

Socio-economic aspects of the greenhouse effect: Climate Fund

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Abstract

The project *Socio-economic aspects of the greenhouse effect: Climate fund* studies the impact of international capital transfers on the efficiency and efficacy of greenhouse gas emission reduction. The absolute costs of emission abatement is substantially lower in less developed countries. The associated reduction of the damage due to conventional air pollution is higher in the richer countries in both absolute and relative terms. The costs of climatic change are relatively higher (but absolute lower) in the developing countries. Prime impacts are on agriculture (in the developing world) and human health (highly valued in the developed world). Costs of emission reduction and climatic change are joined in a nine region, quasi-Ramsey, integrated climate-economy model, called *FUND*. The first calculations with this model show that the (hardly known) dynamics of climate change and the great uncertainties play a critical role, that free riding behaviour need not be as prominent a problem as is generally believed, and that international capital transfers do not seem to substantially influence the optimal emission control, as the regions most interested in climate change do not have much capital to transfer. Negotiated emission caps are likely to alter this conclusion.

1. INTRODUCTION

The project *Socio-economic aspects of the greenhouse effect: Climate fund* is centred around the question: What is the impact of international capital transfers on the efficiency and efficacy of greenhouse gas emission reduction measures? The reason for asking this question is clear: Those countries which are willing and able to pay for greenhouse gas emissions are not necessarily the same as those who can establish this in an efficient and effective manner. The simple fact that enlarging the number of reduction options by allowing international capital transfers lowers, at least not raises, reduction costs is an important motivation. Moreover, climatic change is a global problem, and can only be controlled by international action. This is true because the impact of most countries on the climate is small, individual measures could well disadvantage domestic competitiveness without reducing emissions, and the

risk of free rider behaviour is high. International capital transfers might convince countries to participate in internationally concerted climatic change abatement action. Capital transfers avoid many of the problems associated with joint implementation and emission permits in that emission targets and baseline paths need not be explicitly assessed.

A number of matters need to be discussed in order to investigate the impact of international capital transfers on greenhouse gas emissions. First, the international distribution of the costs and benefits of emission reduction need to be studied (since emission reduction is assumed to be based on a cost-benefit analysis). As little attention has been paid in the literature to the benefits of emission abatement (benefits stand for avoided damage costs of climatic change) and more to the costs, the focus is on the benefit side. This matter is dealt with in Section 2. Section 3 discusses the second phase of the study: The design of an integrated climate economy model, the *Climate Framework for Uncertainty, Negotiation and Distribution*, which is used to calculate the optimal emission control for nine major world regions with and without capital transfers. The results of this model, *FUND*, are presented in Section 4. Section 5 concludes the paper. A number of smaller activities took place along the main line of research, just described. Their results are here briefly presented where appropriate. The subjects covered are the social rate of discount, the dynamics of climate change damage costs, and the impact of uncertainties on optimal emission control.

2. THE COSTS AND BENEFITS OF EMISSION REDUCTION IN AN INTERNATIONAL PERSPECTIVE

The brief discussion on the costs of greenhouse gas emission reduction in this section draws on Tol (1993a, 1994a). The discussion on the costs of climate change and the benefits of the emission reduction draws on Dorland *et al.* (1994), Jansen (1993), Pearce *et al.* (1995) and Tol (1993a, 1994a,c,d, 1995a).

2.1. The Costs of Emission Reduction

Many studies on the costs of reducing the emissions of carbon dioxide by the burning of fossil fuels suggest that the costs are modest or even negative for an emission cut of about 25%. This is caused by the present inefficiency of the energy market and the cheap alternatives (primarily energy switching and saving) available. This goes for most countries, developed, developing and transitional alike. Cost differences between countries seem to be mainly induced by differences in absolute levels of economic prosperity. Knowledge on poorer countries is substantially more limited than knowledge on richer countries, however. The secondary benefits of emission control, i.e., reductions of conventional air pollution, are much higher in the richer countries in both relative and absolute terms. Generally, the costs per tonne of carbon sequestered through afforestation and slowing deforestation is lower in tropical, poorer countries than in extratropical, richer countries because of the lower prices per hectare and higher CO₂ uptake per hectare in the tropics.

2.2. The Damage Costs of Climate Change

Table 1 contains the estimated socio-economic costs of $2\times\text{CO}_2$ climatic change for the present day economy for nine damage categories and nine world regions. Non-market impacts are assessed using (approximate) willingness to pay and willingness to accept compensation methods. Table 1 shows that the impact of climate change on human mortality is the largest category. The sensitive issue what value to place on a statistical life is thus very prominent in the climate debate. Table 1 also shows that the poorer regions, which contributed very little to the past built up of the atmospheric concentration of greenhouse gases, are substantially more vulnerable to climatic change.

Table 1
Total damage costs of $2\times\text{CO}_2$ climate change

damage category	(10^9 \$)	region	(10^9 \$)	(%GP)
coastal defence	9.5	OECD-America	74.0	(1.5)
dryland loss	9.8	OECD-Europe	56.5	(1.3)
wetland loss	18.8	OECD-Pacific	59.0	(2.8)
species loss	22.0	Eastern Europe and		
agriculture	14.5	former USSR	-7.9	(-0.3)
amenity	38.0	Middle East	1.3	(4.1)
life/morbidity	188.0	Latin America	31.0	(4.3)
migration	13.8	South Asia	53.6	(8.6)
natural hazards	1.4	China	18.0	(5.2)
		Africa	30.3	(8.7)
total	315.7	World	315.7	(1.9)

2.3. From Benchmark Damage Costs to Benefits of Abatement

The previous section discussed the best guess impact of $2\times\text{CO}_2$ climate change on the present day economy. This is not what a decision maker would be interested in. First of all, $2\times\text{CO}_2$ is quite an arbitrary benchmark; it will certainly not affect the present day economy. In Tol (1994f, 1995a,b), I argue that climate change damage is dynamic and these dynamics do matter. Six types of dynamics are distinguished: Non-equilibrium climate change socio-economic vulnerability, damage valuation, damage accumulation, learning, and higher-order impacts. Graph 1 displays the optimal carbon emission control according to Nordhaus' *DICE* model in the base case (U), in case the intangible damage is allowed to influence only the utility (U'), and in case the intangible damage is assumed to grow linearly with per capita income (U'').

Second, decision makers are not interested in best guess but in expected damage. The mean damage is much larger than the best guess damage because most uncertainties are positively skewed, most damage functions are convex, and the uncertainties cascade through many levels. Figure 2 displays some

numerical examples of best guess damages and expected damages under limited (optimistic) and profound (pessimistic) uncertainties.

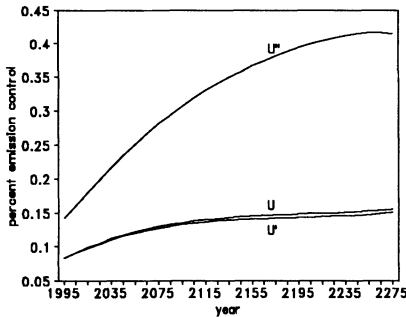


Figure 1. Optimal emission control in *DICE* for three different welfare functions.

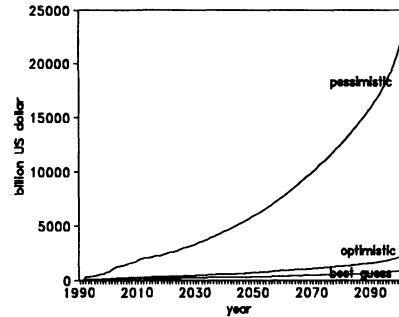


Figure 2. Best guess versus expected damage according to the damage module of *FUND*.

3. THE CLIMATE FRAMEWORK FOR UNCERTAINTY, NEGOTIATION AND DISTRIBUTION

Here we discuss the set-up of the central tool: The *FUND* model. This model is first described by Tol (1994a) and subsequently improved in Tol (1994b,c,d,e,g). Here version 1.4 is discussed. A further revision and a user-friendly version are to be presented early 1995 (Tol, 1995c). *FUND* is a nine-region, quasi-Ramsey closed-loop, integrated climate-economy model for the period 1990-2100. For a general discussion of the current generation of integrated models the reader is referred to Weyant *et al.* (1995). Figure 3 displays a flow diagram. Most boxes have very simple representations in the model. *FUND* is capable of calculating optimal greenhouse gas emission control under certainty and uncertainty, for cooperative and non-cooperative games, and with and without interregional capital transfers. Instruments include fiscal and regulatory measures, and afforestation. The discount rate is one of the most crucial parameters in climatic change cost-benefit analysis but general rules for its value cannot readily be derived (van der Burg, 1993).

4. OPTIMAL GREENHOUSE GAS EMISSION CONTROL

The amount of emission control according to *FUND* is rather high in all the model's optimisation settings. One reason is that version 1.4 only considers emission reduction in the period 1990-2000. Under uncertainty and in the cooperative game, the optimal reduction is higher. As opposed to the literature, where free riding is seen as a major hurdle to arrive at an internationally concerted emission abatement strategy, *FUND* also points at the opposite

behaviour: In some cases it is economically rational to abate more if other regions do the same (Sen's assurance game). As a result of non-linear feedbacks, the marginal damage function is not monotone. The reduction is sensitive to the model parameters, such as the climate sensitivity, the costs of climate change and the costs of emission abatement. In the OECD regions, the secondary benefits, i.e., the reduction in the costs of conventional air pollution, is a very important motivation for emission reduction. Interregional capital transfers do not seem to play a very critical role in emission reduction. Possible explanations are that secondary benefits are transferred as well, capital transfers are costly, and the regions that benefit most from emission reduction have the least to transfer.

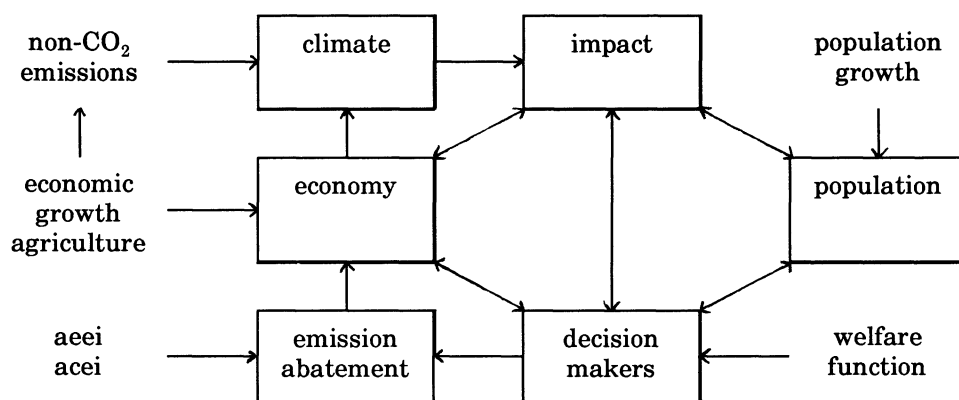


Figure 3. Flow diagram of *FUND*.

5. CONCLUSION

Despite a wide divergence in the regional costs and benefits of greenhouse gas emission control, and despite substantial optimal emission abatement, interregional capital transfers are not found to play a critical role in the emission reduction game. The prime reason appears to be that the regions which have a potential incentive to transfer capital, i.e., the OECD, is more interested in combatting conventional air pollution than climatic change. This situation is likely to change if fixed (instead of optimal) emission trajectories are negotiated, a topic to be studied in the near future.

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