Fondazione Eni Enrico Mattei

Green Taxes:
Environment, Employment and Growth
A Computable General Equilibrium Analysis for Italy

Maurizio Bussolo* and Dino Pinelli**
NOTA DI LAVORO 4.2001

JANUARY 2001

CLIM – Climate Change Modelling and Policy

*OECD, Paris
** Fondazione Eni Enrico Mattei, Milano

Fondazione Eni Enrico Mattei
Corso Magenta, 63, 20123 Milano, tel. +39/02/52036934 – fax +39/02/52036946
E-mail: letter@feem.it
C.F. 97080600154

Green Taxes: Environment, Employment and Growth

A Computable General Equilibrium analysis for Italy

Maurizio Bussolo and Dino Pinelli
OECD, Paris, and FEEM, Milan

Revised version: October 2000

1 Introduction

In the 1970s and 1980s environmental policies in industrialised countries were mainly based on traditional command-and-control approaches. The end of the 1980s saw a surge of interest in economic instruments. In 1987 the report of the World Commission for Environment and Development emphasised their role in environmental policy. In the context of the European Communities the new interest in economic instruments was amplified by the Commission's Task Force Report on the environment and the internal market, the European Parliaments hearing on economic instruments in June 1990 as well as the decision in Rome by the environment council in September 1990 to develop a proposal for a European carbon-energy tax. In 1993 the Delor's White Paper on Growth, Competitiveness and Employment highlighted the possible positive macro-economic implications of such an environmental policy: switching taxation from goods (labour) to bads (pollutants) would increase labour demand and reduce European unemployment level.

Since then, labour and environment policies and their connection with growth have been under increasing scrutiny, and a vast literature has emerged around the idea of a possible "double-dividend": a first dividend in terms of reduction of environmental pollution and a second dividend in terms or welfare improvement from reduction of existing distortionary taxes[1].

The recent debate on double dividend can be roughly divided in two strands (Bosello et al, 1998). A first strand has emphasised individual welfare or utility, derived from consumption, leisure and environmental quality, with less attention paid to the specific modes in which the environmental tax revenues are recycled and their consequences on the economy. The focus is on distortion before and after the tax reform: one of the main theoretical conclusions is that a double dividend does not really exist. This is due to the fact that the new distortions introduced by the green taxes will normally be larger than the pre-existing fiscal distortion offset by the green taxes revenues.[2]

A second strand of research has emphasised the impact that recycled fiscal revenues could have on relevant macroeconomic variables, such as output and employment. Some analysts have studied the potential impact that labour and environmental may have on the potential growth of developing countries.[3] In Europe, given the high level of taxation on labour and the high persistent unemployment, the debate has concentrated upon the existence of a so-called "employment double dividend", i.e. the possibility of achieving better environmental quality by taxing pollutants and lower unemployment rates by using green tax revenues to lower taxes on labour, the high level of those often being perceived as one of the causes of high unemployment rates (Daveri and Tabellini, 2000).

Our paper analyses this second issue not by extending our knowledge of which are the special conditions to get the double dividend, but rather by empirically measuring the potential interactions between environmental and labour policies. In fact, in the theoretical literature the double dividend is measured in welfare terms, so that only if

---

[1] Pearce 1991;Repetto, Dower, Jenkins and Geoghegan 1992; Oates 1993 are seminal works in the field.
[2] See Majocchi (1996) for a survey, Carraro and Siniscalco (1996), Bovenberg and de Mooij (1994), Bovenberg and van der Ploug (1994), Goulder (1994), and Fullerton D & Metcalf G E (1997).
[3] See Bhagwati J. and R.E. Hudec (eds.) (1996) and Krugman, P. (1997).

some aggregate welfare measure shows positive increases due to the introduction of an environmental policy, a double dividend can be established. Policy makers though may be more interested in knowing which are the distributive effects of the environmental policy, what its consequences in terms of employment and potential growth. Aggregate welfare may be slightly reduced by introducing a green tax even when its revenues are recycled to reduce other distortionary taxes, but employment may be increased and the final allocation of the fiscal burden better distributed among the economic agents. This may eventually expand economic growth and make the environmental taxation a more sustainable policy, clearly a double dividend from a policy maker point of view.

Additionally, in this paper, we try to measure the potential interactions between green taxes on a variety of pollutants, overcoming a weakness of previous research that only considered taxes on an idealised theoretical pollutant or on carbon (Pezzey and Park, 1998; Bosello et al, 1998). The debate has also shown that political feasibility of introducing green taxes crucially depends on the sectoral disaggregation of the impact. The disaggregation in 39 sectors of our model allows for an analysis of the sectoral impact of green tax reforms, often neglected by the double-dividend literature.

Initially, in our model, we consider abatement policies alone, holding other policies parameters constant, and measure their effects on growth, sectoral resource allocation and employment. An important result is that the cost in terms of growth of abating emissions is marginal, and that targeting one type of emission de facto reduces all the others pollutants. Then in a second stage, we combine environmental and labour policies and show how they may interact. It is shown that recycling green taxes revenues to reduce taxes on labour further reduces the costs of achieving pollution reduction targets.

The paper is organised as follows. Section 2 describes the most important features of the model. Section 3 succinctly presents the Italian environmental and employment situation, and briefly surveys previous studies on the possible implementation of ecological tax reforms. Section 4 illustrates the model benchmark scenario, where no economic policy is altered. Against it, scenarios of alternative environmental and labour policies are contrasted in section 5. The final section summarises the main conclusions.

2 The model

The model used in this paper is fully described in a technical appendix and is calibrated on data contained in the Social Accounting Matrix estimated for the year 1990, described in detail elsewhere. The version of the SAM used here includes 10 household categories, 39 sectors, 2 labour types, separated trading partners and 13 different polluting emissions.[4] The model is dynamic and solved recursively for the period 1990-2010. The following sub-sections briefly illustrate the model's main characteristics.

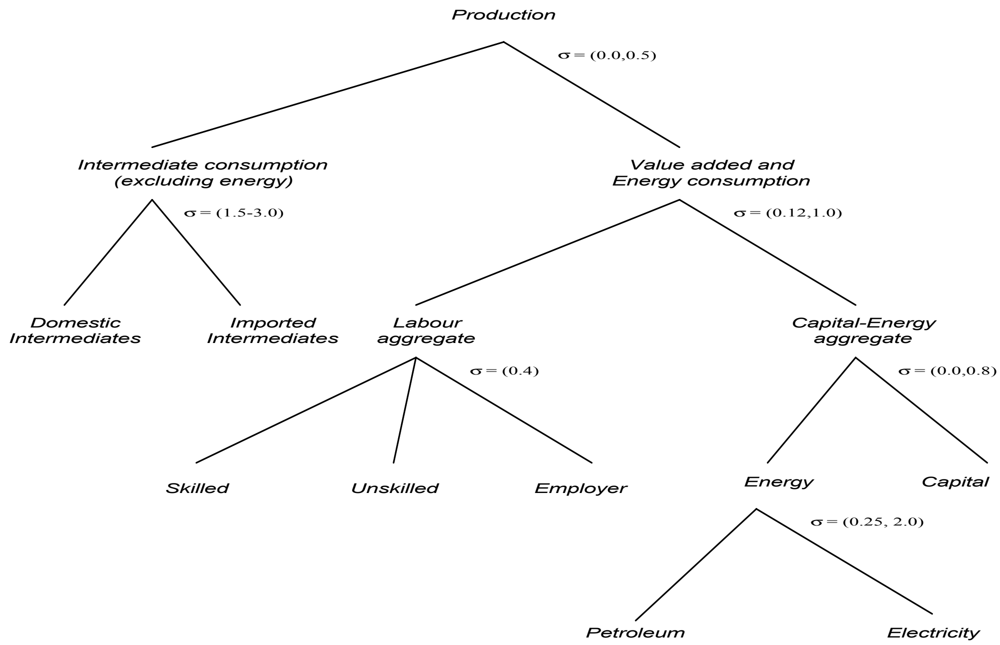
Production

The Constant Elasticity of Substitution (CES) constant returns to scale production function is a nested structure taking into account the assumed substitution possibilities in the choice of production factors. Output results from two composite goods: non-energy intermediates and energy plus value added. The intermediate aggregate is obtained combining all products in fixed proportions (Leontief structure). The value added and

[4] A more sectorally disaggregated SAM could have been used to calibrate the model. The 39-sector SAM though combines enough detail with reasonable tractability. Moreover, this aggregation captures the most important production-emission linkages.

energy components are decomposed in two parts: aggregate labour and capital, which includes energy. Labour is a composite of 2 categories. The capital-energy bundle is further disaggregated into its basic components.[5] By distinguishing between "new" and "old" vintages, the capital existing at the beginning of each period, or already installed, can be separated from that resulting from contemporary investment (putty/semi-putty production function).[6] Finally, the energy aggregate includes two energy substitutes: oil and electricity. Figure 2-1 depicts the nested decision process in the choice of production factors.

Figure 2-1: Nested Production Function



- CES substitution elasticities are differentiated by capital vintage, new capital (higher) elasticities are shown to the right of the comma.
- No substitution is possible among intermediates. Domestic products can be substituted with the corresponding foreign ones.

Substitution elasticities reflect adjustment possibilities in the demand for factors of production originating from variations in their relative prices. Consider particular values[7]: 0.00 between intermediates and value added with *old* capital plus energy; 0.50 between

[5] The particular production function of this model treats energy as a separate factor of production rather than an intermediate input. Energy use is typically highly polluting and the specific nesting structure adopted here allows monitoring more closely energy-related emissions. Moreover bundling energy together with capital is motivated by the fact that new technologies, embodied in new capital goods, are usually energy saving (i.e. energy substituting).

[6] In the short run capital is usually sector-specific, whereas in the long run it can be perfectly mobile across sectors. The "vintages" approach allows integrating in the present dynamic model both short run capital immobility and long run capital mobility. In the modelled economy new capital (equal to the previous period's level of investment) is perfectly mobile and old capital only partially mobile across sectors. Another advantage of the "vintages" approach is that it allows introducing different degrees of substitutability of capital with other factors. In fact, old capital vintage is less substitutable with energy, labour and other inputs than new capital. Both these features add realism to this environment model where increased investment opportunities and new capital goods should embody cleaner technologies and greater adjustment possibilities.

[7] These elasticities are derived from the most recent relevant literature. In fact, they are mostly derived from background studies done for the construction of the OECD GREEN model. See for instance Burniaux, Nicoletti and Oliveira-Martins (1992).

intermediates and value added aggregate incorporating *new* capital plus energy; 0.12 between aggregate labour and *old* capital-energy bundle; 1.00 between aggregate labour and *new* capital-energy bundle; 0.40 among different types of labour; 0.00 between *old* capital and energy; 0.80 between *new* capital and energy; 0.25 among different sources of energy associated with *old* capital; 2.00 among those associated with *new* capital.

Income Distribution and Absorption

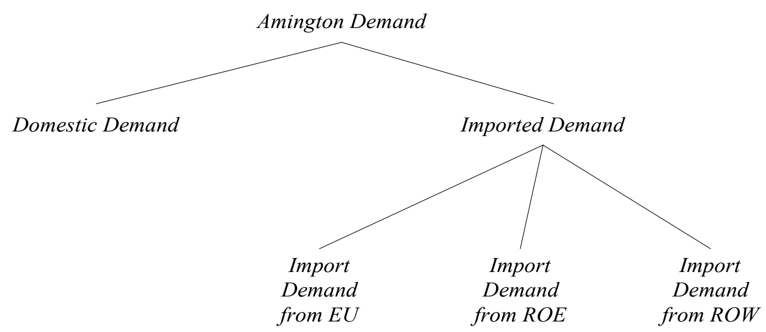
Labour income is allocated to households according to a fixed coefficient distribution matrix derived from the original SAM. Likewise capital revenues are distributed among households, corporations and rest of the world. Corporations save the after-tax residual of that revenue.

Private consumption demand is obtained through maximisation of household specific utility function following the Extended Linear Expenditure System (ELES).[8] Household utility is a function of consumption of different goods and saving. Income elasticities are different for each household and product and vary in the range 0.20, for basic products consumed by the household with highest income, to 1.30 for services.[9] Once their total value is determined, government and investment demands[10] are disaggregated in sectoral demands according to fixed coefficient functions.

International Trade

In the model we assume imperfect substitution among goods originating in different geographical areas.[11] Imports demand results from a CES aggregation function of domestic and imported goods. Export supply is symmetrically modelled as a Constant Elasticity of Transformation (CET) function.

Figure 2-2: Import demand nesting



Producers decide to allocate their output to domestic or foreign markets responding to relative prices. The model implements a two-stage procedure for determining both import demand and export supply. For imports consider Figure 2-2. At the first stage aggregate

[8] A useful reference for the ELES approach is found in Lluch (1973). More detailed explanations of this modelling choice are given in the technical appendix.

[9] Among the various sources for these elasticities see Blanciforti and Green (1983), Eastwood and Craven (1981), Lopez (1989) and Maki (1988).

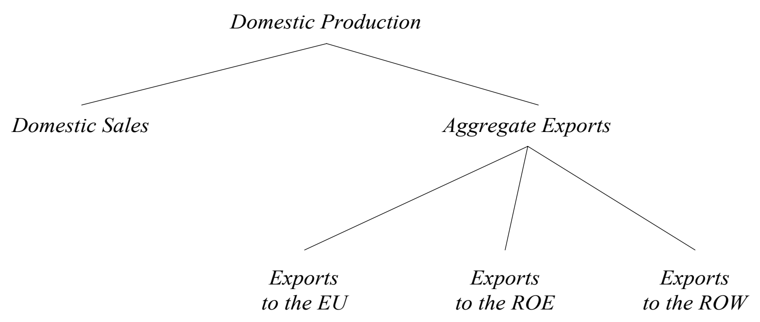
[10] Aggregate investment is set equal to aggregate savings, while aggregate government expenditures are exogenously fixed.

[11] Armington (1969).

demand is decomposed into a domestic component and an aggregate import component. At the second stage, aggregate import demand is allocated across the various trading partners.

Export supply is treated in a symmetric fashion (see Figure 2-3). Producers allocate production between domestic sales and aggregate export sales. At the second stage, aggregate exports are sold to the various trading partners based on the relative price the exporter can receive in each market.[12]

Figure 2-3: Export supply nesting



As Italy is unable to influence world prices the small country assumption holds, and its imports and exports prices are treated as exogenous. The balance of payments equilibrium is determined by the equality of foreign savings (which are exogenous) to the value for the current account. With fixed world prices and capital inflows, all adjustments are accommodated by changes in the real exchange rate: increased import demand, due to trade liberalisation must be financed by increased exports, and these can expand owing to the improved resource allocation. Price decreases in importables drive resources towards export sectors and contribute to falling domestic resource costs (or real exchange rate depreciation).

Model Closure and Dynamics

The equilibrium condition on the balance of payments is combined with other closure conditions so that the model can be solved for each period. Firstly consider the government budget. Its surplus[13] is fixed and the household income tax schedule shifts in order to achieve the predetermined net government position. Secondly, investment must equal savings, which originate from households, corporations, government and rest of the world.

The dynamic structure of the model results from the equilibrium condition between savings and investment. A change in the savings volume influences capital accumulation in the following period. Exogenously determined growth rates are assumed for various

[12] Elasticities between domestic and foreign products are of comparable magnitude for imports demand and exports supply. Their values are 3.00 for agricultural goods, 2.00 for manufactured goods and 1.50 for services. Similar values are used for the second nesting.

[13] Its initial value is determined in the 1990 SAM.

other factors that affect the growth path of the economy, such as: population and labour supply growth rates, labour and capital productivity growth rates and energy efficiency factor growth rate. Agents are assumed to be myopic and to base their decisions on static expectations about prices and quantities. The model dynamics are therefore recursive, generating a sequence of static equilibria.

Emissions

Emissions are determined by either intermediate or final[14] consumption of polluting products. In addition, certain industries display an autonomous emission component linked directly to their output levels. This is introduced in order to include some polluting production processes that would not be accounted for by only considering the vectors of their intermediates consumption. It is assumed that labour and capital do not pollute. Emissions coefficients associated with each type of consumption and production are derived from a previous study[15] on the determinants of polluting intensity for the US and here adapted to the Italian case. A change in sectoral output, or in consumption vectors, both in levels or composition, therefore affects emission volumes. Formally, the total value for a given polluting emission takes the form:

$$E = \sum_i \sum_j \alpha_j C_{i,j} + \sum_i \beta_i X_i^{Output} + \sum_j \alpha_j X_i^{Armington}$$

where i is the sector index, j the consumed product index, C intermediate consumption, X^{Output} output, $X^{Armington}$ final consumption (at the Armington composite goods level), α_j the emission volume associated with one unit consumption of product j and β_i the emission volume associated with one unit production of sector i. Thus, the first two elements of the right hand side expression represent production-generated emissions, the third one consumption-generated emissions.

There are 13 types of polluting substances. Their volume is independently determined and measured in metric tons. Toxic emissions in air (TOXAIR), water (TOXWAT) and soil (TOXSOL) depend primarily on the consumption of chemicals (especially fertilisers for water pollution), oil derived products and mineral products. Bio-accumulative emissions differ from the previous ones for their long term effects on bio organisms, due to their high lead (or other heavy metal) concentration. Again, these are distinguished according to the medium where they are released: into the air (BIOAIR), water (BIOWAT) and soil (BIOSOL). These emissions are a result of the use of mineral and metal products, generally found in construction-related sectors. There are 5 types of toxic substances released in the air: sulphur dioxide (SO2), nitrogen dioxide (NO2) and carbon monoxide (CO), volatile organic compounds (VOC) and suspended particulates (PART). Their levels depend primarily on fuels consumption: oil and coal derived products. Finally, two additional categories of water polluting substances are considered:

[14] Final consumption, in this context, is restricted to households, government and investment demand. Exports are not considered since the analysis is limited to *local* emission.

[15] See Dessus, Roland-Holst, van der Mensbrugghe (1994). Instead of focusing on pollution output at individual industrial sources, they advocate moving back up the production process. Factories producing pollution can be numerous and very dispersed geographically. The evidence reported in their study indicates that only a few commodities are responsible for determining pollution levels when they are consumed as intermediates. Their econometric estimates indicate that over 90 per cent of the variation in emission of most toxic pollution can be explained by consumption of less than a dozen intermediate commodities. Their calculations are based on a 345 sector US input-output table (see Reinert and Roland-Holst (1992)) and on the 1987 IPPS (Industrial Pollution Projection System) database developed at the World Bank for the US (Hettige, Martin, Singh, Wheeler (1994)).

suspended solids (SS) and those measured by their biochemical oxygen demand (BOD). These emissions are related to the consumption of mineral products.

The household utility functions do not include among their arguments any term directly related to environmental qualities. In other words, pollution levels are assumed not to explicitly affect household utility. Despite the theoretical validity of the utility-environment relationship, empirical applications would require estimates for utility values that household assign to environmental qualities. Unfortunately statistical information on which these estimates can be based is still too limited.[16] Likewise, environmental degradation is not assumed to affect production factors productivity. Productivity gains resulting from new investments in greener technology are not measured in this model. Thus, the potential gains from environmental protection policies are almost certainly going to be under-estimated.

Policy Instruments

The model includes a variety of important instruments of economic policy: direct and indirect taxes on production, consumption and revenues, tariffs and other taxes and subsidies on international transactions. Each of these taxes/subsidies is differentiated by sector, product, household, production factor, consumption type or income source. A uniform tax on each unit of polluting emission (for type of toxic substance) is also introduced and paid by the polluter agents. This tax can be endogenously determined if specified levels of emission (abatement) are to be targeted, otherwise it can be exogenously fixed. In this latter case, emissions levels become endogenous.

3 Economic Activity and Environment in Italy

Several reasons make Italy an especially instructive case study for the introduction of a comprehensive green fiscal reform.

Italy shows a relatively high-energy efficiency. Energy supply per unit of GDP is the lowest across OECD countries. As a result, energy-related emission (such as CO_2 and SO_2) shows emission intensity lower than OECD average[17]. The relative high-energy efficiency of Italy makes standard command-and-control measures extremely costly. Economic instruments, such as green taxes, are likely to be more effective.

Italy could benefit substantially from the introduction of economic instruments also to cope with other pollutants, where Italy scores relatively badly:

- despite relatively high energy efficiency, NOx emission per unit of GDP are higher in Italy than OECD average. This is mainly due to high road vehicle. This also contributes to increase pollution in urban areas from PM_{10} and O_3;
- the intensity of use of nitrogen and phosphate in agriculture is among the highest across OECD countries, but actually lower than in most EU countries.

Italy shows higher unemployment rates and lower growth of employment than most OECD countries[18]. Besides, employment levels declined from 1990 to 1998 at a rate of 0.5% pa, compared with a decline across EU countries of only 0.1% pa and an increase across OECD countries of around 0.7% pa. The design of effective policies to reduce unemployment rates and increase the creation of jobs is a high priority in the political agenda and a real national urgency.

---

[16] Perroni and Wigle (1994).

[17] OECD, Environmental Indicators, 1998.

[18] OECD Economic Outlook, December 1999, Table 21, p 247.

Italian labour market bears a higher rate of taxation on labour than in most OECD countries. Including income tax, the total wage gap (difference between net wages perceived by the employees and total costs incurred by employers was just below 45%, the highest in Europe after Denmark and Finland (higher than Sweden)[19]. Reduction of labour costs through reduction of taxation on labour fits into the political agenda of reducing unemployment rate. The implementation of a green tax reform would permit to achieve the objective at no cost for the government budget.

There is still substantial scope for the introduction of economic instruments in environmental policy. The Ministry of Environment (1997) identified ten environmental taxes and six taxes on energy and automobiles (see Table 8-3 in the Appendix). Revenues from those taxes are relatively small. Environmental taxes in 1994 only yielded around 0.3% of GDP. More recently, some taxes with explicit environmental aims have been introduced. A carbon tax was introduced in 1998. The tax took the form of an increase of the existing excise duties on fuels and it is differentiated by fuel type. Expected revenues were Euro 1.0 bn in 1999 and were partially recycled through reduction of taxes on labour incomes. However, the application of the tax was suspended during 1999 to accomodate the increase in world oil prices. Suspension has been subsequently reiterated. In January 1999 it was also introduced a new tax on SO2 and NOx emissions for big combustion plants (power bigger than 50MW). The rate is at Euro 195 per ton per year for SO2 and Euro 53.12 per ton per year for NOx. International comparisons are difficult of differences in tax bases, tax exemptions, tax scope etc.. However, these rates appear considerably smaller than those applied, for example, in Sweden where the tax rate on SO2 is 3650 Euro (1997 prices) per ton per year and the tax rate on NOx emissions 4860 (1997 prices) per ton per year (but revenues are refunded to liable plants in proportion to their energy production).

Several studies have evaluated the potential impact of the introduction of green tax reforms in Italy. To our knowledge all of them concentrated on taxes aimed at reducing CO_2 emissions. Most of them found that substantial reductions of carbon emission could be achieved at virtually not costs in terms of output and with some gains in terms of employment.

Capros et al (1996), use the European model GEM-E3 to simulate the introduction of the European carbon tax (corresponding approx to 24% of the price of oil). They observe a positive double dividend in all EU12 countries modelled. Benefits are higher in the UK and the Netherlands where labour markets are more competitive and lower in Italy, Spain and Greece.

Reduction of CO2 emissions achieved with positive effects on employment are also found in Pireddu (1994 and 1998), who investigates the potential effect of the 'green tax reform' increasing by 10% the existing taxes on energy, and Marsiliani (1998), who investigates the sensitivity of the double dividend to change in the degree of competition in the product and labour market.

Contrasting results are in Carraro, Galeotti and Gallo (1996) who simulate the introduction of a carbon tax following the EC proposal (Official Journal of the EC, 1992) in the WARM model. The revenue of the tax is used to lower payroll taxes. Results are qualitatively similar for all the European countries. In the short-run wages are reduced and employment increases. However, in the longer run (after 10 years), wages tend to

[19] OECD Economic Outlook, Dec 1999; Daveri and Tabellini, 2000.

revert to their baseline level and then to increase afterwards. The increase in households disposable income leads to an increase in consumption, including energy and therefore of emission levels. Table 3-1 reports the central findings of selected studies.

Table 3-1: Empirical results from double dividend literature in Italy

Authors *type of model* *policy shock*	**Results** (expressed as % change from baseline of relevant endogenous variables, except where stated)		
Carraro, Galeotti, Gallo (1996), (1997b) *Based on WARM, an econometric model for European member states.* *Carbon tax as proposed by the Commission (19 Ecu per ton of CO2 - $10 per barrell)*			
After	**2yrs**	**5yrs**	**15yrs**
Employment	0.4	-0.2	0.0
Wages	-2.3	-2.0	2.4
Emissions	-2.3	0.0	5.7
Pireddu, Dufournaud (1994) *Based on Italian AGE static model (CGE)* *10% increase on existing energy taxes*			
After the shock			
GDP	0.2		
Unemp	-0.3		
Marsiliani (1998) *CGE model* *Tax rate equal to 2.5% of energy expenditure*			
After the shock			
Emp rate	3.7		
GDP	2.0		
Energy use	-0.8		
Labour tax/GDP	-1.0		
Capros et al (1994) *GEM-E3 model* *Implementation of the proposed EU carbon tax*			
After the shock			
Emp	44,000 (unit) (or 0.2)		
Energy cons	-3.5		

In order to investigate the introduction of green taxes in Italy, a single-country CGE model has been constructed. The initial interactions between economic activity and the environment – as captured by our model – are presented here below. From a static perspective, the top panel of Table 3-1 depicts the estimates for the sectoral emission intensities for production in 1990, i.e. the volume of emissions per unit of output. The Italian economy has been disaggregated (for a summary presentation) into 8 macro sectors: agriculture (Agri), mining and other primary products (Mining), food products (FoodPr), textiles, highly polluting manufacturing (PollMan), other manufactured products (OthMan), polluting services (PollServ) and services with low rates of pollution (NPlServ).[20] The last column displays economy-wide averages weighted by sectoral

[20] Agriculture is an aggregate sector in the source Input Output table. Mining consists of coal, coke, oil and natural gas (an aggregate sector) plus non-metal and metal mining. Food products include 4 sub-sectors diary, meat, other food, and beverages and tobacco. Textiles are composed of textiles and clothing, and leather. Highly polluting manufacturing aggregates chemicals, oil refinery, iron and steel and metal production, equipment and machinery, rubber and plastic industries. Other manufacturing is composed of electrical durables, autos production, wood, and paper and print.

outputs, the last three rows of the top panel show respectively per cent shares of sectoral production, export to output ratios, and sectoral employment shares of total employment. The bottom panel the row normalised emission coefficients: for each type of emission the sectoral coefficient is compared to the economy-wide average set equal to 100.

From this summary table, it is possible to observe the distribution of emissions intensities across sectors. This depends on the initial input-output structure of the Italian SAM (for the term $\alpha_j C_{ij}$) and on the vector of output (for the term $\beta_i X_i^{Output}$). A sector i would then have a higher pollution intensity (E/X_i^{Output}) the more polluting intermediates it consumes and the higher the value of its own β_i coefficient. By considering the relative weights shown in Table 3-1 (last three rows), it is also possible to see which are the most polluting industries in volume terms and what might be the environmental consequences of changes in the labour factor use, or the employment effects originating from sectoral contraction due to green taxation

Table 3-1: Sectoral emission intensities for production - 1990 (1000 Tons per 10^9 Lira)

	Agri	Mining	FoodPr	Textiles	PollMan	OthMan	PollServ	NPIServ	Total
TOXAIR	8	253	17	22	187	85	65	4	73
TOXWAT	20	142	20	27	88	40	87	10	53
TOXSOL	21	1710	92	28	1128	479	398	11	438
BIOAIR*	40	7924	249	56	6139	2598	968	5	1965
BIOWAT*	2	220	9	5	154	68	78	40	75
BIOSOL*	1348	265543	8345	1797	208507	87558	30761	59	65881
SO2	16	152	11	6	18	10	51	18	34
NO2	9	109	6	4	11	5	29	10	21
CO	1	100	2	1	9	4	16	2	14
VOC	15	55	7	21	60	12	16	4	21
PART	2	26	1	1	3	2	8	2	5
BOD	0	53	14	0	12	10	36	1	16
TSS	0	996	0	0	3	3	264	1	138
Output %	4	8	6	6	13	11	23	29	100
X/Output	5	10	5	23	21	19	3	3	9
Employ. %	11	3	2	5	7	7	32	33	100
Normalised coefficients									
TOXAIR	11	349	24	30	258	116	90	5	100
TOXWAT	38	266	37	50	165	75	163	18	100
TOXSOL	5	390	21	6	257	109	91	3	100
BIOAIR*	2	403	13	3	312	132	49	0	100
BIOWAT*	2	292	11	6	205	90	104	53	100
BIOSOL*	2	403	13	3	316	133	47	0	100
SO2	48	452	32	19	54	29	150	53	100
NO2	44	516	30	18	50	26	139	49	100
CO	10	725	16	5	64	28	114	15	100
VOC	74	266	33	103	291	56	75	20	100
PART	42	481	28	17	48	38	151	47	100
BOD	3	325	87	2	73	62	225	6	100
TSS	0	722	0	0	2	2	192	1	100

* Bio-accumulative pollution intensities are in Kg per billion of Lira

Consider first pollution intensities. Excluding Mining, the aggregate PollMan records the worst case in terms of bio-accumulative substances, and toxic substances. A tax proportional to emission intensities will therefore result in higher production costs for this

Polluting services are electricity production and distribution, and transport services. Non-polluting services are commerce, tourism, communication, banking and insurance, construction, and other services.

sector, which in the base year employs 7 per cent of the labour force. Conversely, a specifically targeted tax levied on SO2, NO2, CO and other water and air pollutants (VOC, PART, BOD, TSS) is likely to affect mostly the polluting services with more serious employment effects.

Although production activity is the dominant environmental agent in the economy, final consumption of goods and services can equally cause considerable pollution, especially for specific emission categories. Analogous results of emissions intensities for consumption are shown in Table 3-2. These estimated intensities refer to consumption of final goods (and services) and do not consider households' waste. Except for water bio-accumulative, consumption generates emissions only in correspondence of polluting manufactured products, as in the case of consumption of refined fuels or chemicals. Bio-accumulative metals and toxic waste released through consumption, similarly to production, usually degrade soil.

Table 3-2: Sectoral emission intensities for final consumption - 1990 (1000 Tons per 10^9 Lira)

	Agri	Mining	FoodPr	Textiles	PollMan	OthMan	PollServ	NPIServ	Total
TOXAIR	0	180	0	0	73	2	0	0	13
TOXWAT	0	480	0	0	140	11	0	0	30
TOXSOL	0	1053	0	0	108	0	0	0	43
BIOAIR*	0	1617	0	0	223	0	0	0	72
BIOWAT*	0	40	0	0	0	0	734	0	242
BIOSOL*	0	55194	0	0	1850	0	0	0	1851
SO2	0	1107	0	0	0	0	0	0	33
NO2	0	644	0	0	0	0	0	0	19
CO	0	106	0	0	0	0	0	0	3
VOC	0	177	0	0	120	0	0	0	18
PART	0	153	0	0	0	0	0	0	5
BOD	0	99	0	0	0	0	0	0	3
TSS	0	52	0	0	0	0	0	0	2
Cons %	4	3	9	7	10	13	33	20	100
Normalised coefficients									
TOXAIR	0	1355	0	0	551	18	0	0	100
TOXWAT	0	1581	0	0	462	37	0	0	100
TOXSOL	0	2456	0	0	253	0	0	0	100
BIOAIR*	0	2256	0	0	311	0	0	0	100
BIOWAT*	0	17	0	0	0	0	304	0	100
BIOSOL*	0	2983	0	0	100	0	0	0	100
SO2	0	3327	0	0	0	0	0	0	100
NO2	0	3327	0	0	0	0	0	0	100
CO	0	3327	0	0	0	0	0	0	100
VOC	0	999	0	0	676	0	0	0	100
PART	0	3327	0	0	0	0	0	0	100
BOD	0	3327	0	0	0	0	0	0	100
TSS	0	3327	0	0	0	0	0	0	100

* Bio-accumulative pollution intensities are in Kg per billion of Lira

4 The Benchmark Scenario

The definition of a plausible evolution for the Italian economy is based on several simplifying hypotheses. The following simulations should therefore not be considered as a forecast exercise, for CGE models are not adequate forecasts tools. In fact, the definition of a growth path, supported by exogenous assumptions, serves the purpose of establishing a scenario with no policy interventions. Impacts of different economic policies are then evaluated against this reference scenario by measuring the variations in the economic aggregates. Fixing values for exogenous variables within a realistic confidence interval seems to imply no major consequences: the relative variations of the different economic aggregates measured during the evaluation of alternative policies with respect to the reference scenario seem *uninfluenced* by those a priori choices.

Growth hypotheses

Crucial growth rates have to be fixed in order to define the reference scenario. The GDP growth rate up to the year 2004 is exogenously determined so that the capital productivity growth rate can be estimated.[21] A yearly average growth rate was estimated at 3.0 per cent, population and labour force are supposed to grow at the same exogenously fixed rate of 2 per cent per year.

A further hypothesis concerns the monetary transfers among agents in the economy and public expenditures. These are supposed to be growing at the same rate as GDP. The government budget surplus is assumed to decrease during the simulation period so that it reaches balance at the year 2010. The last hypothesis on exogenous growth rates assumes that the energy efficiency factor increases at a yearly rate of 1 per cent and labour productivity at 0.5 per cent. Apart from the latter assumptions about efficiency, no other modification affects the current technology.

However, this can become less polluting because of factors' substitution due to changes in tax structure, production and consumption. The remaining part of this section focuses on the joint evolution of Italian economic activity and pollution in the benchmark scenario.

Growth and emissions

The joint evolution of economic activity and emission volumes can be seen in Table 4-1 where the long-term pollution elasticities with respect to production and consumption are depicted. These are measured as the ratio of the yearly average growth rates of polluting emissions to those of production (and consumption, during the period 1991 - 2004) obtained in the benchmark scenario, i.e. without any policy change.

Table 4-1: Emission elasticities - Benchmark scenario 1991 – 2010

	Output	Consumption
TOXAIR	1.25	1.32
TOXWAT	1.19	1.06
TOXSOL	1.29	1.77
BIOAIR	1.26	2.45
BIOWAT	1.19	2.49
BIOSOL	1.27	2.53
SO2	0.79	0.87
NO2	0.84	0.87
CO	0.75	0.86
VOC	0.89	0.84
PART	0.79	0.87
BOD	1.41	1.83
TSS	0.70	0.81

[21] In the reference scenario real GDP growth rate is fixed and the capital productivity growth rate is endogenously determined. In the alternative policies simulations the previously estimated capital productivity growth rate is exogenous and GDP growth rate becomes endogenous.

Notice that aggregate pollution grows more or less at the same rate of economic activity, as the elasticities are very close to unity. In other words, given that output growth rate has been exogenously fixed at 3.0 per cent per year, without policy intervention, we expect this same rate (or a very close one) for the growth of the 13 pollutants considered.

In addition the relative weights of production and consumption generated emissions do not vary significantly during the simulation period.

The analysis of the decomposition of emission by origin can be instructive. Three types of effects are distinguished in the variation of emission levels: the *composition effect* takes into account the modification of the proportion of polluting products in the aggregate output; the *technological effect* reflects changes in pollution due to alteration in the production technology; the *scale effect* describes the impact of increased volumes of output on the environment.

Consider the following identity, which simply states that total emission (for each type of pollutant) is equal to the sum of sectoral emissions:

$$E = \sum_i E_i = \sum_i \left(\frac{X_i^{Output}}{X_{tot}^{Output}} \frac{E_i}{X_i^{Output}} X_{tot}^{Output} \right)$$

The total variation in emission levels can then be measured as the sum of the mentioned three effects by differentiating the shown identity:

$$\partial E = \sum_i \left[\partial \left(\frac{X_i^{Output}}{X_{Tot}^{Output}} \right) \frac{E_i}{X_i^{Output}} + \partial \left(\frac{E_i}{X_i^{Output}} \right) X_i^{Output} + \partial \left(X_{Tot}^{Output} \right) \frac{E_i}{X_{tot}^{Output}} \right]$$

where ∂ is the differential operator, E total emission volume, X_{Tot}^{Output} total output (in real terms), E_i the sectoral emission volumes and X_i^{Output} the sectoral outputs. A similar formula is used in the case of emissions originating from final consumption.[22]

The determinants of variations in the levels of emissions due to changes in production or consumption vectors are displayed in Table 4-2. Observing the values in the *scale effect* column, it clearly emerges that the predominant role in environmental degradation (across all types of emission) is played by the increase in activity volumes. The proportion of polluting goods and services produced and consumed expands from 1991 to 2004, thereby increasing, with the exception of sulphur, nitrogen and carbon oxides and other water and air emissions, the aggregate pollution volumes (*composition effect*). Finally, production technologies appear to be cleaner at the end of the period, specifically because of the improvements derived from the assumed gains in the energy efficiency

[22] In this case, the technological effect is absent, given that each component of final consumption is associated to an emission coefficient invariant with time. The emission volumes variation due to a modified consumption vector takes the form:

$$\partial E = \sum_i \left[\partial \left(\frac{X_i^{Armington}}{X_{Tot}^{Armington}} \right) \frac{E_i}{X_i^{Armington}} + \partial \left(X_{Tot}^{Armington} \right) \frac{E_i}{X_{tot}^{Armington}} \right]$$

where $X_{Tot}^{Armington}$ is total final consumption (of the Armington composite good) in real terms and $X_i^{Armington}$ final consumption in real terms of product i.

factor and from some substitution in production factors (*technology effect*). Bio-accumulative emissions are the exception, but register very low magnitudes.

The actual mechanics of the technology effect deserve some additional elaboration. The production technology specification was briefly described in the previous section, but it is worthwhile highlighting again some of its important characteristics. In the current CGE model production technology is defined as a combination of intermediate inputs and primary factors. Some substitution among these two groups is possible, while intermediate inputs are combined among themselves in fixed proportions. The primary factor bundle is composed of three substitutable components: energy, capital and labour, with energy producing toxic emissions when used. Energy is furthermore decomposed in oil products and electricity, with each of them having different polluting characteristics. Therefore a producer may reduce its emissions at any of the described levels by substituting intermediates and factors, or by replacing energy with non-energy factors, or, finally, by switching among energy sources. Actual substitutions result from alterations in relative prices of the constituents (intermediates and factors), and relative prices are changed, among other things, by indirect tax variations.

Table 4-2: Decomposition analysis of emission variations, 1990-2004 (Benchmark scenario)

			Production			Consumption
	Comp	Techn	Scale	Comp	Techn	Scale
Variation in Volumes (1000 metric tons)						
TOXAIR	499	24	4110	40	0	201
TOXWAT	293	-6	2853	17	0	388
TOXSOL	3559	140	25706	360	0	863
BIOAIR	13640	1080	112324	1424	0	2214
BIOWAT	359	30	3999	4984	0	7639
BIOSOL	469365	36979	3787531	39786	0	60002
SO2	-57	-107	1221	-35	0	376
NO2	-14	-62	811	-20	0	219
CO	-7	-58	484	-4	0	36
VOC	-15	-33	833	-23	0	196
PART	-10	-15	193	-5	0	52
BOD	194	7	1059	27	0	62
TSS	-800	-47	4609	-2	0	17
Variation in %						
TOXAIR	11	1	89	17	0	83
TOXWAT	9	0	91	4	0	96
TOXSOL	12	0	87	29	0	71
BIOAIR	11	1	88	39	0	61
BIOWAT	8	1	91	39	0	61
BIOSOL	11	1	88	40	0	60
SO2	-5	-10	116	-10	0	110
NO2	-2	-8	110	-10	0	110
CO	-2	-14	116	-11	0	111
VOC	-2	-4	106	-13	0	113
PART	-6	-9	115	-10	0	110
BOD	15	1	84	31	0	69
TSS	-21	-1	123	0	0	0

* Bio-accumulative pollution intensities are in metric tons

Even if this specification incorporates a quite complex adjustment process, it should be noticed that some important links between pollution and technology are not precisely taken into account. For instance, innovation or technology transfers, which may explain how substitution among factors and inputs can be realised, are not explicitly modelled.

Besides, emissions reduction, cleaning and other end-of-pipe techniques are not considered. The basic mechanism is governed by an endogenous response to changes in relative prices of factors/inputs and its flexibility is limited by empirical substitution elasticities.

In summary, with no policy intervention, economic activity growth results in a significant increment of emissions despite output and consumption shifts towards less polluting products and the implementation of cleaner technology.

5 Environmental Policy Scenarios

Having defined a 'Business as Usual' (BaU) base scenario, this section examines the interactions between environmental policy and the economy.

In the Environmental Policy Scenarios we consider a progressive reduction of each type of emission (i.e. it consists of 13 different experiments), as follows. Firstly, a target in terms of emissions abatement is exogenously fixed: emissions levels are reduced with respect to the reference scenario by 2 per cent in 1992, 8 per cent in 1998, 17 per cent in 2001 and 25 per cent in the end of the period. Secondly, the target is reached by imposing a uniform tax per unit of emission paid by the agent (consumers and producers) causing that pollution. For an exogenously assigned emission reduction rate in emission volumes, the model endogenously[23] calculates the tax rate. The result is analogous to the implementation of tradeable pollution rights where the equilibrium price of these rights is equal to the applied tax. In theory, a tax like ours, levied on the substance that is causing the environmental problem, is the most efficient. In practice, however, this is not always possible and taxes are levied on a proxy of the emission (like an input in the process/product – taxes on fuels - ; or the of product itself, - tax on batteries), with a loss of efficiency. Therefore, in our case, the particular design of the tax may lead to an underestimation of the economic costs of the implementation of green taxes.

We consider two ways of recycling green tax revenues: in a first scenario (*pure environmental policies*) revenues are returned to households in proportion to their income tax rates; in a second scenario (*co-ordinated environmental and labour policies*) revenues are used to reduce wage taxes across sectors in a uniform way. In both cases, fiscal reforms are revenue-neutral, i.e. the government budget is left unchanged.

In order to render more legible our results presented in the following tables, emissions are aggregated into five groups: toxic pollutants (TOXAIR, TOXWAT, TOXSOL), bio-accumulative metals (BIOAIR, BIOWAT, BIOSOL), oxide emissions (SO_2, NO_2, CO), other air pollutants (VOC, PART) and other water pollutants (BOD, SS). These aggregations are consistent in physical terms and do not hide relative variations of opposite sign. In fact, emissions show a high correlation degree within each group.[24]

Pure Environmental Policies

Table 5-1 summarises the main results in terms of emission elasticities of the first group of simulations, when green tax revenues are returned to households in proportion to income tax. The figures in the table correspond to a percentage change in emission groups with respect to 1 per cent change in total production or consumption. The first row

[23] See the technical specification of the model for more details.

[24] In the following sub-sections the results from the above simulations are presented. For the sake of clarity only global or very aggregated results are shown, even though the model is run with about 50 sectors. Detailed results, averaging more than 3000 values per period are available.

(BaU) shows for each emission group the elasticities of emissions with respect to gross output in the reference scenario, so that, for instance, average yearly growth rates for bio-accumulative emissions in the period 1991 – 2004 in the reference case are estimated to be equal to 1.30 times the average growth rate for production.

Table 5-1: Emission elasticities. Environmental policies

	With respect to production					With respect to consumption				
	Tox	**Bio**	**Nox**	**Air**	**Wat**	**Tox**	**Bio**	**Nox**	**Air**	**Wat**
BaU	1.30	1.30	0.85	0.90	0.89	1.54	2.61	0.88	0.87	1.60
TOXAIR	0.91	0.76	0.73	0.76	0.11	0.92	1.26	0.84	0.76	0.96
TOXWAT	1.18	1.28	0.26	0.53	0.88	0.87	2.51	0.50	0.43	0.51
TOXSOL	0.95	0.82	0.75	0.81	0.34	1.01	1.36	0.87	0.83	1.06
BIOAIR	1.05	0.90	0.80	0.87	0.23	1.31	1.49	0.88	0.87	1.51
BIOWAT	1.04	1.03	0.74	0.86	-0.13	1.39	1.77	0.89	0.88	1.51
BIOSOL	1.05	0.90	0.83	0.88	0.61	1.31	1.49	0.88	0.87	1.57
SO2	1.31	1.31	0.49	0.77	1.07	1.50	2.63	0.56	0.73	1.59
NO2	1.30	1.32	0.45	0.76	1.08	1.47	2.63	0.53	0.72	1.53
CO	1.29	1.29	0.77	0.84	0.39	1.54	2.60	0.88	0.86	1.56
VOC	1.29	1.31	0.56	0.67	0.60	1.47	2.62	0.74	0.66	1.62
PART	1.30	1.31	0.35	0.71	0.02	1.50	2.63	0.57	0.73	1.47
BOD	1.15	1.22	0.78	0.83	0.68	1.04	2.45	0.90	0.84	0.50
TSS	1.30	1.30	0.81	0.89	0.54	1.54	2.61	0.88	0.87	1.56

Notes : *Tox*: toxic pollutants; *Bio*: bio-accumulatives metals; *Nox*: sulphur, nitrogen and carbon oxides; *Air*: other air pollutants; *Wat*: other water pollutants.

The 13 rows below the BaU scenario show the elasticities corresponding to the hypothetical implementation of a specific emission tax. For instance, if a uniform tax were levied on air pollutants (TOXAIR) so that 25 per cent abatement with respect to the benchmark were the target for the year 2004, average yearly growth rates for toxic emissions would be equal to 0.91 times the average growth rate for production. Or, considering consumption originated emissions, 0.92 times the corresponding growth rate for final demand.

The figures of Table 5-1 show clearly that targeted emission taxes have considerable reduction effects. For each simulation, the elasticities of the targeted group (the boxes on the main diagonals of the table) of emission with respect to production are smaller than in the benchmark.

The figures of Table 5-1 show also that a specific abatement policy not only reduces its targeted toxic emissions but also those of other pollutants (the values outside the boxes on the main diagonals of the table). For instance, if a uniform tax were levied on air pollutants (TOXAIR) not only the elasticity of toxic pollutants would pass from 1.30 in the benchmark to 0.91, but also the elasticity of bio-accumulative metals with respect to production would be reduced from 1.30 to 0.76. The only exception is represented by the policies targeted at sulphur and nitrogen oxides: in this case a slight increase with respect to the benchmark is registered in the elasticities for Bio emissions and water pollutants. It appears that, in general, substitution effects among different types of emission are not induced in the production processes. This may be explained by two related facts: firstly specific intermediates (for example oil) are used in the production of most goods and generate emissions of most types, and secondly, given the Leontief structure of intermediate consumption no substitution is possible among them. Thus targeting a specific effluent has the connected beneficial effects of reducing other pollutants.

Aggregate reduction in the emission volumes is primarily the result of the decrease in production generated emissions. And this is due to a shift of production towards less polluting activities as well as, within each activity, to the implementation of cleaner technologies. Table 5-2 shows an example of a detailed decomposition of the various reduction effects, contrasting the values for the benchmark (from Table 4-2) with those for the toxair simulation. A significant lower output for those sectors producing highly polluting goods, up to 20 per cent with respect to the reference scenario in the final year account for a high share of total emission's reduction (*composition effect*). Emissions abatement in the other industries is also obtained through diminished pollution intensities (*technology effect*), as the result of substitution of toxic intermediates with more labour and capital and cleaner energy sources.

Table 5-2 Decomposition analysis of emission variations, 1990-2004 (Toxair simulation and benchmark)

	Production			Consumption		
	Comp	Techn	Scale	Comp	Techn	Scale
Variations in Volumes (1000 metric tons)						
TOXAIR Simulation	-135	-41	2609	-17	0	145
TOXAIR benchmark	499	24	4110	40	0	201
Variations in %						
TOXAIR Simulation	-6	-2	107	-14	0	114
TOXAIR benchmark	11	1	89	17	0	83

Once the environmental effectiveness of the emission taxes has been shown, the next important question concerns their cost in terms of reduced economic growth. Table 5-3 shows average yearly growth rate of GDP in the benchmark and the 13 scenarios. It appears that the different progressive abatement policies examined have quite low costs in output terms. The average yearly GDP growth rate in the simulations is found in the range of 2.7 and 3.0 per cent, very close to the benchmark rate of 3.0 per cent. Employment effects are also negligible, as shown in Table 5-4b below.

Table 5-3: Real GDP growth rates (per cent average yearly rates 1991-2004)

	BaU	Tox		.	Bio			other						
		Air	Wat	Sol	Air	Wat	Sol	SO2	NO2	CO	VOC	PART	BOD	TSS
RGDP	3.0	2.8	2.8	2.8	2.9	2.7	2.9	3.0	3.0	3.0	3.0	3.0	2.8	3.0

This low cost may be explained by several related reasons. Firstly, as explained above, the *composition effect* plays an important role and even if certain sectors reduce considerably their output, and consequently their factor demands, other industries expand and take advantage of the non-polluting resources released by the contracting sectors. Moreover, these expanding activities may as well benefit from the assumed substitution possibilities between different inputs and factors, shifting their technologies towards cleaner input combinations, thus avoiding rising costs due to the emission taxes.[25]

[25] Table 8-1, in the annex to this paper, shows the initial pollution coefficients for both production and consumption (the α's and β's of equation at page 7). It clearly appears that, in the Italian case, these coefficients are concentrated in a few sectors. In fact, targeted emission taxes considerably affect only that small number of industries that are making an

Secondly, the redistribution scheme of the emission tax revenue seems to almost cancel out the distortionary effect of these same taxes. It should be noticed that in the simulations with abatement policies, savings are higher, even in the current model with myopic agents who do not anticipate future emission taxes. This is due to the tax redistribution scheme. Revenues from emission taxes are redistributed to the households as a function of their income tax rates;[26] hence a large part of the increased government transfers they receive is saved. This results in larger investment possibilities and faster capital accumulation, a sort of double dividend effect. Besides new capital vintages enjoy larger production substitution elasticities helping the economy to adjust more quickly without compromising aggregate growth rates.

Co-ordinated environmental and labour policies

Table 5-4 summarises the main results for this second set of simulations, where green taxes revenues are used to reduce wage taxes across sectors in a uniform way so that the government budget is left unchanged (revenue neutrality is maintained).

Table 5-4: Emission elasticities. Environmental policies and wage tax reduction

	With respect to production						With respect to consumption				
	Tox	Bio	Nox	Air	Wat	Ave	Tox	Bio	Nox	Air	Wat
BaU[27]	1.28	1.27	0.80	0.87	0.80		1.49	2.52	0.87	0.85	1.54
TOXAIR	0.84	0.67	0.69	0.72	-0.01	26	0.84	1.11	0.83	0.74	0.86
TOXWAT	1.13	1.26	0.15	0.45	0.83	21	0.77	2.35	0.39	0.33	0.40
TOXSOL	0.89	0.74	0.72	0.78	0.26	11	0.93	1.22	0.86	0.81	0.97
BIOAIR	1.01	0.84	0.76	0.85	0.15	15	1.26	1.39	0.88	0.85	1.44
BIOWAT	0.97	0.96	0.71	0.85	-0.23	18	1.34	1.56	0.89	0.87	1.46
BIOSOL	1.01	0.84	0.78	0.86	0.51	8	1.25	1.37	0.88	0.85	1.51
SO2	1.29	1.29	0.44	0.74	0.99	6	1.45	2.55	0.51	0.69	1.53
NO2	1.28	1.29	0.40	0.73	0.99	6	1.41	2.54	0.48	0.68	1.46
CO	1.27	1.27	0.71	0.81	0.30	9	1.48	2.52	0.86	0.84	1.48
VOC	1.28	1.28	0.54	0.77	0.31	18	1.47	2.53	0.72	0.78	1.46
PART	1.28	1.28	0.29	0.68	-0.05	26	1.44	2.54	0.56	0.71	1.40
BOD	1.11	1.18	0.73	0.80	0.58	7	0.98	2.32	0.91	0.83	0.41
TSS	1.28	1.27	0.76	0.86	0.46	7	1.48	2.52	0.87	0.85	1.49

Notes : *Tox*: toxic pollutants; *Bio*: bio-accumulatives metals; *Nox*: sulphur, nitrogen and carbon oxides; *Air*: other air pollutants; *Wat*: other water pollutants.

As in Table 5-1 results are reported in terms of emission elasticities to production and final demand. It appears that recycling green tax revenue to reduce wage taxes greatly facilitates the adjustment process. As shown in the column 'Ave' in Table 5-4 emission elasticities in this group of simulations are between 26 and 6 per cent lower than in the pure environmental policies simulations whose results are reported in Table 5-1. Considerably lowered labour costs, in conjunction with more expensive polluting

intense use of the polluting inputs. This, jointly with the other reasons exposed in the main text, explains why additional relative price distortions caused by emission taxes are not spread to too many sectors, and why aggregate growth is not affected in a remarkable way.

[26] These are calculated from the base year SAM.

[27] It should be noted that elasticities values for this BaU scenario are slightly different from those presented above. The reason for this discrepancy is that the model has to be recalibrated when the government budget is equilibrated via wage tax *and* direct tax adjustments, and the recalibration affects not only the simulation results but also the BaU scenario. In other words it would have been incorrect to compare experiment scenarios where the adjustment is through the two cited fiscal instruments to a BaU where adjustment is only achieved by altering direct taxes.

material inputs (which now include the green tax), incentive firms to switch towards more labour intensive and cleaner production structures. As in the first set of simulation, a specific abatement policy not only reduces its targeted toxic emission but also those of other pollutants.

"Co-ordinated environmental and labour policies" scenarios show considerably better results with respect to "pure environmental policies" also in terms of employment.

Table 5-5 shows the differential effect of revenue recycling on labour demand, the first row displays percent changes of labour demand when the recycling mechanism involves reductions in the wage tax, whereas the second row presents the same changes when green taxes revenues are exclusively used to reduce direct taxes. The values shown in the table are labour demand's percentage differences between final years of the experiments and final year of the benchmark scenario. In the co-ordinated environmental and labour policies case a small employment double dividend is achieved in most of the 13 simulation exercise. Reducing fiscal distortion against the use of labour facilitates the adjustment of the economy to the new equilibrium with the green taxes: employment increases and emission elasticities are reduced.

Table 5-5: Employment effects. Pure environmental policies and co-ordinated environmental and labour policies

	Toxair	Toxwat	Toxsol	Bioair	Biowat	Biosol	So2	No2	Co	Voc	Part	Bod	Tss
Coord. Policies	6.0	15.0	4.0	2.0	6.0	2.0	1.0	1.0	0.0	0.0	1.0	6.0	0.0
Pure Env Policies	-2.0	-2.0	-2.0	-1.0	-3.0	-1.0	0.0	0.0	0.0	0.0	0.0	-2.0	0.0

6 Conclusion

This paper investigates the potential of a comprehensive green tax reform in Italy. The country is particularly interesting because it shows a relatively high-energy efficiency, so that standard command-and-control measures risk to be extremely costly in reducing energy-related emissions. The use of economic instruments is also useful in targeting other sources of pollution, such as traffic and the use of phosphate and nitrogen in agriculture, where Italy scores relatively worse than most European countries.

While previous studies only simulated the introduction of taxes on CO_2 emission, this paper simulates results for emission taxes targeted to other sources of pollution. It is shown that the introduction of a tax targeted to one single pollutant, also decrease the elasticities of emission to increase in production for other pollutants. Major potential benefits are therefore to be expected from the design of a comprehensive fiscal reform that takes into account spillover effects.

The effect of the introduction of environmental taxes together with the lowering of labour taxation is also investigated. Currently, the high level of taxation on labour participates to sustain a very high unemployment rate and low job creation rate. The reduction of labour costs through reduction of taxation on labour without compromising the government budget would be extremely advantageous. Previous studies on green tax reform shows results for Italy in line with what obtained for other European countries, and generally a small positive double dividend in term of employment creation is found. This paper confirms the positive double dividend.

Two remarks have to be made. Firstly, in our model green taxes are paid in proportion to the emissions of polluting substances. In practice, this is not always possible and often a proxy of the emission has to be taxed, implying a loss of efficiency. Therefore, our results may underestimate the economic costs of achieving a given emission reduction target. Secondly, the positive employment double dividend is obtained on a competitive labour market, where reduction of wage taxes allow a reduction of labour costs and are not eroded in the bargaining process by increases in net wages. This assumptions is likely to lead to optimistic results especially in the Italian case, where unions coverage (the extent to which contracts signed by organised unions extend to the rest of the country) and unions' density (the number of organised unions member net of pensioners divided by the labour force) are both high in comparison with other OECD countries[28], as it is the case with other continental European countries such as France and Germany.

Research agenda for the future include the design of a integrated fiscal reform for the actual fiscal system with the introduction of non-compliance, enforcement costs and tax evasion and the introduction of bargaining in the modelling of the wage formation process.

7 References

Armington, P. (1969), A Theory of Demand for Products Distinguished by Place of Production. *IMF Staff Papers*, Vol. 16.

Bhagwati J. and R.E. Hudec (eds.) (1996), *Fair Trade and Harmonization: Prerequisites for Free Trade*?. Cambridge and London: MIT Press.

Blanciforti L. and R. Green (1983), An Almost Ideal Demand System Incorporating Habits: An Analysis of Expenditures on Food and Aggregate Commodity Groups*, Review of Economics and Statistics*, Vol. 65-3, pp.511 - 515.

Bosello F, Carraro C, Galeotti M (1998), The Double Dividend Issue: Modeling Strategies and Empirical Findings, *FEEM nota di lavoro* 81.98.

Bovenberg A L & de Mooij R A (1996), Environmental Tax Reform and Endogenous Growth, *Journal of Public Economics*, No. 63 207-237.

Bovenberg A L & van der Ploeg F (1996), Optimal Taxation, Public Goods and environmentla Policy with Involuntary Unemployment, Journal of Public Economics No. 62, 59-83.

Burniaux, J.-M., G. Nicoletti and J. Oliveira-Martins (1992), GREEN: a Global Model for Quantifying the Costs of Policies to Curb CO2 Emissions**. *OECD Economic Studie*s**, Vol. 19, Winter.

[28] See Daveri and Tabellini, 2000.

Capros et al (1996), Double dividend analysis, first results of a GEM-E3 , linking the EU12 countries, in *Environmental fiscal reforms and unemployment*, Carraro C and Siniscalco D eds, FEEM and Kluwer Publishers, Dordrecht.

Carraro C, Galeotti M (1997a), Economic growth, International Competitiveness and Environmental Protection: R&D and Innovation Strategies With the WARM model, *Energy Economics* 19, pp 2-28.

Carraro C, Galeotti, M, (1997b), The Benefits of Environmental Fiscal Reforms in an Integrated Europe, *Review of International Economics*, Special Supplement, 111-133, 1997.

Carraro C, Galeotti M & Gallo M (1996), Environmental Taxation and Unemployment: Some Evidence on the 'double dividend hypothesis' in Europe*, Journal of Public Economics*, No 62.141-181.

Carraro and Siniscalco (1996), *Environmental Fiscal Reform and Unemployment*, (Kluwer, Dordrecht).

Daveri F, Tabellini G (2000), Unemployment, Growth and Taxation in Industrialised Countries, *Economic Policy*, April 2000, p 49-104.

Dessus, S., D. Roland-Holst and D. van der Mensbrugghe (1994), Input-Based Pollution Estimates For Environmental Assessment in Developing Countries. *OECD Development Centre Technical Papers*, Vol. 87, Paris.

Ekins P (1999), European Environmental Taxes and Charges: Recent Experiences, Issues and Trends, *Ecological Economics*, 31, 39-62.

Ekins P (1997), On the Dividends from Environmental Taxation, in O' Riordan T (ed) 1997, *Ecotaxation*, Earthscan, London.

European Environment Agency (1998), Statistical Compendium for the Second Assessment, Office for Official Publication of European Communities.

Fullerton D & Metcalf G E (1997), Environmental Taxes and the Double-Dividend Hypothesis: Did You Really Expect Something for Nothing, Working Paper No. 6199.

Goulder L H (1995), Environmental Taxation and the Double Dividend: a Reader's Guide, *International Tax and Public Finance*, 2, 157-183.

Hettige, H., R.E.B. Lucas and D. Wheeler (1992), The Toxic Intensity of Industrial Production: Global Patterns, Trends and Trade Policy. *American Economic Review. Papers and Proceedings,* Vol. 82.

Hill M (1998), The Cost of Reducing SO_2 and NO_x emissions using Imperfect Environmental Taxes: a CGE analysis of Sweden, mimeo, Stockholm School of Economics and The Beijer Institute, Stockholm, Sweden.

Krugman, P. (1997), What Should Trade Negotiators Negotiate About? *Journal of Economic Literature* Vol. XXXV (March), pp. 113–120.

Lopez R.A. (1989), Political Economy of the US Sugar *Policies American Journal of Agricultural Economics*, Vol. 71 pp. 20 - 31.

Lluch, C. (1973), The Extended Linear Expenditure System, *European Economic Review*, Vol. 4.

Majocchi A (1996), Green Fiscal Reform and Employment: A Survey, *Environmental and Resource Economics* No 8 375-397

Maki A. (1988), The Estimation of a Complete Demand System Using the Marginal Rates of Substitution, *The Economics Studies Quarterly*, Vol. 39 pp. 64 - 76.

Marsiliani L (1998), On the quantitative effects of imperfect competition on the double dividend, presented to the World Congress of Environmental and Resources Economists, Venice 1998.

Oates, W E (1993), Pollution Charges as a Source of Public Revenues, in H Giersch (ed) *Economic Progress and Environmental Concerns*, Berlin: Springer-Verlag, 135-142.

OECD, 1999, *Economic Outlook*, December 1999.

OECD, 1998, *Environmental Indicators* 1998.

Pearce D W (1991), The Role of Carbon Taxes in Adjusting to Global Warming, *Economic Journal*, 101, 938-948.

Perroni, C. and R.M. Wigle (1994), International Trade and Environmental Quality: how Important are the Linkages?. *Canadian Journal of Economics*. Vol. 27 (3).

Pezzey J C V and A Park (1998), Reflections on the Double Dividend Debate, *Environmental and Resource Economics*, 11, 593-555.

Pireddu G (1996), Evaluating External Costs and Benefits Resulting from a Cleaner Environment in a Stylised CGE Model.

Reinert, K.A. and D. Roland-Holst (1992) A Detailed Social Accounting Matrix for the United States, *Journal of Economic System Research*, Vol. 4:2, pages 173-87.

Repetto R, Dower RC, Jenkins R and J Geoghegan, 1992, *Green Fees: How a Tax Shift Can Work for the Environment and the Economy*, Washington DC, World Resource Institute.

8 Annex: Italian emission coefficients

Table 8-1: Emissions coefficients for Output

(β_i - expressed in pounds / Million Lira 90)

	ToxAir	ToxWat	ToxSol	BioAir	BioWat	BioSol	SO2	NO2	CO	VOC	PART	BOD	TSS
Agri	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke	0	0	0	0	0	0	0	0	0	0	0	0	0
OilGas	0	0	0	0	0	0	0	0	0	0	0	0	0
EleGasWat	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining	0	0	0	0	0	0	0	0	0	0	0	0	0
NMetMin	0	0	0	0	0	0	0.800	1.987	0	0	0.168	0	0
Chem	0	0	0	0	0	0	0	0	0	0	0	0	0.073
MetProd	0	0	0	0.000	0	0	0	0	0	0	0	0	0
Equipm	0	0	0	0	0	0	0	0	0	0.140	0	0	0
PrecInst	0	0	0	0	0	0	0	0	0	0	0	0	0
EleMach	0	0	0	0	0	0	0	0	0	0	0	0	0
Car	0	0	0	0.000	0	0	0	0	0	0	0	0	0
OthCar	0	0	0	0.002	0	0	0	0	0	0	0	0	0
Meat	0	0	0	0	0	0	0	0	0	0	0	0	0
Dairy	0	0	0	0	0	0	0	0	0	0	0	1.022	0
OthFood	0	0	0	0	0	0	0	0	0	0	0	0	0
BevTob	0	0	0	0	0	0	0	0	0	0.308	0	0	0
Textiles	0.092	0	0	0	0	0	0	0	0	0	0	0	0
Leather	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood	0	0	0	0	0	0	0	0	0.267	0.121	0.081	0	0
PaperPrnt	0.037	0.631	0.101	0	0	0	0.267	0.118	0.098	0	0.034	0.237	0.249
RubPlast	0	0	0	0	0	0	0	0	0	0	0	0	0
OthManuf	0	0	0	0	0	0	0	0	0	0	0	0	0

Construct	0	0	0	0	0	0	0	0	0	0	0	0	0
Recycle	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce	0	0	0	0	0	0	0	0	0	0	0	0	0
HotRest	0	0	0	0	0	0	0	0	0	0	0	0	0
Transp	0	0	0	0	0	0	0	0	0	0	0	0	0
SeaTrsp	0	0	0	0	0	0	0	0	0	0	0	0	0
OthTrsp	0	0	0	0	0	0	0	0	0	0	0	0	0
Communic	0	0	0	0	0	0	0	0	0	0	0	0	0
BankInsOth	0	0	0	0	0	0	0	0	0	0	0	0	0
RealEstate	0	0	0	0	0	0	0	0	0	0	0	0	0
PrivEdu	0	0	0	0	0	0	0	0	0	0	0	0	0
OthServ	0	0	0	0	0	0	0	0	0	0	0	0	0

*Table **8-1**(cont.): Emissions coefficients for Consumption*

(α_i - expressed in pounds / Million Lira 90)

	ToxAir	ToxWat	ToxSol	BioAir	BioWat	BioSol	SO2	NO2	CO	VOC	PART	BOD	TSS
Agri	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal	8.56	0	0	0.87	0.09	0	0	0	198.76	0	17.48	0	4788.72
Coke	56.62	0	445.71	0	0	0	0	0	268.51	139.63	0	0	0
OilGas	1.30	8.00	3.37	0	0	0	28.62	16.65	2.48	4.47	3.96	0	0
EleGasWat	0	0	0	0	0	0	0	0	0	0	0	0	0
Mining	36.27	0	252.70	1.54	0.04	53.05	0	0	0	0	0	0	0
NMetMin	16.15	30.56	115.43	0	0	0	0	0	0	0	0	17.67	0
Chem	3.71	10.07	6.64	0	0	0	0	0	0	8.59	0	0	0
MetProd	0	0	2.21	0.03	0	0.26	0	0	0	0	0	0	0
Equipm	0	0	0	0	0	0	0	0	0	0	0	0	0
PrecInst	0	0	0	0	0	0	0	0	0	0	0	0	0
EleMach	0	0	0	0	0	0	0	0	0	0	0	0	0
Car	0	0	0	0	0	0	0	0	0	0	0	0	0
OthCar	0	0	0	0	0	0	0	0	0	0	0	0	0

Meat	0	0	0	0	0	0	0	0	0	0	0	0	0
Dairy	0	0	0	0	0	0	0	0	0	0	0	0	0
OthFood	0	0	0	0	0	0	0	0	0	0	0	0	0
BevTob	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles	0	0	0	0	0	0	0	0	0	0	0	0	0
Leather	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood	0	0	0	0	0	0	0	0	0	0	0	0	0
PaperPrnt	0.51	2.43	0	0	0	0	0	0	0	0	0	0	0
RubPlast	8.97	0	0	0	0	0	0	0	0	0	0	0	0
OthManuf	0	0	0	0	0	0	0	0	0	0	0	0	0
Construct	0	0	0	0	0.05	0	0	0	0	0	0	0	0
Recycle	0	0	0	0	0	0	0	0	0	0	0	0	0
Commerce	0	0	0	0	0	0	0	0	0	0	0	0	0
HotRest	0	0	0	0	0	0	0	0	0	0	0	0	0
Transp	0	0	0	0	0	0	0	0	0	0	0	0	0
SeaTrsp	0	0	0	0	0	0	0	0	0	0	0	0	0
OthTrsp	0	0	0	0	0	0	0	0	0	0	0	0	0
Communic	0	0	0	0	0	0	0	0	0	0	0	0	0
BankInsOth	0	0	0	0	0	0	0	0	0	0	0	0	0
RealEstate	0	0	0	0	0	0	0	0	0	0	0	0	0
PrivEdu	0	0	0	0	0	0	0	0	0	0	0	0	0
OthServ	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 9-3: Taxes with environmental relevance

	1990	1991	1992	1993	bn ITL 1994
Tassa rifiuti solidi urbani	3.485	4.125	4.840	5.300	5.420
Tributo provinciale tutela amb				150	180
Canone acque	787	449	965	1.090	1.090
Imposta rumore aerei				0	7
Sacchetti di plastica	56	78	72	92	20
Contrib ricicl contenitori oli usati	22	22	25	33	38
Contrib ricicl contenitori vetro			NA	NA	NA
Contrib ricicl contenitori plastica		36	43	45	61
Sovrapp batterie in piombo			17	17	24
Contrib ricicl contenitori alluminio	NA	NA	NA	NA	NA
Total environmental taxes	4.350	4.710	5.962	6.727	6.840
Tasse auto	6.481	7.132	7.835	7.828	7.924
Imposta fabbric oli minerali	30.992	36.665	37.037	37.765	39.068
Imp fabbricazione gas metano	1.344	3.515	4.780	4.742	5.168
Imp fabbricazione gas di petrolio	545	651	691	733	794
Imp consumo energia elettrica	534	541	461	487	1.242
Addizionale energia elettrica	1.406	1.537	1.649	1.662	1.735
Total taxes on autos and energy	41.302	50.041	52.453	53.217	55.931
TOTAL TAXES WITH ENVIRONMENTAL RELEVANCE	45.652	54.751	58.415	59.944	62.771

Source(s): Ministero dell'Ambiente (1997)