Valuing Deaths Caused by Climate Change[1]

Challenges for the Social Cost of Carbon and Global Externalities

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Abstract

How deaths caused by climate change are valued is now among the most consequential choices in the social cost of carbon (SCC): the metric used to account for climate impacts in benefit-cost analysis (BCA). We consider the three BCA approaches with support in the literature and practice: (1) Kaldor-Hicks, which values richer statistical lives more than poorer ones; (2) current U.S. practice, which values all lives equally; and (3) welfare weighting, which reweights Kaldor-Hicks values for diminishing marginal utility and values lives nearly or exactly equally depending on parameter values. All three take the value of statistical life—the willingness to pay for changes in mortality risk—as a descriptive input; they differ in how they aggregate values across winners and losers, which is a normative choice justified with different rationales. The rationale for Kaldor-Hicks is weaker for global externalities than domestic ones because compensation to losers is less likely and autonomy and consumer-sovereignty arguments do not apply. Furthermore, current-generation SCC estimates are inconsistent with Kaldor-Hicks because they use purchasing-power-parity-adjusted money, which is incompatible with the compensation criterion. Rationales for current U.S. practice and welfare weighting are comparatively stronger. Given these complexities, we emphasize reporting the mortality impacts implicit in every SCC in natural physical units—the mortality cost of carbon: the number of deaths per pulse of emissions—before valuation so that normative assumptions are explicit and transparent, as is standard for other impact categories in BCA.

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1. Introduction

Emitting carbon dioxide is an externality: when someone adds carbon dioxide to the atmosphere, external people in other places and at other times are impacted. Economists address externalities by quantifying the social cost of producing the externality. The social cost of carbon (the SCC) is simply the monetized social cost of emitting an extra tonne of carbon dioxide. The SCC has been called the most important concept in climate economics (Nordhaus 2017).

Furthermore, the SCC is the way that climate change is accounted for in benefit cost analysis (BCA). The SCC and BCA are important in policy. Since at least the 1980s, executive orders have required agencies to conduct BCA of major regulations, and Congress has imposed similar requirements in several statutes (McGartland 2021; Sunstein 2004). Starting in 2009, Federal agencies have used the SCC when regulations impact emissions. The SCC has been used to justify hundreds of U.S. regulations with benefits totaling trillions of dollars. The SCC has also been used by at least 15 states and other national governments including Canada and Germany (Prest 2026).

A large and growing literature projects that climate change is likely to cause significant premature death around the world (Bressler et al. 2021; Carleton et al. 2022; K. R. Cromar et al. 2022; Gasparrini et al. 2017; Hales et al. 2014). Because the SCC captures the full range of impacts from emitting an extra tonne of carbon dioxide, part of the SCC includes the deaths caused by adding carbon dioxide, which must be monetized because the SCC is in units of money. This leads to the core research question explored in this study: how should premature deaths caused by climate change be valued?

This is not a new question. In 1995, a chapter from the draft IPCC AR2 report valued premature deaths in developed countries ten times more than premature deaths in developing countries (Pearce 1995a). This led to significant backlash in the IPCC plenary session, where many countries expressed outrage. The environmental minister of India called this approach “absurd and discriminatory” and called for it to be “purged from the process.” In the end, the proposal did not pass the IPCC review process, and the negotiated Summary for Policymakers implicitly rejected the chapter’s approach (Bruce, Lee, and Haites 1996; Grubb 2005; Pearce 1995b).

This question has been less discussed historically in the literature in large part because it was irrelevant given the coverage and the structure of the models used to calculate the SCC. Of the three models used by the U.S. government to calculate the SCC from 2009-2023, two (DICE and PAGE) did not specify how much, if any, of their estimated damages came from mortality (Bressler 2021; EPA 2023), while the other (FUND) projected little damage from mortality (K. Cromar et al. 2021). Furthermore, these models had limited spatial resolution, which limited the ability of the model to consider how climate change impacted people in different parts of the world. For instance, the most prominent model, DICE, was only a single region global model (Nordhaus 2017).

However, the latest generation models first adopted by the U.S. government in 2023 now project that temperature-related mortality is the largest quantified damage source in the SCC (EPA 2023; Rennert et al. 2022). This now makes the question of how to value deaths caused by climate change fundamental in quantifying the SCC. One of the authors (Bressler) served at the Council of Economic Advisers from 2021-2022 during the Interagency Working Group process that ultimately informed the EPA's 2023 SCC update. Indeed, the choice of how to value premature deaths across the world was the most contested methodological issue addressed during this process. The substance of the disagreement, and the considerations on different sides of it, is the subject of this paper.

The stakes of this debate are high. Because premature deaths from temperature-related mortality are projected to be large and overwhelmingly concentrated in poorer parts of the world, the choice of how to value lives around the world is now the most consequential choice in determining the value of the SCC, even more so than discounting (Bressler 2025). Furthermore, the consequences of this debate go well beyond the SCC. BCA as practiced by national governments has historically focused on measuring domestic benefits and costs (Gayer and Viscusi 2016). For most countries, the SCC is likely to be among the first BCA calculations that explicitly projects and monetizes premature deaths in other countries caused by national policy decisions.[2] Thus, the decision of how to monetize premature deaths in the context of climate change may be precedent-setting for how other future global externalities are assessed in BCA.[3] Although the IPCC AR2 controversy occurred 31 years ago, and the underlying issue continues to reoccur in high profile policy settings, the considerations involved with the question of how to monetize premature mortality from climate change remains under-discussed and under-analyzed in the literature. This paper seeks to remedy this.

Before summarizing our findings, it is first necessary to level set on a few points. First, when conducting any BCA, there is the foundational primitive question of *standing*: who counts

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[2] In the U.S., there does not appear to be precedent for a Regulatory Impact assessment (RIA) explicitly projecting and monetizing premature deaths caused in other countries by U.S. policy decisions. A few RIAs have considered impacts in other countries but have not monetized them. For instance, the Mercury and Air Toxic Standard (MATS) RIA discussed the foreign health benefits of U.S. mercury reductions qualitatively, but did not quantify them (Howard and Schwartz 2017; US EPA 2011). Likewise, the 1996 NASA *Final tier 2 environmental impact statement for International Space Station* report considered mortality impacts from falling debris in the U.S. and other countries, but did not monetize the impact (NASA 1996).

[3] For instance, future regulatory impact assessments may determine the costs and benefits of safety regulations for BSL-4 laboratories, which would affect the very small probability of a lab-leak of a pandemic pathogen. The value that the U.S. places on premature mortality in other countries significantly affect the costs and benefits of this sort of regulation as well.

in the analysis and who is left out? SCC estimates have generally aggregated climate impacts globally. Because greenhouse gases emissions are thoroughly mixed across the global atmosphere, emissions contribute to climate damages across the world regardless of where they originate (see EPA 2023 section 1.3 for a thorough discussion and literature review). Some studies disaggregate these global damages geographically and report damages broken down at the country-level (e.g., Ricke et al. 2018). We do not revisit the choice of standing in this study; we analyze the globally aggregated SCC, consistent with the predominant approach in the literature. Second, it is important to recognize that the SCC is one ingredient in a larger benefit-cost analysis. Policies that impact emissions also have other non-climate benefits and costs, such as abatement costs and local air pollution benefits among many others, that must also be considered. Therefore, the research question of how to value deaths from climate change must be considered within the broader context of the choice of the overall *approach to benefit-cost analysis*.

A large literature has discussed the rationale for different BCA approaches, predominantly in the context of domestic benefits and costs, which we review in section 2. Section 3 formally derives each of the three main approaches to BCA considered in this paper and shows how the approaches relate to each other mathematically. Section 4 discusses BCA issues that are raised specifically in the context of valuing GHG emissions, and how the underlying rationales for choosing alternative approaches to BCA fare when applied to global externalities like climate change. Section 5 draws conclusions.

There are *three* main approaches to BCA that have significant support in both the literature and practice/policy, which we summarize in figure 1 below. All three of these approaches take a set of descriptive facts and projections: e.g. the number of lives expected to be saved by the policy, the projected costs of complying with the policy, to name just a few examples. After collecting descriptive facts and projections, a BCA must then choose a procedure for aggregating benefits and costs across the winners and losers from the policy, which is itself a normative choice. Crucially, all three of these approaches use information on value of a statistical life (VSL), which estimates the willingness to pay to avoid a risk of mortality, as one of these descriptive inputs in the BCA, but then make different choices about how this information is used in aggregating benefits and costs, which is summarized in figure 1. Because the choice of aggregation is normative, each of the three BCA approaches have specific rationales that justify why their approach is appropriate, which we discuss in section 2.

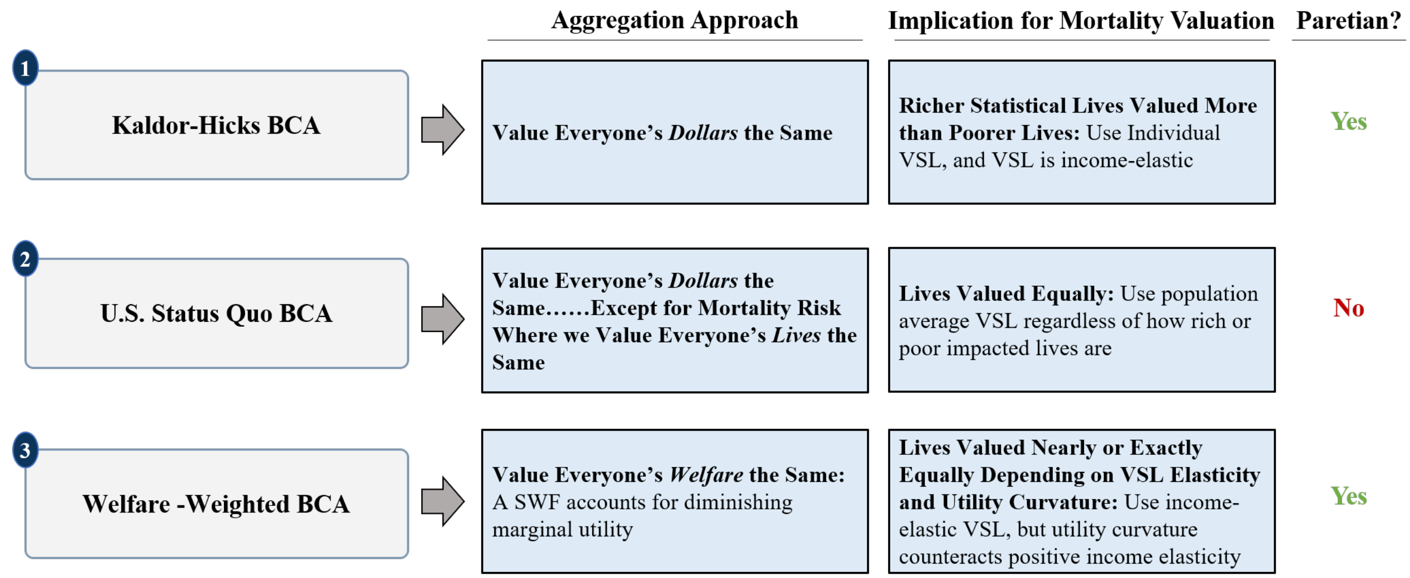

Figure 1: A Summary of the three approaches to BCA that have support in theory and practice.

As we discuss in section 2, both Kaldor-Hicks and welfare-weighting are Paretian, meaning that any time a policy results in a Pareto improvement, both approaches will score the policy as yielding positive net benefits (Bergson 1938; Harsanyi 1955; John R. Hicks 1939; Kaldor 1939; Kaplow and Shavell 2001; Samuelson 1947) . Whereas anytime a policy causes everyone to be worse off, both approaches will score the policy as yielding negative net benefits. The difference between the approaches is how they score non-Pareto-Improving policies, i.e., policies that result in some winners and some losers.

The Kaldor-Hicks approach appeals to the potential compensation test, which is itself a normative choice (Banzhaf 2023; Goulder and Williams 2012; J. R. Hicks 1975; Robbins 1981). This test specifies that if the winners from the policy gain by enough to compensate the loser such that everyone could be better off (even if such compensation does not occur), then such a policy is determined to yield positive net benefits. This potential compensation test counts money to poorer individuals the same as to richer individuals. By contrast, the welfare weighting[4] approach explicitly defines a social welfare function (Atkinson 1970; Bergson 1938; Samuelson 1947) that estimates how the policy's benefits and costs impact social welfare by transforming benefits and costs to account for diminishing marginal utility (i.e., a dollar is more valuable to someone who is very poor than to someone who is very rich). Indeed, choosing a social welfare function is also a normative choice.

The third approach, U.S. Status Quo, is the approach taken by U.S. regulatory practice for decades. It is a hybrid between Kaldor-Hicks and welfare weighting in that it treats non-mortality

[4] Welfare weighting has also been referred to as equity weighting, distributional weighting, income weighting, among other names.

benefits like Kaldor-Hicks, whereas it implicitly treats mortality benefits like welfare weighting by using a single population average VSL to value all statistical lives (Kniesner and Viscusi 2023; Kolstad et al. 2014; Somanathan 2006). This has the effect that for the poor, safety from premature mortality risk will be overvalued relative to other benefits whereas for the rich, safety will be undervalued relative to other benefits. This reweighting of the relative values applied to mortality impacts versus other impacts can result the Pareto principle being violated when individuals make tradeoffs between their own mortality risk and their own non-mortality benefits (Banzhaf 2011, 2023; Kaplow and Shavell 2001). This Pareto violation has been described as a violation of consumer sovereignty/autonomy, but this issue does not apply to externalities where one group's benefits impose costs on another group (Sunstein 2004). Because Kaldor-Hicks and Welfare-Weighting apply the same weights to all mortality and non-mortality categories, they are Paretian and do not have this consumer sovereignty/autonomy issue.

To summarize our conclusions: first, as our analysis makes clear, the issue of monetizing deaths caused by climate change is both complex and controversial. Therefore, it is important to follow the National Academy's suggestions for transparency by showing impacts in their natural physical units, as is standard for other impact categories in BCA.[5] In the case of climate mortality impacts, this means showing the number of deaths. Indeed, is standard practice in BCA to first show the projected number of deaths caused or lives saved because of a policy, then to clearly state the monetization method, and only after that to show the monetized cost. This physical-unit metric implicit in every SCC value is the mortality cost of carbon (MCC): the number of deaths per pulse of emissions. Figure 2 shows how the SCC mortality term is a function of the MCC, and these terms are derived in section 3. The mortality cost of carbon can be aggregated to show the total number of deaths from a pulse of emissions and it can also be broken down across time and space (Bressler 2021, 2025). The total number of deaths from a pulse of emissions can be communicated in multiple ways, e.g, the number of deaths per tonne or the number of tonnes that produce one death. Existing estimates of the MCC, which currently only account for temperature-related mortality, imply that adding on the order of 1,000-10,000 tonnes of carbon dioxide causes one excess death, i.e., an MCC on the order of 10^{-4} deaths per tonne (Bressler 2021, 2025). Showing the physical impact from adding a pulse of emissions is especially important for the SCC; because climate-mortality impacts are projected to be overwhelmingly concentrated in poorer parts of the world, the mortality partial social cost of carbon can vary by two orders of magnitude just by changing the monetization approach despite having an identical underlying MCC (Bressler 2025). While there is an underlying MCC estimate implicit in every SCC estimate, the underlying MCC estimate is rarely reported, having only been reported in the two studies mentioned above. Other studies have reported the total

[5] See Committee on Assessing Approaches to Updating the Social Cost of Carbon et al. (2017), e.g.: "In order to provide a satisfactory degree of transparency, it is desirable for the damages module to report impacts in physical units when possible, such as crop yield changes, mortality, or species effects. These natural-unit measures are more straightforward to compare to the impact literature and require fewer intermediary assumptions to estimate than their monetized counterparts."

number of deaths results from climate change, but that is not the direct input into the SCC, which is the social cost of adding a marginal pulse of emissions. After the MCC is shown, the assumptions about how these deaths are monetized should be clear and transparent. The mortality cost of carbon can also be represented in terms of lost life years if the underlying SCC model is able to project lost life years.

Second, we argue that analysts need to carefully consider the underlying science and economics of the policy being considered, and how these factors impact the normative rationale for choosing each one of the three approaches. As discussed in section 2, we show that the rationale for taking the Kaldor-Hicks approach of valuing richer individuals more than poorer individuals without counteracting marginal utility weights is more compelling when either (1) the population receiving the benefit is the same population that bears the cost, or (2) the population that bears the cost is compensated through another means, such as an optimal tax redistribution system. As we discuss, there is a debate in the scholarship as to whether these rationales are applicable in most domestic contexts. Despite this, countries that use BCA, including the U.S. and the U.K., have historically monetized and continue to monetize all premature deaths at a single population average value (His Majesty's Treasury 2026; Sunstein 2004, 2022). In section 4, we show that these rationales are clearly inapplicable when applied to climate damages caused by greenhouse gas emissions. When those in, e.g., the U.S. burn fossil fuels, they get all the energy benefits but pay only a small portion of the cost from the subsequent climate damages. Furthermore, there is no supra-national tax authority. This implies that, e.g., the people of Niger are not compensated for excess deaths incurred from U.S. emissions decades in the future (Kolstad et al. 2014). Thus, an approach that monetizes excess deaths at a higher value for richer individuals than poorer individuals without counteracting marginal utility weights seems to lack foundation in the climate context, as it amounts to using an implausible thought experiment to justify benefiting some people (usually those who are better-off) at the expense of others (usually those who are worse-off).

Given that these rationales are inapplicable in the climate context, a final way to justify valuing excess deaths at a higher value for the rich compared to the poor is simply to adopt the Kaldor-Hicks potential compensation criterion—which specifies that a policy is net beneficial if those who benefit from a policy could fully compensate those who are harmed and still remain gainers, regardless of if such compensation ends up occurring (also known as a "Potential Pareto Improvement")—as an analytic first principle. However, countries such as the U.S. and the U.K. have long decided not to do this because they have taken the U.S. status quo approach and not the Kaldor-Hicks approach to BCA. And the difference between the U.S. status quo approach and Kaldor-Hicks is not a mere technicality; it is of central importance because of how important mortality benefits are to regulatory BCA (Hemel 2022). For instance, 70% of the total benefits in BCAs of federal regulations historically are directly attributable to the monetized value of reducing mortality (Colmer 2020) and 85% of the benefits from the Clean Air Act Amendment are attributable to the reduction in premature mortality associated with reduction in ambient particulate matter (US EPA 2011). Given that regulatory BCAs have long taken the U.S. Status Quo Approach to BCA and not the Kaldor-Hicks approach, it seems that the analysis of climate impacts is a poor first place to adopt Kaldor-Hicks given that the underlying rationales for Kaldor-Hicks are especially weak in this domain. What remains of the Kaldor-Hicks approach when the underlying rationales do not apply is an implicitly defined Negishi-Weighted social welfare function (as shown in section 3.1), which applies Negishi (i.e. inverse marginal utility) weights that undoes diminishing marginal utility so that, e.g., the social welfare function counts a marginal dollar to a billionaire the same as a marginal dollar to someone below the poverty line.

Furthermore, we show in section 4.4 that the Kaldor-Hicks potential compensation criterion only holds if BCA is conducted using units of money that represent an actual unit of exchange. If costs and benefits are measured in purchasing power parity (PPP) adjusted money—as is typical when calculating the SCC—then Kaldor-Hicks no longer satisfies its own potential compensation criterion. The latest generation estimates of the SCC that have most recently been used in policy (EPA 2023; Government of Canada 2023; Rennert et al. 2022) all use PPP adjustments to calculate the SCC, meaning that these estimates are not consistent with the Kaldor-Hicks approach.

Finally, we conclude that arguments for welfare-weighting are comparatively stronger in the context of a global externality like climate change compared to the domestic context where normative arguments in support of Kaldor-Hicks are more plausible. Welfare weighting applies welfare weights that account for diminishing marginal utility using empirical estimates for the curvature of the utility function. This converts benefits and costs into empirically informed welfare-adjusted dollars. See section 3 for details and further discussion. If one compares social welfare functions, we argue that a social welfare function that accounts for diminishing marginal utility is more normatively attractive than the Negishi weighted social welfare function, which does not. Furthermore, the welfare weighting approach better captures what a typical social planner would naturally care about: the ability of money to buy real net benefits and the welfare people get from those benefits, as opposed to measuring net benefits in units designed to satisfy an implausible thought experiment. In addition, we show that the current U.S. practice implicitly welfare weights premature mortality costs, while it treats other costs and benefits the same way as Kaldor-Hicks, and we establish the parameter conditions under which premature mortality costs are valued equally in monetary terms for both welfare-weighting and the U.S. Status Quo.

2. The Current Practice of Benefit-Cost Analysis

This section proceeds as follows. In 2.1, we provide a quantitative summary of the three approaches. In 2.2, we discuss the Kaldor-Hicks approach to BCA. In 2.3, we discuss welfare-weighted BCA. In 2.4, we discuss the current U.S. practice, and we show that the Kaldor-Hicks potential compensation criterion is not satisfied under this practice.

2.1 Quantitative Summary of the Three Approaches

As shown in Figure 1, there are three approaches to BCA that have support in both theory and practice that vary in the way they address these questions:

1. *Kaldor-Hicks BCA*: Measure all benefits and costs in market dollars, thus not accounting for diminishing marginal utility. Premature deaths are valued based on the estimated individual willingness to pay to avoid premature mortality. As we show in equation (3), BCA under this approach is equivalent to achieving positive net benefits in a Negishi-Weighted Social Welfare function.
2. *Current U.S. Practice BCA*: As with Kaldor-Hicks BCA, measure benefits and costs in market dollars, with one exception: value all premature deaths at the same population-wide value across the population being considered within the purview of the analysis. This is the way that BCA is currently practiced in the U.S. (although as noted previously, this is also the case elsewhere, such as the U.K.) so we refer to this as the current U.S. practice, or the U.S. status quo.
3. *Welfare-Weighted BCA*: All benefits and costs are measured using individual willingness to pay, but then they are welfare-weighted to account for diminishing marginal utility. Under standard parameter values, the elasticity of marginal utility, η, is equal to the elasticity of the VSL, ϵ.[6] This implies that although individuals may value their statistical lives differently in market dollar terms, they value statistical lives equally in welfare terms (Kolstad et al. 2014; Somanathan 2006). We call this approach "Welfare-Weighted BCA."[7]

These three approaches have been discussed, theorized, defended, and criticized at length in the literature going back decades as we discuss below. There is one additional approach to BCA that has significant support in the academic literature: prioritarian-weighted BCA (M. Adler et al. 2017; M. D. Adler and Treich 2015; Ferranna and Fleurbaey n.d.). Like welfare-weighting, prioritarian-weighting also estimates a policy's impact on welfare, but its weights are constructed in such a way to put more weight on the welfare of those who are worse off than those who are

[6] Hemel (2022) refers to BCA that uses inverse income-weights and an income elasticity of VSL equal to 1 as "standard hard-weighted cost-benefit analysis." This weighting approach is consistent with the German government's approach to weighting for the SCC (Matthey and Bünger 2019), and a VSL income-elasticity of 1 has been presented as a standard estimate for policy analysis (Masterman and Viscusi 2018; Robinson, Hammitt, and O'Keeffe 2019; Viscusi and Masterman 2017). Eeckhoudt and Hammitt (2001) and Kaplow (2005) both developed models in which agents have iso-elastic utility functions, and the income elasticity parameter (coefficient of relative risk aversion) nearly approximates the elasticity of VSL. Although there remains uncertainty in the empirical literature around the values of both η and ϵ, estimates for the two values contain significant overlap -- see, e.g., D. J. Acland and Greenberg (2023).

[7] Weights can also be constructed not to match empirically estimated diminishing marginal utility of income, but to reflect societal distributional goals, which some call "equity weights" (Acland and Greenberg 2023). We focus here on empirically informed welfare weights as opposed to equity weights.

better off. Because prioritarian-weighting is not used yet in BCA for government policymaking in the U.S. or other countries, we focus on the three approaches in this paper. See (Bressler 2025) for further discussion, analysis, and SCC estimates of the prioritarian SCC in a latest generation model. Prioritarian-weighted SCC estimates tend to be much higher than the SCC estimates using the other three approaches (M. Adler et al. 2017; Bressler 2025).[8]

Figure 1 summarizes these approaches in general while Figure 2 formalizes the approaches in terms of their underlying social welfare function (SWF), and it shows mathematically how each of the approaches values premature deaths from climate change. We formally derive these expressions in section 3 and discuss them further in section 4, but we describe them briefly here.

	Underlying Social Welfare Function	**SCC Mortality Term**
1 **Kaldor-Hicks BCA**	$W = \sum_{t=1}^{t=T} \sum_{i=1}^{i=n} y_{i,t}\, r_t$	$MCC_{i,t} * VSL_{i,t}$
2 **U.S. Status Quo BCA**	$W = \sum_{t=1}^{t=T} \sum_{i=1}^{i=n} (k_{i,t} - m_{i,t}\overline{VSL_t})\, r_t$	$MCC_{i,t} * \overline{VSL_t}$
3 **Welfare -Weighted BCA**	$W = \sum_{t=1}^{t=T} \sum_{i=1}^{i=n} u_i(y_{i,t})\, r_t$	$MCC_{i,t} * VSL_{i,t} * \left(\frac{y_{x,1}}{y_{i,t}}\right)^{\eta}$

Figure 2 The Underlying Social Welfare Functions, and the mathematical expression for the value placed on premature deaths caused by climate change across the three approaches.

In the first column, each SWF *W* shows how each approach aggregates impacts across *i* regions in each time period *t.* These are general SWFs and not specific to just climate change. Note that the SWF is implicit for Kaldor-Hicks and U.S. Status Quo, but is explicit for welfare weighting. For Kaldor-Hicks, the implicit SWF simply aggregates monetized values across winners and losers in each time period while discounting in each time period *t* with the discount factor *r*. Welfare weighting explicitly defines a utilitarian social welfare function that accounts for diminishing marginal utility with the utility function *u*, which in policy practice is often

[8] Welfare weighting can also be done with other non-utilitarian SWFs (see, e.g., Sen and Foster 1973) , but we focus on the utilitarian SWF with isoelastic utility, since this is the most common SWF used in the literature and in practice (Anthoff, Hepburn, and Tol 2009; Bressler et al. Forthcoming; Errickson et al. 2021; His Majesty's Treasury 2026; Matthey, Bünger, and Eser 2026; OMB 2023; Prest et al. 2024). Because Prioritarian weighting justifies itself by defining its own prioritarian social welfare function, it can also be thought of as a special case of a welfare-weighted social welfare function, although this distinction is semantic.

isoelastic. U.S. status quo differentiates between non-mortality net benefits *k*, which are treated in the same way as Kaldor-Hicks, and mortality costs *m*, which are monetized by the population-wide average VSL in each time period t.

The SCC mortality terms in the second column show how each approach values deaths caused by climate change for each region *i* in each time period *t* (please refer to section 3 for the formal derivation). To calculate the SCC, this mortality term needs to be aggregated with the other non-mortality climate impacts across space and time and discounted, but we focus here on the specific mortality term in each time period in each region to clarify the difference between how the three approaches value premature deaths caused by climate change. Each approach uses information on the VSL across regions in each time period. VSL is an evidence-driven estimate of how much an average individual would pay, in monetary terms, to avoid a specified mortality risk. Methodologically, it is often estimated in labor markets where there are tradeoffs between small amounts of additional near-term safety and wage compensation. Thus, VSL is not intended to represent the government's own assessment of "the value of life," but rather it is intended to capture the tradeoffs individuals make. VSL estimates in the literature vary across many dimensions, especially income. Since those with more ability to pay typically have a higher willingness to pay to avoid mortality risk, VSL estimates for richer individuals tend to be higher than VSL estimates for poorer individuals. For instance, multiple past studies in the climate economics literature have assumed that the VSL has an income elasticity of 1 (Bressler et al. Forthcoming; Carleton et al. 2022; EPA 2023; Rennert et al. 2022), since a VSL income-elasticity of 1 has been presented as a standard estimate for policy analysis (Masterman and Viscusi 2018; Robinson, Hammitt, and O'Keeffe 2019; Viscusi and Masterman 2017). This implies that VSL varies proportionally with income, such that a richer individual with an income 10 times higher than a poorer individual will have a VSL that is 10 times higher than the poorer individual. Because estimates of VSL in future regions is not available, the VSL is estimated in each region in each time period using a benefits-transfer methodology that leverages a currently known VSL estimate, an estimate of the VSL income elasticity, and projections of future regional incomes (see section 3 for more details).

Each approach also uses the mortality cost of carbon (MCC) in region *i* in time period *t*. This represents the number of deaths in region *i* in time period *t* from an extra tonne of emissions. For instance, the 2026 SCC is the monetized social cost of adding an extra tonne of emissions in 2026, and that tonne of emissions produces an MCC in each region in each future time period, which represents the physical mortality impact of adding that tonne of emissions, which is implicit within the SCC.

The Kaldor-Hicks approach uses the VSL estimate in each region *i* in each time period *t* and multiplies this by the MCC in each region *i* in each time period *t*. Since the VSL itself is an estimate of the willingness to pay for mortality risk reduction, Kaldor-Hicks values the lives of people in each place in each region at their estimated willingness to pay without additional adjustments. If the VSL has an income elasticity of 1, as is standard in policy analysis (Masterman and Viscusi

2018; Robinson, Hammitt, and O'Keeffe 2019; Viscusi and Masterman 2017), then lives in each region *i* and each time period *t* are valued proportionally to income, which implies that lives in developing countries are valued at a small fraction of lives in developed countries (see Figure 3 in section 4 for specific examples).

By contrast, the U.S. status quo approach estimates the average VSL across all regions being considered in each time period t. That is, the U.S. status quo approach accounts for average VSL growing over time if the average incomes across all regions also grow over time, but within a specific time period it values all lives equally. Since the SCC considers the global impacts of climate change, the U.S. Status Quo approach uses the global average VSL in each time period, $\overline{VSL_t}$.

Welfare weighting uses the exact same MCC and VSL value as the Kaldor-Hicks approach, $MCC_{i,t} * VSL_{i,t}$, but then it applies the additional welfare weight $\left(\frac{y_{x,1}}{y_{i,t}}\right)^{\eta}$ to this value, which accounts for diminishing marginal utility in each region in each time period. This welfare weight is not ad hoc; it is derived directly from the underlying explicitly defined SWF, which we show in detail in section 3. Recall that this same welfare weight is also applied to all other non-mortality benefits and costs within the same region and time period, a fact that also follows from the SWF derivation in section 3. While the income-elastic VSL term accounts for the fact that people in richer regions will tend to be willing to pay more to avoid mortality risk as they get richer, the welfare weighting term accounts for the fact that a marginal dollar is also less valuable to them as they get richer (Acland and Greenberg 2023; M. D. Adler 2016; Ferranna, Hammitt, and Robinson 2025; Fleurbaey and Abi-Rafeh 2016; Fleurbaey and Hammitt 2024; His Majesty's Treasury 2026; Mirrlees 1978; OMB 2023; Shrader and Mechanick 2026). As we show in section 3, these two terms exactly counteract each other when the curvature of the utility function, η, is exactly equal to the VSL elasticity ϵ, such that lives in all regions are valued exactly equally, like U.S. Status quo. If these values are different, this in principle accounts for real differences in preferences that individuals are estimated to have between life extension as they get richer vs. their diminishing marginal utility. Indeed, multiple lines of empirical and theoretical evidence show that VSL elasticity and utility curvature are linked, although much of the existing literature treats them as separate parameters (Eeckhoudt and Hammitt 2001; Kaplow 2005). But in any case, even when η and ϵ are different, the welfare weighting approach still values deaths caused by climate change much closer to equal than the Kaldor-Hicks approach (see Figure 3 for specific numerical examples).

2.2 Kaldor-Hicks BCA

As discussed, Kaldor-Hicks BCA involves estimating all costs and benefits in market (implicitly Negishi weighted) dollars, the benefits and costs can then be aggregated and assessed using the Kaldor-Hicks potential compensation criterion. A regulation passes the Kaldor-Hicks test, and yields a Kaldor-Hicks improvement, if those who benefit could fully compensate those who are harmed and still remain gainers, regardless of whether such compensation actually occurs (Robinson, Hammitt, and J. Zeckhauser 2016). As we show in equation (3), this is equivalent to achieving positive net benefits in a Negishi-Weighted Social Welfare function (see section 3.1 for formalism). Kaldor-Hicks improvements are often referred to as "potential Pareto improvements" because a Pareto improvement would occur if the winners of the policy were to fully compensate the losers of the policy. Pareto improvements – where at least some individuals are better off, and no individuals are worse off than before – are normatively attractive, and underly the theoretical support for efficient markets in the first and second fundamental welfare theorems of economics.

From its inception (John R. Hicks 1939; Kaldor 1939), a variety of technical and consistency issues were immediately found with the Kaldor-Hicks approach (R. W. Boadway 1974; Gorman 1955; Samuelson 1950; Scitovszky 1941), which we don't cover here. Instead, we focus on a more fundamental issue with the Kaldor-Hicks potential compensation criterion: why does the presence of a mere *potential* Pareto improvement matter if the compensation required to make an *actual* Pareto improvement does not in fact occur? This basic fundamental issue continues to be raised repeatedly over many decades (M. D. Adler 2016; Banzhaf 2023; Baumol 1946; Broome 2024; Kelleher 2025; Little 1957; Robbins 1981; Sen 1987).

Proponents of the potential compensation criterion address these issues in a few different ways, and the answer to this question is a crucial part of the justification for taking the Kaldor-Hicks approach. One line of argument is that regulations should focus on maximizing total resources, which can then be redistributed through tax and transfer programs, which are better tools for redistributing income than alternative means (Kaplow and Shavell 2009). However, this argument is disputed; others counter that, in fact, potential compensation is not synonymous with wealth maximization because it accounts neither for price changes caused by compensation payments[9] nor the costs of redistribution.[10] [11] But critics and proponents of the argument alike

[9] Boadway and Bruce (1984) show that because relative prices can change when post-project compensation is actually paid, a project can pass the formal Kaldor-Hicks benefit-cost test even when it does not in fact make Pareto improvements possible. This is because the prices people will face after compensation is paid may well differ from the prices they face before it is paid. If so, then if the project's "winners" are actually forced to pay the compensation, these winners may prefer the pre-project status quo to the post-compensation outcome.

[10] Hicks foresaw this problem in his original 1939 paper (John R. Hicks 1939): "Since almost every conceivable kind of compensation (re-arrangement of taxation, for example) must itself be expected to have some influence on production, the task of the welfare economist is not completed until he has envisaged the total effects of both sides of the proposed reform; he should not give his blessing to the reform until he has considered these total effects and judged them to be good. If, as will often happen, the best methods of compensation feasible involve some loss in productive efficiency, this loss will have to be taken into account;"

[11] R. Boadway and Keen (1993) observe that when a policy alters the value of the public good/private good bundle associated with a given amount of income, individuals may alter their labor-leisure choices. When some individuals

have noted that the assumption that tax and transfer programs are always the best tools for redistribution will not always hold (Kaplow and Shavell 1994; Liscow 2013; Markovits 2004; Sanchirico 2000b, 2000a) and critics have questioned the relevance of such arguments if redistribution is politically and practically possible through other tools (such as regulation) but not tax and transfer programs (Liscow 2018, 2021; Revesz 2018).

Another line of argument in favor of Kaldor-Hicks is that—over time—net "winners" and "losers" from regulatory changes will alternate, such that no groups are made systematically worse off from a broad portfolio of regulations (John R. Hicks 1941; Polinsky 1972). Critics of this argument argue that the potential compensation approach biases BCA in favor of the rich, and thus decisions made with this approach are systematically biased in favor of the rich as well (Liscow 2018).

Because of these concerns, Arrow et al. (1996) argue that the "modern version" of the compensation principle should ask "whether compensation is *likely* to occur, rather than whether it could *possibly* occur." Amartya Sen (1987) goes a step further by arguing that the Kaldor-Hicks potential compensation principle lacks utility as a concept, since either the compensation is expected to be paid to losers, in which case there is a Pareto improvement and it is redundant to appeal to the potential compensation principle, or compensation is not expected to be paid to losers, in which case an appeal to potential compensation is unconvincing. Sen concludes that the Kaldor-Hicks just ends up implicitly making the interpersonal utility comparisons that it sought to avoid when there are indeed winners and losers from a policy.

One additional argument against the Kaldor-Hicks approach of using an income-elastic VSL without offsetting marginal utility weights is what Daniel Hemel calls "expressive harms," i.e. "the harmful—though not easily quantifiable—effects of agency procedures and policies that predictably send a message to some that their lives are worth less" (Hemel 2022). Hemel argues that the mere fact that Regulatory Impact Assessments attach a higher value to some premature deaths than others may itself lead to an additional cost that should be considered. Hemel also argues that monetizing the deaths of the rich more than the poor is likely to sow mistrust not just in the government writ large, but more specifically it may undermine the enterprise of BCA itself. Finally, compared to the U.S. Status Quo approach, Kaldor-Hicks requires the use of an income-elastic VSL, which increases the information burden on analysts since they must gather information on the incomes of the populations whose mortality is impacted.

2.3 Welfare-Weighted BCA

Mechanically, welfare-weighted BCA begins the same way as Kaldor-Hicks BCA: by estimating all costs and benefits using market dollar-denominated willingness to pay, including the estimated individual willingness to pay to avoid premature mortality. After this, weights are

switch from labor to leisure in the presence of a distortionary tax, total wealth goes down. But Kaldor-Hicks BCA does not count that decline in total wealth as a cost.

applied to account for the fact that a marginal dollar is valued more by lower income people than higher income people (Acland and Greenberg 2023; M. D. Adler 2016; Ferranna, Hammitt, and Robinson 2025; Fleurbaey and Abi-Rafeh 2016; Fleurbaey and Hammitt 2024; His Majesty's Treasury 2026; Mirrlees 1978; OMB 2023; Shrader and Mechanick 2026), and these values are then renormalized to a common welfare-adjusted monetary unit (usually money in the hand of a person with median income, although any reference individual x can be used – see section 3 for details). As with the other BCA approaches, benefits and costs are then aggregated to determine if the benefits of some policy exceed the costs. The process of weighting for diminishing marginal utility transforms the numéraire from units of market money into welfare-weighted units of money, and thus the aggregated net benefits that are consistent with the underlying explicitly defined social welfare function (SWF).

Importantly, these weights are not chosen ad-hoc, but are derived from an explicitly defined social welfare function (SWF), an exercise we show in section 3. Most implementations of welfare-weighting use the standard utilitarian SWF, which has a long tradition in economics (Atkinson 1970; Harsanyi 1953, 1955; Lerner 1944; Vickrey 1945), and especially in climate economics (Anthoff and Emmerling 2019; Anthoff, Hepburn, and Tol 2009; Azar and Sterner 1996; Bressler et al. Forthcoming; Broome 2012; Errickson et al. 2021; Fankhauser, Tol, and Pearce 1997; Hope 2008; Kelleher 2025; Kolstad et al. 2014; Matthey and Bünger 2019; Prest et al. 2024). The utilitarian SWF accounts for the diminishing marginal utility of income across individuals. In the standard isoelastic utility setting, the η parameter, which represents the elasticity of the marginal utility of consumption, controls the curvature of the utility function (see section 3 for formalism). This η parameter can be estimated using multiple lines of evidence (Acland and Greenberg 2023; Groom and Maddison Pr. 2019).

The SWF and its subsequent weights can also be constructed not to match empirically estimated diminishing marginal utility of income, but to reflect societal distributional goals, which some call "equity weights" (Acland and Greenberg 2023). We focus here on welfare weights, which is consistent with the approach recommended in the 2023 OMB update to U.S. Benefit Cost Analysis Guidelines (OMB 2023). The U.K. has endorsed the use of welfare weighting for analysis of highly impactful regulations with substantial distributional effects (His Majesty's Treasury 2026), and Germany uses equity weighting for its SCC estimates (Matthey, Bünger, and Eser 2026). The U.S. government previously sanctioned the use of welfare weighting (using income as the numeraire) to be presented alongside a BCA that takes the status quo approach from 2023-2025 (OMB 2023).

As shown in section 3, under standard parameter values, the weights that account for diminishing marginal utility offset the differences in willingness to pay to avoid mortality so that premature deaths are valued at the same population-wide value after weighting (Kolstad et al. 2014; Somanathan 2006). In the standard case, this implies that although individuals may have quite divergent money-valued VSLs due to income differences, diminishing marginal utility perfectly explains this, which results in individuals across the income spectrum valuing their life equally in welfare terms.

There are multiple rationales for welfare-weighting BCA. First, like Kaldor-Hicks, it is Paretian: it will always score Pareto improving policies positively and policies that make all parties worse off negatively (Bergson 1938; Harsanyi 1955; Kaplow and Shavell 2001; Samuelson 1947) . Second, it is transparent: in comparison to the Kaldor-Hicks and U.S. status quo approaches that are consistent with underlying SWFs that are left implicit (see Figure 2), the welfare weighting approach is explicit about its normative choices because it is clearly derived from an explicitly stated SWF. This makes its normative choices around aggregation visible and open to sensitivity analysis. Third, the welfare weighting approach explicitly measures changes in social welfare. The implicit SWFs behind the other approaches are rarely defended as welfare measures in their own right; e.g. the case for Kaldor-Hicks instead rests on leaving distribution to the tax-and-transfer system, a rationale unavailable for global externalities (see section 4.3).

One drawback of welfare weighting is informational: analysts must know the economic circumstances of those bearing the benefits and costs (Hemel 2022), although this requirement is relaxed in the standard case where the welfare weight and income-elastic VSL exactly offset and all deaths are valued equally. In the SCC application the burden is modest in any case, because regional income projections are already inputs to the models (EPA 2023; Rennert et al. 2022). A second, more practical drawback is limited institutional experience. In the U.S., welfare weighting was sanctioned only briefly, in the 2023 Circular A-4, before its rescission in 2025 (OMB 2023). Guidance abroad is longer-standing, e.g., in the U.K. and (His Majesty's Treasury 2026; Matthey and Bünger 2019).

2.4 The Current U.S. Practice

The current U.S. practice is identical to the Kaldor-Hicks approach with one major exception: it attaches a single population-wide value to all premature deaths regardless of income or other factors. Although a poorer individual will tend to have a lower willingness-to-pay to avoid mortality risks than a richer individual, U.S. regulatory analysis does not make income adjustments to reflect this. Federal agencies have long used a single population average VSL to monetize excess deaths for all Americans, regardless of their income, race, gender, or other demographic factors. For instance, the U.S. Department of Transportation (Timothy 2021) and Homeland Security (Houser and Sunstein 2021) use a 2021 nationwide average VSL of $11.8 million and the Department of Health and Human Services uses a 2021 central VSL estimate of $11.6 million (US Department of Health and Human Services 2021). According to the 2000 EPA Science Advisory Board report that addressed this topic, monetizing excess deaths based on an income-varying VSL "raises difficult moral, ethical, and political issues about which the Committee is not and cannot be in full agreement.." and thus "…the Committee believes that

EPA should not abandon its approach — described in its Guidelines for Preparing Economic Analyses — of using a uniform VSL across populations that vary in the above socioeconomic attributes" (US EPA 2000).

Is the U.S. Status Quo approach consistent with the Kaldor-Hicks potential compensation criterion as has sometimes been claimed? No: the use of a single uniform VSL makes the U.S. Status Quo approach no longer consistent with the potential compensation criterion. This can be illustrated with an example: consider an agency deciding whether to allow a developer to build a factory whose primary cost is causing excess deaths from pollution in a downwind poor community. Although the U.S. average VSL is roughly $11 million, assume that this poor community's actual average VSL is only $5 million. Current U.S. practice would value the excess deaths in this community at the nationwide average $11 million value, whereas Kaldor-Hicks BCA would value those deaths at $5 million. If the BCA of allowing the factory to be built narrowly passes a Kaldor-Hicks potential compensation test valuing each life at $5 million, then it would not pass a benefit-cost test under current U.S. practice that values each life at $11 million. Although the winners of the policy (e.g., the factory's shareholders and consumers of the factory's products) could potentially compensate the losers (the poor community) for their incurred damages, this policy would have net costs under current U.S. practice. Now consider the same example but assume instead that the factory primarily causes excess deaths in a downwind rich community, whose average VSL is in fact $30 million. If the BCA for allowing the factory to be built narrowly passes the benefit-cost test under current U.S. practice, in which each excess death is valued at $11 million, then it would fail the Kaldor-Hicks potential compensation test where each excess death is valued at $30 million. In this case, although the winners of the policy cannot potentially compensate the losers – because the losers have a high VSL and demand large compensation for mortality damages – allowing the factory to be built would still pass the benefit-cost test under current U.S. practice. Furthermore, this difference is not a mere small technicality for U.S. regulatory BCA, e.g., 70% of the total benefits in BCAs of federal regulations historically are directly attributable to the monetized value of reducing mortality (Colmer 2020) and 85% of the benefits from the Clean Air Act Amendment are attributable to the reduction in premature mortality associated with reduction in ambient particulate matter (US EPA 2011).

Several studies in the academic literature have favored the U.S. status quo approach over other approaches for multiple reasons. First, it generally poses the fewest information burdens on analysts (Hemel 2022). Non-mortality benefits are estimated in the same way as Kaldor-Hicks, but less information is required to monetize mortality benefits compared to Kaldor-Hicks and welfare weighting. Because mortality benefits are all monetized with the same uniform VSL, the analyst does not need to collect information on the incomes associated with the estimated deaths caused or lives saved by the policy. Both Kaldor-Hicks and welfare weighting require the analyst to estimate the incomes of the population that is expected to have increased or decreased mortality as a result of the policy, in order to apply an income-elastic VSL. Other studies argue that the U.S. Status Quo Approach is normatively attractive because it welfare-weights mortality impacts implicitly (as we show in section 3) (Kniesner and Viscusi 2023). Stawasz (2026) argues that because the U.S. Status Quo approach is not as clearly tied to an underlying rationale as Kaldor-Hicks (the potential compensation test) or welfare-weighting (a social welfare function), the U.S. Status Quo approach is best supported by a variety of practical, political, and normative factors that he calls "pragmatic pluralism." Like Kaldor-Hicks, the U.S. Status Quo Approach does indeed implicitly define its own SWF as shown in figure 2 and section 3. However, also like Kaldor-Hicks, the underlying SWF is rarely used as a rationale to support the approach.

The U.S. status quo approach has one important drawback compared to both Kaldor-Hicks and Welfare-Weighting in terms of how it measures policies where individuals face tradeoffs between their own mortality risks and other benefits: in such cases it is not always Paretian, meaning that there are cases where it will score projects that make all parties better off negatively and projects that make all parties worse off positively (Banzhaf 2011, 2023; Kaplow and Shavell 2001; Sunstein 2004). This arises because the U.S. status quo implicitly welfare weights mortality impacts by using a population average VSL, while it applies no such weights to non-mortality benefits. Thus it tends to overprotect" the poor and "underprotect" the wealthy (Sunstein 2004). This Pareto violation has been described as a violation of "consumer sovereignty" and "autonomy," but this issue does not apply to externalities where one group's benefits impose costs on another group (Sunstein 2004). Welfare-weighted BCA avoids this issue by applying the same weighting factor to all mortality and non-mortality benefits and costs, and Kaldor-Hicks avoids this issue by not applying any adjustments to the willingness to pay across all mortality and non-mortality benefits and costs.

We can see how this violation of consumer sovereignty/autonomy works in practice by considering a few examples. Take potential regulations involving automobile safety. The government might justify regulations that increase automobile safety in budget cars by weighing the benefits and costs using a nationwide average VSL of $11 million. For poorer Americans who are more likely to buy such cars, and who have lower willingness to pay to avoid mortality risks, such a regulation may force them to buy vehicles with more expensive safety features than they would be willing to purchase themselves. For these poorer Americans, the costs of additional safety features outweigh the value that they place on the reduction in mortality risk. Such a regulation amounts to a "forced exchange," where some individuals are forced by the regulation to make purchases that they would not make themselves make. Such "forced exchanges" have important implications for autonomy. When regulators force their own views on individuals instead of making rules in a way that respects individuals' own free choices, Sunstein argues that this is "insulting their dignity," [12] and McGartland argues that this is a

[12] (Sunstein 2004): "WTP might be defended instead on the ground of personal autonomy. On this view, people should be sovereign over their own lives, and government should respect personal choices about how to use limited

violation of the "consumer sovereignty principle."[13] Both of these observations derive from the same underlying technical issue: the U.S. status quo is not Paretian because it implicitly welfare weights mortality impacts, but it does not welfare weight other categories of impacts. This causes the analysis to not respect the actual tradeoffs that individuals make between mortality reductions and other benefits, which can cause the analysis to score some regulations that make everyone better off negatively and regulations that make everyone worse off (such as the above example) positively when there are tradeoffs between individual mortality risk and other benefits, which violates the Pareto criterion. Welfare weighting and Kaldor-Hicks do not have this problem because they apply their explicit/implicit weights consistently across all categories of benefits and costs, so that the tradeoffs that individuals make across different categories of benefits and costs are respected.

However, these autonomy and consumer sovereignty issues do not apply when those that are benefitting from the regulation are not the ones paying the costs of the regulation. Take the example of the polluting factory above whose primary cost is causing deaths in the downwind poor community. Assume that the downwind community does not get any of the benefit of the factory's production. Monetizing excess deaths in the poor community at the nationwide average VSL of $11 million causes the project to fail the BCA test. This increases the welfare of the community because they do not bear the costs of the pollution and they are not getting any benefits from the factory. Furthermore, assigning the nationwide average VSL to the poor community instead of their true VSL of $5 million is not a violation of their autonomy or their consumer sovereignty, as it saves them from paying a cost on terms that they would find acceptable.[14] The community left up to its own devices would certainly prefer for the plant not to be built, as they only bear its costs without getting benefits.

Now consider the same case except that both the rich community (with an average VSL of $30 million) and the poor community (average VSL of $5 million) are downwind from the factory. Both communities bear costs but receive no benefits. We can see how the U.S. Status Quo Approach compares to the Kaldor-Hicks approach in this case: for Kaldor-hicks, excess

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resources (again so long as those choices are informed). When people decline to devote more than $60 to the elimination of a 1/100,000 risk, it is because they would prefer to spend the money in a way that seems to them more desirable. If regulators do not use people's actual judgments, then they are insulting their dignity."

[13] (McGartland 2021): "For there to be an increase in social welfare, Kaldor–Hicks requires a 'potential' Pareto improvement, which occurs when those who gain from the economic change would be willing to compensate the losers and still be better off. The rules of BCA, including the use of the consumer sovereignty principle, follow from this criterion. This means that BCA must value benefits and costs based on consumers' values, not what a policy maker in Washington thinks the benefits and costs are worth."

[14] See (Sunstein 2004): "The difficulty is that a high VSL, one that exceeds what WTP studies show for poor people, may produce outcomes that are in the best interest of poor people, in the sense that the result is a welfare improvement for them. And if poor people do not bear all of the costs of programs that benefit them, the autonomy argument for WTP is greatly reduced; they are enjoying a benefit (partly) for free, and it does not insult anyone's autonomy to give them a good on terms that they find acceptable."

deaths caused by the same pollution would be valued 6 times more in the rich community than in the poor community, whereas under current U.S. practice, deaths in both communities would be valued the same. Considering that the welfare and autonomy arguments no longer hold in this case, the unequal Kaldor-Hicks result may be difficult to justify. However, even in this case, one can still justify the Kaldor-Hicks approach if one believes that the tax system optimally redistributes income or if one assumes that the government's various regulations end up balancing out in the end so that no group is systematically left worse off, as discussed above. In any case, this requires one to believe that these arguments are empirically true

3. Formally Defining the Three Approaches to BCA

The utility of person i as a function of their consumption c in time t is given by $u_i\left(c_{i,t}\right)$.[15] Assuming isoelastic utility, this term becomes:

$$u_i\left(c_{i,t}\right) = \frac{{c_{i,t}}^{1-\eta}}{1-\eta}$$

Following, e.g. Anthoff, Hepburn, and Tol (2009) and Nordhaus (2017), define the Social Welfare Function (SWF) W as the aggregate of individual utility across the population of n people in time t across all the time periods considered in the analysis from time $t = 1$ to $t = T$, discounted by the discount factor r_t:

$$W = \sum_{t=1}^{t=T} \sum_{i=1}^{i=n} u_i\left(c_{i,t}\right) r_t$$

Note that utility can also be represented as a function of income. For example, the 2023 version of the U.S. guidelines for regulatory benefit cost analysis suggest income weights (OMB 2023), which are derived from an SWF that uses income as a numeraire instead of consumption, as does the UK Green Book (His Majesty's Treasury 2026). There are multiple reasons for this (Bressler, Shimberg, and Gillingham 2023). We choose to represent utility as a function of consumption here, but the same analysis applies when income is used as the numeraire. In figure 2 we show the underlying SWF and SCC mortality term in terms of income, which is consistent with policy guidance that suggests income weighting. Furthermore, great care must be taken to ensure that the choice of numeraire is consistent across all aspects of the analysis including discounting, weighting, and mortality valuation to avoid nonsensical results that can follow from such an inconsistency, like the phantom dismal theorem (Bressler, Shimberg, and Gillingham 2023).

[15] Utility can also be represented as a function of income. We choose to represent utility as a function of consumption here, but the same analysis could be applied in the former case as well. In addition, we can represent utility at the level of the individual *i*, or for a typical representative agent for a region *i*.

The Social Cost of Carbon (SCC) is equivalent to the marginal damage caused by marginal carbon dioxide emissions in some period, for instance in the period $t = 1$:

$$SCC_1 = \frac{\partial W}{\partial E_1} = \frac{\partial \sum_{t=1}^{t=T} \sum_{i=1}^{i=n} u_i(c_{i,t})\, r_t}{\partial E_1}$$

Assuming an exogenous discount factor:

$$SCC_1 = \frac{\partial W}{\partial E_1} = \sum_{t=1}^{t=T} \sum_{i=1}^{i=n} \frac{\partial u_i(c_{i,t})}{\partial E_1} r_t$$

Applying the Chain rule:

$$SCC_1 = \frac{\partial W}{\partial E_1} = \sum_{t=1}^{t=T} \sum_{i=1}^{i=n} \frac{\partial u_i(c_{i,t})}{\partial c_{i,t}} \frac{\partial c_{i,t}}{\partial E_1} r_t \tag{1}$$

Equation (1) is in units of welfare. As discussed in Anthoff, Hepburn, and Tol 2009, this SCC value can be used directly in BCA, but this tends to be inconvenient because other benefits and costs are usually measured in consumption-equivalent dollars. For practical application in BCA, this SCC should be converted into dollars. There are two ways to do this:

(1) Negishi Weighting
(2) Welfare Weighting

3.1 Negishi Weighting (Kaldor-Hicks)

The genesis of Negishi weights is (Negishi 1960) where the author shows that finding a competitive equilibrium of an economy can be cast as a problem of maximizing a weighted sum of consumer utilities subject to budget, production and resource constraints. If $U_i(C_i)$ is individual $i's$ utility from consuming vector C_i and $\alpha_i \geq 0, \sum \alpha_i = 1$ are weights, then maximizing $\sum U_i\,(C_i)\alpha_i$ subject to the constraints gives a competitive equilibrium. Negishi shows that at this equilibrium, the weights α_i are equal to the reciprocals of the marginal utilities of income, which are given by the values of the Lagrange multipliers on the consumers' budget constraints. In this model the weights determine the distribution of welfare, so that consumers with large weights have low marginal utilities and are rich, whereas those with low weights have high marginal utilities and are relatively poor. Any competitive equilibrium is associated with a set of Negishi weights, inversely related to marginal utilities, which "support" that equilibrium in the sense of Negishi's paper. Negishi's weights α_i are exogenous, whereas the Negishi weights used in BCA are endogenous, equaling the reciprocal of marginal utility.

Negishi weights weight each person i's utility by the inverse of their marginal utility. I.e., the Negishi weight $\alpha_{i,t} = 1/\frac{\partial u_i(c_{i,t})}{\partial c_{i,t}}$. Applying this to the welfare-denominated SCC in equation (1):

$$SCC_1 = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n} \alpha_{i,t} \frac{\partial u_i(c_{i,t})}{\partial c_{i,t}} \frac{\partial c_{i,t}}{\partial E_1} r_t = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n} \frac{1}{\frac{\partial u_i(c_{i,t})}{\partial c_{i,t}}} \frac{\partial u_i(c_{i,t})}{\partial c_{i,t}} \frac{\partial c_{i,t}}{\partial E_1} r_t = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n} \frac{\partial c_{i,t}}{\partial E_1} r_t \qquad (2)$$

Thus, Negishi weighting does two things here: (1) It converts the SCC into units of consumption-equivalent dollars, which makes the SCC more convenient to compare with other benefits and costs. (2) It defines a new SWF in consumption-equivalent units that undoes the transformation of consumption units into welfare units. We can see this by applying the antiderivative to equation (2) to extract the Negishi-Weighted SWF W:[16]

$$\int \frac{\partial W}{\partial E_1} dE_1 = \int \sum_{t=1}^{t=T}\sum_{i=1}^{i=n} \frac{\partial c_{i,t}}{\partial E_1} r_t dE_1 = W = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n} c_{i,t}\, r_t \qquad (3)$$

Thus, when the utility function is concave to account for diminishing marginal utility from consumption, the Negishi weight undoes this transformation so that utility is now linear instead of concave in consumption so that, e.g., a marginal dollar given to a rich individual with millions of dollars of consumption each year counts the same as a marginal dollar given to a poor individual with thousands of dollars of consumption each year.

The Negishi-weighted SWF is identical to the SWF that is implicitly used in the Kaldor-Hicks approach to BCA. We can see this because, as discussed above, a policy passes the Kaldor-Hicks potential compensation test if the winners gain enough from the policy to be able to potentially compensate the losers. This is equivalent to a policy change causing positive net benefits, i.e, leading to a positive change in the Negishi-Weighted SWF. That is, a policy passes the Kaldor-Hicks potential compensation test iff it leads to a positive change in the Negishi-Weighted SWF:

$$\Delta W > 0 \equiv \sum_{t=1}^{t=T}\sum_{i=1}^{i=n} \Delta c_{i,t}\, r_t > 0$$

[16] The antiderivative operator technically yields equation (3) plus some constant K: $\int \frac{\partial W}{\partial E_1} dE_1 = \int \sum_{t=1}^{t=T}\sum_{i=1}^{i=n} \frac{\partial c_{i,t}}{\partial E_1} r_t dE_1 = W = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n} c_{i,t}\, r_t + K$. However, in practice, the SWF in equation (3) will be used to compare the impact of multiple policies, and the K will just be subtracted out from both sides when policies are being evaluated, so for simplicity, we leave it out.

Going back to equation (2), the term $\frac{\partial c_{i,t}}{\partial E_1}$ accounts for all of the marginal damages from climate change in consumption equivalents for person (or location) *i* in time *t*. We can split this into mortality and non-mortality terms :

$$\frac{\partial c_{i,t}}{\partial E_1} = \frac{\partial k_{i,t}}{\partial E_1} - MCC_{i,t} * VSL_{i,t}$$

Where the $MCC_{i,t}$ is the mortality cost of carbon in location *i* in time *t*, which represents the marginal excess deaths in location *i* in time *t* in from adding a tonne of carbon dioxide in period 1 (see also Bressler 2025 for more detailed derivation and explanation). Under the Kaldor-Hicks approach, this is monetized by the VSL in location *i* in time *t*. $\frac{\partial k_{i,t}}{\partial E_1}$ represents the non-mortality monetized marginal damages in location *i* in time *t* from adding a tonne of carbon dioxide in period 1. The term $MCC_{i,t} * VSL_{i,t}$ represents the SCC mortality term shown in figure 2. We can plug this back into the SCC term in equation (2) to express the SCC with the SCC mortality and non-mortality terms broken out:

$$SCC_1 = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n}(\frac{\partial k_{i,t}}{\partial E_1} - MCC_{i,t} * VSL_{i,t})\, r_t$$

3.2 Welfare Weighting

We now consider (2) the welfare weighting approach. We start with equation (1), but instead of applying a Negishi weight, we apply a weight that retains the structure of the utility function while converting the SWF from units of welfare into units of dollars: $\mu_{x,1} = 1/\frac{\partial u_x(c_{x,1})}{\partial c_{x,1}}$. This represents the inverse of the marginal utility that some reference person x gets from consumption in time $t = 1$, as in, e.g., Anthoff, Hepburn, and Tol (2009) and Errickson et al. (2021). Thus, this factor converts the SCC from units of welfare into units of money as it is valued on the margin by the reference person x in $t = 1$:

$$SCC_1 = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n}\mu_{x,1}\frac{\partial u_i(c_{i,t})}{\partial c_{i,t}}\frac{\partial c_{i,t}}{\partial E_1}r_t = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n}\frac{\frac{\partial u_i(c_{i,t})}{\partial c_{i,t}}}{\frac{\partial u_x(c_{x,1})}{\partial c_{x,1}}}\frac{\partial c_{i,t}}{\partial E_1}r_t \quad (4)$$

Now, the consumption-equivalent impact from a marginal emission to person i in time t , $\frac{\partial c_{i,t}}{\partial E_1}$, is multiplied by the ratio of the marginal utility of that person and the marginal utility of reference person x in time $t = 1$. Thus, equation (4) represents the welfare-weighted SCC in the general case.

As with Negishi weighting, welfare weighting converts the SCC into units of consumption-equivalent dollars, which makes the SCC more convenient to compare with other benefits and costs. In addition, the Negishi-weighted SCC from equation (2) can actually be interpreted as a special case of the welfare-weighted SCC from equation (4). The Negishi-weighted version assumes that every individual has the same marginal utility of consumption in every time period as the marginal utility of consumption as the reference person x, i.e. $\frac{\partial u_i(c_{i,t})}{\partial c_{i,t}} = \frac{\partial u_x(c_{x,1})}{\partial c_{x,1}}$ $\forall i, t$, and thus $\frac{\frac{\partial u_i(c_{i,t})}{\partial c_{i,t}}}{\frac{\partial u_x(c_{x,1})}{\partial c_{x,1}}} = 1\ \forall i, t$. In other words, the Negishi-weighted SCC treats a marginal dollar to every person equally regardless of whether that person is rich with high consumption or poor with low consumption. This may be because person x is the same as person i $\forall i$ so that each individual's marginal utility of consumption is offset, so that net benefits are measured according to each person's own current dollar valuation of marginal consumption (Abbott and Fenichel 2014). Or it may be because it is assumed that every person i's marginal utility of consumption is equivalent to some individual agent x's marginal utility of consumption.

If we assume that all people have isoelastic utility with a common η curvature parameter, we can simplify equation (4) further:

$$SCC_1 = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n} \frac{\frac{\partial u_i(c_{i,t})}{\partial c_{i,t}}}{\frac{\partial u_x(c_{x,1})}{\partial c_{x,1}}} \frac{\partial c_{i,t}}{\partial E_1} r_t = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n} \frac{{c_{i,t}}^{-\eta}}{{c_{x,1}}^{-\eta}} \frac{\partial c_{i,t}}{\partial E_1} r_t = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n} (\frac{c_{x,1}}{c_{i,t}})^{\eta}\ \frac{\partial c_{i,t}}{\partial E_1} r_t \qquad (5)$$

In this setting, we can see that the consumption-equivalent damage for each person in time t from a marginal emission in time $t = 1$, $\frac{\partial c_{i,t}}{\partial E_1}$, is multiplied by the welfare weight $(\frac{c_{x,1}}{c_{i,t}})^{\eta}$. Thus, in the isoelastic utility setting, Negishi weights implicitly assume that $\eta = 0$ so that $(\frac{c_{x,1}}{c_{i,t}})^{\eta} = 1\ \forall c$. This implies that $u_i(c_{i,t}) = \frac{{c_{i,t}}^{1-\eta}}{1-\eta} = c_{i,t}$, i.e., utility is linear in consumption and $\frac{\partial u_i(c_{i,t})}{\partial c_{i,t}} = 1$.

We can split the marginal damage term $\frac{\partial c_{i,t}}{\partial E_1}$ into mortality component and non-mortality components following section 3.1. After doing this, the SCC equation becomes:

$$SCC_1 = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n} \left(\frac{c_{x,1}}{c_{i,t}}\right)^{\eta}\ (\frac{\partial k_{i,t}}{\partial E_1} - MCC_{i,t} * VSL_{i,t})\, r_t$$

Thus, the SCC mortality term in location i and time $\underline{t}$ is: $\left(\frac{c_{x,1}}{c_{i,t}}\right)^{\eta}\ MCC_{i,t} * VSL_{i,t}$, which is shown in figure 2. Although note, as described at the beginning of this section, we use a consumption numeraire for the analysis in this section, whereas figure 2 shows an income numeraire to align with recent policy guidance in the U.K and U.S. Regardless, the underlying analysis stays the same.

As with the special case of Negishi weighting, the more general weighting approach defines a new SWF in consumption-equivalent units. We can see this by applying the antiderivative to equation (4) to extract the welfare-weighted SWF W:[17]

$$\int \frac{\partial W}{\partial E_1} dE_1 = \int \sum_{t=1}^{t=T} \sum_{i=1}^{i=n} \frac{\frac{\partial u_i(c_{i,t})}{\partial c_{i,t}}}{\frac{\partial u_x(c_{x,1})}{\partial c_{x,1}}} \frac{\partial c_{i,t}}{\partial E_1} r_t dE_1 = W = \sum_{t=1}^{t=T} \sum_{i=1}^{i=n} \frac{u_i(c_{i,t})}{\frac{\partial u_x(c_{x,1})}{\partial c_{x,1}}} r_t$$

When utility is isoelastic, the SWF W becomes:

$$W = (c_{x,1})^{\eta} \sum_{t=1}^{t=T} \sum_{i=1}^{i=n} \frac{{c_{i,t}}^{1-\eta}}{1-\eta} r_t \qquad (6)$$

which is just a constant scaling of the standard underlying utilitarian SWF. As with the Negishi-weighted approach, we can also apply the Kaldor-Hicks potential compensation criterion to this SWF, provided that we make the assumption compensation is possible in dollars that are weighted to the reference person x. Under this assumption, a policy passes the Kaldor-Hicks potential compensation test if it leads to a positive change in the welfare-Weighted SWF.

3.3 Current U.S. Practice

Finally, we turn our attention to the current U.S. practice. Below we show that in the standard isoelastic utility setting with Ramsey discounting, using a uniform VSL implicitly welfare-weights premature mortality costs, but not other costs. Furthermore, when the VSL elasticity ϵ is equivalent to the curvature parameter of the utility function η, the current U.S. practice yields the same net benefit values for premature mortality as welfare weighting, provided that welfare weighting uses average VSL as the reference point.

The current U.S. practice SWF in consumption-equivalent units can be written formally as:

[17] The antiderivative operator technically yields equation (3) plus some constant K. However, in practice, the SWF in equation (3) will be used to compare the impact of multiple policies, and the K will just be subtracted out from both sides when policies are being evaluated, so for simplicity, we leave it out.

$$W = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n}(k_{i,t} - p_{i,t}\overline{VSL_t})r_t \tag{7}$$

Here, we define the new term $k_{i,t}$, which includes all net benefits in consumption-equivalents except for willingness to pay to avoid some mortality risk $p_{i,t}\overline{VSL_t}$, where $p_{i,t}$ is the probability of mortality from mortality risk p for person i in time t and $\overline{VSL_t}$ is the average value of statistical life in time t. As discussed above, the current U.S. practice is Negishi-weighted for all net benefits except for premature mortality risk, which is measured at a population average value.

We can define $VSL_{x,t}$ is the reference person x's VSL in time t, which in the case of U.S status quo is the population average VSL. As the reference person's consumption changes over time, their estimated VSL will change as well as a function of their VSL elasticity. We can use a benefits transfer methodology to estimate how the reference person's VSL will change over time based on their change in consumption using the VSL elasticity parameter ϵ (Robinson, Hammitt, and O'Keeffe 2019): [18]

$$VSL_{x,t} = VSL_{x,1}\left(\frac{c_{x,t}}{c_{x,1}}\right)^{\epsilon}$$

Thus, the current U.S. practice SWF is written formally as:

$$W = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n}(k_{i,t} - p_{i,t}VSL_{x,t})r_t = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n}(k_{i,t} - p_{i,t}VSL_{x,1}\left(\frac{c_{x,t}}{c_{x,1}}\right)^{\epsilon})r_t \tag{8}$$

So far, we have treated the discount factor r_t generally, only specifying that it is some function of time to capture a wide variety of potential discounting procedures. However, now, we will specify a particular discounting procedure: a stochastic discount factor that accounts for the reference person's diminishing marginal utility from consumption growth and the pure rate of time preference, ρ:

$$r_t = \frac{u'(c_{x,t})}{u'(c_{x,1})}\frac{1}{(1+\rho)^t}$$

In the isoelastic utility setting, this is (Rennert et al. 2022):

$$r_t = \left(\frac{c_{x,t}}{c_{x,1}}\right)^{-\eta}\frac{1}{(1+\rho)^t}$$

[18] Here, we represent the benefits transfer based on consumption instead of income to maintain consistency with the other equations, but the same logic holds if we use income everywhere instead of consumption.

Plugging this into equation (8):

$$W = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n}(k_{i,t} - p_{i,t}VSL_{x,1}\left(\frac{c_{x,t}}{c_{x,1}}\right)^{\epsilon})\left(\frac{c_{x,t}}{c_{x,1}}\right)^{-\eta}\frac{1}{(1+\rho)^t}$$

As discussed above, under standard parameter values $\eta = \epsilon$, thus:

$$\begin{aligned} W = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n}(k_{i,t} - p_{i,t}VSL_{x,1}\left(\frac{c_{x,t}}{c_{x,1}}\right)^{\eta})\left(\frac{c_{x,t}}{c_{x,1}}\right)^{-\eta}\frac{1}{(1+\rho)^t} \\ = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n}(\left(\frac{c_{x,t}}{c_{x,1}}\right)^{-\eta} k_{i,t} - p_{i,t}VSL_{x,1})\frac{1}{(1+\rho)^t} \\ = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n} k_{i,t}\, r_t - p_{i,t}VSL_{x,1}\frac{1}{(1+\rho)^t} \end{aligned} \tag{9}$$

The intuition here is that when there is Ramsey discounting and $\eta = \epsilon$ the reference person's VSL grows with consumption by the same rate that future dollars are discounted due to consumption growth, so that future mortality risk is only discounted by the pure rate of time preference ρ. Whereas non-mortality net benefits $k_{i,t}$ are discounted by the full discount factor $r_t = \left(\frac{c_{x,t}}{c_{x,1}}\right)^{-\eta}\frac{1}{(1+\rho)^t}$.

Now consider the fully welfare-weighted SWF to compare it to the U.S. status quo. Because the curvature of the utility function is accounted for in the welfare weight, the discount factor is now just a function of the pure rate of time preference (Anthoff, Hepburn, and Tol 2009):

$$W = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n}\left(\frac{c_{x,1}}{c_{i,t}}\right)^{\eta}(k_{i,t} - p_{i,t}VSL_{i,t})\frac{1}{(1+\rho)^t} \tag{10}$$

To get a best estimate of individual willingness to pay, ideally $VSL_{i,t}$ estimates would be available for all individuals in society and for all risks. However, such estimates are typically not available. Analysts must make estimates for individual VSLs based on broader group-based estimates. Although, as discussed above, individual VSL estimates vary across many dimensions—including the cause of death, income levels, individual risk preferences, and more— it is common in the BCA literature to only vary estimates for income (or consumption) based on the estimated VSL elasticity parameter, ϵ. Because many populations do not have VSL estimates available, it is common to employ a benefits transfer methodology to estimate a particular population's VSL based on another population's VSL estimates, the ratio of the populations' per capita income or consumption, and the VSL elasticity parameter ϵ (Robinson, Hammitt, and O'Keeffe 2019). Below, we calculate population i's VSL in period t based on reference population x's VSL in period 1, population i's per capita consumption in period t $c_{i,t}$, population x's per capita consumption in period t, and the consumption elasticity of VSL ϵ: [19]

$$VSL_{i,t} = VSL_{x,1}\left(\frac{c_{i,t}}{c_{x,1}}\right)^{\epsilon}$$

This is equivalent to:

$$VSL_{i,t} = VSL_{x,1}\left(\frac{c_{x,1}}{c_{i,t}}\right)^{-\epsilon}$$

Plugging this into the welfare-weighted SWF:

$$W = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n}\left(\frac{c_{x,1}}{c_{i,t}}\right)^{\eta} [k_{i,t} - p_{i,t}VSL_{x,1}\left(\frac{c_{x,1}}{c_{i,t}}\right)^{-\epsilon}]\frac{1}{(1+\rho)^t}$$

And then expanding:

$$W = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n}[\left(\frac{c_{x,1}}{c_{i,t}}\right)^{\eta} k_{i,t} - p_{i,t}VSL_{x,1}\left(\frac{c_{x,1}}{c_{i,t}}\right)^{\eta}\left(\frac{c_{x,1}}{c_{i,t}}\right)^{-\epsilon}]\frac{1}{(1+\rho)^t}$$

Yields:

$$W = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n}[\left(\frac{c_{x,1}}{c_{i,t}}\right)^{\eta} k_{i,t} - p_{i,t}VSL_{x,1}\left(\frac{c_{x,1}}{c_{i,t}}\right)^{\eta-\epsilon}]\frac{1}{(1+\rho)^t}$$

As discussed above, under standard parameter values $\eta = \epsilon$, which implies that although individuals may value their statistical lives differently in current dollar terms, they value statistical lives the same in welfare terms. When this is the case:

$$W = \sum_{t=1}^{t=T}\sum_{i=1}^{i=n}\left(\frac{c_{x,1}}{c_{i,t}}\right)^{\eta} k_{i,t}\left(\frac{1}{(1+\rho)^t}\right) - p_{i,t}VSL_{x,1}\frac{1}{(1+\rho)^t} \tag{11}$$

Thus, we can now see that mortality portion of welfare-weighted net benefits in equation, $p_{i,t}VSL_{x,1}\frac{1}{(1+\rho)^t}$, is equivalent in current U.S. practice BCA (equation 9) and fully welfare-weighted BCA (equation 11).

[19] Here, we represent the benefits transfer based on consumption instead of income to maintain consistency with the other equations, but the same logic holds if we use income everywhere instead of consumption.

4. How Climate Change Complicates BCA

In this section, we show that the rationales for taking the Kaldor-Hicks approach, and thus applying higher values to the deaths of the rich than the deaths of the poor, are much more challenged in the context of valuing climate damages than in domestic contexts, while the rationales for welfare weighting and U.S. status quo are comparatively stronger. In 4.1, we show that the Kaldor-Hicks approach of using an unadjusted income-elastic value for premature deaths creates especially large discrepancies in the international context compared to domestic contexts. Whereas the discrepancy between the value given to premature deaths using an income-elastic value between rich and poor U.S. states is 1.65:1, the discrepancy between rich and poor countries is on the order of 100:1. This places an especially large burden on the underlying rationale for taking such an approach to valuing premature deaths caused by GHG emissions. In sections 4.2-4.4, we show that such rationales are in fact much weaker in the climate context than in domestic contexts. In section 4.2, we show that those that pay the climate cost of emissions are largely not those that get the benefit of burning fossil fuels, so the autonomy and consumer sovereignty arguments that are made against the U.S. Status Quo approach (discussed in section 2.4) do not apply to climate change. In section 4.3, we show that arguments around compensation to losers—an important rationale for Kaldor-Hicks—are much less credible in the global GHG emissions context, in particular because there is no supra-national tax authority. And finally in section 4.4, we show that if income projections account for purchasing power parity, as is true for the latest generation estimates of the SCC that have most recently been used in policy (EPA 2023; Government of Canada 2023; Rennert et al. 2022), then the Kaldor-Hicks approach no longer satisfies its own potential compensation criterion, meaning that these estimates are not consistent with the Kaldor-Hicks approach. For these reasons, we conclude that arguments for the current U.S. approach and the welfare-weighting approach are comparatively stronger to the Kaldor-Hicks approach in the context of global externalities such as GHG emissions than in domestic settings.

4.1 A Globally Varying Income-Elastic Premature Death Value Creates Especially Large Discrepancies and Raises the Specter of Expressive Harms

Within the U.S., the largest income discrepancy between states is between Mississippi and New York, where New York has 1.65 the per capita income of Mississippi. Thus, under a Kaldor-Hicks approach to BCA that uses a proportional income-varying value to monetize premature mortality, 1.65 deaths in Mississippi would be valued the same as one premature death in New York. Globally, however, the differences are much greater. For instance, Germany has 87 times the GDP per capita of Niger. Thus, 87 premature deaths in Niger are valued the same as a single premature death in Germany. To give another example, under this approach, a single

Russian death is valued the same as 2.5 Ukrainian deaths. Figure 3 below provides an example illustrating how the three different approaches value lives across the highest and lowest income state in the US and across higher and lower income countries. The general point is to illustrate that the Kaldor-Hicks approach values lives in higher income countries at roughly 1 or 2 orders of magnitude more than lower income countries. Whereas the current U.S. practice values lives exactly equally while welfare weighting values lives either exactly equally or much closer to equally depending on the underlying parameter values.[20] Note that these income values are calculated based on market exchange rates, which is required to be consistent with the Kaldor-Hicks potential compensation principle (a point that we return to below).

Approach	New York : Mississippi (1.65x higher income)	Germany : India (24× higher income)	Germany : Niger (87× higher income)
Kaldor-Hicks *ε = 1*	**1 : 1.65**	**1 : 24**	**1 : 87**
Current U.S. Practice *uniform population-average VSL*	**1 : 1**	**1 : 1**	**1 : 1**
Welfare-Weighted — Standard *ε = 1, η = 1 (Used By Germany; "Standard Weighted BCA" – Hemel 2022)*	**1 : 1**	**1 : 1**	**1 : 1**
Welfare-Weighted (2023 Circular A-4) *ε = 1.5, η = 1.4*	**1 : 1.05**	**1 : 1.37**	**1 : 1.56**

Figure 3: How the three approaches to BCA value deaths in different regions with different levels of income.

These unpalatable results and large discrepancies place an especially large burden on the underlying rationale for using income-varying values to monetize premature deaths in this context, which we cover in more detail below. The 1995 IPCC case mentioned in the introduction of this paper suggests that such a practice is likely to cause backlash because of both its substantive (insofar as BCA guides decision making) and expressive harms. Especially because the poorest countries whose deaths are valued the least – such as most countries in sub-Saharan Africa and South Asia – represent only a small fraction of the historical responsibility for climate change (Ritchie 2019), and because the vast majority of deaths from climate change are projected to happen in those countries (Bressler 2025; Carleton et al. 2022; Gasparrini et al. 2017).

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[20] Note that multiple lines of empirical and theoretical evidence shows that VSL elasticity and utility curvature are linked, although much of the existing literature treats them as separate parameters. For instance, Eeckhoudt and Hammitt 2001; Kaplow 2005 develop theoretical models that show that the utility curvature and VSL elasticity parameters converge, while Hall and Jones 2007; Jones 2016 suggest that VSL elasticity should be greater than utility curvature.

4.2 Those that Benefit from Emissions Reductions Are Not the Same as those Paying for Emissions Reductions

As discussed in section 2, a major line of argument against the U.S. Status Quo approach to BCA is that its inconsistent application of weights across mortality and non-mortality categories overweights safety from mortality risk for the poor while and underweights safety from mortality risk for the rich. This issue causes the U.S. Status Quo approach to negatively score some policies that involve tradeoffs between individuals' own mortality risk and benefits and to positively score some policies that involve the same tradeoff (Banzhaf 2011, 2023; Kaplow and Shavell 2001). This is a violation of the Pareto principle, and some studies in the literature have called this a violation of autonomy and consumer sovereignty (McGartland 2021; Sunstein 2004). However, as discussed above, this issue does not apply to externalities where one group is gaining the benefits and imposing the costs on another group.

For climate change, the SCC is, by definition, the externality cost of adding a tonne of carbon dioxide. Thus, the autonomy/consumer-sovereignty arguments levied against the U.S. Status Quo approach do not apply in the case of climate change, because it is measuring the cost of an externality. When, for instance, individuals in the U.S. produce GHG emissions, they get the benefits of the energy produced, but only pay a small portion of the climate cost of those emissions. The climate cost, including the mortality cost, is spread throughout the whole world, and it is projected to be most severe in poorer countries. In this situation, countries outside the U.S. are not facing a tradeoff between consumption benefits and climate costs; they are only paying costs. Thus, the question facing the U.S. is how much to value the deaths its emissions are causing in different parts of the world. Such a decision cannot be justified on the grounds of respecting autonomy, consumer sovereignty, or the tradeoffs that individuals in poor countries make between consumption benefits and mortality risks, because they are facing no such tradeoff.

We can consider a theoretically similar example to make this clear: consider an international aid organization with a mission to improve health by making investments anywhere in the world. Would it make sense for this aid organization to use the Kaldor-Hicks approach to benefit cost analysis, which uses an income-varying VSL value without any adjustments? If it did, then it would be heavily privileging rich countries relative to poor countries, as Sunstein (2004) argues: "The fact that a poor person in a poor nation would be willing to pay $1 to eliminate a risk of 1/10,000, whereas a wealthy person in a wealthy nation would be willing to pay $100, cannot plausibly be used to defend the view that an international agency should devote its resources to the latter rather than the former." The case of climate change is theoretically analogous to this case since, e.g., the U.S. (or any other country determining the external cost of emitting carbon dioxide) must ask itself how to value the lives of the people across the whole world who are being impacted by its emissions.

4.3 Arguments Around Compensation to Losers Fail in the Context of GHGs

As discussed above, the Kaldor-Hicks approach aggregates individuals' willingness-to-pay using market (implicitly Negishi weighted) dollars and applying an income-elastic value to monetize excess mortality. An important line of argument in favor of this approach is that although the winners may not immediately compensate the losers, potential compensation is likely to occur in other forms in the future through tax-system transfers and other future rules where the winners and losers may be swapped. As the IPCC argued, however, full compensation for the contribution of domestic greenhouse gas emissions towards increasing premature mortality risk in other countries up to centuries in the future is conceptually difficult to estimate, and unlikely to occur (Kolstad et al. 2014).[21] Thus, arguments around compensation, which are plausible arguments in favor of the Kaldor-Hicks approach in the domestic context, fall apart in the climate change context.

To further illustrate the salience of this point: in 1991, a controversial world bank memo argued that toxic waste dumps should be placed in developing countries since the foregone earnings from increased morbidity and mortality is lower in those countries. (Hausman and McPherson 2006). This might seem a somewhat crude argument, but when compensation is considered, the rationale for valuing excess deaths from climate change less in poor countries and more in rich countries is demonstrably weaker than the rationale for dumping toxic waste in poor countries. In the dumping example, when a rich country dumps its toxic waste in a poor country, that poor country will demand compensation for the cost of taking on the rich country's waste. The poor country would estimate the number of excess deaths that such toxic waste is expected to cause, use their own internal VSL to monetize those deaths along with other costs, and then demand compensation that at least exceeds those costs. If the rich country agrees to pay at least this amount, a dumping deal can be agreed to that leaves both countries better off, and a Pareto improvement is achieved. If the rich country is not willing to pay the compensation, the poor country can turn down the offer and ask the rich country to look elsewhere for toxic waste dumping grounds.

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[21] See Kolstad et al. (2014): "It is sometimes assumed that CBA is conducted against the background of efficient markets and an optimal redistributive taxation system, so that the distribution of income can be taken as ideal from society's point of view. If that were true, it might reduce the need for distributional weights. But this is not an acceptable assumption for most projects aimed at climate change. Credit and risk-sharing markets are imperfect at the world level, global coordination is limited by agency problems, information is asymmetric, and no supra-national tax authority can reduce worldwide inequalities. Furthermore, intergenerational transfers are difficult. In any case, the power of taxation to redistribute income is limited because redistributive taxes create inefficiency (Mirrlees 1971). Even optimal taxation would therefore not remove the need for distributional weights. Thus, the assumption that incomes are (second-best) optimally redistributed does not neutralize the argument for welfare weights in aggregating costs and benefits."

For GHG emissions, the possibility that countries will pay compensation for damages is not credible, as the IPCC argues. As a result, GHG emissions are the theoretical equivalent of dumping toxic waste in other countries without giving them any payment for it. If compensation were credible, then using an SCC that monetizes premature deaths in poor countries at a much lower value and premature deaths in rich countries at a much higher value would theoretically match the World Bank dumping example, and Pareto improvements would occur. Even though rich countries would cause damage in poor countries from "dumping" GHGs in the atmosphere, those poor countries would be compensated for the damages, and all parties could be better off. However, such compensation is not credible in the GHG case, and no Pareto improvement follows. Thus, the strength of the case for following the Kaldor-Hicks approach and using different values for rich and poor (already hotly disputed in the domestic context) is at its nadir in the GHG context.

4.4 Purchasing-Power Parity Is Incompatible with Kaldor-Hicks

Finally, there is a practical issue facing the implementation of a Kaldor-Hicks approach to estimating the SCC. The income projections most commonly used in the SCC literature – the SSPs (Riahi et al. 2017) and the recently produced RFF-SPs (Rennert et al. 2021) that are used in the latest generation SCC models (Bressler et al. Forthcoming; EPA 2023; Prest et al. 2024; Rennert et al. 2022) – calculate country-level income projections using purchasing power parity (PPP) instead of market exchange rates. PPP transforms current prices into adjusted prices using weights that account for the ability of money in different places to purchase fixed bundles of goods and services. Like welfare-weighting, it tends to up-weight money in low-income areas and down-weight money in high-income areas.

The issue with PPP as it relates to the Kaldor-Hicks potential compensation principle is that it transforms net benefits from actual units of exchange (i.e. money at current market exchange rates) to another numéraire that – like welfare-weighted dollars – is hypothetical and is not an actual unit of exchange. PPP, like welfare-weighted dollars, adjusts the numéraire (money at current market exchange rates) to capture something that is economically important. In the case of PPP, this is the purchasing power of money. In the case of welfare weights, this is diminishing marginal utility. Both the PPP and welfare weighting conversions arguably convert the money numéraire into units that are more relevant to what a typical social planner would care about: the ability of money to buy goods and services and the welfare people get from those goods and services. But in both cases, this conversion undermines the appeal to the Kaldor-Hicks potential compensation criterion. This matters because the differences between market exchange rates and PPP-adjusted exchange rates are significant between developed and developing countries (where most climate damages are projected), up to a factor of 8 and typically a factor of 2-4x (see example below).

Thus, an approach that estimates all mortality and non-mortality net benefits in PPP adjusted dollars has the same claim to following the Kaldor-Hicks potential compensation principle as welfare-weighting: that is, it necessarily satisfies the Kaldor-Hicks potential compensation principle only if we grant ourselves a hypothetical unit of exchange — that hypothetical unit of exchange being PPP-adjusted dollars here and welfare-adjusted dollars for welfare weighting. If, as in the Kaldor-Hicks approach to BCA, we restrict compensation to units that actually exist as a unit of exchange, then a policy that yields positive net benefits measured in PPP-adjusted money no longer satisfies its own potential compensation criterion.

We can show this with an example: the current market exchange rate of a Nigerian Naira (NGN) to a Swiss Franc (CHF) is approximately 1,650:1.[22] That is, if one were to exchange Naira for Francs in financial markets, one could exchange 1,650 Naira for 1 Franc. However, when purchasing power parity is accounted for between Nigeria and Switzerland, this rate becomes approximately 210:1.[23] That is, 210 Naira could buy the same portion of a fixed basket of goods and services in Nigeria as 1 Franc could buy in Switzerland.

Now assume that one conducts a BCA of some policy in units of PPP adjusted Francs, and this policy yields 1M Francs in benefits to Switzerland, but -1.5M Francs in costs in Nigeria. Thus, this policy appears to yield -0.5M in net benefits. One may conclude that this policy does not pass the Kaldor-Hicks potential compensation test because there are net costs, and no potential Pareto improvement can be reached. We provide a summary of these calculations below in table 1.

However, this is incorrect. This policy actually *does* pass the Kaldor-Hicks potential compensation test. The problem with the above analysis is that it does not consider that the exchange rate between PPP adjusted money – like the exchange rate between welfare adjusted dollars – is hypothetical, and not the exchange rate that is available in the market. Consider that the Swiss can convert 0.2M Francs out of their 1M Francs in benefits into 330M Nigerian Naira at the 1,650:1 Naira:Franc market exchange rate and transfer those 330M Naira to Nigeria. After this transaction, the Swiss end up with 0.8M Francs in net benefits. Recall that the policy caused -1.5M PPP adjusted Francs in costs to the Nigerians. After the transfer, the Nigerians have an extra 330M Naira. Converting this into PPP adjusted Francs yields:
$330M\ Naira\left(\frac{1\ PPP\ adjusted\ Franc}{210\ Naira}\right) = 1.57M\ PPP\ adjusted\ Franc$. Thus, after the transfer, the Nigerians have 0.07M PPP adjusted Francs in net benefits. Thus, as long as the transfer occurs, both the Nigerians and the Swiss enjoy net benefits (0.87M PPP adjusted Francs in total), and

[22] As of September 19, 2026; see https://www.xe.com/currencyconverter/convert/?From=CHF&To=NGN

[23] The PPP rate between Naira and Swiss Francs is the ratio of the two countries' PPP conversion factors. Using the IMF's implied PPP conversion rates for 2025 of roughly 195 Naira and 0.94 Swiss Francs per international dollar https://www.imf.org/external/datamapper/PPPEX@WEO/OEMDC/ADVEC/WEOWORLD, this gives 195/0.94 ≈ 210 Naira per PPP-adjusted Franc.

thus a Pareto improvement results.

Table 1: BCA using PPP-Adjusted Francs

	Net benefits before transfer (PPP-adj. CHF)	Transfer (PPP-adj. CHF)	Net benefits after transfer (PPP-adj. CHF)
Switzerland	1.00M	−0.20M	0.80M
Nigeria	−1.50M	1.57M	0.07M
Total	−0.50M	1.37M	0.87M

A simpler and more straightforward way to see this is just to convert the numéraire for the BCA into units of money at market exchange rates from the beginning, which we show below in table 2. Since in this analysis we are conducting the PPP adjustment based on Swiss Francs so that 1 PPP adjusted Swiss Franc is equivalent to 1 market Franc, we only need to convert the Nigerian costs from PPP adjusted Francs into market-exchange rate Francs, which we do with the following equation:

$$-1.5M\ PPP\ Adjusted\ Francs\left(\frac{210\ Naira}{1\ PPP\ Adjusted\ Francs}\right)\left(\frac{1\ \ Franc}{1650\ Naira}\right) = -0.19M\ Francs$$

Thus, once we do this conversion, we see that the benefits to Switzerland (1M Francs) exceed the costs to Nigeria (0.19M Francs), yielding net benefits (0.81M Francs), thus implying that there is indeed a potential Pareto improvement, as we saw above.

Table 2: BCA using Market Exchange Rate Francs

	Net benefits (market-exchange-rate CHF)
Switzerland	1.00M
Nigeria	−0.19M
Total	0.81M

As this example shows, if benefits and costs are measured in a numéraire that doesn't represent an actual available unit of exchange, then BCA conducted with such a numéraire cannot claim to be supported by the Kaldor-Hicks potential compensation criterion. The only way to ensure that the Kaldor-Hicks potential compensation criterion is satisfied is to measure all costs and benefits in money at market exchange rates. Thus, in the context of the SCC, one would need to estimate the SCC using socioeconomic projections and damage estimates measured in money at market exchange rates as opposed to PPP adjusted money to claim to be following the Kaldor-Hicks approach to BCA. The downside of doing so is that it does not track what an analyst or policymaker would naturally care about: the change in real consumption that is experienced by those affected. This, however, is not the underlying principle that defines the Kaldor-Hicks approach to BCA; the potential compensation principle is. And the potential compensation principle requires benefits and costs to be measured in actual (not hypothetical) units of exchange. All of the latest generation SCC projections that have most recently been used in policy (e.g, EPA 2023; Government of Canada 2023; Rennert et al. 2022) use PPP adjustments, meaning that these estimates are not consistent with the Kaldor-Hicks approach. Because these estimates are also neither consistent with the U.S. Status Quo approach nor welfare weighting, they have been called "Quasi-Kaldor-Hicks" since they follow the underlying rationale of Kaldor-Hicks in measuring the SCC in willingness to pay values without welfare weights, but they are not actually consistent with the Kaldor-Hicks approach (Bressler 2025).

5. Conclusion

Better models have made the valuation of premature deaths the most consequential choice in calculating the SCC. We draw three conclusions. First, because monetizing these deaths is normatively contested, the mortality cost of carbon implicit in every SCC estimate should be reported in physical units before any monetization, as is standard for other impact categories in BCA. Second, the rationales for taking the Kaldor-Hicks approach of valuing richer lives more than poorer lives, especially the idea that winners could be compensated through a tax and transfer system, do not extend to a global, intergenerational externality, and the potential compensation test itself fails when damages are measured in PPP-adjusted dollars. What remains is a Negishi-weighted social welfare function that is rarely defended on its own terms. Third, the U.S. status quo and welfare weighting rest on firmer ground in this setting, and under standard parameter values they value deaths equally or nearly so. Governments already decline to value richer lives more than poorer lives in domestic BCA, where the case for doing so is strongest; climate change is a poor place to start.

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