Complying with the Kyoto targets: an assessment of energy taxes effectiveness in Italy

Public Policy and Social Welfare
A Series Edited by the European Centre

European Centre Vienna

Volume 36

Asghar Zaidi / Ann Harding / Paul Williamson (Eds.)

New Frontiers in Microsimulation Modelling

ASHGATE

Published by

Ashgate Publishing Limited
Wey Court East
Union Road
Farnham
Surrey GU9 7PT
United Kingdom

Ashgate Publishing Company
Suite 420
101 Cherry Street
Burlington, VT 05401-4405
USA

Copy-editing and DTP: Willem Stamatiou
European Centre for Social Welfare Policy and Research
Berggasse 17, 1090 Vienna, Austria

British Library Cataloguing-in-Publication Data. A catalogue record for this book is available from the British Library.

ISBN 978-0-7546-7647-8

Printed by Facultas Verlags- und Buchhandels AG, Vienna, Austria

Contents

List of Figures and Tables

Figures

Chapter 23

Complying with the Kyoto Targets: An Assessment of the Effectiveness of Energy Taxes in Italy

Rossella Bardazzi / Filippo Oropallo / Maria Grazia Pazienza

As is well-known, European Union environmental policy is deeply focused on the issue of climate change. Fighting climate change requires a long-term perspective and international actions and the EU has played a major role in "regime building" in this context. 605

As regards policy tools, a great support for *market-based instruments* can be found in European policy (and in the Kyoto Protocol), as opposed to the traditional command and control approach,[1] and the European Carbon Trading Scheme represents a major success of recent European policy. However, no comparable achievement has been reached in the tax area and, despite several efforts to design an European Carbon Tax, a supranational environmental tax is still lacking. All European countries act autonomously in this field, with the partial exception of an energy tax directive[2] that sets minimum levels of taxation for some energy products in order to avoid harmful fiscal competition.

In the EU-27, total greenhouse gas emissions decreased by 8% from 1990 to 2005. The contribution of the manufacturing sector has been noticeable: the reduction was approximately 17% for EU-27 and 10% for EU-15 compared to base-year levels. As for CO_2 emissions, data show a very slight decrease for EU-27 (-3.5%) and an increase for EU-15, whereas a conspicuous decrease can be found for manufacturing in almost all countries (-17% for

1 According to the OECD (1997: 15), economic instruments can be defined as "those policy instruments which may influence environmental outcomes by changing the costs and benefits of alternative actions open to economic agents ... economic instruments create incentives that encourage people acting more-or-less in their own best interests, simultaneously, to treat the environment in a way that is in the best interests of society".

2 Directive 2003/96/EC.

EU-27). These emission trends show that the EU-15 is not on track to meet its Kyoto target with existing measures and will need to consider carbon sinks and the other flexible mechanisms. Despite this unsatisfactory performance, overall environmental policy in Europe cannot be considered unsuccessful, in particular with regard to energy consumption trends. Unfortunately, in the Italian case, total greenhouse gas emissions rose by 12.1% compared to the base-year level (13% for CO_2). This tendency shows that Italy currently has a considerable distance to its burden-sharing target, even if carbon sinks and other flexible mechanisms are taken into account. According to EEA (2007), Italy is the only European country that appears unable to meet the Kyoto target at the moment. At least some responsibility can be found in policy design and implementation: Italian environmental policy appears confused, wavering and highly influenced by the pressure of lobbies. Notwithstanding some results in decreasing CO_2 intensity, manufacturing CO_2 emissions are still increasing and without evidence of de-coupling, probably because of a general scarcity of environmentally-related investments.

After reviewing some important characteristics of environmental taxes and recent emission trends in Italy, we present summary results from a previous ex ante microsimulation analysis to briefly describe the short Italian experience of the Carbon tax reform. In the final sections of the chapter we extend this model to provide an ex post assessment of the efficacy of energy taxes in Italy with regard to the effect on CO_2 emissions and input mix of industrial sectors by estimating a fixed effect model on a panel of more than 5,000 firms.

1 General characteristics of environmental taxes: energy taxes vs. carbon taxes

As is widely known, the main argument in favour of market-based instruments over regulation is that, in theory, the cost to society of reducing environmental damage is minimized.[3] If a price signal is used to reach an environmental standard, pollution abatement will be undertaken at minimum cost. This is because for firms with a relatively high cost of abatement, it is cheaper to pay the charge than to reduce emissions. On the contrary, firms facing low abatement costs find it cheaper to abate rather than pay the charge. In other words, unlike the traditional command and control ap-

3 See for instance Tietenberg (2006).

proach to environmental policy, economic instruments allow the polluter to choose the level of output and pollution, but a cost is imposed for the pollution produced. If correctly set, the Pigouvian tax rate must be equal to the marginal damage and, as a consequence, if marginal damage varies across countries, tax rates should be set at different levels.

A general evaluation of environmental taxes[4] can be made with regard to different criteria. As an example of market-based instruments, environmental taxes are generally characterized by economic efficiency (in static and dynamic terms), good efficacy (or environmental effectiveness[5]), and relatively low monitoring and administrative costs. On the other hand, the effect on competitiveness has been a major concern of policy-makers in considering possible applications of taxes to energy and other goods and an eventual trade-off between environmental policy and growth policy has to be considered. Moreover, the possibility that environmentally-related taxes, mainly energy taxes, can have a regressive impact on household income distribution and, therefore, on the political acceptance of such a policy, has to be seriously taken into account.[6]

Within this context, a carbon tax is a specific environmental tax that is levied on the carbon content of fossil fuels, which is an efficient way of assigning costs to the carbon dioxide emissions they release when burned for energy.[7,8] Contrary to the case of local pollution, in the case of climate change the marginal damage can be quantified homogeneously across countries.[9] Summing up, an energy tax is imposed on fuels (both fossil fuels and carbon-free sources as nuclear power and renewables), while a carbon tax is restricted to carbon-based fuels only. This difference can explain why a carbon tax is believed to be more efficient in reducing emissions: an energy

4 Defined as "any compulsory, *unrequited* payment to general government levied on tax-bases deemed to be of particular environmental relevance. The relevant tax-bases include energy products, motor vehicles, waste, measured or estimated emissions, natural resources, etc." (see OECD, 2006: 26).

5 The extent of the efficacy depends, among other elements, on the amount of the tax and the availability of substitutes to allow for a change in behaviour. Another crucial element to take into account is the existence, and the range of, exemptions.

6 On this issue, see Pearson (1995) and OECD (2006).

7 Since there is a fixed proportion between carbon and carbon dioxide, it is possible to convert a carbon tax into a carbon dioxide tax. Therefore, the two terminologies are equivalent.

8 A carbon tax equalizes the marginal abatement cost across fuels, and in this way realizes the minimization of the total cost of abatement.

9 Considering several estimates, the social cost of carbon ranges between \$3 and \$95 per tonne of carbon dioxide (see IPPC [2007] or the Stern Review [Stern, 2006]).

tax works through the general cost-saving mechanism, while a carbon tax adds to the cost-saving channel the fuel-substitution channel.

The effectiveness of environmental taxes on industrial firms can be evaluated by using a variety of modelling approaches. First of all, an *ex ante simulation* can be employed in order to provide information on the short-term effect of taxes. This analysis can be based on past behaviour or be merely arithmetical, in the sense that the model simply considers the change in the budget constraint that agents face because of environmental tax, without taking into account any behavioural change. Notwithstanding this evident limitation, microsimulation-based ex ante analysis can calculate the maximum revenue effect of the change in the tax for several typologies of agents, with the objective of assessing the gainers and the losers after the reform.

On the other hand *ex post analysis* replicates the observed behaviour of the system in order to disentangle the different contributions to the observed pattern (i.e. the change of input intensity attributable to tax as opposed to the change attributable to price variation). As a result, the output of the ex post analysis can be employed – as a behavioural starting point – in future ex ante evaluation.

In this chapter we combine the two approaches by estimating the ex post behaviour of firms starting from an arithmetical microsimulation model. Among all criteria for ex post evaluation of environmentally-related taxes, as proposed by OECD (1997), we focus on the ability of tax in reducing CO_2 emissions; however, as pointed out by Agnolucci (2004: 8), it is very difficult to distinguish between the effect of taxes and their effectiveness: assessing the efficacy of tax implies "ascertaining the effects of tax in relation to the expected objectives and targets or to other instruments". As regards the Kyoto target of emissions abatement, for instance, countries implement multiple policies and there is no defined target for each policy.

1.1 *Current use of energy and CO_2 taxes in Europe and in Italy*

Almost all developed countries use environment-related taxes, and the majority of them have a long experience in this regard; these taxes raise revenues between 2.5% and 4% of GDP and constitute on average 8% of total revenues. In many respects, energy taxes are the most significant environment-related taxes because they generate large revenues (more than

90% of total environmental tax revenue comes from energy and vehicles).[10] Energy taxation in the EU is currently regulated by Directive 2003/96/EC (the directive came into force in 2004), setting minimum tax rates for a broad range of energy products. This Directive has widened the scope of the pre-existing EU energy taxation (by including electricity, natural gas and coal) and has increased the minimum rates for transport fuels that had been set by the previous Directive. As a result of these policies, on the whole, taxes on energy increased between 2000 and 2004, and this is particularly true for taxes on fuels.

With regards to Italy, revenue from environmental taxes exhibits a striking increase in nominal terms (80% between 1990 and 2005). However, the importance of environmental taxes in the Italian taxation system has decreased: the revenue from environmental taxes as a proportion of both total taxes and gross domestic product show a remarkable decline between 1990 and 2005. The same trend has been shown for energy taxes.

At EU level, environmental policy has been gaining increasing importance as a device for building integration and taking a leading role in global environmental planning. From this perspective, an environmental pan-European tax has several positive attributes, as it constitutes a market-based instrument and, at the same time, a potential revenue for the EU budget, to be designed directly by the Commission. Moreover, greater harmonization in carbon tax can be efficient as variation in damage costs across countries is of minor importance. A prominent role for environmental taxes was planned for the first time with the EU carbon/energy tax (known as the European carbon tax, COM[92] 226). However, without a general agreement, the proposal was firstly amended and eventually withdrawn by the Commission in 2001. In the meanwhile, because of the lack of an agreement, several European countries have unilaterally introduced supplementary CO_2 taxes, or reshaped their existing energy taxes (among them Sweden, Norway, Finland, Denmark, Italy and Germany).[11]

10 It is not possible to make a distinction between energy taxes and carbon taxes in official revenue figures. However, it is worthwhile to recall that an energy tax is paid on the quantity of energy consumed, whereas the tax design of a carbon tax should be based only on emissions or on the CO_2 content of fossil fuels.

11 An overview on European carbon tax experiences can be found in Bardazzi et al. (2004).

1.2 *The Italian carbon tax*

The Italian Carbon tax entered into force in 1998 (law 488/98) with the aim of reducing environmentally damaging outputs by reshaping the previous energy-related tax rates and including coal and other energy products with high emissions. Moreover, the Italian carbon tax reform was designed as a fiscally neutral reform: the increase in revenue was offset by a decrease in existing social contribution rates. In other words, the reform was based on the "double dividend" hypothesis, where the first dividend was the supposed emission cut and the second dividend an increase in full-time employment through a cut in the labour tax wedge.[12] Furthermore the fiscal neutrality approach has helped to alleviate competitiveness concerns and to increase the political acceptability of the reform. The tax rates originally foreseen in 1999 were supposed to gradually increase up to a target level in 2005, as shown in Table 1.

Table 1: Italian Carbon Tax: main tax rates as provided by law

		1998 (*)	1999	2005
Coal	Euro/1000 kg	0	2,63	21,61
Coke	Euro/1000 kg	0	3,52	30,59
Diesel	Euro/1000 lt	386.03	403,21	467,84
Diesel (heating fuel)	Euro/1000 lt	386.03	403,21	467,84
Heavy oil – industrial use (high sulphur content)	Euro/1000 kg	46.48	63,75	128,73
Heavy oil – industrial use (low sulphur content)	Euro/1000 kg	23.24	31,39	62,04
LPG (fuel vehicle)	Euro/1000 kg	305.57	284,77	206,58
LPG (heating fuel)	Euro/1000 kg	185.52	189,94	206,58
Petrol - leaded	Euro/1000 lt	574.04	578,24	594,05
Petrol - unleaded	Euro/1000 lt	518.25	570,66	594,05
Methan (fuel vehicle)	Euro/1000mc	0	10,85	51,65
Methan (industrial use)	Euro/1000mc	0.01	12,50	20,66

Note: (*) Tax rates in force in the pre-reform system.
Source: Law 488/98.

An ex ante estimation of the impact of the full reform on a manufacturing firm's competitiveness has been performed with a microsimulation model by Bardazzi et al. (2004). The simulation shows that, despite the very high increase for some energy products (such as coal or heavy oil) with respect

12 Moreover a form of earmarking, through subsidies to environmentally-related investments, was designed.

to the pre-reform situation, the compensatory decrease in social contributions would have succeeded in offsetting the increase in energy input expenditure: as a consequence the reform shows an overall negligible effect on profitability (-0.6% for the Gross Operating Surplus), even if impacts appeared highly differentiated by sector due to the variability of energy expenditure as a component of intermediate costs and of the share of labour costs (Table 2).[13]

Table 2: Carbon tax effects on sectoral profitability: ex ante microsimulation analysis on 2000 dataset comparing 2000 and proposed 2005 tax rates

	Change, as a percentage of Gross Operating Surplus in 2000		
	Change in social contributions	Change in energy taxes	Gross Operating Surplus
13-14 Mining	-0.37	5.29	-4.91
15-16 Food	-0.42	0.93	-0.51
17 Textiles	-0.57	1.13	-0.56
18 Wearing apparel	-0.65	1.64	-0.99
19 Luggage, footwear	-0.55	0.37	0.18
20 Wood	-0.42	0.70	-0.28
21 Pulp, paper	-0.42	1.56	-1.14
22 Publishing	-0.52	0.18	0.33
24 Chemicals	-0.37	1.16	-0.79
25 Rubber, plastic products	-0.52	0.59	-0.07
26 Other non-metal. mineral products	-0.41	4.01	-3.60
27 Metallurgic products	-0.46	4.98	-4.52
28 Fabricated metal products	-0.51	0.55	-0.03
29 Machinery, equipment n.e.c.	-0.59	0.25	0.34
30 Office machinery, computers	-0.63	10.36	-9.73
31 Electrical machinery	-0.63	0.29	0.34
32 Communication equipment	-0.36	0.08	0.27
33 Medical, optical instruments	-0.48	0.13	0.35
34 Motor vehicles	-0.71	0.48	0.22
35 Other transport equipment	-0.57	0.25	0.31
36 Furniture and other manufact. products n.e.c.	-0.56	0.31	0.25
Total	**-0.50**	**1.11**	**-0.60**

Source: Bardazzi et al. (2004).

13 The ex ante evaluation compared the effective tax rates in 2000 with the proposed, but never implemented, 2005 tax rates.

As regards results by firm size, very small firms (2-9 persons employed) show on average a higher level of losses from the reform. This is due to the fact that only 25% of the firms of this size have at least one regular employee and, as a consequence, only few firms can benefit from the cut in social contribution rates.[14]

In fact, due to rising international energy prices, the original tax design were not implemented in full, with the planned upwards tax rate revisions halted in 2000. Since then, only minor changes have occurred.

Summing up, Table 2 shows the results of a pure counter-factual simulation, as the full set of planned tax increases did not occur. But what can be said about efficacy of the actual changes in tax rates that took place between the end of the 1990s and 2004? And is there any role for environmental taxes in the process of Italian compliance with Kyoto targets?

2 The microsimulation model and the data

The DIECOFIS microsimulation model for Italian firms is the tool used here to evaluate the impact of energy taxes on industrial energy demand. DIECOFIS has been built and used in recent years within a project financed by the EU Commission in the FP5 framework.[15] Several public policy evaluations have been carried out with this tool to monitor (ex-ante / ex-post) the *effectiveness* of public programmes and to foresee the *effects* of public choices on firms within an impact analysis, ceteris paribus.[16] In particular this microsimulation model is designed to analyse the effects of taxes on enterprises and reproduces the fiscal burden on firms of several items such as social contributions, a regional tax on economic activity (IRAP), corporate taxes and energy excises. Its features make it a very original and path-breaking device for policy impact analysis and for studies on firms' behaviour in

14 More than 90% of all Italian firms belong to the class of 1-9 persons employed. According to Eurostat classification, Italy has the second-highest share of micro-enterprises in the European Union (Eurostat, 2008).

15 DIECOFIS (Development of a System of Indicators on Competitiveness and Fiscal Impact on Enterprise Performance) is a project financed by the Information Society Technologies Programme (IST-2000-31125) of the European Commission and coordinated by the Italian National Institute of Statistics (ISTAT, coordinator Paolo Roberti). The model is run at ISTAT where data are produced but the Institute bears no responsibility for analysis or interpretation of the data.

16 See, among others, Bardazzi, Parisi and Pazienza (2004).

the field of taxation. The coverage of Italian firms includes both small and large enterprises. In fact the DIECOFIS model is based upon a large and detailed database called EISIS (*Enterprise Integrated and Systematized Information System*) which is a micro-funded multi-source business data bank built at the Italian National Statistical Office.[17] The model covers all active enterprises except for those belonging to Agriculture, Forestry and Fishing, to the Financial Sector and to the Public Sector. For studies on energy issues a special (reduced) version of the model has been used in order to take advantage of the statistical information about the energy uses and expenses by firms collected in the Manufacturing Product Survey (*Prodcom*), which covers all manufacturing firms with more than 19 employees and a sample of small manufacturing enterprises with more than 2 and less than 19 employees. These micro-data are very interesting for our purposes as, among other information, they record consumption and expenditures for several energy products. A matching procedure has been built to link the micro-data in the main database with the *Prodcom* energy-related information: as an exact matching was not possible, a statistical matching procedure was implemented in order to reconstruct information at a micro level. Data in the two surveys are merged through a cell-based integration procedure where *Prodcom* is the donor survey and a subset of EISIS related to manufacturing firms with more than 2 workers is the receiving dataset.[18] This matched dataset is available for the years 2000 and 2004 and covers respectively about 18,000 and 20,000 units of the manufacturing sector with more than 2 workers. The distribution of firms in our data for the year 2004 is presented

17 The integrated and systematized information system on enterprises is the result of an integration process of different administrative sources. The first step of this process is the selection of the "spine" information that will be used as a basis for the integration process. In this case, the "spine" is constituted by the statistical register of Italian active enterprises (ASIA) which represents the best "hanger" for data integration purposes. On this hanger, information from the following sources has been added: Large Enterprise Accounts (SCI); Small and Medium Enterprise Survey with less than 100 workers (PMI); Manufacturing Product Survey (Prodcom); Foreign Trade Archive (COE); other surveys such as the Community Innovation Survey (CIS) and the ICT Survey. All of the above ISTAT surveys are based on common EUROSTAT standards and classifications.

18 The cell is an aggregation of units of the same activity sector (NACE 3 digits), employment class (3-19, 20-99, 100-249, >250), geographical area (NW, NE, C, SI). Through these common variables 1,350 cells are identified in the donor survey and matched with firms with the same characteristics in the receiving dataset. The integration procedure and the evaluation of the quality of its performance are presented in the DIECOFIS project deliverables at http://petra1.istat.it/diecofis.

in Table 3 where units are classified according to the NACE 2-digit classification and their size in terms of workers. Both of these characteristics are very important for interpreting our estimation results.[19]

Table 3: Firms' distribution by sector and size (2004)

Sector of economic activity	Employee classes (row percentages, weighted frequencies)			Weighted frequencies	Sample frequencies
	3-49	50-250	> 250		
13-14 Mining	97.1	2.8	0.0	2095	396
15-16 Food	97.0	2.6	0.4	29691	1984
17 Textiles	93.9	5.4	0.6	13225	1578
18 Wearing apparel	97.3	2.4	0.2	19957	933
19 Luggage, footwear	96.2	3.6	0.3	11243	808
20 Wood	98.2	1.7	0.1	13744	730
21 Pulp, paper	90.7	8.0	1.2	2894	493
22 Publishing	97.0	2.7	0.3	11431	714
24 Chemicals	83.1	13.3	3.6	3823	1215
25 Rubber, plastic products	91.5	7.8	0.8	8606	818
26 Other non-metal. mineral products	95.4	4.0	0.6	13812	1421
27 Metallurgic products	84.2	13.5	2.3	2679	856
28 Fabricated metal products	96.8	3.0	0.2	48267	1776
29 Machinery, equipment n.e.c.	91.3	7.6	1.1	21405	2137
30 Office machinery, computers	95.1	4.2	0.7	754	176
31 Electrical machinery	94.0	5.2	0.8	9137	1056
32 Communication equipment	91.3	6.6	2.1	2303	372
33 Medical, optical instruments	95.6	3.7	0.7	6028	612
34 Motor vehicles	74.1	19.0	6.9	1372	419
35 Other transport equipment	92.5	6.0	1.4	2534	450
36 Furniture and other products n.e.c.	96.2	3.5	0.2	19255	1182
Total	**95.2**	**4.2**	**0.6**	**244259**	**20127**

Source: DIECOFIS Model

19 NACE is the sector classification established by Eurostat, see Commission Regulation 29/2002.

Energy data in our dataset include information about expenditures (net of value added taxes) as well as consumption in physical units of several types of energy (electricity, coal, LPG, diesel, gasoline, metallurgic coke, petroleum coke, fuel oil, natural gas, and others). The firm's fiscal burden on energy is computed by applying the excise tax rates of a specific year for each economic activity to the firm's energy consumption by product. Energy prices by source (net of taxes) for each industrial company are endogenously determined. Several indicators are calculated regarding the energy intensity of each firm's industrial production: the weight of the CO_2 tax payments on the endogenous energy expenditure as well as the share of energy costs on intermediate production costs.

Some patterns of energy consumption for the manufacturing sectors may be identified from our micro-data. As shown in Table 4, at the NACE 2-digit level of classification, electricity is the predominant energy source in most sectors. Its share ranges from a minimum of one third of total energy used – sector 26, non-metallic mineral products – to a maximum of three quarters for sector 32 – manufacturing of communication equipment. The use of natural gas as second most-important energy source is also widespread among economic manufacturing activities, while the consumption of other products is more concentrated on specific sectors as production processes require. Finally, energy intensity (tons of oil equivalent over value added) is on average 0.145 but varies between manufacturing activities, reaching a peak value of 0.7 in the most energy-intensive sector (metallurgic products).

For certain energy sources (such as diesel, fuel oil, natural gas and electricity) a variability of prices before taxes can be identified that depends upon firm size. In Table 5, we can observe that smaller firms are penalized with higher prices whereas large enterprises can obtain favourable prices for large amounts on a special contract basis – as for natural gas and electricity – which allows for reductions up to 20% of the average price.

Table 4: Sectoral shares of energy consumption by product and energy intensity (2004)

	coal	diesel	fuel oil	natural gas	electricity	others	energy intensity
13-14 Mining	0.3	50.2	3.4	5.4	37.9	2.8	0.303
15-16 Food	0.3	6.4	4.3	37.6	50.1	1.4	0.248
17 Textiles	0.2	2.3	3.8	33.9	59.1	0.6	0.232
18 Wearing apparel	0.0	12.6	1.9	38.0	45.5	2.0	0.071
19 Luggage, footwear	0.0	6.7	3.7	28.3	59.8	1.4	0.058
20 Wood	0.0	7.3	1.7	26.5	63.8	0.7	0.101
21 Pulp, paper	0.0	1.1	1.5	63.3	33.7	0.4	0.190
22 Publishing	0.0	6.0	0.2	23.3	69.3	1.1	0.265
24 Chemicals	1.1	1.8	11.4	34.4	50.3	0.9	0.156
25 Rubber, plastic products	0.0	1.9	0.9	14.2	82.7	0.3	0.312
26 Other non-metal. mineral products	3.7	3.8	4.8	35.8	32.5	19.4	0.221
27 Metallurgic products	34.9	0.7	2.9	18.5	35.5	7.4	0.698
28 Fabricated metal products	0.0	5.9	0.7	27.8	63.3	2.3	0.100
29 Machinery, equipment n.e.c.	0.0	7.4	1.1	26.6	62.4	2.3	0.054
30 Office machinery, computers	0.0	3.1	0.0	14.8	78.5	3.6	0.021
31 Electrical machinery	0.0	5.3	0.4	21.1	70.0	3.3	0.041
32 Communication equipment	0.0	2.7	0.7	18.8	77.6	0.3	0.187
33 Medical, optical instruments	0.0	6.3	0.9	16.9	74.8	1.1	0.046
34 Motor vehicles	0.0	2.2	0.4	29.7	67.1	0.7	0.126
35 Other transport equipment	0.0	3.6	2.0	27.5	66.3	0.7	0.068
36 Furniture and other products n.e.c.	0.0	8.2	2.1	18.3	69.4	2.0	0.093
Total	**9.0**	**3.9**	**3.5**	**29.5**	**48.3**	**5.7**	**0.145**

Source: DIECOFIS Model.

Table 5: Energy prices by products for manufacturing firms, year 2004 (average=100)

	diesel	heavy oil	natural gas	electricity
under 50 workers	100.16	100.41	100.67	100.18
50 to 250	97.50	95.95	89.95	97.57
above 250	92.39	83.59	80.58	91.38

Source: DIECOFIS Model.

The remainder of this chapter builds upon the microsimulation analysis of carbon tax previously described in section 1.2. Although the planned series

of reforms were not implemented in full, 1998 did see the introduction of carbon taxes in Italy for the first time. The aim, therefore, is to evaluate the environmental effects, in terms of emission reductions, that the introduction of carbon taxes in 1998 set in-train, and to investigate the impact that those changes in carbon taxation had on the demand for specific energy sources.

To this end a balanced panel of firms from the previously described dataset has been built. This panel includes manufacturing firms surveyed both in 2000 and 2004 for which we can analyse possible changes in energy consumption and CO_2 emissions. For each year around 5,600 firms have been selected, of which approximately 60% have at least 100 workers (Large Enterprises, LE); these firms cover about 40% of the total value added of manufacturing sectors. CO_2 emissions have been imputed for each firm using the NAMEA (National Accounting Matrix including Environmental Accounts) accounts on the basis of the types and amounts of energy use and their specific CO_2 emission factors.

3 Environmental effects of the Italian carbon tax

In this study we verify the environmental impact of the implementation – although limited as described in the first part of the chapter – of the carbon tax introduced in 1998. We also investigate the essential features of industrial companies' energy demand for some specific products, with a particular focus on the elasticity to the specific tax component of the energy cost. If energy taxes have affected firms' behaviour, both in choosing a less-pollutant bundle of production inputs and in implementing investments for emission abatement technologies, estimating the elasticities of energy input demands to the rate of carbon tax offers some quantitative insights into the potential impact of a future tax change on energy consumption and, consequently, on CO_2 emissions.[20]

Following the introduction of a carbon tax, tax rates increased in line with the planned path of annual uprating until the year 2000. Between 2000 and 2004, rising global oil prices led to a reduced range of carbon tax increases on diesel, LPG, natural gas fuel, fuel oil and electricity. This scaling back of carbon tax increases may help to explain the lack of success in reducing Italian CO_2 emissions that was outlined in the introduction to this chapter.

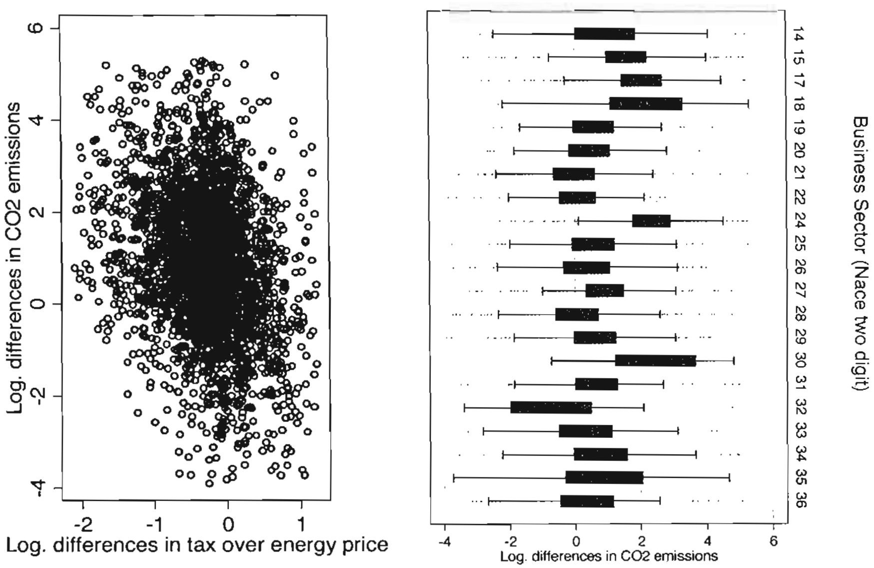
In the light of this policy change, the impact of carbon taxation on CO_2 emissions will clearly have been less than anticipated by our original ex ante

20 A similar issue has been investigated with regard to Scandinavia by Enevoldsen et al. (2007).

model. However, our panel data on changes in firm behaviour between 2000 and 2004 still allow us to model, ex post, the effect on CO_2 gas emissions of a range of factors: the change of the weight of the carbon tax rate relative to full energy price, the change in energy intensity (built on the ratio of energy consumption in tons of oil equivalents and value added), the variation of the share of expenditures for emission abatement and waste disposal on production costs, and the variation in total value added by enterprises.

The left-hand panel of Figure 1 shows the relationship between changes in CO_2 emissions and changes in carbon tax (measured as a proportion of the full energy price). As expected a negative link emerges, although individual firms clearly show significant variability around this broader trend. Moreover, as the right-hand panel of Figure 1 shows, the pattern of changes in CO_2 emissions varies significantly across the different industrial sub-sectors. For this reason indicators of specific manufacturing activities will also be included in our ex post model.

Figure 1: Changes in CO_2 emissions, 2000-2004



Model results are summarized in Table 6.[21] The explanatory variables show the expected signs: the emissions are reduced as the tax ratio on energy

21 The scatter distribution of dependent and independent variables presented some outliers (mostly due to misreporting), which were eliminated from our panel.

cost increases and as the energy intensity and the value-added reduces. Environmentally-related expenditures positively contribute to the reduction of CO_2 emissions.

Table 6: Results for CO_2 emission variations (linear regression with robust variance estimates)

Differences in CO_2 emissions (2004-2000) (log)	Coef.	Std. Err.	t	P>|t|	95% Confidence Interval	
Differences in tax over average energy price (2004-2000) (log)	-0.13	0.04	-3.7	0.0	-0.20	-0.06
Differences in energy intensity (2004-2000) (log)	0.93	0.02	51.6	0.0	0.89	0.96
Differences in environmental expenditures over total production cost (2004-2000) (log)	-0.05	0.01	-3.7	0.0	-0.08	-0.03
Differences in value added (2004-2000) (log)	1.22	0.04	28.3	0.0	1.14	1.31
13-14 Mining	0.12(*)	0.10	1.2	0.2	-0.07	0.31
15-16 Food	1.44	0.04	35.6	0.0	1.36	1.51
17 Textiles	1.88	0.06	32.1	0.0	1.77	2.00
18 Wearing apparel	1.95	0.24	8.3	0.0	1.49	2.42
19 Luggage, footwear	1.60	0.11	14.4	0.0	1.38	1.81
20 Wood	0.57	0.08	7.2	0.0	0.42	0.73
21 Pulp, paper	-0.23	0.09	-2.7	0.0	-0.40	-0.06
22 Publishing	-0.51	0.11	-4.7	0.0	-0.72	-0.29
24 Chemicals	2.54	0.05	53.5	0.0	2.45	2.64
25 Rubber, plastic products	0.47	0.06	7.8	0.0	0.35	0.59
26 Other non-metal. mineral products	0.38	0.06	5.9	0.0	0.25	0.51
28 Fabricated metal products	-0.26	0.05	-5.0	0.0	-0.37	-0.16
29 Machinery, equipment n.e.c.	0.66	0.05	14.2	0.0	0.57	0.76
30 Office machinery, computers	4.04	0.51	8.0	0.0	3.05	5.03
31 Electrical machinery	0.59	0.09	6.5	0.0	0.41	0.77
32 Communication equipment	-0.19(*)	0.24	-0.8	0.4	-0.67	0.29
33 Medical, optical instruments	0.47	0.15	3.2	0.0	0.18	0.75
34 Motor vehicles	0.39	0.08	5.0	0.0	0.24	0.55
35 Other transport equipment	0.28(*)	0.17	1.7	0.1	-0.05	0.61
36 Furniture and other products n.e.c.	-0.36	0.09	-4.1	0.0	-0.54	-0.19
R-squared	*0.676*					

(*) Not significant. Sector 27 (Metallurgic products) is omitted as reference sector.

Although all coefficients are statistically different from zero, the major role in explaining changes in emissions is played by the energy content and the cyclical trend of production, as the coefficient of the tax variable is much smaller (-0.13). However, this result does not contradict the conclusion generally drawn from ex-post evaluation studies that all CO_2 taxes have contributed to reduce emissions. The weakness of the observed impact may be mainly attributed to the limited variation both in gas emissions and in tax rates already pointed out.

The group of coefficients for the industrial sub-sectors is jointly significant (as shown by the F-test performed on the group of coefficients). Thus industry-specific characteristics are relevant to the impact of carbon taxes on CO_2 emissions.[22] Sectoral indicators show that only firms in the pulp and paper industry (sector 21), the printing and publishing industry (22), and communication equipment (32) perform relatively (and significantly, in statistical terms) worse than the metallurgic sector in reducing their gas emissions: these activities are among those covered by the EU emission trading scheme as deemed among the most energy-intensive industrial sectors and therefore a large effort in emission abatement will soon be required to fulfil the obligations of the European Directive.

4 The demand of some energy products: a fixed effect model

Panel data offer a large flexibility with respect to modelling latent heterogeneity not measurable across different enterprises. In the following we present the estimate of the firms' demand for diesel, natural gas, fuel oil and electricity. For the firms of our panel, these products represent 60% of total energy inputs in the year 2000, and the 75% in 2004 as the use of other inputs such as solid fossil fuels decreased. Among these, electricity and natural gas cover the highest share as expected. The demand of each energy product estimated here, takes the following form:

$$\log(energy\_input)_{it} = \alpha_i + \beta_1 \log(VA)_{it} + \beta_2 \log(price)_{it} + \beta_3 \log(tax)_{it} + \beta_4 \log(p\_energy)_{it} + \\ + \beta_5 \log(p\_electr) + \beta_6 (dum\_subsector) + \theta_t + u_i + \varepsilon_{it}$$

The input demand measured in physical terms (log),[23] is a function of value added, input price (net of taxes), an input-specific tax component, the price of all other energy inputs used by each firm (excluding the product in question and electricity), the electricity price, and sectoral characteristics. We intend to investigate the effect on energy demand of the price and fiscal components for each specific product and of the electricity price – which is a major energy input for most sectors, and of the residual bundle of energy carriers used by each firm. The parameter θ_t denotes time dummies that are included to capture the effect of variations in unobserved variables that affect all enterprises in the same way. The parameter β_1 represents the elasticity with respect to value added, while the elasticity of the demand to the price of each product is denoted by β_2, and finally the parameter β_3 indicates the percentage change of consumption due to the unit energy tax.

This model can be estimated by assuming a common intercept for all observations (pooled or cross-section regressions) or by taking into account the panel structure of the data and supposing the relevance of company-specific fixed effects, allowing the intercepts to be different for each firm to control for heterogeneity of the companies. The model with fixed effects can capture the unobserved variables at the firm level u_i – such as the adoption of energy-saving technology and the management attention devoted to the energy content of the production process – that influence each energy input demand. We have run both a pooled regression and a fixed effect model.[24] Results presented here are limited to the latter because the fixed effect model both theoretically and empirically performs better in capturing the latent heterogeneity in the firm panel. Moreover, we have decided to run the model for two different groups of companies to verify how firm size (in terms of number of workers) affects the demand parameters.[25] Estimation results of the complete set of equations for all products are presented in the Annex. Here we present the parameters of own-price elasticities and energy tax elasticities for each product demand (Table 7).

All own-price elasticities have the expected negative sign with the exception of electricity consumption where large enterprises have a positive (not significant) elasticity to price before tax, whereas the SMEs' estimate is -0.77. One interpretation of this result is that large manufacturing companies are, in general, large users receiving electricity at higher voltage and at a

22 All coefficients are computed with respect to sector 27, Metallurgic products, which has been dropped as the most energy-intensive industrial sub-sector.

23 The unit of measure is ton for diesel and fuel oil, thousand of cubic meters for natural gas and Kwh for electricity.

24 We have also compared the fixed effect model with a random effect model on a simpler specification of the demand equation. The Hausman test for all equations was significantly greater than zero meaning that the difference in coefficients with respect to a random effect model is systematic.

25 The two groups include firms up to 100 workers (Small and Medium Enterprises, SME) and firms with more than 100 workers (Large Enterprises, LE).

lower price, so they are less reactive to price changes, as special conditions are provided in their contracts and prices are more stable.[26]

Table 7: Estimates of own-price and energy tax elasticities

Own-price elasticities		
	Small and medium enterprises	Large enterprises
diesel	-0.372	-0.472
natural gas	-1.683	-1.708
fuel oil	-0.567 (*)	-0.893
electricity	-0.768	0.182 (*)
Elasticities to Energy taxes		
	Small and medium enterprises	Large enterprises
diesel	-0.988 (*)	-3.046
natural gas	-3.233	-2.384
fuel oil	-0.502 (*)	-2.456
electricity	-0.433	-0.517

Note: (*) Not significant (below the 95% confidence level).

In general, for all other energy products considered here large firms do react slightly more to price changes and particularly natural gas demand is the most price-elastic with parameters above -1.5% for all companies.

Most important for the purpose of this study is the estimate of the effect of carbon tax changes on energy product demands (bottom panel of Table 7). For all estimated equations, this parameter has the expected (negative) sign and in most cases is statistically different from zero. For diesel and fuel oil, the estimated value is higher for large companies and is always bigger than price elasticity: energy product demand is more reactive to changes in tax rates than in net prices, perhaps because changes in taxes are perceived

26 Italian prices for industrial use of electrical energy, both gross and net of taxes, are among the highest in Europe. The explanation of higher electricity prices in Italy is to be found in the higher tax burden as well as, especially, in the low plant efficiency and in the mix of fuels with a high cost per thermal of unit supplied (ENEA, 2005).

to be more permanent than price changes[27] and therefore their impact on energy demand is higher. These large estimated values imply that there are opportunities to reduce energy consumption, and then gas emissions, at a low cost by appropriately changing carbon tax rates.

The demand of natural gas is particularly sensitive to tax changes, as its consumption has progressively increased in the Italian manufacturing sector substituting the use of solid fossil fuels. From our estimates, SMEs have larger values than LEs for the tax parameter: this result is robust also with respect to the introduction of dummy variables to capture industrial sub-sector-specific differences in technological constraints. Finally, companies of every size reduce their demand of electricity by about 0.5% for every percentage point of increase in carbon taxes per unit of energy. This is the lowest value of the tax elasticities in our set of equations, thus supporting the view that carbon / energy taxes have a lower effect on industrial electricity consumption because there is no adequate substitute for this energy carrier (Enevoldsen et al., 2007). This argument may also be supported by the estimates of parameter β_5 in our equations to investigate how the (gross) price of electricity affects each product demand: most of our estimates are positive but not statistically significant, with the exception of diesel demand where an increase of the electricity price leads to a large increase in consumption for both small and large companies.

As for the other variables included in our equations, whose results are presented in Tables 1-4 of the Annex, some remarks are worthwhile. All elasticities to value added for energy products considered here are positive and significant (except for fuel oil) and do not present large differences between the two groups of large and small / medium enterprises: the only exception is for diesel where the elasticity for LEs (+0.65) is almost twice that of SMEs (+0.42).[28]

27 Barker et al. (1995) suggest this interpretation to explain why taxes should give polluters a bigger incentive to reduce CO_2 emissions.

28 Results of the pooled regression for the same products (not reported here) show a larger value for value-added elasticity, very close to 1.0 for all energy consumptions (i.e. constant returns to scale). This result is consistent with estimates of a simpler model by Bjørner and Jensen (2002) and supports the idea that cross-section (pooled) estimates based on variation in the variables between companies may be better to capture long-term effects while the fixed effect model focuses on the behaviour of the (continuously existing) companies over time and these within-estimates should be interpreted as short-term elasticities. Agnolucci (2004) correctly identifies these short-term coefficients with values smaller than one as an indication of increasing returns to scale: the model indeed suggests that increasing the energy input in the production function by a certain factor t raises the output by a factor which is larger than t.

Our covariates also include the average price of energy products consumed by each firm other than the input of each equation and electricity as mentioned above. However, this variable is never significant, thus showing that our results on price and tax parameters are robust to price changes of other energy products.

Although our panel consists only of two years of observations, the time dummy has a significant effect both in diesel and in natural gas consumption: in 2004, economic activity in the manufacturing industry was basically stagnant compared with the year 2000 although, on a general level, the modest growth in levels of activity has not been accompanied by an improvement in the structural characteristics of the system in terms of energy required for each level of activity.[29] Finally, industrial sub-sector characteristics are relevant to explain some of the demand variability, as shown by the test on the group of coefficients reported at the bottom of each table in the Annex.

6 Final remarks

The Italian path towards compliance with the Kyoto targets so far appears very unsatisfactory compared to the other EU members. This result can partly be explained by the scarcity of (private and public) resources devoted to investment in energy-saving and energy-renewable technologies. On the other hand, the traditional environmental policy instrument, i.e. Pigouvian taxes, has not been managed in a coherent and consistent manner. In fact, a carbon tax reform has been introduced in 1998 by reshaping the previous energy-related tax rates and including coal and other energy products with high emissions. The tax rates originally foreseen in 1998 were supposed to gradually increase up to a target level in 2005, but in a framework of rising international energy prices, the original tax design has never been implemented and in fact only some minor tax rates revisions have been installed since the year 2000. On the basis of a microsimulation model for Italian firms, in this chapter we make an assessment of the effectiveness of the current

29 According to the 2005 Report on Energy and the Environment by ENEA (Italian National Agency for New Technologies, Energy and the Environment), the increase of energy consumption in an extended phase of stagnation of production depends mainly on the resilience of sectors with greater energy intensity and on the simultaneous cutback of sectors with a lower specific consumption, but that represent significant shares of overall industrial output.

environmental tax system on energy products (a mix between an energy tax and a carbon tax). This analysis has been performed on a microsimulation model of manufacturing firms between the years 2000 and 2004. A regression analysis on the effect of taxes on CO_2 emissions and an input demand analysis for some energy products show the efficacy of environmental taxes, even in a framework of rising energy prices.

References

Agnolucci, P. (2004) "Ex Post Evaluation of CO2 Taxes: A Survey", *Working Paper 52*, Tyndall Centre.

Bardazzi, R./Oropallo, F./Pazienza, M.G. (2004) 'Accise energetiche e competitività delle imprese: un'applicazione sull'esperimento della carbon tax' (Energy Taxes and Industrial Competitiveness: The Case of Italian Carbon Tax), *Economia delle fonti di energia e dell'ambiente* 3: 121-164

Barker, T./Ekins, P./Johnstone, N. (1995) *Global Warming and Energy Demand*. London: Routledge.

Bjørner, T.B./Jensen, H.H. (2002) 'Energy Taxes, Voluntary Agreements and Investment Subsidies: a Micropanel Analysis of the Effect on Danish Industrial Companies' Energy Demand', *Resource and Energy Economics* 24: 229-249.

EEA (2007) *Greenhouse Gas Emission Trends and Projections in Europe 2007*, EEA Report No 9/2007.

Enevoldsen, M.K./Ryelund, A.V./Andersen, M.S. (2007) 'Decoupling of Industrial Energy Consumption and CO_2-Emissions in Energy-intensive Industries in Scandinavia', *Energy Economics* 29: 665-692.

Eurostat (2008) 'Enterprises by Size Class Overview of SMEs in the EU', *Statistics in Focus* 31/2008.

IPCC (2007) Fourth Assesment Report, www.ipcc.org

OECD (1997) *Evaluating Economic Instruments for Environmental Policy*. Paris: OECD.

OECD (2006) *The Political Economy of Environmentally Related Taxes*. Paris: OECD.

Pearson, M. (1995) 'The Political Economy of Implementing Environmental Taxes', *International Tax and Public Finance* 2 (2): 357-373

Stern, N. (2006) 'Review on the Economics of Climate Change', H.M. Treasury, UK. http://www.sternreview.org.uk

Tietenberg, T. (2006) *Economia dell'Ambiente*. McGraw Hill.

Annex

Table A.1: Fixed effects model – demand of diesel

	Small Enterprises Coef	Robust S.E.	Large enterprises Coef	Robust S.E.
Log_value added	0.415**	0.131	0.646***	0.154
Log_price_diesel	-0.372*	0.173	-0.472*	0.199
Log_tax_diesel	-0.989	0.796	-3.047**	1.080
Log_price_energy	-0.135	0.076	-0.053	0.085
Log_price_electr	1.868***	0.534	1.497*	0.620
time	-0.182	0.137	-0.676***	0.151
Sector 14	-0.086	0.888	(dropped)	
Sector 15	-0.350	0.986	1.068	1.833
Sector 17	-0.934	1.082	2.739	2.221
Sector 18	-0.981	1.110	3.682	2.236
Sector 19	-1.242	1.077	1.839	2.137
Sector 20	0.015	1.138	0.335	1.404
Sector 21	-0.312	1.038	-0.936	2.165
Sector 22	1.166	1.368	0.855	2.954
Sector 24	-1.168	0.961	1.240	1.831
Sector 25	-0.678	0.779	-0.830	1.437
Sector 26	-0.553	0.864	2.031	1.276
Sector 28	0.005	0.338	1.050	1.093
Sector 29	-0.234	0.688	0.879	1.168
Sector 30	0.004	1.312	(dropped)	
Sector 31	0.262	1.360	1.276	1.765
Sector 32	0.377	1.078	0.861	2.485
Sector 33	0.384	0.835	1.597	1.808
Sector 34	-0.485	1.450	0.730	1.673
Sector 35	-0.133	0.806	0.417	1.446
Sector 36	-0.604	0.745	0.458	1.290
_cons	10.505	5.427	17.502*	7.331
R-Square Overall	0.060		0.110	
R-Square Within	0.168		0.312	
corr(u_i, Xb)	-0.192		-0.504	
Observations	2923		4685	

* p<0.05, ** p<0.01, *** p<0.001

Test on Sectors: SME F(20, 1057) = 1.28 Prob > F = 0.1819
Test on Sectors: LE F(18, 1670) = 6.21 Prob > F = 0.0000

Note: R-square within is a measure of goodness-of-fit after the fixed effects have been controlled for.
Heteroscedasticity robust standard error of estimate are reported (S.E.).

Note: corr(u_i, Xb)is the correlation index between the fixed effect u_i and the model Xb

Table A.2: Fixed effects model – demand of natural gas

	Small Enterprises Coef	Robust S.E.	Large enterprises Coef	Robust S.E.
Log_value added	0.543**	0.168	0.443**	0.138
Log_price_natgas	-1.684***	0.413	-1.708***	0.443
Log_tax_natgas	-3.234*	1.477	-2.384*	1.008
Log_price_energy	-0.112	0.084	0.011	0.069
Log_price_electr	0.345	0.452	0.294	0.383
time	-0.238**	0.077	-0.120	0.065
Sector 14	-1.159	2.784	(dropped)	
Sector 15	-0.990	1.246	0.143	1.127
Sector 17	-0.086	1.300	-0.924	1.485
Sector 18	0.378	1.298	0.129	1.668
Sector 19	-0.740	1.259	-0.919	1.339
Sector 20	-0.236	2.119	-1.177	1.493
Sector 21	1.406	1.394	-0.004	1.182
Sector 22	1.355	1.816	-0.002	1.265
Sector 24	-0.526	1.163	-0.745	1.099
Sector 25	-0.425	1.136	-1.132	1.127
Sector 26	-0.538	1.101	-0.924	1.743
Sector 28	-0.580	0.429	-0.254	0.823
Sector 29	-0.513	0.781	-1.050	0.860
Sector 30	0.173	1.536	(dropped)	
Sector 31	0.512	1.127	-1.379	0.963
Sector 32	1.723	1.306	-1.002	1.216
Sector 33	0.630	1.014	-1.390	1.117
Sector 34	0.267	0.812	-0.737	1.293
Sector 35	-1.269	0.906	0.465	1.447
Sector 36	0.186	1.472	-1.654	0.999
_cons	15.469**	5.500	15.598***	4.459
R-Square Overall	0.152		0.248	
R-Square Within	0.167		0.098	
corr(u_i, Xb)	-0.095		0.0916	
Observations	2915		4880	

* p<0.05, ** p<0.01, *** p<0.001

Test on Sectors: SME F(20, 1066) = 7.31 Prob > F = 0.0000
Test on Sectors: LE F(18, 1762) = 2.78 Prob > F = 0.0001

Note: R-square within is a measure of goodness-of-fit after the fixed effects have been controlled for.
Heteroscedasticity robust standard error of estimate are reported (S.E.).

Note: corr(u_i, Xb)is the correlation index between the fixed effect u_i and the model Xb

Table A.3: Fixed effects model – demand of fuel oil

	Small Enterprises Coef	Robust S.E.	Large enterprises Coef	Robust S.E.
Log_value added	0.306	0.307	0.223	0.251
Log_price_fueloil	-0.567	0.361	-0.894**	0.303
Log_tax_fueloil	-0.502	1.463	-2.457**	0.813
Log_price_energy	-0.049	0.228	-0.363	0.280
Log_price_electr	-1.133	1.479	-0.754	0.741
time	-0.028	1.066	1.297*	0.620
Sector 14	6.884*	3.471	(dropped)	
Sector 15	-2.601***	0.401	(dropped)	
Sector 17	5.912***	0.865	(dropped)	
Sector 18	7.035***	0.703	2.575***	0.337
Sector 19	(dropped)		2.282***	0.395
Sector 20	-0.568	1.016	-1.672	1.891
Sector 21	7.296***	0.969	2.143	2.383
Sector 22	(dropped)		-1.906	2.383
Sector 24	3.809***	0.545	(dropped)	
Sector 25	2.728*	1.082	0.039	2.375
Sector 26	5.264***	0.526	0.786	2.381
Sector 28	2.646**	1.014	0.379	1.057
Sector 29	4.529**	1.432	0.280	1.055
Sector 30	(dropped)		(dropped)	
Sector 31	(dropped)		-1.969	1.889
Sector 32	(dropped)		(dropped)	
Sector 33	2.043	1.085	(dropped)	
Sector 34	(dropped)		-1.408	1.937
Sector 35	4.138**	1.486	2.224	2.395
Sector 36	-4.008	2.191	1.663	1.821
_cons	-2.165	7.703	13.719*	6.280
R-Square Overall	0.017		0.105	
R-Square Within	0.141		0.198	
corr(u_i, Xb)	-0.8223		-0.2672	
Observations	1772		2967	

* p<0.05, ** p<0.01, *** p<0.001

Test on Sectors:	SME	F(10, 508) =	177.68	Prob > F =	0.0000
Test on Sectors:	LE	F(13, 880) =	469.63	Prob > F =	0.0000

Note: R-square within is a measure of goodness-of-fit after the fixed effects have been controlled for.
Heteroscedasticity robust standard error of estimate are reported (S.E.).

Note: corr(u_i, Xb)is the correlation index between the fixed effect u_i and the model Xb

Table A.4: Fixed effects model – demand of electricity

	Small Enterprises Coef	Robust S.E.	Large enterprises Coef	Robust S.E.
Log_value added	0.403***	0.100	0.365***	0.108
Log_price_electr	-0.768*	0.363	0.182	0.293
Log_tax_electr	-0.433***	0.069	-0.517***	0.042
Log_price_energy	-0.046	0.069	0.007	0.072
time	0.053	0.046	-0.036	0.050
Sector 14	0.190	1.363	(dropped)	
Sector 15	-0.441	1.141	-0.185	0.741
Sector 17	-0.603	1.267	-0.347	1.039
Sector 18	-0.866	1.239	-0.386	1.170
Sector 19	-1.107	1.185	-0.658	0.972
Sector 20	0.291	1.335	-1.066	0.833
Sector 21	-0.186	1.281	-0.163	0.962
Sector 22	1.273	1.529	0.185	1.353
Sector 24	-0.111	1.110	-0.337	0.735
Sector 25	0.162	1.019	-0.348	0.738
Sector 26	-0.612	1.167	-0.259	1.648
Sector 28	-0.105	0.493	-0.345	0.518
Sector 29	-0.337	0.679	-0.603	0.559
Sector 30	0.567	1.289	(dropped)	
Sector 31	0.252	0.966	-0.553	0.674
Sector 32	1.641	1.244	-0.054	1.267
Sector 33	0.365	1.008	-0.463	0.724
Sector 34	0.275	0.941	-0.686	1.043
Sector 35	-0.422	0.681	0.215	0.718
Sector 36	0.374	1.333	-1.500*	0.663
_cons	3.804	2.067	6.975***	2.088
R-Square Overall	0.355		0.555	
R-Square Within	0.198		0.347	
corr(u_i, Xb)	0.1358		0.2405	
Observations	3064		4895	

* p<0.05, ** p<0.01, *** p<0.001

Test on Sectors:	SME	F(20, 1152) =	0.84	Prob > F =	0.6680
Test on Sectors:	LE	F(18, 1777) =	1.12	Prob > F =	0.3213

Note: R-square within is a measure of goodness-of-fit after the fixed effects have been controlled for.
Heteroscedasticity robust standard error of estimate are reported (S.E.).

Note: corr(u_i, Xb)is the correlation index between the fixed effect u_i and the model Xb