CO2 Emissions in Italy: a Microsimulation Analysis of Environmental Taxes on Firm's Energy Demand

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CO_2 EMISSIONS IN ITALY: A MICRO-SIMULATION ANALYSIS OF ENVIRONMENTAL TAXES ON FIRMS' ENERGY DEMAND

Rossella Bardazzi, Filippo Oropallo, and Maria Grazia Pazienza[1]

A. Introduction

According to an overwhelming body of scientific literature,[2] the Earth's climate is rapidly changing, predominantly as a result of increases in greenhouse gases caused by human activities (for example, through burning fossil fuels and changing the land surface, etc.). **21.01**

Fighting climate change and its consequences by achieving stabilization of atmospheric greenhouse gas concentrations is a key objective of the European Union (EU). As regards climate change, the EU environmental policy acts under the **21.02**

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[2] Intergovernmental Panel on Climate Change (IPCC), Fourth Assessment Report (2007).

Kyoto Protocol, adopted in 1997 and entered into force in 2005. As is well known, the EU has committed itself to the target of an 8 per cent emissions reduction from the base-year level by 2008 to 2012. Within this overall target, differentiated emission reduction targets have been assigned to Member States under the 'burden-sharing agreement'. The protocol provides a broad list of 'traditional' policies aimed at reaching the target such as environmental taxes, use of renewable energy, energy efficiency, and carbon sinks; moreover, the protocol also establishes three 'flexible mechanisms' (joint implementation, clean development mechanism, and the Emission Trading Scheme), designed to help countries to comply with the target. Finally, the EU has set itself new ambitious targets for 2020 in the Climate Action Plan:[3] a 20 per cent reduction in greenhouse gases, increasing renewable energy use up to 20 per cent of total energy consumption, and a significant increase in energy efficiency. The planned cuts in greenhouse gas emissions call for a substantial shift in firm and consumer behaviour. As regards firms, there is a request for a change in the input mix and for investment in energy-saving technologies. These targets imply costs, whatever the instrument chosen, but instruments differ in economic impact and an optimal policy mix may help to reduce distortions and overall costs. In general terms, a major endorsement for *market based instruments*[4]—as opposed to the traditional command and control approach—can be found in the Kyoto framework and in the new Climate Action Plan.[5]

21.03 In this chapter we try to evaluate the efficacy of energy taxes in Italy with regard to the effect on CO_2 emissions of industrial sectors and on a change in input energy mix chosen by firms. The study is performed through a regression analysis rooted in a micro-simulation model of Italian firms. After a brief review of the current situation regarding emissions and energy efficiency in Italy, we present details on the data set used, the micro-simulation model and the estimation results.

[3] Following the agreement of March 2007, the European Commission approved a Climate Action Plan in January 2008. See European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2008) 30 Final.

[4] According to the Organisation for Economic Cooperation and Development (OECD), *Evaluating economic instruments for environmental policy* (Paris: OECD, 1997), 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'.

[5] A key pillar of the plan is an expansion of the current European Emission Trading Scheme (ETS).

B. Growth and Environment: is Decoupling an Option?

The environmental consequences of economic activity have been analyzed in the literature from different perspectives: starting from the idea of an inescapable trade off between environmental standards and economic growth, sustainable development can be reached only with a decrease of per capita consumption in developed countries; from the opposite view, the standard Environmental Kuznetz Curve hypothesis spreads optimism among developing countries and stresses the role of technological progress for a green growth. However, all European countries are far beyond the turning point of the Environmental Kuznetz Curve and the dilemma of improving living standards without environmental damage is even trickier. The idea of breaking away from the trade-off between environment and growth has been associated with the notion of decoupling, which occurs 'when the growth rate of environmentally relevant variable is less than that of its economic driving force'[6] (as gross domestic product (GDP) for the whole economy or input demand in a sectoral or micro perspective). Basically, behind this idea is a change in the structure of economic systems (ie a shift towards tertiary sectors or a dematerialization of the economy) or a general path of technological progress. In more detail, according to the Porter hypothesis,[7] the same environmental policy can give rise to a double dividend because—whatever the specific instrument may be—it accelerates technological innovation and, as a consequence, improves the competitive position of industries. **21.04**

If decoupling can be identified as a fundamental goal of environmental and industrial policy in developed countries, the problem of how to measure it and how to reach the target is still open. **21.05**

As regards the measurement issue, the analysis of greenhouse gas emissions and GDP growth trends can be quite straightforward. Moreover, following Ekins and Barker (2001) and Agnolucci (2004),[8] emissions can be analysed using several indicators, among which energy intensity and carbon intensity play a prominent role. However, simple indicators must be interpreted with caution, because **21.06**

[6] OECD, Indicators to Measure Decoupling of Environmental Pressure from Economic Growth, (SG/SD(2002)1Final), <http://www.oecd.org> (2002) 11. Decoupling can be defined either in absolute or relative terms. *Absolute* decoupling occurs when the growth rate of the environmentally relevant variable is negative or zero. *Relative* decoupling is said to occur when the rate of environmentally relevant variable is positive, but lower than the rate of GDP.

[7] Porter and van der Linde, 'Toward a New Conception of the Environment-Competitiveness Relationship' (1995) 9(4) *Journal of Economic Perspectives* 97–118.

[8] P Ekins and T Barker, 'Carbon taxes and carbon emission trading' (2001) 15(3) *Journal of Economic Surveys* 325–76; and P Agnolucci, 'Ex post evaluation of CO_2 taxes: a survey', Working Paper 52 (Tyndall Centre, 2004).

in developed economies the relationship between economic driving forces and environmental effects is quite complex.

Emission trends in Europe and Italy

21.07 In the EU, total greenhouse gas emissions (carbon dioxide, nitrous oxide, and fluorinated gases) decreased by 7.9 per cent from 1990 to 2005.[9] After the upward trend observed between 2002 and 2004, this result generates new optimism in the EU and a recent report from EEA[10] underlines that 'the EU-15 can meet, and may even over-shoot, its 2012 Kyoto target... if Member States implement now all additional policies being planned'. According to the EEA report, Italy is among the three Member States whose emission levels indicate that they will not meet the Kyoto target and have consequently allocated specific financial resources in order to comply by means of flexible Kyoto mechanisms.

21.08 A major role in the reduction of greenhouse gas emissions has been performed by European non-energy related industries. Figure 21.1 shows that emissions were reduced by 16 per cent compared to base-year levels in EU-15 and that decoupling has taken place.

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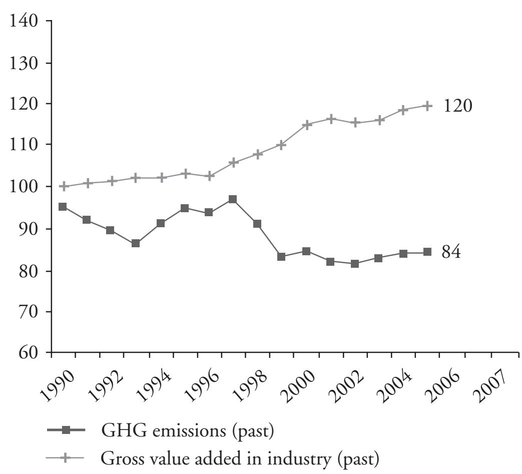

Figure 21.1 Greenhouse gas emissions from industrial processes.
Source: EEA, 'Greenhouse gas emission trends and projection in Europe 2007', EEA Report No 5/2007 (2007).

[9] In the EU-15, the decrease was only 0.6%, and largely due to reductions in Germany and the United Kingdom.
[10] EEA, 'Greenhouse gas emission trends and projections in Europe 2007', EEA Report No 5/2007 (2007).

Albeit in an overall framework of mixed results, environmental policy in Europe can be considered fairly successful, in particular with regard to energy consumption trends. Economic growth is requiring less additional energy inputs and a noticeable reduction of total energy intensity has been recorded (–9.8 per cent for EU 25, see Table 1). This reduction has been influenced both by improvements in energy efficiency and structural changes within the economy.[11] **21.09**

However, this encouraging outcome is the result of heterogeneous contributions of member countries: all new Member States exhibit a sharp decline in energy intensity as a result of the dramatic changes in economic structures, while three of the incumbents, on the contrary, display a rise in energy intensity. **21.10**

Levels of energy intensity are, at the same time, extremely differentiated: relative to the EU 25 average, Estonia shows a level of 214 and Ireland of 74. Energy efficiency is a cost-effective way of cutting greenhouse gas emissions, but its importance should not be overrated, as many countries have already made considerable improvements towards energy-saving technologies. However, considerable potential still remains to be exploited, especially for new member countries. **21.11**

Unfortunately, a very unsatisfactory picture can be sketched for the Italian case and no sign of absolute decoupling can be found in the general trend of greenhouse gas emissions. Focusing on CO_2 emissions, Table 2 shows an increase of 13 per cent compared to base-year level in Italy, mostly attributable to the transport sector. In greater detail, the lefthand side of the figure shows a relative decoupling between 1990 and 2003, but the CO_2 content of GDP is lower by only 3 per cent with respect to 1990. **21.12**

Moreover, the righthand side of Table 2 emphasizes that the positive role of manufacturing—experienced in all other member countries—is smaller (–3.8 per cent) than in the average European case (–15 per cent). **21.13**

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Even decomposing the aggregate indices, the picture does not improve. Figure 21.2 shows that Italy performed worse than the EU-25 with regard to all indicators analysed. In more detail, as for energy intensity, the Italian economy still has one of the lowest absolute values (see Table 1), but no evidence of improvement can be ascertained after 15 years. Moreover, industrial energy intensity has increased, whereas the European industry sector as a whole exhibits an unmistakable decrease. What is more, Italy's performance deteriorates with regard to carbon intensity and CO_2 per capita. **21.14**

[11] This effect was linked to a shift from industry towards services, which are typically less energy intensive, a shift within the industrial sector from energy intensive industries towards higher value added, less energy-intensive industries.

Table 1 Total energy intensity 1995–2004 (1995=100) and total energy intensity in 2004 relative to EU-25 (EU-25=100); increasing ranking by energy intensity 2004

	1995	2000	2001	2002	2003	2004	Energy intensity in 2004 (TOE per million GDP in PPS relative to EU-25)
Ireland	100.0	81.5	80.1	77.2	72.6	73.4	74
Italy	100.0	97.4	95.9	95.8	101.0	101.0	79
Denmark	100.0	84.3	85.9	83.9	86.7	82.7	80
Malta	100.0	76.2	72.1	85.6	87.9	89.6	83
Austria	100.0	92.2	97.8	96.6	102.2	100.2	86
United Kingdom	100.0	90.1	88.7	84.9	84.3	82.4	88
Spain	100.0	98.2	97.6	97.7	98.1	99.4	89
Greece	100.0	98.2	96.3	95.3	92.3	89.5	89
Portugal	100.0	100.6	101.3	105.4	104.2	106.2	91
EU-15	**100.0**	**92.7**	**93.2**	**91.8**	**93.0**	**92.1**	**96**
EU-25	**100.0**	**91.0**	**91.5**	**90.1**	**91.3**	**90.2**	**100**
Germany	100.0	91.1	93.2	91.2	91.9	90.6	102
France	100.0	93.8	94.9	93.9	94.4	93.4	105
Cyprus	100.0	100.5	97.6	96.2	102.5	93.2	107
Netherlands	100.0	84.6	85.1	85.7	88.3	88.8	107
Hungary	100.0	78.8	76.9	75.2	74.7	70.0	113
Luxembourg	100.0	80.8	81.8	83.4	86.2	92.1	114
Belgium	100.0	99.3	95.7	89.0	93.7	89.7	117
Slovenia	100.0	85.2	87.1	86.0	84.2	83.2	119
Latvia	100.0	62.4	62.2	57.9	56.7	54.4	122
Poland	100.0	69.8	69.0	67.0	66.3	63.4	131
Sweden	100.0	81.1	86.3	84.5	82.5	82.6	133
Lithuania	100.0	68.0	70.6	71.5	67.4	64.0	147
Czech Republic	100.0	92.4	91.9	91.1	92.8	88.7	160
Slovakia	100.0	81.8	85.0	82.1	78.4	72.1	168
Finland	100.0	89.8	91.1	94.2	97.3	95.0	169
Estonia	100.0	66.1	69.2	62.9	64.2	62.1	214

Source: EEA, 'Greenhouse gas emission trends and projections in Europe 2006', EEA Report No 5/2007 (2007).

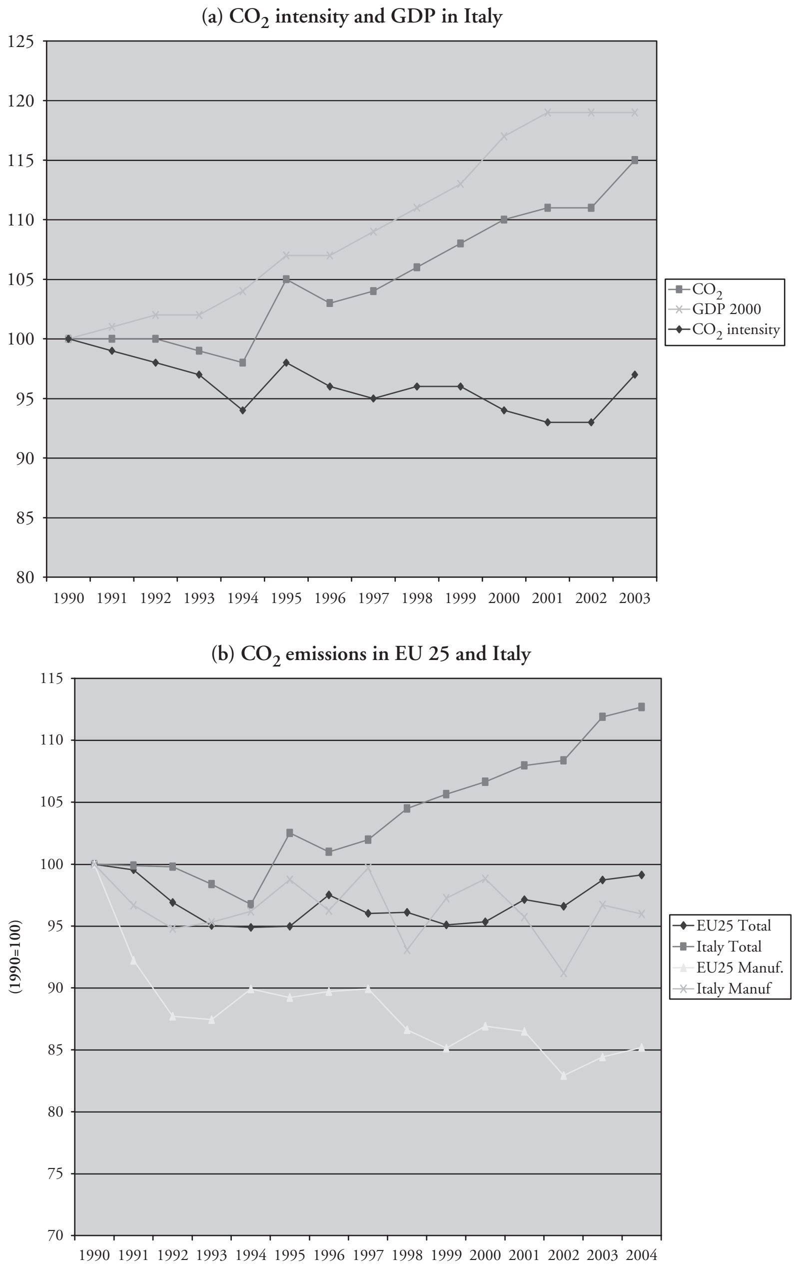

Figure 21.2 Italian emissions and CO_2 intensity of GDP (left) and CO_2 emissions in EU-25 and Italy (right) (indices 1990=100).
Source: Istat (a) and Eurostat (b).

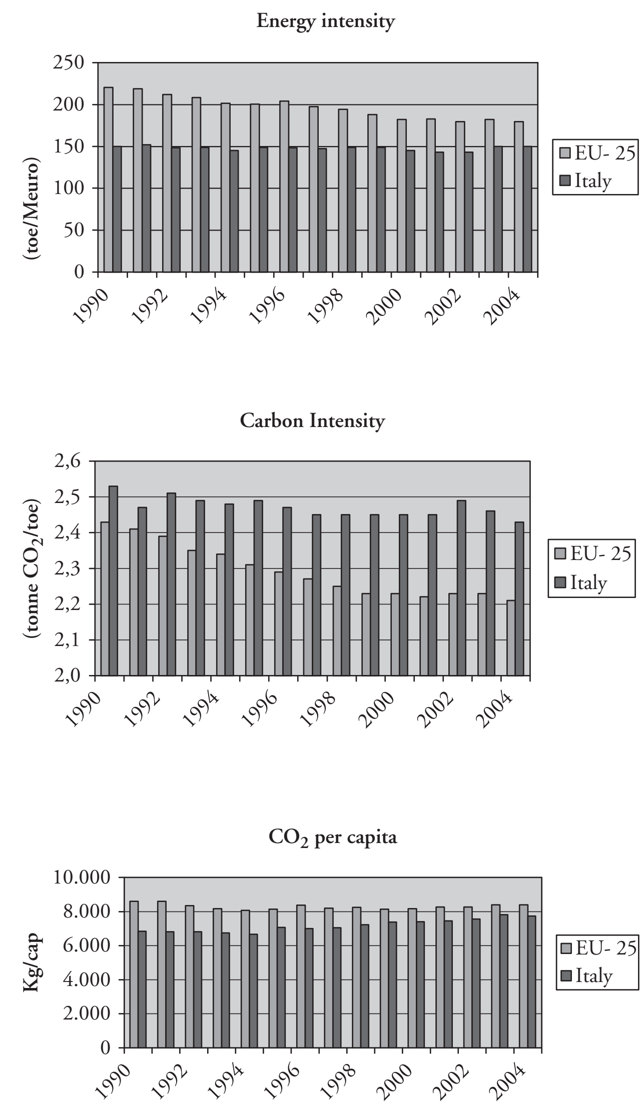

Figure 21.3 Selected indicators for EU-25 and Italy.

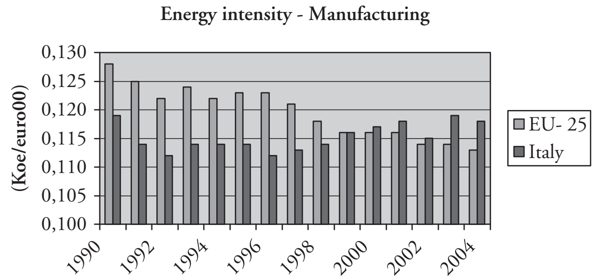

Figure 21.3 (continued) Selected indicators for EU-25 and Italy.
Energy intensity: toe (tonne of oil equivalent)/M€'09 Eurostat.
Energy intensity € in manufacturing kgoe (kilos of oil equivalent) €00, Enea (2007).
Carbon intensity: tons CO_2/tons of equivalent oil,Eurostat.
CO_2 per capital: tons CO_2/population,Eurostat.
Source: European Commission and Enea.

A focus on sectoral emissions in Italy

Drawing details from Italian NAMEA,[12] a comparison between manufacturing sectors can be performed. It is worthwhile stressing that emissions data in the national NAMEA are different from total air emissions recorded in the Eurostat database, mainly as a result of biomass emissions and cross-border activity. Although total emissions are consistent in the two data sets after the above-mentioned corrections are taken into account, the general picture for manufacturing is remarkably different. **21.15**

Table 3 shows that CO_2 emissions have increased for manufacturing by 6 per cent, although the overall CO_2 intensity of manufacturing production (the ratio between CO_2 and production at constant prices) exhibits a sharp decrease. **21.16**

Moreover, all indices exhibit a very high variability, with the most critical situation showed by food and tobacco, plastics, and mechanics. In general terms, CO_2 emissions in Italy appear to be strongly linked to business cycle, probably due to a general scarcity of environmentally related investments. **21.17**

C. Are Environmental Taxes a Useful Tool?

A general evaluation of environmental taxes as a policy instrument can be made with regard to several criteria. As an example of market-based instruments, **21.18**

12 National Accounts Matrix, including Environmental Accounts.

Table 2 Italian selected environmental indicators 1990–2003 (per cent)

	Share in 1990 CO_2 productive emissions	Share in 2003 CO_2 productive emissions	CO_2 change	Turnover change at constant prices	CO_2 intensity change
Mining of metal ores	0.3	0.3	17.0	34.5	7.5
Manufacturing	40.4	39.7	6.0	27.2	–15.9
Manufacture of food products and beverages; tobacco	3.5	2.3	74.0	32.4	32.9
Manufacture of textiles and wearing apparel	7.6	2.6	–12.0	7.5	–15.7
Manufacture of luggage, handbags, saddlery, harness, and footwear	0.7	0.3	2.7	19.7	–10.6
Manufacture of wood, except furniture	0.8	0.3	7.9	36.7	–19.8
Manufacture of pulp, paper, and paper products	3.6	2.1	53.9	22.5	26.7
Manufacture of coke, refined petroleum products, and nuclear fuel	15.3	7.0	21.9	–7.3	31.5
Manufacture of chemicals and chemical products	16.0	3.7	–37.4	21.1	–48.0
Manufacture of rubber and plastic products	1.4	0.7	31.0	57.3	–14.6
Manufacture of other non-metallic mineral products	28.6	11.8	10.7	17.4	–5.6
Manufacture of fabricated metal products, except machinery and equipment	17.2	6.4	–0.2	46.2	–31.7
Manufacture of machinery and equipment not elsewhere classified (NEC)	1.5	1.0	68.4	29.8	33.3
Manufacture of electrical machinery and apparatus NEC	0.8	0.5	48.6	29.5	20.0
Manufacture of motor vehicles, trailers and semi-trailers	2.2	0.8	–7.5	21.1	–21.7
Manufacture of furniture; manufacturing NEC	0.7	0.3	29.1	30.3	3.2
TOTAL ECONOMIC ACTIVITY	100.0	100.0	6.9	31.7	–17.4

Source: ISTAT, NAMEA.

environmental taxes are generally characterized by economic efficiency (both in static and dynamic terms), good efficacy (or environmental effectiveness[13]), 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. Moreover, empirical literature has highlighted that energy taxes can have a regressive impact on household income distribution. Therefore, the political acceptance of such a policy can be seriously jeopardized.[14]

The effectiveness of environmental taxes[15] can be evaluated using different techniques. First of all, an *ex ante simulation* can be employed in order to provide information on the short-term effect of taxes; the analysis can be based on past behaviour or be merely arithmetical, in the sense that models simply consider the change in the budget constraint faced by agents due to the environmental tax, without taking into account any behavioural change. Notwithstanding this evident limitation, the *ex ante* analysis based on micro-simulation models can calculate the maximum revenue effect of the change in the tax for several categories of agent, with the aim of determining the winners and losers after the reform. **21.19**

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 (ie the change of energy intensity attributable to tax as opposed to the change attributable to price variation). Indeed, the output of *ex post* analysis can be employed—as a behavioural starting point—in future *ex ante* evaluations. **21.20**

In this chapter, we try to combine the two approaches by estimating the *ex post* behaviour of firms starting from an arithmetical micro-simulation model. Among all criteria for *ex post* evaluation of environmentally related taxes, as proposed by the Organisation for Economic Cooperation and Development (OECD) (1997),[16] we focus on the ability of a tax to reduce CO_2 emissions directly by stimulating energy efficiency and indirectly by changing the input mix. **21.21**

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

[14] On this issue see Pearson, 'The political economy of implementing environmental taxes' (1995) 2 International Tax and Public Finance 2, 357–73; and OECD, *The Political Economy of Environmentally related taxes* (Paris: OECD, 2006).

[15] As we are interested in the analysis of environmental taxes, it is worthwhile to recall the general definition: environmental taxes can be 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' (OECD, *The Political Economy of Environmentally related taxes* (Paris: OECD, 2006) 26.

[16] OECD, *Evaluating economic instruments for environmental policy* (Paris: OECD, 1997)

21.22 However, as pointed out by Agnolucci (2004),[17] 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, without setting defined targets for each policy.

21.23 Focusing on environmental taxes aimed at reducing GHG emissions, or CO_2 in particular, it is important to recall the distinction between energy taxes and carbon taxes, although such a distinction cannot be traced in official revenue figures. Energy taxes are imposed on the quantity of energy consumed, whereas a carbon tax should be based only on emissions or the CO_2 content of carbon-based fuels. If the goal is to reduce CO_2 emissions only—and not, for instance, energy intensity—a carbon tax exhibits both a higher efficacy (because it puts a burden only on carbon based fuels, exempting energy sources with no CO_2 emissions) and a better cost effectiveness than an energy tax (as it can equalize the cost of CO_2 abatements across fuels).

Current use of energy and CO_2 taxes in Europe and Italy

21.24 Almost all developed countries use environmentally related taxes, and the majority of them have a long experience in this policy. These taxes raise revenues between 2.5 and 4 per cent of GDP and constitute on average 8 per cent of total revenues. In many respects, energy taxes are the most significant environment-related taxes because they generate large revenues (more than 90 per cent of total environmental tax revenue comes from energy and vehicles).

21.25 At EU level, 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 first amended and eventually withdrawn by the Commission in 2001. In the meantime, because of the lack of agreement, several European countries have unilaterally introduced supplementary CO_2 taxes or reshaped their existing energy taxes (among them Sweden Finland, Denmark, Italy, and Germany).[18]

[17] P Agnolucci (n 8 above).

[18] An overview on European Carbon tax experiences can be found in A Baranzini, J Goldemberg, and S Speck, 'A future for carbon taxes' (2000) 32(3) *Ecological Economics* 395–412; Ekins and Barker (n 8 above); and, for the Norwegian case, Bruvoll and Larsen, 'Greenhouse gas emissions do carbon taxes work?' (2004) 32(4) *Energy Policy* 493–505. See also R Bardazzi, F Oropallo, and MG Pazienza, 'Accise energetiche e competitività delle imprese: un'applicazione sull'esperimento della carbon tax' ('Energy taxes and industrial competitiveness: the case of Italian carbon tax') (2004) *Economia delle fonti di energia e dell'ambiente*, no 3, 121–64,

Energy taxation in the EU is currently regulated by Directive 2003/96/EC, which came into force in 2004 and sets minimum tax rates for a broad range of energy products. This directive has widened the scope of pre-existing EU energy taxation (by including electricity, natural gas, and coal) and increased the minimum rates for transport fuels which were set by a previous directive. As a result of these policies, on the whole between 2000 and 2004 taxes on energy increased in the EU, and this is particularly true for taxes on fuels. **21.26**

As regards Italy, revenue from environmental taxes exhibits a striking increase in nominal terms (80 per cent between 1990 and 2005). However, the importance of environmental taxes, after a sharp increase during the 1990s—due to some experiments with green tax reforms (see the box below for a description of the Italian carbon tax)—shows a decrease since the year 2000: the share of revenue in relation to both total tax income and gross domestic product exhibit a contraction. The same trend has been displayed by energy taxes.[19] Nevertheless, Figure 21.3 shows, as a very rough approximation, an inverse correlation between the relevance of environmental taxes and emission patterns for the overall economy. **21.27**

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This inverse relation can be interpreted as a hint that environmental taxes may have some efficacy in cutting emissions. The efficacy of environmental taxes in Italy will be analysed in the following paragraphs. **21.28**

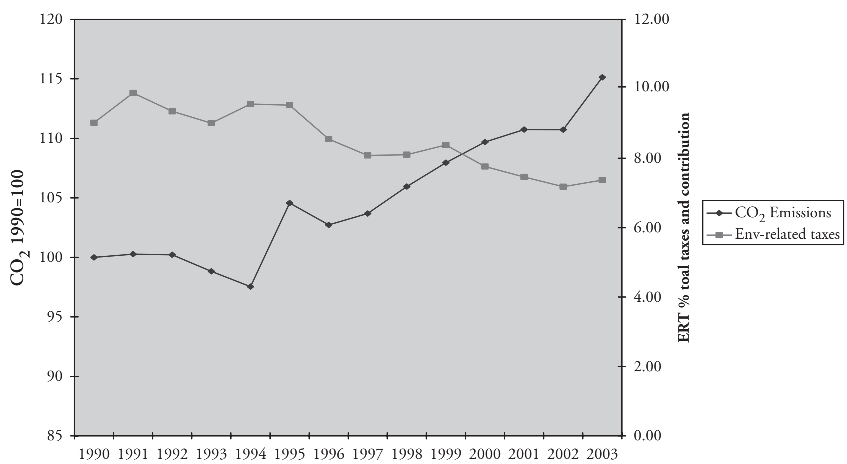

Figure 21.4 Environment-related taxes and CO_2 emissions.
Source: Istat

[19] This is due to the fact that environmental taxes are usually unit taxes, the rate of which is set as a nominal value, the tax base being a physical unit. Without a continuous updating of the nominal tax rate, the relative importance of these taxes decreases as prices increase.

Environmental policy in Italy

Data analysed in previous paragraphs show that emission trends in Italy exhibit a large gap from the target assigned under the European burden sharing agreement. Notwithstanding a satisfactory level of energy intensity and emission levels for manufacturing in 1990, a comparison with European partner trends highlights a remarkable loss in relative position. This pattern has to be linked to the fact that Italian environmental policy appears confused, wavering, and highly influenced by lobbies' pressure.

The carbon tax reform entered into force in 1998 (Law 488/98) is a clear example of these difficulties, as the policy started with a general and coherent design and was halted after two years without any policy substitution. The aim of this reform was to reduce environmentally damaging inputs by reshaping the previous energy-related tax rates and including coal and other high-emission energy products. 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 labour tax wedge.[20] Indeed, the fiscal neutrality approach has contributed to alleviating competitiveness concerns and increasing the political acceptability of the reform.

The tax rates originally foreseen in 1998 were supposed to gradually increase up to a target level in 2005. Unfortunately, in a framework of rising international energy prices, the original tax design has never been implemented and tax rate revisions were halted in 2000. An *ex ante* estimation of the impact of the full reform on manufacturing firms' competitiveness has been performed with a micro-simulation model by Bardazzi, Oropallo, and Pazienza[21] and showed an overall negligible effect on profitability (–0.6 per cent for gross operating surplus), even if effects appeared highly differentiated by sector and firm size due to variability of energy expenditure as a component of intermediate costs and of the share of labour costs.[22]

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20 Moreover, a form of earmarking, through subsidies to environment-related investments, was designed.

21 Bardazzi, Oropallo, and Pazienza (n 18 above).

22 The *ex ante* evaluation referred to the comparison of the effective tax rates in 2000 with the hypothetical tax rates in 2005 if the original tax designed would have been implemented.

D. The Micro-Simulation Model and the Data

The DIECOFIS micro-simulation model for Italian firms has been used to evaluate the government's environmental policy dealing with the implementation of a carbon tax. DIECOFIS has been built and used in recent years within a project financed by the EU Commission in the FP5 framework.[23] This micro-simulation 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. Several public policy evaluations have been carried out with this tool to monitor (*ex ante*/*ex post*) the *effectiveness* of public programs and to foresee the *effects* of public choices on firms within an impact analysis *ceteris paribus*.[24] **21.29**

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.[25] The model covers all active enterprises except for those belonging to agriculture, forestry, and fishing, the financial sector, and the public sector. For this study, a special (reduced) version of the model has been used 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 two 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 exact matching was not possible, a statistical **21.30**

[23] 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 is produced, but the institute bears no responsibility for analysis or interpretation of the data.

[24] See, among others, R Bardazzi, V Parisi, and MG Pazienza, 'Modelling direct and indirect taxes on firms: a policy simulation' (2004) 33(1 & 2) *Austrian Journal of Statistics* 237–59.

[25] 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 have been placed: Large Enterprise Accounts (SCI); Small and Medium Enterprise Survey with less than 100 workers (PMI); Manufacturing Product Survey (Prodcom); Foreign Trade Archive (COE); and 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.

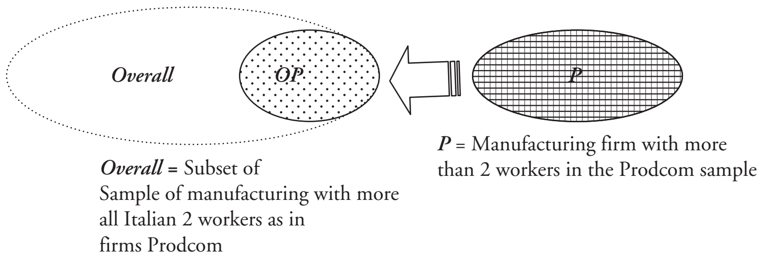

Figure 21.5 Integration scheme of different survey data.

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matching procedure was implemented in order to reconstruct information at a micro level. As summarized in Figure 21.4, the data in OP and P are merged through a cell-based integration procedure.[26]

21.31 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 two workers. The energy data includes information about expenditures (net of value added taxes) as well as the consumption in physical units of several types of energy (electricity, coal, LPG, diesel, gasoline, metallurgic coke, petroleum coke, fuel oil, natural gas, and others). Then the model computes the firm fiscal burden on energy given by the excise tax rates of a specific year for each economic activity applied to the firm energy consumption by products and, accordingly, energy prices (net of taxes) by source 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, and the share of energy cost on intermediate production costs.

21.32 Some patterns of energy consumption for the manufacturing sectors may be identified from our dataset of micro-data. As shown in Table 4, at NACE two-digit level of classification,[27] electricity is the predominant energy source in most sectors as its share ranges from a minimum of one-third of total energy used (sector 26, non-metallic mineral products[28]) to a maximum of three-quarters by sector 32 (manufacturing of communication equipment). The use of natural gas as the second

[26] The cell is an aggregation of units of the same: activity sector (NACE three digits), employment class (3–19, 20–99, 100–249, and >250), and geographical area (NW, NE, C, SI). The integration procedure and evaluation of the quality of its performance are presented in the Diecofis project deliverables at <http://petra1.istat.it/diecofis>.

[27] NACE is the sector classification established by Eurostat see Commission Regulation 29/2002.

[28] Sector 26 uses almost 20% of other energy inputs over its total consumption, as it includes the manufacturing of cement, where the use of petroleum coke as a production input is necessary.

most important energy source is also widespread among economic manufacturing activities, while the consumption of other products is more concentrated on specific sectors as required by production processes, such as the use of coal by the

Table 3 Shares of energy consumption by sector 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 not elsewhere classified	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 NEC	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 4 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.

metallurgic sector (27) and the consumption of fuel oil in producing chemicals (24), cement and construction products (26), and metallurgic products (27). Finally, energy intensity (tonnes of oil equivalent over value added) is on average 0.145, but varies between the manufacturing activities, reaching a peak with the most energy-intensive sector (metallurgic products) at a value of 0.7.

21.33 A variability of prices before taxes for certain energy sources (such as diesel, fuel oil, natural gas, and electricity) can be identified depending on the localization and size of firms. 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 allow reductions of up to 20 per cent of the average price.

21.34 The present study builds on previous research (Bardazzi, Oropallo, and Pazienza (2004))[29] where an *ex ante* analysis of the introduction of a carbon tax in Italy has been performed (see box above). This work aims at giving an original contribution on this topic, as we intend to evaluate *ex post* not only the economic effects of the carbon tax on manufacturing firms, but also the environmental effects in terms of emissions reductions, and to investigate the impact of carbon taxation on the demand of specific energy sources.

21.35 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. Over the two years, approximately 5,600 firms have been selected, of which roughly 60 per cent have a minimum of 100 workers (large enterprises, LE); these firms cover about 40 per cent of the total value added of manufacturing sectors. CO_2 emissions have been imputed for each firm using the NAMEA accounts on the basis of energy uses and their specific CO_2 emission factors.

[29] Bardazzi, Oropallo, and Pazienza (n 18 above).

E. Estimation Results

The micro-panel of industrial Italian firms has been used to explore two different 21.36
issues. As carbon taxes are meant to affect firm behaviour in choosing a less-pollutant bundle of production inputs, our first aim is to assess whether the Italian energy excises have been effective with regard to this goal, notwithstanding the limited implementation of their original design. Secondly, we intend to 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. This analysis could reveal the potential impact of a future tax rate change on energy inputs consumption and, consequently, on gas emissions.[30]

Regression of CO_2 emissions

In this section we describe some results of the model as to the environmental effec- 21.37
tiveness of the carbon tax designed and applied in Italy. As described in the above box, the increase in tax rate linked to Italian carbon tax was abolished in 2000 and, subsequently, few minor changes have been adopted. This may help to explain the limited success in reducing CO_2 emissions in recent years as previously shown. In particular, between the years 2000 and 2004 of our panel, only a few tax rates have been increased: diesel, LPG, natural gas fuel, fuel oil, and electricity.

Given this framework, a relevant impact of the carbon tax on gas emissions could 21.38
not be expected. However, we have estimated the effect of a set of variables on the variation of CO_2 gas emissions between 2000 and 2004 on our panel: the change of the weight of carbon tax rate over the full energy price; the change in the energy intensity (built on the ratio of energy consumption in tonne of oil equivalent 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. Finally, an indicator for different industrial sub-sectors has been introduced in the equation to capture specific effects on emissions due to differences in production technology. Moreover, in order to have a good specification of the model, a logarithmic transformation of the variables has been made.

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The relationship between the variation of CO_2 gas emissions in our panel and the 21.39
set of covariates is shown in Figure 21.5. A positive link between the change in emissions and the variation of energy intensity is clearly visible, while the negative link with tax variation shows a higher variability. Moreover, the pattern of

[30] A similar issue has been investigated with regard to Scandinavia by MK Enevoldsen, AV Ryelund, and MS Andersen, 'Decoupling of industrial Energy consumption and CO_2 emissions in energy-intensive industries in Scandinavia' (2007) 29 *Energy Economics* 665–92.

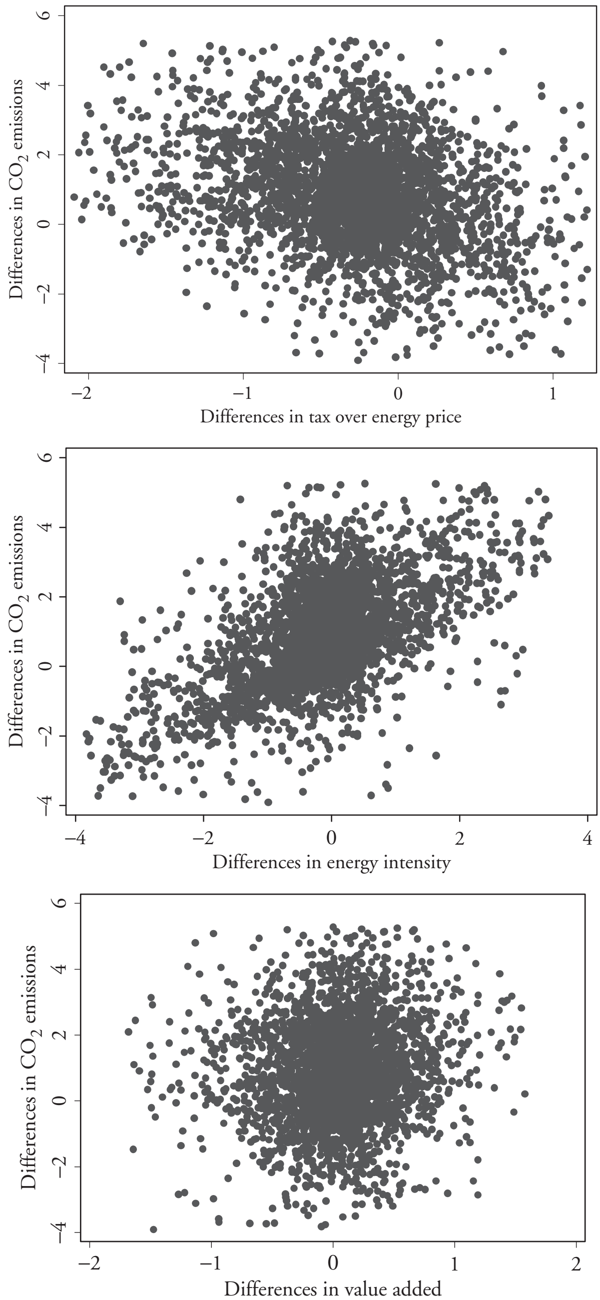

Figure 21.6 Scatter plots and box plot by sector of variation of CO_2 emissions.

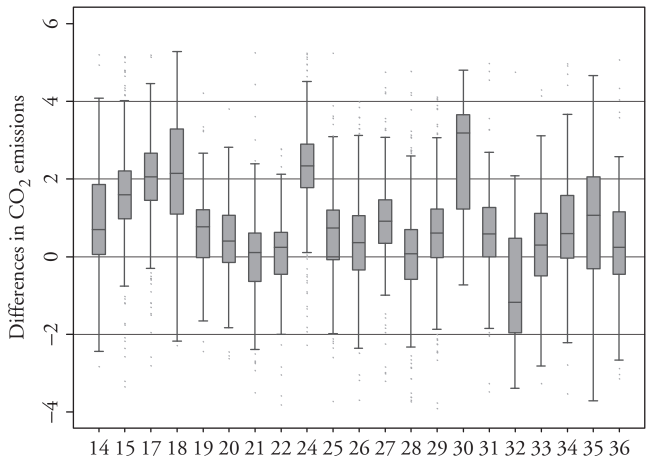

Figure 21.6 (continued) Scatter plots and box plot by sector of variation of CO_2 emissions.

CO_2 emission variations is particularly diversified across the different industrial sub-sectors (fourth panel of the figure). For that reason, indicators of specific manufacturing activities have been considered in the estimation model.

Estimation results are summarized in Table 6.[31] The explanatory variables show the expected signs: the emissions are reduced as the tax ratio on energy cost increases and as both the energy intensity and the value added are lower. Environmental-related expenditures positively contribute to the reduction of gas emissions. **21.40**

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 and it may be primarily attributed to the limited variation both in gas emissions and tax rates already mentioned. **21.41**

The group of coefficients for the industrial sub-sectors is jointly significant (as shown by the F-test performed on the coefficients as a whole), thus industry-specific characteristics are relevant in their impact on CO_2 emissions. In particular, all coefficients are computed with respect to sector 27, metallurgic products, **21.42**

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

Table 5 Results for CO_2 emissions variations (linear regression with robust variance estimates)

Differences in CO_2 emissions (2004–2000) (log)	Coef.	Std. Err.	t	P>|t|	[95% Conf.	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 not elsewhere classified (NEC)	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 NEC	–0.36	0.09	–4.1	0.0	–0.54	–0.19
R-squared	0.676					

(*) Not significant

Sector 27 (Metallurgic products) is omitted which has been dropped as the most energy-intensive industrial sub-sector. It is interesting to note that only firms in the pulp and paper industry (sector 21), 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. It is worthwhile recalling that these activities are among those covered by the EU Emission Trading Scheme as deemed among the most energy-intensive industrial sectors.

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

Panel data offers a large flexibility with respect to modelling latent heterogeneity 21.43
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 per cent of total energy inputs in the year 2000, and 75 per cent in 2004 as the use of other inputs such as solid fossil fuels decreased. Among these, electricity and natural gas account for the highest share, as expected. The demand of each energy product estimated here takes the following form:

$$\log\,(energy\_inputs)_{it} = \alpha_i + \beta_i \log\,(VA)_{it} + \beta_2 \log\,(price)_{it}$$
$$\beta_3 \log\,(tax)_{it} + \theta_t + u_i + \varepsilon_{it}$$

The input demand (in logarithm) measured in physical terms[32] is a function of 21.44
value added, the price of input (net of taxes), and the tax component. The parameters θ_t denote 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 will indicate the percentage change of consumption due to the tax per unit of input.

This simple model can be estimated by assuming a common intercept for all 21.45
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 unobserved 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, the management attention devoted to the energy content of production process—which influence each energy input demand.

[32] The unit of measure is tonne for diesel and fuel oil, 1,000 cubic metres for natural gas, and KWh for electricity.

21.46 We have run both a pooled regression and a fixed-effect model. Results presented here (Table 7) 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) influences the demand parameters.

21.47 Elasticities to value added for all energy products considered here are all positive and significant (except for fuel oil) and do not present large differences between the two groups of large and small-to-medium enterprises: the only exception is for diesel, where the elasticity for LEs (+0.68) is almost twice that of small and medium-sized enterprises (SMEs) (+0.42). A similar difference between companies also occurs in the estimate of diesel price elasticity: large firms do react more to price changes (–0.48), while for smaller companies, a variation in price is not statistically significant in determining the demand for diesel. Results of the pooled regression for the same products (not reported here) showed a larger value for value-added elasticity, very close to 1.0 for all energy consumptions (ie constant returns to scale).

Table 6 Fixed-effects model

Diesel equation	**Small enterprises**		**Large enterprises**		**Natural gas equation**	**Small enterprises**		**Large enterprises**	
	Coef.	S.E.	Coef.	S.E.		Coef.	S.E.	Coef.	S.E.
Log value added	0.42	0.09	0.68	0.11	Log value added	0.55	0.12	0.45	0.10
Log price	–0.23(*)	0.12	–0.48	0.15	Log price	–1.60	0.29	–1.65	0.27
Log tax	–0.77(*)	0.47	–2.99	0.75	Log tax	–3.58	1.04	–2.17	0.60
Time	–0.24	0.10	–0.56	0.11	Time	–0.27	0.05	–0.10	0.04
Constant	2.88(*)	3.14	13.86	5.07	Constant	13.94	3.71	13.41	2.48
Observations	*2966*		*4687*		*Observations*	*2915*		*4894*	
R-Square overall	*0.221*		*0.177*		*R-Square overall*	*0.469*		*0.342*	
R-Square within	*0.122*		*0.273*		*R-Square within*	*0.146*		*0.08*	
Corr(u_i, Xb)	*0.209*		*–0.06*		*Corr(u_i, Xb)*	*0.444*		*0.392*	
rho	*0.715*		*0.56*		*rho*	*0.737*		*0.732*	
Hausman test	*16.22*		*11.02*		*Hausman test*	*148.54*		*166.9*	

(*)Not significant *(*)Not significant*

Table 6 Fixed-effects model—Cont'd

Fuel oil equation	**Small enterprises**		**Large enterprises**		**Electricity equation**	**Small enterprises**		**Large enterprises**	
	Coef.	S.E.	Coef.	S.E.		Coef.	S.E.	Coef.	S.E.
Log value added	0.31(*)	0.22	0.25(*)	0.18	Log value added	0.39	0.07	0.37	0.08
Log price	–0.71	0.25	–0.97	0.21	Log price	–0.69	0.25	0.15(*)	0.20
Log tax	–0.34(*)	0.99	–2.02	0.57	Log tax	–0.41	0.05	–0.51	0.03
Time	–0.20(*)	0.71	0.83(*)	0.42	Time	–0.04(*)	0.03	–0.03(*)	0.03
Constant	2.54(*)	4.78	11.70	4.03	Constant	3.83	1.17	6.50	1.37
Observations	*1763*		*2970*		*Observations*	*3071*		*4904*	
R-Square overall	*0.273*		*0.160*		*R-Square overall*	*0.6073*		*0.58*	
R-Square within	*0.073*		*0.169*		*R-Square within*	*0.1745*		*0.3366*	
Corr(u_i, Xb)	*0.380*		*0.138*		*Corr(u_i, Xb)*	*0.542*		*0.376*	
rho	*0.768*		*0.66*		*rho*	*0.747*		*0.667*	
Hausman test	*32.28*		*33.13*		*Hausman test*	*91.48*		*119.2*	

(*)Not significant *(*)Not significant*

R-square within is a measure of goodness-of-fit after the fixed effects have been controlled for.
Heteroscedasticity robust standard error of estimates are reported (S.E.).
Rho indicates the fraction of variance due to within variability (u_i).
The Hausman test is significantly greater than zero and it means that the difference in coefficients, to respect a random effect model, is systematic.

This result is consistent with the estimates of a similar model by Bjørner and Jensen (2002)[33] 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.[34] **21.48**

[33] TB Bjørner and HH Jensen, 'Energy Taxes, Voluntary Agreements and Investment Subsidies: a Micropanel Analysis of the effect on Danish Industrial Companies' Energy Demand' (2002) 24 *Resource and Energy Economics* 229–49.

[34] P Agnolucci (n 8 above)correctly identifies these short-term coefficients 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.

21.49 Price elasticities for LEs are also higher for fuel oil and natural gas demand: for the latter they are above –1.5 per cent for all companies. A special case is electricity: as shown in the table, large companies have a positive (not significant) elasticity to price before the tax, whereas for SMEs the estimate is –0.69. One nearby interpretation of this result is that large manufacturing companies are, in general, large users receiving electricity at higher voltage and at a lower price, so they are less reactive to price changes, as special conditions are provided in their contracts and prices are more stable.[35]

21.50 Most important for the purpose of this research is the estimate of β_3, that is the effect of carbon tax changes on energy product demands. For all estimated equations, this parameter has the right (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 to be more permanent than price changes[36] 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.

21.51 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: in a larger version of the model, where we included dummy variables for capturing industrial sub-sectors' specific differences in technological constraints, the estimated value did not change much and the group of sectoral dummies was not statistically significant in explaining natural gas consumption. Finally, companies of every size reduce their electricity demand by about 0.5 per cent for every percentage point of increase in carbon taxes per unit of energy.

21.52 Although our panel consists only of two years of observations, the time dummy has a significant effect both in diesel and natural gas consumption: in 2004, economic activity in the manufacturing industry was basically stagnant compared to the year 2000, although, on a general level, the modest growth in levels of activity

[35] Italian prices for industrial use of electrical energy, both gross and net of taxes, are among the highest in Europe, with different variations with respect to the weighted average, according to the consumption level considered. The explanation of higher electricity prices in Italy is to be found, as well as in the higher tax burden, especially in the low plant efficiency and in the mix of fuels with a high cost per thermal of unit supplied (ENEA, 2005 Rapporto Energia e Ambiente 2004, Enea Roma).

[36] T Barker, P Ekins, and N Johnstone, *Global warming and energy demand* (London: Routledge, (1995) suggest this interpretation to assess that taxes should give polluters a bigger incentive to reduce CO_2 emissions.

has not been accompanied by an improvement in the structural characteristics of the system in terms of energy required for each level of activity.[37]

F. Final Remarks

The Italian path toward the compliance of the Kyoto targets so far appears to be quite unsatisfactory when compared with the other EU Member States. 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, that is Pigouvian taxes, has not been managed in a coherent and consistent manner. In fact, a carbon tax reform was introduced in 1998 by reshaping the previous energy-related tax rates and including coal and other high-emissions energy products. The tax rates originally set 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 rate revisions have been implemented since 2000. On the basis of a micro-simulation model for Italian firms, in this chapter we make an assessment of the effectiveness of the current environmental tax system on energy products (a mix between an energy tax and carbon tax). This analysis has been performed on a micro-simulation 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 good efficacy of environmental taxes, even in a framework of rising energy prices. **21.53**

[37] 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 which represent significant shares of overall industrial output.