Lessmann, Kai; Edenhofer, Ottmar; Bauer, Nico

Working Paper
Mitigation Strategies and Costs of Climate Protection: The effects of ETC in the hybrid Model MIND

Nota di Lavoro, Fondazione Eni Enrico Mattei, No. 150.2005

Provided in Cooperation with:
Fondazione Eni Enrico Mattei (FEEM)

Suggested Citation: Lessmann, Kai; Edenhofer, Ottmar; Bauer, Nico (2005) : Mitigation Strategies and Costs of Climate Protection: The effects of ETC in the hybrid Model MIND, Nota di Lavoro, Fondazione Eni Enrico Mattei, No. 150.2005, Fondazione Eni Enrico Mattei (FEEM), Milano

This Version is available at:
http://hdl.handle.net/10419/73955

Terms of use:
Documents in EconStor may be saved and copied for your personal and scholarly purposes.
You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

www.econstor.eu
Mitigation Strategies and Costs of Climate Protection: The effects of ETC in the hybrid Model MIND
Ottmar Edenhofer, Kai Lessmann and Nico Bauer

NOTA DI LAVORO 150.2005

DECEMBER 2005

CCMP – Climate Change Modelling and Policy

Ottmar Edenhofer, Potsdam Institute for Climate Impact Research
Kai Lessmann, Potsdam Institute for Climate Impact Research
Nico Bauer, Paul Scherrer Institute (PSI)

This paper can be downloaded without charge at:
The Fondazione Eni Enrico Mattei Note di Lavoro Series Index:
http://www.feem.it/Feem/Pub/Publications/WPapers/default.htm

Social Science Research Network Electronic Paper Collection:
http://ssrn.com/abstract=871447

The opinions expressed in this paper do not necessarily reflect the position of Fondazione Eni Enrico Mattei
Corso Magenta, 63, 20123 Milano (I), web site: www.feem.it, e-mail: working.papers@feem.it
This paper is one of a series published by FEEM on the theme of innovation modeling in the context of the challenge of stabilising atmospheric concentrations of greenhouse gases, as part of the Innovation Modeling Comparison Project. This is an international project launched and overseen by the Steering Committee of the informal International Programme on the Economics of Atmospheric Stabilisation.* The broad aim of the collaboration is to advance understanding of the economic issues surrounding atmospheric stabilisation, and the specific aims of the IMCP are to provide insights into the "state of the art" and implications of endogenous modeling of technical change in global energy-environment models when applied to various levels of atmospheric stabilisation.

Members of the Steering Committee provided review comments on earlier drafts and the paper has been forwarded to external review, the final results will be published as a Special Issue of the Energy Journal. The papers have all been encouraged to draw on a common baseline (the "Common Poles-Image baseline") and to report results in comparable formats, so as to facilitate intercomparison of the different modeling results. All the results and judgements expressed here remain the responsibility of the authors.

The work presented here was funded by the Volkswagen Foundation, Project II/78470, which the authors gratefully acknowledge. FEEM fund the working papers series, and seed money for the coordination work of the Innovation Modeling Comparison Project was provided by UK Department of Environment, Food and Rural Affairs and the German Ministry of Environment.

The authors are also grateful to Elmar Kriegler for productive discussions and helpful comments on an earlier version of this paper.
Mitigation Strategies and Costs of Climate Protection: The Effects of ETC in the Hybrid Model MIND

Summary

MIND is a hybrid model incorporating several energy related sectors in an endogenous growth model of the world economy. This model structure allows a better understanding of the linkages between the energy sectors and the macro-economic environment. We perform a sensitivity analysis and parameter studies to improve the understanding of the economic mechanisms underlying opportunity costs and the optimal mix of mitigation options. Parameters representing technological change that permeates the entire economy have a strong impact on both the opportunity costs of climate protection and on the optimal mitigation strategies, e.g. parameters in the macro-economic environment and in the extraction sector. Sector-specific energy technology parameters change the portfolio of mitigation options but have only modest effects on opportunity costs, e.g. learning rate of the renewable energy technologies. We conclude that feedback loops between the macro-economy and the energy sectors are crucial for the determination of opportunity costs and mitigation strategies.

Keywords: Endogenous technological change, Climate change mitigation costs, Integrated assessment, Growth model, Energy sector, Integrated assessment

JEL Classification: O41, Q40, Q43, Q55, C61, D99

We are grateful to Elmar Kriegler for productive discussions and helpful comments on earlier version of this paper. This work was funded by the Volkswagen Foundation, Project II/78470, which we gratefully acknowledge.

Address for correspondence:

Kai Lessmann
Potsdam Institute for Climate Impact Research (PIK)
P.O. Box 60 12 03
14412 Potsdam Germany
E-mail: lessman@pik-potsdam.de
1. Setting the Scene

The Innovation Modeling Comparison Project (IMCP) explores the consequences of endogenous technological change (ETC) for the economics of stabilizing atmospheric carbon dioxide (CO₂) concentration. This paper contributes to the IMCP by presenting an analysis of technological change at different levels and in different sectors in the Model of Investment and technological Development (MIND). MIND combines an intertemporal endogenous growth model of the macro-economy with sector-specific and technological details taken from the field of energy system modeling. In particular, we explore the impact of endogenous technological change on opportunity costs and mitigation strategies in the framework of a social cost-effectiveness analysis.

We explore the impact of ETC in a social cost-effectiveness framework because we want to understand how technological change is induced by climate policy. Several studies have already incorporated aspects of ETC in this framework (Buonanno et. al. 2003, Chakravorty et. al. 1997, Goulder and Mathai 2002, Kypreos and Barreto 2000, Nordhaus and Boyer 2000, Nordhaus 2002, Popp 2004a, 2004b). The added value of MIND arises mainly from two features: First, we incorporate a wide spectrum of relevant mitigation options at least at a highly aggregate level. MIND incorporates improvement of energy efficiency, carbon capture and sequestration (CCS), renewable energy technologies, and traditional non-fossil fuels (large hydropower and nuclear). Second, technological change in MIND has an endogenous formulation with R&D investments in labor and energy productivity, learning-by-doing, and vintage capital in the different energy sectors. We believe that including these features of ETC is essential for the assessment of macro-economic mitigation costs and the portfolio of mitigation options. MIND is a hybrid model merging features from bottom-up models and top-down models. It resembles a bottom-up model because it comprises several energy sectors. However, the technologies are represented at a more aggregated level than in energy system models. We have embedded these sectors within a macro-economic environment in order to evaluate the feedbacks between the macro-economy and the energy sector (for another example of such an exercise, see Manne et. al. 1995). We will show that these feedbacks are crucial for an understanding of opportunity costs and mitigation strategies in an economy faced with climate policy.

The next section briefly introduces the model and its calibration, highlighting the improved treatment of CCS in MIND 1.1. The main part of this paper is the discussion of technological change within MIND in section 3. Section 4 concludes.

2. The model structure of MIND 1.1

The model equations of MIND are introduced and discussed in Edenhofer, Bauer and Kriegler (2005). The model version 1.0 presented therein has been extended by Bauer (2005). In his work, Bauer replaces exogenous scenarios of Carbon Capture and Sequestration (CCS) with a technologically detailed, endogenous treatment of the CCS option (model version 1.1). This study uses MIND 1.1, slightly adjusted to meet the requirements of the IMCP and enhanced by a more sophisticated carbon cycle (Hoos et al. 2001). The following section
provides a summary of the model structure and parameter calibrations. Model
equations are restricted to the parameters treated in the sensitivity analyzes and
parameter studies in this article; for a comprehensive discussion of the model
structure we refer to Edenhofer et al. (2005) and Bauer (2005).

MIND is an integrated assessment model comprising a model of the world
economy with particular attention paid to the energy sector, and a climate
module computing global mean temperature changes. MIND therefore allows us
to assess the impacts of constraints to climatic change on the economy in cost-
effectiveness analyzes.

MIND models economic dynamics by adopting an endogenous growth
framework. It calculates time paths of investment and consumption decisions
that are intertemporally optimal. The objective is to maximize social welfare,
which is defined as the present value of utility (pure rate of time preferences is 1
%), which is a function of per capita consumption exhibiting diminishing
marginal utility. Most economic activity is subsumed in an aggregate CES
production function (equation 1), the output $Y_A$ of which describes the gross
world product (GWP).\(^1\)

\[
Y_A = \Phi_A \left[ \xi_A \left( A^L L_A \right)^{-\rho_A} + \xi_E \left( B^E E \right)^{-\rho_E} + \xi_K K_A^{-\rho_K} \right]^{1/\rho_A}
\]  

(1)

The income share related parameters $\xi_A$ are calibrated so that the actual
income shares of labor $L_A$, energy $E$, and capital $K_A$ relate to each other as
66:4:30. Total factor productivity $\Phi_A$ is a fixed scalar calibrated to such a value
that historical output of 2000 is reproduced. The elasticity parameter $\rho_A$
determines the elasticity of substitution $\sigma_A = (1+\rho_A)^{-1}$. In some integrated
assessment models, the elasticity of substitution between capital and energy is
0.4 for developed countries and 0.3 for developing countries (Manne et al.
1995). We have chosen an overall elasticity of substitution for all three factors
of $\sigma_A = 0.4$. Labor $L_A$ is described by an exogenous population scenario adopted
from the common POLES/IMAGE baseline (CPI, Vuuren et al. 2003), and the
capital stock $K_A$ is built up through investments and depreciates at a rate of 5 %.
The initial value of $K_A$ is derived from $Y_A$ and an estimated capital coefficient.
Capital coefficients computed from the OECD database and from PWT6.1 for
different countries cluster around 2.5. Since energy sector capital is separate
from $K_A$, we assume a lower capital coefficient of 2.0. Variables $A$ and $B$
denote the productivities of labor and energy, respectively, and are stock variables
determined by R&D investments according to equation (2):

\[
\frac{\dot{A}}{A} = \alpha_A \left( \frac{RD_A}{Y} \right)^{\gamma_A}, \quad \text{with } A(t = \tau_i) = A_0
\]  

(2)

\[
\frac{\dot{B}}{B} = \alpha_B \left( \frac{RD_B}{Y} \right)^{\gamma_B}, \quad \text{with } B(t = \tau_i) = B_0
\]  

(3)

$RD_A$ and $RD_B$ are investment flows controlled by the central planner. The
role of parameters $\gamma_A$ and $\gamma_B$ is to decrease marginal productivity of R&D
investments, which happens for values lower than unity. They are set to 0.05 and
0.1, respectively. Parameters $\alpha_A$ and $\alpha_B$ determine the productivity of R&D

\(^{1}\) MIND is implemented in discrete time steps of 5 years. In the model equations of this text we
present the more intuitive continuous formulations, e.g. in case of derivatives.
investment. They are calibrated at such a rate that spending 1% of the GWP on energy R&D increases the energy efficiency parameter by 2.25%; when 2.5% of GWP is spent on labor R&D, the labor efficiency parameter increases by 2%.

The energy input to aggregate production, $E$, is an additive composite of fossil energy, renewable energy, and traditional non-fossil energy, the latter given exogenously. Fossil energy is produced from energy conversion capital and primary energy input in a CES production function. Fossil resources are converted to primary energy using an exogenous assumption about the carbon/energy ratio of the fossil fuel mix, its availability being described by a model of resource extraction. Resource $R$ is extracted by capital $K_{res}$, the average productivity of which is subject to a scarcity effect ($\kappa_{res,s}$) and a learning-by-doing effect ($\kappa_{res,l}$):

$$R = \kappa_{res} K_{res}$$  \hspace{1cm} (4)

$$\kappa_{res} = \kappa_{res,s} \kappa_{res,l}$$  \hspace{1cm} (5)

The initial resource extraction is $R = 6.4$ GtC (SRES), assumed to be produced by a capital stock of $K_{res} = 5$ trillion $\text{SUS}$. This determines $\kappa_{res,l}$ because $\kappa_{res,s}$ is normalized to unity.

The scarcity effect $\kappa_{res,s}$ is determined by the marginal costs of resource extraction $C_{res}^{\text{mar}}$:

$$\kappa_{res,s} = \frac{\chi_1}{C_{res}^{\text{mar}}}$$  \hspace{1cm} (6)

In equation 6, parameter $\chi_1$ as well as the marginal costs in 2000 are set to $\text{\$113}$. During the simulation, marginal costs $C_{res}^{\text{mar}}$ increase with cumulative resource extraction $CR_{res}$ according to equations 7 and 8.

$$C_{res}^{\text{mar}} = \chi_1 + \chi_2 \left( \frac{CR_{res}}{\chi_3} \right)^{\chi_4}$$  \hspace{1cm} (7)

$$CR_{res}(t) = \int_{\tau_1}^{t} R(t') dt', \quad \text{with } CR_{res}(t = \tau_1) = 0$$  \hspace{1cm} (8)

Parameter $\chi_1$ denotes initial costs of the fossil resource, the exponent $\chi_4$ controls the curvature of the function, i.e. the timing of increasing costs, $\chi_2$ gives the marginal costs once the amount described by $\chi_3$ has been extracted. We parameterize this function in accordance with Rogner’s (1997) empirical assessment of world hydrocarbon resources arriving at the values $\chi_2 = 700$, $\chi_3 = 3500$ and $\chi_4 = 2$.

The learning-by-doing effect of capital productivity $\kappa_{res,l}$ depends on the ratio of actual resource extraction $E_{res,l}$ to initial resource extraction $E_{res,l}^0$. 

---

3
The factor $\beta_{\text{res},l} = 0.4$ dampens the learning-by-doing effect: a rapid increase in extraction induces a loss in productivity gains relative to the same increase in extraction spread over a longer time period. Furthermore, productivity gains from learning saturate when productivity approaches its maximum value $\kappa_{\text{res},l}^{\max}$ which is set to twice its initial value. Parameter $\tau_{\text{res},l}$ determines the speed of learning and is set to 100 years.

Renewable energy $E_{\text{ren}}$ is produced by capital $K_{\text{apren}}$ which is employed at $FLH_{\text{ren}} = 2190$ full load hours per year.

$$E_{\text{ren}}(t) = FLH_{\text{ren}} \ast Kap_{\text{ren}}(t)$$

(10)

$$Kap_{\text{ren}}(t) = \int_t^{\tau_{\text{apren}}} \omega(t-t')\kappa_{\text{ren}}(t')I_{\text{ren}}(t')dt'$$

(11)

The available renewable energy capital stock in each point in time is determined by summing over the investments into renewable energy $I_{\text{ren}}$ in preceding time steps multiplied with the productivity of installed capital $\kappa_{\text{ren}}$. Depreciation is modeled by weights $\omega$ which determine the fraction of capital that still remains, $\omega_1$ to $\omega_7$ are set to 1.0, 0.9, 0.8, 0.7, 0.5, 0.15, 0.05, and $\omega_i = 0$ if $i > 7$. This allows to model different capital productivities for different vintages of the capital stock. Capital productivity $\kappa_{\text{ren}}$ indeed changes in time because the costs of renewable energy equipment $c_{\text{ren}}$ decrease, subject to learning-by-doing.

$$\kappa_{\text{ren}} = \frac{1}{c_{\text{ren}}(t') + c_{\text{floor}}}$$

(12)

The inverse of floor costs $c_{\text{floor}} = 500$ US$/kW constrains capital productivity from above, while $c_{\text{ren}}$ starts out at $c_{\text{ren},0} = 700$ US$/kW and decreases with cumulative installed capital $CKap_{\text{ren}}$:

$$CKap_{\text{ren}} = \int_{\tau_0}^t Kap_{\text{ren}}(t')dt'$$

(13)

The following equation describes the dynamics of learning-by-doing in the renewable sector:
\[
C_{\text{ren},t} - C_{\text{ren},t-1} = C_{\text{ren},0} C_{\text{Kap}}^{\beta_{\text{ren}}} (C_{\text{Kap}} - C_{\text{Kap},t-1}) \times \left( \frac{C_{\text{Kap},t-1}}{C_{\text{Kap},t}} \right)^{\beta_{\text{res,l}}}
\]

with \( C_{\text{ren}} (t = t_1) = C_{\text{ren}}^0 \).

The learning parameter \( \mu_{\text{ren}} \) determines the learning rate \( lr \) and reflects a learning rate of 15\%, i.e. investment costs decrease by 15\% with every doubling of cumulative installed capacity. Parameter \( \beta_{\text{ren}} \) within the last factor of the right hand side of the equation causes a dampening similar to \( \beta_{\text{res,l}} \) in the learning-by-doing equation of the fossil resource extraction (equation 9). Set to \( \beta_{\text{ren}} = 0.4 \), it prevents learning that is too fast.

There are three sources of carbon dioxide emissions: fossil fuel combustion, leakage from sequestered CO\(_2\), and emissions from land-use and land-use change. The latter are described by an exogenous time series. Since fossil resources are measured in tons of carbon, resource use \( R \) and emissions \( Em \) coincide, except for land-use emissions and Carbon Capturing and Sequestration (CCS):

\[
\dot{E}_m(t) = R(t) + \text{LULUC}(t) - R_{\text{cap}}(t) + \text{LEAK}(t) ,
\]

where \( R_{\text{cap}} \) denotes the amount of CO\(_2\) captured in a given year; \( \text{LEAK} \) denotes leakage.

CCS is modeled as a chain process distinguishing six steps: CO\(_2\) is captured at point sources (1) and transported via pipelines to sequestration sites (2). There, the CO\(_2\) needs to be compressed (3) before it is injected into the sequestration site (4). Then, it either remains in the site (5) or leaks into the atmosphere (6). Processes 1-4 are capital intensive and are modeled as capital stocks representing available capacities for the individual processes. Capacities are built up by investments according to the following equation:

\[
K_{pq}(t) = \int_0^t \omega_q (t - t') r_{pq}^q (t') I_{pq}(t') dt',
\]

Variables \( K_{pq} \) denote the capacities, index \( p \) denotes the process step, and the index \( q \) denotes different investment alternatives such as one of five distinct capture technologies or one of six distinct sequestration alternatives. Weighting parameters \( \omega \) introduce a depreciation scheme for different vintages of the capital stocks, similar to equation 11 in case of renewable energy. Investments are denoted \( I_{pq} \) and the investment costs are \( c_{pq} \). Investment costs for capturing capacity range from \(-100\) SUS/tC to \(-450\) SUS/tC depending on the specific capture technology. When the productivity of CCS investments is varied in parameter studies later on in this paper, the same relative change is applied to the investment costs of each technology.

In addition to the limitation inflicted by the necessity to build up capacity, the amount of carbon that may be captured is limited by a static and a dynamic constraint. The static constraint limits the amount of carbon which can be captured from a large power plant as a fraction of the resource use in the business-as-usual scenario. The dynamic constraint defines an upper limit of investments into the specific capture technologies in each period. The upper limit is defined as a share of the investments in the power generation sector. The
rationale is that the capability of retrofit investments in large power plants depends on the total amount of investments undertaken in the power generation sector.

The injection of CO\textsubscript{2} into particular sequestration sites demands two different kinds of facilities: compressors and injection wells (steps 3 and 4). The modeling approach takes into account that both facilities demand investments and secondary energy. In steps 5 and 6, the modeling approach considers the capacity constraint of each sequestration alternative \( j \) and leakage of sequestered carbon: Leakage is described by a rate, and the capacity of each sequestration alternative is the upper bound for the cumulative amount of CO\textsubscript{2} that is injected into each sequestration alternative.

3. The Role of Endogenous Technological Change in MIND

In which ways does endogenous technological change matter in policy scenarios computed with MIND? In the following sections, we provide an answer to this question with the help of a sensitivity analysis and miscellaneous parameter studies (for a first parameter study with MIND see Bauer et. al 2005). In the sensitivity analysis, we rank important technology-related model parameters according to their influence on two model outputs: the opportunity costs of climate protection and the mix of options used for CO\textsubscript{2} mitigation. We then study the effect of parameter variations on the same model outputs and analyze the underlying economic dynamics. All model runs constrain the atmospheric CO\textsubscript{2} concentration level to 450 ppm.

3.1 Local Sensitivity Analysis

Figure 1a and 1b show the influence of important parameters of MIND on opportunity costs of climate policy (1a) and on the mix of mitigation options (1b). The former are measured as losses of gross world product (GWP), accumulated from 2000 to 2100 and discounted to present value at a rate of 5 %, relative to the business-as-usual scenario. The latter is represented by the ratio of the two dominant options, renewable energies and CCS, where a ratio of unity implies that the same amount of CO\textsubscript{2} reductions may be attributed to each of the mitigation options. Parameter influence is measured by the response of the model to a 5 % variation of the parameter. Starting point is the set of parameters from model calibration. We vary one parameter at a time, hence the effects reflect local sensitivity. Local sensitivity analysis only assesses parameter sensitivity at one point in parameter space. It neglects the fact that sensitivities may be tremendously different at other points in parameter space. A measure of global sensitivity, i.e. a measure that takes into account simultaneous variation of several parameters, would remedy this shortcoming and is hence preferable. In this paper we stick with the analysis of local sensitivity for two reasons: First, the model response to a change in a single parameter under \textit{ceteris paribus} condition is an intuitive measure. Second, the computational burden for a local analysis is much lower. We stress that while our analysis assesses model sensitivities as a property of the model and hence sheds light on the influence of parameters and the potential influence of their uncertainties on model results, we do not take into account parameter uncertainties. Therefore, we make no statements about the relative importance of parameters for the uncertainty of the computed results but about the potential influence on the results.
As figure 1a indicates, the greatest influence on opportunity costs is exerted by the elasticity of substitution $\sigma_A$, followed by the parameters describing the availability of fossil resources, and the effectiveness of R&D investments in labor productivity. The latter and the top three parameters have a positive effect on costs, i.e. costs increase with the parameters, whereas assuming higher future costs of fossil resources decreases costs. The following ranks are occupied by the productivity of energy efficiency R&D and the learning rate of the renewable energy technologies, followed by two more sector specific parameters, the learning parameter in fossil resource extraction and the efficiency of investments in CCS. Overall, the relatively small responses of the model to parameter variations (less than 5 %) increase the confidence in the
robustness of the computed opportunity costs. In the next two sections we will explore the reasons for this observation and explore the role of technological change in it.

Figure 1b shows in which way the same parameters influence the mix of mitigation options. A comparison between figure 1a and figure 1b indicates that the ranking has changed. Most notably, the elasticity of substitution has dropped to the last rank, but also two resource related parameters, $\chi_2$ and $\chi_3$, have dropped a few slots. Conversely, the parameterization of labor R&D, the learning rate of renewable technologies, and the efficiency of CCS investments have risen in the hierarchy. Overall, the mitigation mix is more sensitive (with variations up to 10\%) than the mitigation costs in figure 1a. This does not come as a surprise: GWP losses are closely related to social welfare, the maximization of which is the objective of MIND. Therefore, GWP loss is deliberately kept at a minimum. The mix of mitigation options, on the other hand, is determined to be cost-effective. Naturally, when parameter changes alter the competitiveness of mitigation options, the influence on the mitigation mix is significant.

### 3.2 Determinants of the Opportunity Costs

This section takes a closer look at the opportunity costs of climate protection. In the following we present parameter studies varying two parameters simultaneously. This enables us to discuss the effects of varying these parameters, as well as analyzing the interdependencies between them, hence taking a first step beyond a sensitivity analysis that is only local. Naturally, many parameters remain fixed at their default levels, so this analysis is still very much local in character. But by restricting us to the variation of two parameters at a time, we maintain the possibility of an intuitive graphical presentation of the results providing deeper insights into the workings of MIND.
We start out by taking a look at the engine of endogenous growth in MIND: R&D investments that drive labor and energy efficiencies. Figure 2a displays the productivity of these investments. While the two parameters are similar with respect to the process they describe – accumulation of a knowledge stock increasing the productivity of an input factor to aggregate production – their effects on opportunity costs are contrary. An enhanced effectiveness of labor productivity R&D raises costs, while better energy efficiency R&D reduces GWP losses. This is due to opposite effects on the mitigation gap, i.e. the discrepancy of CO₂ emissions between business-as-usual and climate policy scenarios: More effective labor R&D stimulates additional economic growth and implies higher CO₂ emissions in the baseline. More effective energy R&D investments on the other hand facilitate much better energy efficiency in the baseline, and hence lower CO₂ emissions. The mitigation gap characterizes the challenge for the economy posed by climate protection goals and manifests itself in the opportunity costs.

Figure 2b compiles two parameters with an effect of the second type: the elasticity of substitution in the aggregate production sector, and the estimated size of the available fossil resources. Figure 2b shows that costs increase with the elasticity of substitution. This, too, we attribute to baseline effects: Higher elasticity of substitution implies a more flexible production technology which induces higher economic growth in business-as-usual. Therefore, achieving 450 ppm requires a substantial departure from the baseline and is relatively costly. A variation of the resource base has a bigger impact on the mitigation costs if the elasticity of substitution is relatively high. Low values of the elasticity of substitution lessen economic growth and consequently imply a lower demand for energy. At low energy demand, relaxing the scarcity of the resource has less of an effect. In general, a larger resource base allows higher economic growth in business-as-usual. When climate policy constrains resource use, it devalues exhaustible resource as an economic asset and diminishes the rent income of their owners. The loss of rent income increases with the resource base because a relatively cheap and abundant resource can no longer be used as input in production.
We take yet a closer look at the fossil resource base. Figure 2c studies the variation of the size of the resource base $\chi_3$ and parameter $\chi_4$. Parameter $\chi_4$ as well as the resource base are proxy variables for the technological progress in the extraction sector. Increasing $\chi_3$, i.e. assuming more abundant resources, results in cheaper short to medium term supply of the fossil resource. Increasing $\chi_4$ trades a slow and steady increase of the marginal costs for a steeper increase at a later time – thus making the resource cheaper and more easily available in the short to medium term. High values of $\chi_4$ allow higher economic growth in the business-as-usual case and induce a relatively large mitigation gap. For high values of $\chi_4$ the marginal costs of extraction are essentially constant. Under this condition an increased resource base has a moderate impact on macro-economic mitigation costs. For low values of $\chi_4$, an increased resource base has a slightly higher impact on the macro-economic costs because marginal improvements in extraction already increase the shadow price of the resource. This parameter study shows that climate protection becomes relatively costly if there is a high rate of technological progress in the exploration and extraction of fossil fuels. Accelerated technological progress in the extraction sector makes climate policy more costly, because such policy devalues assets (resources and capital stock in the corresponding sectors). Therefore, special attention ought to be paid to assumptions about resource availability and their uncertainties.

Contrary effects can be observed if technological progress decreases the costs of mitigation technologies. The impact on opportunity costs is shown in figure 2d. We explore two parameters which are both closely related to mitigation options: the efficiency of investments into Carbon Capture and Sequestration technologies (CCS) and the learning rate of renewable energy technologies. Varying these two parameters shifts the competitive advantage between the two mitigation options and, consequently, the extent to which they are used. It turns out that the efficiency of CCS investments has no strong impact on the overall opportunity costs if the learning rate of renewable energy technologies is relatively high. The reason is that renewables are modeled as a backstop technology, i.e. as a carbon-free energy source, and need no non-reproducible input for energy production. In contrast to the renewables, CCS investments only bridge from the fossil fuel age to a carbon-free era. CCS makes the transition of the energy system smoother but has severe limitations if fossil fuels become more costly because of increasing marginal extraction costs at the end of the 21st century. At the same time, renewable energy becomes cheaper because of learning-by-doing. It is plausible that this effect cannot be altered by high efficiencies of CCS investments. At low learning rates of the backstop technology CCS becomes more important.

### 3.3 Mitigation strategies

In this section we analyze the impact of the same parameters explored in the previous section on the option portfolio of an optimal mitigation strategy. Mitigation options are compared on the basis of the amount of CO$_2$ that they enable the economy to reduce. For the CCS option, this is straightforward: it is simply the amount of captured and sequestered CO$_2$ (less the amount that leaks from the sequestration site). In case of energy related mitigation options, i.e. renewable energy and energy efficiency improvements, the corresponding amount of "mitigated CO$_2$ emissions" was derived from the equivalent amount of energy from fossil fuels. In MIND, the degree of efficiency on converting primary- into final energy is determined endogenously in the production
function of the fossil sector. In this ex post analysis, however, we estimate the "equivalent" amount of fossil energy by assuming a fix coefficient. The remaining mitigation options, namely energy savings by substitution of energy at the levels of energy transformation and aggregate production, are visualized as the difference to the total reduction of CO₂.

Figure 3: Figures 3a-f show how the mix of mitigation options varies in parameter studies. CO₂ reductions caused by avoiding the use of fossil fuels (renewable energy, energy efficiency improvements, and substitution) are estimated from the alternative use of fossil fuels. Dashed lines indicate the default parameter value.

Figure 3a shows that the amount of CCS within the portfolio of mitigation options increases with the assumed resource base. The cumulative amount of CO₂ reduced by renewables within the next century decreases, energy efficiency remains constant and energy savings increase. An increasing resource base
implies increasing rents for the owners. This increasing rent income makes CCS a more profitable option. Due to high economic growth and relatively cheap fossil fuels, the return on investment in renewables falls short of the returns on CCS investments.

In figure 3b, energy savings (reduction of energy consumption by substituting energy by capital in different sectors) become more profitable if the elasticity of substitution increases; at the same time, the importance of energy efficiency decreases.

A more surprising result is obtained in figure 3c and 3d. In figure 3c an increasing productivity of R&D investment in labor enhancing activities also increases the share of renewables in the mitigation portfolio. The explanation is as follows: Economic growth induces additional energy demand that is met by carbon-free technologies. Due to high economic growth, marginal extraction costs of fossil fuels increase sooner, and thus CCS is less competitive compared to renewables. In contrast, when R&D investments in energy efficiency become more productive, the mitigation gap shrinks, and the share of renewables within the mitigation portfolio decreases (3d). Interestingly, changes in the productivity of energy R&D investments affect the baseline rather than providing a more attractive mitigation option: In this study, the energy efficiency parameter varies from 63 to 245 % of its regular value in 2100 in the baseline, the latter implying that energy use in 2100 is decreased by 60%. In contrast, climate policy only induces 0.4 to 2.7 % additional increases of the efficiency parameter. In conclusion, higher energy efficiency and a lower baseline for economic growth reduce the demand for renewables. The importance of the renewable energy option depends heavily on the underlying economic growth path.

As figure 3e shows, high learning rates in the renewable energy sector reduce the optimal amount of CCS substantially. In that sense CCS can be seen as a joker-option if the learning rate of the renewables is relatively low. It is also remarkable that energy savings are less important when the learning rate is relatively high because the energy demand can be met by the carbon-free renewables. Learning-by-doing reduces the price of electricity produced by renewables and increases the demand for renewables which reduces their costs further. This feedback loop makes CCS less important. As figure 3f indicates, this effect can be counteracted by an increasing efficiency of CCS-investments.

4. **Concluding Remarks**

In which ways does technological change matter? Our analysis shows that technological change works in two “directions”: We identify technological progress that permeates the entire economy and technological progress that is restricted in its effects to a single sector. Examples for such sector-specific technological change are learning-by-doing effects associated with renewable energy technologies and resource extraction, as well as technological progress in CCS, here modeled via its investment efficiency. In MIND, parameters associated with such sector-specific technological change have a significant impact on the optimal mix of mitigation options. For example, an increased learning rate increases the share of renewables, and improved investment efficiency in CCS increases the share of CCS within the entire portfolio of mitigation options.

---

2 We refer to the impact of a parameter in terms of a relatively large potential influence, i.e. a large sensitivity of results to changes of this parameter. Recall, however, that the actual uncertainty about parameters is not taken into account.
(figures 1b and 3ef). However, these parameters are less important in determining the overall opportunity costs of climate protection which measure the impact on the overall economy (figure 1a).

In contrast, there is technological change with significant impact on the macro-economic growth process, evident in its influence on opportunity costs. Such technological change is described by parameters of the macro-economic environment, like the elasticity of substitution, and the parameters characterizing the effectiveness of labor- and energy R&D investments. Labor R&D investments in particular have a strong influence on macro-economic growth as well as the mix of mitigation options. Progress in resource extraction is an example of sector-specific technological change with a macro-economic impact. This progress is characterized by the parameters of Rogner’s scarcity curve and has been shown to exert a significant influence on opportunity costs. The most prominent effect of these parameters is their impact on the baseline.

We conclude that feedbacks between the macro-economy and the energy system are crucial for determining mitigation costs and the development of the mitigation portfolio in time. The case of technological change in resource extraction shows how sector-specific processes may exert significant influence on the macro-economy, while the impact of labor R&D productivity on the share of renewable energy is an example of macro-economic influence on a distinct sector.

This has implication for policies. A sector-specific policy that fostered technological change in the extraction sector induced by increasing prices in the oil or gas market would increase the opportunity costs of climate protection. A policy that increased the economy-wide energy efficiency in all energy related sectors would reduce the costs of climate protection substantially. Enhancing technological change in the extraction sector made sense if decision makers only intended to increase energy security. However, they ought to take into account the impact of such a policy on the opportunity costs of climate protection.

The results presented here indicate that partial-equilibrium models omitting intertemporal and inter-sectoral aspects can be misleading for designing a climate- and energy policy. Thus, they stress the utility of hybrid models incorporating endogenous technological change at the sector level as well as at the macro-economic level. Moreover, hybrid models pose a coherent framework not only for the assessment of the opportunity costs and portfolios of mitigation strategies but also for the design of climate- and energy policy instruments.

REFERENCES
**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.repec.org

**NOTE DI LAVORO PUBLISHED IN 2004**

<table>
<thead>
<tr>
<th>Year</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETA 2.2004</td>
<td>Masahisa FUJITA and Shlomo WEBER: Strategic Immigration Policies and Welfare in Heterogeneous Countries</td>
<td></td>
</tr>
<tr>
<td>PRA 3.2004</td>
<td>Adolfo DI CARLUCCIO, Giovanni FERRI, Cecilia FRALE and Ottavio RICCHI: Do Privatizations Boost Household Shareholding? Evidence from Italy</td>
<td></td>
</tr>
<tr>
<td>ETA 4.2004</td>
<td>Victor GINSBURGH and Shlomo WEBER: Languages Disenfranchisement in the European Union</td>
<td></td>
</tr>
<tr>
<td>PRA 7.2004</td>
<td>Sandro BRUSCO, Giuseppe LOPOMO and S. VISWANATHAN (lxv): Merger Mechanisms</td>
<td></td>
</tr>
<tr>
<td>PRA 8.2004</td>
<td>Wolfgang AUSSENNEGG, Pegaret PICHLER and Alex STOMPER (lxv): IPO Pricing with Bookbuilding, and a When-Issued Market</td>
<td></td>
</tr>
<tr>
<td>PRA 9.2004</td>
<td>Pegaret PICHLER and Alex STOMPER (lxv): Primary Market Design: Direct Mechanisms and Markets</td>
<td></td>
</tr>
<tr>
<td>PRA 11.2004</td>
<td>Bjarne BRENDSTRUP and Harry J. PAARSCH (lxv): Nonparametric Identification and Estimation of Multi-Unit, Sequential, Oral, Ascending-Price Auctions With Asymmetric Bidders</td>
<td></td>
</tr>
<tr>
<td>PRA 12.2004</td>
<td>Ohad KADAN (lxv): Equilibrium in the Two Player, k-Double Auction with Affiliated Private Values</td>
<td></td>
</tr>
<tr>
<td>PRA 13.2004</td>
<td>Maarten C.W. JANSEN (lxv): Auctions as Coordination Devices</td>
<td></td>
</tr>
<tr>
<td>PRA 14.2004</td>
<td>Gadi FIBICH, Arieh GAVIOUS and Aner SELA (lxv): All-Pay Auctions with Weakly Risk-Averse Buyers</td>
<td></td>
</tr>
<tr>
<td>PRA 15.2004</td>
<td>Orly SADE, Charles SCHNITZLEIN and Jaime F. ZENDER (lxv): Competition and Cooperation in Divisible Good Auctions: An Experimental Examination</td>
<td></td>
</tr>
<tr>
<td>CCMP 16.2004</td>
<td>Marta STRYSZOWSKA (lxv): Late and Multiple Bidding in Competing Second Price Internet Auctions</td>
<td></td>
</tr>
<tr>
<td>PRA 17.2004</td>
<td>Slim Ben YOUSSEF (lxv): R&amp;D in Cleaner Technology and International Trade</td>
<td></td>
</tr>
<tr>
<td>NRM 18.2004</td>
<td>Angela ANTOCI, Simone BORGHESI and Paolo RUSSU (lxvi): Biodiversity and Economic Growth: Stabilization Versus Preservation of the Ecological Dynamics</td>
<td></td>
</tr>
<tr>
<td>NRN 19.2004</td>
<td>Anna ALBERINI, Paolo ROSSO, 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</td>
<td></td>
</tr>
<tr>
<td>NRM 21.2004</td>
<td>Jacqueline M. HAMILTON (lxvii): Climate and the Destination Choice of German Tourists</td>
<td></td>
</tr>
<tr>
<td>NRM 23.2004</td>
<td>Pius ODUNGA and Henk FOLMER (lxvii): Profiling Tourists for Balanced Utilization of Tourism-Based Resources in Kenya</td>
<td></td>
</tr>
<tr>
<td>NRM 24.2004</td>
<td>Jean-Jacques NOWAK, Monther SAHLI and Pasquale M. SGRO (lxvii): Tourism, Trade and Domestic Welfare</td>
<td></td>
</tr>
<tr>
<td>NRM 26.2004</td>
<td>Juan Luis EUGENIO-MARTÍN, Noelia MARTÍN MORALES and Riccardo SCARPA (lxvii): Tourism and Economic Growth in Latin American Countries: A Panel Data Approach</td>
<td></td>
</tr>
<tr>
<td>NRM 27.2004</td>
<td>Raúl Hernández MARTÍN (lxvii): Impact of Tourism Consumption on GDP. The Role of Imports</td>
<td></td>
</tr>
<tr>
<td>NRM 29.2004</td>
<td>Marian WEBER (lxvii): Assessing the Effectiveness of Tradable Landuse Rights for Biodiversity Conservation: an Application to Canada’s Boreal Mixedwood Forest</td>
<td></td>
</tr>
<tr>
<td>NRM 30.2004</td>
<td>Trond BJORNDAL, Phoebe KOUNDOURI and Sean PASCOE (lxvii): Output Substitution in Multi-Species Trawl Fisheries: Implications for Quota Setting</td>
<td></td>
</tr>
</tbody>
</table>
An Application to the Recreational Value of Forests
Andrea BIGANO and Stef PROOST:
(lxvi): Biodiversity Conservation on Private Lands: Information Problems and
Signe ANTHON and Bo JELLEMARK THORSEN
Francesco RICCI
Ingo BRÄUER and Rainer MARGGRAF
Dinko DIMITROV, Peter BORM, Ruud HENDRICKX and Shao CHIN SUNG:
Participation in and Compliance with Public Voluntary
Anastasios XEPAPADEAS and Constadina PASSA
Valentina BOSETTI, Mariaester CASSINELLI and Alessandro LANZA
in WTI Oil Forward and Futures Returns
Correlations in the Returns on Oil Companies Stock Prices and Their Determinants
Heterogeneous Agents
Implications
Possibilities of the Contingent Valuation Method
E.C.M. RUIJGROK
Netherlands
Resources on Smallholder Farms in Hungary: Institutional Analysis
Technology-based Climate Protocol
Analysis of Extractive Reserves in the Brazilian Amazon
Analysis to Evaluate Environmentally Conscious Tourism Management
Effects on Energy Scenarios
Regulatory Choices
E.(lxvi): Reducing Acidification: The Benefits of Increased Nature Quality. Investigating the
Wildlife Conservation and Management in Kenya: Towards a Co-management Approach
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
Gernot KLEPPER and Sonja PETERSON: The EU Emissions Trading Scheme: Allowance Prices, Trade Flows, Competitiveness Effects
GG
Scott BARRETT and Michael HOEL: Optimal Disease Eradication
CTN
Danko DIMITROV, Peter BORM, Ruud HENDRICKX and Shao CHIN SUNG: Simple Priorities and Core
Stability in Hedonic Games
SIEV
Francesco RICCI: Channels of Transmission of Environmental Policy to Economic Growth: A Survey of the Theory
Anna ALBERINI, Maureen CROPPER, Alan KRUPNICK and Nathalie B. SIMON: Willingness to Pay for Mortality Risk Reductions: Does Latency Matter?
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
Timo GOESCHL and Tun LIN (lxvi): Biodiversity Conservation on Private Lands: Information Problems and Regulatory Choices
Tom DEDEURWAERDERE (lxvi): Bioprospection: From the Economics of Contracts to Reflexive Governance
Karin REHDANZ and David MADDISON: The Amenity Value of Climate to German Households
CCMP
Koen SMEKENS and Bob VAN DER ZWAAN: Environmental Externalities of Geological Carbon Sequestration Effects on Energy Scenarios
Valentina BOSETTI, Mariaester CASSINELLI and Alessandro LANZA (lxvii): Using Data Envelopment Analysis to Evaluate Environmentally Conscious Tourism Management
Timo GOESCHL and Danilo CAMARGO IGLIORI (lxvi): Property Rights Conservation and Development: An Analysis of Extractive Reserves in the Brazilian Amazon
Barbara BUCHNER and Carlo CARRARO: Economic and Environmental Effectiveness of a Technology-based Climate Protocol
Eliasios PAPYRAKIS and Reyer GERLAGH: Resource-Abundance and Economic Growth in the U.S.
Györgyi BELA, György PATAKI, Melinda SMALE and Mariann HAJDÚ (lxvi): Conserving Crop Genetic Resources on Smallholder Farms in Hungary: Institutional Analysis
E.C.M. RUIJGROK and E.E.M. NILLESEN (lxvi): The Socio-Economic Value of Natural Riverbanks in the Netherlands
ETA
Gianimit YARDSAS and Anastasios XEPAPADEAS: Uncertainty Aversion, Robust Control and Asset Holdings
GG
Anastasios XEPAPADEAS and Constadina PASSA: Participation in and Compliance with Public Voluntary Environmental Programs: An Evolutionary Approach
Michael FINUS: Modesty Pays: Sometimes!
NRM
Tord BJÖRNDAHL and Ana BRASÃO: The Northern Atlantic Bluefin Tuna Fisheries: Management and Policy Implications
Alejandro CAPARRÓS, Abdelhakim HAMMOUDI and Tarik TAZDAÏT: On Coalition Formation with Heterogeneous Agents
Massimo GIOVANNINI, Margherita GRASSO, Alessandro LANZA and Matteo MANERA: Conditional Correlations in the Returns on Oil Companies Stock Prices and Their Determinants
Alessandro LANZA, Matteo MANERA and Michael MCALEER: Modelling Dynamic Conditional Correlations in WTI Oil Forward and Futures Returns
Margherita GENIUS and Elisabetta STRAZZERA: The Copula Approach to Sample Selection Modelling: An Application to the Recreational Value of Forests
Rob DELLINK and Ekko van IERLAND: Pollution Abatement in the Netherlands: A Dynamic Applied General Equilibrium Assessment

Rosella LEVAGGI and Michele MORETTO: Investment in Hospital Care Technology under Different Purchasing Rules: A Real Option Approach

Salvador BARBERA and Matthew O. JACKSON (lxx): On the Weights of Nations: Assigning Voting Weights in a Heterogeneous Union

Alex ARENAS, Antonio CABRALES, Albert DÍAZ-GUILERA, Roger GUIERMÁ and Fernando VEGA-REDONDO (lxx): Optimal Information Transmission in Organizations: Search and Congestion

Francis BLOCH and Armando GOMES (lxx): Contracting with Externalities and Outside Options

Rabah AMIR, Efsynnii DIAMANTOU and Licun XUE (lxx): Merger Performance under Uncertain Efficiency Gains

Francis BLOCH and Matthew O. JACKSON (lxx): The Formation of Networks with Transfers among Players

Daniel DIEMEIJER, Hylia ERASLAN and Antonio MERLO (lxx): Bicamerality and Government Formation

Rod GARRATT, James E. PARCO, Cheng-ZHONG QIN and Amnon RAPOPORT (lxx): Potential Maximization and Coalition Government Formation

Kfir ELIAZ, Debraj RAY and Ronny RAZIN (lxx): Group Decision-Making in the Shadow of Disagreement

Sanjeev GOTAL, Marco van der LEIJ and José Luis MORAGA-GONZÁLEZ (lxx): Economics: An Emerging Small World?

Edward CARTWRIGHT (lxx): Learning to Play Approximate Nash Equilibria in Games with Many Players

Finn R. FÖRSUND and Michael HOEL: Properties of a Non-Competitive Electricity Market Dominated by Hydroelectric Power

Elissaios PAPYRAKIS and Reger GERLACH: Natural Resources, Investment and Long-Term Income

Marzio GALEOTTI and Claudia KEMPFERT: Interactions between Climate and Trade Policies: A Survey

A. MARKANDYA, S. PEDROSO and D. STREIMIKIENE: Energy Efficiency in Transition Economies: Is There Convergence Towards the EU Average?

Rolf GOLOMBEK and Michael HOEL: Climate Agreements and Technology Policy

Sergei IZMALKOV (lxx): Multi-Unit Open Ascending Price Efficient Auction

Gianmarco I.P. OTTAVIANO and Giovanni PERI: A. MARKANDYA, S. PEDROSO and D. STREIMIKIENE: Multi-Unit Open Ascending Price Efficient Auction

Sanjeev GOTAL, Marco van der LEIJ and José Luis MORAGA-GONZÁLEZ (lxx): Economics: An Emerging Small World?

Massimino DEL GAITTO: Agglomeration, Integration, and Territorial Authority Scale in a System of Trading Cities. Centralisation versus devolution

Pierre-André JOUVET, Philippe MICHEL and Gilles ROTILLON: Equilibrium with a Market of Permits

Bob van der ZWAAN and Reyer GERLACH: Climate Uncertainty and the Necessity to Transform Global Energy Supply

Francesco BÓSSELLO, Marco LAZZARIN, Roberto ROSON and Richard S.J. TOL: Economy-Wide Estimates of the Implications of Climate Change: Sea Level Rise

Gustavo BERGANTIÑOS and Juan J. VIDAL-PUGA: Defining Rules in Cost Spanning Tree Problems Through the Canonical Form

Siddhartha BANDYOPADHYAY and Mandar OAK: Party Formation and Coalitional Bargaining in a Model of Proportional Representation

Hans-Peter WEIKARD, Michael FINUS and Juan-Carlos ALTAMIRANO-CABRERA: The Impact of Surplus Sharing on the Stability of International Climate Agreements

Chiara M. TRAVISI and Peter NIJKAMP: Willingness to Pay for Agricultural Environmental Safety: Evidence from a Survey of Milan, Italy, Residents

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

Valentina BOSETTI and David TOMBERLIN: Real Options Analysis of Fishing Fleet Dynamics: A Test

Alessandra GORIA e Gretel GAMBARELLI: Economic Evaluation of Climate Change Impacts and Adaptability in Italy

Masstino FLORIO and Mara GRASSEN: The Missing Shock: The Macroeconomic Impact of British Privatisation

John BENNETT, Saul ESTRIN, James MAW and Giovanni URG: Privatisation Methods and Economic Growth in Transition Economies

Kira BÖRNER: The Political Economy of Privatization: Why Do Governments Want Reforms?

Pehr-Johan NORBACK and Lars PERSSON: Privatization and Restructuring in Concentrated Markets

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

Sanjeev GOTAL, Marco van der LEIJ and José Luis MORAGA-GONZÁLEZ (lxx): Economics: An Emerging Small World?

Massimino DEL GAITTO: Agglomeration, Integration, and Territorial Authority Scale in a System of Trading Cities. Centralisation versus devolution

Pierre-André JOUVET, Philippe MICHEL and Gilles ROTILLON: Equilibrium with a Market of Permits

Bob van der ZWAAN and Reyer GERLACH: Climate Uncertainty and the Necessity to Transform Global Energy Supply

Francesco BÓSSELLO, Marco LAZZARIN, Roberto ROSON and Richard S.J. TOL: Economy-Wide Estimates of the Implications of Climate Change: Sea Level Rise

Gustavo BERGANTIÑOS and Juan J. VIDAL-PUGA: Defining Rules in Cost Spanning Tree Problems Through the Canonical Form

Siddhartha BANDYOPADHYAY and Mandar OAK: Party Formation and Coalitional Bargaining in a Model of Proportional Representation

Hans-Peter WEIKARD, Michael FINUS and Juan-Carlos ALTAMIRANO-CABRERA: The Impact of Surplus Sharing on the Stability of International Climate Agreements

Chiara M. TRAVISI and Peter NIJKAMP: Willingness to Pay for Agricultural Environmental Safety: Evidence from a Survey of Milan, Italy, Residents

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

Valentina BOSETTI and David TOMBERLIN: Real Options Analysis of Fishing Fleet Dynamics: A Test

Alessandra GORIA e Gretel GAMBARELLI: Economic Evaluation of Climate Change Impacts and Adaptability in Italy

Masstino FLORIO and Mara GRASSEN: The Missing Shock: The Macroeconomic Impact of British Privatisation

John BENNETT, Saul ESTRIN, James MAW and Giovanni URG: Privatisation Methods and Economic Growth in Transition Economies

Kira BÖRNER: The Political Economy of Privatization: Why Do Governments Want Reforms?

Pehr-Johan NORBACK and Lars PERSSON: Privatization and Restructuring in Concentrated Markets

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

Sanjeev GOTAL, Marco van der LEIJ and José Luis MORAGA-GONZÁLEZ (lxx): Economics: An Emerging Small World?
Price Sealed-Bid Auctions: The Incidence of Commissions in Auction Markets
Maximization and the Multiple-Good Monopoly and Evidence from Timber Auctions
Roberto BURGUET

Externalities in Stabilization Policies?

Bookbuilding is Dominating Auctions

Real Option Analysis

ČHerbert DAWID, Christophe DEISSENBERG and Pavel ŠEV

Influence of World Energy Prices

Latent-Class Approach Based on Intensity of Participation

Riccardo SCARPA and Mara THIENE

: Comparing Individual-Specific Benefit Estimates

Christian EGENHOFER, Kyriakos GIALOGLOU, Giacomo LUCIANI, Maroessa BOOTS, Martin SCHEEPERS, Valeria COSTANTINI, Giovanni Di BARTOLOMEO and Wilfried PAUWELS

Pressure Groups in the Kyoto Protocol’s Adoption Process

Johan EYCKMANS

Policy Analysis? A Robustness Exercise with the FEEM-RICE Model

Carlo CARRARO and Marzio GALEOTTI

Does Endogenous Technical Change Make a Difference in Climate Policy Analysis? A Robustness Exercise with the FEEM-RICE Model

Alejandro M. MANELLI and Daniel R. VINCENT

: Marginal Abatement Cost Curves in General Equilibrium: The

Gernot KLEPPER and Sonja PETERSON

: Instant Efficient Pollution Abatement Under Non-Linear Taxation and Asymmetric Information: The Differential Tax Revisited

Patrick BAJARI, Stephanie HOUGHTON and Steven TADELIS

: The Value of Flexibility in the Italian Water Service Sector: A

Chiara D’ALPAOS and Michele MORETTO

: The World Bank’s Prototype Carbon Fund and China

ZhongXiang ZHANG

: The Question of Generation Adequacy in Liberalised Electricity Markets

Maria BERRITELLA, Andrea BIGANO, Roberto ROSON and Richard S.J. TOL

: Asset Accumulation, Fertility Choice and Nondegenerate Dynamics in a Small Open Economy

Nicola ACOCELLA, Giovanni Di BARTOLOMEO and Wilfried PAUWELS

: Transport Energy Security. The Unseen Risk?

Barbara BUCHNER and Silvia DALL’OLIO

: An Integrated Assessment Framework for Water Resources Management: A DSS Tool and a Pilot Study Application

Carlo GIUPPONI, Jaroslav MYSIAK and Anita FASSIO

: Behavioral Biases of Dealers in U.S. Treasury Auctions

Patrick BAJARI, Stephanie HOUGHTON and Steven TADELIS

: Time Profile of Climate Change Stabilization Policy

ZhongXiang ZHANG

: Optimal Procurement Auction for a Buyer with Downward Sloping Demand: More

Barbara BUCHNER and Silvia DALL’OLIO

: Equilibrium of Scoring Auctions

Patrick BAJARI, Stephanie HOUGHTON and Steven TADELIS

: Sequential vs. Single-Round Uniform-Price Auctions

Patrick BAJARI, Stephanie HOUGHTON and Steven TADELIS


Victor GINSBURGH, Patrick LEGROS and Nicolas SAHUGUET

: How to Win Twice at an Auction. On

Patrick BAJARI, Stephanie HOUGHTON and Steven TADELIS

: How to Win Twice at an Auction. On

Patrick BAJARI, Stephanie HOUGHTON and Steven TADELIS

: On Capturing Oil Rents with a National Excise Tax Revisited

François DEGEORGE, François DERRIEN and Kent L. WOMACK

: An Almost Ideal Sharing Scheme for Coalition Games with

Johan EYCKMANS

: Does Endogenous Technical Change Make a Difference in Climate

Gernot KLEPPER and Sonja PETERSON

: An Integrated Assessment Framework for Water

Carlo GIUPPONI, Jaroslav MYSIAK and Anita FASSIO

: The Emergence of Large Shareholders in Mass Privatized Firms: Evidence from Poland and the Czech Republic

Mauro FABIANO, Gabriella CAMARSA, Rosanna DURSI, Roberta IVALDI, Valentina MARIN and Francesca PALMISANI: Integrated Environmental Study for Beach Management: A Methodological Approach

Irena GROSFELD and Iraj HASHI

: The Question of Generation Adequacy in Liberalised Electricity Markets

Maria BERRITELLA, Andrea BIGANO, Roberto ROSON and Richard S.J. TOL

: Nonparametric Tests for Common Values in First-

Patrick BAJARI, Stephanie HOUGHTON and Steven TADELIS

: Bidding for Incompelete Contracts

Patrick BAJARI, Stephanie HOUGHTON and Steven TADELIS

: Comparing Open and Sealed Bid Auctions: Theory and Evidence from Timber Auctions

David GOLDREICH

: The World Bank’s Prototype Carbon Fund and China

ZhongXiang ZHANG

: Instant Efficient Pollution Abatement Under Non-Linear Taxation and Asymmetric Information: The Differential Tax Revisited

Patrick BAJARI, Stephanie HOUGHTON and Steven TADELIS

: The World Bank’s Prototype Carbon Fund and China

ZhongXiang ZHANG

: Asset Accumulation, Fertility Choice and Nondegenerate Dynamics in a Small Open Economy

Nicola ACOCELLA, Giovanni Di BARTOLOMEO and Wilfried PAUWELS

: The Emergence of Large Shareholders in Mass Privatized Firms: Evidence from Poland and the Czech Republic

Mauro FABIANO, Gabriella CAMARSA, Rosanna DURSI, Roberta IVALDI, Valentina MARIN and Francesca PALMISANI: Integrated Environmental Study for Beach Management: A Methodological Approach

Irena GROSFELD and Iraj HASHI
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 9.2005 Angelo ANTOCCI: 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
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 PIGLIA: 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
CTN 23.2005 Michael FINUS, Pierre v. MOUCHE and Bianca RUNDSHAGEN: Uniqueness of Coalitional Equilibria
CTN 25.2005 Somdeb LAHIRI: The Core of Directed Network Problems with Quotas
NRM 27.2005 Massimiliano MAZZANTI 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-VALINAS: 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 CALVÒ-ARMENGOL and Rahimi ILKILIÇ (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
Carlo CARRARO, Carmen MARCHIORI and Alessandra SGOBBI: Abnormal Returns in Privatization Public Offerings: The Case of Portuguese Firms

Anna ALBERINI, Valentina ZANATTA and Paolo ROSATO: Combining Actual and Contingent Behavior to Estimate the Value of Sports Fishing in the Lagoon of Venice

Michael FINUS and Bianca RUNDHAGEN: Participation in International Environmental Agreements: The Role of Timing and Regulation

Lorenzo PELLEGRINI and Reyer GERLAGH: Are EU Environmental Policies Too Demanding for New Members States?

Matteo MANERA: Modeling Factor Demands with SEM and VAR: An Empirical Comparison

Carlo CARRARO, Johan EYCKMANS and Michael FINUS: Optimal Transfers and Participation Decisions in R&D Networks

Maia DAVID and Bernard SINCLAIR-DESGAGNÉ: Environmental Regulation and the Eco-Industry

Alireza NAGHAVI: Multilateral Environmental Agreements and Trade Obligations: A Theoretical Analysis of the Doha Proposal

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

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

Gernot KLEPPER and Sonja PETERSON: Emissions Trading, CDM, JI, and More – The Climate Strategy of the EU

Maia DAVID and Bernard SINCLAIR-DESGAGNÉ: The Pigouvian Tax Rule in the Presence of an Eco-Industry

Helmut KARL, Antje MÖLLER, Ximena MATUS, Edgar GRANDE and Robert KAISER: Environmental Innovations: Institutional Impacts on Co-operations for Sustainable Development

Dimitra VOUVAKI and Anastasios XEPAPADEAS: Criteria for Assessing Sustainable Development: Theoretical Issues and Empirical Evidence for the Case of Greece

Andreas LÖSCHEL and Dirk T.G. RÜBBELKE: Network Capital and Social Trust: Pre-Conditions for ‘Good’ Diversity?

Irene VALSECCHI: A Role for Instructions

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

Christoph A. SCHALTEGGER and Benno TORGLER: Trust and Fiscal Performance: A Panel Analysis with Swiss Data

Anna ALBERINI, José SEMPERE-MONERRIS and Vincent J. VANNETELBOSCH (lxxii): A Characterization of Stochastically Stable Networks

Irene VALSECCHI: Applications of Negotiation Theory to Water Issues

Carlo CARRARO, Carmen MARCHIORI and Alessandra SGOBBI: Advances in Negotiation Theory: Bargaining, Coalitions and Fairness

Sandra WALLMAN: The Determinants of Social Capital in Greece Compared to Countries of the European Union

Eric M. USLANER (lxxv): Varieties of Trust

Thomas P. LYON (lxxiv): Citizenship Laws and International Migration in Historical Perspective

Grazzetta BERTOCCHI and Chiara STROZZI: Applications of Negotiation Theory to Water Issues

Anna BOGOMOLNAIA, Michel LE BRETON, Alexei SAVVATEEV and Shlomo WEBER (lxxii): Information Channels in Labor Markets, On the Resilience of Referral Hiring

Matthias O. JACKSON and Alison WATTS (lxxii): Social Games: Matching and the Play of Finitely Repeated Games

Anna BOGOMOLNAIA, Michel LE BRETON, Alexei SAVVATEEV and Shlomo WEBER (lxxii): The Egalitarian Sharing in Provision of Public Projects

Francesco FERI: Stochastic Stability in Network with Decay

Aart van der HEIDE, Jeroen C.J.M. van den BERGH, Ekko C. van IERLAND and Paulo A.L.D. NUNES: Multilateral Environmental Agreements and Trade Obligations: A Theoretical Analysis of the Doha Proposal

Alessandra CASELLA and Nobuyuki HANAKI (lxxii): From the Theory of the Firm to FDI and Internalisation: A Survey

Elsbeth van HYLCAMMA VLEJG (lxxv): A Characterization of Stochastically Stable Networks

Carlo CARRARO, Carmen MARCHIORI and Alessandra SGOBBI: Applications of Negotiation Theory to Water Issues

Carlo CARRARO, Carmen MARCHIORI and Alessandra SGOBBI: Advances in Negotiation Theory: Bargaining, Coalitions and Fairness

Sandra WALLMAN: On the Determinants of Social Capital in Greece Compared to Countries of the European Union

Alessandra CASELLA and Nobuyuki HANAKI (lxxii): From the Theory of the Firm to FDI and Internalisation: A Survey

Alessandra CASELLA and Nobuyuki HANAKI (lxxii): From the Theory of the Firm to FDI and Internalisation: A Survey

Carlo CARRARO, Carmen MARCHIORI and Alessandra SGOBBI: Applications of Negotiation Theory to Water Issues

Carlo CARRARO, Carmen MARCHIORI and Alessandra SGOBBI: Advances in Negotiation Theory: Bargaining, Coalitions and Fairness

Sandra WALLMAN (lxxiv): Network Capital and Social Trust: Pre-Conditions for ‘Good’ Diversity?

Asimina CHRISTOFOROU (lxxiv): On the Determinants of Social Capital in Greece Compared to Countries of the European Union

Réno SÀNSA and Ercole SORI (lxxv): Governance of Diversity Between Social Dynamics and Conflicts in Multicultural Cities. A Selected Survey on Historical Bibliography

Margherita GRASSO and Matteo MANERA: Asymmetric Error Correction Models for the Oil-Gasoline Price Relationship

Umberto CHERUBINI and Matteo MANERA: Hunting the Living Dead A “Peso Problem” in Corporate Liabilities Data

Hans-Peter WEIKARD: Cartel Stability under an Optimal Sharing Rule

Joëlle NOAILLY, Jeroen C.J.M. van den BERGH and Cees A. WITHAGEN (lxxvi): Local and Global Interactions in an Evolutionary Resource Game

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

Maximiliano MAZZANTI and Roberto ZOBOLI: Economic Instruments and Induced Innovation: The Case of End-of-Life Vehicles European Policies

Anna LASUT: Creative Thinking and Modelling for the Decision Support in Water Management

Valentina BOSETTI and Barbara BUCHNER: Using Data Envelopment Analysis to Assess the Relative Efficiency of Different Climate Policy Portfolios

IEM 89.2005

Valentina BOSETTI: Sustainability of Urban Sprawl: Environmental-Economic: The Determinants of Individuals’ Attitudes Towards the Italians Willing to Pay to Reduce Their Risks?

Giulio CAINELLI, Susanna MANCINELLI and Massimiliano MAZZANTI: Social Capital, R&D and Industrial Districts

IEM 95.2005

Rosella LEVAGGI, Michele MORETTO and Vincenzo REBBA: Quality and Investment Decisions in Hospital Care when Physicians are Devoted Workers

CCMP 88.2005

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

PRG 91.2005

Carlo CAPUANO: Abuse of Competitive Fringe

PRCG 92.2005


CCMP 93.2005

Sabrina AUCI and Leonardo BECCETTI: 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 TAVIDAI: Bargaining with Non-Monolithic Players

ETA 96.2005


CCMP 97.2005


CCMP 98.2005

Likelihood of an International Climate Agreement

Valeria COSTANTINI, Riccardo CRESCENZI, Fabrizio De FILIPPIS, and Luca SALVATICI: Bargaining in the Agricultural Negotiations of the Doha Round: Similarity of Interests or Strategic Choices?

An Empirical Assessment

IEM 100.2005

Giliola FREY and Matteo MANERA: Econometric Models of Asymmetric Price Transmission

IEM 101.2005

Alessandro COLOGNI and Matteo MANERA: Oil Prices, Inflation and Interest Rates in a Structural Cointegrated VAR Model for the G-7 Countries

KTHC 102.2005

Chiara M. TRAVISI and Roberto CAMAGNI: Sustainability of Urban Sprawl: Environmental-Economic Indicators for the Analysis of Mobility Impact in Italy

ETA 103.2005

Livingstone S. LUBOOBI and Joseph Y.T. MUGISHA: HIV/AIDS Pandemic in Africa: Trends and Challenges

SIEV 104.2005

Anna ALBERINI, Erik LICHTENBERG, Dominic MANCINI, and Gregmar I. GALINATO: What is Something I Ate? Implementation of the FDA Seafood HACCP Program

SIEV 105.2005

Anna ALBERINI and Aline CHIABAI: Urban Environmental Health and Sensitive Populations: How Much are the Italians Willing to Pay to Reduce Their Risks?

SIEV 106.2005


CTN 107.2005

Michele BERNASCONI and Matteo GALIZZI: Coordination in Networks Formation: Experimental Evidence on Learning and Salience

KTHC 108.2005

Michele MORETTO and Sergio VERGALLI: Migration Dynamics

NRM 109.2005

Antonio MUSOLESI and Mario NOSVELLI: Water Consumption and Long-Run Urban Development: The Case of Milan

SIEV 110.2005

Benmo TORGERLER and Maria A. GARCIA-VALIÑAS: The Determinants of Individuals’ Attitudes Towards Preventing Environmental Damage

SIEV 111.2005

Alberto LONGO and Anna ALBERINI: What are the Effects of Contamination Risks on Commercial and Industrial Properties? Evidence from Baltimore, Maryland

SIEV 112.2005

Anna ALBERINI and Alberto LONGO: The Value of Cultural Heritage Sites in Armenia: Evidence from a Travel Cost Method Study

CCMP 113.2005

Mikel GONZALEZ and Rob DELLINK: Impact of Climate Policy on the Basque Economy

NRM 114.2005

Gilles LAFFORGUE and Wald OUESLATI: Optimal Soil Management and Environmental Policy
Valuing Ecosystem Services with Fishery Rents: A Lumped-Parameter Approach to Hypoxia in the Neuse River Estuary

Protecting Marine Biodiversity: A Comparison of Individual Habitat Quotas (IHQs) and Marine Protected Areas

The Evolution of Enterprise Reform in Africa: From State-owned Enterprises to Private Participation in Infrastructure — and Back?

Italy’s Privatization Process and its Implications for China

Detecting Starting Point Bias in Dichotomous-Choice Contingent Valuation Surveys

A Solution to Matching with Preferences over Colleagues

Dissipation of Knowledge and the Boundaries of the Multinational Enterprise

Firm’s Intangible Assets and Multinational Activity: Joint-Venture Versus FDI

A MERGE Model with Endogenous Technological Change and the Cost of Carbon Stabilization

Analysis of Technological Portfolios for CO2 stabilizations and Effects of Technological Changes

Induced Technological Change in a Limited Foresight Optimization Model

The Value of ITC under Climate Stabilization

Privatization in Africa: What has happened? What is to be done?

Contest with Attack and Defence: Does Negative Campaigning Increase or Decrease Voters’ Turnout?

Political Cycles: The Opposition Advantage

Dynamic Controllability with Overlapping Targets: A Generalization of the Tinbergen-Nash Theory of Economic Policy

Induced Technological Change in a Limited Foresight Optimization Model

Risk Management of Daily Tourist Tax Revenues for the Maldives

Distributional Effects

Risk Management of Daily Tourist Tax Revenues for the Maldives

Growth, Conventional Production and Tourism Specialisation: Technological Catching-up Versus Terms-of-Trade Effects

International Tourism and Economic Growth: a Panel Data Approach

An Open Source Based Data Warehouse Architecture to Support Decision Making in the Tourism Sector

Tourism Immiserization: Fact or Fiction?

Social Carrying Capacity of Mass Tourist Destinations from the Point of View of the Economic Growth Theory

Migration, Unemployment and Net Benefits of Inbound Tourism in a Developing Country

Does Hazardous Waste Matter? Evidence from the Housing Market and the Superfund Program

Mitigation Strategies and Costs of Climate Protection: The effects of ETC in the Hybrid Model MIND

Protection: The effects of ETC in the Hybrid Model MIND

Valuation of ITC under Climate Stabilization

Economic-Climate Model

A Comparison of Individual

Economic-Climate Model

Detecting Starting Point Bias in Dichotomous-Choice Contingent Valuation Surveys

Political Cycles: The Opposition Advantage

Dynamic Controllability with Overlapping Targets: A Generalization of the Tinbergen-Nash Theory of Economic Policy

Induced Technological Change in a Limited Foresight Optimization Model

Risk Management of Daily Tourist Tax Revenues for the Maldives

Distributional Effects

Risk Management of Daily Tourist Tax Revenues for the Maldives

Growth, Conventional Production and Tourism Specialisation: Technological Catching-up Versus Terms-of-Trade Effects

International Tourism and Economic Growth: a Panel Data Approach

An Open Source Based Data Warehouse Architecture to Support Decision Making in the Tourism Sector

Tourism Immiserization: Fact or Fiction?

Social Carrying Capacity of Mass Tourist Destinations from the Point of View of the Economic Growth Theory

Mitigation Strategies and Costs of Climate Protection: The effects of ETC in the Hybrid Model MIND

Protection: The effects of ETC in the Hybrid Model MIND

Valuation of ITC under Climate Stabilization

Economic-Climate Model

A Comparison of Individual
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 23-25, 2003.

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.

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.

This paper was presented at the ENIGME Workshop on “Governance and Policies in Multicultural Cities”, Rome, June 5-6, 2003.

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

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.

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.

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

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.

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

This paper was presented at the ENGIIME Workshop on “Diversity as a source of growth” Rome November 18-19, 2004.

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.

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.

This paper was presented at the Second International Conference on "Tourism and Sustainable Economic Development - Macro and Micro Economic Issues” jointly organised by CRENoS (Università di Cagliari and Sassari, Italy) and Fondazione Eni Enrico Mattei, Italy, and supported by the World Bank, Chia, Italy, 16-17 September 2005.
## 2004 SERIES

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Editor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCMP</td>
<td>Climate Change Modelling and Policy</td>
<td>Marzio Galeotti</td>
</tr>
<tr>
<td>GG</td>
<td>Global Governance</td>
<td>Carlo Carraro</td>
</tr>
<tr>
<td>SIEV</td>
<td>Sustainability Indicators and Environmental Valuation</td>
<td>Anna Alberini</td>
</tr>
<tr>
<td>NRM</td>
<td>Natural Resources Management</td>
<td>Carlo Giupponi</td>
</tr>
<tr>
<td>KTHC</td>
<td>Knowledge, Technology, Human Capital</td>
<td>Gianmarco Ottaviano</td>
</tr>
<tr>
<td>IEM</td>
<td>International Energy Markets</td>
<td>Anil Markandya</td>
</tr>
<tr>
<td>CSRM</td>
<td>Corporate Social Responsibility and Sustainable Management</td>
<td>Sabina Ratti</td>
</tr>
<tr>
<td>PRA</td>
<td>Privatisation, Regulation, Antitrust</td>
<td>Bernardo Bortolotti</td>
</tr>
<tr>
<td>ETA</td>
<td>Economic Theory and Applications</td>
<td>Carlo Carraro</td>
</tr>
<tr>
<td>CTN</td>
<td>Coalition Theory Network</td>
<td></td>
</tr>
</tbody>
</table>

## 2005 SERIES

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Editor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCMP</td>
<td>Climate Change Modelling and Policy</td>
<td>Marzio Galeotti</td>
</tr>
<tr>
<td>SIEV</td>
<td>Sustainability Indicators and Environmental Valuation</td>
<td>Anna Alberini</td>
</tr>
<tr>
<td>NRM</td>
<td>Natural Resources Management</td>
<td>Carlo Giupponi</td>
</tr>
<tr>
<td>KTHC</td>
<td>Knowledge, Technology, Human Capital</td>
<td>Gianmarco Ottaviano</td>
</tr>
<tr>
<td>IEM</td>
<td>International Energy Markets</td>
<td>Anil Markandya</td>
</tr>
<tr>
<td>CSRM</td>
<td>Corporate Social Responsibility and Sustainable Management</td>
<td>Sabina Ratti</td>
</tr>
<tr>
<td>PRA</td>
<td>Privatisation, Regulation, Antitrust</td>
<td>Bernardo Bortolotti</td>
</tr>
<tr>
<td>ETA</td>
<td>Economic Theory and Applications</td>
<td>Carlo Carraro</td>
</tr>
<tr>
<td>CTN</td>
<td>Coalition Theory Network</td>
<td></td>
</tr>
</tbody>
</table>