CHAPTER 23

The Ethics of Measuring Climate Change Impacts

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**Abstract**

This chapter qualitatively lays out some of the ways that climate change impacts are evaluated in integrated assessment models (IAMs). Putting aside the physical representations of these models, it first discusses some key social or structural assumptions, such as the damage functions and the way growth is modelled. Second, it turns to the moral assumptions, including parameters associated with intertemporal evaluation and interpersonal inequality aversion, but also assumptions in population ethics about how different-sized populations are compared and how we think about distributing goods across or within times. The intention is to survey the morally important assumptions that go into estimates of the social cost of carbon, the costs of carbon dioxide to society.

**Keywords:** climate change, climate ethics, climate impacts, integrated assessment models, mitigation, social cost of carbon, philosophy of economics

# Introduction

On the one hand, estimating the economic costs of climate impacts involves physical, social, and moral uncertainties, making estimation difficult and sensitive to assumptions. On the other hand, without estimates of those costs to guide policy, we would be adrift with respect to optimal policy choice. In particular, if trying to generate the appropriate balance of costs and benefits from marginal emissions, we need some estimates of the effects that those emissions will cause.

There are ways around requiring estimates of these economic costs. Instead of the more comprehensive *cost-benefit analysis* (CBA), we could adopt *cost-effectiveness analysis* (CEA), where we adopt some exogenously given intended target (e.g. from a political decision-maker), and the question is how to most inexpensively reach that target. For instance, we might think that it is important to get to net-zero greenhouse gas emissions by 2050, and the question is just how to get there with least cost (CEA) instead of whether, all things considered, that is the optimal or appropriate target (CBA) [1].

However, this is insufficient for more ambitious intentions such as if the goal is to internalize the climate externality from emissions [2]. For instance, if we wish to introduce optimal carbon taxes, this will require estimates of the economic costs of these climate impacts. Carbon taxes are influential, and also interact with other conditions and circumstances (e.g. including the coronavirus disease 2019 (COVID-19) context [3].

The primary economic concept for these costs is the *social cost of carbon* (SCC), which is an estimate of the cost to society of a marginal ton of CO2 (i.e. the SCC is usually expressed in terms of USD/tCO2) [4].

One of the key tools used to estimate the SCC are *integrated assessment models* (IAMs) which combine simple climate modules with simple economic modules. For concreteness, this chapter will focus on models similar to *DICE-2016R2* (DICE stands for “Dynamic Integrated Climate-Economy”) models [5] but, as the discussion here is more methodological than quantitative, they apply to many similar models [6].

To start with, we can set aside the physical components of these models. They are relatively simple: an atmospheric stock of CO2 drives temperatures and CO2 decays as it settles through ocean layers [7]. The issues of interest here arise in the factual and moral assumptions. Section 2 discusses several key factual assumptions pertaining to the economics. Here, ‘factual assumptions’ means economic phenomena that are in principle observable without moral evaluation. Section 3 discusses the moral assumptions which have to do with how the states of the model are valued, where this can be subject to, inter alia, how wide the scope of evaluation is (e.g. does it consider regional/national or international impacts) or how future impacts are to be traded off against current ones. Section 4 concludes with an overview of the moral importance of considering modelling assumptions.

# Factual Assumptions

This Section addresses several key structural economic assumptions, identifying them as factual (or non-moral) because they are in principle observable given sufficient macroeconomic or population information. The difference between considerations in this and the next Section is sometimes expressed as the difference between positive and normative economics, or between descriptive and prescriptive economics, where the former is meant to be based on observed values and the latter involves moral judgment [8][9]. For instance, we can observe that the mean member of a population saves at a particular rate which implies a certain level of discounting or care about long-term consumption behaviour, but for prescriptive or normative purposes that does not settle the normative question of how society *should* or *ought* to consider the future [10][11].

The assumptions in this Section are not normative or prescriptive in this sense; they are in principle observable in an unproblematic way. That is not to say that they are *easy* to observe. It may be that it will take a long time either to analyse or to collect the relevant information. For instance, with damage functions about responsiveness to climate change we may have to make decisions before we have observed the relevant harms and before we are able to base the damage functional forms on observed data. However, it is still factual in the sense adverted here because afterwards if we had sufficient data, we could in principle observe the impact of various mean surface temperatures on consumption and production—and we could do so without making moral judgments.

The structural assumptions discussed here are as follows:

1. consumption—its measurement and homogeneity;
2. equality of consumption—the distribution of consumption and ways of relaxing this assumption;
3. endogenous versus exogenous growth—the total factor productivity growth and climate impacts on it; and
4. damage functions—the functional form of various damage functions.

## Consumption

One key structural assumption in most models is that all costs and benefits to the public at large are expressed in terms of consumption equivalents. Whatever goods and services are being demanded, there is a homogenous good which we call *consumption* (usually represented *c*) that it can be converted into. This is necessary because climate impacts are not directly expressed in currency; the SCCs require the assumption that those impacts can be expressed in monetary equivalents. In practice, consumption can be measured or estimated by using a financial currency like dollars which are fungible and can be used to purchase goods of various types.

Some environmental theorists reject this assumption. They point out that some of the systems affected by climate change, like wetlands and tropical forests, provide *ecosystem services*, or contributions of the natural world to goods people value. These ecosystem services, they worry, are either (i) difficult to price in markets, and thus to convert into consumption via financial currency, especially when they are taken to have intrinsic value; or (ii) difficult to exchange for other forms of consumption in principle.

In terms of the first difficulty, pricing goods, it is correct that ecosystem services are rarely priced in markets, and if reflected in market prices, usually indirectly. However, familiar valuation methods from economics can be used even for environmental and ecosystem services, ranging from adjusted market prices (where market prices are adjusted for distortions); production function methods (where the ecosystem service is taken to be an input to a production function and valued according to its effect on output); revealed preference methods (where some choices are observed and valuations inferred from the selections made); and stated preference methods (where choices are posited and valuers indicate their preferences in surveys) [12].

In terms of the second difficulty, substitutability, it is true that there are limited substitution options for some ecosystem services. However, this is standardly accommodated by positing rapidly increasing marginal value as the services are reduced or degraded [12]. However, some believe this is not enough. They distinguish between weak and strong sustainability, where *weak sustainability* indicates that we can in principle substitute between consumption and natural capital providing ecosystem services and *strong sustainability* indicates that the damages to ecosystems and services are in principle not substitutable with respect to other types of consumption (e.g. Norton distinguishes between ‘natural capital’ and ‘human built capital’ [13]). Doing so requires more than simply thinking some ecosystem services are very valuable; it requires the stronger claim that without some (minimal) level of ecosystem services, there can be no meaningful type of well-being, regardless of the level of human built capital. Intuitively, there is no level of human consumption that can make up for degraded natural capital. An influential economic analysis which distinguish between human built capital and environmental capital finds that this distinction can greatly increase the SCC [14].

## Equal per capita consumption

Even granting that we can measure the climate impacts in terms of a single homogenous good, which we call consumption, many IAMs further simplify by assuming that the good is spread evenly, or that we are considering a representative median agent, or that the world is represented by a single homogenous region. All of these ways of simplifying avoid the actual heterogeneity of consumption. Taking a representative agent which effectively ignores this heterogeneity may appear to be a worrying structural assumption.

There is an important reason that equal per capita consumption is assumed. First, each agent has a utility function which translates consumption to utility. If consumption can be costlessly shared and utility functions are identical (both idealising assumptions), then the most preferable distribution of consumption is a uniform distribution. Subsection 24.3.4 expands on these utility functions, which are key moral assumptions in the model.

Given these identical agents and uniform consumption distributions, it is more tractable computationally to have a single region with a single agent. However, this assumption can and has been relaxed. This assumption can be relaxed by taking an outcome which is equivalently valued to the uniform distribution, or by making the model itself more complex.

The first option is straightforward. For any given heterogenous consumption in a population, we can find the hypothetical level of perfectly equally distributed consumption that would match it in value. This hypothetical level is the ‘equally distributed equivalent’ (EDE) (e.g. [4]). In this manner, working with a homogenous population can be thought of as the proxy for all of the heterogenous distributions taken to be equivalent by the objective function which represents the goals of the model (sometimes a social welfare or value function).

The second option is to explicitly model regional or spatial inequality. First, the DICE model, which uses a single world region, also has a ‘regional’ counterpart called RICE [15]. Second, we can add greater regional heterogeneity by having various income levels within regions, yielding a ‘nested inequality’ counterparts of DICE called NICE [16] [17]. The NICE authors find that, if we are averse to inequality, that points both *against* sending resources to the (presumably richer) future and *for* sending resources to those worse-off in the future who, on heterogenous models, may be poor like the present poor even when mean consumption has risen in the future. But the extent of these effects depends on whether the climate damages are proportional to wealth or more or less than proportional. Both are plausible; it could be that having greater wealth means that you have more and more valuable capital at risk to various extreme events or it could be that having greater wealth means having greater adaptive and protective capacity so that more capital is shielded from climate impacts.

The key point is that, while many climate IAMs are highly simplified, the structural assumptions that yield their simplifications can be relaxed with more data and computing power. With more heterogenous populations, we can have more complex policy analysis but also more realistic outcomes to evaluate.

## Endogenous versus exogenous growth

In IAMs like DICE, growth of consumption is given by a combination of exogenous factors that exponentially increase total production. These factors are the number of producers, or labour, and an (assumed) increasing productivity for any given level of labour and capital. A key assumption in the standard models is that the growth is exogenous, meaning that its increase is mostly independent of the other parameters involved in production. (Mostly, because damage in a year can lead to losses in future productivity by, for instance, reducing the amount of savings. But this is a relatively indirect mechanism for climate impacts to harm growth prospects.)

In response to this, Dietz and Stern suggest an extension of DICE which incorporates endogenous growth by expanding the ways that climate impacts could harm growth [7]. First, they suggest that it could either reduce the capital stock, via mechanisms like loss of built environment in the face of coastal incursion, or could reduce the productivity of capital, via mechanisms like poorer infrastructure performance in changing environmental conditions. Second, they suggest that climate impacts could reduce the total factor productivity. In other words, given the same capital and labour inputs in subsequent periods, you have less production. For instance, in a warming climate, people may be uncomfortable and move more slowly leading to less productive economic activity.

Stern pointed out that modelling growth as endogenous in climate context makes the downside risk much greater [18]. If there are ways that climate could damage the trajectory of economic activity, that is much worse than having annual climate costs, since a single hit to productivity permanently damages growth whereas the annual climate costs are each temporary.

## Damage functions

One of the most difficult structural assumptions involve the functional form and calibration of damage functions. Almost by definition, climate changed impacts will be unlike those previously observed so extrapolation is highly uncertain. Some economists, like Robert Pindyck claim that the damage functions are so indefensible empirically or theoretically that they should be viewed as little more than crude guesses [19] [20]. This is exacerbated by the limited incentives for improving damage functions in IAMs. Indeed, for related reasons, Nordhaus designated the damage functions ‘placeholders subject to further research’ [21].

The standard reduced form damage function in DICE is quadratic:

where is the damage at time , and is the global mean temperature at time . The parameters and are estimated by fitting the damage function to various expected costs at particular temperatures. However, since observed temperatures have not varied outside of a range of C for millennia, this fitting is highly speculative. Furthermore, even if points at low temperatures are correct, they underdetermine the functional form beyond those temperatures.

Recent alternative ways of estimating the effects of temperature rise have drawn on large datasets of *local* climate anomalies to distinguish potential effects on human behaviour and macroeconomic variables. These new empirical techniques might be more successful than the discussions of the functional forms of damages. For instance, we can run statistical analyses on large-n samples [22] [23] [24]. By comparing longitudinally (comparisons within regions) as opposed to cross-sectionally (comparisons across regions), it is easier to avoid cultural and other factors that might lead to spurious correlations. Roughly speaking, the idea is that by looking at the same regions over longer historical periods, we have a large number of data points which we can analyze in terms of the deviation from historical norms and index to social outcomes of interest (whether social outcomes like violent conflict or macroeconomic factors like productivity). They find various relationships, but several of them are roughly u-shaped, in that deviations both colder and warmer from the mean correlate with increases in the social outcomes of interest, e.g. increased conflict both when it is colder and warmer than average. Of course, even these new methods run up against the predictive limitations of data when future weather is far outside the norm; in these cases, there are fewer historical cases and more uncertainty. Assuming the climate continues to warm, these limits on observation matter.

These ways of estimating the damages from climate impacts help address the structural assumptions involved in damage functions. While more drastic changes in climate will outrun the observed weather events, it is certainly the case that it has remained difficult to improve and calibrate these damage functions.

Having introduced some important factual or structural assumptions, we can now turn to the moral assumptions.

# Moral Assumptions

This Section discusses moral assumptions and introduces arguments for various choices. The primary intentions are to give a sense of the variety of moral assumptions that are taken for granted in SSC estimates and to introduce some alternatives to the standard assumptions.

## Utilitarianism versus other moral theories

The most prominent moral assumption in calculating the cost of climate impacts is the moral theory adopted. DICE is implicitly committed to *(total) discounted utilitarianism*, a particular member of the family of theories called *consequentialist*. Total discounted utilitarianism means that evaluation of actions is conducted solely in terms of outcomes (consequentialism), the value of those outcomes is governed by the sum of utility (where utility is an increasing function of consumption) (total), all the utilities at a time are valued equally (utilitarianism), but future utility is discounted to generate a net present value (discounted). All of these assumptions can be relaxed. For our purposes, we can be agnostic between various different interpretations of utility, but the classical interpretations are pleasure and satisfaction of preferences, with the latter having been especially influential in economics.

A moral theory that does not evaluate actions purely in terms of outcomes is *deontological*. For these theories, some actions are ruled out as morally impermissible because, for instance, they violate rights or side-constraints. That means that an action could have very positive consequences overall but might involve sacrificing or killing an innocent; deontological theories will rule out this type of action as immoral or impermissible regardless of the consequences (or perhaps the consequences are weighted very lightly or only relevant in terms of tie-breaking). In the context of climate economics, if we are considering actions that might be side-constraints which cannot be violated, then IAMs and similar tools are unnecessary. We could model this by increasing the social cost of such actions to very high finite values or infinite values, but these options introduce further complexities having to do with comparing risk with large finite or infinite disvalues [25]. Alternatively, we can have a two-step procedure where an act is first checked for its permissibility and then subjected to CBA.

Setting such deontological side-constraints to the side, we have *consequentialist* theories which evaluate actions purely in terms of outcomes, whether actual or expected. The most common class of consequentialist theories evaluate actions purely by considering outcomes in terms of utility. If the utilities at a time are unweighted in the evaluation, then we have *utilitarianism*. If they are weighted, then we have one of several variations on utilitarianism. Before considering utilitarianism, we can consider two particular ways of weighting utilities which are of especial interest in climate economics. The first because it is commonly done and the second because it yields an interesting class of moral theories. The first is *Negishi weighting*, where subpopulations are weighted in such a way that the weights are proportional to the inverse of the marginal utility meaning that the subpopulational distribution of consumption is optimal, regardless of the shape or pattern of distribution (e.g. [26]). The ostensive purpose of this is to remove moral evaluation of extant distributions, yielding some type of value-freedom [4], but of course Negishi weighting introduces its own value-judgments: current distributions, whatever they are, are taken to be morally justifiable (at least from the optimising utilitarian perspective).

The second variation for weighting utility is where those with lower utility are weighed more heavily. This yields some form of *prioritarianism*, since (moral) priority is given to those who have less utility. In *deterministic* contexts (where the outcome is known or correctly believed conditional on actions chosen), this can be difficult to distinguish from utilitarianism, since utilitarians already give priority to those with less consumption (which we can take to indicate financial means), so prioritarianism just indicates that there is another weighting on top of the utilitarian one. In these contexts, there is an additional moral question: not only do we need to determine the elasticity of marginal utility of consumption (discussed in Subsection 23.3.3), but we also need to determine the degree of priority of those at a lower level of utility [27] [28].

If we do not weight the utility, then all utility is valued equally (e.g. regardless of who it accrues to). This yields *utilitarianism*. Note that valuing all utility equally does not imply—and under normal assumptions rejects—the claim that all *consumption* is valued equally. That is because it is assumed that marginal consumption generates greater utility when it is given to those with lower initial consumption. This chapter takes the degree of this effect to be a moral issue about how much we are averse to consumption inequality in society, and is discussed in Subsection 23.3.3.

However, even if we take all the simultaneous (intratemporal) utility to be equally valuable, it does not follow that we weight future (intertemporal) utility to be equally valuable. If we do take it all equally, we have *total (undiscounted) utilitarianism*. If we weight future utility less when evaluating outcomes, then we have *total discounted utilitarianism*. The next Subsection discusses reasons for both of these positions.

## Time preference/discounting

One of the most highly debated moral assumptions in IAMs arises out of the discounting problem, that is the issue of how (future) costs and benefits are ‘discounted’ to make them comparable in present terms (overviews include [29], [30], [31] and [32], which this Subsection draws on).

One important point to recognise is that economists tend to talk about discounting in impure, or consumption terms, since they are concerned with more observable and measurable units whereas philosophers tend to talk about discounting in pure, or utility/welfare terms, since they are concerned with the morally relevant units and consumption is not intrinsically valuable. This has led to some confusion in ethical discussions, as discounting in pure and impure terms are not directly comparable. This is especially challenging in contexts where ‘the discount rate’ is ambiguously invoked.

The key to time preference in standard IAMs is the Ramsey Rule [33] [34]. The Ramsey Rule involves discounting in terms of the consumption of individuals. It governs the optimal consumption path given some common assumptions—and is technically an approximation. It can be stated in a very compact form which relates the social discount rate on the left-hand side to what is sometimes called the social rate of time preference on the right-hand side.

The social rate of time preference is the sum of the pure rate of time preference (the Greek letter , “delta”) and a term which is the product of the growth rate of consumption and the elasticity of marginal utility of consumption (the Greek letter , “eta”), which is discussed at greater length in the following Subsection 23.3.3:

Intuitively, discounting of consumption depends on both pure discounting, that is, factors which are not particular to consumption but time itself (or things correlated with time) () and the diminishing marginal value of consumption as consumption grows (). It may also helpful to think of pure discounting as discounting applied in the pure units of utility or welfare, i.e. as a utility discount rate. To give a sense of potential values, is usually taken to be between 0 and 0.015 (i.e. 0 to 1.5% per year);  is usually taken to be anywhere between 0.5 and 4; and g is usually taken to be between 0.01 and 0.03 (i.e. 1 to 3% per year).

There are two morally interesting questions regarding discounting. The first is what arguments can be adduced for a positive and whether any of these are convincing; the second is what the role of is and how it should be determined. The first of these is discussed in this Subsection; the second in the following Subsection. Here, the growth rate of consumption can be set aside, because its value is factual or non-moral in the sense that if we have sufficient macroeconomic data about consumption patterns, we do not need to make moral judgments to indicate at what rate consumption grows.

While the vast majority of moral philosophers think that pure time preference is immoral (indeed, the creator of the optimal savings approach advocated a zero rate of pure time preference Ramsey [35]), there are notable dissenters. The common view amongst philosophers is that the IAMs are utilitarian (or at least consequentialist) and utilitarianism is committed to impartial increase in utility. Impartiality requires treating utility at different times equally so pure discounting is immoral [10] [31]. Here, I will discuss two reasons for questioning the common view.

First, we might think that our connections to those further away are weaker, and Arrow argues that it is reasonable to consider them less heavily since we have ‘agent-centred prerogatives’ to weight them less [36], drawing on [37]. This is a *permission*; we are allowed to count them less according to this view since we are able to prioritise our own connections and projects. Arrow claims that this arises because the cost to our own connections and projects would be overwhelming or overdemanding if we did not have a positive pure time preference.

Second, we might distinguish between the present value of the future from the eventual value [38] and emphasise that there are important differences between the future as viewed from the present and at that point. As indicated before, positive values of can be justified for considerations that grow with time. In this vein, one important difference between the present and the future is that the future is *uncertain* relative to the present and, insofar as that uncertainty grows in a predictable manner, that gives a principled reason for discounting in pure terms as a way of introducing that uncertainty [39].

## Elasticity of marginal utility of consumption

The next moral assumption involves the conversion of consumption into something morally relevant like welfare or utility (which we can take as synonymous). The parameter that governs this conversion, the *elasticity of marginal utility of consumption*, tells us how utility increases in percentage terms given a percent increase in consumption. This is a key parameter characterising *individual utility functions*.

It is standard to assume that marginal consumption, or equal small additions of consumption, yield decreasing utility (i.e. the function has a positive first derivative or is increasing, but a negative second derivative or increases at a diminishing rate). In IAMs this parameter can reflect multiple considerations, all of which have moral importance, but we will focus on two especially relevant. The first is inequality aversion, where the evaluator is averse to a given unit of consumption being distributed to someone who has greater consumption compared to less consumption. The second is risk aversion, where the evaluator is averse to a given unit of consumption being distributed to an outcome with greater consumption compared to an outcome with less consumption.

While we can observe individual’s risk aversion and inequality aversion within their own lives, this assumption is moral because there is no moral reason to privilege observed risk aversion and inequality aversion. A slightly different way of expressing the same idea is that observing how people trade-off between various goods in their own lives gives us no guidance about how to trade-off between various goods across different people [33].

## Population ethics

One branch of formal ethics involves the comparison of various populations [40]. While this is called population ethics, or population axiology, the moral issues are not about optimal population size or number of children, but the comparison of population outcomes. These outcomes may vary in size but also in which individuals are taken to be identical (i.e. the same individual) across the outcomes. Intuitively, there is an important moral difference when outcomes involve substituting a person with another who has greater utility (say) compared to if someone improves the utility of one person from one outcome to another.

In the context of the SCC, we can lay out two versions of utilitarianism depending on different population ethics assumptions and see that the change can have significant effects. The standard form of utilitarianism assumed in IAMs is *total utilitarianism* (or ‘*totalism*’), where the evaluation of an outcome is the sum total of utility across all agents in that outcome. The most influential alternative is *average utilitarianism* (or ‘*averagism*’), where the evaluation of an outcome is the average (mean) utility across all agents in that outcome.

While there are many alternative theories in population ethics [40], the distinction between total and average utilitarianism is already highly significant. Scovronick and colleagues found that the choice between these theories can have as much impact on the SCC as different positions on the discounting problem [41]. More precisely, with a larger population, increases in temperature are relatively worse under total utilitarianism than average utilitarianism, since climate impacts lower the average more slowly than they affect the total value of the outcome, especially when the population is large in expectation.

While this comparison between two theories in population ethics gives us some understanding of the moral assumptions, there are many more theories that could be adopted with a wide array of potential impacts on estimates of the SCC.

## Scope of morality

Philosophers often use the term ‘scope’ to indicate the range of morally considerable beings. This is a morally important assumption that is easy to overlook. This Subsection will consider whether the scope should be regional/national (‘domestic’) or global; the next Subsection will consider whether the scope should be broadened beyond human beings to other sentient or other beings. This subsection draws heavily on work done in Mintz-Woo [42].

In March 2017, the Trump administration issued an Executive Order (EO) on Promoting Energy Independence and Economic Growth. Among other things, the EO limits the SCC to only the expected domestic impacts, as opposed to the global impacts.

While the choice between domestic or global SCCs may appear arcane, here are two reasons to think otherwise. First, the actual impact of this rule change is significant. Since greenhouse gases are long-lived and disperse freely in the atmosphere, the effects of that marginal ton fall on many different countries in a highly varied manner; restricting the effects to any single country ignores international impacts, resulting to a lower SCC. Second, it acts as synecdoche for the broader orientation of the Trump administration. The question that the administration poses is whether nationals should care about foreigners.

The morally interesting puzzle is why, as the Obama administration and others contended, carbon regulatory analysis should appeal to (at least some) global costs and benefits, but not analyses of other targets of regulation [43]. Other potential targets include, but are not limited to, terrorism, illegal drugs and infectious diseases [44]. This is on its face surprising; what could be so special about the SCC when typical US regulatory impact analyses only consider domestic impacts?

This Subsection offers the following response to this moral puzzle, based on reinforcing norms in the face of commons tragedies with observable responses. The relevant fact about carbon is that its negative effects are predominantly global and not domestic. In this sense, considering only domestic impacts would greatly bias or distort estimates of the SCC.

We can see setting domestic and global SCCs as a form of defecting or cooperating, since each time a country considers only domestic impacts, it will under-reduce relative to the social optimum and since the optimal outcome for all is that every country considers global impacts. However, climate change is different from other commons problems in two especially important aspects.

First, it is iterated, meaning that instead of a one-off decision, countries can respond to observed decisions of others. Second, those decisions are observable, meaning that we can see whether countries adopt global or domestic SCCs.

In fact, countries which have instituted SCCs have in almost all cases introduced ones with values that are greater than they would be if they included only domestic impacts ([45], Appendix B).

In this context, a moral argument in favour of continuing to adopt global SCCs lies in the minimal principle that, when facing iterated commons problems where other members are known to be cooperating, in order to generate and reinforce cooperative norms, one also ought to cooperate. This is minimal, since it does not require that one cooperate first. It is also weaker than moral claims made in the literature that, in light of financial capacity and historical emissions, countries like the United States morally ought to *lead* with respect to climate action [46] [47]. If we accept this minimal principle, then the SCC should reflect global climate impacts.

## Anthropocentrism

The next moral scope assumption is the restriction to human beings’ utility. Existing SCC estimates rarely include non-human impacts, but in principle we might adopt several views that would support their inclusion.

It is worth distinguishing three categories of moral worth as discussed by environmental ethicists [48] [49]. We start with *anthropocentrism*, the view that only human beings are morally considerable, as this is the default assumption in these types of economic contexts.

Singer forcefully argued that anthropocentrism was too narrow, since we can take experiences or preferences to be the morally relevant objects, and human beings are not the only beings with experiences or preferences [50]. This justifies *sentientism*, the view that any beings with the relevant experiential states are morally considerable. Singer’s version of sentientism is the view that all interests matter equally, and only and all beings that can experience pain or pleasure thereby have interests.

Goodpaster argued that Singer’s view was itself too narrow, since, he suggested, experiences are not morally considerable by themselves, since sentience is an adaptive capacity of living organisms to improve their fitness [51]. This suggests, Goodpaster claims, that sentience cannot be of moral importance itself as it is there to support something else, which presumably is of moral importance. Goodpaster concluded that the only non-arbitrary designation is every living being, whether sentient or not (e.g. including both flora and fauna).

Both extensions beyond human beings for a SCC would involve radical changes to estimating SCCs. However, drawing on the discussion on ecosystem service valuation, there are multiple standard ways of coming to value goods not priced in markets [12]. Each of these would require some assumptions about what is taken to be of (equal) moral importance. However, most of these methods appeal to human estimations of those values. For instance, contingent valuation of ecosystems requires people to estimate the worth *to them* of various types of ecosystems and their services. Trying to get beyond human valuation is more challenging. For instance, adopting Singer’s consideration of equal interests would require some way of estimating and comparing the interests of non-humans while adopting Goodpaster’s view would require all living beings to be comparable in some way. One way, for instance, that this could be attempted is via lost biomass where the relevant unit is living matter. While this moral assumption is still in the process of being discussed [52] [53], recognising this as a moral assumption is the first step to incorporating it into the SCC.

# Conclusion

When we are presented with the economic costs of a climate policy, a figure given in financial terms can appear value-free. The purpose of this chapter was to draw attention to the variety of assumptions that are needed to generate these estimates. This is not to say that these estimates should be rejected or not included in our policy evaluations. Instead, it is to say that the choices that we make in terms of both moral and non-moral assumptions can have great impact on the choices of polices that society adopts. For that reason, we should consider our assumptions carefully and adopt them carefully with an eye towards the long term.

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