

Millock, Katrin; Nauges, Céline

**Working Paper**

## The French Tax on Air Pollution: Some Preliminary Results on its Effectiveness

Nota di Lavoro, No. 44.2003

**Provided in Cooperation with:**

Fondazione Eni Enrico Mattei (FEEM)

*Suggested Citation:* Millock, Katrin; Nauges, Céline (2003) : The French Tax on Air Pollution: Some Preliminary Results on its Effectiveness, Nota di Lavoro, No. 44.2003, Fondazione Eni Enrico Mattei (FEEM), Milano

This Version is available at:

<https://hdl.handle.net/10419/118078>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**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.*

**The French Tax on Air Pollution:  
Some Preliminary Results  
on its Effectiveness**

Katrin Millock and Céline Nauges  
NOTA DI LAVORO 44.2003

**APRIL 2003**

CLIM – Climate Change Modelling and Policy
--

Katrin Millock, CIRED (CNRS-EHESS)  
Céline Nauges, LEERNA, INRA-Toulouse

This paper can be downloaded without charge at:

The Fondazione Eni Enrico Mattei Note di Lavoro Series Index:

[http://www.feem.it/web/attiv/\\_wp.html](http://www.feem.it/web/attiv/_wp.html)

Social Science Research Network Electronic Paper Collection:

[http://papers.ssrn.com/abstract\\_id=XXXXXX](http://papers.ssrn.com/abstract_id=XXXXXX)

The opinions expressed in this paper do not necessarily reflect the position of  
Fondazione Eni Enrico Mattei

# **The French Tax on Air Pollution: Some Preliminary Results on its Effectiveness**

## **Summary**

Empirical evidence evaluating the efficiency of economic instruments is still rare, despite significant theoretical advances over the last decades. The objective of this paper is to evaluate one form of environmental taxation, the French tax on air pollution from 1990-99. While starting out in 1985 as a tax levied only on emissions of sulphur dioxide (SO<sub>2</sub>), the tax base was subsequently extended to encompass also emissions of nitrogen oxides (NO<sub>x</sub>), hydrochloric acid (HCl), and volatile organic compounds (VOC). The revenues of the French tax on air pollution were earmarked for abatement subsidies and the financing of air quality surveillance systems. Using a plant-level database, we find a negative, significant effect of the tax on emissions of SO<sub>2</sub>, NO<sub>x</sub>, and HCl. The abatement elasticity with regard to the tax is quite small, however.

**Keywords:** Environmental tax, emissions regulation, earmarking, air quality

**JEL:**H00, H23, Q25, Q28

*Address for correspondence:*

Katrin Millock  
CIRED, CNRS UMR 8568  
45 bis, avenue de la Belle Gabrielle  
94 736 Nogent-sur-Marne  
France  
Phone: (33)5.61.12.88.76  
Fax: (33)5.61.12.85.20  
E-mail: millock@centre-cired.fr

# The French Tax on Air Pollution: Some Preliminary Results on Its Effectiveness

Katrin Millock, CIRED (CNRS-EHESS)  
and Céline Nauges, LEERNA, INRA-Toulouse

11th March 2003

## Abstract

Empirical evidence evaluating the efficiency of economic instruments is still rare, despite significant theoretical advances over the last decades. The objective of this paper is to evaluate one form of environmental taxation, the French tax on air pollution from 1990-99. While starting out in 1985 as a tax levied only on emissions of sulphur dioxide ( $\text{SO}_2$ ), the tax base was subsequently extended to encompass also emissions of nitrogen oxides ( $\text{NO}_x$ ), hydrochloric acid ( $\text{HCl}$ ), and volatile organic compounds ( $\text{VOC}$ ). The revenues of the French tax on air pollution were earmarked for abatement subsidies and the financing of air quality surveillance systems. Using a plant-level database, we find a negative, significant effect of the tax on emissions of  $\text{SO}_2$ ,  $\text{NO}_x$ , and  $\text{HCl}$ . The abatement elasticity with regard to the tax is quite small, however.

## 1 Introduction

Empirical evidence on the actual effects of economic instruments is rare, despite significant theoretical advances over the last decades on the efficiency of economic instruments such as taxes or tradeable permits. One exception is the recent policy lesson drawn from the market in tradeable sulphur permits that was introduced by the United States Clean Air Act Amendments in 1990 (Joskow and Schmalensee, 1998; Joskow, Schmalensee and Bailey, 1998 ; Stavins, 1998). It has also been possible to measure the efficiency of the permit market created for the lead phasedown in the United States between 1982 and 1987 (Kerr and Maré, 1996). Most of these evaluations concern the United States, though, whereas Europe, for instance, has relied to a larger extent on environmental taxes. The question of assessing the impact of environmental taxes is complicated. First, environmental taxes in Europe have almost always been set at a level lower than that justified by environmental damages, and have rather been used for revenue-raising purposes. Is it fair to evaluate the environmental impact and economic efficiency of an

instrument whose primary purpose is to raise revenue? Second, environmental taxes do not operate in isolation. In Europe, they usually complement traditional regulations by technology standards and are in many cases used to speed up the introduction of new technology. How to entangle the effect of environmental taxes from other forms of regulation simultaneously in use represents a major difficulty. Third, the necessary data (preferably plant-level) is hard to find.

The purpose of this paper is to evaluate one form of environmental taxation, the revenue-recycled air pollution charge that was in use in France from 1985-1999. This is one of few actual ex post analyses of specific environmental taxes, with the exception being the detailed evaluation of the Swedish emissions charge on nitrogen oxides by Höglund (2000) and Sterner and Höglund (2000).<sup>1</sup> The paper presents an econometric analysis based on plant-level data of emission levels for four major air pollutants: sulphur dioxide ( $\text{SO}_2$ ), nitrogen oxides ( $\text{NO}_x$ ), volatile organic compounds (VOC) and hydrochloric acid (HCl). The French air pollution tax has been interpreted as an example of a revenue-raising instrument, of which the revenues were allocated to abatement subsidies and the financing of air quality surveillance. However, despite the relatively low level of the tax (as compared to charges implemented in Scandinavia, for example) the abatement obtained from the recycled revenues may lead to a positive impact in terms of reduced emission levels. In this paper we situate the French air pollution tax in its regulatory context, review the related literature, and present some preliminary results on the impact of the tax.

## 2 Regulatory Framework

Regulation of air pollution is significantly affected by the international Convention on Long Range Transboundary Air Pollution, which was signed in 1979 following intense debate on acid deposition caused by transboundary air pollution. Since its entry into force in 1983, the Convention has been extended by several protocols. In 1985, the so called Helsinki Protocol was signed that stipulated a reduction of sulphur emissions (or their transboundary fluxes) by at least 30 per cent. The proportional reduction target was abandoned in 1994 in favour of an approach basing targets on critical loads, where the target load differs according to countries' sensibility to acidification. Over the years, the Convention has been extended to encompass the control of

---

<sup>1</sup>Brännlund and Kriström (2001) evaluate the impact of the Swedish energy taxation by estimating production functions on a panel of 150 district heating plants, and simulating the resulting changes in emissions of sulphur, nitrogen oxides, particulates and carbon dioxide.

nitrogen emissions (the Sofia Protocol of 1988), volatile organic compounds (1991), heavy metals (1998), and persistent organic pollutants (1998). In 1999, the Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-Level Ozone was signed. The Protocol sets emission ceilings for 2010 for sulphur (measured as  $\text{SO}_2$ ),  $\text{NO}_x$ , VOC and ammonia ( $\text{NH}_3$ ). In aggregate, the Protocol aims at a reduction for the European Community of 75% of sulphur emissions, 49% of  $\text{NO}_x$  emissions, 57% of VOC emissions and 15% of ammonia emissions in terms of 1990 emissions and including both mobile and fixed sources.

The international Convention on Long Range Transboundary Air Pollution has been a driving factor for regulatory action on behalf of the European Union, which in turn drives national regulation in France. The most significant directive was issued in 1988 to limit sulphur and nitrogen emissions from large combustion plants with a capacity exceeding 50 MW thermal (Directive 88/609/EEC ). The Directive stipulated emission limits for new plants and national ceilings for total emissions. In the year 2000, agreement was reached on an amendment of the Large Combustion Plant Directive including stricter emission limits for 1 January 2008. Another relevant piece of European legislation is the Integrated Pollution Prevention and Control (IPPC) Directive (96/61/EC) that sets out to reduce pollution from fixed sources using a licensing procedure for each plant based on Best Available Technique.

### 3 Literature Review

#### 3.1 Applied regulatory analysis

The existing literature can be classified into three major categories: analyses of national strategic behaviour using game theory, assessments of the macro-economic impact of  $\text{SO}_2$  and  $\text{NO}_x$  abatement, and surveys and analyses of existing regulations in different countries.

Murdoch, Sandler and Sargent (1997) focus on the transboundary public good aspect of sulphur and nitrogen oxides emissions. They underline the physical differences of the two pollutants in explaining why the response to regulation has been so different for  $\text{NO}_x$  versus  $\text{SO}_2$  emissions. Modeling countries' abatement as a non-cooperative Nash response, they derive voluntary levels of abatement in excess of those stipulated in international conventions on long range transboundary air pollution. In an empirical test, the representation of voluntary emission reductions holds for  $\text{SO}_2$ . For  $\text{NO}_x$ , the authors note that the transboundary effect is larger and that countries thus have a larger strategic incentive at the supranational level. Also, the Sofia Protocol that

stipulated reductions in both  $\text{SO}_2$  and in  $\text{NO}_x$  emissions did not come into effect until 1991, that is, at the end of the study period, and it did therefore not have a deterring effect on  $\text{NO}_x$  emissions. Furthermore, it is more difficult to implement  $\text{NO}_x$  abatement policies since the main source of  $\text{NO}_x$  emissions is traffic. Sulphur emissions, on the other hand, are more easily controlled since the larger part emanates from publicly owned power plants. For the  $\text{NO}_x$  problem, the authors conclude that the collective action problem first has to be solved at a national level before being confronted on the international plan.

Alfsen, Birkelund and Aaserud (1995) combine a sectoral European energy model that covers nine European countries with the RAINS emission transport- and deposition model, in order to simulate the impact on emissions of  $\text{CO}_2$ ,  $\text{SO}_2$  and  $\text{NO}_x$  of the energy/carbon tax proposed by the European Commission in 1992. The abatement costs used in the model of transboundary pollution are from the RAINS model, and represent technical cost measures. They find that the impact of the tax and the deregulation of the power sector are larger on  $\text{SO}_2$  emissions than on  $\text{NO}_x$ , since 70% of the  $\text{NO}_x$  emissions in the model area in the year 2000 come from the transport sector, which is unaffected by energy sector deregulation and the European Commission energy tax proposal. When appraising the costs of reaching the targets stipulated in the Helsinki and Sofia Protocols, the authors find that  $\text{NO}_x$  abatement costs are less elastic than  $\text{SO}_2$  abatement costs. In particular, Norway and France have high marginal abatement costs for  $\text{NO}_x$ , which is explained by an inflexible energy structure, and those countries would face high total control costs to implement the targets in the Sofia Protocol. The authors underline that the use of economic instruments to control one pollutant has to take into account its effects on other pollutants.

Van Rompuy (1997) simulates the effects of Belgian regulation of  $\text{SO}_2$  and  $\text{NO}_x$  emissions in a partial equilibrium model. The regulation imposes three constraints on central electricity producers in order to conform with the EC Large Combustion Plant Directive: a 1% sulphur content limit on fuels used in electricity generation, a  $\text{SO}_2$ - $\text{NO}_x$  emission reduction scheme for 1991-2003, and technological standards for new power plants. The author finds that the regulatory costs to Belgium exceed the national environmental benefits, since much of the sulphur and  $\text{NO}_x$  reduction benefits the rest of Europe. An important result is that the side effects on  $\text{CO}_2$  emissions can be important (in this case a 51% reduction compared to the no regulation scenario), mainly because the regulation induces a shift away from coal power plants to nuclear energy.

Larsen (1997) evaluates the macro economic effects of  $\text{NO}_x$  abatement in the Norwegian economy using a disaggregated sector model. The abatement measures studied in the industrial sector are the installation of low- $\text{NO}_x$  combustion technology in one of the three major petrochemical plants and the installation of catalytic converters at the major oil refinery. The author confirms the presence of secondary economic effects of abatement measures but concludes that the macro economic effects of the increased investment costs are low for the Norwegian economy in terms of reduction in GDP or private consumption.

For  $\text{NO}_x$  emissions in particular, Cansier and Krumm (1997) provide a useful survey of the existing economic regulation of  $\text{NO}_x$  emissions in Scandinavia, France, the Netherlands and Japan. The French and Swedish  $\text{NO}_x$  taxes are compared; the Swedish tax rate is 100 times higher than its French counterpart. The Swedish reimbursement system is aimed at decreasing the amount of nitrogen emissions per energy unit, whereas the French allocation system of subsidies is less transparent. In both countries, the coverage of emission sources is incomplete, since the transport sector is excluded. Furthermore, the thresholds for taxation create some inefficiency in either system.

### **3.2 Theoretical analysis of output-based refunding**

The French tax system that we study here resembles partly the Swedish  $\text{NO}_x$  charge in that tax revenues are rebated back to industry, although on a different basis. The Swedish charge is automatically refunded based on useful energy whereas the French tax is refunded in the form of abatement subsidies for tax-paying companies. One particular interest of our study is to compare the distributional impact of the French tax compared to alternative refunding mechanisms. We therefore briefly review the main results on output-based refunding.

Fischer (2001a) analyses and compares three variants of output-based refunding of environmental policy revenues: tradeable performance standards, output-rebated emission taxes and output-allocated emission permits. The analysis is done for a representative firm with a fixed emissions ratio from output and an emission reduction cost function that is linear in output. Under output-based rebating of emission taxes, total tax revenue is rebated back to the firms according to their share of industry output. A tradeable performance standard fixes the average emission rate and firms are free to sell any reductions below this standard ; if it produces at an above average emission rate, it instead has to purchase emission permits. Assuming perfect



competition, output-rebated emission taxes and tradeable performance standards are equivalent. Although the same marginal incentive for emission reductions holds as under an emission tax, the firm will produce a higher level of output compared to the optimal solution. Consequently, for any given emission rate, tradeable performance standards or output-based rebating of emission taxes induce less emission reductions than would the optimal policy of a Pigovian tax. Similarly, output-allocated permits also raises the marginal cost of emission reductions.<sup>2</sup>

Fischer (2001b) extends the basic model to allow for incomplete competition and imperfect participation. When firms' market shares are significant, the output-based subsidy will give incentives for yet further output increases and the consequence could be a shift in industry structure towards more high-emitting firms compared to an emission tax with a fixed output subsidy. If there also is imperfect competition in the output market, the optimal subsidy to correct for this distortion should be inversely related to the elasticity of demand; with heterogeneous firms, however, an output-based rebating system cannot achieve optimality. Leakage effects from unregulated sectors cause further distortion, and in such situations the subsidy implied in an output-based rebating system can either be too small or too large, so that in some cases no subsidy is a dominating policy.

Recent policy attention to output-based allocation of environmental tax revenues stems in part from the success of the Swedish refunded  $\text{NO}_x$  charge on emissions from fixed sources. Under this system, a  $\text{NO}_x$  tax is levied on large fixed emission sources<sup>3</sup> who are required to install continuous emission meters, and the revenues are refunded to participants directly based on their final production of useful energy. Between 1992 and 1998, the 200 combustion plants that initially were targeted by the regulation reduced their average emission rates by 40%.<sup>4</sup> Sterner and Höglund (2000) analyse output-based refunding of emission taxes with special attention to the Swedish experience. The authors argue that the output effect empirically has been negligible in the Swedish case, since the cost share of the charge is low, the demand elasticity of the product is low, and there are large technical abatement possibilities. Since the Swedish scheme rebates tax revenues according to plant production of useful energy, the output in the model is effectively

---

<sup>2</sup>Fischer (2001a) also discusses some additional disadvantages with output-based allocation of environmental tax revenue: defining output and the relevant sector coverage, and unexpected entry and exit effects following manipulation of eligibility for an output subsidy.

<sup>3</sup>Defined initially as units with a production of useful energy above 50 GWh per boiler. The system was extended in 1996 to include all boilers with a useful energy production above 40 GWh, and from 1997, all boilers with at least 25 GWh of useful energy per year.

<sup>4</sup>Measured in kg  $\text{NO}_x$ /MWh useful energy.

energy, an input into most production processes. It would seem that for a profit-maximizing firm that produces part of its own energy input, the incentive effects of the Swedish scheme are somewhat different from those stipulated under a general output-based refunding scheme. Energy could be seen as a secondary output in a multiple output production process and a limitation of existing analyses is the lack of discussion of this discrepancy between the models and the existing regulation. The system is aimed at encouraging reductions in emissions in relation to useful energy output, and all industrial sectors, apart from the metals industry, have reduced their average emission ratios. Certain sectors are doing better than others under the system; The distributional effect of the charge shows that the energy sector has gained in aggregate and that the paper and pulp sector has been a net payer to the system. That does not account for earlier abatement investments, however, but it suggests that the complementarity between output production and fuel generation may be important in explaining the effect of the Swedish refunded  $\text{NO}_x$  charge.

The existing literature notes that the effect on output is suboptimal and leads to too many firms in the industry in the long run. However, other dynamic effects of output-based refunding policies are not directly examined, such as its effects on innovation and technology adoption.

### 3.3 Survey of empirical econometric papers

Recent empirical papers dealing with air quality regulation focus mainly on two types of impacts: impact on air quality (Henderson, 1996) and impact on firms through their level of compliance (Nadeau, 1997), choice of location (Henderson, 1996) and economic performance (productivity, employment...) (Greenstone, 2001; Gray and Shadbegian, 1994). The datasets used in these studies have been built following surveys conducted exclusively on American firms.

Henderson (1996) examines effects of ground-level ozone regulation on air quality and economic activity. Contrary to past studies, and using panel data, this author shows that local regulation has non-perverse effects on air quality and on firm location decisions. As explained by Henderson (1996), “the location of polluting activity, high concentration readings, and the designation of nonattainment status are of course all strongly positively correlated, cross-sectionally; so air quality indeed is worse in nonattainment areas,<sup>5</sup> and polluting firms are predominantly found there”.

---

<sup>5</sup>After 1970, the Environmental Protection Agency (EPA) established separate national air quality standards for four pollutants. Counties were thus designed “attainment” or “nonattainment” counties.

Nadeau (1997) looks at the effectiveness of the Environmental Protection Agency (EPA) in reducing the time that manufacturing plants spend in a state of noncompliance. The novelty of this paper lies first in the fact that it focuses on the length of time that plants spend in violation of EPA regulation and second, in the fact that it separates the effects of two types of EPA activity: monitoring and enforcement. Using data on 175 plants in the pulp and paper industry on the 1979-1989 period, Nadeau (1997) shows that the EPA is effective at reducing the time plants spend violating standards.

Greenstone (2001) estimates the effects of environmental regulation on industrial activity, using a broad dataset made of 1.75 million plant observations covering the 1967-87 period. Regulation is measured by the county-level attainment/nonattainment designations for each of the four pollutants targetted by the EPA. Controlling for plant-specific, industry-specific and county-specific effects, Greenstone (2001), using a simple linear static model, estimates the impact of the 1970 Clean Air Act Amendments on growth of employment, investment and shipments of manufacturers. Using a simultaneous-equations model, the author finds that the Clean Air Act Amendments substantially retarded the growth of polluting manufacturers in nonattainment counties.

Gray and Shadbegian (1994) analyse empirically the impact of environmental regulation on productivity using plant-level data for three industries: paper mills, oil refineries and steel mills, for the 1979-1990 period. These authors focus on Total Factor Productivity (TFP),<sup>6</sup> examining both productivity levels and growth rates for each plant, and their relationship to the regulatory measures. They find that plants which spend more on pollution abatement are significantly less productive. One of the difficulties in this analysis is that some unobserved characteristics of the plant (for example the quality of the plant management) might bias the estimates: if a more productive plant is more likely to comply with regulations, this would tend to create a negative correlation between abatement costs and productivity.

Using the same data set, Gray and Shadbegian (2001) study differences in the impact of environmental regulation across different plants within a single industry (the paper and pulp industry here). They find a significant negative relationship between pollution abatement costs and productivity levels, which is almost entirely due to mills which incorporate a pulping process.

A common feature of these papers is that they point out that the impacts of air quality

---

<sup>6</sup>TFP is measured as the difference between output (measured by the value of shipments) and the weighted average of inputs (labour, material and energy expenditures, and capital stock).

regulation have to be studied at a local level and on an industry-by-industry basis.

## 4 The French Tax on Air Pollution

Whereas previous plant-level econometric analyses concern US data almost exclusively, our analysis is done on panel data on firms subject to the French tax on air pollution.<sup>7</sup> The French tax on air pollution (la taxe parafiscale sur la pollution atmosphérique, or TPPA) belongs to the special tax category of parafiscal taxes that do not need approval by parliament and whose purpose is to benefit the payers of the special tax, by definition an earmarked tax. One of its original purposes was to finance investments in air quality surveillance systems. However, its creation was also inspired by the French water pollution charges which are levied upon industrial water users and then recycled in the form of abatement subsidies. The event that spurred its implementation was the European debate on acid rain. In the 1980's, it was clear that policy action was demanded on a European level. France, on the other hand, could do relatively little to reduce its sulphur emissions per unit of energy use, since it had already reduced emission levels through its investment in nuclear energy. Additional incentives were sought to motivate industry to undertake further abatement action.

Initially introduced in 1985 for SO<sub>2</sub> emissions, the government order on the TPPA was extended in 1990 to include also emissions of NO<sub>x</sub> and HCl, and in 1995 to include VOC.<sup>8</sup> The tax was imposed from 1990 on any entity that fulfills either of two criteria: a maximum combustion capacity equal to or exceeding 20 MW or annual emissions of more than 150 tonnes of either SO<sub>2</sub>, NO<sub>x</sub>, HCl, or VOC. Household waste incineration plants with a capacity exceeding 3 tonnes an hour were also subject to the tax.

In 1990, the tax rate targeting SO<sub>2</sub>, NO<sub>x</sub> and HCl emissions was put at a level of 150 FF/tonne.<sup>9</sup> It was increased in 1995 to 180FF/tonne for SO<sub>2</sub>, NO<sub>x</sub>, HCl, and VOC and in 1998 to 250FF/tonne for NO<sub>x</sub> and VOC. If the total tax due was less than 1,000 FF for a unit, no tax was levied. In 1997, this made for a total of 1,454 tax payers.

The revenue from the TPPA was earmarked for subsidies to abatement or for preparatory

---

<sup>7</sup>For other evaluations on European data, see the recent paper by Brännlund and Kriström (2001), in which they estimate production functions on panel data for 150 Swedish district heating plants for the period 1989-1996 and simulate the impact of changes in energy taxation.

<sup>8</sup>The extension in 1995 also included small particulate matter, but the tax rate was set at zero for those emissions. For administrative purposes, the inclusion of particulate matter allowed companies to apply for abatement subsidies also for such emissions. We will not consider this particular pollutant in the empirical analysis.

<sup>9</sup>Approximately USD 23/tonne.

technical studies (corresponding to 75% of the tax revenues), with the rest aimed at investment in air quality surveillance systems. The tax was administered by the French Agency for Environment and Energy Management (ADEME)<sup>10</sup> which received 6% of the tax revenue for its administration costs.

The system was based on self-reporting of emissions from the previous year by 15 April. ADEME reports a high level of enforcement: over 90% of taxes due were actually paid. The TPPA in fact raised two major controversies. First, upon its set-up, industry contested the distribution of the tax revenue to investment in air pollution surveillance systems, arguing that all of the tax revenue should be recycled in the form of abatement subsidies. Second, and more important for estimation purposes, major chemical companies contested that N<sub>2</sub>O counted as an air pollutant according to the (old) Law on Air Pollution from 1961, and consequently refused to pay for those emissions, only paying for NO and NO<sub>2</sub> emissions.

In the year 2000, the TPPA was replaced by a general pollution tax<sup>11</sup> levied by the customs authorities and no longer administered by ADEME, who nevertheless continues to handle requests for abatement subsidies paid out of the general government budget. Our analysis thus encompasses the period when the TPPA was an integrated earmarked tax system.

## 5 Descriptive analysis

Data have been provided by ADEME. This database includes all plants subject to taxation following air regulation in France. 1,942 plants have been recorded between 1990 and 1999. For each plant, information is given on its geographical location, the activity sector it belongs to, the total amount of emissions for four pollutants (SO<sub>2</sub>, NO<sub>x</sub>, HCl and VOC), the total amount of taxes paid to the agency, and the maximum combustion capacity (in MW). All monetary amounts are in FF1990. The index used is the price of sales of industrial products (source: INSEE, the French National Statistical Institute).

In Figure 1, we report total emissions of VOC and HCl (in tonnes) and total emissions per unit of combustion capacity (emissions are in tonnes/MW) of NO<sub>x</sub> and SO<sub>2</sub> for each year between 1992 and 1998.<sup>12</sup> Since NO<sub>x</sub> and SO<sub>2</sub> emissions originate mainly from the combustion of fossil fuels, we work with emissions per unit of combustion capacity in order to correct for

---

<sup>10</sup> Agence de l'Environnement et de la Maîtrise de l'Energie.

<sup>11</sup> La Taxe Générale sur les Activités Polluantes (TGAP).

<sup>12</sup> In 1995 emissions were recorded for a six-month period only and have thus been readjusted.

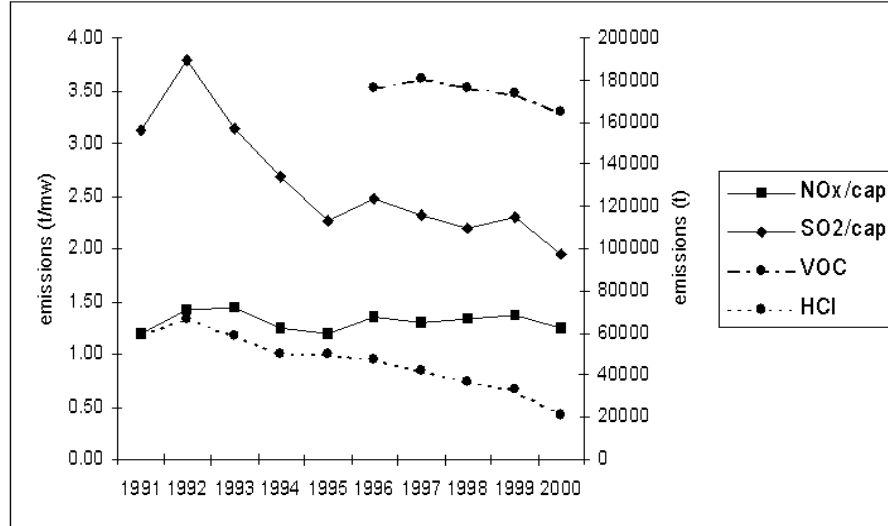


Figure 1: Total emissions of the four pollutants for the period 1990-1999

size effects. Note that emissions of VOC only were taxed, and thus reported, from 1995. The largest emissions (in tonne/MW) are SO<sub>2</sub> emissions, followed by NO<sub>x</sub>. In absolute levels, VOC emissions are greater than HCl emissions. We note a slight increase of all types of emissions in the beginning of the period (in 1992), followed by a net decrease in the case of SO<sub>2</sub> emissions, a slight decrease in the case of HCl and VOC whereas emissions of NO<sub>x</sub> in terms of tonnes per capacity remained almost constant all along the period.

In Table 1, we report total emissions for the period by sector. Most of the NO<sub>x</sub> emissions come from the sector of electricity production (28%) and from the chemical industry (23%). The third big polluter is the sector of other nonmetallic products, accounting for 13% of total NO<sub>x</sub> emissions. Main emitters of SO<sub>2</sub> are the sectors of coke (30% of total emissions) and electricity production (26%). For HCl emissions, the waste management sector is the main contributor to emissions (62% of total emissions). The two other sectors emitting HCl are electricity (16%) and heating (13%). For VOC, emissions are due in almost equivalent proportions to the sectors of chemistry (20%), plastic and rubber (21%), coke (15%) and the car industry (14%).

As explained in Section 4, the revenue from the taxes is earmarked for subsidies to abatement or for technical studies. We will consider from now on subsidies to abatement only. In Figure 2 we report the number of granted subsidies per year and their total monetary amount in millions

Table 1: Total emissions (in tonne) for the 1990-1999 period by sector

Sector	NO <sub>x</sub>		SO <sub>2</sub>		HCl		VOC	
	Total	%	Total	%	Total	%	Total	%
Extraction	19,695	0.5%	58,136	0.8%	4,532	1.0%	329	0.0%
Food & agri. prod.	114,950	3.0%	344,528	4.5%	3,798	0.8%	21,478	2.3%
Textile	8,241	0.2%	31,882	0.4%	480	0.1%	13,952	1.5%
Paper	92,520	2.4%	235,672	3.1%	3,700	0.8%	55,041	5.8%
Printing	636	0.0%	223	0.0%	376	0.1%	52,958	5.6%
Coke	310,643	8.1%	2,284,857	29.9%	885	0.2%	138,822	14.6%
Chemistry	870,345	22.8%	552,092	7.2%	12,938	2.8%	188,301	19.8%
Plastic & rubber	58,575	1.5%	205,197	2.7%	3,272	0.7%	194,970	20.5%
Other nonmetallic	494,812	13.0%	428,399	5.6%	5,588	1.2%	9,842	1.0%
Metallurgy	9,507	0.2%	85,055	1.1%	882	0.2%	76,977	8.1%
Iron and steel	274,826	7.2%	579,842	7.6%	4,335	0.9%	24,024	2.5%
Car industry	18,674	0.5%	55,455	0.7%	776	0.2%	129,097	13.6%
Electricity prod.	1,065,235	27.9%	1,945,922	25.5%	73,083	15.7%	2,119	0.2%
Heat prod.	219,328	5.7%	667,978	8.8%	58,162	12.5%	2,004	0.2%
Gas prod.	44,733	1.2%	1,014	0.0%	486	0.1%	1,090	0.1%
Waste management	184,986	4.8%	110,186	1.4%	290,086	62.4%	6,632	0.7%
Other industries	32,644	0.9%	46,211	0.6%	1,485	0.3%	32,502	3.4%
Total	3,820,350	100.0%	7,632,649	100.0%	464,864	100.0%	950,138	100.0%

of francs (1990 MF). The number of projects financed globally increased during the period, reaching a maximum of 63 in 1997. The total amount distributed was quite high in 1991 and decreased regularly until 1996. During the last two years, subsidies almost doubled (160MF in 1997 and 153MF in 1998).

These subsidies are not distributed equally between sectors as shown in Table 2. The chemistry sector got the highest number of abatement projects financed (70 projects), followed by the sector of coke (36), plastic and rubber (30) and waste management (28). We note also that the sector of gas production and the sector of extraction did not get any subsidy between 1990 and 1998. In terms of monetary amount, 40% of total subsidies were equally shared between the sectors of chemistry and electricity production (210MF each). The sectors of coke and of iron and steel received respectively 13% and 11% of total subsidies. It is no surprise that subsidies are granted mainly to the biggest polluters.

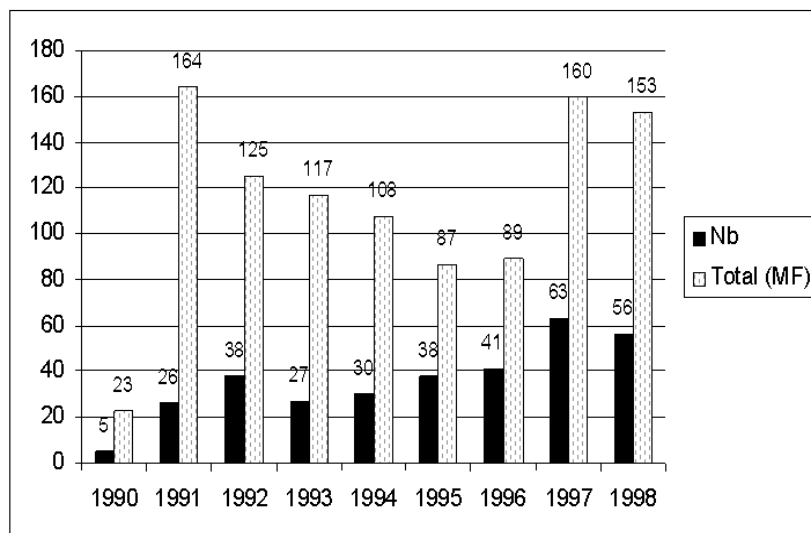


Figure 2: Number and total amount of subsidies for each year

Table 2: Number and total amount of subsidies by sector for the 1990-1999 period

Sector	Nb	Tot. (MF)	%
Extraction	0	0	0%
Food & agri. prod.	5	7	1%
Textile	6	7	1%
Paper	14	36	4%
Printing	14	23	2%
Coke	36	134	13%
Chemistry	70	208	20%
Plastic & rubber	30	52	5%
Other nonmetallic	21	40	4%
Metallurgy	15	18	2%
Iron and steel	24	114	11%
Car industry	11	62	6%
Electricity prod.	13	210	20%
Heat prod.	11	10	1%
Gas prod.	0	0	0%
Waste	28	66	6%
Other industries	26	38	4%
Total	324	1,025	100%



## 6 Theoretical model

For the theoretical framework we use the model of Khanna and Zilberman (1997) who formalize the view of pollution as a result from waste in input use. Consider a plant using a polluting input in its production process (for example, energy from fossil fuel, or solvent-based paints). To simplify the analysis, assume that the plant produces a single output,  $q$ , and that the plant is a price-taker both in the input and output markets. A plant can choose to invest ( $i = 1$ ) or not ( $i = 0$ ) in a new equipment that would increase input-use efficiency. The production function  $f$  is written as a function of useful input  $e$  and a productivity parameter  $\beta$  :  $q_i = f(\beta_i e_i)$  and possesses the usual properties:  $f_e > 0$  and  $f_{ee} < 0$ . The parameter  $h$  is used to account for efficiency in input use, where  $h$  is the ratio of useful input to applied input:  $h_i(\theta) = \frac{e_i}{a_i}$ . The production function can thus be written  $q_i = f(\beta_i h_i(\theta) a_i)$ . Firms are heterogenous in that the input use efficiency depends on management or other firm characteristics:  $h(\theta)$  with  $\theta$  distributed on a scale from 0 to 1. Input use efficiency increases with the heterogeneity index, but at a decreasing rate:  $h_\theta > 0$  and  $h_{\theta\theta} < 0$ . Adopting the input-saving technology improves efficiency:  $h_1(\theta) > h_0(\theta)$  for  $0 < \theta < 1$ . In other words, less applied input is required with the new technology for producing the same level of output (or equivalently the production function with the new equipment is always above the production function without the new equipment). Whereas efficiency in input use depends on the firm type and on technology, the parameter  $\beta$  is a direct productivity effect associated only with the technology itself. For all  $\theta$ , a precision technology is defined as a technology with  $\beta_1 > \beta_0 = 1$ . Investing in the new technology implies a fixed cost ( $I_1 > 0$  and  $I_0 = 0$ ) and increases the marginal cost of input ( $w_1 > w_0$ ) (to account for a more skill-intensive technology).  $P$  is the unit output price. The cost function is written  $C_i(a) = I_i + w_i a_i$ . The profit function thus reads  $\Pi_i(a_i) = P f(\beta_i h_i(\theta) a_i) - C_i(a_i)$ .

### 6.1 Benchmark case

As a benchmark, define the situation without any regulation at all. In a first stage, the plant chooses the optimal level of input with and without the new equipment solving the program:

$$\text{Max } \Pi_i(a_i) = P f(\beta_i h_i(\theta) a_i) - C_i(a_i); \quad i = 0, 1.$$

Optimal input use  $a_i^*$  is determined by the following first-order condition:

$$P\beta_i h_i(\theta) f'(\beta_i h_i(\theta) a_i^*) = w_i; \quad i = 0, 1. \quad (1)$$

The value of the marginal product of input should equal its marginal cost. When  $i = 1$ , we have  $\beta_1 f'(\beta_1 h_1(\theta) a_1^*) = w_1 / (P h_1(\theta))$  and when  $i = 0$ , the optimal input is given by  $f'(\beta_0 h_0(\theta) a_0^*) = w_0 / (P h_0(\theta))$ . Whenever the marginal productivity effect of the new technology exceeds its marginal cost increase, applied input use is higher with the new technology than with the old:  $a_1^* > a_0^*$  when  $\beta_1 \frac{h_1}{h_0} > \frac{w_1}{w_0}$ .

In a second stage, the plant compares the profit obtained with and without the new equipment. New equipment will be acquired if  $\Pi_1^* > \Pi_0^*$ , or equivalently if

$$I_1 < P[f(\beta_1 h_1(\theta) a_1^*) - f(h_0(\theta) a_0^*)] + w_0 a_0^* - w_1 a_1^*. \quad (2)$$

A plant is more likely to adopt the new equipment if the fixed investment cost  $I_1$  is low, the revenue differential  $P(q_1^* - q_0^*)$  (which is positive if  $a_1^* > a_0^*$ ) is high and the cost differential  $(w_1 a_1^* - w_0 a_0^*)$  is low.

## 6.2 Introducing emissions regulation

Assume now that input consumption produces a proportional amount of pollution: the total amount of emissions  $z$  is a constant share  $\gamma$  of the applied input. Equivalently, we have the relationship  $z_i = \gamma_i a_i$ . All else equal, the adoption of a new precision technology reduces the pollution coefficient and  $\gamma_1 < \gamma_0$ . Existing French regulation can be modelled as an emission standard  $N$  backed up by a penalty for non-compliance  $F$ . Assuming that the standard is binding, the firm maximizes

$$\Pi_i(a_i) = P f(\beta_i h_i(\theta) a_i) - C_i(a_i) - F(\gamma_i a_i - N); \quad i = 0, 1.$$

and chooses a level of input use equal to

$$\beta_i f'(\beta_i h_i(\theta) a_i^*) = \frac{w_i + F' \gamma_i}{P h_i(\theta)}; \quad i = 0, 1. \quad (3)$$

As expected from theory, with perfect enforcement the result resembles an emission tax. An emission tax increases the marginal cost of applied input, leading to a reduced level of output (comparing equation 3 with equation 1). However, if enforcement is less than perfect and

exceptions and delays are accorded, combining existing regulation with an emission tax  $t$  would give additional incentives for polluting firms. In the French regulatory situation with the TPPA, the firm thus maximizes

$$\Pi_i(a_i) = Pf(\beta_i h_i(\theta) a_i) - C_i(a_i) - F(\gamma_i a_i - N) - t\gamma_i a_i; \quad i = 0, 1.$$

Optimal input use is now given by

$$\beta_i f'(\beta_i h_i(\theta) a_i^*) = \frac{w_i + F'\gamma_i + t\gamma_i}{Ph_i(\theta)}; \quad i = 0, 1. \quad (4)$$

In both cases, the optimal applied input  $a_i^*$  is lower than in the scenario without a tax. Now, a plant will invest if

$$I_1 < P[f(\beta_1 h_1(\theta) a_1^*) - f(h_0(\theta) a_0^*)] + w_0 a_0^* - w_1 a_1^* + F(\gamma_0 a_0^* - \gamma_1 a_1^*) + t\gamma_0 a_0^* - t\gamma_1 a_1^*. \quad (5)$$

Compared to the benchmark case, a plant is now more likely to invest in a clean technology the higher is the tax rate and the higher is the regulatory threat of enforcing an emission standard.

The linear relation between applied input and emissions in this model holds as a good approximation for SO<sub>2</sub> emissions and more or less for use of hydrochloric acid and solvents leading to VOC emissions. For NO<sub>x</sub> emissions, on the other hand, the link between the energy input and resulting emissions is more intricate. It depends amongst other things on the process combustion temperature. The model should thus be interpreted as a first approximation of the firm's input use and choice of adopting a clean technology. Below, we present preliminary results from estimation of Equation (4), which determines the emission level given the technology choice.

## 7 Econometric analysis

Observations come from an unbalanced panel data set. Estimations are made for the 1,915 plants with strictly positive tax payments (if the tax due did not exceed 1,000FF, no tax was levied). We estimate separately four models, one for each pollutant. Regarding NO<sub>x</sub> and SO<sub>2</sub>, the dependent variable is the amount of yearly emissions by unit of combustion capacity (i.e. total emissions of the plant / maximum combustion capacity). This is to avoid size effects in the estimation. In the case of VOC and HCl, the dependent variable is the total amount of yearly emissions (we were not able to control for size for those pollutants).<sup>13</sup> The theoretical framework

---

<sup>13</sup>In the case of VOC, the regression is run on data posterior to 1995, when taxation of this pollutant began.

showed how emissions depend on input use, which in turn is determined by input price, output price, firm characteristics, regulatory norms and the tax level. Regulatory norms are firm-specific in France and it is impossible to obtain data on those. We include as regressors the level of the tax (tax per tonne for the pollutant considered), the sectoral dummies,<sup>14</sup> and the regional Gross Domestic Product (to control for economic activity in the regions). In the case of  $\text{NO}_x$ ,  $\text{SO}_2$  and VOC we also introduce a proxy for the price of oil, the one input for which prices are readily available. We use the Brent index for crude oil (source: Direction des Ressources Énergétiques et Minérales in France, 2003), which varies with time only. The panel form of the data allows us to control for unobserved plant-specific effects. The four models are estimated using Generalized Least Squares. Estimation results are reported in Table 3.

Quality of adjustment varies from 0.11 (R-squared) in the model fitting HCl emissions to 0.25 in the model for  $\text{NO}_x$ . A large part of the emissions variability still remains unexplained by these preliminary estimations. The unit tax has the expected negative sign in all cases even if it is significant in three models over four only. Except for the case of VOC, a greater level of the unit tax leads to a significant reduced amount of pollution, all other things being equal. The elasticity of emissions with respect to the tax is -0.15 for  $\text{NO}_2$ , -1.40 for  $\text{SO}_2$ , -0.06 for VOC and -2.71 for HCl.

Many sectoral dummies are statistically significant with respect to the electricity sector, chosen as the base case. The estimation results confirm the importance of particular industries for the emissions of certain pollutants. All else equal, a firm in the coke sector or in the metallurgy sector has much higher  $\text{SO}_2$  emissions per unit of combustion capacity. Likewise, a firm in the coke sector, in the car industry or in the metallurgy sector, would have significantly higher emissions of VOC.

The coefficient of the regional GDP is almost equal to zero in all four models. So we do not find any significant impact of the regional economic activity on the level of emissions. It is likely that regional GDP is too crude an indicator to control for the level of economic activity. Future research will incorporate firm-specific variables to account for the level of economic activity (value added or turnover).

The Brent index for crude oil has a significant and negative impact on  $\text{SO}_2$  emissions. This is what was expected as most of  $\text{SO}_2$  emissions originate from energy combustion. The estimated

---

<sup>14</sup>In each model, the electricity sector is chosen as the reference.

Table 3: Estimation results for the four pollutants

	NO <sub>x</sub> emissions (t/MW)			SO <sub>2</sub> emissions (t/MW)		
	Coef.	Std. Err.	p-value	Coef.	Std. Err.	p-value
constant	4.3929	0.9625	0.0000	13.6288	1.3071	0.0000
tax	-0.0024	0.0011	0.0220	-0.0391	0.0026	0.0000
Other industries	-3.2943	1.0665	0.0020	-4.3373	1.4056	0.0020
Other nonmetallic products	1.6747	1.0625	0.1150	0.4621	1.3962	0.7410
Plastic & rubber	-2.3496	1.1315	0.0380	-1.7951	1.4781	0.2250
Chemistry	-0.2813	1.0498	0.7890	-0.7122	1.3922	0.6090
Coke	-1.8098	1.4724	0.2190	9.0411	1.9019	0.0000
Waste	7.8915	1.0468	0.0000	2.0046	1.3736	0.1440
Printing	-3.9758	1.9087	0.0370	-5.3157	2.4703	0.0310
Food & agri. products	-3.2601	1.0129	0.0010	-2.7461	1.3337	0.0390
Car industry	-3.5236	1.2303	0.0040	-4.1642	1.6392	0.0110
Extraction	-2.7548	1.7915	0.1240	0.4207	2.2287	0.8500
Paper	-2.7039	1.1142	0.0150	-0.4234	1.4778	0.7740
Textile	-3.5019	1.2296	0.0040	-2.9778	1.6360	0.0690
Metallurgy	-3.4187	1.3786	0.0130	3.4821	1.8291	0.0570
Heat production	-3.3590	0.9890	0.0010	-3.7792	1.2996	0.0040
Gas production	-0.7746	1.4550	0.5940	-5.4588	2.4056	0.0230
Iron and steel	-2.6724	1.1301	0.0180	-3.2091	1.4764	0.0300
Regional GDP	0.0000	0.0000	0.1620	0.0000	0.0000	0.0010
Brent index	0.0164	0.0095	0.0840	-0.0435	0.0088	0.0000
Nb of obs.	11,230			10,672		
R <sup>2</sup>	0.25			0.12		
	VOC emissions (t)			HCl emissions (t)		
	Coef.	Std. Err.	p-value	Coef.	Std. Err.	p-value
constant	39.2870	99.2579	0.6920	717.3484	66.9084	0.0000
tax	-0.0860	0.0703	0.2210	-2.1878	0.2646	0.0000
Other industries	107.2305	107.9028	0.3200	-317.1838	81.4641	0.0000
Other nonmetallic products	27.0947	110.9392	0.8070	-324.0153	59.1940	0.0000
Plastic & rubber	377.1087	104.5526	0.0000	-306.4785	76.7523	0.0000
Chemistry	361.9981	104.1611	0.0010	-295.0163	64.6446	0.0000
Coke	746.1684	120.1007	0.0000	-284.3979	151.9854	0.0610
Waste	-5.2562	101.9789	0.9590	-131.9511	55.4152	0.0170
Printing	395.5574	127.8858	0.0020	56.5190	302.7676	0.8520
Food & agri. products	161.7766	126.9678	0.2030	-349.6873	61.2467	0.0000
Car industry	515.7755	115.0877	0.0000	-333.3831	106.3163	0.0020
Extraction	31.4620	322.2374	0.9220	-172.4242	134.0631	0.1980
Paper	378.9330	116.7600	0.0010	-304.8827	82.8141	0.0000
Textile	132.2103	134.3641	0.3250	-342.3384	90.0767	0.0000
Metallurgy	462.2797	123.1043	0.0000	-284.9776	97.8360	0.0040
Heat production	14.8264	135.5255	0.9130	-309.7334	57.2706	0.0000
Gas production	118.5143	244.3531	0.6280	121.7373	302.5430	0.6870
Iron and steel	119.0981	118.8534	0.3160	-307.8316	74.0657	0.0000
Regional GDP	0.0000	0.0002	0.8690	0.0000	0.0001	0.8490
Brent index	-0.4268	0.7282	0.5580	.	.	.
Nb of obs.	3,061			3,320		
R <sup>2</sup>	0.20			0.11		

\* NO<sub>x</sub> include both NO<sub>2</sub> and N<sub>2</sub>O. However, we exclude N<sub>2</sub>O from the analysis because the union of chemical producers has been refusing to pay the tax for this pollutant since 1990.

coefficient is also negative in the model for VOC but it is not significant. The positive sign found in the  $\text{NO}_x$  model is somewhat surprising.

Overall, the estimations show that the tax had a significant negative effect, but that the abatement elasticity with regard to the tax rate was quite small. Furthermore, these estimations provide an upper bound on the abatement elasticity. Environmental taxes in Europe seldom operate in isolation, but are rather to be seen as a complement to traditional command-and-control regulation. A shortcoming of the current work is that we have not been able to control for the technology standards defined in operating permits for each industry. Such standards have most likely not changed over the period, however, and some of the inter-firm variation in standards may have been captured by the industrial sector dummies in the current analysis.

## 8 Conclusions

We have estimated a random-effect model for air pollution emissions on a panel data set comprising around 1,900 French firms over the period 1990-99. Despite the relatively low level of the tax, statistically significant reductions in emissions are found for emissions of  $\text{SO}_2$ ,  $\text{NO}_x$  and HCl. The estimations show that the instrument has had the largest impact on  $\text{SO}_2$  and HCl emissions. On the other hand, the overall effectiveness and economic efficiency of the French air pollution tax can only be assessed by a complete model incorporating subsidies as well as taxes. The next step in the research is therefore to include the effect of the subsidies paid out of the revenues from the tax, which in fact was earmarked for abatement subsidies.

## References

- [1] ADEME, Taxe parafiscale sur la pollution atmosphérique, Rapport d'Activité 1990/95, 1995, 1996, 1997, Agence de l'Environnement et de la Maîtrise de l'Energie, Paris, France.
- [2] Knut H. Alfsen, Hugo Birkelund, and Morten Aaserud (1995), Impacts of an EC Carbon/Energy Tax and Deregulating Thermal Power Supply on  $\text{CO}_2$ ,  $\text{SO}_2$  and  $\text{NO}_x$  Emissions, *Environmental and Resource Economics* 5(2), March 1995, 165-189.
- [3] Runar Brännlund and Bengt Kriström (2001), Too Hot to Handle: Benefits and Costs of Stimulating the Use of Biofuels in the Swedish Heating Sector, *Resource and Energy Economics* 23(4), 343-358.

- [4] Dieter Cansier and Raimond Krumm (1997), Air Pollutant Taxation: An Empirical Survey, *Ecological Economics* 23, 59-70.
- [5] Carolyn Fischer (2001a), Rebating Environmental Policy Revenues: Output-Based Allocations and Tradeable Performance Standards, RFF Discussion Paper 01-22, Washington DC: Resources for the Future.
- [6] Carolyn Fischer (2001b), Output-Based Rebating: Imperfect Competition and Imperfect Participation, manuscript, Washington DC: Resources for the Future.
- [7] Wayne B. Gray and Ronald J. Shadbegian (1994), Pollution Abatement Costs, Regulation and Plant-Level Productivity, U.S. Bureau of the Census - Working Paper CES 94-14.
- [8] Wayne B. Gray and Ronald J. Shadbegian (2001), Plant Vintage, Technology, and Environmental Regulation, U.S. Bureau of the Census - Working Paper CES 01-08.
- [9] Michael Greenstone (2001), The Impacts of Environmental Regulations on Industrial Activity: Evidence from the 1970 and 1977 Clean Air Act Amendments and the Census of Manufactures, NBER Working Paper Series, WP 8484.
- [10] J. Vernon Henderson (1996), Effects of Air Quality Regulation, *American Economic Review*, 86(4), 789-813.
- [11] Lena Höglund (2000), Essays on Environmental Regulation with Applications to Sweden, Ph.D. dissertation, Department of Economics, Göteborg University.
- [12] Paul L. Joskow and Richard Schmalensee (1998), The Political Economy of Market-Based Environmental Policy: The U.S. Acid Rain Program, *Journal of Law and Economics* 41(1), 37-83.
- [13] Paul L. Joskow, Richard Schmalensee and Elizabeth Bailey (1998), The Market for Sulfur Dioxide Emissions, *American Economic Review* 88(4), 669-685.
- [14] Suzi Kerr and David Maré (1996), Efficient Regulation Through Tradeable Permit Markets: The United States Lead Phasedown, Department of Agricultural and Resource Economics, University of Maryland at College Park, Working Paper 96-06.

- [15] Madhu Khanna and David Zilberman (1997), Incentives, precision technology and environmental protection, *Ecological Economics* 23, 25-43.
- [16] Bodil Merethe Larsen (1997), Economic Impacts of Reducing NO<sub>x</sub> Emissions in Norway, *Environmental and Resource Economics*, 9(1), January 1997, 125-132.
- [17] James C. Murdoch, Todd Sandler, and Keith Sargent (1997), A Tale of Two Collectives: Sulphur versus Nitrogen Oxides Emission Reduction in Europe, *Economica*, 64(254), May 1997, 281-301.
- [18] Louis W. Nadeau (1997), EPA Effectiveness at Reducing the Duration of Plant-Level Non-compliance, *Journal of Environmental Economics and Management*, 34, 54-78.
- [19] Robert N. Stavins (1998), What Can We Learn from the Great Policy Experiment? Lessons from the SO<sub>2</sub> Allowance Trading, *Journal of Economic Perspectives* 12(3), 69-88.
- [20] Thomas Sterner and Lena Höglund (2000), Output Based Refunding of Emissions Payments: Theory, Distribution of Costs, and International Experience, RFF Discussion Paper 00-29, Washington DC: Resources for the Future.
- [21] Joeri Van Rompuy (1997), Current SO<sub>2</sub>-NO<sub>x</sub> Regulations for Electricity Generation in Belgium: Emission Abatement Effects and Cost-Benefit Analysis, *Journal of Energy Finance and Development*, 2(2), 185-196.



## NOTE DI LAVORO DELLA FONDAZIONE ENI ENRICO MATTEI

### Fondazione Eni Enrico Mattei Working Paper Series

Our working papers are available on the Internet at the following addresses:

[http://www.feem.it/web/attiv/\\_wp.html](http://www.feem.it/web/attiv/_wp.html)

<http://papers.ssrn.com>

SUST	1.2002	<i>K. TANO, M.D. FAMINOW, M. KAMUANGA and B. SWALLOW: <u>Using Conjoint Analysis to Estimate Farmers' Preferences for Cattle Traits in West Africa</u></i>
ETA	2.2002	<i>Efrem CASTELNUOVO and Paolo SURICO: <u>What Does Monetary Policy Reveal about Central Bank's Preferences?</u></i>
WAT	3.2002	<i>Duncan KNOWLER and Edward BARBIER: <u>The Economics of a "Mixed Blessing" Effect: A Case Study of the Black Sea</u></i>
CLIM	4.2002	<i>Andreas LÖSCHEL: <u>Technological Change in Economic Models of Environmental Policy: A Survey</u></i>
VOL	5.2002	<i>Carlo CARRARO and Carmen MARCHIORI: <u>Stable Coalitions</u></i>
CLIM	6.2002	<i>Marzio GALEOTTI, Alessandro LANZA and Matteo MANERA: <u>Rockets and Feathers Revisited: An International Comparison on European Gasoline Markets</u></i>
ETA	7.2002	<i>Effrosyni DIAMANTOUDI and Eftichios S. SARTZETAKIS: <u>Stable International Environmental Agreements: An Analytical Approach</u></i>
KNOW	8.2002	<i>Alain DESDOIGTS: <u>Neoclassical Convergence Versus Technological Catch-up: A Contribution for Reaching a Consensus</u></i>
NRM	9.2002	<i>Giuseppe DI VITA: <u>Renewable Resources and Waste Recycling</u></i>
KNOW	10.2002	<i>Giorgio BRUNELLO: <u>Is Training More Frequent when Wage Compression is Higher? Evidence from 11 European Countries</u></i>
ETA	11.2002	<i>Mordecai KURZ, Hehui JIN and Maurizio MOTOLESE: <u>Endogenous Fluctuations and the Role of Monetary Policy</u></i>
KNOW	12.2002	<i>Reyer GERLAGH and Marjan W. HOFKES: <u>Escaping Lock-in: The Scope for a Transition towards Sustainable Growth?</u></i>
NRM	13.2002	<i>Michele MORETTO and Paolo ROSATO: <u>The Use of Common Property Resources: A Dynamic Model</u></i>
CLIM	14.2002	<i>Philippe QUIRION: <u>Macroeconomic Effects of an Energy Saving Policy in the Public Sector</u></i>
CLIM	15.2002	<i>Roberto ROSON: <u>Dynamic and Distributional Effects of Environmental Revenue Recycling Schemes: Simulations with a General Equilibrium Model of the Italian Economy</u></i>
CLIM	16.2002	<i>Francesco RICCI (I): <u>Environmental Policy Growth when Inputs are Differentiated in Pollution Intensity</u></i>
ETA	17.2002	<i>Alberto PETRUCCI: <u>Devaluation (Levels versus Rates) and Balance of Payments in a Cash-in-Advance Economy</u></i>
Coalition Theory	18.2002	<i>László Á. KÓCZY (liv): <u>The Core in the Presence of Externalities</u></i>
Network Theory	19.2002	<i>Steven J. BRAMS, Michael A. JONES and D. Marc KILGOUR (liv): <u>Single-Peakedness and Disconnected Coalitions</u></i>
Coalition Theory	20.2002	<i>Guillaume HAERINGER (liv): <u>On the Stability of Cooperation Structures</u></i>
Network Theory	21.2002	<i>Fausto CAVALLARO and Luigi CIRAOLO: <u>Economic and Environmental Sustainability: A Dynamic Approach in Insular Systems</u></i>
CLIM	22.2002	<i>Barbara BUCHNER, Carlo CARRARO, Igor CERSOSIMO and Carmen MARCHIORI: <u>Back to Kyoto? US Participation and the Linkage between R&amp;D and Climate Cooperation</u></i>
CLIM	23.2002	<i>Andreas LÖSCHEL and ZhongXIANG ZHANG: <u>The Economic and Environmental Implications of the US Repudiation of the Kyoto Protocol and the Subsequent Deals in Bonn and Marrakech</u></i>
ETA	24.2002	<i>Marzio GALEOTTI, Louis J. MACCINI and Fabio SCHIANTARELLI: <u>Inventories, Employment and Hours</u></i>
CLIM	25.2002	<i>Hannes EGLI: <u>Are Cross-Country Studies of the Environmental Kuznets Curve Misleading? New Evidence from Time Series Data for Germany</u></i>
ETA	26.2002	<i>Adam B. JAFFE, Richard G. NEWELL and Robert N. STAVINS: <u>Environmental Policy and Technological Change</u></i>
SUST	27.2002	<i>Joseph C. COOPER and Giovanni SIGNORELLO: <u>Farmer Premiums for the Voluntary Adoption of Conservation Plans</u></i>
SUST	28.2002	<i><u>The ANSEA Network: Towards An Analytical Strategic Environmental Assessment</u></i>
KNOW	29.2002	<i>Paolo SURICO: <u>Geographic Concentration and Increasing Returns: a Survey of Evidence</u></i>
ETA	30.2002	<i>Robert N. STAVINS: <u>Lessons from the American Experiment with Market-Based Environmental Policies</u></i>

NRM	31.2002	<i>Carlo GIUPPONI and Paolo ROSATO: <u>Multi-Criteria Analysis and Decision-Support for Water Management at the Catchment Scale: An Application to Diffuse Pollution Control in the Venice Lagoon</u></i>
NRM	32.2002	<i>Robert N. STAVINS: <u>National Environmental Policy During the Clinton Years</u></i>
KNOW	33.2002	<i>A. SOUBEYRAN and H. STAHN : <u>Do Investments in Specialized Knowledge Lead to Composite Good Industries?</u></i>
KNOW	34.2002	<i>G. BRUNELLO, M.L. PARISI and Daniela SONEDDA: <u>Labor Taxes, Wage Setting and the Relative Wage Effect</u></i>
CLIM	35.2002	<i>C. BOEMARE and P. QUIRION (lv): <u>Implementing Greenhouse Gas Trading in Europe: Lessons from Economic Theory and International Experiences</u></i>
CLIM	36.2002	<i>T. TIETENBERG (lv): <u>The Tradable Permits Approach to Protecting the Commons: What Have We Learned?</u></i>
CLIM	37.2002	<i>K. REHDANZ and R.J.S. TOL (lv): <u>On National and International Trade in Greenhouse Gas Emission Permits</u></i>
CLIM	38.2002	<i>C. FISCHER (lv): <u>Multinational Taxation and International Emissions Trading</u></i>
SUST	39.2002	<i>G. SIGNORELLO and G. PAPPALARDO: <u>Farm Animal Biodiversity Conservation Activities in Europe under the Framework of Agenda 2000</u></i>
NRM	40.2002	<i>S.M. CAVANAGH, W. M. HANEMANN and R. N. STAVINS: <u>Muffled Price Signals: Household Water Demand under Increasing-Block Prices</u></i>
NRM	41.2002	<i>A. J. PLANTINGA, R. N. LUBOWSKI and R. N. STAVINS: <u>The Effects of Potential Land Development on Agricultural Land Prices</u></i>
CLIM	42.2002	<i>C. OHL (lvi): <u>Inducing Environmental Co-operation by the Design of Emission Permits</u></i>
CLIM	43.2002	<i>J. EYCKMANS, D. VAN REGEMORTER and V. VAN STEENBERGHE (lvi): <u>Is Kyoto Fatally Flawed? An Analysis with MacGEM</u></i>
CLIM	44.2002	<i>A. ANTOCI and S. BORGHESI (lvi): <u>Working Too Much in a Polluted World: A North-South Evolutionary Model</u></i>
ETA	45.2002	<i>P. G. FREDRIKSSON, Johan A. LIST and Daniel MILLIMET (lvi): <u>Chasing the Smokestack: Strategic Policymaking with Multiple Instruments</u></i>
ETA	46.2002	<i>Z. YU (lvi): <u>A Theory of Strategic Vertical DFI and the Missing Pollution-Haven Effect</u></i>
SUST	47.2002	<i>Y. H. FARZIN: <u>Can an Exhaustible Resource Economy Be Sustainable?</u></i>
SUST	48.2002	<i>Y. H. FARZIN: <u>Sustainability and Hamiltonian Value</u></i>
KNOW	49.2002	<i>C. PIGA and M. VIVARELLI: <u>Cooperation in R&amp;D and Sample Selection</u></i>
Coalition	50.2002	<i>M. SERTEL and A. SLINKO (liv): <u>Ranking Committees, Words or Multisets</u></i>
Theory		
Network		
Coalition	51.2002	<i>Sergio CURRARINI (liv): <u>Stable Organizations with Externalities</u></i>
Theory		
Network		
ETA	52.2002	<i>Robert N. STAVINS: <u>Experience with Market-Based Policy Instruments</u></i>
ETA	53.2002	<i>C.C. JAEGER, M. LEIMBACH, C. CARRARO, K. HASSELMANN, J.C. HOURCADE, A. KEELER and R. KLEIN (liii): <u>Integrated Assessment Modeling: Modules for Cooperation</u></i>
CLIM	54.2002	<i>Scott BARRETT (liii): <u>Towards a Better Climate Treaty</u></i>
ETA	55.2002	<i>Richard G. NEWELL and Robert N. STAVINS: <u>Cost Heterogeneity and the Potential Savings from Market-Based Policies</u></i>
SUST	56.2002	<i>Paolo ROSATO and Edi DEFRANCESCO: <u>Individual Travel Cost Method and Flow Fixed Costs</u></i>
SUST	57.2002	<i>Vladimir KOTOV and Elena NIKITINA (lvii): <u>Reorganisation of Environmental Policy in Russia: The Decade of Success and Failures in Implementation of Perspective Quests</u></i>
SUST	58.2002	<i>Vladimir KOTOV (lvii): <u>Policy in Transition: New Framework for Russia's Climate Policy</u></i>
SUST	59.2002	<i>Fanny MISSELDT and Arturo VILLAVICENCO (lvii): <u>How Can Economies in Transition Pursue Emissions Trading or Joint Implementation?</u></i>
VOL	60.2002	<i>Giovanni DI BARTOLOMEO, Jacob ENGWERDA, Joseph PLASMANS and Bas VAN AARLE: <u>Staying Together or Breaking Apart: Policy-Makers' Endogenous Coalitions Formation in the European Economic and Monetary Union</u></i>
ETA	61.2002	<i>Robert N. STAVINS, Alexander F. WAGNER and Gernot WAGNER: <u>Interpreting Sustainability in Economic Terms: Dynamic Efficiency Plus Intergenerational Equity</u></i>
PRIV	62.2002	<i>Carlo CAPUANO: <u>Demand Growth, Entry and Collusion Sustainability</u></i>
PRIV	63.2002	<i>Federico MUNARI and Raffaele ORIANI: <u>Privatization and R&amp;D Performance: An Empirical Analysis Based on Tobin's Q</u></i>
PRIV	64.2002	<i>Federico MUNARI and Maurizio SOBRERO: <u>The Effects of Privatization on R&amp;D Investments and Patent Productivity</u></i>
SUST	65.2002	<i>Orley ASHENFELTER and Michael GREENSTONE: <u>Using Mandated Speed Limits to Measure the Value of a Statistical Life</u></i>
ETA	66.2002	<i>Paolo SURICO: <u>US Monetary Policy Rules: the Case for Asymmetric Preferences</u></i>
PRIV	67.2002	<i>Rinaldo BRAU and Massimo FLORIO: <u>Privatisations as Price Reforms: Evaluating Consumers' Welfare Changes in the U.K.</u></i>
CLIM	68.2002	<i>Barbara K. BUCHNER and Roberto ROSON: <u>Conflicting Perspectives in Trade and Environmental Negotiations</u></i>
CLIM	69.2002	<i>Philippe QUIRION: <u>Complying with the Kyoto Protocol under Uncertainty: Taxes or Tradable Permits?</u></i>
SUST	70.2002	<i>Anna ALBERINI, Patrizia RIGANTI and Alberto LONGO: <u>Can People Value the Aesthetic and Use Services of Urban Sites? Evidence from a Survey of Belfast Residents</u></i>
SUST	71.2002	<i>Marco PERCOCO: <u>Discounting Environmental Effects in Project Appraisal</u></i>

NRM	72.2002	<i>Philippe BONTEMS and Pascal FAVARD: <u>Input Use and Capacity Constraint under Uncertainty: The Case of Irrigation</u></i>
PRIV	73.2002	<i>Mohammed OMRAN: <u>The Performance of State-Owned Enterprises and Newly Privatized Firms: Empirical Evidence from Egypt</u></i>
PRIV	74.2002	<i>Mike BURKART, Fausto PANUNZI and Andrei SHLEIFER: <u>Family Firms</u></i>
PRIV	75.2002	<i>Emmanuelle AURIOL, Pierre M. PICARD: <u>Privatizations in Developing Countries and the Government Budget Constraint</u></i>
PRIV	76.2002	<i>Nichole M. CASTATER: <u>Privatization as a Means to Societal Transformation: An Empirical Study of Privatization in Central and Eastern Europe and the Former Soviet Union</u></i>
PRIV	77.2002	<i>Christoph LÜLSFESMANN: <u>Benevolent Government, Managerial Incentives, and the Virtues of Privatization</u></i>
PRIV	78.2002	<i>Kate BISHOP, Igor FILATOTCHEV and Tomasz MICKIEWICZ: <u>Endogenous Ownership Structure: Factors Affecting the Post-Privatisation Equity in Largest Hungarian Firms</u></i>
PRIV	79.2002	<i>Theodora WELCH and Rick MOLZ: <u>How Does Trade Sale Privatization Work? Evidence from the Fixed-Line Telecommunications Sector in Developing Economies</u></i>
PRIV	80.2002	<i>Alberto R. PETRUCCI: <u>Government Debt, Agent Heterogeneity and Wealth Displacement in a Small Open Economy</u></i>
CLIM	81.2002	<i>Timothy SWANSON and Robin MASON (Iv): <u>The Impact of International Environmental Agreements: The Case of the Montreal Protocol</u></i>
PRIV	82.2002	<i>George R.G. CLARKE and Lixin Colin XU: <u>Privatization, Competition and Corruption: How Characteristics of Bribe Takers and Payers Affect Bribe Payments to Utilities</u></i>
PRIV	83.2002	<i>Massimo FLORIO and Katuscia MANZONI: <u>The Abnormal Returns of UK Privatisations: From Underpricing to Outperformance</u></i>
NRM	84.2002	<i>Nelson LOURENÇO, Carlos RUSSO MACHADO, Maria do ROSÁRIO JORGE and Luís RODRIGUES: <u>An Integrated Approach to Understand Territory Dynamics. The Coastal Alentejo (Portugal)</u></i>
CLIM	85.2002	<i>Peter ZAPFEL and Matti VAINIO (Iv): <u>Pathways to European Greenhouse Gas Emissions Trading History and Misconceptions</u></i>
CLIM	86.2002	<i>Pierre COURTOIS: <u>Influence Processes in Climate Change Negotiations: Modelling the Rounds</u></i>
ETA	87.2002	<i>Vito FRAGNELLI and Maria Erminia MARINA (Iviii): <u>Environmental Pollution Risk and Insurance</u></i>
ETA	88.2002	<i>Laurent FRANCKX (Iviii): <u>Environmental Enforcement with Endogenous Ambient Monitoring</u></i>
ETA	89.2002	<i>Timo GOESCHL and Timothy M. SWANSON (Iviii): <u>Lost Horizons. The noncooperative management of an evolutionary biological system.</u></i>
ETA	90.2002	<i>Hans KEIDING (Iviii): <u>Environmental Effects of Consumption: An Approach Using DEA and Cost Sharing</u></i>
ETA	91.2002	<i>Wietze LISE (Iviii): <u>A Game Model of People's Participation in Forest Management in Northern India</u></i>
CLIM	92.2002	<i>Jens HORBACH: <u>Structural Change and Environmental Kuznets Curves</u></i>
ETA	93.2002	<i>Martin P. GROSSKOPF: <u>Towards a More Appropriate Method for Determining the Optimal Scale of Production Units</u></i>
VOL	94.2002	<i>Scott BARRETT and Robert STAVINS: <u>Increasing Participation and Compliance in International Climate Change Agreements</u></i>
CLIM	95.2002	<i>Banu BAYRAMOGLU LISE and Wietze LISE: <u>Climate Change, Environmental NGOs and Public Awareness in the Netherlands: Perceptions and Reality</u></i>
CLIM	96.2002	<i>Matthieu GLACHANT: <u>The Political Economy of Emission Tax Design in Environmental Policy</u></i>
KNOW	97.2002	<i>Kenn ARIGA and Giorgio BRUNELLO: <u>Are the More Educated Receiving More Training? Evidence from Thailand</u></i>
ETA	98.2002	<i>Gianfranco FORTE and Matteo MANERA: <u>Forecasting Volatility in European Stock Markets with Non-linear GARCH Models</u></i>
ETA	99.2002	<i>Geoffrey HEAL: <u>Bundling Biodiversity</u></i>
ETA	100.2002	<i>Geoffrey HEAL, Brian WALKER, Simon LEVIN, Kenneth ARROW, Partha DASGUPTA, Gretchen DAILY, Paul EHRlich, Karl-Goran MALER, Nils KAUTSKY, Jane LUBCHENCO, Steve SCHNEIDER and David STARRETT: <u>Genetic Diversity and Interdependent Crop Choices in Agriculture</u></i>
ETA	101.2002	<i>Geoffrey HEAL: <u>Biodiversity and Globalization</u></i>
VOL	102.2002	<i>Andreas LANGE: <u>Heterogeneous International Agreements – If per capita emission levels matter</u></i>
ETA	103.2002	<i>Pierre-André JOUVET and Walid OUESLATI: <u>Tax Reform and Public Spending Trade-offs in an Endogenous Growth Model with Environmental Externalities</u></i>
ETA	104.2002	<i>Anna BOTTASSO and Alessandro SEMBENELLI: <u>Does Ownership Affect Firms' Efficiency? Panel Data Evidence on Italy</u></i>
PRIV	105.2002	<i>Bernardo BORTOLOTTI, Frank DE JONG, Giovanna NICODANO and Ibolya SCHINDELE: <u>Privatization and Stock Market Liquidity</u></i>
ETA	106.2002	<i>Haruo IMAI and Mayumi HORIE (Iviii): <u>Pre-Negotiation for an International Emission Reduction Game</u></i>
PRIV	107.2002	<i>Sudeshna GHOSH BANERJEE and Michael C. MUNGER: <u>Move to Markets? An Empirical Analysis of Privatisation in Developing Countries</u></i>
PRIV	108.2002	<i>Guillaume GIRMENS and Michel GUILLARD: <u>Privatization and Investment: Crowding-Out Effect vs Financial Diversification</u></i>
PRIV	109.2002	<i>Alberto CHONG and Florencio LÓPEZ-DE-SILANES: <u>Privatization and Labor Force Restructuring Around the World</u></i>
PRIV	110.2002	<i>Nandini GUPTA: <u>Partial Privatization and Firm Performance</u></i>
PRIV	111.2002	<i>François DEGEORGE, Dirk JENTER, Alberto MOEL and Peter TUFANO: <u>Selling Company Shares to Reluctant Employees: France Telecom's Experience</u></i>

PRIV	112.2002	<i>Isaac OTCHERE</i> : <u>Intra-Industry Effects of Privatization Announcements: Evidence from Developed and Developing Countries</u>
PRIV	113.2002	<i>Yannis KATSOULAKOS and Elissavet LIKOYANNI</i> : <u>Fiscal and Other Macroeconomic Effects of Privatization</u>
PRIV	114.2002	<i>Guillaume GIRMENS</i> : <u>Privatization, International Asset Trade and Financial Markets</u>
PRIV	115.2002	<i>D. Teja FLOTHO</i> : <u>A Note on Consumption Correlations and European Financial Integration</u>
PRIV	116.2002	<i>Ibolya SCHINDELE and Enrico C. PEROTTI</i> : <u>Pricing Initial Public Offerings in Premature Capital Markets: The Case of Hungary</u>
PRIV	1.2003	<i>Gabriella CHIESA and Giovanna NICODANO</i> : <u>Privatization and Financial Market Development: Theoretical Issues</u>
PRIV	2.2003	<i>Ibolya SCHINDELE</i> : <u>Theory of Privatization in Eastern Europe: Literature Review</u>
PRIV	3.2003	<i>Wietze LISE, Claudia KEMFERT and Richard S.J. TOL</i> : <u>Strategic Action in the Liberalised German Electricity Market</u>
CLIM	4.2003	<i>Laura MARSILLANI and Thomas I. RENSTRÖM</i> : <u>Environmental Policy and Capital Movements: The Role of Government Commitment</u>
KNOW	5.2003	<i>Reyer GERLAGH</i> : <u>Induced Technological Change under Technological Competition</u>
ETA	6.2003	<i>Efrem CASTELNUOVO</i> : <u>Squeezing the Interest Rate Smoothing Weight with a Hybrid Expectations Model</u>
SIEV	7.2003	<i>Anna ALBERINI, Alberto LONGO, Stefania TONIN, Francesco TROMBETTA and Margherita TURVANI</i> : <u>The Role of Liability, Regulation and Economic Incentives in Brownfield Remediation and Redevelopment: Evidence from Surveys of Developers</u>
NRM	8.2003	<i>Elissaios PAPYRAKIS and Reyner GERLAGH</i> : <u>Natural Resources: A Blessing or a Curse?</u>
CLIM	9.2003	<i>A. CAPARRÓS, J.-C. PEREAU and T. TAZDAÏT</i> : <u>North-South Climate Change Negotiations: a Sequential Game with Asymmetric Information</u>
KNOW	10.2003	<i>Giorgio BRUNELLO and Daniele CHECCHI</i> : <u>School Quality and Family Background in Italy</u>
CLIM	11.2003	<i>Efrem CASTELNUOVO and Marzio GALEOTTI</i> : <u>Learning By Doing vs Learning By Researching in a Model of Climate Change Policy Analysis</u>
KNOW	12.2003	<i>Carole Maignan, Gianmarco OTTAVIANO and Dino PINELLI (eds.)</i> : <u>Economic Growth, Innovation, Cultural Diversity: What are we all talking about? A critical survey of the state-of-the-art</u>
KNOW	13.2003	<i>Carole Maignan, Gianmarco OTTAVIANO, Dino PINELLI and Francesco RULLANI (Ivix)</i> : <u>Bio-Ecological Diversity vs. Socio-Economic Diversity. A Comparison of Existing Measures</u>
KNOW	14.2003	<i>Maddy JANSSENS and Chris STEYAERT (Ivix)</i> : <u>Theories of Diversity within Organisation Studies: Debates and Future Trajectories</u>
KNOW	15.2003	<i>Tuzin BAYCAN LEVENT, Enno MASUREL and Peter NIJKAMP (Ivix)</i> : <u>Diversity in Entrepreneurship: Ethnic and Female Roles in Urban Economic Life</u>
KNOW	16.2003	<i>Alexandra BITUSIKOVA (Ivix)</i> : <u>Post-Communist City on its Way from Grey to Colourful: The Case Study from Slovakia</u>
KNOW	17.2003	<i>Billy E. VAUGHN and Katarina MLEKOV (Ivix)</i> : <u>A Stage Model of Developing an Inclusive Community</u>
KNOW	18.2003	<i>Selma van LONDEN and Arie de RUIJTER (Ivix)</i> : <u>Managing Diversity in a Globalizing World</u>
Coalition Theory Network	19.2003	<i>Sergio CURRARINI</i> : <u>On the Stability of Hierarchies in Games with Externalities</u>
PRIV	20.2003	<i>Giacomo CALZOLARI and Alessandro PAVAN (Ivix)</i> : <u>Monopoly with Resale</u>
PRIV	21.2003	<i>Claudio MEZZETTI (Ivix)</i> : <u>Auction Design with Interdependent Valuations: The Generalized Revelation Principle, Efficiency, Full Surplus Extraction and Information Acquisition</u>
PRIV	22.2003	<i>Marco LiCalzi and Alessandro PAVAN (Ivix)</i> : <u>Tilting the Supply Schedule to Enhance Competition in Uniform-Price Auctions</u>
PRIV	23.2003	<i>David ETTINGER (Ivix)</i> : <u>Bidding among Friends and Enemies</u>
PRIV	24.2003	<i>Hannu VARTIAINEN (Ivix)</i> : <u>Auction Design without Commitment</u>
PRIV	25.2003	<i>Matti KELOHARJU, Kjell G. NYBORG and Kristian RYDQVIST (Ivix)</i> : <u>Strategic Behavior and Underpricing in Uniform Price Auctions: Evidence from Finnish Treasury Auctions</u>
PRIV	26.2003	<i>Christine A. PARLOUR and Uday RAJAN (Ivix)</i> : <u>Rationing in IPOs</u>
PRIV	27.2003	<i>Kjell G. NYBORG and Ilya A. STREBULAIEV (Ivix)</i> : <u>Multiple Unit Auctions and Short Squeezes</u>
PRIV	28.2003	<i>Anders LUNANDER and Jan-Eric NILSSON (Ivix)</i> : <u>Taking the Lab to the Field: Experimental Tests of Alternative Mechanisms to Procure Multiple Contracts</u>
PRIV	29.2003	<i>TangaMcDANIEL and Karsten NEUHOFF (Ivix)</i> : <u>Use of Long-term Auctions for Network Investment</u>
PRIV	30.2003	<i>Emiel MAASLAND and Sander ONDERSTAL (Ivix)</i> : <u>Auctions with Financial Externalities</u>
ETA	31.2003	<i>Michael FINUS and Bianca RUNDSHAGEN</i> : <u>A Non-cooperative Foundation of Core-Stability in Positive Externality NTU-Coalition Games</u>
KNOW	32.2003	<i>Michele MORETTO</i> : <u>Competition and Irreversible Investments under Uncertainty</u>
PRIV	33.2003	<i>Philippe QUIRION</i> : <u>Relative Quotas: Correct Answer to Uncertainty or Case of Regulatory Capture?</u>
KNOW	34.2003	<i>Giuseppe MEDA, Claudio PIGA and Donald SIEGEL</i> : <u>On the Relationship between R&amp;D and Productivity: A Treatment Effect Analysis</u>
ETA	35.2003	<i>Alessandra DEL BOCA, Marzio GALEOTTI and Paola ROTA</i> : <u>Non-convexities in the Adjustment of Different Capital Inputs: A Firm-level Investigation</u>

GG	36.2003	<i>Matthieu GLACHANT</i> : <u>Voluntary Agreements under Endogenous Legislative Threats</u>
PRIV	37.2003	<i>Narjess BOUBAKRI, Jean-Claude COSSET and Omrane GUEDHAMI</i> : <u>Postprivatization Corporate Governance: the Role of Ownership Structure and Investor Protection</u>
CLIM	38.2003	<i>Rolf GOLOBBEK and Michael HOEL</i> : <u>Climate Policy under Technology Spillovers</u>
KNOW	39.2003	<i>Slim BEN YOUSSEF</i> : <u>Transboundary Pollution, R&amp;D Spillovers and International Trade</u>
CTN	40.2003	<i>Carlo CARRARO and Carmen MARCHIORI</i> : <u>Endogenous Strategic Issue Linkage in International Negotiations</u>
KNOW	41.2003	<i>Sonia OREFFICE</i> : <u>Abortion and Female Power in the Household: Evidence from Labor Supply</u>
KNOW	42.2003	<i>Timo GOESCHL and Timothy SWANSON</i> : <u>On Biology and Technology: The Economics of Managing Biotechnologies</u>
ETA	43.2003	<i>Giorgio Busetti and Matteo MANERA</i> : <u>STAR-GARCH Models for Stock Market Interactions in the Pacific Basin Region, Japan and US</u>
CLIM	44.2003	<i>Katrin MILLOCK and Céline NAUGES</i> : <u>The French Tax on Air Pollution: Some Preliminary Results on its Effectiveness</u>

(I) This paper was presented at the Workshop “Growth, Environmental Policies and Sustainability” organised by the Fondazione Eni Enrico Mattei, Venice, June 1, 2001

(li) This paper was presented at the Fourth Toulouse Conference on Environment and Resource Economics on “Property Rights, Institutions and Management of Environmental and Natural Resources”, organised by Fondazione Eni Enrico Mattei, IDEI and INRA and sponsored by MATE, Toulouse, May 3-4, 2001

(lii) This paper was presented at the International Conference on “Economic Valuation of Environmental Goods”, organised by Fondazione Eni Enrico Mattei in cooperation with CORILA, Venice, May 11, 2001

(liii) This paper was circulated at the International Conference on “Climate Policy – Do We Need a New Approach?”, jointly organised by Fondazione Eni Enrico Mattei, Stanford University and Venice International University, Isola di San Servolo, Venice, September 6-8, 2001

(liv) This paper was presented at the Seventh Meeting of the Coalition Theory Network organised by the Fondazione Eni Enrico Mattei and the CORE, Université Catholique de Louvain, Venice, Italy, January 11-12, 2002

(lv) This paper was presented at the First Workshop of the Concerted Action on Tradable Emission Permits (CATEP) organised by the Fondazione Eni Enrico Mattei, Venice, Italy, December 3-4, 2001

(lvi) This paper was presented at the ESF EURESCO Conference on Environmental Policy in a Global Economy “The International Dimension of Environmental Policy”, organised with the collaboration of the Fondazione Eni Enrico Mattei, Acquafredda di Maratea, October 6-11, 2001

(lvii) This paper was presented at the First Workshop of “CFEWE – Carbon Flows between Eastern and Western Europe”, organised by the Fondazione Eni Enrico Mattei and Zentrum für Europäische Integrationsforschung (ZEI), Milan, July 5-6, 2001

(lviii) This paper was presented at the Workshop on “Game Practice and the Environment”, jointly organised by Università del Piemonte Orientale and Fondazione Eni Enrico Mattei, Alessandria, April 12-13, 2002

(lvix) This paper was presented at the ENGIME Workshop on “Mapping Diversity”, Leuven, May 16-17, 2002

(lvx) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications”, organised by the Fondazione Eni Enrico Mattei, Milan, September 26-28, 2002

## 2002 SERIES

<b>CLIM</b>	<i>Climate Change Modelling and Policy</i> (Editor: Marzio Galeotti )
<b>VOL</b>	<i>Voluntary and International Agreements</i> (Editor: Carlo Carraro)
<b>SUST</b>	<i>Sustainability Indicators and Environmental Valuation</i> (Editor: Carlo Carraro)
<b>NRM</b>	<i>Natural Resources Management</i> (Editor: Carlo Giupponi)
<b>KNOW</b>	<i>Knowledge, Technology, Human Capital</i> (Editor: Dino Pinelli)
<b>MGMT</b>	<i>Corporate Sustainable Management</i> (Editor: Andrea Marsanich)
<b>PRIV</b>	<i>Privatisation, Regulation, Antitrust</i> (Editor: Bernardo Bortolotti)
<b>ETA</b>	<i>Economic Theory and Applications</i> (Editor: Carlo Carraro)

## 2003 SERIES

<b>CLIM</b>	<i>Climate Change Modelling and Policy</i> (Editor: Marzio Galeotti )
<b>GG</b>	<i>Global Governance</i> (Editor: Carlo Carraro)
<b>SIEV</b>	<i>Sustainability Indicators and Environmental Valuation</i> (Editor: Anna Alberini)
<b>NRM</b>	<i>Natural Resources Management</i> (Editor: Carlo Giupponi)
<b>KNOW</b>	<i>Knowledge, Technology, Human Capital</i> (Editor: Gianmarco Ottaviano)
<b>IEM</b>	<i>International Energy Markets</i> (Editor: Anil Markandya)
<b>CSRM</b>	<i>Corporate Social Responsibility and Management</i> (Editor: Sabina Ratti)
<b>PRIV</b>	<i>Privatisation, Regulation, Antitrust</i> (Editor: Bernardo Bortolotti)
<b>ETA</b>	<i>Economic Theory and Applications</i> (Editor: Carlo Carraro)
<b>CTN</b>	<i>Coalition Theory Network</i>