Environmental Taxes: A Comparison of French and Swedish Experience from Taxes on Industrial Air Pollution*

Katrin Millock, Céline Nauges and Thomas Sterner**

Introduction

Environmental taxes are used to quite a large extent in European countries. OECD data show that these taxes represent around 3 percent of GDP on average (OECD 2003). The coverage and levels of environmental taxes is highly variable between countries. For example, Sweden, Norway and Denmark charge a tax on sulphur emissions (measured as sulphur dioxide, SO_2) which is approximately EUR 1300/tonne in Denmark and EUR 1600/tonne in Sweden, whereas SO_2 taxes in Italy, France, Switzerland and Spain, for instance, are all less than EUR 50/tonne (Sterner 2002). Most often, though, such taxes are used as complements to existing command-and-control regulation by emission standards. In order to overcome political resistance to environmental taxes, some countries adopted a system of earmarking under which the revenues of the charge are returned to the aggregate population of taxed firms.

In Sweden, the charge on NOx emissions from industrial boilers is automatically and fully refunded to the industries that paid the tax on the basis of their energy use (Sterner and Höglund 2000). This has led to a large number of abatement investments, fuel switching and other measures that reduced emission coefficients by about 50 percent within just 5 years for the 190 large plants that were first targeted. These plants now have very low emissions by international standards. The French air pollution tax from 1985–1999 constitutes another example of such an earmarked environmental tax, of which the revenues were used to subsidize pollution-reducing investments (abatement) at tax-paying emission sources.

Here we present recent empirical evidence on the ex post efficiency of this environmental tax. The French tax on air pollution partly resembles the Swedish NOx charge in that revenues were rebated back to industry, although in a more indirect manner (the firms have to apply for subsidies for specific abatement investments). Also, in Sweden, the tax rates for SO_2 and NO_x emissions are almost 100 times higher than the French tax rates. Notwithstanding, the analysis is of some interest since we use unique panel data on plant characteristics in order to assess the ex post effect of the combined tax and subsidy.

The French tax on air pollution

The French tax on air pollution ("taxe parafiscale sur la pollution atmosphérique", la TPPA) that we evaluate here was introduced initially in 1985 for SO_2 emissions, and subsequently extended in 1990 to encompass NO_x[1] and hydrochloric acid (HCl) and then in 1995 also emissions of volatile organic compounds (VOC)[2]. From 1990 onwards, the tax was imposed on any entity that fulfilled 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_2, NO_x, 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 targeting SO_2, NO_x, and HCl emissions was set at a rate of approximately EUR 23/tonne. It was increased in 1995 to EUR 28/tonne, and again in 1998 to EUR 38/tonne for NO_x and VOC only. If the total tax due was less than EUR 153 for a unit, no tax was levied. This made for a total of tax-paying sources ranging from 1200 in 1990 to nearly 1500 in 1999. The system targeted air pollution from fixed sources only and did not comprise emissions from the transport sector.

The tax was administered by the French Agency for Environment and Energy Management

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** Katrin Millock is chargé de recherche CNRS, based at CIRED, Céline Nauges is chargé de recherche LEERNA-INRA, and Thomas Sterner is Professor in Environmental Economics, Department of Economics, University of Gothenburg, Sweden, and University Fellow, Resources For the Future, Washington DC.

[1] The tax is levied on the sum of nitrogen oxide (NO) and nitrogen dioxide (NO2), expressed in units of NO2, and nitrous oxide (N2O).

[2] The extension in 1995 also included small particulate matter, but at that date the tax rate was set at zero for those emissions. In the empirical analysis presented here, we concentrate on the three major pollutants: SO2, NOx and VOC.

(ADEME)[3] which received 6 percent of the tax revenues towards its administration costs. The system was based on self-reporting of emissions from the previous year, and ADEME reports a high level of enforcement: over 90 percent of taxes due were actually paid. The revenues from the tax were earmarked for subsidies to abatement investments or for research and development, corresponding to 75 percent of total tax revenues. Any plant subject to the TPPA could apply for a subsidy, which was awarded according to percentage rates of the additional fixed capital investment for emission reductions: 15 percent for standard abatement technologies, and 30 percent for particularly innovative technologies. There was also an additional 10 percent subsidy for small and medium-sized companies. A study of ADEME data shows that almost all applications were funded, and in this sense, there was to a certain extent an automatic refunding of the tax revenues to the aggregate population of companies. The distributional impact, however, depended on whether a plant took the initiative to ask for an abatement subsidy.

In the year 2000, the TPPA was replaced by a general pollution tax[4] levied by the customs authorities and no longer administered by ADEME, which nevertheless continues to handle requests for abatement subsidies paid out of the general government budget. Our analysis encompasses the period when the TPPA was an integrated earmarked tax system.

Applied analysis

The empirical analysis (Millock and Nauges 2003b) aims to explain the level of emissions by a plant, controlling for the tax rate, the characteristics of the plant in terms of its production process (maximum combustion capacity and energy consumption) and financial information available at the firm level (value added, self-financing capacity). We also control for technological change or equivalently for subsidies requested from ADEME by a plant willing to invest in an abatement technology. The choice of the plant to benefit from the system of subsidies, which may be endogenous in the model, is described as a function of the tax rate and firm level data, namely, the number of employees, self-financing capacity and value added. We do not observe any penalty in case of non-compliance but we use the average number of measurement points with at least one exceedance of an hour of the air quality standards as a proxy for the compliance level in the region where the plant is located.

Information regarding emissions, taxes, and subsidies were collected at ADEME for each plant subject to taxation according to French air pollution regulation over the period 1990-98. A search for plant ID numbers allowed us to match the existing plant-level emission data with firm-level data from the annual business survey made by the French Ministry of Industry. Finally, in order to include the effect of differences in compliance and enforcement of technology based standards, we have added data from IFEN, the French National Institute of the Environment, on exceedance of air quality standards.

The analysis focuses on three pollutants (SO_2, NO_x, VOC) and five industrial sectors (plastic and rubber, cars, iron and steel, coke, and chemistry). These sectors were chosen because of their large contribution to overall pollution and because of their high rate of subsidy requests for pollution abatement. The sector of plastic and rubber, and the car industry are VOC emitters, whereas the other three sectors primarily emit SO_2 and NO_x.

The main objective of the study was to evaluate the abatement elasticity with regard to the tax and the subsidy. Separate estimations were made for each of the five sectors. In general, the tax had a significant negative impact on VOC and SO_2 emissions, but not on NOx emissions (for which abatement is technically more difficult). All else equal, the higher the tax rate, the higher the probability that the firm applied for an abatement subsidy. The effect of the subsidy, however, generally seemed to have increased emissions significantly and to an extent that dwarfed the negative impact of the tax. Finally, the impact of business data is often found significant but varies by sector. We describe below in more detail the impact of each group of variables.

Tax and subsidy

Table 1 sums up the main results regarding the impact of the tax and the subsidy on emissions by sector.

[3] Agence de l'Environnement et de la Maîtrise de l'Energie.
[4] La Taxe Générale sur les Activités Polluantes (TGAP).

Table 1

Impact of the tax and the subsidy on emissions by sector

	Plastic & rubber		Car industry		Iron & steel		Coke		Chemistry	
	Tax	Subs.	Tax	Subs.	Tax	Subs.	Tax	Subs.	Tax	Subs.
VOC em.	–	+	ns	+	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
NO_x em.	n.a.	n.a.	n.a.	n.a.	ns	–	ns	+	–	ns
SO_2 em.	n.a.	n.a.	n.a.	n.a.	–	ns	ns	+	–	+

Note: "ns" means that the tax/subsidy has a non-significant (at the 10% level of confidence) impact on emissions.

As far as VOC emissions are concerned, the tax had a negative effect on emissions but it is significant only for plants belonging to the sector of plastic and rubber. As there is no inter-firm variation in the tax rate, we may capture a general trend in addition to the direct effect of the tax. The data do not allow us to distinguish, e.g., a sharpening of technology standards. We thus have to caution that the results should be interpreted as an upper bound on the tax response.

Except for the model of the chemistry sector, the NO_x tax is not significant in any of the models even if it has the expected negative sign. We attribute this to the TPPA regulation's statutes for monitoring. Under the TPPA regulation, firms could choose between using direct emissions monitoring or using standardised emission factors to estimate emissions from fuel consumption data. For SO_2 emissions, the use of emission factors may proxy real emissions quite well. For NO_x emissions, on the contrary, accurate real emissions monitoring would have been more important since emissions vary strongly with fine-tuning of plant operations. The incentive effect of the tax thus seems to have been larger for SO_2 emissions than for NO_x emissions (as can be seen from Table 1), since an estimation of NO_x emissions gives weaker incentives for abatement investments. It is only in the sector of coke, which is an industry in decline, that the SO_2 tax had no significant impact on emissions.

Furthermore, we find that a higher tax rate did increase the probability to apply for a subsidy and to install new abatement equipment in the sectors of plastic and rubber, iron and steel, coke, and chemistry.

The effect of the rebating in the form of a subsidy towards abatement technology differs according to sector but in general the abatement subsidy appeared to have had a positive impact on emissions (except for the iron and steel industry). The most likely explanation of this result is a kind of output or "rebound" effect. The installation of an end-of-pipe abatement technology can have a rebound effect similar to what has been observed for energy efficiency improvements. Even if emission coefficients are reduced (as they are almost bound to be by a specific abatement subsidy) there may well have been increases in production that were sufficiently large to reverse this effect on absolute emission levels. Unfortunately, we did not have data on individual production that allowed us to quantify this effect.

Regulatory pressure

As concerns regulatory pressure, plants located in regions with a larger exceedance of air quality SO_2 standards invest more in abatement technology, all other things equal. Surprisingly, the opposite effect was found in the case of NO_x.

Business data

In general, large plants (measured as those with a high number of employees) were more likely to invest in a new abatement technology. Larger firms can be assumed to have better information about available subsidies and financing possibilities. The impact of self-financing capacity and value added on the investment decision vary by sector. Plants with a higher self-financing capacity and a lower valued added are more likely to invest in a new abatement technology in the sectors of iron and steel, and chemistry. In the coke sector, the opposite holds.

The Swedish Refunded Emission Payment on NO_x

There are several reasons behind Sweden's decision to refund emission taxes for NO_x. A crucial problem in this context is that a tax on all point sources of airborne NO_x emissions was impossible since monitoring was too expensive for small units. NO_x emissions are not like sulphur emissions which can easily be calculated based on the sulphur content of the fuel. NO_x emissions are largely due to the chemical reaction in the combustion chamber between nitrogen and oxygen from the air. The extent and speed of this reaction is highly nonlinear in temperature and other combustion parameters. This has two implications: Firstly it implies that there is a large scope for NO_x reduction through various technical measures. The environmental charge should therefore stimulate innovation in abatement technology. Secondly, physical measurements and monitoring are absolutely necessary. Experience from the Swedish program has shown that it is not just the abatement equipment but the fine-tuning of operation that leads to NO_x reduction. Actual monitoring is required both for outside inspectors and, indeed, for plant engineers to know emissions levels and therefore which measures are successful. If small units were to be excluded because of high measurement costs, a high tax levied only on large units would encourage the operation of small, and less efficient units. The politically feasible solution, which still allowed for a high charge level, was to impose the fee only on the large combustion furnaces but refund it to the same group of firms.

The fee (of SEK 40 per kg which is at current rates above 4,000 EUR/ton) initially applied to all boilers producing at least 50 GWh of energy per year. Roughly 200 plants were affected including not only the energy sector but also pulp and paper mills, food, metal and other manufacturing as well as waste incineration plants. In 1996 and 1997, the limits for eligibility were lowered to 40 and 25 GWh/year, respectively, bringing in about 170 new units into the scheme. The Swedish EPA manages the scheme at a small administrative cost amounting to 0.2–0.3 percent of revenues. The entire, remaining, revenue of about 600 million SEK (about € 70 million) per year is refunded. Table 2 shows that the refunded emission payment has indeed had some quite significant effects in reducing emission coefficients.

Table 2

The development of emission coefficients in the Swedish NO_x scheme

– kg NO_x /MWh produced energy –

	1992	1995	1997	1999	2000
Min	0.13	0.10	0.08	0.07	0.06
Max	0.99	0.78	1.04	0.88	0.90
Median 190	0.39	0.23	0.21	0.19	0.19
Average	0.41	0.27	0.28	0.26	0.25

Note: Minimum (maximum) emission coefficients are average for the 10 best (worst) plants. Median 190 is the median coefficient for the 190 firms that were included throughout the period. The "average" also includes plants that were included as the scheme was enlarged to cover more (and smaller) units.

Conclusion

The results indicate that the overall effectiveness of a revenue rebating scheme where the rebate is tied to abatement subsidies like the French air pollution tax system during the 1990s can be questioned. In general, the tax had a significant negative impact on SO_2 and VOC emissions, but not on NO_x emissions. We attribute this difference in the impact to the French regulation's monitoring procedures for emissions. The lack of real emissions monitoring severed the link between the tax base and actual emissions and diluted the incentive effect of the tax for this particular pollutant. All else equal, the higher the tax rate, the higher the probability that the firm applied for an abatement subsidy. The combined subsidy, however, generally increased emissions significantly and to an extent that dwarfed the negative impact of the tax. Nevertheless, our results vary by sector and show the importance of a disaggregated analysis.

In addition to these results, we furthermore find that the combined tax/subsidy biased the technology adoption decision towards investing in end-of-pipe measures rather than clean technology in the sense of a reorganization of production, input use, etc. In fact, the proportion of end-of-pipe investments in our sample varies from 62 percent in the sector of plastic and rubber to almost 90 percent for SO_2 and NO_x emissions in the chemistry sector (ADEME). Part of the difference in the proportion of end-of-pipe investments between sectors is due to the fact that substitution and recycling of inputs may be more feasible for VOC emissions than for NO_x and SO_2 emissions. Nevertheless, the high prevalence of end-of-pipe investments is also due to the rules for granting a subsidy. Since subsidies were set as fixed percentages of the capital investment cost, this biased the incentives towards capital-intensive end-of-pipe measures.

So what policy advice might be given to improve upon the functioning of environmental taxes on air pollution, in particular? By comparison with Scandinavian environmental taxes, the French tax on air pollution was set at a relatively low level. It is likely that this level was too low to warrant most of the relevant and effective abatement technologies. This is a fundamental problem when it comes to NO_x emissions where abatement is fairly costly and the tax level thus needs to be very high in order to provide a real incentive for firms to abate. It implies that the political economy of the instrument chosen is very important. It appears that the automatic and full rebating of the Swedish tax made it politically easier to set a sufficiently high tax level and this may be a vital advantage of that form of rebating.

We would argue, however, that there are other fundamental institutional features of the tax that need to be addressed in order to improve the incentives effect of the tax. In the first place, monitoring of real emissions is a vital prerequisite to keep the link between the tax base and emissions, in particular for emissions of NO_x. It is instructive, in this regard, to compare the French tax on NO_x with the Swedish revenue-recycled charge on NO_x from industrial sources (Millock and Sterner 2004). The refunding of the revenue of the Swedish NO_x charge was motivated in part by the requirement to install costly monitoring equipment. The experience with the Swedish NO_x charge showed that it is not simply the installation of abatement equipment that matters but its fine-tuning and continued adjustment to the production process, in particular for NO_x emissions, where emissions depend not only on the fuel input but also on process factors such as the temperature and oxygen content of the combustion chamber. Precise monitoring equipment encourages the firm to continually minimize emissions. In the absence of real time monitoring, even the plant engineers themselves will not know which controls increase or decrease NO_x emissions, and they will thus be unable to fine tune them.

The other important design feature concerns the mechanism by which the tax revenues are refunded to the tax-payers. Under the French regulation, tax revenues were used to subsidize abatement investments and the selection of projects was made following an administrative procedure. Such a rule has at least three drawbacks. First, firms may receive subsidies for investments that they would have undertaken anyway. Second, there is no built-in check on the ex post efficiency or proper use of subsidized abatement equipment. By comparison, the revenues from the Swedish NO_x charge were refunded in relation to the amount of energy produced by the specific plant. An automatic refunding rule like that of the Swedish NO^x charge provides continuous incentives to firms to reduce emissions and become more efficient in terms of emissions per energy unit. Such a refunding rule can be envisaged in the case of emissions deriving from energy use, since a common measurement unit (energy) exists across different industrial sectors. It would be difficult for emissions such as VOC that derive from different kinds of solvents, however. Third, the calculation of subsidies as a percentage of capital costs seems likely to have created a bias towards end-of-pipe measures rather than towards production processes that recycles or substitutes polluting inputs.

In conclusion, refunded environmental taxes have a real potential to reduce emissions in an efficient manner, but as with all instruments, the institutional design of the tax system is crucial.

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