that the twelve regions of the NICE model have different carbon prices implies an optimal carbon price for the USA that is greater by 690% in 2035, and a full mitigation in the USA that comes 110 years earlier.

Non additivity of corrections

The increases in the optimal carbon price due to the different factors listed above are not additive, because on the optimal path the increase in price due to one of the parameters already protects against climate impacts and undercuts the increase needed when the other parameters come into play.

For instance, under the assumption of an equal (instead of proportional) distribution of absolute damages, the introduction of a greater magnitude of climate impacts implies an increase in the carbon price in 2035 of only 4% (the absolute increase in the price being ¾ of its previous value).

Summary table: Effect on the 2035 carbon price and point of full mitigation of changing select assumptions compared to standard RICE/NICE model runs. Each assumption was explored

independently and the effects are not additive. See above text for a summary of each, and references below for more details.

New assumption	Change in 2035 carbon price (%)	Point of full mitigation
Climate damages disproportionately hurt the poor (4)	~200% increase	50 years earlier
Mitigation costs disproportionately hurt the poor (3)	~60% decrease	50 years later
Climate damages increase more steeply with temperature (3, 5)	~20% increase	No effect
UN "high" versus UN "medium" population trajectory (2)	~30% increase	20 years earlier
World economic convergence rate 50% lower (2)	<5% increase	No effect
Regional vs global carbon prices (1)	Depends on the region	Depends on the region

It is possible to see the scenarios for the optimal policy depending on the distribution of damages and the scale of damages, as well as test other values of the time preference and inequality aversion parameters, on our public climate policy simulator: http://climatepolicysimulator.princeton.edu/

References:

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