

# 10\$ a ton of carbon ? The Stern-Nordhaus Controversy :

## Methodological and Ethical Issues

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### Abstract

The Stern-Nordhaus controversy has been emblematic of the economic and ethical debate around the formulation of a discount rate and a carbon price. The aim of this article is to study this controversy in order to shed light on the epistemological and ethical postulates implicitly accepted by the two economists in their work, and more broadly in the integrated models concluding to a social cost of carbon. These implicitly accepted postulates are 1) the comprehension of economic rationality solely as the maximization of expected utility, and 2) a consequentialist point of view. The latter compartmentalize the scope of the ethical debate into cleavages over the formulation of an *optimal* discount rate. This article aims to broaden the ethical debate around these integrated models by questioning the implicit normativity of how economic rationality is at play in these models and proposes a new way of conceiving individual responsibility in the face of climate change.

## Introduction

During the 2000's, a controversy has become emblematic opposing The Stern Review (Stern, 2007) and Nordhaus' Review of the Stern Review (Nordhaus, 2007). Both economists use Integrated Assessment Models (hereafter IAMs<sup>1</sup>, respectively the PAGE model and the DICE model) so as to give the most precise estimations of the costs and benefits of an abatement of Greenhouse Gas (hereafter GHG) policy. Their goal is to best guide a policy-maker in regards to maximizing social welfare under uncertainty and risk. They do so by formulating a Social Cost of Carbon (hereafter SCC) so as to match the social cost of GHG emissions with the economic costs of abatement policies. While the two models used by Stern and Nordhaus share most of the same theoretical foundations (they share the same utility function<sup>2</sup>, the same decision framework, they assume the same economic growth over the two centuries to come (Espagne et al., 2012)), they completely differ when setting the value of the

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<sup>1</sup>An integrated model is an economic model that *integrates* the data or the methodology of another natural science such as physics, chemistry, geology ecc.

<sup>2</sup>A more detailed presentation of the similarities and the differences of those two models is operated in section 3

discount rate and therefore reach radically opposite conclusions.

This controversy started by an attack from Nordhaus stating that “even though it was published by a university press — it is not standard academic analysis” (Nordhaus, 2007 p.688) but rather a political document that advocates sharp reductions of GHG in the near term. Nordhaus emphasizes that the methodological flaws in the Stern review are not to be undermined, because “they are fundamental for good science” (*Ibid*) implying that Stern’s work could not be labeled as scientific, or at least not as “good science”<sup>3</sup>. Stern answers these attacks in his lecture during the annual American Economists Association meeting in 2008 which lead to the publication of an (*academic*) article (Stern, 2008), stating that Nordhaus’assumptions “involve a real possibility of devastating climatic changes” (Stern, 2008 p.6). Stern and Nordhaus continue to quote each others’ works to these days (Stern, 2013 pp.847-848 ; Stern et al., 2021 pp 4-6 and p.14, p.18, pp.25-26, p.45 ; Stern and Stiglitz, 2023 p.278 ; Nordhaus, 2017 p.1520 ; Nordhaus, 2019 p.2005) making this controversy still relevant today.

The aim of this paper is 1) to analyse this controversy in order to illustrate why the discount rate and the social cost of carbon have been emblematic of both theoretical and ethical debates. 2) To broaden the ethical debate by questioning how the standard hypothesis of rationality shared by IAMs prevent us from conceiving a satisfying individual responsibility in regards to climate challenges.

This paper first sheds light on the methodological issues related to using integrated models to tackle ecological issues through the analysis of a controversy. Secondly, I present in details this Stern-Nordhaus controversy, and more broadly their uses of the PAGE and DICE models. Explaining this controversy will lead us to question the ethical debate that stemmed from this controversy, and how it focused on the discount rate. Thirdly, based on the analysis of this controversy, I suggest that an ethical blind spot remains unquestioned : by concluding to a Social Cost of Carbon (SCC), these IAMs seek to internalize the negative externalities produced by a certain level of consumption or production. Such process aims at causally inferring an accountability but ends up conflating the notion of individual responsibility with that of accountability. Therefore, I argue in this paper that interrogating the acceptance of responsibility, and its implicit normativity, can reshape the ethical debate surrounding the use of IAMs.

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<sup>3</sup>Nordhaus doesn’t truly define what “good science” stands for (except a “peer reviewed publication”) nor does he seem to realize that claiming that another scientific work is not “good science” is actually a normative claim, making it tantamount to a political claim rather than a scientific one.

# 1 Models and Methodology

This controversy revolves around two IAMs, namely the PAGE model (used by Stern in his Review [Stern, 2007] but developed by Chris Hope<sup>4</sup> and his assistants since the 1990's (Hope et al., 1993 ; Hope et al., 1997 ; Hope, 2006 Hope, 2011)) and the DICE model (used and developed by Nordhaus since the 1990's, with its latest version being released on april 2023 (Nordhaus, 1993 ; Nordhaus, 2007 ; Nordhaus, 2017 ; Nordhaus, 2018 ; Nordhaus, 2019 ; Nordhaus and Barrage, 2023)). The literature studying and reviewing the IAMs is quite vast and expanding fast (Weyant, 2017)<sup>5</sup> but I want to emphasise the uniqueness that IAMs have. Examining an IAM means analysing a certain type of economic model itself. Weyant (Weyant, 2017) argues that there are two types of IAMs: firstly the detailed process IAMs which study climate change mitigation “without necessarily valuing or aggregating all possible impacts into a single measure of projected climate damages” (Weyant, 2017 p.115). Another type of IAMs are the “aggregate benefit-cost analysis” that focus on “calculating carbon emissions trajectories and carbon prices that maximize global welfare” (*ibid*). I will focus on that second type of IAMs as I am focusing around the PAGE and DICE models which both conceptualize abatement policies that maximize social welfare through a pricing of carbon emissions.

As a matter of fact, examining an IAM is like studying an experiment in a “controlled mini-world” (Mäki, 2005) which aims at detailing possible abatement policies, their cost and their benefits. I am grounding this argument on Mäki's work (Mäki, 2005) as I am implying that these IAMs are to be conceived as experiments insofar as they aim at representing several factors – namely the economic cost of abatement policies and the benefits in terms of social welfare – in order to best guide a policy maker. To be more precise, the PAGE model is a Monte Carlo simulation<sup>6</sup> which allows the economist to run a large number of scenarios (on average a thousand) by setting arbitrarily the value of various parameters (risk aversion, discount rate, elasticity of the social marginal utility of consumption). The policy-maker (and thus the decision-maker) is therefore not faced with a single and outright result, but rather with a distribution of probabilities with regards to environmental damages, economic costs ecc. Even though the DICE model is not based on a Monte Carlo simulation, the same argument can be made as the DICE model runs several scenarios and thus offers the same type of distribution probabilities. As such, IAMs can be conceptualized like Mäki conceives economic models, that's to say “an isolated system that is a simple an controlled mini-world in contrast to complex and uncontrolled

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<sup>4</sup>Chris Hope is an Emeritus Reader at Cambridge Judge Business School in Policy Modelling, and was an advisor to the Stern Review

<sup>5</sup>For a historical point of view see (van Beek et al., 2020) ; (Bonen et al., 2014) ; (Goodess et al., 2003) ; (Gambhir et al., 2019) ; (Weyant, 2017). For a methodological and epistemological point of view (Schneider, 1997) ; (Tol and Fankhauser, 1998) ; (Ackerman et al., 2009) ; (Stern et al., 2021).

<sup>6</sup>A Monte Carlo simulation is an algorithm or a mathematical technique that aims at estimating the probabilities of uncertain events.

maxi-world.” Mäki’s main argument is that economic models serve two main objectives: 1) isolating and thus controlling a “mini-world” so that this mini world serves as 2) a representative system of the more complex world (i.e the resemblance aspect). In such a way, Mäki argues that “theoretical models are experiments, and that material experiments are models”. When dealing with IAMs, one can obviously see how they are manipulations of mini-worlds so as to be the most resembling and representative of different trajectories for the maxi-world : they rely on simulations, isolating several theoretical factors to assess different practical economic policies. Yet, the material of these manipulations is what should hold our attention: IAMs draw their manipulations from both economics and from other natural sciences (e.g physics, geology, biology, earth and climate sciences ecc.). In the aggregate benefit-cost analysis, these manipulations conclude to a pricing of GHG, namely a carbon price or the “social cost of carbon” (SCC). As such, the IAMs represent an interesting specific economic model : their theoretical approach relies on other natural sciences and their material relies on a pricing of an externality (namely GHG emissions).Based on these manipulations and the resemblance with the maxi-world they imply, ethical assumptions are crucial as to how you conceive the world, the importance you grant future generation, equity ecc. As a matter of fact, these models-experiments have revolved the ethical debate around the discount rate (Beckerman and Hepburn, 2007 ; Broome, 2008 ; Dietz et al., 2007 ; Hansen, 2011). A more precise and detailed argument around the discount rate is developed in section 2 and 3 of this paper.

This article focuses on a specific controversy for several reasons. Firstly, studying this Stern-Nordhaus controversy allows us to establish a preliminary observation: within environmental economics, the practical applications of GHG reduction policies are up to harsh debates among economists, both politically – should the economist expertise not be normative when guiding a policy-maker? is it possible not to be normative when dealing with climate change? – and academically – what can the models tell us? Secondly, from a methodological standpoint, studying a controversy best brings to light the presuppositions and assumptions implicitly accepted by scientists (Dascal, 1998 ; Lemieux, 2007 ; Pestré, 2007 ; Debaz, 2017 ; Truc and Jullien, 2023). While the Stern-Nordhaus controversy doesn’t revolve around a scientific breakthrough, studying the controversy can shed light on a more “generalized questioning (...) of their adversaries’ factual, methodological, and conceptual presuppositions” (Dascal, 1998 p.151.) The goal of this paper is to ground our argument on such analysis to identify the implicit assumptions that such a controversy rises. In other words, this paper aims at interrogating how and why the controversy around Stern and Nordhaus shaped the ethical debate around the discount rate.

## 2 The Controversy

Before highlighting the main differences that oppose Stern and Nordhaus, let's focus on their shared common ground. Both Stern's Review and Nordhaus' review use IAMs (namely the PAGE model for Stern's Review and the DICE model for Nordhaus' work) which in turn, share most of their theoretical principles. Both of them aim at estimating the SCC when dealing with climate change issues. In order to do so, they first conceptualize GHG emissions as a negative externality that needs to be internalised (Stern, 2007 p.xviii ; Stern, 2008 p.24 ; Nordhaus, 2019 pp 1991-1992). In order to quantify both the economic costs of implementing a GHG abatement policy and the benefits in terms of social welfare, a carbon price is formulated (i.e we assign a numeraire to the emission of a ton of carbon). Setting a price for the emission of a ton of carbon is tantamount to the formulation of a shadow price which serves as an indicator to measure the damage caused by a certain level of carbon pollution (Pearce, 2003). The point of this carbon pricing is to be able to match the social cost of greenhouse gas emissions with the economic costs of abatement policies (*ibid*). Due to its intertemporal scope, the SCC may not solely be evaluated through the interest rate or the marginal growth of capital, but rather needs another discounting parameter that accounts for future – and existing – generations : the discount rate (Gaspard and Missemmer, 2022). The discount rate is a parameter that can be defined by combining several social welfare variables (pure time preference, risk aversion and intertemporal inequality aversion) with the exogenous consumption growth rate which is subsumed into GDP growth (*ibid* p.210). To put it bluntly “the discount rate is simply the proportionate rate of fall of the value of the numeraire used in the policy evaluation” (Stern, 2008 p.12) that's to say, it is used to compare the depreciation of a given variable through different time periods. Stern and Nordhaus both use Ramsey's function of optimal growth<sup>7</sup>:

$$r_t = \delta + \eta g_t$$

$r_t$  represents the consumption discount rate at time  $t$  and  $\delta$ <sup>8</sup> represents the pure rate of time preference, namely the utility discount rate,  $\eta$  represents the elasticity of the marginal utility of consumption, and  $g$  represents the growth rate of consumption. So what does  $\delta$  actually represent ?  $\delta$  represents how much weight or importance we grant the future generation. The higher  $\delta$  is the less importance we grant them (we delay our effort to reduce our GHG emissions because the emphasis is put on the existing generation, and we thus set a very low SCC). Conversely, the lower  $\delta$  is the more we consider the next generations' welfare and utility (we stress our effort to reduce our GHG emissions in the near term, thus setting a high SCC).

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<sup>7</sup>While they rely on Ramsey's work (Ramsey, 1928, the optimal growth function is not found *per se* in the 1928 article. The function was later adjusted by (Koopmans, 1963) and (Cass, 1965).

<sup>8</sup>In Nordhaus' work (Nordhaus, 2007 ; Nordhaus, 2018 Nordhaus and Barrage, 2023)  $\rho$  replaces the letter  $\delta$  but the meaning behind the letter stays the same.

From this level of consumption, they deduce a certain level of utility, calculated through the following function:  $U(t) = \frac{C(t)^{1-\eta}}{1-\eta}$

Where  $C$  represents consumption at a time  $t$  and  $\eta$  represents the elasticity of marginal utility of consumption. It should be noted here that the utility function obviously depends on the level of consumption  $C$  and the marginal elasticity of utility  $\eta$ . Let us therefore examine why changing the value of the elasticity of marginal utility of consumption ( $\eta$ ) also has major implications for economic assessments of climate change. If we give a high value to  $\eta$ , then we are modelling and representing an economic agent with a great capacity to modify and adapt their consumption in regards to the climate change issues (for example, they would stop eating meat, consume locally, ecc.). If, on the other hand, we give  $\eta$  little value, then the utility function of the economic agent will be much more rigid and they will be much less likely to adapt their consumption to the climate challenges (they will not change their consumption habits). Hence why, setting the value of  $\eta$  and  $\delta$  has deep methodological implications and why it is the root of the controversy.

Finally, from this level of utility, they deduce a level of social welfare, calculated in the standard way in welfare economics (Stern, 2007) by the following function:  $W = \int_{t=1}^{\infty} U(t)e^{-(\delta t)}dt$ .

Where  $W$  designates the level of social welfare and is calculated by means of an integral, representing an infinite horizon and a discrete value of time (each year is represented by a  $t$  ranging from 1 to infinity). This is followed by a standard utility function  $U(t)$ , where  $\delta$  indicates the utility discount rate and the formula  $e^{-(\delta t)}$  describes a standard Poisson process.<sup>9</sup>

Yet, even though they share most of the same theoretical framework, they drastically differ in the way they set the value of  $\delta$  and this is where the controversy lies. In his attack against Stern, Nordhaus advocates a non-normative approach and determines the value of  $\delta$  to be 1,5% per year and the value of  $\eta$  to be 2. He justifies these values because they were “consistent with market interest rates and saving rates” (Nordhaus, 2007 p.698). (Espagne et al., 2012) explains that the observed interest rates were 4,1% which gives us  $1.5 + 2 * 1.3 = 4.1$  (Nordhaus assumed an economic growth of 1,3% per year). On the other end of this controversy, Stern assumed a normative approach against the so-called positive position of Nordhaus and set the value of  $\delta$  to be as low as possible, i.e 0,1% and  $\eta$  at 1. He directly refers to Nordhaus’Review when he argues that setting the value of  $\delta$  at 2% would “impl[y] that the utility of a person born in 1995 would be “worth” (have a social weight) roughly half that of

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<sup>9</sup>A Poisson process is a process most often used to model queues or to count independent units (in this case years  $t$ ) which follow one another according to a discount rate (i.e. according to a certain chance) noted here  $\delta$  in order to model the successive years and the importance attached to them ( $\delta$ ).

a person born in 1960. This type of discrimination seems very hard to justify as an ethical proposition and would be unappealing to many” (Stern, 2008 p.15). As a consequence, they conclude to two very different SCC in order to conceive the optimal abatement policy. On the one hand, Nordhaus advocates for what he calls the “climate policy-ramp”, that’s to say progressively tightening abatement policies, which offer shallow reductions in the near-term and sharp reduction from 2050 to 2100, hence why he sets the value of  $\delta$  so high. With the use of the 2007 version of his DICE model, he concludes to an estimated SCC of \$35 per ton of carbon in 2015, \$85 in 2050 and \$206 in 2100 (he indexes the dollar value on its value in 2005, (Nordhaus, 2007 p.698)). On the other hand, Stern advocates for sharp reductions in the near term (i.e before 2030) but doesn’t *per se* advocates for a carbon price of 300\$ a ton of carbon, which is nowhere to be found in Stern, 2007 or Stern, 2008. So where does this price comes from ? From the commentators of the Review, namely Nordhaus, 2007 ; Tol and Yohe, 2006 Tol and Anthoff, 2013. For instance, Tol and Anthoff, 2013 demonstrates how the price of a ton of carbon can vary according to the value we arbitrarily place on  $\delta$ . Based on the same utility functions, if we assume a standard risk aversion of 1 and  $\delta$  of 0.1% - in other words if we attach almost the same importance to future generations as to our own - as proposed by Stern, 2007, we obtain a carbon price of 374\$ per ton, but if we take a  $\delta$  of 3%<sup>10</sup> then the carbon price plummets to 10\$ per ton.

Hence why this controversy is so polarising: implicit assumptions drastically shaped the way the IAMs work to assess the optimal abatement policy. Hence why the ethical debate surrounding such controversy revolved around the fairness (in regards of intergenerational equity, intragenerational equity and risk aversion) of the discount rate (Atkinson et al., 2009 ; Dietz et al., 2007 ; Beckerman and Hepburn, 2007 ; Broome, 2008 ; Hansen, 2011). I argue in this paper that this ethical debate emerging from the Stern-Nordhaus controversy has been so prominent that it blinded other ethical assumptions at stake in this controversy.

### 3 An Ethical Blind Spot : Rationality and Responsibility

The aim of this third section is to question the implicit assumptions at play in these models in order to broaden the ethical considerations involved. The main objective of the PAGE and DICE – an other IAMs – is to formulate a carbon price, so as to match the social cost of greenhouse gas emissions with the economic costs of abatement policies. Hence, the SCC is formulated with the aim of internalising a negative externality (GHG emissions). The SCC is therefore used in order to operate a causal inference between a level of consumption and a level of pollution. As a consequence, individual responsibility is conflated with causal accountability and the ethical debate that surrounds such controversy was

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<sup>10</sup>In other words if we attach slightly more importance to our generation than to future generations

shaped according to this conflation. Moreover, the controversy is rooted in the cost-benefit analysis (which is assumed by Stern, 2008 p.16 and by Nordhaus, 2019 p.2001) which introduces 1) a utilitarian standpoint – the economic agent seeks to maximise their expected utility – (Gaspard and Missemer, 2022) and 2) a consequentialist point of view – we evaluate the economic cost of abatement policies solely based on expected social welfare<sup>11</sup> – (Beckerman and Hepburn, 2007). According to Beckerman and Hepburn, 2007 the welfare economic approach developed in these IAMs “has no room, for ethical dimensions concerning the processes by which out-comes are reached” (p.188). I argue that the ethical debate surrounding the use of IAMs when dealing with climate issues can be broadened if we question the implicit assumptions related to the utilitarian and consequentialist standpoints.

As a matter of fact, an alternative approach emerged in the early 2000s with an attempt to integrate an ethical reflection on individual responsibility into the debate on carbon pricing (Bazin et al., 2004, Ballet et al., 2007). The argument developed by Bazin Ballet and Touahri can be summed up as follows: formulating a carbon price and therefore internalising an externality can work up to a certain threshold beyond which carbon taxation becomes counter-productive and encourages individual consumption. To show this, they introduce a new variable into their consumption function,  $\alpha$ , which represents the level of individual responsibility ranging from 0 (no responsibility) to 1 (the agent directs all his consumption towards reducing his environmental impact and individual pollution). The model developed by Bazin et al., 2004 is innovative in the sense that it does not conceptualise the well-being of future generations solely through the savings of previous generations and the inherited capital, but it also depends on the level of responsibility shown by these previous generations. Their consumption function is defined as :

$$C_{t+1} = [1 - \alpha(m_{t+1})](1 + r_{t+1} - \delta)s_t$$

Where  $C_{t+1}$  denotes the level of consumption of a generation at time  $t+1$ ;  $\alpha$  denotes the individual responsibility of each agent, which is multiplied to a certain level of tax denoted by  $(m_{t+1})$ ;  $r$  represents the interest rate,  $\delta$  the rate of capital depreciation for the period  $t$ ; and  $s_t$  denotes the level of savings for the period  $t$ . To put it simply, this function represents the level of consumption of a generation at a time  $t+1$  ; this level of consumption is calculated by two factors, namely individual responsibility  $[1 - \alpha(m_{t+1})]$  multiplied by the level of savings at this same period  $(1 + r_{t+1} - \delta)s_t$ .

Let’s focus on the variable calculating individual responsibility  $[1 - \alpha(m_{t+1})]$ . Note that the higher the taxation  $(m_{t+1})$ , the lower the responsibility  $[1 - \alpha(m_{t+1})]$  since it is constructed through the formula  $1 -$  the level of taxation. Thus, although it may seem counter-intuitive, the authors demonstrate

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<sup>11</sup>In that case the expected social welfare designates the sum of all the individual expected utilities.

how the introduction of a carbon tax can lead to an increase in consumption and therefore prove to be counter-productive. Bazin et al., 2004 summarise their argument through the maxim “*Since I pay, I am permitted to consume*”. Grounding our study on such analysis, we argue that carbon taxation grants the economic agent a “moral holiday”. The term moral holiday is taken from William James’ Second Lesson on Pragmatism (James, 2011). For James, a moral holiday is “to let the world wag in its own way, feeling that its issues are in better hands than ours and are none of our business” (p.135). Furthermore, I argue in this context that the carbon tax gives a moral holiday to the economic agent in the sense that it gives them the impression that the negative externality ensued from their consumption is fully internalized by the market through such pricing. The economic agent has this insouciance as if his own life horizon was infinite, or as James puts it to “drop the worry of our finite responsibility.” (*ibid*). Hence the formulation of a carbon price is tantamount to giving an economic agent an impression of acquittal, as if the level of pollution generated by its consumption were no longer within its responsibility because what truly matters was the formulation of a fair carbon price. The main flaw that I adress to Bazin et al., 2004 is the lack of ethical theorisation of individual responsibility. In their paper, individual responsibility is solely a variable varying from 0 to 1 and even though they quote some philosophical work (Jonas, 2013 they do not dwelve into the ethical debates surrounding individual responsibility.

In regard to the moral holiday of the economic agent there is a theoretical bridge to be drawn here with a certain American branch in environmental philosophy (Larrère, 1997) which asserts that, when dealing with climate change issues, it is not our moral responsibility to reduce our own level of individual consumption. For Sinnott-Armstrong (Sinnott-Armstrong, 2005 ; Sinnott-Armstrong and Howarth, 2005) or Johnson (Johnson, 2003) the consequences (positive or negative) of a change in consumption on an individual scale are too minute to constitute a real argument in favour of individual responsibility. Consequently, both in environmental economics and in American environmental philosophy, individual responsibility is not seen as a sufficiently convincing object of research from a theoretical point of view. This theoretical bridge relies on the consequentialist standpoint. When examining if reducing or adapting our own level of consumption will make an impact on the climate change issues, we are faced with a negative assertion. However, a collective reduction of an agregate level of consumption may have some beneficial impact. We are thus facing a classical prisoner’s dilemma. Hence why the consequentialist standpoint limits our conception of individual responsibility when dealing with climate change issues. In order to overcome such a dilemma, one must question “the processes by which out-comes are reached” (Beckerman and Hepburn, 2007 p.188) and thus question the way an economic agent commits with these climatic issues.

My position is that the ethical debate must also comprehend a reflection on the implicit normativity of economic rationality at stake in the IAMs. Each model, through the same social welfare function, conceives an economic agent seeking to maximise his or her expected utility, insofar as climate change necessarily implies a choice under uncertainty. There is, consequently, a certain implicit understanding of economic rationality behind these models that needs to be questioned and clarified. More precisely, following the categorisation proposed by (Blume and Easley, 2016), we can state that Stern, Nordhaus, and more broadly the IAMs mobilise the Subjective Expected Utility Theory. This categorisation of economic rationality was first developed and theorised by (Savage, 1972) in order to account for the degree of belief from a decision-maker in the probability of a certain event. Applied to climate issues, this theory of subjective expected utility represents the degree of belief that the decision-maker attaches to climate risks and intergenerational well-being. Let's be clear, the goal of IAMs and environmental cost-benefit analysis is not to assert anything about the cognitive or psychological capacities of the economic agent, but they use this conception of economic rationality as a postulate from which they can deduce a set of properties that make the macroeconomic model mobilised in their study coherent (Herfeld, 2022). According to Herfeld, the expected utility approach is mainly used as a normative theory in a much broader theoretical framework in order to explain macroeconomic phenomena. The challenge for economic models such as PAGE and DICE is to "arrive at an adequate description of the social interaction processes that link individual choices at the microeconomic level and robust models at the macroeconomic level" (Herfeld, 2018). To be more precise, IAMs are not used to conceptualise an individual choice, but they still assume a certain acceptance of individual rationality so as to broaden their framework and study complex macroeconomic phenomena. The Stern-Nordhaus controversy sheds light on how the formulation of a carbon price implies that the negative externalities arising from an economic agent's consumption are *de facto* internalised<sup>12</sup>. This approach does not allow any reflection on the rationality at play in these models and the implicit normativity that ensues from it, insofar as this internalisation process is not carried out by the agent themselves but by the introduction of a carbon price. Limiting the reflection on the economic agent's rationality has consequently restricted the acceptance of individual responsibility for the pollution caused by their consumption. Individual responsibility has thus been conflated with causal accountability.

The notion of accountability has been increasingly studied in the field of "ecological economics" since the 2000's (Neumayer, 2000 ; Biermann and Gupta, 2011). More recently, Sareen and Wolf, (2021) have defined accountability as "a process of evaluation by which an actor or an action is assessed in relation to contextual norms or institutional logics. Further, accountability demands that

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<sup>12</sup>At least in theory.

these evaluations are linked to application of sanctions and subsidies - i.e., incentives, both negative and positive - that reshape competitive dynamics and the demography of relevant populations (e.g., firms, technologies, routines)” (p.2). Sareen and Wolf argue that the concept of accountability, and the causal inference to subsidies or fees, puts the best foot forward to advance ecological transitions. Here, responsibility is conceived solely as retribution for the consequences - positive or negative - of one’s actions, and therefore perfectly covers the process of internalising negative externalities already present in environmental cost-benefit analysis. The economic agent is responsible for the externalities caused by their level of consumption insofar as they are accountable for it, i.e. they cause of a certain level of pollution. Moreover, even when they explicitly state the notion of responsibility instead of accountability (Rodrigues et al., 2006 ; Lenzen and Murray, 2010), they conceive it as an indicator in order to measure “the quantitative contribution of each agent to the environmental problem” (Rodrigues et al., 2006) or as a theoretical framework making it possible to “quantify the carbon footprint as a consumer(downstream responsibility) or as a producer (upstream responsibility)” (Lenzen and Murray, 2010.) These articles remain vague as to the distinction they make between *accountability* and *responsibility*. Although ecological economics is defined as - among other things - a methodological questioning of our relationship with nature (Dube, 2021 ; Spash, 2013 ; Missemer and Franco, 2022), there is still a gap and a blatant impermeability between economics and philosophy on the question of responsibility. The two fields, thus, suffer from the same limitation: the absence of an interdisciplinary ethical reflection aimed at redefining the theoretical boundaries of environmental economics in favour of a more profound ethical reflection on individual responsibility.

I propose two ways of understanding this principle of ethical responsibility in regards to climate change :

1) Ethical responsibility can be understood as the endogeneization of the economic agent’s preferences in view of climate change. This approach is rather centered on microeconomics (**mattauch’economics’2022, dasgupta’consumer’2016, ohara’endogenous’2002, daube’moral’2016**). In other words, when faced with the challenges of climate change, the economic agent will adapt their consumption choices to reduce their individual impact. This is what we may call the “perceived responsibility” insofar as the economic agent perceives the harmful consequences of his preferences and therefore adapts them a posteriori.

2) Ethical responsibility can be understood as the formulation of a Sen-ish critique of economic rationality. The notion of responsibility thus engages an ethical reflection on the decision-making process

that leads an economic agent to make a decision. This approach is rather centered on the philosophy of economics (**sen'behaviour'1973; sen'rational'1977; sen'goals'1985; sen'individual'1990; sen'maximization'1997; sen'rationality'2004 peacock'amartya'2019, peter'rationality'2007**). This is what we may call "procedural responsibility", insofar as we question the process of decision (or rather the process of deliberation). In *Rationality and Freedom*, Sen evokes "our intense preoccupation with the world must be deeply integrated with the analytical use of formal mathematical reasoning (p.65)". In other words, the main criticism that can be addressed to IAMs, understood as mini-worlds resembling the maxi-world, is that they do not question the way in which economic agents engage with climate issues.

## 4 Conclusion

The Stern-Nordhaus controversy embodies a vast divergence between the IAMs when dealing with issues related to the integration of climate change into economic theory. They rely heavily on implicit hypotheses formulated by the scientist in charge of modelling. The value of the discount rate crystallized this controversy and shaped the ensuing ethical debate. Depending on the value given to the discount rate, the SCC differs radically from one economic model to another. However, while the question of the fairness of an arbitrarily fixed value may be an ethical debate in itself, it should not be the only one.

The SCC implies at least two epistemological assumptions, namely the maximisation of expected utility and consequentialism, which are rarely questioned from an epistemological and ethical point of view in the field of environmental economics. Questioning these points of view is the first step in broadening the ethical debate surrounding the use of integrated assessment models to tackle climate change. This article has shown that the Stern-Nordhaus controversy has highlighted how the formulation of a social cost of carbon is in fact based on a system of causal inference that conflates the notion of individual responsibility with that of causal responsibility. Questioning the implicit normativity in this understanding of economic rationality leads us to ponder over the process by which an economic agent can be responsible and respect ethical imperatives rather than being narrow-minded.

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