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COMMENTARY

Optimal climate policy is a utopia: from quantitative to qualitative cost-benefit analysis

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Abstract

The dominance of quantitative cost-benefit analysis (CBA) and optimality concepts in the economic analysis of climate policy is criticised. Among others, it is argued to be based in a misplaced interpretation of policy for a complex climate–economy system as being analogous to individual inter-temporal welfare optimisation. The transfer of quantitative CBA and optimality concepts reflects an overly ambitious approach that does more harm than good. An alternative approach is to focus the attention on extreme events, structural change and complexity. It is argued that a qualitative rather than a quantitative CBA that takes account of these aspects can support the adoption of a minimax regret approach or precautionary principle in climate policy. This means: implement stringent GHG reduction policies as soon as possible.

Keywords: Catastrophes; Complexity; Extreme events; Growth theory; History; Issue linking; Minimax regret; Precautionary principle; Uncertainty

JEL classification: D81; O11; Q25; Q27; Q43

1. Introduction

The economic analysis of climate policy is dominated by the technique of quantitative cost-benefit analysis (CBA) and the notion of 'optimal policy', elaborated with optimal growth theory.[1] This article presents a fundamental critique of these approaches. The intention is not to denounce all current research on climate policy instruments. For example, the evaluation of taxes, permits and joint implementation on the basis of cost-effectiveness, given a fixed reduction objective, is certainly fruitful. It will be argued, however, that an overall quantitative CBA evaluation and comparison of policy options that aim to reach distinct reduction percentages, as well as a choice of optimal climate policy based on models of optimal growth, are overly ambitious.

The best that can then be hoped for is a qualitative empirical analysis, in particular a qualitative trade-off

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[1] Some models in this vein, which have played a prominent role in the IPCC and international policy debates, are DICE (Nordhaus, 1991), RICE (Nordhaus and Yang, 1996), CETA (Peck and Teisberg, 1992), MERGE (Manne and Richels, 1992) and FUND (Tol et al., 1995). Kelly and Kolstad (1999) offer a short overview.

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of costs and benefits—i.e. a sort of qualitative CBA. This is consistent with what common sense tell us, namely that in the face of extreme uncertainty quantitative analysis has difficulty to outperform qualitative analysis, because quantitative information is either lacking or unreliable. The latter is characteristic of potential climatic change during the next hundred years.

This reasoning may seem disappointing to, and is in fact strongly opposed by, economists who think that a complete quantified analysis is the only worthwhile method in the economic analysis of climate issues. It is indeed very tempting to employ all the traditional formal tools available to economists in dealing with what is perhaps the most complex issue of humanity—climate change. Fortunately, the alternative approach presented here turns out to provide both very concrete and far-reaching implications for climate policy. Perhaps this is comforting to those that are skeptical of qualitative analysis.

The structure of this paper is as follows. Section 2 identifies four fundamental problems associated with applying quantitative CBA to climate change and policy. Section 3 discusses additional problems associated with the application of optimal growth theory to climate change. Section 4 pays particular attention to the meaning of a combination of extreme uncertainty and potential climate catastrophes for economic modelling and analysis. Section 5 presents an alternative approach to climate economics, based on taking into account extreme events, complexity and structural change via a qualitative CBA, and examines its policy implications. Section 6 concludes.

2. Quantitative cost-benefit analysis of climate policy scenarios: fundamental problems

Undertaking a quantitative CBA of the enhanced greenhouse effect and the risk of climate change faces four fundamental problems.

First, in order to undertake such a CBA, a concrete change, scenario or project needs to be defined. This can cover a reduction of greenhouse gas (GHG) emissions, a climate change, or a combination of these alternative futures. Since the benefits of climate policy are the avoided costs of climate change, regardless of the scenario, the potential climate change needs to be known. However, there is considerable uncertainty about each phase of the cause–effect chain: GHG emissions; effects on climate; ecological and hydrological consequences; social-economic responses; and impacts on human health and world-wide welfare distribution. Trying to take a middle way, by valuing an intermediate scenario with partial reduction, makes the exercise only more difficult, because costs and benefits will be related to the economic consequences of both reduction measures and climate change. Current studies are incomplete in that they omit an assessment of the costs of adaptation, and limit themselves to reduction and damage costs (Metz et al., 2001).[2] Furthermore, extreme and irreversible events are not taken into account or unsatisfactorily: extremely low or high temperatures; an extreme sea level rise; a reversal of the Gulf Stream; a tidal wave due to large ice floes on Greenland and Antarctica breaking off into the ocean; 'runaway carbon dynamics' caused by positive feedback mechanisms in the biosphere; and changes in climate subsystems such as the 'El Niño Southern Oscillation' (Easterling et al., 2000; Reilly et al., 2001). The omission of these is incomprehensible given that the ultimate reason for studying climate change is a concern for extreme events. Or, in any case, the studies that have not taken into account the extreme events should not be taken all too seriously, and the respective researchers/authors should be modest about the policy implications of their analyses (see also Azar and Lindgren, 2003, Section 3).

Second, the consequences of any climate policy, and its derived costs and benefits, have not yet occurred, and are therefore hypothetical. Assessment of damage costs is based on many assumptions and much guessing. Moreover, the quality and range of cost estimates is much lower for developing than developed countries. The most influential cost estimates included in the Intergovernmental Panel on Climate Change (IPCC) report of 1995, although presented as if based on a range of studies, lean to a

[2] Some damage cost estimates cover the cost of (incomplete) adaptation, but more often than not it is assumed that adaptation will be cost-free (Tol et al., 1998).

large extent on an earlier generation of studies, all of which in turn are based on an EPA study for the USA (Demeritt and Rothman, 1999). A specific problem is that a considerable share of the estimated costs of climate change involves costs of illness, accidents and mortality of humans. To assess such costs, estimated 'values of a statistical life' have been used. These are, however, problematic at a global scale, because of economic and cultural heterogeneity as well as a skewed income distribution. Illustrative of this problem is that studies which have influenced IPCC positions employ 'values of life' between rich and poor countries that differ by a factor 15 (Pearce et al., 1996).

Third, assessment of many costs and benefits of climate scenarios requires the use of monetary valuation techniques. These can only be applied to a *change*, regardless of whether a compensation or equivalence principle serves as the economic-theoretical basis. Environmental changes to be valued under extreme climate change scenarios are large. They are comparable in size to a change that served as the basis for an ambitious study that tried to estimate the value of all ecosystems on Earth (Costanza et al., 1997). Economists have criticised this study (Anonymous, 1998; Forum, 1998; Pearce, 1998). Their most important argument was that valuation can only apply to a change that is small when compared with income, because monetary valuation proceeds through income compensation or equivalence. Valuation of the entire biosphere really comes down to asking people to indicate which income change would compensate them, i.e. leave their individual welfare level unaltered, for the loss of the biosphere. Essentially, this assumes that money is a good substitute for climate change, or that money can 'buy back' climate stability.

Fourth, unanimity among economists and philosophers is lacking when intergenerational discounting is discussed. The fundamental question is whether individual and *intra*generational discounting can be extended to a context of public investments and *inter*generational effects. An argument against this is that a society, as opposed to an individual, does not have a finite life, and hence no time preference, which is the ultimate basis of discounting. A society is after all not bounded in time, as it always includes multiple, overlapping generations, so that one can regard it as continuous and immortal (Howarth, 1998).[3] Moreover, even if one decides to use discounting in evaluating climate scenarios, then another problem arises: namely, that the choice of any particular discount rate is arbitrary, i.e. lacks a firm theoretical basis. This is especially problematic, since a very small alteration in the discount rate can result in enormously large changes in the net present value, the CBA decision-criterion (Azar and Sterner, 1996). A large part of the variation in results of studies that have undertaken a quantitative CBA of climate policy is due to this sensitivity.

3. Climate policy as an instrument for optimal economic growth?

Nordhaus was the first to elaborate the notion of an optimal climate policy: namely by combining the neoclassical theory of optimal growth with a very simplified climate module (Nordhaus, 1991). Numerical simulations, by him and others, suggested that it is optimal to let CO_2 emissions triple over the next hundred years. This is consistent with a much more limited reduction of GHGs than ultimately regarded as safe by the IPCC. A comparison with world models seems useful here. "The Limits to Growth" study in 1972 presented the first world model, which was subsequently put to the sword by economists, mainly for having an overly simplistic structure and lacking sound data. But the current economy–climate models suffer from exactly the same weaknesses, being in fact the latest generation of world models.[4]

A drawback of the optimisation studies and quantitative CBA is that a known intergenerational welfare function is assumed. This has the form of a net present value criterion, which involves discounting. Aside from the point of arbitrariness of the discount rate

[3] Based on the results of a survey among 2160 economists, Weitzman (2001) finds that even if every individual believes in a constant discount rate, the wide spread of opinion on what is the appropriate social discount rate causes it to decline significantly over time. Extrapolation of this finding supports a zero long term or intergenerational discount rate.

[4] Irony has it that Nordhaus, founder of the economic modeling approach to integrated climate assessment, expressed firm criticism on both the original "Limits to growth" study and its follow-up (Nordhaus, 1973, 1992).

noted above, such an approach represents a very limited interpretation of intergenerational justice. To address the latter, alternative specifications of intergenerational welfare have been proposed. Examples are 'minimax regret' and 'maximin welfare' criteria, which focus on the worst possible outcome for any future generation. They can be based on the contractual theory of justice developed by the philosopher John Rawls (1972), and have been advocated, among others, by two Nobel laureates in economics (Arrow, 1973; Solow, 1974).

A stringent climate policy will in due time lead to structural changes in the economy, including technological innovations and alterations in sector structure, products, and institutional arrangements. Assessing an optimum with a quantitative CBA is based on reducing all these changes to independent costs, which implicitly assumes that one cost category is equivalent to another, and that interactions among sectors do not exist. This can easily support incorrect reasoning. For example, assume an extreme scenario in which climate change decimates the entire agricultural sector. A calculation of the implied costs assuming independence of categories will result in an estimate of only 1–2% of GDP for most developed countries. But evidently the loss of agriculture means that the entire basis of food production will collapse, with unforeseeable consequences for the stability of the world economy.

Azar and Schneider (2002) provide another argument to be careful with interpreting costs in the context of long-term climate change and policy. At first glance, current studies suggest that the absolute cost range, to reach what is regarded by the IPCC as "safe" concentrations of CO_2, is in the range of US$1–20 trillion. Although this may seem impressive, it turns out to imply only a few—1 to 3—years delay in achieving a specific level of income in the distant future.[5] This is not surprising, as the highest cost estimate has the same order of magnitude as the current global GDP. In other words, seen in a long-term perspective, the costs of a stringent climate policy are marginal in economic terms.

In a response to Azar and Schneider, Gerlagh and Papyrakis (2003) argue that the cost argument can be extended towards benefits, which is based on the critical assumption that damages will not be extreme. They phrase this as follows: "In the end, the costs of unconstrained climate change do not seem to threaten future economic development and welfare." (p. 326). But later they state: "As it stands, these costs [of climate change] are beyond our understanding, not only empirically, but also on a fundamental theoretical level."(p. 327). The latter is inconsistent with the first statement, but consistent with the argumentation in the present article.

4. The role of extreme uncertainty and catastrophes in economic optimisation models of climate change

Optimisation is further complicated by extreme uncertainty. Whereas quantifiable risks can be taken into account by performing sensitivity analysis and specifying probability distributions, such an approach will not work for extreme uncertainty characterised by surprises and ignorance. Model estimates of the costs of climate change lead to a variation of 1.5–10% of national GDP, with higher percentages mostly relating to developing countries. These estimates are, however, based on the assumption that all costs can be determined and that the temperature rise is limited, i.e. not more than 4 °C. But, if moderate uncertainties about the effects and the temperature rise are taken into account, expected costs turn out to be significantly higher. Drastic outcomes, such as climate change damage in excess of 10% of GDP in 2050, and a steady decline of per capita income after 2100, cannot be excluded (Tol, 1997, p.223).

Existing economic research has emphasised uncertainty and economic irreversibility in relation to overinvestment in greenhouse gas emission reduction measures and optimal learning (e.g. Kolstad, 1994; Birge and Rosa, 1996; Ulph and Ulph, 1997; Fisher and Narain, 2003). Uncertainty has been predominantly addressed through non-extreme scenarios and parameter sensitivity analysis in all the major climate economic studies (Heal and Kriström, 2002). Extreme

[5] The delay evidently depends on income growth. Global income during the 21st century is expected to increase about tenfold (on average 2.35% per annum). Azar and Schneider (2002, p. 77) calculate that "If the cost by the year 2001 is as high as 6% of global GDP and income growth is 2 % per year, then the delay time is 3 years . . .". Note that 6% is a high estimate according to current economic studies.

environmental events have received almost no attention. Exceptions seem to be, given the titles of the articles, Yohe (1996), Pizer (1999), Gjerde et al. (1999) and Baranzini et al. (2003). But on closer inspection none of these really introduces complete uncertainty or very extreme catastrophes, let alone a combination of the two. Most of them adopt the parameter sensitivity analysis approach which results in stochastic, expected cost-benefit analysis. For example, Gjerde et al. employ a hazard function and Baranzini et al. a Poisson processes to formalise the probability of a climate catastrophe, both of which represent limited uncertainty.

In one of his models, Nordhaus (1994) formalises a climate catastrophe through an extreme nonlinearity in a damage cost curve at a temperature threshold, but assumes at the same time that the threshold is known to the policy maker with complete certainty. The main feature of climate (and virtually all) catastrophes is precisely that extreme uncertainty and extreme consequence go hand in hand. Assuming one of both away results in completely underestimating or neglecting the true complexity of the issue. Nevertheless, already in a setting of limited uncertainty and limited consequence, and in the absence of continuous climate change damage, both Gjerde et al. (1999) and Baranzini et al. (2003) find that it is urgent to adopt very high levels of greenhouse gas abatement as soon as possible.

The main disadvantage of all the economic studies mentioned is that they try hard to stay in the framework of quantitative cost-benefit analysis—or net present value (Von Neumann-Morgenstern utility) maximization—namely by limiting the uncertainty so as to capture it in states of the world and associated continuous or discrete probability distributions.[6] This approach implies a complete focus on efficiency at the cost of neglecting unsustainability due to extreme events. This shortcoming is a special case of the problem identified in the conceptual approach by Woodward and Bishop (2000). These respected economists state that "Non-economists are often sceptical about the applicability of economics to long-term environmental issues such as global warming. Perhaps they sense intuitively what most economists have not yet recognised .... The efficiency criterion... does not help us to distinguish between sustainable and unsustainable time paths. " (p109). The essence is that concepts like efficiency and optimality are irrelevant in the context of extreme uncertainty in combination with potential catastrophes. Stated in other words, by denying the possibility of climate catastrophes and emphasising the cost and irreversibility of reduction policies, a biased picture of the economic rationale behind global warming policy results.

Very recently, Tol (2003)—who characterises himself as being "squarely in the CBA camp" (p.266)—raised the relevant question whether uncertainty about climate change is too large to usefully apply expected CBA. He starts from the presumption that this is the case if the probabilities of catastrophic scenarios are so low that the variance of the expected outcome is finite. He then shows with numerical simulations that in his own model (FUND) this is not the case. Even the uncertainty about the difference between outcomes of laissez-faire and stringent policy scenarios turns out to be infinite. In this numerical case the uncertainty about climate change is definitely too large to apply cost-benefit analysis. Tol's conclusion hits the motivation for this paper right in the middle: "It is clear, however, that climate change tests decision analytic tools to the extreme. The results in this paper show that economic analyses of climate policy should be interpreted with more than the usual care." (p.282).

5. Dealing with complexity and history: qualitative CBA

The climate system is complex and can behave chaotically (Margolis and Kammen, 1999; Rind, 1999).[7] Complexity implies that causal connections

[6] In fact, the main conclusion of most of these studies is that efficient policy or choice of instruments is affected by uncertainty, not that a fundamentally new perspective on policy and its analysis results. Pizer (1999) possibly offers the most broad treatment of economic and climate uncertainties in terms of number of stochastic parameters.

[7] Add to this the other dimensions of global change that may interact in nonlinear and unknown ways with climate change, such as land use, deforestation, water use, destruction of wetlands, acid rain, human control of a sizeable portion of primary production, and emission of large amounts of artificial substances.

between a multitude of potential factors and effects cannot be identified, let alone be quantified. In this context, a 'post-normal science' has been pleaded for, characterised by "uncertain facts, values in dispute, high stakes and urgent decisions" (Funtowicz and Ravetz, 1993). The climate problem satisfies all four characteristics. Because of its urgency, the new borne climate economics has unusually rapidly attained political influence, with all risks involved. Whether a more mature climate economics will ever be able to catch the complexity of the climate–biosphere–economy system in a comprehensive model is debatable.

Even if a quantitative CBA analysis of climate change or policy is not feasible, it makes sense to start from the premise that climate policy should be based on some qualitative trade-off of costs and benefits, i.e. a qualitative CBA. Note, however, that framing choices as trade-offs can be debated, also in the context of global environmental problems. See, for example, Bromley and Paavola (2002). Criteria of fairness have been argued to be less objectionable as well as amenable to formalization (see Woodward, 2000; Krysiak and Krysiak, 2003). A two-stage meta-model for evaluating climate change and policy results. A qualitative CBA in a first stage precedes the choice of a concrete, operational and quantifiable criterion or objective in a second stage. Given the first stage, it would still meet the basic trade-off that most economists think is rational before taking action.

A qualitative CBA can focus on a comparison of the magnitude of net costs of climate damage, GHG reduction and adaptation under no climate policy versus a stringent climate policy. This would be consistent with the 'minimax regret' criterion. The maximum magnitude of the costs will be significantly lower under the stringent climate policy. To appreciate this, note first that humans, as opposed to the biosphere, can through intelligence and cooperation anticipate and purposefully adapt to moderate changes in their environment. Moreover, whereas the biosphere can manage perfectly well without the human economy, the latter depends crucially on the former. In other words, their relationship is fundamentally asymmetric. Nevertheless, climate policy is often seen as a trade-off between 'comparable' risks of natural and economic instability. But these risks are not comparable at all. With a *given global environment* under a stringent climate policy, humans can not predict economic changes with certainty, but they can guide and control them within boundaries. However, under *extreme changes in the global environment*—due to a lax or lacking climate policy—the risk is present that the fragile world economy will respond in an erratic way to a large number of changing environmental variables, notably when these—as in the climate–biosphere system—show catastrophic, irreversible and discontinuous features. Any control of economic change is then out of the question. The upshot is that economic adaptation under stable natural conditions, enhanced by a stringent climate policy, is easier and safer than under unstable natural conditions resulting from a lax climate policy.

A qualitative trade-off of net costs of stringent-policy and no-policy scenarios, based on the insights of the previous section, supports this conclusion. There it was argued that the costs of climate change may be underestimated—see the agriculture example—and that the costs of climate policy may be overestimated—see the Azar/Schneider argumentation in Section 3. These insights taken together suggests a clear choice in favour of a stringent climate policy. In fact, the Azar/Scheider (2002, 2003) approach is very much in line with the current proposal to step away from a complete quantitative CBA and instead judge the relative magnitude of the damage and reduction costs. Witness their statement: "Thus, we do not see costs and benefits in a symmetrical cost-benefit logic, but rather as an equity problem and a risk management dilemma." (Azar and Schneider, 2003, p. 331). As argued above and by Azar and Schneider, the climate damage cost far exceeds the GHG reduction cost. Add to this the irrevocability of climate catastrophes, and the degree of irreversibility of reduction investments appears very modest in comparison. Enough reason to adopt a clear precautionary principle in climate policy—no further economic optimisation needed.

The foregoing suggests that neither decision making based on quantitative CBA nor waiting until more information comes available are clever strategies. The implementation of the Precautionary Principle in climate policy emerges as the only rational strategy, provided that one is seriously concerned about both economic and environmental conditions faced by future generations (Gollier et al., 2000).[8] In other words, a strong sustainability approach results from not accepting a wait-and-see policy when uncertainty is beyond a certain threshold (Krysiak and Krysiak, 2003). Finally, an often-heard argument against the Precautionary Principle is that climate policy means that alternative public goals have to be sacrificed. But whereas, for instance, less health care and education can indeed reduce growth and welfare, they are not connected to extreme and discrete changes at a global scale. For this reason, climate policy deserves to be treated as fundamentally different from other areas of public policy.

Note that the approach proposed here differs from the option and quasi-option value approaches well documented in the literature (even in environmental economics textbooks; see Perman et al., 2003, chapter 13). The main disadvantage of using these in the context of climate change risks is that they represent conceptual rather than operational approaches. The reason is that they assume that identification of states of the world and associated (subjective) probability distributions over these is possible. The conceptual nature is further indicated by the simple two-period structure of the models used. This does not deny the value of the (quasi-)option value approach. For instance, Schimmelpfennig (1995) applies a model of quasi-option value to arrive at the conclusion that investing in renewable energy technology creates an option value, which can be interpreted as the value of flexibility, i.e. keeping options open. Heal and Kriström (2002) clarify the relevance of the approach as: "Most economists, if asked to think of a justification for this principle [the precautionary principle], would probably couch it in terms of learning, irreversibilities and option values ..." (p. 26).

The complexity of climate policy analysis is further increased by the fact that, from a justice perspective, it really needs to take into account the link between the extremely skewed international distribution of income and human history over the last few centuries (Rose and Kverndokk, 1999). The relevance of history has two dimensions. First, the risks of climate change are the result of an accumulation and long residence time of GHGs in the atmosphere. Second, economic history is characterised by unfair trade, colonialism and other historical contingencies. Western countries have a historical responsibility because they have enjoyed high economic growth since the Industrial Revolution, which was associated with an intensive use of fossil fuels, the fundamental cause of the human contribution to GHGs in the atmosphere. The neglect of historical responsibility in the current analyses reflects a political choice that lacks any basis in science and ethics. Presenting such politically biased information to politicians as if value-free will only reinforce already opportunistic strategies in international climate negotiations.

From a global justice perspective, it also makes sense to undertake 'issue linking' (Folmer et al., 1993). This means that international negotiations about climate policy are connected to negotiations about other structural world problems. Obvious themes to be linked are terrorism, poverty and development, and trade (WTO). Research can provide information about how one set of countries, for instance the EU, can negotiate more effectively with another, for instance North America, by identifying the conditions that will promote coalitions around combined standpoints on climate and other themes. Such a linking approach resembles the way compromises are made by political parties in coalition governments—common in many European countries—so as to meet their objectives. It can in fact be regarded as a step forward in global governance and democracy.

6. Conclusions

Taking into account all fundamental and pragmatic points of the critique presented here, implies that economists need to be more careful in applying traditional theories and methods of economic analysis for the purpose of climate policy. The application of quantitative—stochastic or expected—CBA to scenarios of climate change and policy is not just indefensible on academic grounds, it can even provide the wrong incentives for international climate negotiations. Notably, the suggestion that a choice among

[8] In technical terms, this provision means that an individual or society shows prudence, which can be associated with a utility or welfare function that has a positive third derivative, implying a tendency towards saving in the face of increasing uncertainty about future welfare (Heal and Kriström, 2002).

alternative options—complete, partial or no reduction—can be supported by quantitative CBA, has been grist to the mill of the principal opponents of a serious climate policy. As a result, current climate economics contains an implicit bias towards supporting the status quo.

A methodologically relevant general point is that in the face of extreme uncertainty a quantitative analysis is often unable to offer more informative insight than a qualitative analysis. The reason is that the extreme uncertainty does not disappear by adding more quantitative sophistication to the method of analysis. Since quantification requires the adoption of a number of assumptions, it can even lead to incorrect insights, and thus do more harm than good. All economic studies, also the ones that on first sight seem to address catastrophes and extreme uncertainty, somehow limit the extent of both, which can be explained by the desire to stick to the optimization framework.

It has been proposed here that complexity and extreme events related to climate change imply that a qualitative CBA is more credible than a quantitative CBA. In addition, it has been argued, on the basis of theoretical and empirical considerations, that a qualitative CBA supports the use of a minimax regret approach or precautionary principle in climate policy: implement stringent GHG reduction policies as soon as possible. The relevance of adding extreme events to the analysis is almost trivial: our serious worry about climate change is entirely based upon their possible occurrence. Therefore, it seems fair to conclude that economic analyses which have neglected them should not be taken very seriously.

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