ECONOMICS BULLETIN

Is international cooperation on climate change good for the environment?

Alberto Ansuategi
University of the Basque Country

Marta Escapa
University of the Basque Country

Abstract

In this paper we construct an overlapping generations model with climate−economy interactions, where the world is split into two regions. We resort to numerical simulations of the calibrated model to analyze the effect of international cooperation on both the economy and the climate. The results show that, when we consider short−lived governments and international income transfers are allowed, cooperation may lead in the short run to higher environmental degradation than what it would arise in the non−cooperative scenario.

Financial support from grants 9/UPV 00I01−I01−14548/2002 and SEC2001−0687 is gratefully acknowledged.
Citation: Ansuategi, Alberto and Marta Escapa, (2004) "Is international cooperation on climate change good for the environment?." *Economics Bulletin*, Vol. 17, No. 7 pp. 1−11
Submitted: October 11, 2004. **Accepted:** November 29, 2004.
URL: http://www.economicsbulletin.com/2004/volume17/EB−04Q00001A.pdf

1. INTRODUCTION

Cooperation among countries to reduce greenhouse gas emissions (GHG emissions hereafter) is crucial to tackle the global warming problem. There are several papers (Eyckmans and Finus (2004), Eyckmans and Tulkens (2003), Germain *et al.* (2003, 1997) and Yang (1999)) that use an infinitely-lived agent framework to show how international transfers may facilitate international cooperation to reduce GHG emissions. Another branch of the literature deals with the intergenerational nature of the global warming problem and uses an overlapping generations framework to study intertemporal efficiency and intergenerational distribution issues. Examples include Ansuategi and Escapa (2002), Gerlagh and Zwaan (2001a, 2001b), Gerlagh (2000), Howarth (1996, 1998 and 2000) Marini and Scaramozzino (1995), Rasmussen (2003), and Stephan et al. (1997). However, the study by John and Pecchenino (1997) is the only published article where the international and intergenerational dimensions of environmental problems are jointly considered. John and Pecchenino conclude that international agreements with transfers that lack an intergenerational perspective could actually harm the environment.

The main aim of our paper is to check whether John and Pecchenino's result applies to climate change or not. For this purpose, we construct and calibrate a two-region version of the overlapping generations model of climate-economy interactions described in Howarth (1998). Our simulations for a set of scenarios show that international cooperation among short lived governments may increase GHG emissions in the short run.

The paper is organized as follows. After this introduction, section 2 presents the model. Section 3 describes the command optimum for the non cooperative and the cooperative scenarios. The model is calibrated in section 4 and numerical results and conclusions are presented in section 5.

2. THE MODEL

In our model of global climate-economy interactions the world is divided into two regions: North and South. Each region is assumed to produce a single commodity which can be used for either consumption or investment. Population growth and technological change are exogenous, whereas capital accumulation is determined through optimization of life-cycle saving by individuals. The model does not consider inter-regional trade in goods or capital nor inter-regional mobility of labor, but unilateral transfers of output between the North and the South (q_t) are allowed.

At each date $t = 0,1,...T$ and in each region $i = North, South$ a new generation of n_t^i identical individuals is born who lives at dates t and $t+1$. Individuals of generation t will be young in t and old in $t+1$. A typical person born at date t in region i enjoys the consumption levels c_{yt}^i in youth and c_{ot+1}^i in old age. It is assumed that individuals do not get utility from leisure and so supply their unit of labor inelastically to the production sector at each stage of life, earning a real wage of w_t^i in youth and w_{t+1}^i in old age. Besides, each individual receives net income transfers p_{yt}^i and p_{ot+1}^i from the regional government at dates t and $t+1$.

Individual preferences are represented by an additive separable utility function defined over per capita consumption in youth and in old age:

$$u_t^i = u(c_{yt}^i) + \frac{1}{1+r^i} u(c_{ot+1}^i) \quad r^i \geq 0, u'(.) > 0, u''(.) < 0 \tag{1}$$

where r^i represents individuals' pure time preference in region i.

Agents are born with no assets and choose to end up with zero assets when they die. The aggregated saving of the young in region i at time t ($S_t^i \equiv n_t^i s_t^i$) generates the aggregated capital stock ($K_{t+1}^i \equiv n_t^i k_{t+1}^i$) that is used in region i at time $t+1$ to produce output in combination with the aggregated labor supply ($N_{t+1}^i \equiv n_{t+1}^i + n_t^i$) and the residual emissions of GHGs (E_{t+1}^i) in region i at time $t+1$. The investment in capital of the young in region i at time t (k_{t+1}^i) is rented out at an interest rate r_{t+1}^i to the production sector to help financing consumption in old age.

Production at time t in region i is organized by competitive firms that use constant returns technology:

$$Y_t^i = f_t^i(K_t^i, N_t^i, E_t^i, T_t) \tag{2}$$

We assume that $f_t^i(.)$ is increasing in capital (K_t^i), labor (N_t^i) and GHG emissions (E_t^i) and decreasing in the change of mean global temperature relative to the pre-industrial norm (T_t). The time subscript on the production function allows for exogenous technological change.

The change of mean global temperature relative to the pre-industrial norm (T_t) is a global public bad that will be determined by the time path of GHG emissions in the past:

$$T_t = T_t\left(\sum_i E_0^i, \ldots, \sum_i E_{t-1}^i\right) \tag{3}$$

Thus, current emissions will imply increased future environmental degradation and hence reduced future output. We will therefore assume that each regional government taxes GHG emissions at a rate v_t^i to account for their negative impact on production.

It is known that the competitive equilibrium does not in general support an optimal distribution of welfare[1]. In this model two types of intervention are required in order to achieve an optimal distribution of welfare. First, emissions must be properly priced (emission taxes). Second, income transfers (p_{yt}^i and p_{ot+1}^i) have to be selected with the intention of maximizing social welfare. In the next section we show how income transfers and emission taxes vary depending on the cooperative nature of short lived governments[2].

---

[1] Ansuategi et al. (2003) contains a complete characterization of the competitive equilibrium for this economy.

[2] We focus on decisions by short-lived governments, since it is in this case, if in any, where we can expect international cooperation not to result in an improvement in future environmental conditions.

3. THE COMMAND OPTIMUM

3.1. Non-Cooperative Short-Lived Governments

We will first consider the case of short-lived regional governments (NCSL governments hereafter) that do not behave cooperatively[3].The short-lived nature of the government implies that pigovian taxes will be designed to pursue an efficient allocation of resources from an intergenerationally limited perspective and those effects that outlive the two generations represented by the government will be ignored. The non-cooperative nature of the government implies that pigovian taxes will be designed in order to yield a within-regional efficient allocation of resources. In other words, GHG emissions will be locally priced according to their marginal impact on the local economy and ignoring their marginal impact on the rest of the world economy.

At each point in time, t, the NCSL government maximizes the following social welfare function:

$$W_t^i = \frac{1}{1+r^i} u(c_{ot}^i) + \frac{1}{1+R^i}\left[u(c_{yt}^i) + \frac{1}{1+r^i} u(c_{ot+1}^i)\right] \tag{4}$$

where $\left[1+R^i\right]^{-1}$ represents the weight the government in region i attaches to the life-cycle utility of a typical young person relative to the life-cycle utility of a typical old person. The NCSL regional government's decisions are subject to a set of constraints related to individuals' budget, consumption possibilities in region i at times t and $t+1$ and release of revenues raised by the tax on GHG emissions through net income transfers.

3.2. Cooperative Short-Lived Governments

In the case of short-lived regional governments that do behave cooperatively (CSL governments hereafter), pigovian taxes will be designed in order to yield a cross-regional efficient allocation of resources. This means that GHG emissions will be locally priced according to their marginal impact on the global economy. Note also that, as cooperative governments will think global we will assume that inter-regional transfers of output will take place.

In what follows we will represent variables referring to the South with an asterisk to distinguish them from variables referring to the North. At each point in time, t, CSL governments maximize the following social welfare function:

$$\begin{aligned} W_t = a\left[\frac{1}{1+r} u(c_{ot}) + \frac{1}{1+R}\left[u(c_{yt}) + \frac{1}{1+r} u(c_{ot+1})\right]\right] + \\ +(1-a)\left[\frac{1}{1+r^*} u(c_{ot}^*) + \frac{1}{1+R^*}\left[u(c_{yt}^*) + \frac{1}{1+r^*} u(c_{ot+1}^*)\right]\right] \end{aligned} \tag{5}$$

---

[3] We assume that the non cooperative situation is represented by the open loop Nash solution which implies that governments commit themselves to an optimal policy and cannot react to any deviations from that optimal policy.

where a and $(1-a)$ represent the weight attached to the local welfare of the North and the South, respectively, subject to different budget constraints.

4. CALIBRATION OF THE MODEL

We calibrate the model based on the technical constraints of Yang's (1999) two region version of the RICE model developed by Nordhaus and Yang (1996). Both models simulate economy-environment interactions using an infinitely lived agent framework. In Yang's modified RICE model the North represents the USA, Japan and the European Union, while the South includes the Former Soviet Union, China and the rest of the world in the original RICE model. Table 1 presents the numerical values and functional forms used in this paper. A detailed explanation of the calibration of the model is provided in Ansuategi *et al.* (2003). Here we will just address four technical considerations concerning:

1. The choice of the pure rates of time preference (r and r^*): we have chosen them to equate the rates of capital accumulation in the NCSL scenario and the modified RICE model. This has led us to consider a pure rate of time preference of 0.5%/year both in the North and in the South.
2. The choice of the international welfare weights (a): we have considered several values (ranging from $a = 0,2$ to $a = 0,8$) in order to analyze how they affect to the cooperative solution. These different welfare weights may reflect different degrees of either bargaining power or interregional altruism of cooperative short lived governments.
3. The choice of the intergenerational discount rates (R and R^*): for the sake of simplicity, we have decided to assume that it is institutionally infeasible to implement an intergenerational transfers scheme. This implies that, independently on the rate of intergenerational discount rate chosen by society in each region, governments will lack the necessary instruments to pursue the desired distribution of welfare between generations. Thus, not being able to re-allocate initial endowments, there will be a single "efficient" allocation of resources within each region.
4. The choice of the time horizon T: we have chosen year 2490 (T=15) as the final year in the analysis.

TABLE I
MODEL CALIBRATION

DESCRIPTION	UNITS	YEAR	NORTH	SOUTH
Initial population	Billion people	2000	0.77521	5.88921
Young people	%	2000	50	65
Initial capital stock	Trillion dollars	2000	38.99	15.32
Depreciation rate	%	t	10	10
Young people	Billion people	t	$n_{yt} = 0.42944 - 0.04183(0.21054)^t$	$n^*_{yt} = 4.29933 - 0.9752(0.68129)^t$
Production function	Trillion dollars per generation	t	$Y_t = A_t K_t^{0.25} N_t^{0.75}$	$Y^*_t = A^*_t K^{*\,0.25}_t N^{*\,0.75}_t$
Potential emissions (with no abatement)	Billion tons of Carbon-equivalent	t	$E_{ot} = (0.0746 + 0.0708(0.4661)^t)Y_t$	$E^*_{ot} = (0.0893 + 0.4258(0.6484)^t)Y^*_t$
Total factor productivity	-	t	$A_t = (1105.5 - 801.04(0.7748)^t)\left(1 - 0.01155\left(T_t/2.5\right)^{1.5}\right)\left(1 - 0.07\left(1 - E_t/E_{ot}\right)^{2.89}\right)$	$A_t = (758.118 - 711.1(0.8139)^t)\left(1 - 0.016\left(T_t/2.5\right)^{1.5}\right)\left(1 - 0.12\left(1 - E_t/E_{ot}\right)^{2.89}\right.$
Effect of stock of GHG on temperature change	°C	t	$T_t = \left(5.92\ln\left(Q_t/590\right) + F_t\right)/1.41$	
Dynamics of theatmospheric stock of GHG	Billion tons of Carbon-equivalent	t	$Q_{t+1} - 590 = 0.64\left(\sum_i E^i_t\right) + (1 - 0.00833)^{35}\left(Q_t - 590\right)$	
Radiative forcing	W/m²	t	$F_t = 1.42 - 0.764 * (0.523)^t$	

5. RESULTS AND CONCLUSIONS

In this section we present the numerical results obtained using both GAMS and the solver routine of Excel. Figures 1 and 2 show how climate change and total emissions evolve under the CSL and NCSL scenarios. The number in brackets represents the value of a .

FIGURE 1
TEMPERATURE CHANGE

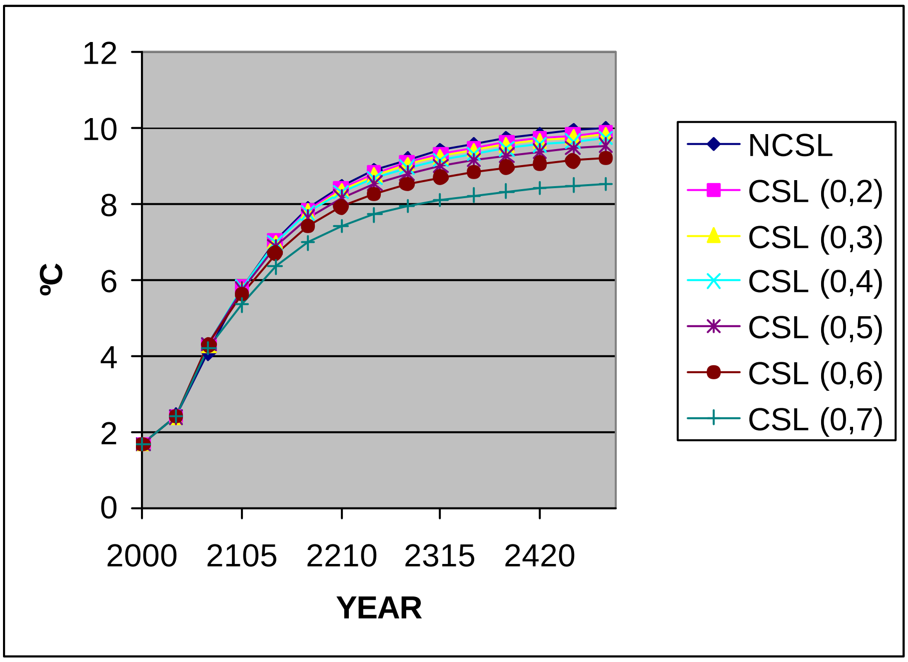
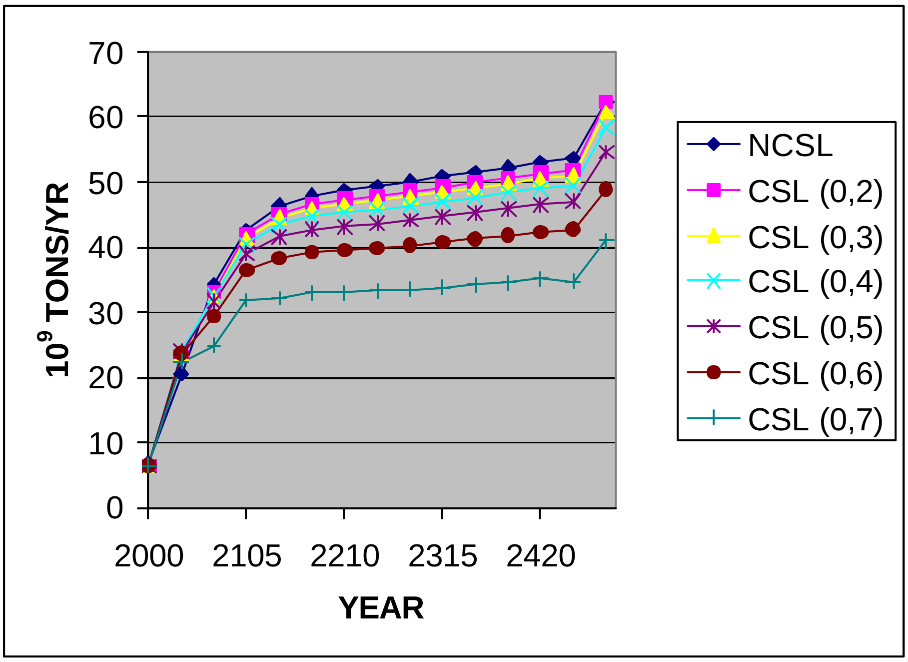


FIGURE 2
GHG EMISSIONS



Several results follow:

1. The NCSL scenario leads to higher environmental degradation in the long run than any CSL scenario.
2. The higher the welfare weight attached to the North under cooperation, the lower environmental degradation in the long run.
3. It may happen that some CSL scenarios lead to higher environmental degradation in the short-run than the NCSL scenario. In fact, this seems to be happening when the welfare weight attached to the North is 20%.

Result no 3 is in line with the cautionary note of John and Pecchenino (1997): "*international agreements with transfers that lack an intergenerational perspective could actually harm the environment*". This result is more clearly illustrated in Figures 3 and 4. The intuition behind our result is the following: When $a = 0{,}2$, given that (1) international agreements capture that the South's social welfare has to be weighted four times as much as the social welfare of the North and (2) the North is initially richer than the South, there are important transfers of income from North to South. This implies that some growing potential is transferred from North to South. These transfers imply an increase in total emissions of GHGs, due to the fact that the South produces using a technology that it is less environmentally friendly.

FIGURE 3
TEMPERATURE CHANGE IN THE SHORT RUN

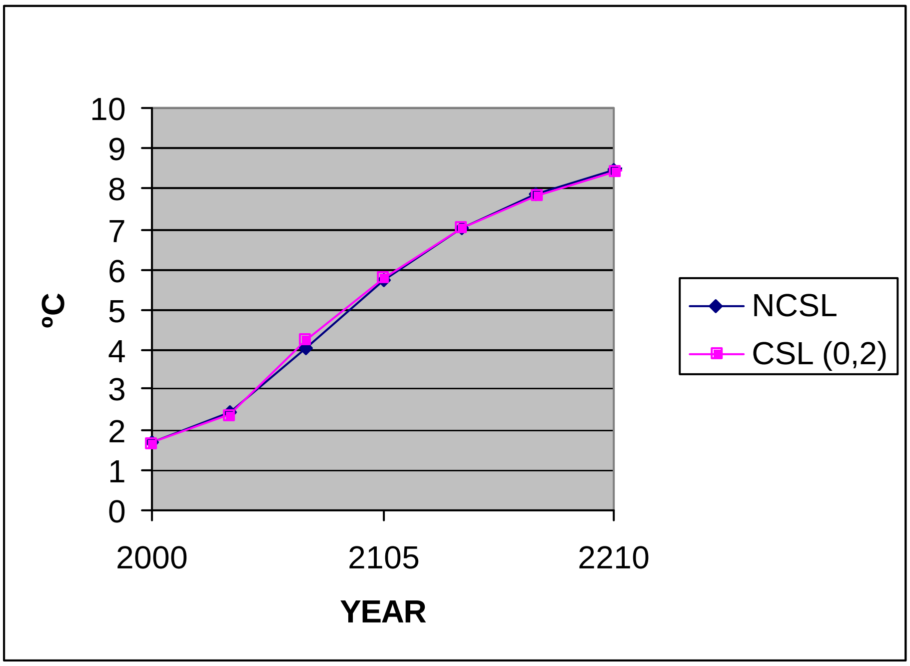
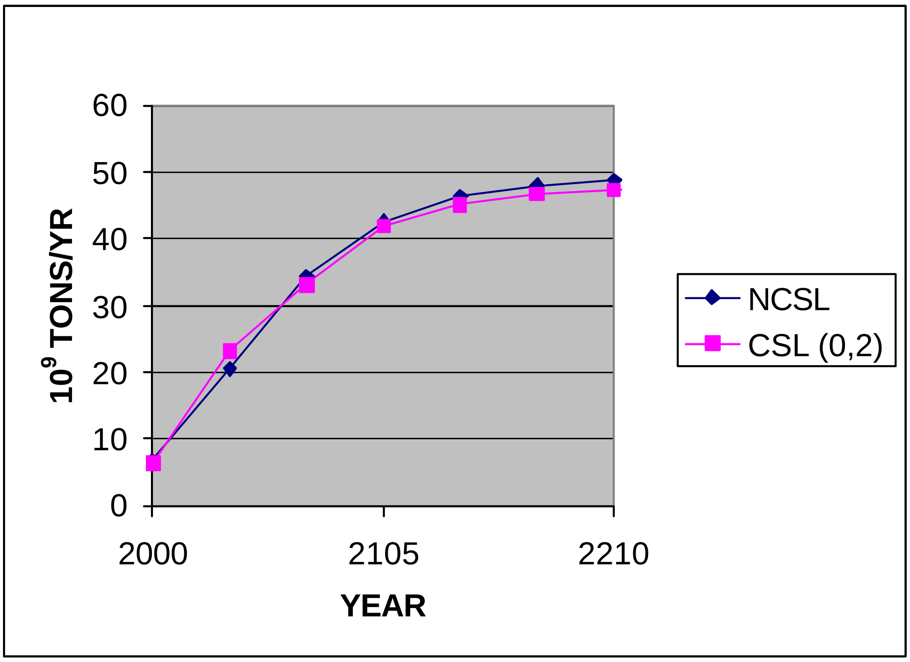
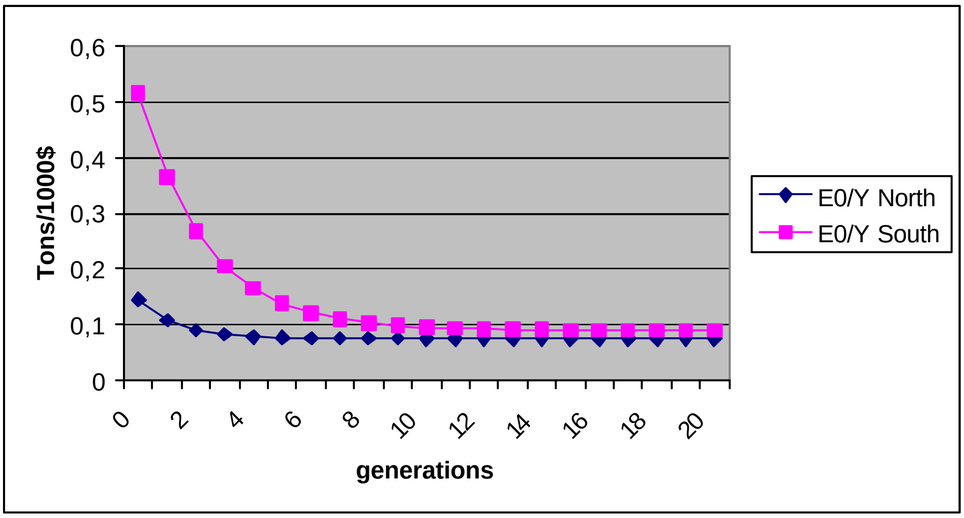


FIGURE 4
GHG EMISSIONS IN THE SHORT RUN



Thus, the exogenous nature of energy-saving technological change is an important driving force behind our result (see Figure 5). Energy-saving technological change cannot be stimulated with growth. Consequently, accelerating the growth in the South may result in greater environmental degradation unless it is accompanied with higher abatement effort. The incentives to implement higher abatement effort are clearly weakened by the short-lived nature of the government.

FIGURE 5
ENERGY-SAVING TECHNOLOGICAL CHANGE



One may think that the result will be reversed if we introduce endogenous technical change in the model. In fact, an extension for future work is to check whether the results we have obtained here remain valid when we incorporate endogenous technological change. There is an open debate on whether the transfer of technology will make a difference in the prospects for tackling the climate change problem. Some recent studies (Barrett (2001, 2003)) have proposed to replace international cooperation on GHG emission control with international cooperation on climate-related technological innovation and diffusion, arguing that incentives to free-ride are smaller in the second case. However, Carraro and Buchner (2004) obtain that, even though a self-enforcing agreement is more likely to emerge when countries cooperate on environmental technological innovation than when they cooperate on emission abatement, the adoption of new technologies stimulates economic growth both in developed and in developing countries in such a way that global emissions may increase.

REFERENCES

Ansuategi, A. and M. Escapa (2002), "Economic Growth and Greenhouse Gas Emissions", *Ecological Economics* **40**, 23-37.

Ansuategi, A., M. Escapa and A. Pérez (2003), "International and Intergenerational Dimensions of Climate Change: North-South Cooperation in an Overlapping Generations Framework", Ikerlanak IL 06/03.

Barrett, S. (2001), "Towards a Better Treaty". Policy Matters 01-29, Washington, DC: AEI Brookings Joint Center for Regulatory Studies.

Barrett, S. (2003), *"Environment and Statecraft: the Strategy of Environmental Treaty-Making"*, Oxford University Press, 2003.

Carraro, C. and B. Buchner (2004), "Economic and Environmental Effectiveness of a Technology-based Protocol", CEPR Discussion Paper No. 4412.

Eyckmans, J. and H. Tulkens (2003), "Simulating coalitionally stable burden sharing agreements for the climate change problem", *Resource and Energy Economics* **25**, 299-327.

Eyckmans, J. and M. Finus (2004), "New Roads to International Environmental Agreements: The Case of Global Warming", mimeo.

Gerlagh, R. and B.C.C. van der Zwaan (2001a), "Overlapping Generations versus Infinitely-Lived Agent. The Case of Global Warming". In D. Hall and R. Howarth (eds.),*"The Long-Term Economics of Climate Change: Beyond a Doubling of Greenhouse Gas Concentrations"*, JAI Press, Stanford, Connecticut.

Gerlagh, R. and B.C.C. van der Zwaan (2001b),"The Effects of Ageing and an Environmental Trust Fund in an Overlapping Generations Model on Carbon Emissions Reductions", *Ecological Economics* **36** (2), 311-326.

Gerlagh, R. (2000),"Discounting and Sustainability in applied IAMs". In C. Carraro (ed.), *“Efficiency and Equity of Climate Change Policy”*, Kluwer Academic Press.

Germain, M., P. Toint, H. Tulkens and A. Zeeuw (2003), "Transfers to Sustain Core-Theoretic Cooperation in International Stock Pollutant Control", *Journal of Economics Dynamics and Control* **28**, 79-99.

Germain, M., P. Toint and H. Tulkens (1997), "Financial Transfers to Ensure Cooperative International Optimality in Stock Pollutant Abatement", In Duchin, F. Faucheux, S., Gaudy, J. and Nicolai (eds), *“Sustainability and Firms: Technological Change and Changing Regulatory Environment”*, Edward Elgar, Celtenham UK-Brookfield US.

Nordhaus, W.D. and Z. Yang (1996),"A Regional Dynamic General-Equilibrium Model of alternative Climate-change Strategies". *American Economic Review* **86**(4), 741-765.

Howarth, R.B. (1996), "Climate Change and Overlapping Generations", *Contemporary Economic Policy* **14**, 100-111.

Howarth, R.B. (1998), "An Overlapping Generations Model of Climate-Economy Interactions", *Scandinavian Journal of Economics* **100**, 575-591.

Howarth, R.B. (2000), "Climate Change and the Representative Agent", *Environmental and Resource Economics* **15**, 135-148.

John, A. and R.A. Pecchenino (1997), "International and Intergenerational Environmental Externalities", *Scandinavian Journal of Economics* **99**(3), 371-387.

Marini, G. and P. Scaramozzino (1995), "Overlapping Generations and Environmental Control". Journal of Environmental Economics and Management 29, 64-77.

Rasmussen T.N.(2003), "Modelling the Economics of Greenhouse Gas Abatement: An Overlapping Generations Perspective", *Review of Economic Dynamics* **6**, 99-119.

Stephan, G., G. Müller-Fürstenberger and P. Previdoli (1997), "Overlapping Generations or Infinitely-Lived Agents: Intergenerational Altruism and the Economics of Global Warming", *Environmental and Resource Economics* **10**, 27-40.

Yang, Z. (1999), "Should the North Make Unilateral Technology Transfers to the South? North-South Cooperation and Conflicts in Responses to Global Climate Change", *Resource and Energy Economics* **21**, 67-87.