Coalition Formation under Uncertainty: The Stability Likelihood of an International Climate Agreement

Rob Dellink, Michael Finus and Niels Olieman

NOTA DI LAVORO 98.2005

JULY 2005

CCMP – Climate Change Modelling and Policy

Rob Dellink, *Environmental Economics and Natural Resources Group, Wageningen University*
Michael Finus, *Institute of Economic Theory, Department of Economics, University of Hagen*
Niels Olieman, *Operations Research and Logistics Group, Wageningen University*

Coalition Formation under Uncertainty: The Stability Likelihood of an International Climate Agreement

Summary

Results derived from empirical analyses on the stability of climate coalitions are usually very sensitive to the large uncertainties associated with the benefits and costs of climate policies. This paper provides the methodology of Stability Likelihood that links uncertainty about benefits and costs of climate change to the stability analysis of coalitions in a stochastic, empirical setting. We show that the concept of Stability Likelihood improves upon the robustness and interpretation of stability analysis. Our numerical application is based on a modified version of the climate model STACO. It turns out that the only non-trivial coalition structure with a relatively high Stability Likelihood (around 25 percent) is a coalition between the European Union and Japan, though quantitative results depend especially on the variance in regional benefits from abatement.

Keywords: Climate change, Coalition formation, International environmental agreements, Uncertainty

JEL Classification: C79, H87, Q54

Special thanks to Ivo Mulder for his research assistance and to Ekko van Ierland and John Janmaat for their comments on an earlier draft; the usual disclaimer applies.

Address for correspondence:

Rob Dellink
Wageningen University
Hollandseweg 1
6706 KN Wageningen
The Netherlands
E-mail: Rob.Dellink@wur.nl

1. Introduction

There are many obstacles that prevent the formation of effective international environmental agreements (IEAs) as well as high participation. Two of the most important obstacles are free-riding and uncertainty.

First, IEAs aim at providing a public good and therefore most countries face strong free-rider incentives. Typically, for each region it is more profitable if other regions cooperate, while own abatement activities are kept at a low level. How free-riding undermines successful formation of IEAs has been studied extensively using game theoretical models, as in Hoel (1992), Cararro and Siniscalco (1993) and Barrett (1994) and also in empirical climate models such as Botteon and Carraro (1997, 1998), Tol (2001), Bosello *et al.* (2003), Eyckmans and Finus (2005), and Finus *et al.* (2005). A main conclusion of this literature is that stable coalitions improve only marginally upon the non-cooperative outcome because either stable coalitions are small or the abatement level that can be sustained in larger coalitions is very low. However, regardless of the specific model, all of these papers determine stable coalitions in a deterministic setting.

Second, the uncertainties surrounding the future impacts of climate change are large, complicating the formation of an agreement of joint action. In particular, the benefits from abatement that arise in the distant future are highly uncertain, but also abatement costs are not fully known. These issues are highlighted in Roughgarden and Schneider (1999), Tol (2002) and Tol (2005). This implies that decisions on climate strategies must be made without full knowledge of their impacts. However, regardless of how uncertainty is captured in these papers and what this means for optimal abatement strategies, success can only be evaluated if free-rider incentives are also included in the analysis.

The novel contribution of our paper is that it brings both strands in the literature together. It illustrates a methodology to calculate the stability of all possible coalition structures in a stochastic, empirical setting. Our concept of Stability Likelihood (SL) determines the *likelihood* that a coalition structure is stable, taking into account the uncertainty of the model parameters. That is, we model uncertainty via probability functions on parameter values and therefore can directly evaluate the robustness of results and the validity of qualitative conclusions. This contrasts with deterministic coalition models that can only compute whether a coalition is stable or not. This is often not innocuous for at least two reasons. First, in a deterministic setting coalitions are either stable or unstable, even though differences in payoff between equilibrium and deviation strategies are very small. Small changes in parameter values, which are not accurately known, can invalidate the conclusions. Second, uncertainty in parameter values is only indirectly accounted using sensitivity analyses, where each analysis is itself subject to the first problem.

We apply the SL-concept to a two-stage cartel formation game that has been widely used in the literature (cf. Finus *et al.*, 2005). In the first stage, countries decide whether to participate in an IEA for reducing greenhouse gases and in the second stage they choose their abatement strategies. Generally, there can be uncertainty in both stages. More precisely, when (i) deciding on participation there can be uncertainty regarding climate impacts and abatement costs; and (ii) hence also about other players' participation strategies; and when (iii) choosing the abatement level there can be uncertainty regarding climate impacts and abatement costs. We consider the first option. This means that countries face uncertainty regarding the parameter values of the benefit and cost functions when deciding on participation, but choose their optimal abatement level after learning the "true" values in the second stage. The stability likelihood (SL) concept therefore identifies the probability that regions took the correct participation decision. We leave the last two options for further research that may make use of results obtained for instance in Ulph and Maddison (1997), Na and Shin (1998), Ulph (2004), Baker (2004) and Kolstad (2005).

In Section 2, we present our model of coalition formation and introduce the concept of stability likelihood. Section 3 discusses the calibration of the model, including the distribution functions used for the uncertain model parameters. Section 4 presents and discusses result of our stability analysis. Section 5 concludes.

2. The model of coalition formation

Consider a set of N heterogeneous players, each representing a region of the world. In the first stage, regions decide whether to become a member of an international agreement (IEA) or to remain an outsider. Announcement $c_i = 1$ means "Region *i* joins the coalition" and announcement $c_i = 0$ "Region *i* remains an outsider"; a coalition structure *c* is described by announcement vector $c=(c_1, \ldots, c_N)$. The set of players that announce 1 are coalition members and is denoted as $k = \{ i \mid c_i = 1, \forall i = 1,..., \mathrm{N} \}$.

In the second stage, regions choose their abatement levels. This leads to abatement vector $q = (q_1,...,q_{\mathrm{N}})$. The payoff of an individual region i, $\pi_i(q, \mathrm{b})$ depends on abatement vector q (and hence on the strategy of all regions, due to the public good nature of abatement) and on a vector of model parameters b.

We solve the game backwards assuming that strategies in each stage must form a Nash equilibrium. For the second stage, this entails that abatement strategies form a Nash equilibrium between coalition *k* and the remaining non-signatories. That is,

$$[1] \qquad \sum_{i \in k} \pi_i(q_k^*, q_{-k}^*, \mathrm{b}) \geq \sum_{i \in k} \pi_i(q_k, q_{-k}^*, \mathrm{b}) \quad \forall q_k \quad \text{and}$$
$$\pi_i(q_k^*, q_i^*, q_{-i}^*, \mathrm{b}) \geq \pi_i(q_k^*, q_i, q_{-i}^*, \mathrm{b}) \qquad \forall q_i$$

where q_k is the abatement strategy vector of coalition *k*, q_{-k} the vector of all regions not belonging to *k*, q_i the strategy of non-signatory *i*, and q_{-i} the strategy vector of all other non-signatories except *i*. An asterisk denotes equilibrium strategies. Computationally, this implies that non-signatories ($i \notin k$) that announced $c_i = 0$ will choose their abatement strategies so as to maximize their individual payoff $\pi_i(q, \mathrm{b})$, whereas all signatories ($i \in k$) that announced $c_i = 1$ jointly maximize the aggregate payoff of their coalition $\sum_{i \in k} \pi_i(q, \mathrm{b})$, taking the abatement strategies of all other regions as given. Strategically, this means that the behaviour of non-signatories towards all other regions is selfish and non-cooperative; signatories behavior is cooperative towards their fellow members, but non-cooperative towards outsiders. Economically, this means strategies are group (but not globally) efficient within coalition *k*. Hence, the equilibrium economic strategy vector q^* corresponds to the classical "social or global optimum" if coalition *k* comprises all countries, *i.e.* the grand coalition forms, and corresponds to the classical "Nash equilibrium" if coalition *k* comprises only one member or is empty. Thus, any inefficiency stems from the fact that *k* is not the grand coalition.

Since in the context of our empirical model the equilibrium abatement vector q^* is unique for every coalition structure *c* and a given set of parameters b (see the proof in Olieman and Hendrix 2004), we can construct a vector of optimal payoffs for every coalition structure *c*, $v_i(c, \mathrm{b}) \equiv \pi_i(q^*, \mathrm{b})$.

We now turn to the first stage. Also in the first stage, strategies form a Nash equilibrium. That is, no signatory that announced $c_i = 1$ should have an incentive to change its announcement to $c_i^{'} = 0$ (internal stability) and no non-signatory that announced $c_i = 0$ should want to announce $c_i^{'} = 1$ instead (external stability). For our purposes, this condition can be summarized compactly by the payoff stability indicator function $f(c, b)$, which assigns the value 1 to a stable announcement vector (*i.e.* stable coalition) and the value 0 to an unstable announcement vector (*i.e.* unstable coalition):

$$[2] \quad f(c, \mathrm{b}) = \begin{cases} 1 & \text{if } (v_i(c, \mathrm{b}) - v_i(c^{'}, \mathrm{b}) \geq 0) \text{ for all } \left| c - c^{'} \right| = 1 \text{ and for all } i = 1, .., \mathrm{N} \\ 0 & \text{else} \end{cases}$$

The function $f(c, \mathrm{b})$ will take on the value 1 if for all regions the payoff for announcement c is higher than, or equal to, the payoff associated with alternative announcements $c^{'}$. These alternatives are constructed by changing the announcement of one player at a time: $\left|c-c^{'}\right|=1$ is only true if the vector $c^{'}$ differs from vector c in one element.

In a deterministic model parameter b may be based on estimation but is treated as given. In contrast, we construct a stochastic model by replacing the deterministic parameter b with stochastic variable $\boldsymbol{b}$ which is characterised by probability space $\left(\mathrm{B}, B, \mathrm{Pr}\right)$ and probability density function $g\left(b\right)$. Consequently, function $f\left(c,\boldsymbol{b}\right)$ becomes a Bernoulli variable, meaning that we can assign a likelihood to the event that $f\left(c,\boldsymbol{b}\right)=1$.

The stability likelihood of coalition structure c is defined as SL= $\mathrm{Pr}\left\{f\left(c,\boldsymbol{b}\right)=1\right\}$ which equals $\int_{\mathrm{B}} f\left(c,b\right)\cdot g(b)\,\mathrm{d}b$. Assuming that $f(.)$ is a correct representation of reality, we can interpret SL as the probability that coalition structure c can be claimed stable.

Given the complexities of the model, we cannot find an analytical solution for SL, and therefore resort to numerical calculations. The stability likelihood is calculated using a Monte Carlo sampling technique: we generate M samples b_{m} from $\boldsymbol{b}$; based on these samples we can estimate the stability likelihood with $\hat{SL}=\frac{1}{\mathrm{M}}\sum_{\mathrm{m}=1}^{\mathrm{M}} f\left(c,\mathrm{b}_{\mathrm{m}}\right)$ that has an estimated variance of $\frac{1}{\mathrm{M}-1}\left(\hat{SL}\left(1-\hat{SL}\right)\right)$.

A more detailed discussion of the stability likelihood concept and computation methods can be found in Olieman and Hendrix (2004).

3. Calibration of the model

3.1. Introduction

In this section, the calibration of the empirical model, called STACO (STAbility of Coalitions) is described. For more detailed information on the model and calibration procedure, see Dellink *et al.* (2004) and Finus *et al.* (2005). The model comprises benefit and cost functions for twelve world regions: USA (USA), Japan (JPN), European Union (EEC), other OECD countries (OOE), Eastern European countries (EET), former Soviet Union (FSU), energy exporting countries (EEX), China (CHN), India (IND), dynamic Asian economies (DAE), Brazil (BRA) and "rest of the world" (ROW). The philosophy behind the construction of the model comprises two items. First, the model must be simple enough to allow for sufficient samples to be calculated within reasonable time[1]. Second, the model should still reflect important results and features of integrated assessment models in terms of overall magnitudes of global emissions and concentration, abatement costs from regional abatement and benefits from global abatement over some time period. Therefore, the model focuses on carbon dioxide, but the exogenous level of other greenhouse gases is included in the calibration of the benefit function (*cf.* Nordhaus, 1994). The analysis calculates the net present value of a stream of net benefits starting in 2010 and covering a time period of 100 years in order to capture the long-run effects of global warming. We model a one-shot cartel game and analyse only single deviations. The model is a simple version of an integrated assessment model and hence results should only be interpreted as a numerical example. Nonetheless, we believe that our numerical example illustrates the usefulness of SL as an indicator, as we include the best available information on the probability density functions of the model parameters.

3.2. Elements of the empirical model

The payoff function of region i is given by:

[3a] $$\pi_i = \sum_{t=1}^{T} (1+r)^{-t} (B_{it}(q_t) - AC_{it}(q_{it}))$$

where T denotes the time horizon, t=2011,...,2110; r is the discount rate; B_{it} are benefits from global abatement ($q_t = \sum_{i=1}^{N} q_{it}$); and AC_{it} are abatement costs from individual abatement q_{it}.

The payoff function is calculated as the net present value of a stream of net benefits from abatement between 2010 and 2110 and thus reflects discounted avoided damages minus discounted abatement costs. Regional abatement costs are a function of the level of individual abatement by region i, while regional benefits depend on global abatement efforts.

Assuming stationary abatement strategies ($q_{it} = q_i/100$), benefits in year t can be expressed as a function of global abatement over the entire period. Furthermore, we consider that the stock of CO_2 can be approximated by a linear function of emissions and that damages are linear in the stock of CO_2.[2] It follows that annual benefits from reduced emissions are also linear in the level of abatement:

---

[1] We need around 40,000 samples to get sufficient accuracy in the estimate of SL. This implies around 2 billion calculations of optimal regional abatement and payoff levels (40,000 times 12 regions times 4096 possible coalitions).

[2] The details of this approximation are given in Dellink *et al.* (2004).

[4a] $B_t(q) = \varphi_t \cdot q$

where φ_t denotes marginal benefits in period *t* from total abatement over the entire period. This parameter also includes the effects of limited retention of GHGs in the atmosphere and decay of the stock of GHGs over time. As abatement in period *t* will lead to benefits in all periods from *t* onwards, these marginal benefits are time-dependent.

Discounted total benefits, $TB(q)$, are then expressed as

[4b] $TB(q) = \gamma \cdot q$

where γ represents discounted marginal benefits in \$/ton carbon equivalents and is calculated as $\gamma = \sum_{t=2011}^{2110} (1+r)^{-t} \cdot \varphi_t$.

Regional benefits are assumed to be a share of global benefits from abatement:

[4c] $TB_i(q) = s_i \cdot TB(q) = s_i \cdot \gamma \cdot q$

where s_i is the share of total benefits for region i.

For the specification of the abatement cost function, estimates of the EPPA model are used (Ellerman and Decaux, 1998). They assume an annual abatement cost function for region *i* of the following form:

[5a] $AC_{it}(q_{it}) = \frac{1}{3} \cdot \alpha_i \cdot (q_{it})^3 + \frac{1}{2} \cdot \beta_i \cdot (q_{it})^2$

For the total abatement costs of region i, $TAC_i(q_i)$ the same functional form is used, summed over the entire time horizon. Assuming stationary strategies and a constant discount rate, as in the case of benefits, the total abatement cost function becomes

[5b] $TAC_i(q_i) = \rho \cdot \left(\frac{1}{3} \cdot \alpha_i \cdot (q_i)^3 + \frac{1}{2} \cdot \beta_i \cdot (q_i)^2 \right)$

with $\rho = \sum_{t=2011}^{2110} (1+r)^{-t}$

Taken together, the payoff function can be written as:

[3b] $\pi_i = TB_i(q) - TAC_i(q_i)$.

Generally, all model parameters are uncertain. However, we have insufficient information to fully estimate the probability density functions of all parameters at a regional level. A more advanced meta-analysis of published and unpublished estimates would require a study of its own and therefore is beyond the scope of the current paper. Hence, we consider only uncertainty in the benefit and cost parameters γ, s_i, α_i and

β_i . Other parameters such as emissions in 2010, the decay rate of greenhouse gases and the discount rate are assumed known with certainty. Calibration of emissions and concentrations is based on the widely known DICE-model by Nordhaus (1994). The discount rate r is set at 2% per year.

3.3. Global Benefit Function

The distribution function for the global level of benefits (γ) is based on a recent study by Tol (2005). The probability density function for peer-reviewed studies as presented by Tol can be closely mimicked by a 2-sided exponential function. This function is described by four pieces of information: (i) the 5 percentile point; (ii) the value where the two sides of the exponential function are separated (assuming this is above the 5 percentile point); (iii) the cumulative probability density at this separation value; and (iv) the 95 percentile point (assuming this is above the separation value). The first piece of information is given by the value that corresponds to a cumulative probability of 5%; this value equals -9 \$/ton, implying a strictly positive probability that benefits from abatement are negative. The point of separation between both sides of the function is given by the mode and equals 5 \$/ton; the associated cumulative probability density is 13%. Finally, the point on the right side of the function is given by the 95% cumulative probability density and equals 245 \$/ton. These numbers are summarised in Table 1 and the corresponding histogram of all drawn samples is shown in Appendix I.[3] This distribution function implies that there is a probability of around 9 percent that the benefits of abatement are zero or negative; if this is the case, the optimal abatement quantities are zero, and regions are indifferent to cooperation.

Table 1. Characteristics of the 2-sided exponential distribution function for the global benefit function (γ).

	Value
5% density	-9 \$/ton
mode	5 \$/ton
density at mode	13%
95% density	245 \$/ton

3.4. Regional Benefit Shares

The distribution function for the regional benefit shares (s_i) is based on insights from a study by Tol (2002), though this source does not provide sufficient information on the

[3] Note that the mean value of this function (77 \$/ton) differs from the value (37 \$/ton) used in Finus *et al.* (2005).

functional form of the distribution function of these shares. We opt for a gamma distribution that can handle the lower bound of the shares such that no region receives a negative share of the benefits. Moreover, as the shares can vary between zero and one and the mean value is typically close to zero, the distribution function should be skewed, as is the case for a gamma distribution. As the choice for a gamma distribution function may to some extent seem arbitrary, we will subject it to a sensitivity analysis in section 4.3.

The mean values used for the regional shares are the values reported in the deterministic setting of the STACO model, which are in turn based on Fankhauser (1995) and Tol (1997). Standard deviations are based on expert judgement, using in particular Tol (2002). Typically, standard deviations are of the same order of magnitude as mean values, and are lower for OECD countries than for the other regions. The regional numbers are represented in Table 2; for a better understanding, the corresponding histograms for the USA and China are shown in Appendix I.

Table 2. Characteristics of the gamma distribution function for the share parameters in the benefit function (s_i).

Region	Lower bound	Mean	Standard deviation
USA	0	0.2263	0.1414
JPN	0	0.1725	0.1078
EEC	0	0.2360	0.1475
OOE	0	0.0345	0.0216
EET	0	0.0130	0.013
FSU	0	0.0675	0.0675
EEX	0	0.0300	0.0300
CHN	0	0.0620	0.0620
IND	0	0.0500	0.1000
DAE	0	0.0249	0.0498
BRA	0	0.0153	0.0306
ROW	0	0.0680	0.1360

After the samples of the regional shares are drawn, all shares are scaled up or down to force the sum of shares to unity. This implies that the regional shares do not strictly follow the gamma distribution and the resulting variance in the shares is smaller than in the original gamma distribution.[4] Though rescaling is not a necessary condition for the working of the model, the restriction on the sum of shares is enforced to avoid an impact of variations in this parameter on global benefit levels. The consequences of this specification will be investigated in a sensitivity analysis in section 4.3.

3.5. Abatement Cost Functions

The regional abatement cost function contains two parameters (α_i and β_i), which cannot be assumed to be independent. Typically, empirical studies report only variations in the marginal abatement costs without providing information on how the slope and curvature of the MAC function vary. Therefore, we assume the functional form of the abatement cost curves to be given, and vary the level of marginal abatement costs per region in the simulations. This implies that both parameters in the abatement cost functions move simultaneously and in the same direction.

Table 3. Characteristics of the normal distribution for the parameters in the abatement cost function (α_i and β_i).

	α_i		β_i	
Region	Mean	St. dev.	Mean	St. dev.
USA	0.00050	0.00006	0.00398	0.00050
JPN	0.01550	0.00194	0.18160	0.02270
EEC	0.00240	0.00030	0.01503	0.00188
OOE	0.00830	0.00104	0.00000	0.00000
EET	0.00790	0.00198	0.00486	0.00122
FSU	0.00230	0.00058	0.00042	0.00011
EEX	0.00320	0.00080	0.03029	0.00757
CHN	0.00007	0.00002	0.00239	0.00060
IND	0.00150	0.00038	0.00787	0.00197
DAE	0.00470	0.00118	0.03774	0.00944
BRA	0.56120	0.14030	0.84974	0.21244
ROW	0.00210	0.00053	0.00805	0.00201

4 More information on the impact of this rescaling on the probability density function can be obtained from the authors upon request.

We assume a normal distribution function; the mean is based on the deterministic version of the STACO model, which is in turn based on Ellerman and Decaux (1998). The normal distribution is chosen as there seems no reason to assume a skewed distribution. The standard deviation for the abatement cost parameters are based on information in the IPCC report of 2001 (Metz *et al.*, 2001). Due to lack of regional information, the standard deviation is calibrated to 12.5 percent of the mean for OECD regions and 25 percent for non-OECD regions. Hence, the variation in abatement costs is typically much smaller than the variation in benefits for most regions. The key inputs for the normal distribution are shown in Table 3 and for USA and China the corresponding probability density functions are illustrated in Appendix I.

4. Results

Using the confidence intervals and distribution functions described above, we calculate the Stability Likelihood (SL) of all 4096 possible coalition structures. The results of this simulation are reported and discussed in Section 4.1. Section 4.2 investigates an alternative scenario with lower probability of extreme observations for the benefits from abatement, by adoption much stricter bounds on the distribution function of the global benefit parameter. These stricter bounds are chosen such that the mean value of global benefits coincides with the deterministic value for global benefits used in Finus *et al.* (2005), thereby allowing a direct comparison between the deterministic and stochastic settings. Section 4.3 briefly discusses the results of some sensitivity analyses on the uncertainty of the various parameters and the associated distribution functions. All simulations are carried out with a confidence interval of 95% on the second digit of SL ($\sigma_{SL} = 0.0025$).

4.1. Results for the base specification

Table 4 presents the main results for those coalition structures that have the highest SL and for the Grand Coalition.

Note that the stability of the All-Singletons structure is not uniquely defined. If all regions announce $c_i = 0$, then SL=1 by definition. However, if all regions announce $c_i = 0$ except one, then SL may be lower, because external stability is no longer automatically guaranteed. In this case, the highest SL is obtained if JPN announces $c_i = 1$ and all other regions $c_i = 0$ with SL=0.40. That is, the likelihood that none of the other regions wishes to join JPN is 40%. In the All-Singletons structure abatement efforts amount to only 70 Gton per century, or an annual abatement of 5.8 percent of global emissions in 2010. This leads to a discounted payoff of almost 8.8 trillion US$ over the century.

Table 4. Results for selected coalition structures (mean values).

Coalition	SL (fraction)	Strict SL (fraction)	Total abatement (Gton)	Abatement (% of emissions)	Total payoff (bln $)
All-Singletons	Undefined	undefined	69.4	5.8%	8775
JPN,EEC	0.24	0.15	74.5	6.2%	9251
USA,JPN	0.15	0.06	79.1	6.6%	9663
USA,EEC	0.14	0.05	84.7	7.1%	10090
JPN,BRA	0.12	0.02	69.7	5.8%	8824
JPN,ROW	0.11	0.02	76.7	6.4%	9613
EEC,ROW	0.11	0.01	79.2	6.6%	9835
JPN,IND	0.10	0.01	78.0	6.5%	9773
JPN,FSU	0.10	0.01	75.8	6.3%	9475
EEC,BRA	0.10	0.01	70.1	5.9%	8857
EEC,FSU	0.10	0.01	78.4	6.6%	9699
Grand coal.	0.09	0	326.3	27.3%	27360

The Grand Coalition would lead to much larger abatement efforts and a higher global payoff than no cooperation, as the gains of cooperation are fully reaped. However, the Grand Coalition has a low SL. In fact, the Grand Coalition is only stable when there are no benefits to be reaped from abatement, *i.e.*, when the global benefit parameter is zero or negative. In such cases, the optimal abatement level is zero, and regions are indifferent to cooperation. In the calculation of SL, this is interpreted as stable. Therefore, Table 4 also reports “Strict SL”, which equals SL minus the probability that regions are indifferent to cooperation (“probability of indifference”).

Only a few non-trivial coalition structures have a positive strict SL. All these coalition structures are small and improve only little over the All-Singletons structure. This shows the important information the SL-concept provides that cannot be obtained in a deterministic setting. For instance, in the deterministic STACO model analysed in Finus *et al.* (2005), no stable non-trivial coalition could be found for the base parameter values. Only if the global benefit parameter is raised by 20 percent a coalition of Japan and European Union turns out to be stable. In the stochastic setting, we obtain the probability that this coalition structure is stable, given the uncertainty of the benefit and abatement cost parameters: in 24 percent of the samples this coalition structure turns out to be stable (15 percent if the stability condition is strict).

The regional results for the coalition of Japan and European Union are given in Table 5. Though the standard deviations of the abatement levels are rather big, there is a probability of more than 90% that abatement levels are strictly positive, implying that the implicit distribution function for abatement levels is right-skewed. Though they are not part of the coalition, the largest abatement efforts are carried out by China and the USA. These regions have strong incentives to unilaterally reduce their emissions because of relatively low marginal abatement costs compared to their marginal benefits.[5] For Japan and the European Union, marginal abatement costs are equal to the sum of marginal benefits of this coalition, reflecting the first order condition implied by the assumption of joint welfare maximisation of coalitions as explained in section 2.[6]

Table 5. Regional results for coalition JPN and EEC.

	Total abatement (Gton)		Abatement (% emis)	Total payoff (bln $)		MAC ($/ton)	MB ($/ton)	Incentive (bln $)
Region	Mean	Standard deviation	Mean	Mean	Standard deviation	Mean	Mean	Mean
USA	20.31	16.01	8.4%	2050	4313	17.6	17.3	-247
JPN	2.83	2.68	5.1%	1650	3525	31.7	13.3	-79
EEC	12.29	9.15	8.8%	2043	4213	31.7	17.9	-12
OOE	2.30	1.71	3.7%	369	817	2.9	2.8	-127
EET	1.14	1.20	2.2%	141	406	1.1	1.1	-145
FSU	5.64	5.11	5.6%	670	1712	5.4	5.3	-221
EEX	1.40	2.01	1.2%	312	850	2.5	2.4	-206
CHN	21.02	24.19	8.9%	611	1739	4.9	4.8	-1282
IND	3.30	5.59	5.2%	441	1647	3.6	3.5	-289
DAE	0.81	1.80	2.0%	245	1008	1.9	1.9	-167
BRA	0.03	0.08	0.2%	151	636	1.2	1.2	-11
ROW	3.42	5.54	4.9%	568	2117	4.7	4.6	-227

[5] This is in line with the arguments put forward by the Bush administration: the USA will not ratify the Kyoto protocol, but will carry out abatement efforts in its own interest.

[6] For singletons, the equality between regional MAC and regional MB holds for samples where marginal benefits are nonnegative, but not necessarily for the mean values. Similarly, regional MAC equals coalitional MB for coalition members only at the level of individual samples with nonnegative marginal benefits.

The last column in Table 5 shows the mean incentive to change membership: for example, if the USA were to join the coalition of Japan and European Union, it's mean payoff would be reduced by 247 bln \$. Similarly, Japan and European Union would have a lower payoff of 79 and 12 bln \$, respectively, if they were to leave the coalition. It turns out that the mean values for the incentive to change membership are negative for all regions. Thus, a model that only looks at mean values would come to the conclusion that this coalition is both internally and externally stable. But the corresponding SL is only 24%, implying that in three quarter of all samples the coalition is unstable. This clearly illustrates the importance of using a more sophisticated stability indicator, such as SL, when the probability density functions of the model parameters are strongly skewed.

The relationship between the samples of global marginal benefits and the corresponding global abatement levels is illustrated in Figure 1 for the All-Singletons structure. For samples with negative marginal benefits, optimal abatement levels are zero. For positive marginal benefits, there is a clear positive correlation between the marginal benefits and abatement levels, but the relation is not linear: as marginal abatement costs increase quadratic in abatement levels, higher marginal benefits lead to a less than proportional increase in abatement levels.

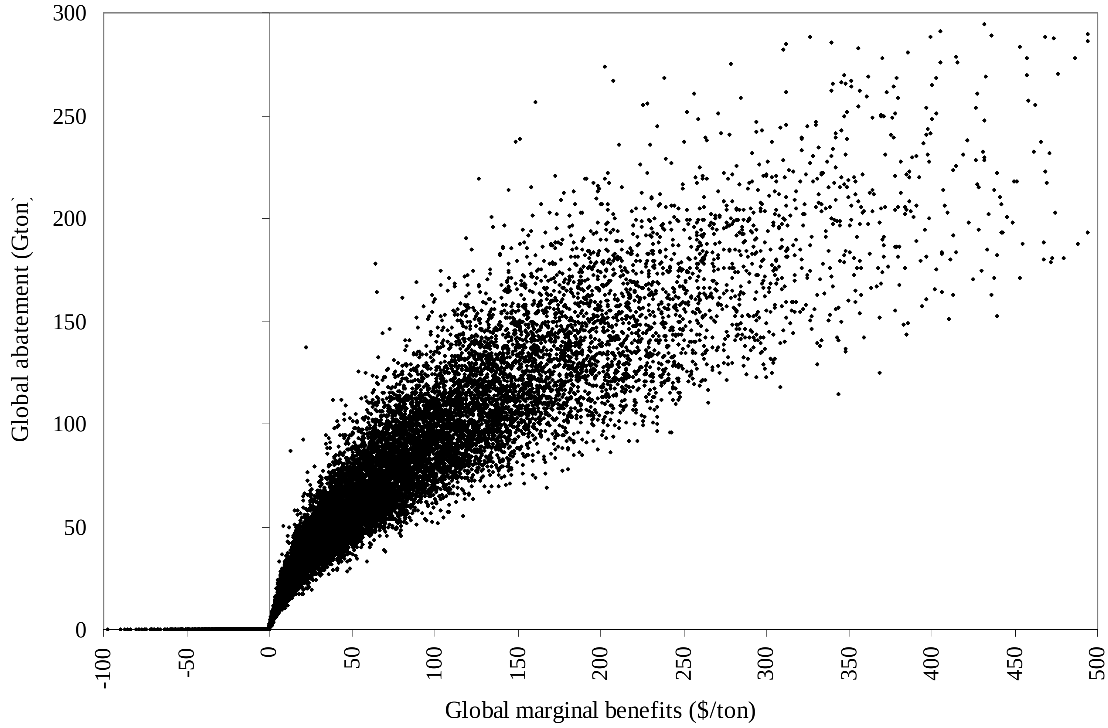

Figure 1. Relationship between global marginal benefits and global abatement levels for the All-Singletons structure.

The graph clearly shows the dispersion in global marginal benefits that is generated by the distribution function and the resulting dispersion in optimal global abatement levels. The bulk of samples produce global marginal benefits between 0 and 200 $/ton, with corresponding optimal abatement levels of less than 200 Gton over the century, though outliers may have a value of more than 800 $/ton for marginal benefits, while abatement levels can be up to 400 Gton.

As we may recall, stability of a coalition structure comprises internal and external stability. The internal SL, *i.e.* the Stability Likelihood when considering only internal stability, of the coalition between Japan and the European Union is somewhat larger than the 'total' SL (0.33 vs. 0.24), as shown in Table 6.[7] This implies that in some samples, the coalition structure is internally stable, but one or more other regions wish to join this coalition, making it externally unstable. For most samples (67 %), however, this coalition structure is not internally stable.

Table 6. Internal stability likelihood (ISL) and SL of selected coalition structures.

Coalition	ISL	SL	Coalition	ISL	SL
JPN,EEC	0.33	0.24	FSU,CHN	0.22	0.09
USA,EEC	0.33	0.14	OOE,EET	0.22	0.09
OOE,EEX	0.29	0.09	EET,EEX	0.22	0.09
OOE,FSU	0.28	0.09	USA,OOE	0.20	0.09
OOE,CHN	0.28	0.09	EET,FSU	0.19	0.10
USA,JPN	0.27	0.15	EEC,FSU	0.19	0.09
EEX,CHN	0.24	0.09	OOE,DAE	0.19	0.09
EET,CHN	0.24	0.09	OOE,IND	0.18	0.09
FSU,EEX	0.23	0.09	OOE,ROW	0.18	0.09
USA,FSU	0.23	0.10	Grand coalition	0.09	0.09

In the vast majority of the coalition structures, including all coalition structures with 4 coalition members or more, there is at least one region that wishes to leave the coalition and ISL equals SL. Thus, internal stability can be identified as the main problem in achieving larger and more ambitious coalitions.[8]

---

[7] Note that the singleton coalition structures are internally stable by definition; hence, their ISL equals unity.

[8] Many large coalitions have an external SL of almost 1; the external SL of coalition {JPN,EEC} equals 0.64.

4.2. Results for the alternative specification with lower mean global benefits

It is clear that the probability density function used for global marginal benefits is of crucial importance for the results of the analysis. Moreover, estimates of future benefits from abatement are widely acknowledged to be highly uncertain. Therefore, we carry out an alternative simulation with a different assumption on the global benefit parameter γ. Table 7 shows results assuming that the 5 percentile point is set to 0 \$/ton and the 95 percentile point is set to 110 \$/ton. This implies that extreme values are rare and that the mean value for global marginal benefits is reduced from 77 to 37 \$/ton. This lower mean is in line with the value for global marginal benefits used in the deterministic setting in Finus *et al.* (2005).

Table 7. Results for selected (non-trivial) coalition structures (mean values) using smaller bounds on global benefit parameter γ.

Coalition	SL (fraction)	Strict SL (fraction)	Mean total abatement (Gton)	Total payoff (bln \$)
All-Singletons	undefined	undefined	44.5	2520
JPN,EEC	0.20	0.15	47.9	2660
USA,JPN	0.11	0.06	51.2	2790
USA,EEC	0.10	0.05	55.2	2929
JPN,BRA	0.07	0.02	44.7	2532
JPN,ROW	0.07	0.02	49.5	2774
EEC,ROW	0.06	0.01	51.2	2844
JPN,IND	0.06	0.01	50.3	2819
EEC,BRA	0.06	0.01	45.0	2543
JPN,FSU	0.06	0.01	49.1	2738
EEC,IND	0.06	0.01	52.1	2894
Grand coal.	0.05	0.00	225.8	8353

For all coalition structures, the SL is lower than in the base specification. This is partly due to the lower probability of negative marginal benefits (this probability is reduced to 5%) and partly due to the fact that mostly positive outliers of marginal benefits are removed from the model. The ranking (in terms of SL) of the different coalition structures is largely unchanged, implying that the level of global marginal benefits changes only the quantitative results, but not qualitative conclusions.

The lower benefits clearly reduce optimal abatement levels. In the All-Singletons structure, global abatement levels drop from around 70 Gton per century to 45 Gton. It is obvious that the reduction in mean marginal benefits does not translate into a proportional reduction in mean abatement levels (*cf.* Figure 1). This is due to the non-linear nature of the model: the quadratic marginal abatement cost functions imply that lower marginal benefits lead to less than proportionately lower abatement levels. The lower benefits and abatement levels also lead to lower pay-offs (2.5 trillion $ versus 8.8 trillion $ in the base specification).

These quantitative results for the alternative specification are roughly comparable to the results of the deterministic setting (*cf.* Finus *et al.*, 2005). They found that none of the coalition structures is stable, but that the coalition of the European Union and Japan is stable when the global benefit level is raised by at least 20 percent. In the stochastic setting, this translates into an SL for this coalition structure that is higher than all others, but well below unity.

4.3. Results of the sensitivity analyses

In order to shed light on the robustness of our previous conclusions, a series of sensitivity analyses have been carried out. The main results of alternative assumptions regarding the uncertainty of the main model parameters are reported in Table 8. A second set of sensitivity analyses concerns the functional forms used in the simulations, and is reported in Table 9.

Table 8. Stability Likelihood of selected coalition structures under different model specifications.

Coalition	Base specification	No uncertainty w.r.t. s_i	No uncertainty w.r.t. γ	No uncertainty w.r.t. α_i, β_i
JPN,EEC	0.24	0.63	0.17	0.24
USA,JPN	0.15	0.09	0.07	0.15
USA,EEC	0.14	0.09	0.06	0.14
JPN,BRA	0.12	0.09	0.02	0.11
JPN,ROW	0.11	0.09	0.02	0.11
EEC,ROW	0.11	0.09	0.02	0.10
JPN,IND	0.10	0.09	0.01	0.10
JPN,FSU	0.10	0.09	0.01	0.10
EEC,BRA	0.10	0.09	0.01	0.10
EEC,FSU	0.10	0.09	0.01	0.10
Grand coal.	0.09	0.09	0	0.09

The general result that emerges from these sensitivity analyses is that although the levels regional abatement levels and payoffs depend on several model parameters, the sensitivity of the value of SL is much smaller. Essentially, the value of SL depends crucially on two elements: (i) the variance in regional benefit shares (s_i), and (ii) the variance and level of the global benefit level (γ), but only through changes in the probability of negative benefits. Reducing the uncertainty with respect to the regional benefit shares from the model greatly reduces the variability of stability over the different coalitions. Thus, when regional benefit shares are known, it becomes much easier to predict which regions have incentives to collaborate and which don't: only the coalition structure of Japan and European Union has an SL that is higher than the probability of indifference.

Table 9. Stability Likelihood of selected coalition structures under different model specifications.

Coalition	Base specification	Normal distribution s_i	Normal distribution γ	Gamma distribution α_i, β_i	$\sum s_i$ varies from unity
JPN,EEC	0.24	0.26	0.32	0.24	0.24
USA,JPN	0.15	0.13	0.24	0.15	0.15
USA,EEC	0.14	0.14	0.23	0.14	0.14
JPN,BRA	0.12	0.09	0.20	0.11	0.11
JPN,ROW	0.11	0.09	0.20	0.11	0.11
EEC,ROW	0.11	0.09	0.20	0.10	0.11
JPN,IND	0.10	0.06	0.20	0.10	0.10
JPN,FSU	0.10	0.07	0.20	0.10	0.10
EEC,BRA	0.10	0.08	0.19	0.10	0.10
EEC,FSU	0.10	0.08	0.19	0.10	0.10
Grand coal.	0.09	0.01	0.19	0.09	0.09

For the ranking of the different coalition structures in terms of their SL, we get an even stronger result: in all simulations, the same structures emerge as the most stable. In all cases the coalition of Japan and European Union has the highest SL, followed by USA and Japan and USA and European Union. Thus, we can conclude that SL provides a highly robust indicator of the stability of climate coalitions.

Finally, the impact of rescaling regional benefits to sum to unity is investigated by removing this assumption from the model. Thus, global benefit levels vary not only with the variations in the global benefit parameter, but also with the sum of the regional shares. It turns out that this assumption is not of major significance: the results remain very similar to the base specification.

5. Discussion

This paper investigates the formation and stability of coalitions on an international climate agreement. We introduce a methodology to calculate the stability of all possible coalition structures in a stochastic, empirical setting. The concept of Stability Likelihood (SL) provides a notion of stability that conveys much more relevant information than the ordinary binary outcome: stable / unstable.

The numerical application shows that the SL concept contributes to a better understanding of stability of coalition structures under uncertainty. The results suggest that for most possible climate coalition structures there is at least one region that is better off by changing it's actions, thereby making these structures unstable. This includes important coalition structures such as the coalition of industrialised countries and the Grand Coalition. The lack of stability holds for the wide range of possible values for regional abatement costs and benefits, as described by the respective probability distribution functions. Only when benefits from abatement are zero or negative (calibrated to be around 9 percent in the base specification), *i.e.* when climate change does not pose a problem, will regions be indifferent to signing an agreement. In such cases, the optimal abatement levels will be zero, regardless of coalition formation. Consequently, there is only a limited number of coalition structures with a SL larger than the probability of indifference.

The non-trivial coalition structure with the highest SL is the coalition of Japan and the European Union, with an SL equal to 24 percent. This relatively low number stresses the difficulties in striking an international environmental agreement. In fact, the highest Stability Likelihood (40 percent) is achieved when Japan takes the initiative to participate in a small coalition, as none of the other regions is willing to join Japan.

It is important to note that the coalition structures with relatively high SL hardly improve over the All-Singletons case: abatement efforts are only slightly higher than when there is no international collaboration at all. If coalition structures are stable, they are small and only marginally improve upon the All-Singletons case in terms of global welfare, global emissions and concentrations, confirming the results of the deterministic literature.

The gains from co-operation that are at stake in the case of global warming are large according to our model. This is not only true for the absolute amount of global net benefits in the global optimum (Grand Coalition Structure), but also when this number is put in perspective to net benefits in the All-Singletons case. The conclusion can be drawn that additional mechanisms have to be included in the international negotiations to overcome the large free rider incentives; such additional mechanisms could take the form of a scheme for international transfers or issue linking.

The calculated SL of the different coalition structures is robust in terms of the distribution functions used, the variance in regional abatement costs and the global level of benefits from global abatement, but sensitive to the variance in the regional distribution of benefits. Unfortunately, regional benefits from abatement are very uncertain, and international research on adaptation and damage costs is still in its infancy. Therefore, it is of utmost importance to get better information on this issue.

There are many ways in which the analysis above can be ameliorated. First, better estimates of the variance on regional benefits may be obtained via a meta-analysis of the existing literature, similar to what Tol (2005) did for global benefits. Secondly, the empirical model used to calculate the regional payoffs can be extended to a fully-fledged computable general equilibrium model. Together, these two extensions will improve the empirical validity of the numerical example. Thirdly, asymmetric information and learning may give more insight in the actual position of individual players in the international negotiations. Finally, the analysis can be extended to decision making under uncertainty, *e.g.* by using utility functions to describe risk-aversion of players. Nonetheless, the current application already shows that many relevant results and interpretations can be obtained by investigating the Stability Likelihood of coalition structures.

References

Baker, E., 2004, "Uncertainty and learning in a strategic environment: global climate change", *Resource and Energy Economics* 27, pp. 19-40.

Barrett, S., 1994, "Self-enforcing international environmental agreements", *Oxford Economic Papers* 46, pp. 804-878.

Bosello, F., B. Buchner and C. Carraro, 2003, "Equity, development, and climate change control", *Journal of the European Economic Association* 1, pp. 601-611.

Botteon, M. and C. Carraro, 1997, "Burden-sharing and coalition stability in environmental negotiations with asymmetric countries", In: Carraro, C. (ed.), *International environmental negotiations: strategic policy issues*. Edward Elgar, Cheltenham, ch. 3, pp. 26-55.

Botteon, M. and C. Carraro, 1998, "Strategies for environmental negotiations: issue linkage with heterogeneous countries", In: Hanley, N. and H. Folmer (eds.), *Game theory and the global environment*, Edward Elgar, Cheltenham, ch. 9, pp. 180-200.

Carraro, C. and D. Siniscalco, 1993, “Strategies for the iternational potection of the environment”, *Journal of Public Economics* 52, pp. 309-328.

Dellink, R.B., M. Finus, E.C. van Ierland and J.-C. Altamirano, 2004, *Empirical background paper of the STACO model*, Mimeo, University of Wageningen; available on the STACO website: http://www.sls.wau.nl/enr/staco

Ellerman, A.D. and A. Decaux, 1998, *Analysis of post-Kyoto CO2 emissions trading using marginal abatement curves*, Joint program on the science and policy of global change Report 40, MIT, Cambridge.

Eyckmans, J. and M. Finus, 2005, “Coalition formation in a global warming game: how the design of protocols affects the success of environmental treaty-making”, *forthcoming* in Natural Resource Modeling.

Fankhauser, S., 1995, *Valuing climate change*, Earthscan, London.

Finus, M., E.C. van Ierland and R.B. Dellink, 2005, “Stability of climate coalitions in a cartel formation game”, forthcoming in *Economics of Governance*.

Hoel, M., 1992, “International environment conventions: the case of uniform reductions of emissions”, *Environmental and Resource Economics* 2, pp. 141-159.

Kolstad, C.D., 2005, “Piercing the veil of uncertainty in transboundary pollution agreements”, *Environmental and Resource Economics* 31, pp. 21-34.

Olieman, N.J. and E.M.T. Hendrix, 2004, “Stability likelihood of coalitions in a two-stage cartelgame: an estimation method”, forthcoming in *European Journal of Operations Research*.

Metz, B., O. Davidson, R. Swart and J. Pan (ed.), 2001, *Climate change 2001: mitigation* Cambridge University Press, Cambridge.

Na, S. and H.S. Shin, 1998, “International environmental agreements under uncertainty”, *Oxford Economic Papers* 50, p. 173-185

Nordhaus, W.D., 1994, *Managing the global commons*, MIT Press, Cambridge, MA.

Roughgarden, T. and S.H. Schneider, 1999, “Climate change policy: quantifying uncertainties for damages and optimal carbon taxes”, *Energy Policy* 27, pp. 415-429.

Tol, R.S.J., 1997, *A decision-analytic treatise of the enhanced greenhouse effect*, PhD. Thesis, Vrije Universiteit, Amsterdam.

Tol, R., 2001, “Climate coalitions in an integrated assessment model”, *Computational Economics* 18, pp. 159-172.

Tol, R.S.J., 2002, "Estimates of the damage costs of climate change: part 1: benchmark estimates", *Environmental and Resource Economics* 21, pp. 47-73.

Tol, R.S.J., 2005, "The marginal damage costs of carbon dioxide emissions: an assessment of the uncertainties", *Energy Policy* 33, pp. 2064-2074.

Ulph, A. and D. Maddison, 1997, “Uncertainty, learning and international environmental policy coordination”, *Environmental and Resource Economics* 9, p. 451-466.

Ulph, A., 2004, “Stable international environmental agreements with a stock pollutant, uncertainty and learning”, *The Journal of Risk and Uncertainty* 29 (1), 53-73.

Appendix I. Histograms for the uncertain model parameters

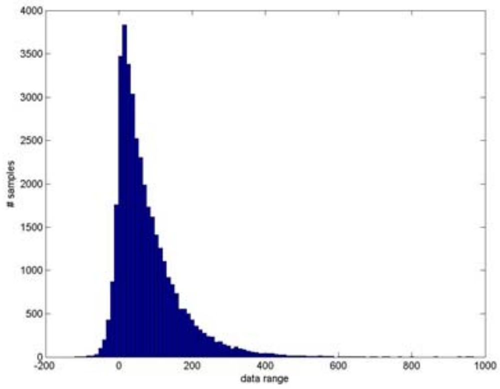

Figure A.1. Histogram for the global benefit parameter (γ).

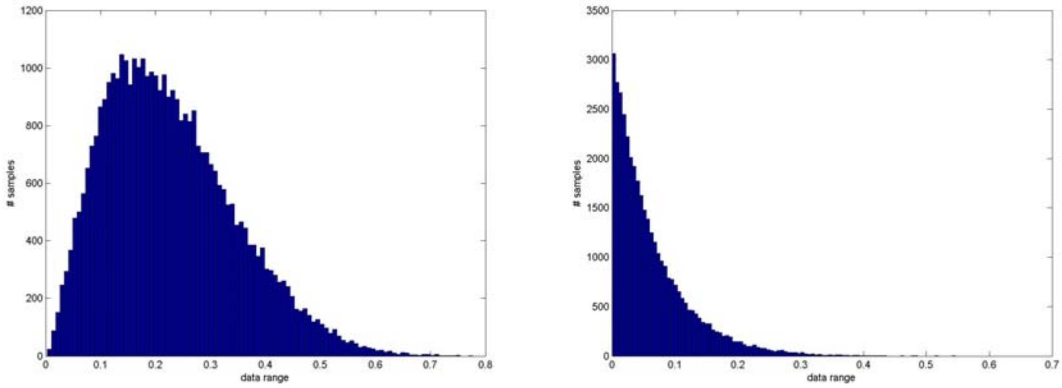

Figure A.2. Histogram for the regional benefit parameters (s_i) for USA and China, respectively.

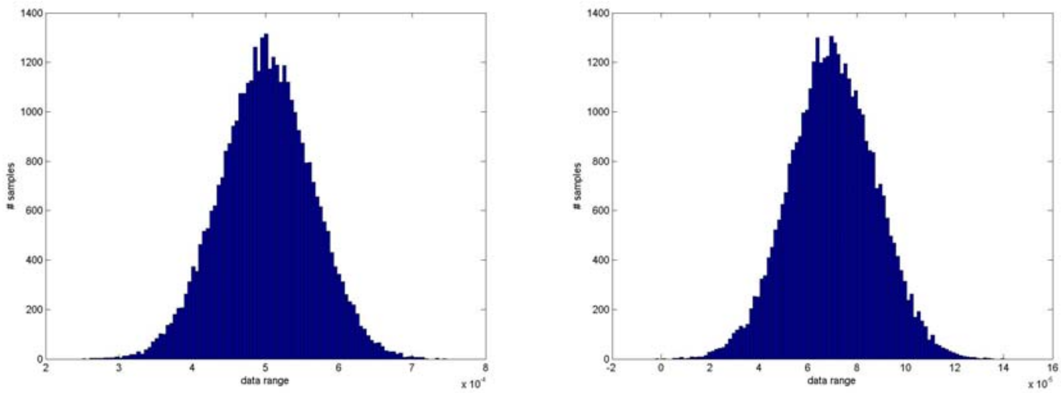

Figure A.3. Histogram for the regional abatement cost parameter (α_i) for USA and China, respectively.

NOTE DI LAVORO DELLA FONDAZIONE ENI ENRICO MATTEI

Fondazione Eni Enrico Mattei Working Paper Series

Our Note di Lavoro are available on the Internet at the following addresses:
http://www.feem.it/Feem/Pub/Publications/WPapers/default.html
http://www.ssrn.com/link/feem.html
http://www.repec.org

NOTE DI LAVORO PUBLISHED IN 2004

IEM	1.2004	*Anil MARKANDYA, Suzette PEDROSO and Alexander GOLUB*: Empirical Analysis of National Income and So2 Emissions in Selected European Countries
ETA	2.2004	*Masahisa FUJITA and Shlomo WEBER:* Strategic Immigration Policies and Welfare in Heterogeneous Countries
PRA	3.2004	*Adolfo DI CARLUCCIO, Giovanni FERRI, Cecilia FRALE and Ottavio RICCHI:* Do Privatizations Boost Household Shareholding? Evidence from Italy
ETA	4.2004	*Victor GINSBURGH and Shlomo WEBER:* Languages Disenfranchisement in the European Union
ETA	5.2004	*Romano PIRAS:* Growth, Congestion of Public Goods, and Second-Best Optimal Policy
CCMP	6.2004	*Herman R.J. VOLLEBERGH:* Lessons from the Polder: Is Dutch CO2-Taxation Optimal
PRA	7.2004	*Sandro BRUSCO, Giuseppe LOPOMO and S. VISWANATHAN* (lxv): Merger Mechanisms
PRA	8.2004	*Wolfgang AUSSENEGG, Pegaret PICHLER and Alex STOMPER* (lxv): IPO Pricing with Bookbuilding, and a When-Issued Market
PRA	9.2004	*Pegaret PICHLER and Alex STOMPER* (lxv): Primary Market Design: Direct Mechanisms and Markets
PRA	10.2004	*Florian ENGLMAIER, Pablo GUILLEN, Loreto LLORENTE, Sander ONDERSTAL and Rupert SAUSGRUBER* (lxv): The Chopstick Auction: A Study of the Exposure Problem in Multi-Unit Auctions
PRA	11.2004	*Bjarne BRENDSTRUP and Harry J. PAARSCH* (lxv): Nonparametric Identification and Estimation of Multi-Unit, Sequential, Oral, Ascending-Price Auctions With Asymmetric Bidders
PRA	12.2004	*Ohad KADAN* (lxv): Equilibrium in the Two Player, k-Double Auction with Affiliated Private Values
PRA	13.2004	*Maarten C.W. JANSSEN* (lxv): Auctions as Coordination Devices
PRA	14.2004	*Gadi FIBICH, Arieh GAVIOUS and Aner SELA* (lxv): All-Pay Auctions with Weakly Risk-Averse Buyers
PRA	15.2004	*Orly SADE, Charles SCHNITZLEIN and Jaime F. ZENDER* (lxv): Competition and Cooperation in Divisible Good Auctions: An Experimental Examination
PRA	16.2004	*Marta STRYSZOWSKA* (lxv): Late and Multiple Bidding in Competing Second Price Internet Auctions
CCMP	17.2004	*Slim Ben YOUSSEF:* R&D in Cleaner Technology and International Trade
NRM	18.2004	*Angelo ANTOCI, Simone BORGHESI and Paolo RUSSU* (lxvi): Biodiversity and Economic Growth: Stabilization Versus Preservation of the Ecological Dynamics
SIEV	19.2004	*Anna ALBERINI, Paolo ROSATO, Alberto LONGO and Valentina ZANATTA:* Information and Willingness to Pay in a Contingent Valuation Study: The Value of S. Erasmo in the Lagoon of Venice
NRM	20.2004	*Guido CANDELA and Roberto CELLINI* (lxvii): Investment in Tourism Market: A Dynamic Model of Differentiated Oligopoly
NRM	21.2004	*Jacqueline M. HAMILTON* (lxvii): Climate and the Destination Choice of German Tourists
NRM	22.2004	*Javier Rey-MAQUIEIRA PALMER, Javier LOZANO IBÁÑEZ and Carlos Mario GÓMEZ GÓMEZ* (lxvii): Land, Environmental Externalities and Tourism Development
NRM	23.2004	*Pius ODUNGA and Henk FOLMER* (lxvii): Profiling Tourists for Balanced Utilization of Tourism-Based Resources in Kenya
NRM	24.2004	*Jean-Jacques NOWAK, Mondher SAHLI and Pasquale M. SGRO* (lxvii):Tourism, Trade and Domestic Welfare
NRM	25.2004	*Riaz SHAREEF* (lxvii): Country Risk Ratings of Small Island Tourism Economies
NRM	26.2004	*Juan Luis EUGENIO-MARTÍN, Noelia MARTÍN MORALES and Riccardo SCARPA* (lxvii): Tourism and Economic Growth in Latin American Countries: A Panel Data Approach
NRM	27.2004	*Raúl Hernández MARTÍN* (lxvii): Impact of Tourism Consumption on GDP. The Role of Imports
CSRM	28.2004	*Nicoletta FERRO:* Cross-Country Ethical Dilemmas in Business: A Descriptive Framework
NRM	29.2004	*Marian WEBER* (lxvi): Assessing the Effectiveness of Tradable Landuse Rights for Biodiversity Conservation: an Application to Canada's Boreal Mixedwood Forest
NRM	30.2004	*Trond BJORNDAL, Phoebe KOUNDOURI and Sean PASCOE* (lxvi): Output Substitution in Multi-Species Trawl Fisheries: Implications for Quota Setting
CCMP	31.2004	*Marzio GALEOTTI, Alessandra GORIA, Paolo MOMBRINI and Evi SPANTIDAKI:* Weather Impacts on Natural, Social and Economic Systems (WISE) Part I: Sectoral Analysis of Climate Impacts in Italy
CCMP	32.2004	*Marzio GALEOTTI, Alessandra GORIA ,Paolo MOMBRINI and Evi SPANTIDAKI:* Weather Impacts on Natural, Social and Economic Systems (WISE) Part II: Individual Perception of Climate Extremes in Italy
CTN	33.2004	*Wilson PEREZ:* Divide and Conquer: Noisy Communication in Networks, Power, and Wealth Distribution
KTHC	34.2004	*Gianmarco I.P. OTTAVIANO and Giovanni PERI* (lxviii): The Economic Value of Cultural Diversity: Evidence from US Cities
KTHC	35.2004	*Linda CHAIB* (lxviii): Immigration and Local Urban Participatory Democracy: A Boston-Paris Comparison

KTHC	36.2004	*Franca ECKERT COEN and Claudio ROSSI* (lxviii): Foreigners, Immigrants, Host Cities: The Policies of Multi-Ethnicity in Rome. Reading Governance in a Local Context
KTHC	37.2004	*Kristine CRANE* (lxviii): Governing Migration: Immigrant Groups' Strategies in Three Italian Cities – Rome, Naples and Bari
KTHC	38.2004	*Kiflemariam HAMDE* (lxviii): Mind in Africa, Body in Europe: The Struggle for Maintaining and Transforming Cultural Identity - A Note from the Experience of Eritrean Immigrants in Stockholm
ETA	39.2004	*Alberto CAVALIERE:* Price Competition with Information Disparities in a Vertically Differentiated Duopoly
PRA	40.2004	*Andrea BIGANO and Stef PROOST:* The Opening of the European Electricity Market and Environmental Policy: Does the Degree of Competition Matter?
CCMP	41.2004	*Micheal FINUS* (lxix): International Cooperation to Resolve International Pollution Problems
KTHC	42.2004	*Francesco CRESPI:* Notes on the Determinants of Innovation: A Multi-Perspective Analysis
CTN	43.2004	*Sergio CURRARINI and Marco MARINI:* Coalition Formation in Games without Synergies
CTN	44.2004	*Marc ESCRIHUELA-VILLAR:* Cartel Sustainability and Cartel Stability
NRM	45.2004	*Sebastian BERVOETS and Nicolas GRAVEL* (lxvi): Appraising Diversity with an Ordinal Notion of Similarity: An Axiomatic Approach
NRM	46.2004	*Signe ANTHON and Bo JELLESMARK THORSEN* (lxvi): Optimal Afforestation Contracts with Asymmetric Information on Private Environmental Benefits
NRM	47.2004	*John MBURU* (lxvi)*:* Wildlife Conservation and Management in Kenya: Towards a Co-management Approach
NRM	48.2004	*Ekin BIROL, Ágnes GYOVAI and Melinda SMALE* (lxvi)*:* Using a Choice Experiment to Value Agricultural Biodiversity on Hungarian Small Farms: Agri-Environmental Policies in a Transition al Economy
CCMP	49.2004	*Gernot KLEPPER and Sonja PETERSON:* The EU Emissions Trading Scheme. Allowance Prices, Trade Flows, Competitiveness Effects
GG	50.2004	*Scott BARRETT and Michael HOEL:* Optimal Disease Eradication
CTN	51.2004	*Dinko DIMITROV, Peter BORM, Ruud HENDRICKX and Shao CHIN SUNG:* Simple Priorities and Core Stability in Hedonic Games
SIEV	52.2004	*Francesco RICCI*: Channels of Transmission of Environmental Policy to Economic Growth: A Survey of the Theory
SIEV	53.2004	*Anna ALBERINI, Maureen CROPPER, Alan KRUPNICK and Nathalie B. SIMON:* Willingness to Pay for Mortality Risk Reductions: Does Latency Matter?
NRM	54.2004	*Ingo BRÄUER and Rainer MARGGRAF* (lxvi): Valuation of Ecosystem Services Provided by Biodiversity Conservation: An Integrated Hydrological and Economic Model to Value the Enhanced Nitrogen Retention in Renaturated Streams
NRM	55.2004	*Timo GOESCHL and Tun LIN* (lxvi): Biodiversity Conservation on Private Lands: Information Problems and Regulatory Choices
NRM	56.2004	*Tom DEDEURWAERDERE* (lxvi): Bioprospection: From the Economics of Contracts to Reflexive Governance
CCMP	57.2004	*Katrin REHDANZ and David MADDISON:* The Amenity Value of Climate to German Households
CCMP	58.2004	*Koen SMEKENS and Bob VAN DER ZWAAN:* Environmental Externalities of Geological Carbon Sequestration Effects on Energy Scenarios
NRM	59.2004	*Valentina BOSETTI, Mariaester CASSINELLI and Alessandro LANZA* (lxvii): Using Data Envelopment Analysis to Evaluate Environmentally Conscious Tourism Management
NRM	60.2004	*Timo GOESCHL and Danilo CAMARGO IGLIORI* (lxvi):Property Rights Conservation and Development: An Analysis of Extractive Reserves in the Brazilian Amazon
CCMP	61.2004	*Barbara BUCHNER and Carlo CARRARO*: Economic and Environmental Effectiveness of a Technology-based Climate Protocol
NRM	62.2004	*Elissaios PAPYRAKIS and Reyer GERLAGH*: Resource-Abundance and Economic Growth in the U.S.
NRM	63.2004	*Györgyi BELA, György PATAKI, Melinda SMALE and Mariann HAJDÚ* (lxvi): Conserving Crop Genetic Resources on Smallholder Farms in Hungary: Institutional Analysis
NRM	64.2004	*E.C.M. RUIJGROK and E.E.M. NILLESEN* (lxvi): The Socio-Economic Value of Natural Riverbanks in the Netherlands
NRM	65.2004	*E.C.M. RUIJGROK* (lxvi): Reducing Acidification: The Benefits of Increased Nature Quality. Investigating the Possibilities of the Contingent Valuation Method
ETA	66.2004	*Giannis VARDAS and Anastasios XEPAPADEAS*: Uncertainty Aversion, Robust Control and Asset Holdings
GG	67.2004	*Anastasios XEPAPADEAS and Constadina PASSA*: Participation in and Compliance with Public Voluntary Environmental Programs: An Evolutionary Approach
GG	68.2004	*Michael FINUS*: Modesty Pays: Sometimes!
NRM	69.2004	*Trond BJØRNDAL and Ana BRASÃO*: The Northern Atlantic Bluefin Tuna Fisheries: Management and Policy Implications
CTN	70.2004	*Alejandro CAPARRÓS, Abdelhakim HAMMOUDI and Tarik TAZDAÏT*: On Coalition Formation with Heterogeneous Agents
IEM	71.2004	*Massimo GIOVANNINI, Margherita GRASSO, Alessandro LANZA and Matteo MANERA*: Conditional Correlations in the Returns on Oil Companies Stock Prices and Their Determinants
IEM	72.2004	*Alessandro LANZA, Matteo MANERA and Michael MCALEER*: Modelling Dynamic Conditional Correlations in WTI Oil Forward and Futures Returns
SIEV	73.2004	*Margarita GENIUS and Elisabetta STRAZZERA*: The Copula Approach to Sample Selection Modelling: An Application to the Recreational Value of Forests

CCMP	74.2004	*Rob DELLINK and Ekko van IERLAND*: Pollution Abatement in the Netherlands: A Dynamic Applied General Equilibrium Assessment
ETA	75.2004	*Rosella LEVAGGI and Michele MORETTO*: Investment in Hospital Care Technology under Different Purchasing Rules: A Real Option Approach
CTN	76.2004	*Salvador BARBERÀ and Matthew O. JACKSON* (lxx): On the Weights of Nations: Assigning Voting Weights in a Heterogeneous Union
CTN	77.2004	*Àlex ARENAS, Antonio CABRALES, Albert DÍAZ-GUILERA, Roger GUIMERÀ and Fernando VEGA-REDONDO* (lxx): Optimal Information Transmission in Organizations: Search and Congestion
CTN	78.2004	*Francis BLOCH and Armando GOMES* (lxx): Contracting with Externalities and Outside Options
CTN	79.2004	*Rabah AMIR, Effrosyni DIAMANTOUDI and Licun XUE* (lxx): Merger Performance under Uncertain Efficiency Gains
CTN	80.2004	*Francis BLOCH and Matthew O. JACKSON* (lxx): The Formation of Networks with Transfers among Players
CTN	81.2004	*Daniel DIERMEIER, Hülya ERASLAN and Antonio MERLO* (lxx): Bicameralism and Government Formation
CTN	82.2004	*Rod GARRATT, James E. PARCO, Cheng-ZHONG QIN and Amnon RAPOPORT* (lxx): Potential Maximization and Coalition Government Formation
CTN	83.2004	*Kfir ELIAZ, Debraj RAY and Ronny RAZIN* (lxx): Group Decision-Making in the Shadow of Disagreement
CTN	84.2004	*Sanjeev GOYAL, Marco van der LEIJ and José Luis MORAGA-GONZÁLEZ* (lxx): Economics: An Emerging Small World?
CTN	85.2004	*Edward CARTWRIGHT* (lxx): Learning to Play Approximate Nash Equilibria in Games with Many Players
IEM	86.2004	*Finn R. FØRSUND and Michael HOEL*: Properties of a Non-Competitive Electricity Market Dominated by Hydroelectric Power
KTHC	87.2004	*Elissaios PAPYRAKIS and Reyer GERLAGH*: Natural Resources, Investment and Long-Term Income
CCMP	88.2004	*Marzio GALEOTTI and Claudia KEMFERT*: Interactions between Climate and Trade Policies: A Survey
IEM	89.2004	*A. MARKANDYA, S. PEDROSO and D. STREIMIKIENE*: Energy Efficiency in Transition Economies: Is There Convergence Towards the EU Average?
GG	90.2004	*Rolf GOLOMBEK and Michael HOEL* : Climate Agreements and Technology Policy
PRA	91.2004	*Sergei IZMALKOV* (lxv): Multi-Unit Open Ascending Price Efficient Auction
KTHC	92.2004	*Gianmarco I.P. OTTAVIANO and Giovanni PERI*: Cities and Cultures
KTHC	93.2004	*Massimo DEL GATTO*: Agglomeration, Integration, and Territorial Authority Scale in a System of Trading Cities. Centralisation versus devolution
CCMP	94.2004	*Pierre-André JOUVET, Philippe MICHEL and Gilles ROTILLON*: Equilibrium with a Market of Permits
CCMP	95.2004	*Bob van der ZWAAN and Reyer GERLAGH*: Climate Uncertainty and the Necessity to Transform Global Energy Supply
CCMP	96.2004	*Francesco BOSELLO, Marco LAZZARIN, Roberto ROSON and Richard S.J. TOL*: Economy-Wide Estimates of the Implications of Climate Change: Sea Level Rise
CTN	97.2004	*Gustavo BERGANTIÑOS and Juan J. VIDAL-PUGA*: Defining Rules in Cost Spanning Tree Problems Through the Canonical Form
CTN	98.2004	*Siddhartha BANDYOPADHYAY and Mandar OAK*: Party Formation and Coalitional Bargaining in a Model of Proportional Representation
GG	99.2004	*Hans-Peter WEIKARD, Michael FINUS and Juan-Carlos ALTAMIRANO-CABRERA*: The Impact of Surplus Sharing on the Stability of International Climate Agreements
SIEV	100.2004	*Chiara M. TRAVISI and Peter NIJKAMP*: Willingness to Pay for Agricultural Environmental Safety: Evidence from a Survey of Milan, Italy, Residents
SIEV	101.2004	*Chiara M. TRAVISI, Raymond J. G. M. FLORAX and Peter NIJKAMP*: A Meta-Analysis of the Willingness to Pay for Reductions in Pesticide Risk Exposure
NRM	102.2004	*Valentina BOSETTI and David TOMBERLIN:* Real Options Analysis of Fishing Fleet Dynamics: A Test
CCMP	103.2004	*Alessandra GORIA e Gretel GAMBARELLI:* Economic Evaluation of Climate Change Impacts and Adaptability in Italy
PRA	104.2004	*Massimo FLORIO and Mara GRASSENI*: The Missing Shock: The Macroeconomic Impact of British Privatisation
PRA	105.2004	*John BENNETT, Saul ESTRIN, James MAW and Giovanni URGA*: Privatisation Methods and Economic Growth in Transition Economies
PRA	106.2004	*Kira BÖRNER*: The Political Economy of Privatization: Why Do Governments Want Reforms?
PRA	107.2004	*Pehr-Johan NORBÄCK and Lars PERSSON*: Privatization and Restructuring in Concentrated Markets
SIEV	108.2004	*Angela GRANZOTTO, Fabio PRANOVI, Simone LIBRALATO, Patrizia TORRICELLI and Danilo MAINARDI*: Comparison between Artisanal Fishery and Manila Clam Harvesting in the Venice Lagoon by Using Ecosystem Indicators: An Ecological Economics Perspective
CTN	109.2004	*Somdeb LAHIRI*: The Cooperative Theory of Two Sided Matching Problems: A Re-examination of Some Results
NRM	110.2004	*Giuseppe DI VITA*: Natural Resources Dynamics: Another Look
SIEV	111.2004	*Anna ALBERINI, Alistair HUNT and Anil MARKANDYA*: Willingness to Pay to Reduce Mortality Risks: Evidence from a Three-Country Contingent Valuation Study
KTHC	112.2004	*Valeria PAPPONETTI and Dino PINELLI*: Scientific Advice to Public Policy-Making
SIEV	113.2004	*Paulo A.L.D. NUNES and Laura ONOFRI*: The Economics of Warm Glow: A Note on Consumer's Behavior and Public Policy Implications
IEM	114.2004	*Patrick CAYRADE*: Investments in Gas Pipelines and Liquefied Natural Gas Infrastructure What is the Impact on the Security of Supply?
IEM	115.2004	*Valeria COSTANTINI and Francesco GRACCEVA:* Oil Security. Short- and Long-Term Policies

IEM	116.2004	*Valeria COSTANTINI and Francesco GRACCEVA:* Social Costs of Energy Disruptions
IEM	117.2004	*Christian EGENHOFER, Kyriakos GIALOGLOU, Giacomo LUCIANI, Maroeska BOOTS, Martin SCHEEPERS, Valeria COSTANTINI, Francesco GRACCEVA, Anil MARKANDYA and Giorgio VICINI*: Market-Based Options for Security of Energy Supply
IEM	118.2004	*David FISK*: Transport Energy Security. The Unseen Risk?
IEM	119.2004	*Giacomo LUCIANI*: Security of Supply for Natural Gas Markets. What is it and What is it not?
IEM	120.2004	*L.J. de VRIES and R.A. HAKVOORT*: The Question of Generation Adequacy in Liberalised Electricity Markets
KTHC	121.2004	*Alberto PETRUCCI*: Asset Accumulation, Fertility Choice and Nondegenerate Dynamics in a Small Open Economy
NRM	122.2004	*Carlo GIUPPONI, Jaroslaw MYSIAK and Anita FASSIO*: An Integrated Assessment Framework for Water Resources Management: A DSS Tool and a Pilot Study Application
NRM	123.2004	*Margaretha BREIL, Anita FASSIO, Carlo GIUPPONI and Paolo ROSATO*: Evaluation of Urban Improvement on the Islands of the Venice Lagoon: A Spatially-Distributed Hedonic-Hierarchical Approach
ETA	124.2004	*Paul MENSINK*: Instant Efficient Pollution Abatement Under Non-Linear Taxation and Asymmetric Information: The Differential Tax Revisited
NRM	125.2004	*Mauro FABIANO, Gabriella CAMARSA, Rosanna DURSI, Roberta IVALDI, Valentina MARIN and Francesca PALMISANI*: Integrated Environmental Study for Beach Management:A Methodological Approach
PRA	126.2004	*Irena GROSFELD and Iraj HASHI*: The Emergence of Large Shareholders in Mass Privatized Firms: Evidence from Poland and the Czech Republic
CCMP	127.2004	*Maria BERRITTELLA, Andrea BIGANO, Roberto ROSON and Richard S.J. TOL*: A General Equilibrium Analysis of Climate Change Impacts on Tourism
CCMP	128.2004	*Reyer GERLAGH*: A Climate-Change Policy Induced Shift from Innovations in Energy Production to Energy Savings
NRM	129.2004	*Elissaios PAPYRAKIS and Reyer GERLAGH*: Natural Resources, Innovation, and Growth
PRA	130.2004	*Bernardo BORTOLOTTI and Mara FACCIO*: Reluctant Privatization
SIEV	131.2004	*Riccardo SCARPA and Mara THIENE*: Destination Choice Models for Rock Climbing in the Northeast Alps: A Latent-Class Approach Based on Intensity of Participation
SIEV	132.2004	*Riccardo SCARPA Kenneth G. WILLIS and Melinda ACUTT*: Comparing Individual-Specific Benefit Estimates for Public Goods: Finite Versus Continuous Mixing in Logit Models
IEM	133.2004	*Santiago J. RUBIO*: On Capturing Oil Rents with a National Excise Tax Revisited
ETA	134.2004	*Ascensión ANDINA DÍAZ*: Political Competition when Media Create Candidates' Charisma
SIEV	135.2004	*Anna ALBERINI*: Robustness of VSL Values from Contingent Valuation Surveys
CCMP	136.2004	*Gernot KLEPPER and Sonja PETERSON*: Marginal Abatement Cost Curves in General Equilibrium: The Influence of World Energy Prices
ETA	137.2004	*Herbert DAWID, Christophe DEISSENBERG and Pavel ŠEVČIK*: Cheap Talk, Gullibility, and Welfare in an Environmental Taxation Game
CCMP	138.2004	*ZhongXiang ZHANG*: The World Bank's Prototype Carbon Fund and China
CCMP	139.2004	*Reyer GERLAGH and Marjan W. HOFKES*: Time Profile of Climate Change Stabilization Policy
NRM	140.2004	*Chiara D'ALPAOS and Michele MORETTO*: The Value of Flexibility in the Italian Water Service Sector: A Real Option Analysis
PRA	141.2004	*Patrick BAJARI, Stephanie HOUGHTON and Steven TADELIS* (lxxi): Bidding for Incompete Contracts
PRA	142.2004	*Susan ATHEY, Jonathan LEVIN and Enrique SEIRA* (lxxi): Comparing Open and Sealed Bid Auctions: Theory and Evidence from Timber Auctions
PRA	143.2004	*David GOLDREICH* (lxxi): Behavioral Biases of Dealers in U.S. Treasury Auctions
PRA	144.2004	*Roberto BURGUET* (lxxi): Optimal Procurement Auction for a Buyer with Downward Sloping Demand: More Simple Economics
PRA	145.2004	*Ali HORTACSU and Samita SAREEN* (lxxi): Order Flow and the Formation of Dealer Bids: An Analysis of Information and Strategic Behavior in the Government of Canada Securities Auctions
PRA	146.2004	*Victor GINSBURGH, Patrick LEGROS and Nicolas SAHUGUET* (lxxi): How to Win Twice at an Auction. On the Incidence of Commissions in Auction Markets
PRA	147.2004	*Claudio MEZZETTI, Aleksandar PEKEČ and Ilia TSETLIN* (lxxi): Sequential vs. Single-Round Uniform-Price Auctions
PRA	148.2004	*John ASKER and Estelle CANTILLON* (lxxi): Equilibrium of Scoring Auctions
PRA	149.2004	*Philip A. HAILE, Han HONG and Matthew SHUM* (lxxi): Nonparametric Tests for Common Values in First-Price Sealed-Bid Auctions
PRA	150.2004	*François DEGEORGE, François DERRIEN and Kent L. WOMACK* (lxxi): Quid Pro Quo in IPOs: Why Bookbuilding is Dominating Auctions
CCMP	151.2004	*Barbara BUCHNER and Silvia DALL'OLIO*: Russia: The Long Road to Ratification. Internal Institution and Pressure Groups in the Kyoto Protocol's Adoption Process
CCMP	152.2004	*Carlo CARRARO and Marzio GALEOTTI*: Does Endogenous Technical Change Make a Difference in Climate Policy Analysis? A Robustness Exercise with the FEEM-RICE Model
PRA	153.2004	*Alejandro M. MANELLI and Daniel R. VINCENT* (lxxi): Multidimensional Mechanism Design: Revenue Maximization and the Multiple-Good Monopoly
ETA	154.2004	*Nicola ACOCELLA, Giovanni Di BARTOLOMEO and Wilfried PAUWELS*: Is there any Scope for Corporatism in Stabilization Policies?
CTN	155.2004	*Johan EYCKMANS and Michael FINUS*: An Almost Ideal Sharing Scheme for Coalition Games with Externalities
CCMP	156.2004	*Cesare DOSI and Michele MORETTO*: Environmental Innovation, War of Attrition and Investment Grants

CCMP	157.2004	*Valentina BOSETTI, Marzio GALEOTTI and Alessandro LANZA*: How Consistent are Alternative Short-Term Climate Policies with Long-Term Goals?
ETA	158.2004	*Y. Hossein FARZIN and Ken-Ichi AKAO*: Non-pecuniary Value of Employment and Individual Labor Supply
ETA	159.2004	*William BROCK and Anastasios XEPAPADEAS*: Spatial Analysis: Development of Descriptive and Normative Methods with Applications to Economic-Ecological Modelling
KTHC	160.2004	*Alberto PETRUCCI*: On the Incidence of a Tax on PureRent with Infinite Horizons
IEM	161.2004	*Xavier LABANDEIRA, José M. LABEAGA and Miguel RODRÍGUEZ*: Microsimulating the Effects of Household Energy Price Changes in Spain

NOTE DI LAVORO PUBLISHED IN 2005

CCMP	1.2005	*Stéphane HALLEGATTE*: Accounting for Extreme Events in the Economic Assessment of Climate Change
CCMP	2.2005	*Qiang WU and Paulo Augusto NUNES*: Application of Technological Control Measures on Vehicle Pollution: A Cost-Benefit Analysis in China
CCMP	3.2005	*Andrea BIGANO, Jacqueline M. HAMILTON, Maren LAU, Richard S.J. TOL and Yuan ZHOU*: A Global Database of Domestic and International Tourist Numbers at National and Subnational Level
CCMP	4.2005	*Andrea BIGANO, Jacqueline M. HAMILTON and Richard S.J. TOL*: The Impact of Climate on Holiday Destination Choice
ETA	5.2005	*Hubert KEMPF*: Is Inequality Harmful for the Environment in a Growing Economy?
CCMP	6.2005	*Valentina BOSETTI, Carlo CARRARO and Marzio GALEOTTI*: The Dynamics of Carbon and Energy Intensity in a Model of Endogenous Technical Change
IEM	7.2005	*David CALEF and Robert GOBLE*: The Allure of Technology: How France and California Promoted Electric Vehicles to Reduce Urban Air Pollution
ETA	8.2005	*Lorenzo PELLEGRINI and Reyer GERLAGH*: An Empirical Contribution to the Debate on Corruption Democracy and Environmental Policy
CCMP	9.2005	*Angelo ANTOCI*: Environmental Resources Depletion and Interplay Between Negative and Positive Externalities in a Growth Model
CTN	10.2005	*Frédéric DEROIAN*: Cost-Reducing Alliances and Local Spillovers
NRM	11.2005	*Francesco SINDICO*: The GMO Dispute before the WTO: Legal Implications for the Trade and Environment Debate
KTHC	12.2005	*Carla MASSIDDA*: Estimating the New Keynesian Phillips Curve for Italian Manufacturing Sectors
KTHC	13.2005	*Michele MORETTO and Gianpaolo ROSSINI*: Start-up Entry Strategies: Employer vs. Nonemployer firms
PRCG	14.2005	*Clara GRAZIANO and Annalisa LUPORINI*: Ownership Concentration, Monitoring and Optimal Board Structure
CSRM	15.2005	*Parashar KULKARNI*: Use of Ecolabels in Promoting Exports from Developing Countries to Developed Countries: Lessons from the Indian LeatherFootwear Industry
KTHC	16.2005	*Adriana DI LIBERTO, Roberto MURA and Francesco PIGLIARU*: How to Measure the Unobservable: A Panel Technique for the Analysis of TFP Convergence
KTHC	17.2005	*Alireza NAGHAVI*: Asymmetric Labor Markets, Southern Wages, and the Location of Firms
KTHC	18.2005	*Alireza NAGHAVI*: Strategic Intellectual Property Rights Policy and North-South Technology Transfer
KTHC	19.2005	*Mombert HOPPE*: Technology Transfer Through Trade
PRCG	20.2005	*Roberto ROSON*: Platform Competition with Endogenous Multihoming
CCMP	21.2005	*Barbara BUCHNER and Carlo CARRARO*: Regional and Sub-Global Climate Blocs. A Game Theoretic Perspective on Bottom-up Climate Regimes
IEM	22.2005	*Fausto CAVALLARO*: An Integrated Multi-Criteria System to Assess Sustainable Energy Options: An Application of the Promethee Method
CTN	23.2005	*Michael FINUS, Pierre v. MOUCHE and Bianca RUNDSHAGEN*: Uniqueness of Coalitional Equilibria
IEM	24.2005	*Wietze LISE*: Decomposition of CO2 Emissions over 1980–2003 in Turkey
CTN	25.2005	*Somdeb LAHIRI*: The Core of Directed Network Problems with Quotas
SIEV	26.2005	*Susanne MENZEL and Riccardo SCARPA*: Protection Motivation Theory and Contingent Valuation: Perceived Realism, Threat and WTP Estimates for Biodiversity Protection
NRM	27.2005	*Massimiliano MAZZANTỊ and Anna MONTINI*: The Determinants of Residential Water Demand Empirical Evidence for a Panel of Italian Municipalities
CCMP	28.2005	*Laurent GILOTTE and Michel de LARA*: Precautionary Effect and Variations of the Value of Information
NRM	29.2005	*Paul SARFO-MENSAH*: Exportation of Timber in Ghana: The Menace of Illegal Logging Operations
CCMP	30.2005	*Andrea BIGANO, Alessandra GORIA, Jacqueline HAMILTON and Richard S.J. TOL*: The Effect of Climate Change and Extreme Weather Events on Tourism
NRM	31.2005	*Maria Angeles GARCIA-VALIÑAS*: Decentralization and Environment: An Application to Water Policies
NRM	32.2005	*Chiara D'ALPAOS, Cesare DOSI and Michele MORETTO*: Concession Length and Investment Timing Flexibility
CCMP	33.2005	*Joseph HUBER*: Key Environmental Innovations
CTN	34.2005	*Antoni CALVÓ-ARMENGOL and Rahmi İLKILIÇ* (lxxii): Pairwise-Stability and Nash Equilibria in Network Formation
CTN	35.2005	*Francesco FERI* (lxxii): Network Formation with Endogenous Decay
CTN	36.2005	*Frank H. PAGE, Jr. and Myrna H. WOODERS* (lxxii): Strategic Basins of Attraction, the Farsighted Core, and Network Formation Games

CTN	37.2005	*Alessandra CASELLA and Nobuyuki HANAKI* (lxxii): Information Channels in Labor Markets. On the Resilience of Referral Hiring
CTN	38.2005	*Matthew O. JACKSON and Alison WATTS* (lxxii): Social Games: Matching and the Play of Finitely Repeated Games
CTN	39.2005	*Anna BOGOMOLNAIA, Michel LE BRETON, Alexei SAVVATEEV and Shlomo WEBER* (lxxii): The Egalitarian Sharing Rule in Provision of Public Projects
CTN	40.2005	*Francesco FERI*: Stochastic Stability in Network with Decay
CTN	41.2005	*Aart de ZEEUW* (lxxii): Dynamic Effects on the Stability of International Environmental Agreements
NRM	42.2005	*C. Martijn van der HEIDE, Jeroen C.J.M. van den BERGH, Ekko C. van IERLAND and Paulo A.L.D. NUNES*: Measuring the Economic Value of Two Habitat Defragmentation Policy Scenarios for the Veluwe, The Netherlands
PRCG	43.2005	*Carla VIEIRA and Ana Paula SERRA*: Abnormal Returns in Privatization Public Offerings: The Case of Portuguese Firms
SIEV	44.2005	*Anna ALBERINI, Valentina ZANATTA and Paolo ROSATO*: Combining Actual and Contingent Behavior to Estimate the Value of Sports Fishing in the Lagoon of Venice
CTN	45.2005	*Michael FINUS and Bianca RUNDSHAGEN:* Participation in International Environmental Agreements: The Role of Timing and Regulation
CCMP	46.2005	*Lorenzo PELLEGRINI and Reyer GERLAGH*: Are EU Environmental Policies Too Demanding for New Members States?
IEM	47.2005	*Matteo MANERA*: Modeling Factor Demands with SEM and VAR: An Empirical Comparison
CTN	48.2005	*Olivier TERCIEUX and Vincent VANNETELBOSCH* (lxx): A Characterization of Stochastically Stable Networks
CTN	49.2005	*Ana MAULEON, José SEMPERE-MONERRIS and Vincent J. VANNETELBOSCH* (lxxii): R&D Networks Among Unionized Firms
CTN	50.2005	*Carlo CARRARO, Johan EYCKMANS and Michael FINUS*: Optimal Transfers and Participation Decisions in International Environmental Agreements
KTHC	51.2005	*Valeria GATTAI*: From the Theory of the Firm to FDI and Internalisation:A Survey
CCMP	52.2005	*Alireza NAGHAVI*: Multilateral Environmental Agreements and Trade Obligations: A Theoretical Analysis of the Doha Proposal
SIEV	53.2005	*Margaretha BREIL, Gretel GAMBARELLI and Paulo A.L.D. NUNES*: Economic Valuation of On Site Material Damages of High Water on Economic Activities based in the City of Venice: Results from a Dose-Response-Expert-Based Valuation Approach
ETA	54.2005	*Alessandra del BOCA, Marzio GALEOTTI, Charles P. HIMMELBERG and Paola ROTA*: Investment and Time to Plan: A Comparison of Structures vs. Equipment in a Panel of Italian Firms
CCMP	55.2005	*Gernot KLEPPER and Sonja PETERSON*: Emissions Trading, CDM, JI, and More – The Climate Strategy of the EU
ETA	56.2005	*Maia DAVID and Bernard SINCLAIR-DESGAGNÉ*: Environmental Regulation and the Eco-Industry
ETA	57.2005	*Alain-Désiré NIMUBONA and Bernard SINCLAIR-DESGAGNÉ*: The Pigouvian Tax Rule in the Presence of an Eco-Industry
NRM	58.2005	*Helmut KARL, Antje MÖLLER, Ximena MATUS, Edgar GRANDE and Robert KAISER*: Environmental Innovations: Institutional Impacts on Co-operations for Sustainable Development
SIEV	59.2005	*Dimitra VOUVAKI and Anastasios XEPAPADEAS* (lxxiii): Criteria for Assessing Sustainable Development: Theoretical Issues and Empirical Evidence for the Case of Greece
CCMP	60.2005	*Andreas LÖSCHEL and Dirk T.G. RÜBBELKE*: Impure Public Goods and Technological Interdependencies
PRCG	61.2005	*Christoph A. SCHALTEGGER and Benno TORGLER*: Trust and Fiscal Performance: A Panel Analysis with Swiss Data
ETA	62.2005	*Irene VALSECCHI*: A Role for Instructions
NRM	63.2005	*Valentina BOSETTI and Gianni LOCATELLI*: A Data Envelopment Analysis Approach to the Assessment of Natural Parks' Economic Efficiency and Sustainability. The Case of Italian National Parks
SIEV	64.2005	*Arianne T. de BLAEIJ, Paulo A.L.D. NUNES and Jeroen C.J.M. van den BERGH*: Modeling 'No-choice' Responses in Attribute Based Valuation Surveys
CTN	65.2005	*Carlo CARRARO, Carmen MARCHIORI and Alessandra SGOBBI*: Applications of Negotiation Theory to Water Issues
CTN	66.2005	*Carlo CARRARO, Carmen MARCHIORI and Alessandra SGOBBI*: Advances in Negotiation Theory: Bargaining, Coalitions and Fairness
KTHC	67.2005	*Sandra WALLMAN* (lxxiv): Network Capital and Social Trust: Pre-Conditions for 'Good' Diversity?
KTHC	68.2005	*Asimina CHRISTOFOROU* (lxxiv): On the Determinants of Social Capital in Greece Compared to Countries of the European Union
KTHC	69.2005	*Eric M. USLANER* (lxxiv): Varieties of Trust
KTHC	70.2005	*Thomas P. LYON* (lxxiv): Making Capitalism Work: Social Capital and Economic Growth in Italy, 1970-1995
KTHC	71.2005	*Graziella BERTOCCHI and Chiara STROZZI* (lxxv): Citizenship Laws and International Migration in Historical Perspective
KTHC	72.2005	*Elsbeth van HYLCKAMA VLIEG* (lxxv): Accommodating Differences
KTHC	73.2005	*Renato SANSA and Ercole SORI* (lxxv): Governance of Diversity Between Social Dynamics and Conflicts in Multicultural Cities. A Selected Survey on Historical Bibliography
IEM	74.2005	*Alberto LONGO and Anil MARKANDYA*: Identification of Options and Policy Instruments for the Internalisation of External Costs of Electricity Generation. Dissemination of External Costs of Electricity Supply Making Electricity External Costs Known to Policy-Makers MAXIMA

IEM	75.2005	*Margherita GRASSO and Matteo MANERA*: Asymmetric Error Correction Models for the Oil-Gasoline Price Relationship
ETA	76.2005	*Umberto CHERUBINI and Matteo MANERA*: Hunting the Living Dead A "Peso Problem" in Corporate Liabilities Data
CTN	77.2005	*Hans-Peter WEIKARD*: Cartel Stability under an Optimal Sharing Rule
ETA	78.2005	*Joëlle NOAILLY, Jeroen C.J.M. van den BERGH and Cees A. WITHAGEN* (lxxvi): Local and Global Interactions in an Evolutionary Resource Game
ETA	79.2005	*Joëlle NOAILLY, Cees A. WITHAGEN and Jeroen C.J.M. van den BERGH* (lxxvi): Spatial Evolution of Social Norms in a Common-Pool Resource Game
CCMP	80.2005	*Massimiliano MAZZANTI and Roberto ZOBOLI*: Economic Instruments and Induced Innovation: The Case of End-of-Life Vehicles European Policies
NRM	81.2005	*Anna LASUT*: Creative Thinking and Modelling for the Decision Support in Water Management
CCMP	82.2005	*Valentina BOSETTI and Barbara BUCHNER*: Using Data Envelopment Analysis to Assess the Relative Efficiency of Different Climate Policy Portfolios
ETA	83.2005	*Ignazio MUSU*: Intellectual Property Rights and Biotechnology: How to Improve the Present Patent System
KTHC	84.2005	*Giulio CAINELLI, Susanna MANCINELLI and Massimiliano MAZZANTI*: Social Capital, R&D and Industrial Districts
ETA	85.2005	*Rosella LEVAGGI, Michele MORETTO and Vincenzo REBBA*: Quality and Investment Decisions in Hospital Care when Physicians are Devoted Workers
CCMP	86.2005	*Valentina BOSETTI and Laurent GILOTTE*: Carbon Capture and Sequestration: How Much Does this Uncertain Option Affect Near-Term Policy Choices?
CSRM	87.2005	*Nicoletta FERRO*: Value Through Diversity: Microfinance and Islamic Finance and Global Banking
ETA	88.2005	*A. MARKANDYA and S. PEDROSO*: How Substitutable is Natural Capital?
IEM	89.2005	*Anil MARKANDYA, Valeria COSTANTINI, Francesco GRACCEVA and Giorgio VICINI*: Security of Energy Supply: Comparing Scenarios From a European Perspective
CCMP	90.2005	*Vincent M. OTTO, Andreas LÖSCHEL and Rob DELLINK*: Energy Biased Technical Change: A CGE Analysis
PRCG	91.2005	*Carlo CAPUANO*: *Abuse of Competitive Fringe*
PRCG	92.2005	*Ulrich BINDSEIL, Kjell G. NYBORG and Ilya A. STREBULAEV* (lxv): Bidding and Performance in Repo Auctions: Evidence from ECB Open Market Operations
CCMP	93.2005	*Sabrina AUCI and Leonardo BECCHETTI*: The Stability of the Adjusted and Unadjusted Environmental Kuznets Curve
CCMP	94.2005	*Francesco BOSELLO and Jian ZHANG*: Assessing Climate Change Impacts: Agriculture
CTN	95.2005	*Alejandro CAPARRÓS, Jean-Christophe PEREAU and Tarik TAZDAÏT*: Bargaining with Non-Monolithic Players
ETA	96.2005	*William BROCK and Anastasios XEPAPADEAS* (lxxvi): Optimal Control and Spatial Heterogeneity: Pattern Formation in Economic-Ecological Models
CCMP	97.2005	*Francesco BOSELLO, Roberto ROSON and Richard S.J. TOL* (lxxvii): Economy-Wide Estimates of the Implications of Climate Change: Human Health
CCMP	98.2005	*Rob DELLINK, Michael FINUS and Niels OLIEMAN*: Coalition Formation under Uncertainty: The Stability Likelihood of an International Climate Agreement

(lxv) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications” organised by Fondazione Eni Enrico Mattei and sponsored by the EU, Milan, September 25-27, 2003

(lxvi) This paper has been presented at the 4th BioEcon Workshop on “Economic Analysis of Policies for Biodiversity Conservation” organised on behalf of the BIOECON Network by Fondazione Eni Enrico Mattei, Venice International University (VIU) and University College London (UCL) , Venice, August 28-29, 2003

(lxvii) This paper has been presented at the international conference on “Tourism and Sustainable Economic Development – Macro and Micro Economic Issues” jointly organised by CRENoS (Università di Cagliari e Sassari, Italy) and Fondazione Eni Enrico Mattei, and supported by the World Bank, Sardinia, September 19-20, 2003

(lxviii) This paper was presented at the ENGIME Workshop on “Governance and Policies in Multicultural Cities”, Rome, June 5-6, 2003

(lxix) This paper was presented at the Fourth EEP Plenary Workshop and EEP Conference “The Future of Climate Policy”, Cagliari, Italy, 27-28 March 2003

(lxx) This paper was presented at the 9th Coalition Theory Workshop on "Collective Decisions and Institutional Design" organised by the Universitat Autònoma de Barcelona and held in Barcelona, Spain, January 30-31, 2004

(lxxi) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications”, organised by Fondazione Eni Enrico Mattei and Consip and sponsored by the EU, Rome, September 23-25, 2004

(lxxii) This paper was presented at the 10th Coalition Theory Network Workshop held in Paris, France on 28-29 January 2005 and organised by EUREQua.

(lxxiii) This paper was presented at the 2nd Workshop on "Inclusive Wealth and Accounting Prices" held in Trieste, Italy on 13-15 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics

(lxxiv) This paper was presented at the ENGIME Workshop on “Trust and social capital in multicultural cities” Athens, January 19-20, 2004

(lxxv) This paper was presented at the ENGIME Workshop on “Diversity as a source of growth” Rome November 18-19, 2004

(lxxvi) This paper was presented at the 3rd Workshop on Spatial-Dynamic Models of Economics and Ecosystems held in Trieste on 11-13 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics

(lxxvii) This paper was presented at the Workshop on Infectious Diseases: Ecological and Economic Approaches held in Trieste on 13-15 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics.

2004 SERIES	
CCMP	*Climate Change Modelling and Policy* (Editor: Marzio Galeotti)
GG	*Global Governance* (Editor: Carlo Carraro)
SIEV	*Sustainability Indicators and Environmental Valuation* (Editor: Anna Alberini)
NRM	*Natural Resources Management* (Editor: Carlo Giupponi)
KTHC	*Knowledge, Technology, Human Capital* (Editor: Gianmarco Ottaviano)
IEM	*International Energy Markets* (Editor: Anil Markandya)
CSRM	*Corporate Social Responsibility and Sustainable Management* (Editor: Sabina Ratti)
PRA	*Privatisation, Regulation, Antitrust* (Editor: Bernardo Bortolotti)
ETA	*Economic Theory and Applications* (Editor: Carlo Carraro)
CTN	*Coalition Theory Network*

2005 SERIES	
CCMP	*Climate Change Modelling and Policy* (Editor: Marzio Galeotti)
SIEV	*Sustainability Indicators and Environmental Valuation* (Editor: Anna Alberini)
NRM	*Natural Resources Management* (Editor: Carlo Giupponi)
KTHC	*Knowledge, Technology, Human Capital* (Editor: Gianmarco Ottaviano)
IEM	*International Energy Markets* (Editor: Anil Markandya)
CSRM	*Corporate Social Responsibility and Sustainable Management* (Editor: Sabina Ratti)
PRCG	*Privatisation Regulation Corporate Governance* (Editor: Bernardo Bortolotti)
ETA	*Economic Theory and Applications* (Editor: Carlo Carraro)
CTN	*Coalition Theory Network*