5.0 NITROGEN OXIDES (NO_X) TAXES AND CHARGES

5.1 Introduction

Air pollutants are a category of pollutants that give special cause for concern in the environmental field. The fact that they are unseen and unavoidable, allied to the fact that some are known to have impacts upon human health, makes it important to seek to minimise their effect.

Though some air pollutants are less detectable than other pollutants, the links between air pollutants and mortality / morbidity are increasingly well researched. The majority of work carried out on in the field of economic valuation concerning the effects of pollution has been carried out with respect to air pollutants. The interest in understanding exposure response functions linking air quality to mortality and morbidity, and to the growth of crops and forests, has underpinned the major part of this literature.

Most NO_x emissions (NO and NO_2 expressed as NO_2 equivalents), a consequence of all combustion, are formed by the effect of high temperature on atmospheric nitrogen and do not (like sulphur) come from an impurity in the fuel. There are also further difficulties in measuring and reducing emissions from both mobile and stationary sources. Nitrogen Oxides, have been shown to have important effects on human health, both through direct effects and through their role in the creation of low-level ozone. In addition, due to their effects on acidification, they have been implicated in damage to forests and crops. For these reasons, attempts at reducing emissions of NOx are especially important.

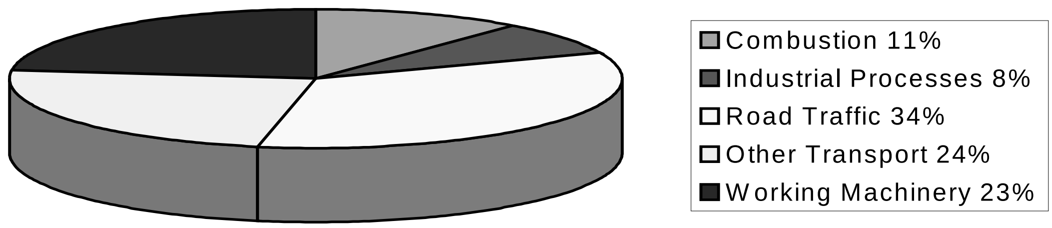
We have studied three countries, Sweden, France, and Spain (Galicia), with an emphasis on Sweden, where the fortunate combination of good data and an interesting policy design were available. The countries differ in their application of policies to address nitrogen oxides (NO_x), i.e. with respect to tax/charge level, use of revenues, design of policy etc.

5.2 The NO_x Charge in Sweden[1]

Introduction

Sweden is especially vulnerable to acidification due to the specific granite bedrock covering most of the country. This has made the precursors of acid rain, nitrogen oxides (NO_x) and sulphur dioxide (SO_2) important environmental policy targets in Sweden (and Norway), although deposition in Sweden of acid precursors often results from emissions elsewhere. As can be seen in Figure 2, mobile sources of NO_x account for approximately 80% of total NO_x emitted. The reduction in NO_x emissions between 1980 and 1995 has been rather modest (approximately 20%). This can be compared to the reduction of 80% (between 1980 and 1995) of emitted sulphur dioxide. The less successful reduction of nitrogen oxides is due largely to inherent technical difficulties. The charge on the large combustion plants to be described here has however been rather successful.

Figure 2. Distribution of Swedish NO_x Emissions, 1997



Source: SCB (1998)

Design of the Charge

In 1990 the Swedish Parliament decided to introduce a tax of 40 SEK (4,43 EUR) per kilogram of NO_x emitted from all combustion plants producing at least 50 GWh useful energy per year. The tax came into effect on January 1992, and affected about 200 plants. The setting of the charge level to 40 SEK/kg NO_x was based on the results of a study by the Swedish Environmental Protection Agency (SEPA, 1987). The Swedish NO_x charge has remained constant (in nominal terms).

[1] This part is based mainly on Höglund (1999) and SEPA (1997).

The charge is on the one hand a very high charge - more than 200 times higher than the French charge. On the other hand the charge is distributed back to the polluting companies in relation to the amount of energy produced by the specific plant. This means that the polluting industry as a whole does not pay anything to society – and it is presumably this fact that has made the charge politically feasible.

The design mechanism was partly chosen due to the fact that only large combustion plants are obliged to pay the charge. The decision to exclude smaller plants was based partly on the high costs of metering which (together with abatement costs) were considered unreasonable for smaller plants. If a tax without refunds had been applied to only a subsection of some industry then this would have been unfair compared to other firms in the same industry. In this case, if the tax were applied only to the large plants, companies like Gothenburg Energy would have an incentive to set up several small combustion plants instead of one big one and this is typically not desirable (from any viewpoint including emissions of NO_x and other pollutants).

As the system developed and turned out to be effective, costs for abatement and metering have fallen and the criterion for inclusion has been lowered twice: in 1996 plants producing at least 40 GWh useful energy per year were included and in 1997 the boundary was lowered to 25 GWh. In 1992, only 200 plants were subject to the charge, compared to 400 plants in 1998.

Revenue and Use of Revenues

The character of the system with a refunded emission charge implicitly means that some of the firms (cleaner than average) will make a net profit while the rest will make a net payment. Total payments from the charge (which is refunded to the plants) is presented in Table 12. Note the effect of the falling threshold in 1996/97 so that charge payments increased.

Table 12. Total Revenue Levels for the NO_x Charge 1992-1998.

Year	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Total revenue in SEK million (EUR million)	612 (68)	533 (59)	521 (58)	501 (56)	643 (71)	604 (67)	585 (65)

Source: SEPA (1999).

Organisational Roles and Administration

The administration of the charge is carried out by the Swedish Environmental Protection Agency (SEPA), and has been kept at a very low cost, approximately 0.3% of revenues collected. The metering costs are estimated at approximately 3% of total charges paid. The emissions are measured by equipment approved by SEPA. If the firm does not measure its emissions, a standard assessment is used. All plants are obliged to fill in a form regarding their energy production and NOx emitted. SEPA audits the firms and randomly selects a number of firms each year for inspection. The goal is to make an inspection of each firm every fifth year. In the beginning of each calendar year the plants send in the form declaring their respective emissions and energy produced. The firms have to pay their net charge before October 1st and SEPA refunds the plants before December 1st each year. Each firm can have several production units, which are monitored separately. This two-month period keeps cashflow problems to a minimum.

Environmental Effects and Linkages to Other Instruments

The NO_x charge has been rather successful. Firms adapted quickly to this economic policy instrument, and emissions were even reduced before the introduction of the charge (incentive effect). Table 13 below shows that the emissions of nitrogen oxides per unit of output (measured as kg NO_x / MWh) have decreased.

Table 13. Summary Statistics Regarding Combustion Plants Subject to the Charge 1992-1998

Year	Number of production units (combustion plants)	NO_x emissions (tons)	Produced energy	kg NO_x / MWh produced energy
1992	181	15305	37465	0.41
1993	189	13333	41158	0.32
1994	202	13025	45193	0.29
1995	210	12517	46627	0.27
1996	274	16083	57150	0.28
1997	371	15107	54911	0.28
1998	374	14617	56367	0.26

Source: SEPA (1999)

The positive environmental effect was biggest in the beginning of the period, but there are still improvements going on, although at a decreasing rate. This is somewhat obscured by the fact that the new smaller plants have been brought into the system since 1996/7. These have higher emissions per unit of output. The average for the original (larger) plants actually fell to 0.26 and 0.25 for 1997 and 1998 respectively.

In addition to the NO_x charge, many plants are subject to local regulations. Hence, people argue that the reduction in NO_x has been due to both the refunded charge, and standards. According to one study, approximately two thirds of the total reduction in NO_x can be attributed to the charge, and the rest to the standards (ÅF-Energikonsult AB, 1996). The methodology for this division is however shaky and typically it seems that almost all the plants are operating *below* their legal requirements. It might be the case that the standards alone would achieve 1/3 of the reduction but that the charge alone would give almost the same effect as the charge plus the standards! According to SEPA it is reasonable to assume that if the NO_x charge had not come into effect in 1992, the NO_x emissions would have been 25% higher from combustion in 1995.

It is also of importance to take into account possible side effects of the reduction in NO_x. Ammonia, laughing gas (N_2O), and particularly carbon monoxide may increase due to increased abatement. These increases were (in total) less than a quarter of the reduction in NO_x (SEPA 1997b). It is however not easy to compare the associated environmental damage as against the benefits of NO_x reduction, each of which may depend on a number of ambient factors, as well as on the underlying exposure-response functions which characterise these other emissions.

The advantage of using a refundable charge instead of an “ordinary” tax is that it gives a strong incentive for reduction in emissions even though the firms liable are not subject to a heavy economic burden (see Sterner & Höglund (2000) for a formal analysis of the optimality of the instrument[2]). The fact that the net payment for the companies is smaller than a tax (and indeed 0 on average) has made this instrument much more acceptable to firms. The Swedish NO_x charge has shown that it is possible to create an environmental policy instrument that is financially neutral, and that can be an alternative to tradable permits. The assumption of a potential strategic behaviour by smaller companies to produce more energy to avoid the charge (with one-year time lag) does not seem to be validated by the available data. Also this type of behaviour is unlikely since the number of firms is large.

Effect on Producers, Competitiveness Impacts

Compared to the costs of production, the charge is small and thus for the purposes of this evaluation and for the purposes of a general discussion the most reasonable generalisation is to say there are no price effects due to the charge itself.

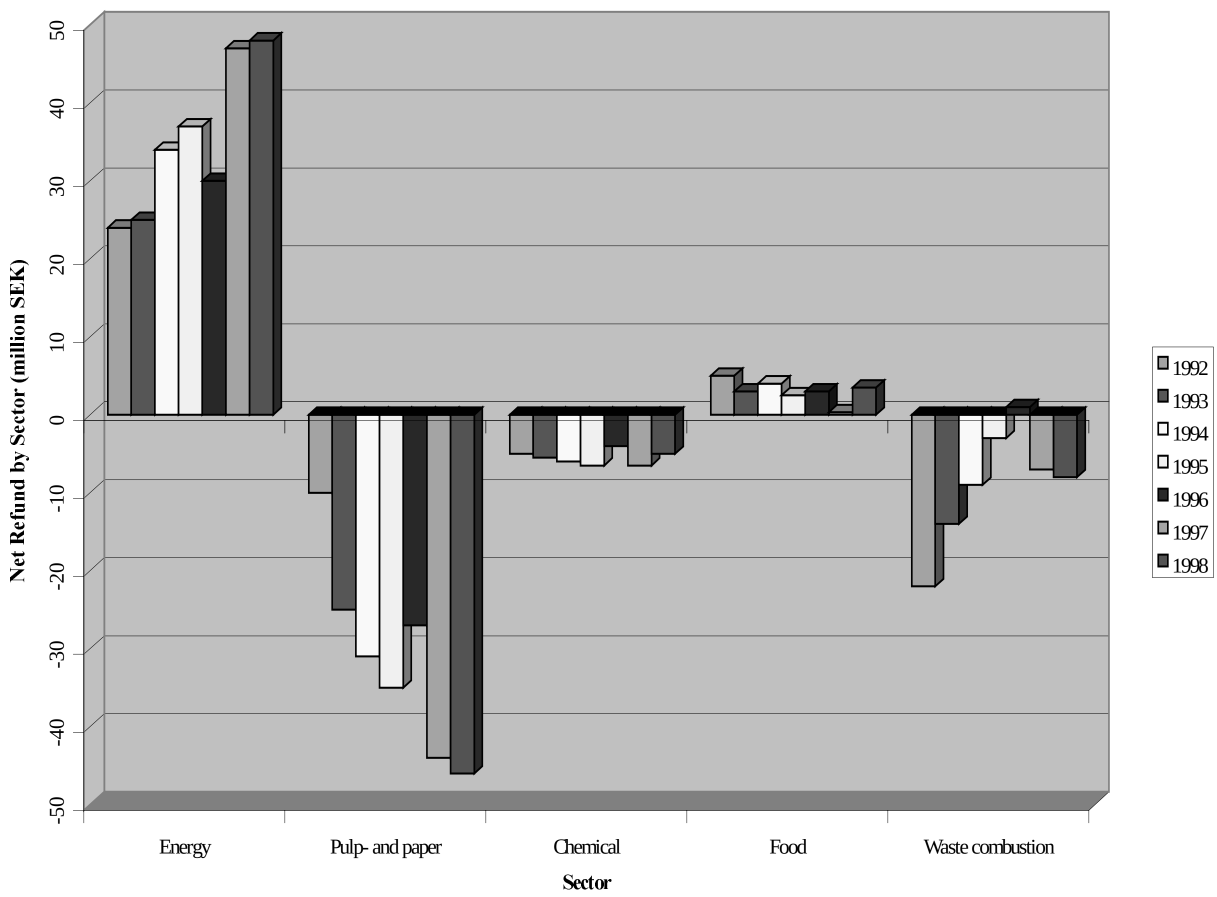
The refundable charge system was designed to be as neutral as possible regarding aggregate competitiveness. Still, there are some possible effects on individual producers, that need to be studied. The sectors affected by the charge are the food and beverages industry, wood and wood products industry, paper and paper products industry, metal products - machinery and equipment industry, chemicals industry, energy industry and waste combustion industry. If we look at how industries are influenced by the NO_x charge, the paper and paper products industry is subject to a total net payment of the charge of approximately SEK 47 million, while the power industry has a positive net revenue of SEK 49 million for 1998.

The net revenues, both positive and negative, for the other industries are significantly smaller, less than SEK 10 million - in absolute terms - except for the waste combustion industry in 1992-93 (SEPA, 1999 – see Figure 3). The total cost differential between firms should also

[2] There are various complications. For instance for firms with large market shares the abatement incentives will not be quite optimal. This problem was negligible for the case studied since the largest market share was approximately 3%. Still it could be a problem in other contexts.

take into account the different costs of abatement investment. As it happens, the abatement cost plus the refunded charge (positive or negative) is for each sector less than 1% of the total production value of each respective sector (see Table 14).
Assessments of potential impact on competitiveness indicate that the pulp and paper industry is the sector that pays the most due to the NOx charge. There are however “winners” and “losers” at the firm level as well. Within each industry there are some firms that are winners and some that are losers. The general pattern is however that the “winners” are found in the energy sector (e.g. the firm which receives most gets SEK 10 millions back), while losers are found in the pulp- and paper sector (e.g. the firm which pays most pays SEK 6 millions).

Figure 3. Net Refunding Per Sector, 1992-1998 (Million SEK).



Source: SEPA (1999)

Table 14. Mean Annual Abatement Costs Per Plant By Sector and Year in Million SEK/Year (Thousand EUR/Year) (1990 Prices)

Sector	***1992***	***1993***	***1994***	***1995***	***1996***
Energy	*0.602 (67)*	*0.640 (71)*	*1.452 (161)*	*1.359 (151)*	*1.682 (187)*
Pulp and paper	*0.128 (14)*	*0.230 (26)*	*0.244 (27)*	*0.298 (33)*	*0.396 (44)*
Chemical and food	*0.080 (9)*	*0.103 (11)*	*0.125 (14)*	*0.138 (15)*	*0.166 (18)*
Waste combustion	*0.537 (60)*	*0.609 (66)*	*1.030 (114)*	*0.997 (111)*	*1.241 (138)*
All sectors	*0.379 (42)*	*0.427 (47)*	*0.842 (93)*	*0.794 (88)*	*0.985 (109)*

** Starting from zero cost at January first, 1990 and assuming the expected life-time of fixed investments to be ten years.*
Source: Höglund (1999)

Internal Market Effects

The instrument affects only domestic producers of energy so there are no effects on the internal market. Energy could be imported just as before so there is no restraint on the free movement of goods, in this case, energy.

Impacts on Trade

Since there were no price effects there would logically be no aggregate effects on trade. If there were any effects there would of course be a weak incentive to locate production to areas without the environmental instrument under discussion. In this case there would be some incentive to re-locate power production to for instance Denmark. There are already such incentives due to the sulphur and carbon dioxide taxes in Sweden and the refunded NO_x charge would thus only have a very marginal effect in that broader context (any re-location would already have occurred).

Impact on Employment

It is possible to argue that the NO_x charge has increased the demand for abatement technologies significantly in some sectors, and, hence, more people would be employed in the abatement technology sector, but these effects are likely to be small at least in the short and medium term. The employment effects at firm level are probably also of negligible size. Finally, SEPA's administration of the charge implies no significant employment effects (0.3% of revenues of the NO_x charge are administration costs, and this allows roughly two people to be employed full-time). To sum up, the effects on employment from the NO_x charge are negligible.

5.3 The NO_x Charge in France[3]

Design and Development of the Tax

French taxes on nitrogen oxides are part of a wider piece of legislation covering several air pollutants. In 1985 France started to apply the 'polluter pays principle' by taxing SO_2 emissions (at 130 FF/ton). This law was, in 1990, renewed and then expanded to incorporate NO_x and hydrochloric acid (HCl).

An assessment of the tax showed that NO_x emissions were reduced by 27,000 tons per year which, comparing to emissions in the mid 90s, corresponds to a reduction of roughly 6% of the total.

The base for the tax is either measured emissions or declared quantities of a firm's emissions. Those liable to taxation are power stations and waste incineration plants, which have capacity that exceeds[4] 20 MW and a combustion potential of three tons per hour. Furthermore any production plant which emits more than 150 tons NO_x per year is also taxed for excessive emissions.

In 1990 the charge was set at 150 FF per ton of NO_x [5]. In 1995 and 1997 it was again renewed, some values being raised and then lowered. From the 1st of January 1998 the tax has been FF 250 per ton NO_x. (SO_x , HCl:180 FF/ton, NMHC/VOC: 250 FF/ton).

Revenue and Use of Revenues

Tax revenues from the air emissions are used for environmental purposes. Table 16 shows the allocation of the tax revenues collected. Note that these figures include tax revenues from all emissions controlled (sulphur being the largest followed by nitrogen oxides). Therevenue from the NO_x charge has accounted for roughly 30% of the revenue from all air emission taxes between 1991 and 1996. The remaining revenues come from taxes on the other emissions. In Table 15, we present revenues from the NO_x tax and total tax revenues including tax revenues from SO_2, VOC, and HCL.

[3] This section is based upon ADEME (1998, 1997, 1996a, and 199b) and Cansier and Krumm (1997).

[4] This is generally a higher larger minimum requirement than for the Swedish plants. 20 MW with an operating period of say 5000 hrs/yr would produce 100 GWh (compared to 50 or 25 GWh is Sweden).

[5] Particulates (PM), Non-Methane Hydrocarbons (NMHC) and other solvents and volatile chemicals were in principle included although at a tax rate of 0).

Table 15. NO_X Emissions and Charge Levels

Year	NO_x (tons)	Charge Level in FF (EUR)	Gross charge revenues from NO_x tax in FF million (MEUR)	Gross revenues all air pollutants in FF million (MEUR)
1991	191 992	150 (22.9)	28.8 (4.4)	114.8 (17.5)
1992	412 272	150 (22.9)	61.8 (9.4)	225.9 (34.4)
1993	306 056	150 (22.9)	45.9 (7.0)	197.8 (30.2)
1994	309 252	150 (22.9)	46.4 (7.1)	167.5 (25.5)
1995	255 328	180 (27.4)	46.0 (7.0)	157.3 (24.0)
1996	385 026	180 (27.4)	69.3 (10.6)	233.2 (35.5)
1997	378 000	180 (27.4)	68.0 (10.3)	218.5 (33.3)

Source: ADEME (1996a-b, 1997, and 1998)

Table 16. Distribution Of Tax Revenues Collected.

Tax revenues spent on:	Revenues 1996-1998
Abatement equipment	65.6 %
Monitoring equipment	16.6 %
Research & Development	10.0 %
Studies	2.5 %
Total	94 %
Administration	6 %

Source: Personal communication with Claude Simon, ADEME.

Organisational Roles and Administration

The Ministry for Energy and Environment through the Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME) administers the tax. As can be seen in table 6% of total tax revenues is used for administration with another 12.5% for research. About 17% is spent on monitoring and the largest share of total revenue (65.6%) is used to support companies working on R&D for pollution abatement or to help finance actual abatement investments.

Environmental Effect and Linkages to Other Instruments

The procedure of refunding tax revenues in France can be seen as tax financed subsidies for abatement equipment and the environmental benefits claimed by the ADEME refer to the effects of abatement equipment financed. In most cases, industries do not actually measure NO_x emissions but use “rule of thumb” emission coefficients. It is therefore impossible to judge (but rather unlikely) that the emission taxes have any incentive effect operating through mechanisms to do with fine tuning as in the Swedish case where payment is based on actual measurements. Instead the emission reductions are due exclusively to the installed equipment.

According to ADEME, estimated emission reductions for the abatement equipment installed were about 9% in 1995 and 56 ktonnes or 13% in 1997.

Impacts on Trade, Competitiveness and Employment

This charge probably does not have any measurable effect in the direct sense on prices. Furthermore, the proceeds are to a very large extent returned to the polluting industries (and paradoxically, this could lead to a reluctance to make adjustments which are not funded by revenues). This mechanism is not as transparent as in the case of the Swedish NOx charge, but still the revenue is used to subsidise abatement. The net effect is that industry bears some (small) abatement costs, which will not have any measurable effect at the macro level of prices and employment[6].

Effects on the Internal Market

As regards the internal market, there appear to be no effects. Presumably, partly because the price effects are insignificant, there is no issue of penetration by foreign energy suppliers (and this is likely to be especially true in respect of waste incineration plants – the price differential would have to be such as to make it worthwhile transporting the waste outside France).

[6] Naturally there may be positive employment effects in the abatement and monitoring activities and there could be exports from such industries in the future but these must be weighed against the loss in employment due to general equilibrium effects of (microscopically) higher production costs. The distribution of tax revenues for subsidies to buy equipment, might also in principle, have effects on competitiveness but again, the effects will be small.

5.4 NO_x Taxes in Galicia, Spain[7]

Introduction

We originally intended to write about Italy, but have, in spite of many attempts, failed to find much information about the Nitrogen Oxides tax there. The only information made available to us was that the rate is ITL 203,000 per tonne (over 104 EUR/ton) which is quite high (compared to Spain and France) but it only covers combustion plants whose capacity is over 50 MW and emissions exceeding the standards specified in the EU Large Combustion Plant Directive. This seems to suggest it is only applied in special cases as a form of penalty. Also the charge is new (since 1998) and thus there are for that reason alone, few possibilities for carrying out a good evaluation of impacts. We have therefore chosen to discuss the case of the regional tax in Galicia here.

Spain has no NO_x charges as a country but the autonomous region of Galicia does have such a tax since 1995. The a tax on atmospheric contamination (Impuesto de Contaminación Atmosférica Ley 12/1995, de 29 de Diciembre) covers both NO_x and SOx

Design and Development

The tax level is basically 5000 Pesetas/ton of NO_x or about EUR 30/tonne. However its detailed design is somewhat more complex with, currently, three different tiers:

- The first 1 000 tons of NO_x are exempted.
- Between 1 001 and 50 000 tons of NO_x the cost is 5 000 Ptas/ton
- EachEvery ton over 50 000 tons of NO_x costs 5 500 Ptas.

The tax has remained constant over the years. There are plans to introduce a fourth tier in the near future.

The amount to be paid is calculated through direct measurement of emissions or through the use of emission factors supplemented by some form of inspection. We have not been able to assess the relative importance of the two mechanisms.

Revenue and Use of Revenues

Approximately 5% of the total revenues are dedicated to a special fund for environmental restoration to deal with the negative effects of the emissions while the rest goes to the main regional budget.

[7] This section is based upon personal communication with Susana Bokobo and documents from the government in Galicia.

Table 17. Revenue in thousand pesetas (million EUR), & Estimated NO_x Emissions[8] (tons)

District	**1996**	**1997**	**1998**	**1999**
A CORUÑA	2,101,888 (12,6)	2,129,596 (12,8)	2,408,575 (14,5)	2,456,838 (14,7)
LUGO	52,005 (0.31)	56,630 (0.34)	62,190 (0.37)	64,022 (0.38)
OURENSE	0	0	0	0
PONTEVEDRA	0	0	0	0
VIGO	0	0	0	0
TOTAL (Kptas)	2,153,893 (12,91)	2,186,226 (13,14)	2,470,765 (14,87)	2,520,860 (15,08)
Total Emissions[9)]	431	437	494	504

It is interesting to speculate why Galicia is the only Spanish region to have this kind of tax. Diversity in tax systems is in itself not necessarily surprising since the regions are autonomous with respect to fiscal policy and hence each region has to make its own decisions. Some years ago Galicia experienced SO_2 emissions levels of 738 tons, i.e. 34% of the Spanish total SO_2 emissions while Galicia's NO_x emissions were 83 tons, i.e. 10% of the Spanish total. Galicia is thus a centre of industrial activity and thus of pollution but not the only one in Spain. The same would apply for instance to the País Vasco and to Asturias.

Environmental Effectiveness, Efficiency and Linkages to Other Instruments

According to our information the tax is seen mainly as a means of raising revenue for the region. Little is known about what effects it has had, if any, on emission coefficients. Judging from Table 17 only, it is not possible to say whether the tax has had any abatement effect. The fact that the NO_x fees collected are rising quite fast and thus that emissions must be rising too (almost 20% in four years) would however suggest that there is no significant abatement activity yet.

Impacts on Prices, Trade, Internal Market, Employment and Competitiveness

We do not have very detailed data but as far as we can judge the analysis must be the same as in the case of the French tax: the tax is so small as to not reasonably having any measurable effect in this sense.

9) Based on the simplified assumption that all emissions are charged a flat rate of 5000 Ptas/ton (tariff 2).

5.5 Summary

We have studied three countries – Sweden, France, and Spain (Galicia), which have chosen to apply different levels and designs of tax or charge to the emissions of NO_x. The systems chosen vary significantly in various dimensions (see Table 18).

Table 18: Characterisation of Charges / Taxes Across Dimensions

Criterion:	**Sweden**	**France**	**Galicia (Italy[9])**
Charge Level in (EUR/ton)	5 430	43.4	EUR32.6 (EUR109)
Pollutants covered	NO_x only (there are other taxes for S)	NO_x, SO_x, HCl VOC etc	NO_x, SO_x
Character of charge	Charge	Charge	Tax
Use of Funds	Returned to companies	Abatement, Research etc	General (5% for restoration)

It is however notable that the most striking difference is the level of the charge itself. The charge level in Sweden is very high (also compared to the US where comparable permit prices are around 109 EUR/ton) whereas the taxes/charges in Italy, Galicia and France are relatively low. The fact that the charge is so high in Sweden was presumably only possible – politically- due to its special construction with the refunding. It is somewhat difficult to compare the results analytically since Sweden has a much higher degree of detailed monitoring – as is indeed natural with such a high charge level.

The overall conclusions must however be that a high charge like the Swedish one is the only really effective way of getting a sizeable reduction in emissions. In 1998 the Swedish system has achieved a 30% reduction in NO_x emissions (Kg) per unit of output (see Table 13) compared to 1992. The French and Spanish taxes are more fiscal in character but in the French system the revenues are used to subsidise abatement equipment. This naturally also results in reduced emissions. According to the estimates as much as 10% reductions may have been achieved.. A word of warning however may be needed. In the Swedish case where all sources were monitored continuously, it was typically found that the mere installation of equipment generally did not have as great an effect on emissions as it "should"have according to the rules of thumb produced by engineers. In order to realise the emission reductions, companies found that they had to do a large amount of experimentation with trimming and operational adjustments. These can only be done if there is continuous time

[9] We were originally supposed to evaluate Italy, but due to lack of information we switched to Galicia, Spain. In this table, however, we present some information from the Italy case.

monitoring and if there really are charges based on actual measured emissions that the engineers and technicians strive to reduce.

In order to achieve large reductions this kind of measurement is thus most likely needed together with fairly stiff charges. To make these charges politically acceptable, it may well be necessary to have some form of refunding mechanism.

In general it can be said that there are no traceable effects regarding effects on internal market, trade impacts, employment effects, competitiveness effects, i.e. the charges/taxes are that low so that they will have no measurable effect on the macro level.