Industrial CO_2 emissions in Italy: a microsimulation analysis of energy taxes

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Overview and main results

- In this paper we analyze the efficacy of Italian Carbon tax on CO_2 emission pattern and energy demand of industrial firms.
- The analysis is based on a microsimulation model for Italian firms (Diecofis model).
- Estimations show a significant effect of tax rates on emissions and energy inputs demand.

Outline

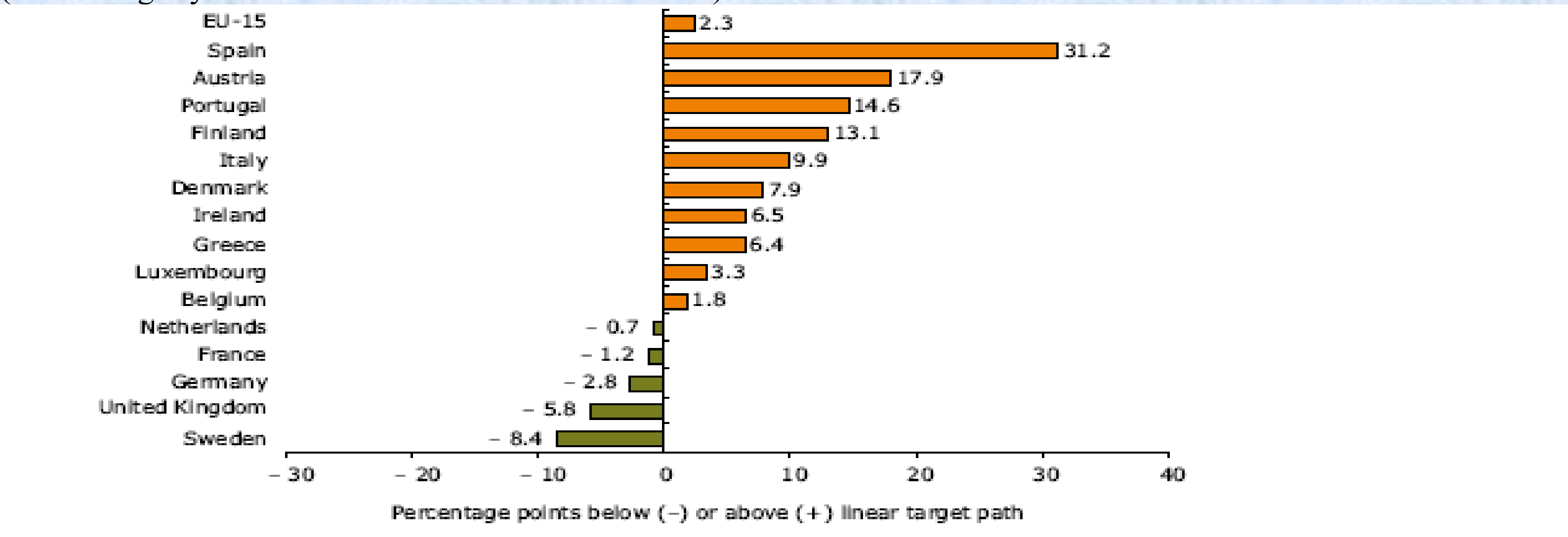
- Stylized facts: emissions and environmentally related taxes (ERTs) in EU and Italy
- The microsimulation model
- Estimation results

Stylized facts: emissions and energy/CO_2 taxes in EU and Italy

- Even if there is a huge variability across member countries, European trends in GHG emissions are not consistent with the Tokyo target. This is particularly true for Spain, Austria, Portugal and Italy.

Distance to target for EU-15 Member States in 2004

(Including Kyoto mechanisms and carbon sinks)



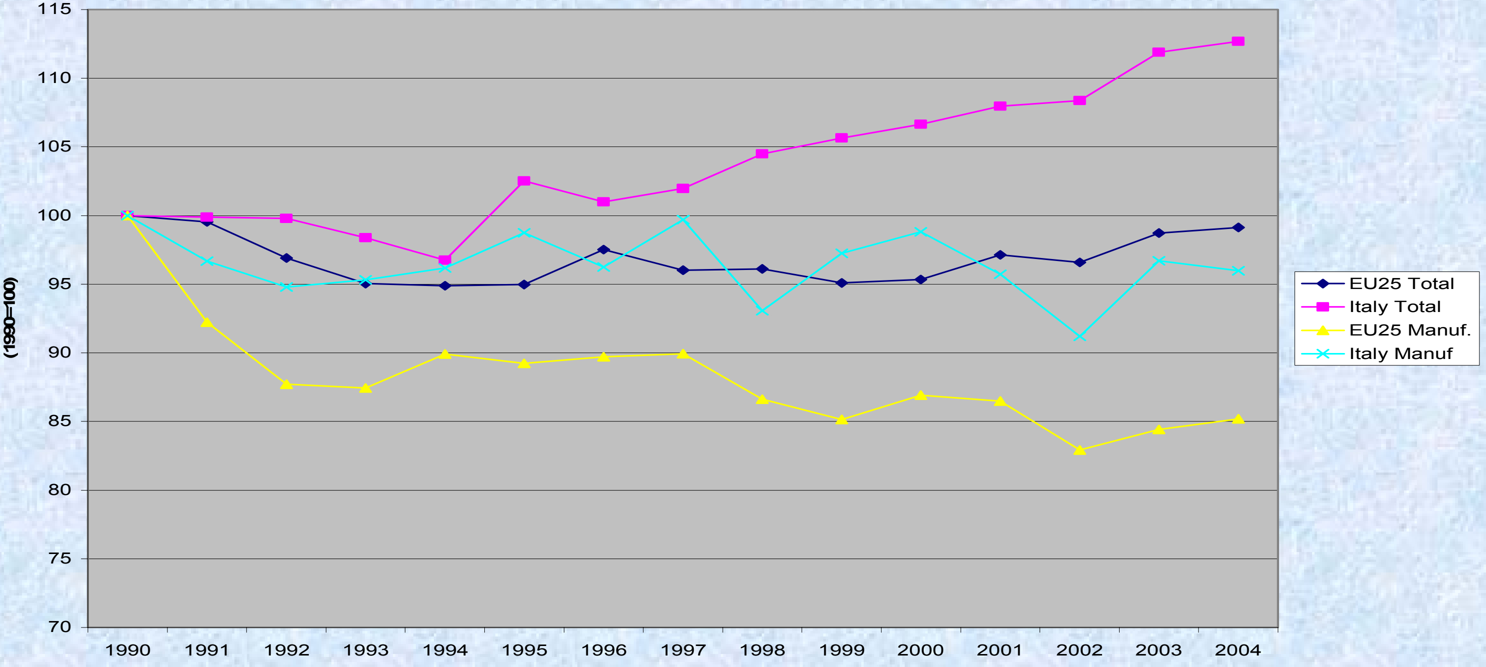
Source: EEA (2006)

Stylized facts: emissions and energy/CO_2 taxes in EU and Italy

As for CO_2 emissions, EU-25 shows a very slight decrease (-1%), whereas a conspicuous decrease can be found for manufacturing in almost all countries (-15%).

Since 1990, Italian total CO_2 emissions rose by 13%. This overall trend is mainly attributable to the transport sector; on the other hand, the contribution of manufacturing is smaller (-3,8%) than in the average European case.

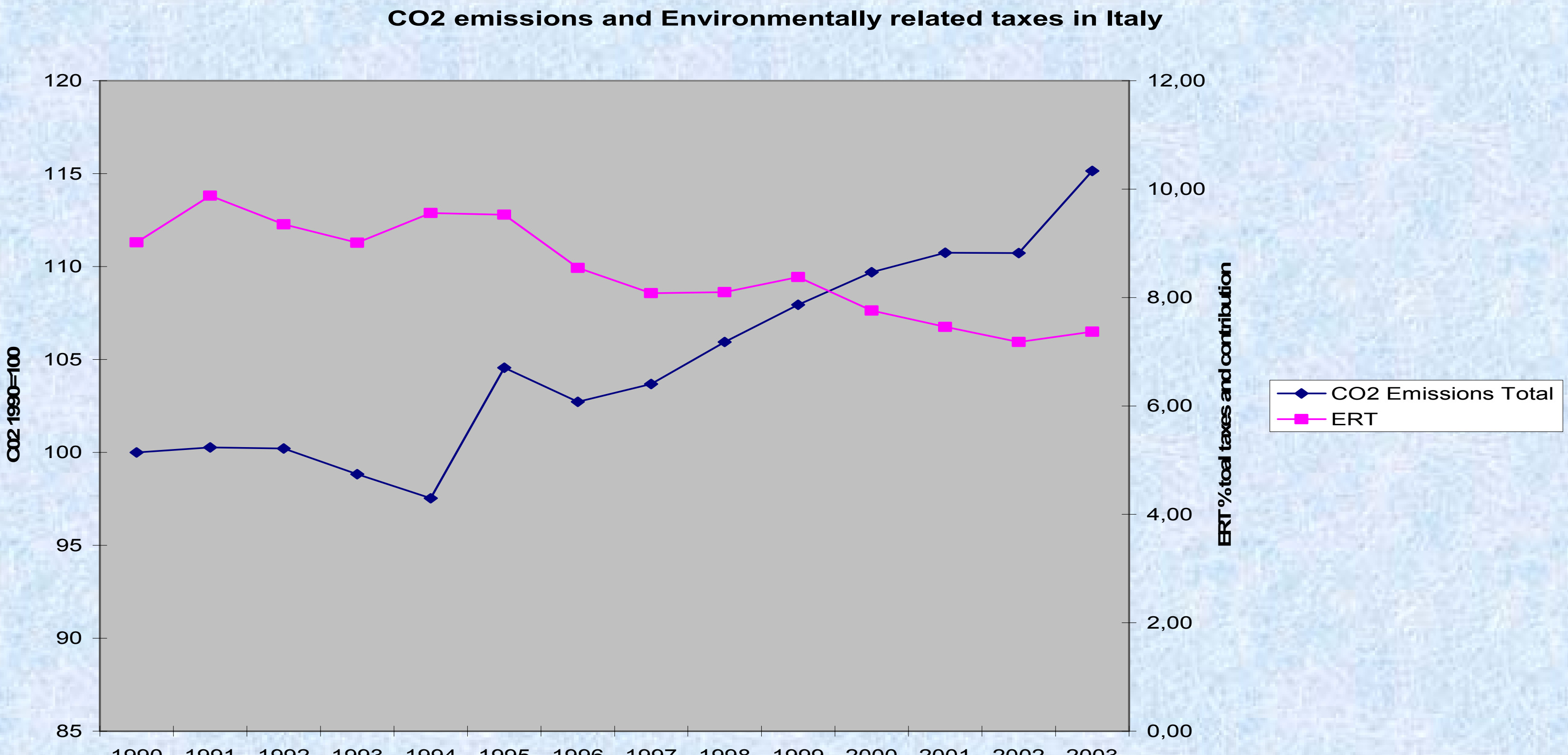
CO_2 Emissions in EU25 and Italy



Source: Eurostat

Stylized facts: emissions and energy/CO2 taxes in EU and Italy

- ERTs in EU exhibit a sharp increase during nineties, with some experiments of green tax reforms and carbon taxes. A general decrease has been recorded after 2000.
- As a very rough approximation, an inverse correlation between importance of environmental taxes and emission patterns can be found in the Italian case.



Stylized facts: The Italian Carbon Tax

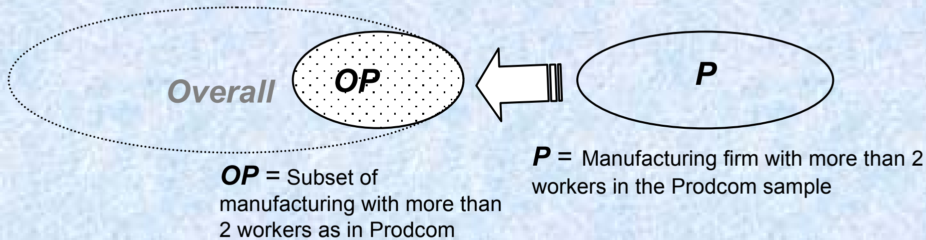
- After the adoption of the Kyoto Protocol, a Carbon Tax was introduced in Italy (law 488/98) as the main pillar of environmental policy.
- The aim of this reform was to reduce environmental damaging inputs by reshaping the previous energy-related tax rates and including coal and other high-emissions energy products.
- The reform was based on the "double dividend" hypothesis (fiscal *neutrality* through a cut in labour tax wedge).
- 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 the reform was basically "frozen".
- Current energy tax rates are much lower than the original targeted rates.

DIECOFIS microsimulation model (1/3)

- The DIECOFIS model has been built within a project financed by the EU and coordinated by the Italian Institute of Statistics.
- The overall model is an arithmetic microsimulation model designed to analyze the effects of taxes on enterprises (social security contributions, severance pay, regional business tax, corporation tax and energy excises).
- The DIECOFIS model is based upon a detailed database that represents all active enterprises (excluding Agriculture, Financial Sector and Public Sector) .

DIECOFIS microsimulation model (2/3)

- Energy taxes are modelled only for manufacturing firms in order to take advantage of a specific Survey on output and energy inputs (*Prodcom*). A statistical matching procedure was implemented to merge the two datasets.



- The energy model is available for the years 2000 and 2004 and covers 20.000 units of the manufacturing sector with more than 2 employees.
- Data includes information about expenditures as well as consumption in physical units of several types of energy (such as electricity, coal, diesel, petrol, coke, fuel oil, natural gas, and others).

DIECOFIS microsimulation model (3/3)

- Moreover, 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.
- About 5.600 firms have been selected, of which approximately 60 per cent have at least 100 workers (Large Enterprises, LE). The panel represents 40% of the total value added of manufacturing.
- CO_2 emissions for these firms have been imputed using the NAMEA accounts.

Regression analysis

- The aim of this analysis is to evaluate the environmental efficacy and to disentangle the different contributions to the observed pattern (i.e. the change of input intensity due to tax as opposed to the change due to price variation).
- The evaluation of environmental effectiveness has been measured with regard to:
  - change in CO_2 emissions (OLS regression for differences between 2004 and 2000)
  - effects of taxes on energy demand (fixed effects model).

Regression: 1) CO_2 emissions

R-squared	0.6765
Root MSE	0.967

lvar_emissions	**Coef.**	**Std. Err.**	**t**	**P>|t|**	**[95% Conf.**	**Interval]**
lvar_tax_price	-0.132	0.04	-3.78	0	-0.201	-0.064
lvar_energ_int	0.929	0.02	51.5	0	0.893	0.964
lvar_envexp	-0.054	0.01	-3.66	0	-0.084	-0.025
lvar_valueadd	1.221	0.04	28.26	0	1.136	1.305
13-14 Mining	0.118	0.1	*1.22*	0.22	-0.071	0.308
15-16 Food	1.434	0.04	35.59	0	1.355	1.513
17 Textiles	1.882	0.06	32.13	0	1.767	1.997
18 Wearing apparel	1.954	0.24	8.25	0	1.49	2.418
19 Luggage, footwear	1.596	0.11	14.4	0	1.379	1.813
20 Wood	0.57	0.08	7.16	0	0.414	0.726
21 Pulp, paper	-0.229	0.09	-2.69	0.01	-0.396	-0.062
22 Publishing	-0.507	0.11	-4.66	0	-0.721	-0.294
24 Chemicals	2.545	0.05	53.78	0	2.452	2.637
25 Rubber, plastic products	0.472	0.06	7.84	0	0.354	0.59
26 Other non-metal. mineral products	0.385	0.06	5.94	0	0.258	0.511
28 Fabricated metal products	-0.265	0.05	-4.95	0	-0.37	-0.16
29 Machinery, equipment n.e.c.	0.663	0.05	14.17	0	0.572	0.755
30 Office machinery, computers	4.036	0.51	7.99	0	3.045	5.026
31 Electrical machinery	0.59	0.09	6.54	0	0.413	0.767
32 Communication equipment	-0.195	0.24	*-0.8*	0.43	-0.675	0.284
33 Medical, optical instruments	0.469	0.15	3.22	0	0.183	0.754
34 Motor vehicles	0.393	0.08	5.02	0	0.24	0.547
35 Other transport equipment	0.28	0.17	*1.68*	0.09	-0.047	0.607
36 Furniture and other manufact.	-0.364	0.09	-4.11	0	-0.537	-0.19

lvar_emiss	Differ. in CO2 emissions (2004-2000) (log)
lvar_tax_price	Differ. in tax over average energy price(2004-2000)(log)
lvar_energ_int	Differ. in energy intensity (2004-2000) (log)
lvar_envexp	Differ. in environmental expenditures over total production cost (2004-2000)
lvar_valueadd	Differ. in value added (2004-2000) (log)

Regression: 1) CO_2 emissions

- All coefficients have the expected signs and are statistically different from zero. However, the major part in explaining changes in emissions is played by the energy intensity (0.92) and the cyclical trend of production (1.22), as the coefficient of the tax variable is much smaller (-0.13)
- This role of $C0_2$ taxes in reducing emissions is found in most empirical evaluation studies on other European experiences.

Regression: 2) demand of energy products

- The effect of excise taxes on the firms' demand for diesel, natural gas, fuel oil and electricity has been estimated by a fixed effect model.
- These products represent the 75% of total energy inputs of manufacturing in the year 2004.
- The demand of each energy product takes the following form:

$$L\_energy\_product_{it} = \alpha_i + \beta_1 \, L\_VA + \beta_2 \, L\_price + \beta_3 \, L\_tax + \theta_t + \varepsilon_{it}$$

Regression: 2) demand of energy products

		Small enterprises		Large enterprises	
Diesel					
R-Square	*Overall*		*0.22*		*0.173*
R-Square	*Within*		*0.114*		*0.27*
sigma-v			*1.346*		*1.296*
Observations			*2966*		*4706*
		Coef	**S.E.**	**Coef**	**S.E.**
l_VA		0.396***	0.093	0.674***	0.112
lprice_diesel		-0.195	0.116	-0.414**	0.139
ltax_diesel		-0.707	0.476	-2.881***	0.742
time		-0.266**	0.093	-0.614***	0.103
_cons		2.652	3.154	12.892*	5.015
Natural Gas					
R-Square	*Overall*		*0.469*		*0.342*
R-Square	*Within*		*0.146*		*0.08*
sigma-v			*1.488*		*1.496*
Observations			*2915*		*4894*
		Coef	**S.E.**	**Coef**	**S.E.**
l_VA		0.554***	0.115	0.455***	0.096
lprice_natgas		-1.598***	0.291	-1.642***	0.272
ltax_natgas		-3.577***	1.037	-2.021***	0.565
time		-0.267***	0.051	-0.098*	0.042
_cons		13.936***	3.708	12.818***	2.372

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

Regression: 2) demand of energy products

		Small enterprises		Large enterprises	
Fuel Oil					
R-Square	*Overall*		*0.275*		*0.162*
R-Square	*Within*		*0.076*		*0.169*
sigma-v			*2.133*		*1.8*
Observations			*1765*		*2966*
		Coef	**S.E.**	**Coef**	**S.E.**
l_VA		0.269	0.229	0.252	0.184
lprice_hoil		-0.797**	0.257	-0.966***	0.206
ltax_hoil		-0.901	1.065	-1.992***	0.573
time		0.202	0.763	0.814	0.425
_cons		5.607	5.265	11.624**	4.041
Electricity					
R-Square	*Overall*		*0.607*		*0.58*
R-Square	*Within*		*0.175*		*0.337*
sigma-v			*1.105*		*0.999*
Observations			*3071*		*4904*
		Coef	**S.E.**	**Coef**	**S.E.**
l_VA		0.390***	0.07	0.368***	0.076
lprice_electr		-0.686**	0.251	0.149	0.204
ltax_electr		-0.413***	0.047	-0.511***	0.029
time		0.043	0.032	-0.032	0.032
_cons		3.830**	1.167	6.497***	1.374

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

Regression: 2) demand of energy products

- For all estimated equations, the tax parameters have the right (negative) sign and in most cases are statistically significant.
- Elasticities to value added for all energy products are positive and significant and do not present large differences between small and large enterprises (except for diesel)
- Breakdown by firm size is important for significativity and with regard to tax effects

Regression: 2) demand of energy products

- The possibility to distinguish between price before taxes and tax due has been proven an important feature of our microsimulation model.
  - A) There is a relevant price variability by firm size for certain products (electricity, natural gas)
  - B) The effect of taxes is larger than the price effect, probably because firms perceive tax changes as long-lasting and react more than to price changes (Barker et al. 1995).

Concluding remarks

- Emission trend in Italy exhibits a large distance to the target assigned under the Kyoto Protocol.

- The regression analysis has highlighted that excises can contribute to a reduction of CO_2 emissions and to a change in energy input demand mix.

Further developments

- Dataset extension (improvement of time dimension)
- Link the arithmetic model and the behavioural equations: i.e. counterfactual behavioural simulation of the original Carbon Tax reform → effects on total emissions, input demands and competitiveness (an ex ante, static simulation of the original reform can be found in Bardazzi Oropallo Pazienza (2004))