Clive L. Spash

Trying to Find the Right Approach to Greenhouse Economics

Some Reflections upon the Role of Cost-Benefit Analysis

Abstract: The approach to controlling greenhouse gas emissions suggested by simple neoclassical economic models has appeared in prominent mainstream journals. This entails weighing up the costs of control compared to the benefits of avoiding damages due to global climate change. This paper presents a critique of extending the microeconomic project based methodology to a complex global problem; raising issues of uncertainty and ignorance. An alternative to simple utilitarianism is seen to be necessary and the potential of a deontological approach is argued to be greater with regard to policy decisions concerning future generations.

I. Introduction

The contribution of economists to the greenhouse debate can be broadly divided into determining how seriously the threat needs to be taken and what action is most efficient to achieve agreed upon policies. The first area is the realm of cost-benefit analysis (CBA) and modelling intergenerational welfare. The second concentrates upon alternative policy instruments such as carbon taxes versus tradeable pollution permits, and the impacts of different tax structures on various industrial sectors. The majority of economists are far more comfortable with this latter role because the tools of conventional economics can be applied and many of the existing models developed for other purposes can be used, eg., merely by changing one sector to represent energy production or increasing the price of fossil fuel inputs. Hence trade, optimal control and game theory models have been repeatedly applied in the economic literature on global warming. However, this second area of research also works within the framework set up by the first and must accept the theoretical approach which is common to both, and in particular the utilitarian philosophy and trade-off assumptions. Thus, while the following sections concentrate upon CBA and intergenerational issues, the constraints to economic techniques which are identified have broader implications. In the next section the CBA approach is outlined and critically analyzed. A comprehensive treatment of CBA in the environmental context is given by Hanley and Spash (1993). The discussion here raises the issues of uncertainty, individual preference formation and intergenerational ethics, each of which is dealt with in turn.

Analyse & Kritik 16 (1994), S. 186-199

II. CBA of Greenhouse Gas Control

The movement towards the adoption of a CBA approach to this issue can be seen on at least two fronts. First, legislation concerning public projects has become increasingly environmentally concerned because of a publicly recognised need to conserve scarce resources. Current legislation in Europe requires the use of environmental impact assessment (where impacts are measured in physical units) for certain projects, under Directive 85/337. While CBA is an alternative paradigm for measuring environmental impacts, in the United States (US) environmental impact assessment was followed chronologically by Regan's executive order 12291, mandating the use of CBA for public projects and policies. Hence CBA has been more commonly applied in the US, so influencing the economic literature and the policy debate on global warming. Second, the imposition of greenhouse gas (GHG) constraints and/or alternative technologies in developing countries will need some justification. Preventing development projects because of their adverse impacts on global climate may disproportionately affect the economies of less developed countries, who can rightly point out that developed countries increased their own GHG emissions levels during early industrialisation.

Faced with the threat of global warming, society has three options: do nothing, prepare to adapt, or reduce emissions of GHGs. The first implies that the greenhouse effect is either unimportant or beneficial. The second and third options take the problem seriously enough to warrant action, and could be carried out simultaneously. Adaptation would include measures such as strengthening sea defences, changing cropping patterns, organizing population migration and increasing irrigation. A policy solely relying on adaptation implies that humans have the ability to adapt to all future consequences and to offset undesirable physical effects, and that this option is less costly than control. Irreversible damages, uncertainty and ignorance of future consequences argue in favour of controlling GHGs. However, to the extent that global warming is already irreversibly underway, society has no choice but to adapt. The third option is the one most commonly studied by economists and forms the focus for the following discussion.

The economic approach to deciding how serious the problem is and what action to take involves weighing-up the costs of control against the benefits of preventing damages, resulting in a picture such as Figure 1. Global warming could be reduced by cutting CO_2, CH_4, CFC and N_2O emissions and/or by increasing sinks for GHGs (eg., reforestation). A stream of costs and a stream of benefits are associated with such actions. Optimal levels of GHG reductions could, in principle, be deduced from an examination of how costs and benefits of control vary with the level of reduction. Marginal control costs will be higher the greater are the reductions in emissions and the quicker a given reduction is attempted. The marginal benefits of reducing GHGs will fall with the level of control, since fewer damages are avoided per unit of GHG reduced. The optimal level of control will occur when the marginal benefits of GHG reductions, in present value terms, are just equal to marginal control costs. This optimal level is shown as E^* in Figure 1. If the assumptions concerning control costs and benefits are correct (eg., there are no discontinuities in the functions), this analysis implies that the optimal reduction in GHGs will be less than 100%, since the output associated with GHG production is valued more highly the scarcer it becomes.

<u>*Figure 1*</u>

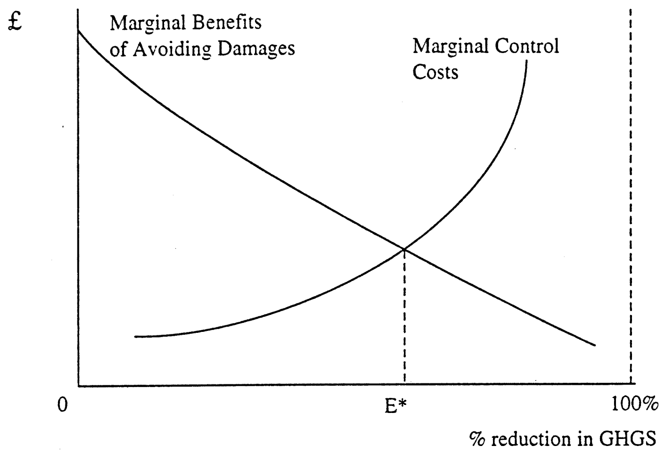

Figure 13.2: Costs and benefits of reducing GHG's

Source: Hanley and Spash (1993) Figure 13.2.

The earliest example of a CBA of GHG control is d'Arge (1975), with little work since then until the early 1990s (a notable exception is Cumberland et al. 1982). Recent approaches range from the country specific (Ingham/Ulph 1991) to world models (Manne/Richels 1991), and from partial equilibrium (IEA, 1989) to general equilibrium studies (Bergman 1991). Surveys of this work may be found in Hoeller et al. (1991) and Ayres and Walter (1991). The almost exclusive focus of these studies is the control cost of CO_2 reductions with exceptions such as Nordhaus (cited below) and Cline (1992).

The work of Nordhaus (1982; 1991a; 1991b) is well known and worth analyzing closer to convey the general CBA approach and some of its flaws. In his most recent studies, Nordhaus divides the USA into three sectors by susceptibility to climate change: (i) very susceptible, such as agriculture; (ii) medium susceptibility, such as construction; and (iii) unsusceptible, such as finance. These sectors accounted for 3%, 10% and 87% respectively of US Gross National Income (GNI) in 1981. The economic benefits of emissions reductions in the high and medium sensitivity sectors is slight (only 0.25% of GNI, or $6.23 billion for double CO_2-equivalent) because these account for a low proportion of total GNI. Marginal damage costs under three scenarios are: $1.83/ton CO_2 for low damages (0.25% of GNI), $7.33/ton CO_2 for medium damages (1% of GNI) and $66/ton CO_2 for high damages (2% of GNI). Nordhaus excludes undesirable effects of global warming on non-marketed resources (such as wildlife), viewing such impacts as too difficult to value. However, he states, "my hunch is that the overall impact upon human activity is unlikely to be bigger than 2% of total world output" (Nordhaus 1991a, 933). In calculating control costs, he assumes GHG reductions will be achieved by methods offering the lowest control cost. He argues that control costs will depend on how fast reductions in GHGs are required, and that marginal control costs will increase steeply beyond a 10% reduction. Thus, Nordhaus calculates the optimal control policy for the greenhouse effect as being to cut CFCs by 9% and CO_2 by 2% under the medium damages scenario (assuming a 1% discount rate).

Such minimalist recommendations have been criticized as misleading, for example, by Daily et al. (1991) and Ayres and Walter (1991). The latter make three main points. First, up to a certain point, the costs of reducing GHGs are negative. In other words, society would be better off reducing its use of substances generating GHGs. This principally means cutting energy demand, since energy production and consumption comprise the single largest source. There are two reasons for this conclusion: (i) due to market distortions energy is currently overused, and (ii) profitable opportunities for energy conservation exist but are currently ignored. Ayres and Walter provide case-study evidence for Italy and the US; whilst Fitzroy (1992) cites similar evidence produced by Flavin and Lenssen (1990). Thus, some GHG emissions can be cut at no net cost. This implies, ceteris paribus, a higher optimal level of emission reduction than the case where control costs are always positive.

Second, cutting GHG emissions has environmentally beneficial side-effects in addition to reducing global warming. CFC reductions will help reduce stratospheric ozone depletion. If a carbon tax were imposed coal consumption would be cut, since coal would face a higher tax rate than either oil or natural gas due to its relatively high carbon content by weight. Reduced coal use would reduce SO_2 emissions and so lower acid deposition. Substitution of renewable energy sources for fossil fuels would reduce pollution externalities. In general, fossil fuels are associated with dispersed temporal and spatial chemical impacts, while renewable energy sources tend to have local physical ones, i.e., lower external costs (Spash/Young 1995). Afforestation would generate a stream of non-market amenity benefits, depending on the type of forestry planted. In fact, the UK Forestry Commission now includes carbon absorption benefits when appraising new tree planting (Whiteman 1991).

Finally, Nordhaus extended his estimates for the US economy to the world level (as does Cline 1992), and Ayres and Walter target their criticism at these world figures. As d'Arge and Spash (1991) have pointed out, developing countries are more susceptible to global warming with extensive dependence upon climate sensitive production, a limited ability to adapt, and a sizeable population of subsistence farmers. In criticising Nordhaus, Fitzroy (1992) points out that climate change combined with soil erosion in food-producing regions would reduce world food supplies at a time when the world population will have doubled. Declining levels in major world aquifers would aggravate this situation. Ayres and Walter revise Nordhaus' estimates of the area of land lost upwards by a factor of ten, and increase the value of land lost in LDCs, such as Bangladesh. They also add an amount to cover the cost of resettling refugees forced to move as a result of sea-level rise. Even without attempting to include non-market effects, these revisions result in benefits of reducing global warming ten times greater than the medium damage scenario estimates given by Nordhaus.

An obvious next step would be to include the economic value of non-market benefits related to actions which reduce global warming. While much work in environmental economics during the last 20 years has focused on such non-market valuation, the application of benefit measurement techniques to the greenhouse effect confronts two key problems. First, many individuals may be unsure as to the meaning of the greenhouse effect and its related damages, and the implications to them of preventing an increase in emission of GHGs. Whilst the valuation of benefits under uncertainty has been the subject of attention in the environmental economics literature (eg., Meier/Randall 1991), others have expressed concerns that poorly informed consumers cannot be relied upon to make sensible decisions about complex environmental phenomena (eg., Sagoff 1988). Second, individuals may be unwilling to trade-off increases/decreases in global warming against losses/gains in income. If a certain proportion of the population hold rights-based beliefs this would prevent them from agreeing to such trade-offs. For example, environmental campaigners might believe that future generations have the right to live in their own homeland regardless of the utility this gives, or of the costs to society. Such non-compensatory decision rules are referred to by neoclassical economists as representing 'lexicographic preferences'. These two issues are now considered in more detail.

III. Uncertain Futures

Introducing uncertainty has lead some economists to argue that reducing GHG emissions is desirable even if the expected costs of doing so are known to exceed the expected benefits (eg., Cline 1992; Spash/Hanley 1994). The reasoning is based upon society being risk averse. Thus, the costs of reducing GHG emissions by 75% might be known to be $1 trillion. The benefits of reducing GHG emissions might range from $0.25 trillion to $10 trillion, with an expected value of $0.8 trillion. If society is risk averse, it can prefer to incur the certain loss of $1 trillion (the 'certainty equivalent') rather than the expected loss of $0.8 trillion, with the potential for higher losses. Thus, GHG control could be regarded as an insurance premium against known but uncertain future states of the world, where the probability of those states occurring is known or knowable. This would be consistent with an expected utility framework, and could justify a safe minimum standard approach. Once a threshold with a safe margin has been chosen, the economy could be 'safely' allowed to emit GHGs.

However, in a fragmented world, risk aversion leads to a risk externality; that is, the risk is placed upon 'other' societies (eg., future generations), rather than leading to GHG control. Thus, (world?) government intervention would then be required to correct both a pollution and a risk externality. More seriously, this economic approach to an uncertain world requires that potential future states are reduced to probabilistic events. As a result Spash and Clayton (1995) note several questionable, implicit assumptions are being made by the analyst.

(i) A cause and effect relationship can be established to determine the outcomes to be included in the set of possible future states; a difficult task for global warming.

(ii) Probabilities can be associated with all future states of the world. The problem is, an action leading to an event may be recognized as a possible state but without a probability being attached to the outcome. Thus, an event can be expressed as uncertain yet have no associated probability of occurrence. The probability itself may be unknown or non-existent. (Such a division of risk and uncertainty can be found in Keynes [1921] 1973).

(iii) The type of missing knowledge being analyzed concerns the risk associated with the occurrence of outcomes. However, all the models of the behaviour of complex systems, such as environmental and economic systems or their interactions, are imprecise and limited in their scope. These limitations arise for a number of reasons: ignorance about a particular system, ignorance about the behaviour of a class of systems, and the indeterminate nature of some complex systems (which can become chaotic at various points). This means the behaviour of such systems can only be modelled in probabilistic terms for limited domains or for a limited time.

(iv) The distribution of risk over space and time is unimportant when judging appropriate action. Yet, many decisions involve choosing between options that have different risks for different people at different times. Part of the issue here concerns the perception of risk. The general public has been observed to reject very low-probability, high-loss risks which experts judge to be acceptable (Freeman 1993, 260). Thus, the experts could vastly underestimate the potential welfare costs that these risks impose upon people.

In addition to these problems there are areas of ignorance related to sources of utility. First, there are elements, substances, and organisms on the planet which have yet to be utilised directly by humans. This can be viewed as uncertainty and ignorance over future use patterns. For example, losses in biodiversity due to global warming can cause future losses of which present humans are ignorant. Second, many of the features of nature that are directly utilised in economic processes are dependent on features of nature that are indirectly utilised. Current biomass depends on an ecological infrastructure which enables flows into human systems but is ignored itself. Thus, stratospheric ozone can be depleted by CFCs so allowing higher levels of UV-B radiation to reach the surface of the planet, this would in turn affect the marine biota at the base of the food chain on which harvested species of fish depend. In this way, uncertainty and ignorance pertain to ecosystems functions in addition to risk.

Once the arguments above are accepted, an optimal level of the insurance premium would be undefinable. Thus, while GHG control can be viewed as an insurance premium this definition tends to reject the wider concepts of uncertainty and of ignorance. Society needs to accept that there are some areas of ignorance which cannot be easily placed into the framework of knowledge about systems (Faber et al. 1992). In general, where altering the potentialities of systems causes changes which are, in principle, unpredictable the appropriate response is to maintain options. This implies accepting the importance of different views on the same problem, questioning current knowledge, and emphasising criteria of flexibility and reversibility (Spash/Clayton 1995).

IV. Non-Compensatory Choices

The typical approach to the valuation of non-market environmental assets (such as wildlife) in environmental economics has been to treat such assets identically to marketed goods and services (e.g., Braden/Kolstad 1991). A standard theoretical assumption is the existence of the direct utility function which includes all items of value. The willingness-to-pay (WTP) of an individual to prevent a loss of an item relates to the impact on their utility function. An individual would therefore be prepared to give up some consumption of other goods to maintain their utility level constant if reducing GHGs made them better-off. The WTP amounts are typically summed across all affected individuals to obtain an aggregate WTP figure. Similarly, the minimum compensation demanded to accept an increase in GHGs can be calculated. In this case expenditure on other goods needs to rise to compensate for the damages caused by global warming, keeping the agent at their initial level of welfare. The welfare measures of WTP and WTAC are expected to diverge, due to the potential for loss aversion (Knetsch, 1990), income effects (Willig 1976) and substitution effects (Adamowicz/Bhardwaj/MacNab 1993).

However, besides the information problems outlined above, some individuals may treat certain environmental goods differently from the manner suggested by this theoretical framework. If an individual believes that aspects of the environment, such as wildlife, have an absolute right to be protected, then that individual will refuse all money trade-offs which decrease what is regarded as an environmental commodity in the neoclassical framework (Spash/Hanley 1995). Thus, WTAC would be infinite, since the respondent believes that GHG damages should remain at or below their current level (i.e., no increases in GHGs should be allowed). Simultaneously, WTP to reduce GHGs can be positive or zero depending upon the income constraint. In fact individuals may express a zero WTP as a protest against the implication that such things as the rights of future generations could be traded for other goods or money.

Such a non-compensatory stance can be viewed as evidence of a lexicographic preference. Lexicographic preferences mean that utility functions including GHG reductions are undefinable for an individual (since the axiom of continuity is violated), and that indifference surfaces are single points (Gravelle/Rees 1992). The implication is that one good is immeasurably more important than another which leads to lexicographic preferences being regarded as unrealistic and unlikely to occur in economics (Malinvaud 1972, 20). However, some evidence for the existence of lexicographic preferences has been put forward eg., Stevens et al. (1991) and Spash and Hanley (1995).

A belief system which denies trade-offs drives at the heart of modern welfare economics which has been built around the Kaldor-Hicks potential compensation test. This test allows for projects to be approved where there is the potential to make at least one person better-off and none worse-off, i.e., some potential resource distribution after the project could achieve a Pareto improvement. Thus, knowledge of the required potential compensation is necessary and, in the neoclassical framework, would be based upon individual preferences. This criterion becomes inoperable once compensatory amounts become infinite. Furthermore CBA itself is meaningless under non-compensatory preferences. The extent to which this issue is relevant to GHG control depends, at least partially, upon how far future generations can be compensated for damages they suffer as a result.

V. Responsibilites to Future Generations

Spash (1994) has argued that the greenhouse effect could have serious impacts upon future generations while actually benefiting their predecessors. This section briefly presents the central argument, which emphasises the importance of alternative ethical viewpoints. More specifically, the consideration of rights for future generations is discussed as being particularly relevant to GHG control.

One problem arising from the use of CBA to determine GHG control is the treatment of the distant future as effectively valueless. This is the case despite perfect information, i.e., even if all costs and benefits could be calculated from individual preferences. As Nordhaus has stated:

> "The efficient degree of control of GHGs would be essentially zero in the case of high costs, low damages, and high discounting; by contrast, in the case of no discounting and high damages, the efficient degree of control is close to one-third of GHG emissions." (1991a, 936)

The distribution of net costs in the future, and net benefits now, makes the emission of GHGs appear falsely attractive. Spash (1993), has criticised four common reasons for giving less weight to the expected future damages of long-term environmental pollution, than if they were to occur now. These concern who constitutes the electorate, uncertainty over future preferences, the extinction of the human race, and uncertainty over future events. Without these justifications discounting loses its moral imperative. CBA as commonly applied would use an arbitrary but positive social discount rate. Thus, implicitly, some concern for the future effects of global warming would be shown, but the extent of this concern would depend upon the discount rate chosen. The problem which faces economists, in falling back on the use of a positive rate, is that their policy conclusions still have serious long-term implications which raise the need for a moral justification for the procedure. This is made clear by the comparision of economic viewpoints on discounting and philosophic positions on obligations to future generations which are summarised in Table 1.

<u>*Table 1*</u>

Discounting and Obligations to Future Generations

Economic Viewpoints

(i) An infinite discount rate should be used
(ii) The intergenerational (between generations) discount rate should be greater than zero but less than infinity
(iiia) The intra-temporal (within a generation) and intergenerational discount rates should be the same; or
(iiib) the appropriate discount rate is zero
(iv) A negative intertemporal discount rate should be used

Philosophic Viewpoints

(i) No moral obligations beyond the future exist
(ii) Moral obligations to the future exist, but the future is assigned less weight than the present
(iii) Rights and interests of future persons are the same as those of contemporary persons
(iv) Moral obligations to the future exist, and the future is assigned more weight than the present

However, there is a persistent view that the current generation should be unconcerned over the loss or injury caused to future generations because they will benefit from advances in technology, investments in both man-made and natural capital, and direct bequests. Adams (1989, 1274) has raised this exact issue in terms of alleviating our responsibilities for global warming. While fossil fuel combustion implies foregone opportunities for future generations, they "typically benefit (in the form of higher material standards of living) from current investments in technology, capital stocks, and other infrastructure". However, this line of reasoning confuses actions taken for two separate reasons. That future generations may be better-off has nothing to do with societies consciously deciding to compensate the future.

If society has in fact been undertaking investments with the express purpose of compensating future generations for global warming, the lack of publicity has been conspicuous. More importantly this would imply that the extent to which the future will be better off has in some sense been balanced against *all* the long-term environmental problems. That is, society cannot take global warming and see the future as better off, and then ignore global warming and take ozone depletion as compensated, and then ignore ozone and balance nuclear waste against supposed future well-being. Each case of long-term damage implies compensation which is distinct from catering for the general needs of future individuals.

This distinct nature of such compensatory transfers has been neglected (Spash/d'Arge 1989; Spash 1993; 1994). The greenhouse effect creates an asymmetric distribution of losses and gains over time. Intergenerational compensation would counterbalance the negative outcomes of global warming by positive transfers, while not interfering with basic transfers. For example, assuming egalitarianism, the maintenance of the same welfare level fails to compensate for global warming. Yet the suggestion has been made that spreading the costs of global warming equitably across generations is an acceptable solution (Crosson 1989).

The problem with the latter approach arises from the economic view that changes in units of welfare are equivalent regardless of their direction. The standard approach of economists can be traced at least as far back as Bentham ([1843] 1954, 438), who regards an evil as reparable when an individual is indifferent between sustaining the evil with compensation and avoiding the evil altogether. Unfortunately, this approach treats harm as reversible by good. In general, doing harm is not cancelled out by doing good. If an individual pays to have a road straightened and saves two lives a year, they cannot shoot one motorist a year and simply calculate an improvement (Barry 1983). This argument is most apparent: where the right to life is involved, but can be extended to other areas where rights are accepted to exist. For example, assume individuals of a nation are accepted to have a right to live in their own homeland. Sea level rise due to global warming floods the Maldives and violates this right. Of course the Maldavians can be relocated and compensated, but this approach is unacceptable given the previously stated right.

The objection free-market economists might raise to the imposition of such rights is that freely contracting parties are prevented from entering into agreements of their own free will. That is, the individual is their own best judge of welfare changes. If the Maldavians believe they are better off in their new homeland then who is to deny the acceptability of this exchange. The difficulty in the intergenerational context is that the individuals who will be impacted are unavailable for comment. In order to protect these individuals from unjustified harm rights could be used, so that what appeared to be a problem for the use of rights can be viewed as an argument in their favour. In fact, this approach would define harm as a violation of the rights adopted by society.

The appeal to the 'safe minimum standard' can be viewed as an example of constraining economic trade offs by introducing rights. This standard advocates the protection of species, habitats, and ecosystems unless the costs of doing so are 'unacceptably large'. In the case of global warming Batie and Shugart (1989) argue that the safe minimum standard would support emission reductions despite apparently high costs. However, the withdrawal of the right of say a species to exist at some cost implies a basis of the right within utilitarian morality. This view contrasts with rights in the context of a deontological philosophy.

A deontological philosophy sees certain features in a moral act as themselves having intrinsic value. For example, lying is wrong regardless of the consequences; see Pojman (1989). This viewpoint contrasts with teleological systems which consider the ultimate criterion of morality in some non-moral value that results from actions. Neo-classical economists operate with a teleological outlook but a considerable number of individuals may exist who hold to deontological philosophies. For example, the refusal to play and extreme bidding found in contingent valuation studies may be symptomatic of this.

The economic process of exchange can be viewed as the transfer of goods and services within a framework of established rights. In this case rights are only valid in as far as the institutional setting allows them to exist. Yet the question being probed here is one of the existence of a right of future generations in the sense of a natural-right, not merely the recognition by a piece of legislation in a particular society at a particular time that such a right is valid. A natural-right can be defined as a right based upon intrinsic value (see Nash 1989). The UN charter of human rights represents an internationally accepted set of goals to which the world aspires. The fact that these rights are violated does not reduce their importance. Yet within these rules there is little comfort for future generations. A generous reading would only protect the future indirectly under articles intended to protect the current generation. Public concern is starting to be expressed regarding this oversight and this has reached the extent of a global petition to the United Nations (Cousteau Society 1991).

If rights which protect future individuals from the results of our GHG emissions are accepted to exist the scope for trade-offs commonly assumed in economics will be drastically reduced. Compensation payments are no longer licences for society to pollute, provided the damages created are less than the amount of compensation. In which case compensation cannot be used to excuse the continuation of GHG emissions. Irreversible damages which will occur regardless of GHG emissions reductions would require compensation. In order to protect the future from potential infringements upon this right actions with uncertain intertemporal consequences would have to be avoided, and environmentally benign production and consumption processes encouraged.

Due to the cost of enforcing the rights of future generations to remain unharmed the current generation has a vested interest in denying those rights. Continuing to emit GHGs at current rates denies the future the right to remain undamaged and asserts the dominance of the current generation. The current generation is then being asked to change the present rights structure, as found within society, in a manner detrimental to its own interest. The dictatorship of the current generation allows the imposition of damages regardless of the gain now and the extent of future damages.

VI. Conclusions

CBA runs into problems due to uncertainty in the estimation of benefits, attitudes towards future generations and, more fundamentally, the very size of the problem (there is a point at which marginal welfare analysis loses its theoretical basis). These problems prevent a clear answer as to what should be done and economics cannot, of course, provide a complete answer. The costs of reducing CO_2 emissions may be quite high, but because the benefits of reducing emissions are beyond economists' ability to estimate, the extent to which control options should be adopted, on efficiency grounds alone, is unknown. Thus, a practical way forward is to adopt 'no regret' or 'double dividend' policies. These are actions which can be justified on their own account, but which also reduce global warming. Such policies include solving third world food insecurity, increasing energy efficiency, cutting CFC emissions, preventing deforestation and encouraging reforestation. Similarly, if energy prices are below their marginal social cost (excluding global warming impacts), then raising energy prices will make utilization more efficient and reduce GHG emissions.

The economists' appeal to CBA attempts to take losses and gains of controlling harmful activities directly into account. In doing so the rights of future generations are violated when the costs of controlling the greenhouse effect are deemed to exceed the benefits of that control. The use of CBA therefore denies the existence of inalienable rights, i.e., harm and good are seen as equivalent. However, harm is recognisably different from good and the deliberate infliction of harm is morally objectionable, as recognised in modern democracies. If remaining unharmed is defined as a set of rights given to future individuals actual compensation is required if these rights are violated. If at all possible these rights should not be violated and people should be freed from actions which deliberately externalise the risk of damages by imposing it upon others. These issues begin to reflect upon the role of CBA and some of the problems apparent with WTA measures where a structure of rights enforces a compensation principle.

The task of defining harms will be difficult, but as suggested earlier the U.N. charter of human rights provides guidance. A further difficulty arises in being uncertain as to when an action might result in the violation of such rights. In terms of the greenhouse effect there is a strong case to believe numerous contraventions of these basic rights will occur. The point here is to emphasise a fundamental basis for human action in morality.

Bibliography

Adamowicz, W. L./V. Bhardwaj/B. MacNab (1993), Willingness to Pay and Willingness to Accept Compensation, in: *Land Economics 69 (4)*, 416-427

Adams, R. M. (1989), Global Climate Change and Agriculture: An Economic Perspective, in: *American Journal of Agricultural Economics 71(5),* 1272-1279

Ayres, R. U./J. Walter (1991), The Greenhouse Effect: Damages, Costs and Abatement, in: *Environmental and Resource Economics 1(3),* 237-270

Barry, B. (1983), Intergenerational Justice in Energy Policy, in: D. MacLean/P. G. Brown (eds.), *Energy and the Future*, Totowa, 15-30

Batie, S. S./H. H. Shugart (1989), The Biological Consequences of Climate Changes: An Ecological and Economic Assessment, in: N. J. Rosenberg/W. E. Easterling/P. R. Crosson/J. Darmstadter (eds.), *Greenhouse Warming: Abatement and Adaptation*, Washington

Bentham, J. ([1843] 1954), The Psychology of Economic Man, in: *The Economic Writings of Jeremy Bentham. Vol. 3*, W. Stark (ed.), London, 421-450

Bergman, L. (1991), General Equilibrium Effects of Environmental Policy: A CGE-Modelling Approach, in: *Environmental and Resource Economics 1(1)*, 43-62

Braden, J./C. Kolstad (1991), *Measuring the Demand for Environmental Quality*, Amsterdam

Cline, W. R. (1992), *The Economics of Global Warming*, Essex

Cousteau Society (1991), Protecting the Rights of Future Generations, in: *Calypso Log*, August

Crosson, P. R. (1989), Climate Change: Problems of Limits and Policy Responses, in: N. J. Rosenberg/W. E. Easterling/P. R. Crosson/J. Darmstadter (eds.), *Greenhouse Warming: Abatement and Adaptation*, Washington, 69-82

Cumberland, J. H./J. R. Hibbs/I. Hoch (eds.) (1982), *The Economics of Managing Chlorofluorocarbons: Stratospheric Ozone and Climate Issues*, Baltimore

Daily, G. C./P. R. Ehrlich/H. A. Mooney/A. H. Ehrlich (1991), Greenhouse Economics: Learn Before You Leap, in: *Ecological Economics 4*, 1-10.

d'Arge, R. C. (ed.) (1975), *Economic and Social Measures of Biological and Climatic Change. Vol. 6: Climate Impact Assessment Program*, US Department of Transport

– /C. L. Spash (1991), Economic Strategies For Mitigating the Impacts of Climate Change on Future Generations, in: R. Costanza (ed.), *Ecological Economics: The Science and Management of Sustainability*, New York, 367-383

Faber, M./R. Manstetten/J. L. R. Proops (1992), Humankind and the Environment, in: *Environmental Ethics 1(3)*, 217-241

Fitzroy, F. (1992), Economic Aspects of Global Warming: A Comment, in: *Green Values: Scottish Environmental Economics Discussion Group Newsletter 5*, 4-7

Flavin, C./N. Lenssen (1990), *Beyond the Petroleum Age: Designing a Solar Economy*, Worldwatch Institute, Washington

Freeman, A. M. (1993), *The Measurement of Environmental and Resource Values: Theory and Methods*, Washington

Gravelle, H./R. Rees (1992), *Microeconomics*, Essex

Hanley, N./C. L. Spash (1993), *Cost-Benefit Analysis and the Environment*, Aldershot

Hoeller, P./A. Dean/J. Nicolaisen (1991), Macroeconomic Implications of Reducing Greenhouse Gas Emissions: A Survey of Empirical Studies, in: *OECD Economic Studies 16*, 45-78

International Energy Authority (1989), *Energy and the Environment*, Paris

Ingham, A./A. Ulph (1991), Carbon Taxes and the UK Manufacturing Sector, in: F. Dietz/F. van der Ploeg/J. van der Straaten (eds.), *Environmental Policy and the Economy*, Amsterdam., 197-240

Keynes, J. M. ([1921] 1973), *A Treatise on Probability*, London

Knetsch, J. (1990), Environmental Policy Implications of the Disparity Between Willingness to Pay and Compensation Demanded, in: *Journal of Environmental Economics and Management 18*, 227-237

Malinvaud, E. (1972), *Lectures on Microeconomic Theory*, Amsterdam

Manne, A./R. Richels (1991), Global CO_2 Emission Reductions: The Impacts of Rising Energy Costs, in: *The Energy Journal 12(1)*, 87-102

Meier, C./A. Randall (1991), Use Value Under Uncertainty, in: *Land Economics 67(4)*, 379-389

Nash, R. F. (1989), *The Rights of Nature: A History of Environmental Ethics*, Madison

Nordhaus, W. (1982), How Fast Should We Graze the Global Commons?, in: *American Economic Review Association Papers and Proceedings 72(2)*, 242-246

– (1991a), To Slow or Not to Slow: The Economics of the Greenhouse Effect, in: *Economic Journal 101*, 920-938

– (1991b), A Sketch of the Economics of the Greenhouse Effect, in: *American Economic Review 81(2)*, 146-150

Pojman, L. P. (1989), *Ethical Theory: Classical and Contemporary Readings*, Belmont

Sagoff, M. (1988), *The Economy of the Earth*, Cambridge

Sen, A. K. (1982), Approaches to the Choice of Discount Rates For Social Cost-Benefit Analysis, in: R. C. Lind (ed.), *Discounting for Tome and Risk in Energy Policy*, Baltimore, 325-353

Spash, C. L. (1994), Double CO_2 and Beyond, in: *Ecological Economics 10(1)*, 27-36

– (1993), Economics, Ethics and Long-Term Environmental Damages, in: *Environmental Ethics 15(2)*, 117-132

– /A. Clayton (1995), The Maintenance of Natural Capital: Motivations and Methods, in: *Environmental Values*, forthcoming

– /R. C. d'Arge (1989), *Compensation of Future Generations for Adverse Climatic Changes*, Presented at the Western Economic Association International Meeting, Lake Tahoe, June 18-22, 1-37

– /N. Hanley (1994), *Cost-benefit Analysis and the Greenhouse Effect*, Ecological Economics Discussion Paper 94/6, Environmental Economics Research Group, Economics Department, University of Stirling

– / – (1995), Preferences, Information and Biodiversity Preservation, in: *Ecological Economics*, forthcoming

– /A. Young (1995), Environmental Imperatives and Renewable Sources of Energy, in: S. Shojai (ed.), *Global Oil Markets*, forthcoming

Stevens, T./J. Echevarria/R. Glass/T. Hager/T. More (1991), Measuring the Existence Value of Wildlife: What Do CVM Estimates Really Show?, in: *Land Economics 67(4)*, 390-400

Whiteman, A. (1991), *A Comparison of the Financial and Non-Market Costs and Benefits of Replanting Lowland Forests*, Presented to the Scottish Environmental Economics Discussion Group

Willig, R. (1976), Consumers' Surplus Without Apology, in: *American Economic Review 66*, 589-597