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Normative Aspects in Modeling the Urgency of Climate Policy

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Normative aspects in modeling the urgency of climate policy

Arthur Zito Guerriero[*], Jakob Kapeller[**], Jörg Ankel-Peters[***]

Abstract

The social cost of carbon (SCC) is the central concept of benefit-cost analysis in climate economics. The SCC provides guidance on the urgency of climate policy as it expresses the present value of expected future damages associated with the emission of one additional ton of CO_2. This paper summarizes key normative assumptions underlying the calculation of the SCC and illustrates how these crucially affect the magnitude of final estimates. Building on a social welfare framework, we discuss the treatment of risk, time (discounting), and inequality (equity weights). Moreover, we present the normative choices related to how SCC estimates monetize non-market damage, in particular the loss of human lives. Based on a database of 515 studies with original SCC estimates (Tol, 2026), we document how the literature deals with these normative issues. In doing so, we find significant variation in the treatment of normative aspects across studies, but also across different normative dimensions. For instance, while the literature justifies the use of a time discount rate based on the assumption of diminishing marginal utility, equity aspects between countries or regions are often ignored. We conclude by stressing that while the SCC can help structuring societal deliberation about climate policy, greater clarity and transparency on the underlying normative assumptions is necessary.

Keywords: climate change, social welfare, normativity, discounting, distribution, risk, value-neutrality

JEL-Codes: D61, D63, Q54

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1. Introduction

The social cost of carbon (SCC) is often presented as the most important number in climate economics (Early, 2021; Nordhaus, 2017). It summarizes future damages caused by the emission of an additional ton of CO_2 in one single monetary value and, hence, can be used as a key parameter for policy design (Greenstone et al., 2013). In the spirit of benefit-cost analysis (BCA), policies that abate one ton of CO_2 at a cost lower than the SCC are worthwhile, since the benefits outweigh the cost. Hence, the SCC provides a quantification that indicates how urgent climate policy should act, as a higher SCC justifies more expensive interventions by rendering them economically reasonable. SCC values are often conceived and presented as objective, largely value-neutral calculations that can guide policy to identify the best possible decisions on scientific grounds rather than by reference to politically determined targets. Indeed, within the SCC framework, an "optimal" emissions path can be derived (Barrage & Nordhaus, 2024). However, as we demonstrate in this paper, SCC estimates are never value-neutral: determining this "optimal" emission path necessarily requires making a series of normative choices. Climate policy inevitably creates winners and losers. Deciding which policy is "optimal" therefore entails weighing competing interests, an exercise that is inherently normative. Framing SCC estimates and the policies derived from them as "value-neutral" thus represents an attempt to frame an inherently political question as a technical debate (Dooley et al., 2021).

Many authors have discussed the explicit or implicit ethical considerations involved in SCC estimates (e.g. Broome, 2012; Fleurbaey et al., 2019; Kelleher, 2025), although within economics this debate is often restricted to the issue of discounting practices (e.g. Arrow et al., 2014; Dasgupta, 2008; Drupp et al., 2018). To make core normative dimensions of the SCC salient, this paper provides a systematic analysis of the ethical assumptions underlying SCC estimates. We show how they directly impact the magnitude of SCC estimates and thereby shape conclusions about the urgency and stringency of climate policy. Building on a social welfare framework, we identify four normative dimensions that are particularly consequential for SCC estimates: (i) intertemporal discounting, (ii) distributional considerations and equity weights, (iii) risk and uncertainty, and (iv) the valuation of non-market damages.

In this context, the shape of the utility function assumed has consequences for several dimensions mentioned above: the assumption of diminishing marginal utility implies that certain damages are discounted: Those (a) associated with more optimistic scenarios, (b) borne by richer individuals/countries, and (c) taking place in the richer future (assuming sustained positive growth rates). This implicit weighting reflects the egalitarian implications inherent in the assumption of diminishing marginal utility, which have been matter of discussions since the early 19th century (Bentham, 1983; Lerner, 1944; Little, 1992; Robbins, 2007).

Empirically, our paper documents how these normative dimensions are treated in the SCC literature using a database of 515 studies that provide original SCC estimates (Tol, 2026). We show that while discount rates have received increased attention since the early 2000s, nearly half of recent studies still report SCC estimates based on a single discount rate, without conducting sensitivity analyses. Even more strikingly, the use of equity weights, an established method for accounting for income inequality across regions (Anthoff et al., 2009; Anthoff & Emmerling, 2019; Hope, 2008; Prest et al., 2024), have become substantially rarer over time, accounting for fewer than 5% of recently published papers (2020–2025).

Our paper hence emphasizes that climate policy is inherently political, as it requires ethical judgments that cannot be settled by scientific consensus, but are, rather, a matter of ethical inquiry and political deliberation (Broome, 2012; Hulme, 2020, 2022). Clarifying these normative assumptions underlying SCC estimates is a prerequisite for aligning the parameters with public perception and ethical foundations.

2. The welfare foundations of the SCC

The SCC can be defined as the difference in the total welfare between a business-as-usual scenario (assuming current CO_2 emission projections) and a scenario in which one additional ton of CO_2 is emitted, expressed in present monetary values (Kelleher, 2025). Most SCC estimates are derived from integrated assessment models that are explicitly grounded in a social welfare function (SWF). However, even approaches that only calculate monetary damages without explicitly modeling welfare losses can often be interpreted as equivalent to an SWF with particular parameter values. To clarify how SCC estimates are constructed and to make explicit the normative assumptions embedded in them, we introduce a SWF framework that is sufficiently flexible to encompass both explicit SWF-based models and those that do not formally specify a welfare function.

Specifically, we define a SWF that captures the key logic of welfare assessments in climate modeling and sums utility across individuals *i*, time *t*, and possible states of the world *s* (with probability p_s), and discounts future utility with a pure rate of time preference (PRTP) δ.

$$W = \sum_{s=1}^{S}\sum_{t=1}^{T}\sum_{i=1}^{I} p_s U(c_{sti})(1+\delta)^{-t} = \sum_{t=1}^{T}\sum_{i=1}^{I} E\big(U(c_{ti})\big)(1+\delta)^{-t} \tag{1}$$

Here, $U(c_{sti})$ denotes the utility that an individual derives from consuming c_{sti}. However, in practice, researchers rarely consider the consumption level of each individual separately. Instead, they typically rely on mean consumption at different levels of aggregation, where the global mean is the most common choice, although some studies employ regional or national averages. In contrast, we anchor the SWF in individual utility to show how alternative approaches can be treated as special cases of the more general framework.

Implications of this function critically hinge on the assumed curvature of $U(c_{sti})$. In most applications, individual contributions to social welfare are represented by an isoelastic utility function, whose curvature is governed by a parameter $\eta \in \mathbb{R}$, the elasticity of marginal utility of consumption. Formally, the isoelastic utility function is defined as

$$U(c_{sti}) = \begin{cases} \dfrac{c_{sti}^{1-\eta}}{1-\eta} & ,\eta \neq 1 \\ \ln(c_{sti}) & ,\eta = 1 \end{cases} \tag{2}$$

In this setup, $\eta = 0$ implies that utility is treated as a linear function of consumption, while $\eta > 0$ captures the case of diminishing marginal utility. Correspondingly, higher values of η mean that the marginal utility of consumption (i.e., how much enjoyment is achieved from an additional unit of consumption) diminishes faster with higher consumption levels. The case with $\eta = 1$ corresponds to logarithmic utility, where relative changes in consumption imply constant absolute changes in utility, i.e., if two individuals need to pay an amount equal to 1% of their consumption level, they will suffer the same absolute utility loss, regardless of how rich they are. As η increases, more weight is given to changes in the consumption level of poorer individuals. In the limit, as $\eta \to \infty$, only the utility of the poorest individual matters, and maximizing the SWF becomes equivalent to adopting the maximin principle.

The SCC can be understood as the aggregate welfare loss caused by the emission of one additional ton of CO_2. For each individual i, in each period t and state of the world s, we define the associated monetary damage $\Delta_{s,t,i}$ as the reduction in consumption induced by this marginal emission. To make damages comparable across individuals, each $\Delta_{s,t,i}$ is translated into a welfare-equivalent monetary loss for a reference individual i^*. This conversion is obtained by scaling $\Delta_{s,t,i}$ by the marginal rate of substitution between individual i and the reference individual, given by the ratio of their marginal utilities. Therefore, the SCC is a local approximation of the welfare impact of CO_2, which implies that applying such an SCC to a large amount of additional emissions (e.g. by scaling up the SCC with some expected additional future damage) will lead to a downward bias in estimates.

Assuming an isoelastic utility function implies $\left(\frac{U'(c_{s,t,i})}{U'(c_{i^*})}\right) = \left(\frac{c_{i^*}}{c_{s,t,i}}\right)^{\eta}$; hence, the SCC can be formalized as[1]

$$SCC_{i^*} = \sum_{s=1}^{S}\sum_{t=0}^{T}\sum_{i=1}^{I} p_s \left(\frac{c_{i^*}}{c_{s,t,i}}\right)^{\eta} (1+\delta)^{-t}\Delta_{s,t,i} = \sum_{t=0}^{T}\sum_{i=1}^{I} E\left[\left(\frac{c_{i^*}}{c_{t,i}}\right)^{\eta} \Delta_{t,i}\right](1+\delta)^{-t} \quad (3)$$

[1] In this formulation, SCC_{i^*} is refered only with the index to a specific individual i^*. A more general specification would also include indexes for the time point and the consumption path that is considered the base-line scenario. For simplicity, this time point is assumed to lie in the present (t=0) and we only consider one baseline scenario.

As indicated, the key parameter η that regulates the curvature of the utility function impacts simultaneously several normative dimensions. Assuming $\eta > 0$, the factor $\left(\frac{c_{i^*}}{c_{s,t,i}}\right)^{\eta}$ is greater than 1 when $c_{i^*} > c_{s,t,i}$. Thereby, $\left(\frac{c_{i^*}}{c_{s,t,i}}\right)^{\eta}$ intuitively captures distributional concerns by assigning greater weight to costs borne by poorer individuals (Anthoff et al., 2009), as presented in greater detail in Section 2. However, it simultaneously affects the treatment of time and uncertainty, because $c_{s,t,i}$ refers to the consumption of individuals in different time points and in different states of the world. Under the assumption of positive economic growth, future individuals are expected to be wealthier than the reference individual in the present, which implies a positive discount rate, as discussed in greater detail in Section 3. In addition, changes in welfare associated in variations in $c_{s,t,i}$ across states of the world will reflect the degree of risk aversion implied by diminishing marginal utility. This is because the latter assumption implicitly puts greater value on more pessimistic states and less on very favorable ones. This aspect is discussed further in Section 4.

It is worth noting that equation (3) allows for deriving an SCC without explicitly computing a SWF. When doing so, monetary damages $\Delta_{s,t,i}$ are aggregated using weights given by $\left(\frac{c_{i^*}}{c_{s,t,i}}\right)^{\eta}$ and the discount factor $(1+\delta)^{-t}$. While these weights can be derived from an underlying SWF, practical implementations can proceed by applying and modifying such weights directly, without making the welfare-theoretic foundations explicit. More generally, a range of alternative specifications is used in practice, and identifying an explicit SWF that fully rationalizes these choices is not always straightforward, even though it would be conducive to a rigorous normative justification of the underlying assumptions.

Indeed, we will show that the notion of diminishing returns is not consistently applied across different normative dimensions (Del Campo et al., 2024), which creates additional complexities when trying to capture and evaluate the normative stances and decision in modern climate economics. Some generalized frameworks have been developed to formalize and justify treating these issues separately (Anthoff & Emmerling, 2019; Berger & Emmerling, 2020; Epstein & Zin, 1989). However, the essential discussion, of whether these dimensions should or should not be treated differently, is of normative nature. Some argue that different individuals in different time points should be treated in the same way as different individuals in different points of space, an argument that can be extended to different states of the world (Del Campo et al., 2024).

3. Time and normativity: the issue of discounting

SCC estimates directly depend on how much weight is given to the welfare of future generations. This aspect is captured by employing a social discount rate (SDR), which is used to translate future cost and benefits in today's value. The issue of discounting is probably the most widely acknowledged normative aspect in the SCC literature (e.g. Heal & Millner, 2014; Nesje et al., 2023) and the importance of this factor has been emphasized repeatedly (Groom et al., 2022). For example, Rennert et al. (2022) demonstrate that the mean SCC among studies using an SDR of 3% is $80, whereas it is $308 among those using an SDR of 1.5%. Moreover, Moore et al. (2024) show that the use of different discount rates accounts for 25% of the variance between SCC estimates in the literature.

The importance of discounting is related to the fact that even seemingly minor changes in SDRs can have a significant impact on the valuation of costs and benefits occurring in the medium and long term. As Figure 1 indicates the choice of a SDR has a substantial impact on the discounted value of future payoffs, which is particularly significant against the background that the worst consequences of global warming are expected to occur in the long-run.

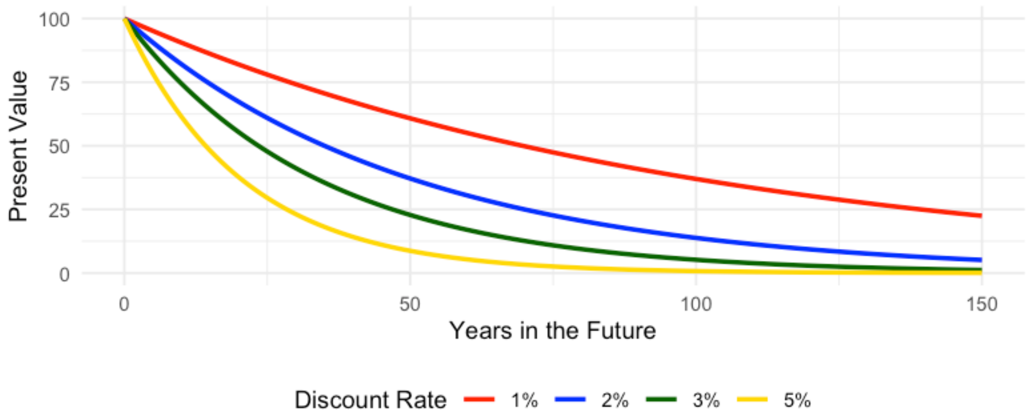

Figure 1: Present value of a future damage of $100

The implications of alternative choices for the SDR have gained salience after the controversy between Nordhaus (2007) and Stern et al. (2006). Here, it became clear that the main explanation for the difference in SCC estimates between both authors (and, consequently, the climate policy each endorsed) lays in the different SDR used. The controversy sparked deep discussions regarding how the SDR should be determined, and whether they should be based on objective or normative grounds.

Nordhaus argued that the SDR should be based on market interest rates, as proxy for opportunity costs. This position can be justified by the fact that later benefits imply foregone investment earnings, while later costs from carbon emissions imply additional opportunities for reaping the returns from investing today instead of paying for the abatement of carbon emissions later. This is sometimes referred to as the "descriptivist" reasoning, as it allegedly does not depend on any normative judgement. Some authors emphasize, however, that such choices nonetheless have a normative character even when based on established market signals (Heal & Millner, 2014; Kelleher, 2019).

As interest rates change over time, SCC estimates based on this approach are sensitive to developments in the financial markets. For example, SCC estimates have increased remarkedly in times of decreased interest rates (Bauer & Rudebusch, 2023) and can be expected to decrease in more recent years, as interest rates have risen.

A second line of reasoning, defended by Stern, refers to a consumption perspective instead of an investment perspective, and is derived directly from normative considerations. In this "prescriptivist" line of argument (Kelleher, 2017), future damages are discounted for two reasons: first, the prescriptivist approach assumes that earlier utility is assigned a greater weight in social welfare evaluation, reflecting the assumption that utility enjoyed in the present is intrinsically more valuable than utility enjoyed in the future.[2] This ethical judgement is formalized through the introduction of a *pure rate of time preference* δ (PRTP) on future utility, as in equation (1). Second, assuming diminishing marginal utility, the same monetary damage will be associated with a smaller utility loss in the future if real economic growth rates are positive.

These two considerations derive naturally from the SWF presented in equation (1), as shown in the appendix and presented by Dasgupta (2008). From this prescriptivist approach follows the Ramsey (1928) formula, which captures both aspects in the expression: $SDR = \delta + \eta g$. Here the rate of consumption growth g is weighted by the elasticity of marginal utility of consumption η, as presented in Equation (2). The PRTP is a parameter that discounts future utility per se, implying that future individuals have less impact on the total welfare sum than present ones. The term ηg, in contrast, does not imply a lower valuation of future utility but rather accounts for the fact that future individual's utility derived from additional consumption differs depending on whether they will be richer or poorer.

Most applications of the Ramsey formula assume positive growth rates,[3] meaning the future damages are downweighed. However, negative growth rates would imply that future damages should receive more weight than present ones, which would lead to a strong increase in SCC estimates. Likewise, assuming higher growth rates would imply lower SCC estimates.

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[2] Surveys show that the majority of economists working on the SDR consider both descriptive and prescriptive considerations to be important in the choice of the SDR (Drupp et al., 2018), while philosophers attach more importance to prescriptive reasons (Nesje et al., 2023).

[3] An extended version of the Ramsey rule takes into account the uncertainty related to future growth trajectories. Higher uncertainty regarding future growth paths implies the use of lower discount rates. The intuitive rationale is that precautionary savings are more important when future incomes are uncertain.

In this sense, different assumptions about future technological development have important implications for SCC estimates. First, faster technological progress leads to higher growth rates, which, through the Ramsey formula, imply a higher SDR and therefore lower SCC values. Second, technological change—particularly in the direction of greener technologies—can alter the expected trajectory of emissions. Assuming a baseline with lower future emissions decrease the damages associated with an additional emission of one ton of CO_2, again reducing the SCC. While debates about alternative technological scenarios are often politicized and very optimistic assumptions can downplay the urgency of current mitigation efforts, they are not inherently normative. Rather, they concern differing projections about future states of the world, not normative disagreements on the relative desirability of those states.

The PRTP is often seen as an especially contentious issue (Greaves, 2017). Many authors have put forward arguments that the use of a PRTP greater than zero is unethical, as they consider that different generations should be treated equally (e.g. Caney, 2009; Moellendorf, 2014; Parfit, 1987; Stern et al., 2006; Tarsney, 2017), a position that has been defended even by Ramsey (1928). As it is often argued, any positive PRTP means that individuals are discriminated against based on their year of birth.

At the same time, the use of a PRTP equal to zero has also been considered too demanding with respect to current generations, as it imposes considerable altruistic demands on the present for the sake of future generations. With a zero PRTP, even tiny benefits to infinitely many future generations can rationalize substantial sacrifices by the present generation, as argued by Arrow (Arrow, 1999) building on the work of Koopmans (1960). In a similar vein, Broome (2012) argues that a low discount rate might be ethically legitimate but politically detrimental, insofar as present generations are the ones who effectively make the political decisions and would not be willing to incur significant sacrifice for the sake of future individuals.

A final line of reasoning considers that the PRTP also depends on extinction risks: if humanity were to vanish within the planning horizon considered by the SCC for reasons unrelated to climate change, no damages would occur after the extinction. In a scenario in which no human exists, total welfare is zero regardless of whether we emit one additional ton of CO_2 or not. Following this line of thinking, Stern et al. (2006) employ a PRTP of 0.1%, which corresponds to a 9.5% risk of extinction within the next 100 years. Assuming an existential risk of one in six over the same period (Ord, 2020) implies a PRTP of about 0.18%. Although these values may appear small, their quantitative implications for the SCC can be substantial, given the high sensitivity of SCC estimates to the choice of the SDR. As noted above, a difference of 1.5 percentage points in the SDR can increase the SCC by a factor of nearly four (Rennert et al., 2022).

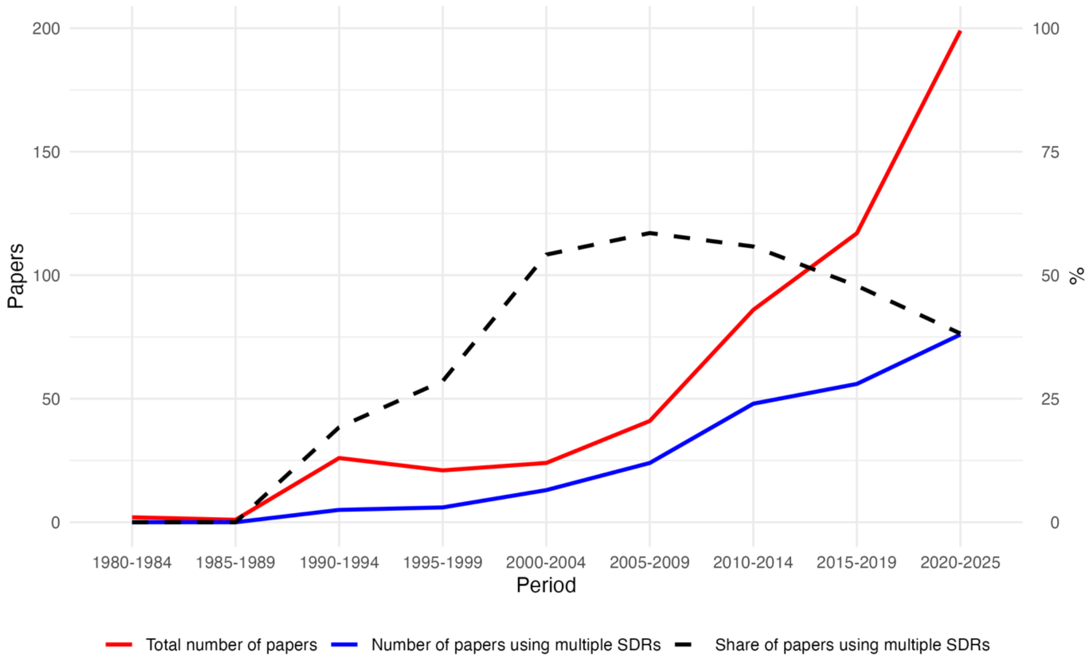

Figure 2: Proportion and total number of published studies with original SCC estimates using multiple discount rates. Authors´ calculations based on Tol (2026).

The choice of the SDR was a central point of debate in the SCC literature in the 2000s, with the Nordhaus–Stern controversy being one of the most prominent examples. Given that no single SDR value could be considered definitive or uncontested, many studies reported SCC estimates under alternative discount rate assumptions. As shown in Figure 2, around 60% of studies in the 2000s presented results based on multiple SDRs. However, even if still frequent, this practice has declined over time. Among more recent studies (2015–2025), more than half rely on a single SDR and therefore do not assess the sensitivity of their results to the choice of the SDR.

4. Distribution of costs and benefits: the role of equity weights

The consequences of climate change will be distributed very unequally across the globe. Most of the damage is expected to occur in low-income regions, affecting poor households disproportionately. Starting from the conventional diminishing utility assumption, this expectation implies an over-proportional loss of social welfare as changes in consumption of comparatively poor individuals and households will have a comparatively stronger impact on welfare.

However, most SCC estimates do not account for this aspect but rather use the average of (global) consumption at time t, $\overline{c_t}$, as core variable of interest, which means that the impact of diminishing marginal utility, as represented by η, is sidestepped and differences in consumption within the same generation are effectively treated linearly (i.e., as if η was equal to zero). This practice amounts to abstracting from interpersonal or regional inequalities by effectively employing the following SWF:

$$W = \sum_{s=1}^{S}\sum_{t=1}^{T} p_s U(\bar{c}_{st})(1+\delta)^{-t} = \sum_{t=1}^{T} E\big(U(\bar{c}_t)\big)(1+\delta)^{-t} \qquad (4)$$

This is equivalent to the formulation in Equation (1) only when assuming that all individuals have identical consumption in each time point or when U is considered to be linear. Hence, every damage counts the same, no matter where it occurs and who bears the costs. As a consequence, the implication of diminishing marginal utility implicit in the utility function is bracketed out – the distributional dimension gets linearized no matter how U is exactly specified. With such a specification, climate models ignore differences in endowments, mitigation capacities or resilience factors across individuals. Hence, although this approach can be framed as “neutral” in terms of distributional considerations, it still contains the implicit normative assumption that distributional aspects within each generation can be ignored.

One key option to account for distributional consideration in such analyses are equity weights,[4] which have been proposed for BCA in general (Adler, 2016; Fleurbaey & Abi-Rafeh, 2016) as well as SCC estimates in particular (Anthoff et al., 2009; Anthoff & Emmerling, 2019; Hope, 2008; Prest et al., 2024) and have been employed by governmental assessments (e.g. Clarkson & Deyes, 2002; Umweltbundesamt, 2007).

To illustrate the logic of equity weights, consider the following example. Assuming a logarithmic utility function (i.e., $\eta = 1$), costs and benefits of the same share of total consumption of different individuals count the same in terms of utility and welfare. For example, a 10$ damage for a person with 100$ total consumption would be equivalent to a 1,000$ damage for a person with a total consumption of 10,000$. For the case $\eta \to \infty$, even a marginal damage for the poorest individual would be equivalent to an infinite damage to richer individuals (as far as this individual remains richer after paying these costs). In the case of $\eta = 0$, each damage is accounted for by its monetary value, independent of the consumption level of the affected individual, even when taking disaggregated data on consumption into account.

In virtually all scenarios about global damage distribution, incorporating equity weights lead to higher SCC estimates. The implications for the SCC are substantial. Prest et al. (2024) show that employing equity weights can increase the SCC by a factor of eight. It is important to note that, in practice, such distributional analyses are only conducted at the level of countries or regions, thus assuming no inequality within these regions. If one would truly consider

[4] Some authors prefer the term *"welfare weights"* (Kelleher, 2025), arguing that these weights do not directly encode considerations on fairness, equity, or justice, but instead reflect differences in the welfare impact of consumption arising from diminishing marginal utility. Despite this terminological preference, these expressions generally refer to the same practice. In some cases, however, conceptual distinctions are drawn. For instance, Acland and Greenberg (2023) distinguish between *"equity weights"* – understood as normative weights applied by a social planner to prioritize disadvantaged individuals – and *"utility weights,"* which adjust monetary costs to account for differences in marginal utility. We adopt the term *"equity weights"* for consistency with the prevailing literature, although we do not introduce a theoretical differentiation akin to Acland and Greenberg (2023).

inequality between individuals – as implicitly suggested by the welfare function introduced above –, the effect would be even stronger.

Despite the considerable impact equity weights have on SCC estimates, the SCC literature has hardly examined the implications of including such weights in recent years. Only a tiny fraction of recently published studies on this subject use equity weights (see Figure 3). Using Tol (2026)'s dataset, we observe a declining trend in the use of equity weights, which were much more common in the 2000s than today: almost 40% of the studies published between 2000 and 2005 used some kind of equality-weighting, while between 2020 and 2025 this share was lower than 5%.

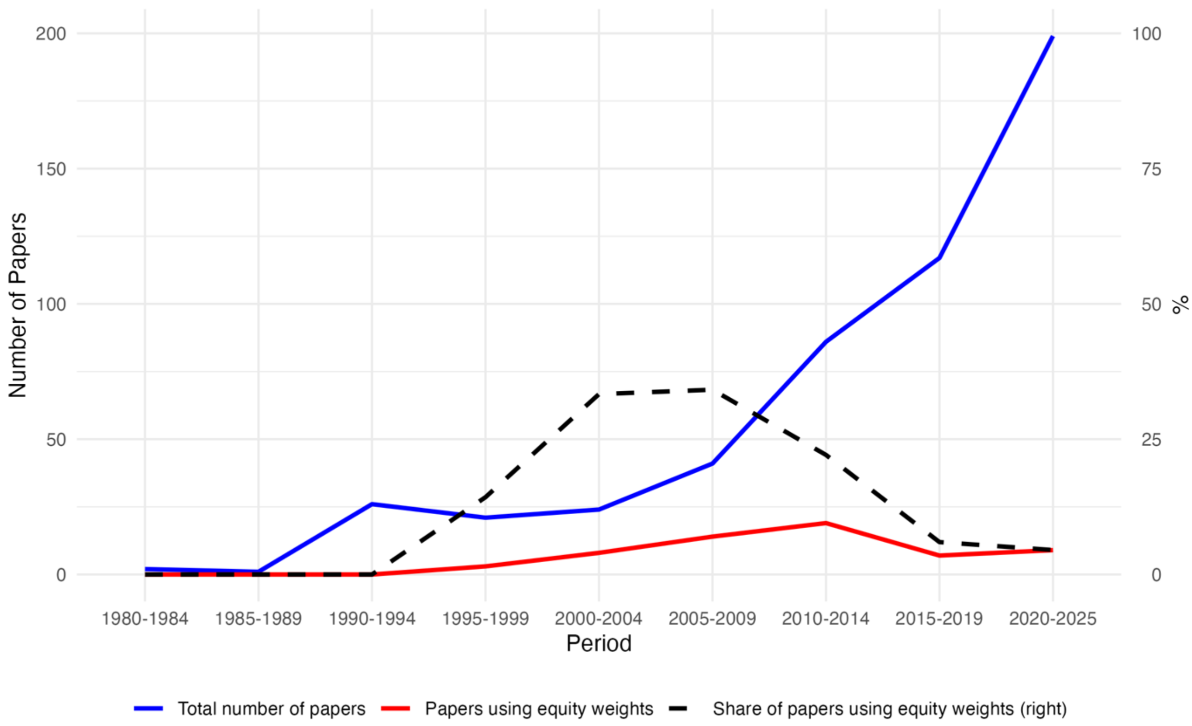

Figure 3: Number and share of published studies with original SCC estimates that use equity weights. Authors´ calculations based on Tol (2026).

A common justification for this neglect of equity weights is made with reference to the Kaldor-Hicks compensation criterion (e.g. Anthoff et al., 2009; Fleurbaey & Abi-Rafeh, 2016; Hicks, 1939; Kaldor, 1939) according to which a policy is economically efficient if those who gain could – in principle – compensate those who lose, even if no actual transfers occur. This principle is also known as the potential Pareto principle, as the possibility of compensation implies that a Pareto improvement is possible, in the sense that all individuals could be made better off. In this sense, no reference to a SWF is needed and calculations can be made by comparing aggregate monetary outcomes. One could argue that the Kaldor-Hicks criterion avoids interpersonal comparisons of utility altogether and is therefore neutral with respect to value judgments. However, adopting this criterion is itself a normative choice, which has long been subject to criticism (De Scitovszky, 1941).

For example, Sen (2000) argues that this criterion is either redundant or unacceptable. If compensation is actually implemented, this corresponds to a scenario in which all individuals are made better off. In that case, the Pareto criterion suffices to rank alternatives, rendering the Kaldor–Hicks criterion redundant. Conversely, when such compensation is not intended, the evaluation would impose losses on some individuals for the benefit of others, which Sen considers unacceptable. For example, this principle could justify additional damages in poor countries due to expected gains in rich countries. While climate policy explicitly integrates considerations on compensations (e.g., as part of Article 9 of the Paris Agreement), whether these compensations ever materialize to an extent that justifies ignoring equity weights is questionable.

5. Expected values vs. uncertain futures: conceptualizing risk

Future climate damage cannot be predicted with certainty. Both the link between emissions and global warming as well as the link between global warming and damages are subject to uncertainty (Pindyck, 2021; Stainforth, 2023). Furthermore, the SCC also depends on future trends in economic variables, such as growth rates, which similarly cannot be foreseen with certainty. Hence, models can only describe possible scenarios rather than known outcomes and estimating an SCC requires normative choices regarding how these scenarios should be weighted when aggregated. For example, one needs to decide how to compare-unlikely but very large damages against smaller damages that are highly probable.–These choices substantially affect SCC estimates and the climate policies they imply (Lemoine, 2021).

Following standard reasoning, risk aversion is typically captured by the elasticity of marginal utility, η, as indicated in Equation (2). Higher values of η imply stronger risk aversion, assigning greater weight to damages occurring in worse scenarios. Many SCC estimations assume diminishing marginal utility, that is, some $\eta > 0$, which would automatically impose risk aversion on the social planner's decision making. However, it is common practice in SCC calculations to effectively assume "risk neutrality" (Kopp et al., 2012; EPA, 2023), which means that all damages are weighted exactly according to their expected probability of occurrence (Valentini & Vitale, 2019). In the framework of Equation (2), this would correspond to setting $\eta = 0$, implying constant marginal utility.

However, as η also governs both intertemporal discounting and equity weighting, setting $\eta = 0$ implies not only risk neutrality but also no equity weights and a SDR determined solely by the PRTP. For this reason, the literature often circumvents this complication by calculating the utility of the expected value of damages instead of the expected welfare loss. This procedure corresponds to the SWF below and allows to simultaneously assume "risk neutrality", while subjecting temporal discounting independently (and, possibly, equity weightings) to η.

$$W = \sum_{t=1}^{T} \sum_{i=1}^{I} U\left(\sum_{s=1}^{S} p_s\,(c_{sti})\right)(1+\delta)^{-t} = \sum_{t=1}^{T} \sum_{i=1}^{I} U\big(E(c_{ti})\big)(1+\delta)^{-t} \tag{5}$$

This procedure is akin to the case of equity weights, where the impact of diminishing marginal utility is sidestepped when taking average consumption level at each point in time instead of disaggregated values. Similarly, taking the average of possible future states sidesteps the implications of diminishing marginal utility for the treatment of risk. One consequence is that standard reasoning in terms of "risk neutrality" does not account for the fact that regulatory bodies might want to take into account the risk-averse preferences found in their constituencies, which want to avoid bad outcomes more than they want to promote good outcomes. However, it is not clear what attitude a social planner should adopt, especially because the risks associated with climate change are not equally distributed across individuals (Rohde & Rohde, 2015).

Additional questions arise from the observation that the current rate of increase in atmospheric CO_2 concentrations is unprecedented and climate change may trigger nonlinear and potentially irreversible processes, commonly described as tipping points (Rietkerk et al., 2021), we have no solid basis for inferring probabilities from past experiences. As a consequence, climate projections often include fat-tailed projection of losses. In this case, assuming some degree of risk aversion and a fat-tailed probability distribution of catastrophic climate events imply that SCC estimates may fail to converge, with expected marginal damages becoming unbounded (Weitzman, 2009). This result, known as the *dismal theorem*, clearly indicates that stronger mitigation policies should be adopted as precaution to these catastrophic scenarios (Weitzman, 2014), although it excludes the possibility of using BCA to provide an exact measure of how strong climate policy should act.

Moreover, some authors argue that climate related uncertainties cannot be quantified (Rising et al., 2022), as they constitute "deep" or "Knightian" uncertainties (Xepapadeas, 2024). In this case, defining climate policy solely through quantified BCA has limited feasibility. Under deep uncertainty, no precise SCC can be estimated and, thus, no meaningful quantitative BCA can be conducted. In such cases, policy decisions must instead be informed by qualitative risk assessments. In this sense, the IPCC advises its authors to "provide some sense of the nature and degree of uncertainty" (Reisinger et al., 2020), even when the associated risks cannot be quantified.

When BCA is infeasible, alternative decision criteria are required (Sunstein, 2021, Anthoff & Tol, 2014; Aurland-Bredesen, 2020; Martin & Pindyck, 2015). One such approach is the maximin principle, which focuses exclusively on the worst possible outcome and is equivalent to letting η approach infinity. Such a principle of rationality is appealing, as extinction – the arguably worst outcome – should be avoided at all costs.

However, the maximin principle has already been criticized (e.g. Sunstein, 2021). When probabilities are known, it appears unreasonable to ignore all but the worst outcome, particularly when low-probability risks are associated with large potential gains of high probability. Conversely, when probabilities are unknown, maximin may instead lead to excessive focus on speculative, low-probability scenarios. The future is unknown in many different ways, and it is possible to speculate about many different threats to societies such as geopolitical shifts and pandemics, but also catastrophic scenarios ranging from volcanic eruptions to engineered pandemics, nuclear war and unaligned artificial intelligence (Ord, 2020). Treating extinction as the sole criterion could therefore lead to policy paralysis, as it is unclear which risk should receive priority (Sunstein, 2006).

Focusing exclusively on the worst imaginable scenarios can have serious consequences. While climate change is expected to cause substantial and highly probable damages, the probability that it leads to human extinction appears to be low (Ord, 2020). Reducing extinction risk at all costs could shift attention toward other unlikely catastrophes while tolerating large, near-certain climate damages. Hence, when juxtaposed to risk neutrality, the maximin approach can be understood as the opposite extreme solution, with many shades of precautionary approaches in between that are reflected by the different degrees of risk aversion implicit in the utility function represented in Equation (2). There, a higher preference for a precautionary attitude would be reflected by a correspondingly larger value of η.

It has long been argued that uncertainty should not be used as a justification for delaying climate policy (United Nations, 1992). Even under a modestly precautionary approach, the existence of credible arguments that environmental degradation may lead to severe future outcomes is sufficient to justify significant policy action, even if the magnitude and probability of damages are uncertain. The temperature targets of the Paris Agreement, for example, aim to reduce the probability of catastrophic outcomes deemed plausible by climate science, even though their precise probabilities are unknown. These targets, hence, reflect a precautionary attitude without reproducing the strong constraints imposed by an uncompromising maximin approach.

6. Valuation of what? Essentialist aspects in the valuation of future states

SCC estimates aim to account for all future damages caused by emissions, which are expected to occur in very different dimensions. This setup creates a dimensionality problem, i.e., how to add up very different types of damage, which is typically resolved by monetarization. This is conceptually straightforward for goods and services traded on markets, but for others it is obviously a stretch: how to assign monetary values to biodiversity, the beauty of natural landscapes or physical harm that people are likely to be exposed to? Arguably, a significant part of damages that enter SCC estimates fall into those almost-impossible-to-value categories. The extent to which such costs are reflected in the SCC therefore depends on normative judgments about their importance.

Often, many consequences of global warming that could be considered important in a broader sense are not included in the models used to calculate climate damages. Examples are loss of biodiversity, costs associated with human migration or wildfire-related impacts of climate change (Kelleher, 2025). Not considering such factors avoids obvious problems related to their monetary valuation, but also introduces some caveats in the interpretation of the results obtained, as important dimensions are not being accounted for. At the same time, researchers are continuously refining SCC estimates in that regard by including ever broader conceptions of damages, such as the health consequences of climate-induced wild fire (Qiu et al., 2025), the impacts on the ocean (Bastien-Olvera et al., 2026) or on the coral reefs (Chen et al., 2015). Among those factors that have been introduced in the calculations of SCC, one of the most important is the monetary valuation of human lives, as climate change is predicted to increase mortality in various ways. Deciding how to monetize human lives is clearly a normative decision, which involves deep ethical consideration.

The value of human lives is often estimated employing the concept of *value of statistic life*, e.g. the willingness to pay to reduce the mortality risk. Richer individuals are normally willing to pay more to reduce their mortality risks, so this approach assigns more weight to the increased mortality risk of richer individuals (or countries). The justification of this practice hinges on the Kaldor-Hicks criterion (Broome, 2024), as the individuals with increased mortality risks could, in principle, be compensated in accordance with their subjective valuation of the importance of this risk. This approach has been adopted by the U.S. Environmental Protection Agency (EPA, 2023) and is often used in the academic literature (e.g. Carleton et al., 2022).

Some authors consider this approach inconsistent with the widely held moral intuition that all humans have equal dignity – hence, lives should be assigned the same value for all individuals. Indeed, according to this approach, one single death in Ireland is accounted the same as 76 deaths in Niger (Bressler, 2025). To account for this aspect, the global mean willingness-to-pay can be used as a yardstick to monetize mortality in all countries, thus assigning the same value for the lives of all individuals. According to Bressler (2025), adopting this second approach makes the SCC increase from $237 to $380, all other things being equal. Another option is to consider the diminishing marginal utility directly and to adjust the willingness to pay with reference to the relevant income level, that is, to use equity weights analogously to other costs. Adopting equity weights and valuing mortality in this manner can increase the SCC estimate by a factor of 50 (Bressler, 2025).

7. Conclusion

The SCC is sometimes presented as a device for depoliticizing climate policy by identifying an "optimal" emissions path grounded in scientific analysis. Yet optimality is always conditional on specific normative assumptions (Huwe & Frick, 2022). It does not remove politics from climate policy; rather, it just formalizes normative choices within the language of economics. The legitimacy of SCC-based policy guidance therefore depends not on claims of neutrality, but on the transparency and consistency of its ethical foundations.

In this sense, the SCC is not a value-neutral metric but fundamentally integrates a series of normative judgments. To make this point salient, this paper has examined the main normative dimensions embedded in SCC estimates, showing that disputes over the required urgency in climate policy are often rooted in ethical disagreement rather than uncertainty about climate dynamics or their economic impact. This paper does not advocate any particular ethical stance. Its aim is to make the normative dimensions of SCC estimation explicit, which we conceive as a precondition for informed academic debate and democratic deliberation.

Any SCC estimate necessarily weighs costs and benefits borne by different income groups, countries, and generations — even in cases where distributional objectives are not explicitly stated. Ethical considerations also play a central role in determining what counts as valuable, that is, which types of damages are included and how they are monetized. Although these choices imply substantial variation in SCC estimates (e.g. Bressler, 2025; Lemoine, 2021; Prest et al., 2024; Reisinger et al., 2020), many SCC estimations do not discuss them in due depth. Making the normative foundations of SCC estimates transparent is therefore essential for aligning environmental policies with societal values and political feasibility.

We have shown that the assumption of diminishing marginal utility plays a central role as it captures key normative aspects of standard SCC estimates. In standard applications, assuming an iso-elastic utility function, this aspect is regulated by the parameter η, the elasticity of marginal utility. Higher values of η assign greater weight to damages borne by poorer individuals, whether these individuals live in different regions, in future generations, or in alternative states of the world. In this sense, η simultaneously governs distributional weighting across space, intertemporal valuation, and attitudes toward risk. However, choosing different values for η has opposing effects on SCC estimates. A higher η implies a higher discount rate for the typical scenario assuming positive growth rates and, thus, a *lower* SCC. At the same time, it also implies higher levels of risk and inequality aversion, and thus a *higher* SCC. While a positive η is commonly invoked to justify discounting under the assumption of economic growth, the same reasoning is usually not made for inequality and risk.

The inconsistent treatment of marginal utility undermines the internal coherence of the theoretical framework and, by doing so, makes the typical ethical stances applied less plausible and convincing. While some argue that these dimensions should indeed be treated independently (Anthoff & Emmerling, 2019; Berger & Emmerling, 2020; Epstein & Zin, 1989), the empirical literature rarely engages in the intricate ethical discussion required to justify these methodological choices.

Normative commitments arise not only from the specification of parameters such as the PRTP and η, but also from the choice of decision framework itself. Determining how scientific evidence is translated into policy advice is an ethical issue on its own right and relying on BCA is only one among several possible approaches. As discussed in Section 5, the profound uncertainty surrounding future climate and economic trajectories – particularly in the presence of fat-tailed risks – may render BCA practically infeasible in the context of climate policy. In the face of such uncertainty, alternative decision criteria should be considered (Sunstein, 2006, 2021).

Some authors argue that a more realistic strategy is to move away from BCA and adopt a cost-effectiveness framework, in which politically determined goals are set and policy instruments are chosen to achieve them at minimum cost (Ackerman & Heinzerling, 2002; Ackerman & Stanton, 2012; Farber, 2015; Platz, 2025). The Paris Agreement reflects such an approach by establishing temperature limits without direct reference to SCC estimates (Broome, 2024). This precautionary solution avoids the pitfalls of a strict maximin approach by still allowing further emissions and compromises with other societal goals. While the maximin approach can lead to political paralysis, as it is unclear which risks should be prioritized, setting emission limits provides clear guidance for climate policy. The determination of these limits ultimately remains a political decision. While this may raise concerns about arbitrariness, the SCC does not offer a value-neutral alternative.

Future research should engage more systematically with the ethical foundations of SCC modeling. Discussing the normative premises of the analysis should be an integral component of any study that estimates the SCC.

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Appendix

The Ramsey formula can be derived from a framework such as the one presented in equations (1) and (3). Besides the discount rate δ, which is explicitly stated in the SWF, the factor ηg derives naturally from the concavity of the utility function. To see how this is the case, consider a simple case in which there is no intra-temporal inequality and no risk involved. Thereby, c_t is the per capita social consumption in time t. Moreover, consider a constant consumption growth rate of *g.* Then, the formula for the SCC presented in (3) simplifies to:

$$SCC_{i^*} = \sum_{t=0}^{T} \left(\frac{c_0}{c_0(1+g)^t}\right)^{\eta} (1+\delta)^{-t}\Delta_t = \sum_{t=0}^{T} (1+g)^{-\eta t}(1+\delta)^{-t}\Delta_t \qquad (4)$$

The approximation holds: $(1+g)^{-\eta t}(1+\delta)^{-t} \approx (1+\delta+g\eta)^{-t}$, which corresponds to the discount rate from the Ramsey formula, $\delta + g\eta$. As we assume discrete time, this is an approximation, which is very accurate for small η, g, δ. If we considered continuous time, this equivalence would hold exactly, as the discount factor simplifies to $e^{-t(g\eta+\delta)}$.