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ENVIRONMENTAL TAXATION IN AN ENLARGED EUROPE: A REGIONAL PERSPECTIVE

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ABSTRACT

The recent enlargement of the European Union brings many opportunities, but also presents many challenges. While some regions and industries are likely to experience welfare gains and increased turnover respectively, others will likely find themselves net losers in this new system.

One particularly relevant issue at the current time is that of the environment. This is understandable given the substantial consequences of movements of goods and pollution across Europe. Broad differences in trade patterns and environmental policy still exist between European countries (in particular between those of the existing states and those of the new accession countries) meaning that environmental and trade policies can influence the structure of whole economies and emissions levels. Of particular concern in the context of European enlargement is the idea of *leakage* of heavy industries to the new accession countries where labour costs are lower, but industry is typically more polluting.

This paper therefore examines the effects should measures be taken to anticipate and avert such an increase in pollution, specifically through the introduction of a tax on various pollutants, harmonised at the European level. As the European Emissions Trading Scheme is already in place to deal with greenhouse gas emissions within Europe, we instead focus on other pollutants, namely Nitrogen Oxides (NO_x) and Sulphur Dioxide (SO_2). These are not global in nature as are greenhouse gases, but rather have also localised effects.

There are many techniques that could be utilised for such a study, but this paper employs one of the most comprehensive. CGE modelling is a three stage process for analysing the potential impacts of policy changes or other economic shocks to a system. At the first stage, economic parameters (such as the substitutability of imported goods for domestically produced and goods, the substitutability between polluting and non-polluting input factors of

production) are estimated from real world data. Secondly, a model featuring a system of constraints embodying the equilibrium conditions that must exist in an economy is constructed and solved to find the underlying state of the current economy. Finally, changes are made to this model to simulate the implementation of the potential policies. Comparing the results of the initial model and those of the simulated cases allows the impact of the policy change to be seen quantitatively. Here, by constructing a model at country and sectoral level, we are able to assess the economic effects of different levels of pollution taxation on individual countries' industries.

Typically however, individual regions specialise in a small number of industries. Therefore, welfare effects predicted at the national level may not be exactly mirrored at a regional level. As a case study, we examine the likely effects of these country level results on the Apulia region which is largely dependant on agriculture and heavy industries. The results of the CGE model predict a decrease in the output and employment associated with manufacturing in Italy in general and especially in the oil industry. At the national level, this is largely offset by the advent of cheaper goods manufactured in the accession countries, but has a potentially negative impact on the regional economy of Apulia, in particular in Brindisi and Taranto which are involved in the energy industry sector.

1. INTRODUCTION

Europe has just undergone its largest change socially, politically and economically since that triggered by the fall of the Berlin Wall nearly 30 years earlier. This change is the enlargement of the European Union (EU) to incorporate 12 new nations from Central and Eastern Europe. The first 10 of these nations acceded on 1st May 2004 and were later joined on 1st January 2007 by Bulgaria and Romania. Such a large increase in the size of the EU will undoubtedly lead to massive changes to the region's economy. For some industries and regions, this increase will be an unqualified economic advantage, while others may find themselves disadvantaged by the changes in production and trade relationships that develop. Diversity between regions within a country is an important issue in this context; the best interests of a country as a whole do not always coincide with those of all its regions. For example, in a developed country, removing agricultural subsidies saves tax payers in general money, but will have a large negative impact on any region that is largely rural. It is important therefore to assess the implications of any (inter)national policy at a regional level in order to assess what extra aid or support may be necessary to deal with the impact of a policy.

In addition to the massive increase in size of the EU, the accession countries are typically quite distinct economically from those of the existing member states. In general, these new members are poorer than the existing member states and also have a greater proportion of their workforce and economy dependent on heavy industry. Lower costs generally, and of wages in particular, are a powerful economic incentive for industries in the existing member states to move to the acceding countries. Such factors are even greater draws now that trade tariffs have been abolished with these countries' accession. A further factor which may tempt heavy industry to relocate are the typically laxer environmental standards in Eastern European countries. This coupled with the more pollution intensive machinery in these countries leads to real environmental concerns, especially at a time when environmental issues are becoming more important to people worldwide. Heavy industry is generally relatively unimportant economically to existing member states so their movement eastwards may be seen as mainly an environmental issue. However this rule does not apply to all regions. Some regions of the existing member states are heavily reliant on the manufacturing industries present in those regions; any shift of these industries to newly acceded countries will have important economic consequences for these areas.

In order to mitigate an increase in pollution due to the migration of the most highly polluting industries, several policy instruments exist which the European Union may utilise. One approach that has already been adopted is the European Union Emissions Trading Scheme (EU ETS). Under this scheme, the amount of carbon dioxide (CO_2) that industry can emit is capped at a given level, and firms require permits in order to produce emissions. These are subject to an initial allocation process and are then tradable between firms. This mechanism is the keystone of the EU's approach to meeting the greenhouse gas emission reduction targets mandated by the Kyoto protocol. It appears likely that this will also be the backbone of any post-Kyoto agreement signed by the EU.

The EU ETS deals with air pollution in the form of CO_2, and is due to be expanded to include other greenhouse gases. However there are other pollutants which are not part of the scheme and which are unlikely to be included in any future incarnations of it. This is due to the EU ETS being concerned with the emission of greenhouse gases. Many other emissions produced by industry have other negative effects however. Two such pollutants which this paper focuses on are nitrogen oxides (NO_X) and sulphur dioxide (SO_2). Both these substances are culpable for acid rain and are linked to pulmonary health problems. For reducing these pollutants, schemes other than emission trading may be more appropriate for reducing emissions; emissions of CFCs were reduced through the Montreal Protocol, which establishes a timetable for reductions leading to an outright global ban on their production. Another option that is available to policy makers is the introduction of a tax on energy inputs.

The introduction of new technology and a set of EU tax on energy inputs have been successful in reducing, for example, sulphur emissions throughout Europe 15. However, acid rain problem still remain. More recently, a Framework of Air Quality Directives (European Union, 1996) has been developed by the Community to reduce, among other things, sulphur dioxide, nitrogen oxide, particulate and ozone. The Council conclusion of 1997 recognised that it would not be possible to achieve the long-term target for the whole Europe by 2010. There is space, then, to consider further policies to help countries reaching these targets. An emission (Pigouvian) tax, though theoretically efficient as the price as an emission permit, would contribute to reach optimal pollution. The consequences of this latter approach on the structure of the EU economies are considered in this study.

Over the last thirty years Computable General Equilibrium (CGE) modelling has been widely used to study and simulate the relationship between the whole economy and policy. In contrast to other numerical models used in microeconomics analysis, CGE models determine relative price and factor demand and real exchange rates. Inflationary effects are not taken into account. The last decade has, in fact, seen a massive development of CGE to model the macroeconomic effects of environmental policy on both the environment and the economic structure of a ingle or a multitude of countries (i.e. the Kyoto Protocol). The rationale behind the use of CGE to model the environment is that any changes in exogenous conditions are likely to have general equilibrium effects either at a regional level or at a global scale. In fact, whilst some environmental problems have site-specific effects such as local air quality in urban areas, others are global in nature. Acid rain or climate changes are examples of environmental problems caused by pollutants being transboundary by their nature. Multiple effects are therefore expected to affect consumer welfare and the environment. To model the link between energy use and emissions is the primary scope of appropriately designed CGE models able to elucidate and quantify the effects of simultaneous trade and environmental policies on the economy and environment.

To date, the on-going GEM-E3 model (Kouvaritakis et al., 2002) based on modelling the energy, environment and economy interactions of the EU considers only the existing EU member states and attempts to analyse harmonisation of energy taxation. In contrast, there is no evidence of applied CGE modelling in the context of regulating transboundary air pollution in an enlarged Europe that considers the simultaneous effects of harmonisation of pollution and trade taxation.

While it is possible to construct a CGE model of the European Union at a national level, the contrary is true if one need to disaggregate the analysis at regional level. Firstly, the availability and reliability of the required data such as Input-Output (IO) Tables or Social Accounting Matrices (SAMs) at this level is a problem. IO and SAMs at regional level are only available for some regions. While some regions have high quality data available on their local industries and populace, this is not universally available. In Italy, for example, the Regional Institute for Economic Planning of Tuscany (IRPET) has built the first IO study at multi-regional level in Italy dated back to the year 1999. Environmentally extended IO tables and regional transboundary fluxes of main pollutants are not available at regional level. Secondly, the computational complexity of solving the CGE model places such a detailed model beyond the capability of currently available technology. We therefore build a CGE model at EU national level and analyse how Apulia regional "real-world" data would be affected given policy simulation results for Italy.

The rest of this paper now proceeds as follows. Section 2 presents an overview of the background on the interactions between environmental policy and international trade. Section 3 then describes the construction of a CGE model which is capable of simulating the effect of implementing a pollution tax policy at a country and industry level, giving particular attention to the effects on Italy. Section 4 then turns to a regional perspective on the matter by showing how the results at a higher level can be applied at the regional level. This is done through a case study of the Apulia region of southern Italy. Section 5 draws policy implications of the findings. Finally, Section 6 concludes.

2. OVERVIEW OF ENVIRONMENT AND INTERNATIONAL TRADE

The debate on the links between international trade and the environment and the government's decision to integrate pollution control mechanisms mainly focus on welfare effects and creation (or destruction) of employment opportunities and how free trade policies affect the environment.

Efforts, over the last decades, have been made to integrate local and international environmental policies in the political economy agenda of countries. The Montreal Protocol, the Kyoto Protol or the recent EU 20-20-20 policy on renewable energy are ambitious examples of environmental policy at global or European scale that translate into actions to be taken at regional or municipal level. The prime motive is the recognition of increasing pollution levels by raising the scale of economic activity (Panayotou, 1993; Lopez, 1994; De Lucia and Leonida, 2001).

International trade theory suggests that technology and endowment of inputs of production are considered the source for comparative advantages. In fact, different availability of technology and/or production inputs increases a country's comparative advantages if that country specialises in the production of goods and services embedding low technology costs. (Ricardo, 1817). In contrast, Hecksher-Olin theory suggests that depending on the availability of inputs endowments and assuming technology being constant across countries, comparative advantages arise by differences in relative costs of inputs factors.

Endowments of environmental inputs are relevant in explaining comparative advantages in the production of goods and services *á la* Ricardo because the comparative advantage would be determined by the assimilative capacity of the environment. However, demand for environment also depends upon income. Giersch (1974), argues that demand for environment may be valued differently across countries since preferences across individuals are not identical. In this case, comparative advantages would reflect individual preferences for the environment given that pollutants are considered as by-product of consumption and production activities. Siebert (1977) considers the environment as an additional factor to production or as a policy instrument. Whether in the first case models are constructed such that country's specialisation assumptions would consider the environment as a determinant of trade; i.e its influences on the location, specialisation and trade between developed and developing countries, its limitations for exports activities in developed countries and stimulus to imports in the developing world, its effects over time on comparative advantages given a change in environmental preferences. In the second case, it is the influence of environmental policy that would affect trade; i.e on comparative advantages, geographical distribution of trade and location of industries.

The potential trade effects of various pollution control regulations across countries has been widely analysed in the pioneering works of d'Arge and Kneese (1972), d'Arge (1972), Siebert (1977). In the study of d'Arge and Kneese (1972) four major topics are taken into account that are relevant to the trade and environment interactions: international aspects of the environment, the magnitude of environmental policy at micro and macro levels, how to mitigate pollution in a free-trade context. The first topic is relevant given the need for international cooperation on monitoring spillover effects of pollution generated by increasing industrial activities in the Asian continent. The magnitude of environmental policy at micro and macro levels and the takes into account the costs of national and international charges and subsidies, welfare effects and externality distortion. In this context, the use of domestic environmental standards as non-tariff barriers is criticised as being a protectionist policy from those that advocate free-trade as a goal to achieve economic growth and development. In fact, a subsidy would increase the opportunity costs of producing imported goods domestically with an impact on comparative advantage of that country.

In the case of an open economy with transboundary pollution, d'Arge (1972), the free movement of capital deteriorates the environment of the countries from which capital flows. Mis-allocation of capital across countries also emerges when countries adopting a subsidy system fail, in the long term, to increase marginal productivity of capital across countries.
Enforcement of environmental regulation is therefore required to mitigate pollution under free trade barrier considerations.

Siebert (1977) argues in favour of environmental regulation as a constraint to use resources at optimum. He considers an open economy model with two commodities and one resource input in which pollution depends on production activities. Static analysis results of relative commodity prices as a function of pollutant emissions suggests that the enforcement action of governments leads industries to internalise external effects of environmental regulation.

In the studies of McGuire (1991); Markusen et al. (1993) and Rauscher (1993) a well designed theoretical analysis under the free movement of capital and labour hypothesis is presented. While McGuire (1991) and Rauscher (1993) argue that under the assumption of constant relative prices across commodities, labour would migrate and capital inflow would rise; Markusen et al. (1993) adduce that the impact of environmental regulation on firms' location decisions is that of decreasing the number of firms within a country relocating towards a country with less stringent environmental regulations.

The problem of the long-range nature of certain pollutants arise the question whether free trade is a useful policy to reduce transboundary pollution. To date, there is no international institution to enforce a Pigouvian tax which is efficient at theoretical grounds. Therefore, to argue for trade policies as a possible approach to control transnational pollution is a viable solution. Recent studies such as those of Barrett (1994), Conrad (1992), Carraro and Siniscalco (1992), and Ulph (1997), to cite a few, have used the term *strategic environmental policy* meaning the use of environmental policy which would favour exports rather than abating pollution. This, though, has been criticised by environmentalist because it would create *ecological dumping*.

2.1 The issue of harmonization in transboundary pollution

The term harmonisation of national environmental regulations implies the introduction of identical environmental standards over the set of countries belonging to a federation of countries such athat or the European Union. The harmonisation principle is claimed to be not efficient in ecological terms, given that it would not take into account the assimilative capacity of the environment which differ across countries.

In the model by Anderson and Blackhurst (1992), harmonisation is considered as an average weight of all regulations. In this case, European countries which lag behind economically prosperous countries would worsen their natural and environmental resources; on the other hand, richer member states would increase their capital endowment given that harmonisation of environmental regulations would increase the marginal productivity of their capital. Therefore, the whole direction of mobile production factor will worsen as a result of harmonisation of environmental policies.

However, the case for harmonisation of environmental policies has been claimed to be adopted in the energy sector and in particular on road transport fuels (Newberry, 2001). This is to encourage countries to adopt more efficient transport policies and discouraging, at the same time, tax arbitrage across countries. It is on this ground that the EU needs considerable efforts toward energy tax harmonisation, taking into account also the possibility of harmonising emission taxations. Some benefits, in the form of emission reduction for example, may in fact occur when harmonisation of emission taxation is used to deal with transboundary pollution. In this case, harmonisation is considered as a form of cooperation across countries when a system of legally binding rules is adopted.

3. A CGE MODEL FOR ENVIRONMENT AND TRADE

"Computational General Equilibrium models (CGE) deal explicitly with the interrelationships between different markets and sectors of the economy, translating the theoretical Walrasian General Equilibrium concept into realistic models that represent the economy". (De Lucia, 2007)

In the pioneering work of Arrow and Debreu (1954) an economy analysed under general equilibrium conditions considers a set of economic agents interacting in the markets with an equal number of goods and commodities. Agents are price takers and determine their demand and supply by optimising utility and / or production functions. Under given market conditions, such as for example perfect competition, there exists a market clearing solution where agents are satisfied. This solution is found following a tâtonement process (Kakutani, 1941) around a fixed point which satisfies Walras' Law. CGE models embed this process and those obtaining the Arrow-Debreu solution are called Optimisation Equilibrium Models.

Over the recent years, the increase in the use of CGE models has been influential when considering policy considerations. This is because in applied policy analysis various economic mechanisms are able to be taken into account such as a number of closure rules defying a Keynesian economy from a neo-classical one, or labour market specifications, or market structure.

"A [..] difficulty of CGE models applied to environmental policy is the lack of detailed data" (De Lucia, 2007). In particular, information on environmental abatement costs is of difficult availability. Modellers would, in this case, progress with an estimation analysis and, at a second stage, incorporate the estimated results of the abatement costs into the CGE model (Capros et. al, 1995). Specific assumptions are then required to adjust goods and services of real world data to environmental taxation policy.

The 1990s has seen the advent of international research on CGE models analysing external pollution effects caused by pollution activities. Major studies aimed at assesseing climate change policies at the expenses of acid rain problems. At aggregated country level, Burniaux et al. (1992), developed the OECD GREEN model, further extended by Yang et al. (1996) with the MIT-EPPA model. Manne and Richels (1992) proposed the bottom-up Global 2100 model, while Nordhaus (1994) and Nordhaus and Yang (1996) developed the well known DICE and RICE models respectively. A common feature of these models is the benchmark case. This concerns, in particular, the determination of CO_2 emissions on the assumptions of countries' GDP rate of growth which increases because of common assumptions of savings, technology, and labour force changes.

Static environmental CGE models can be found in the works of Whalley and Wigle (1990); Bergman (1990); Xie and Saltzman (2000). Whalley and Wigle (1990) designed a three regions and five sectors global model to study the effects of a 50% cut in CO_2 emissions worldwide. This study shows the need of international agreements to reduce CO_2 emissions and the necessity to consider some forms of transfers between developed and developing countries to bind developing countries to commit for global environmental international agreements.

Bergman's work (1990) contributed to study estimates of SO_2, NO_X and CO_2 emissions in Sweden assuming emissions would have remained constant at 1988 levels given changes in abatement technologies as well as the establishment of tradable emissions permits nationwide, while Xie and Saltzman (2000) develop a model to assess optimal environmental policies in China.

3.1 *The structure of the CGE model*

This section presents a stylised structure of the CGE model developed in De Lucia (2007). The simple model comprises of the producer, consumer and a trade structure. It is a static model for existing European (EU)[1] denoted with subscript "*i*" and Accession (AC)[2] countries, denoted with subscript "*j*". Countries are assumed to embody the same technology in their production; the same preferences in their consumer and trade structures; therefore the following description for EU countries is the equivalent for AC countries.

3.1.1 The production structure

The production function is a nested function as illustrated in Figure 1.

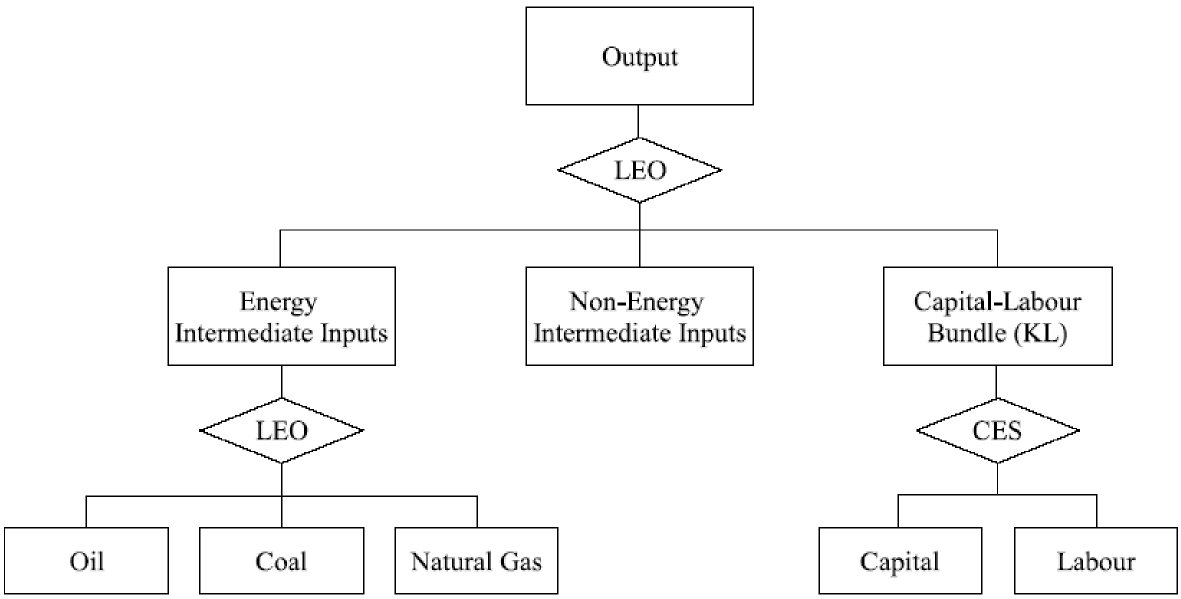

Figure 1. The Production Function

In Figure 1, starting from above, the production in the *first* nest is composed of the total aggregate of output produced in a given period of time[3] through a Leontief's technology. This is given by mixing energy intermediates (E_i), non-energy intermediates (NE_i), and a capital and labour value added bundle (KL_i). At the *second* nest, the value added bundle is given by a

[1] Here is intended the composition of European countries at EU 15, before the 1st of May 2004.
[2] These are: the Czech Republic, Slovakia, Hungary, Poland, Estonia, Latvia, Lithuania, Slovenia, Cyprus, Malta, Bulgaria and Romania. The first 10 countries entered the EU on the 1st of May 2004, while the last two on the 1st of May 2007.
[3] Generally this is intended a period of one year.

combination of capital (K_i) and labour (L_i) employing CES[4] technology. The energy aggregate is given by considering fixed proportions of coal (E_{1i}), gas (E_{2i}) and oil (E_{3i}) in the production process. For simplicity, E_{1i}, E_{2i} and E_{3i} are denoted with E_{ei} where $e \in E$.

Production and Pollution Polluting activities are considered as by-product of production by using energy inputs. To take into account the possibility for perfect mixing transboundary pollution, the following equation is considered:

$$Z_i = Z_{di} + Z_{dj} \tag{1}$$

where Z_i, the amount of pollution in country *i*, is given by Z_{di}, the fraction of pollution in country *i*, and Z_{dj} the fraction of pollution generated in country *j* and affecting country *i*. d_{ij} is the “pollution transfer coefficient" matrix of $I \times J$. In the presence of national emission targets to comply with the Framework of Air Quality Directives (European Union, 1996), the national emission target can be written such as:

$$\sum_{i,j} (d_i + d_j) Z_i < \tilde{Z}_i \tag{2}$$

where $\tilde{Z}_i$ is the national emission target and $\sum_{i,j} (d_i + d_j) Z_i$ is the sum of pollution activities from country *i* to country *j*.

Taking into account equations (1) and (2) the corresponding Leontief’s function as shown Figure 1 is given, in analytical terms, by the following equation:

$$Q_i = \min(NE_i(E_{ei}(Z_i(Z_{di}, Z_{dj})), KL_i(K_i, L_i))) \tag{3}$$

where Q_i is the aggregate output. Whereas, NE_i and E_{ei} are given by the following equations:

$$NE_i = \min\left(\frac{NE_{1i}}{a_{1i}} \dots \frac{NE_{ni}}{a_{ni}}\right) \tag{4}$$

$$E_{ei}(Z_i) = \min\left(\frac{E_{e1i}(Z_{1i})}{b_{1i}} \dots \frac{E_{e3i}(Z_{3i})}{b_{3i}}\right) \tag{5}$$

where $a = 1....n$ and $b = 1....n$ are technical inputs coefficients for non-energy and energy inputs; n denotes industry sectors.

The CES specification of the KL value added bundle is determined as follows:

$$KL_i = F_{2i}\left[\alpha_{2Ki} K_i^{\sigma_{2i}} + \alpha_{2Li} L_i^{\sigma_{2i}}\right]^{\frac{1}{\sigma_{2i}}} \tag{6}$$

[4] Constant Elasticity of Substitution

where F_{2i} is the technology parameter in the *second* nest; $\alpha_{2Ki,2Li}$ are the share parameters for capital and labour satisfying the condition that $\alpha_{2Ki} + \alpha_{2Li} = 1$; and σ_{2i} is the elasticity of substitution parameter such that $0 < \sigma_{2i} < \infty$. Producer maximises its profits such that:

$$Max\Pi_{KL,K,L,E,Z,NE} = P_{Qi} Q_i (NE_i (E_{ei} (Z_i (Z_{di}, Z_{dj})), KL_i (K_i, L_i))) - \text{costs} \quad (7)$$

where P_{Qi} is the price of aggregate output in country *i*. The FOCs[5] with respect to pollution activities (national and transboundary) are determined as follows:

$$\frac{\partial \Pi Q_i}{\partial Z_i} = P_{Qi} \frac{\partial Q_i}{\partial E_{ei}} \frac{\partial E_{ei}}{\partial Z_i} = P_{Zi} + \sum_j P_{Zj} \quad (8)$$

where P_{Zi} is the shadow price (national emission tax) of polluting generating in country *i* and $\sum_j P_{Zj}$ is the sum of all shadow prices (non-national emission taxes) of polluting generating activities in country *j*.

Harmonisation of environmental policy If the hypothesis of harmonisation of emission taxation, as policy implemented to reach the targets set by the Framework of Air Quality Directives (European Union, 1996), were taken into account in the context of this study then Pigouvian taxes would be the same across countries, such that:

$$P_{Zi}^H = P_{Zj}^H \qquad \forall i, j \quad (9)$$

where $P_{Zi,j}^H$ is the harmonised level of emission taxation. The debate on harmonisation of environmental policies focuses on satisfying marginal optimality conditions at national and aggregate (European) level. Considering the specific assumption that: $P_{Zi}^H \leq P_{Zi}$ or $P_{Zi}^H \geq P_{Zi}$ and $P_{Zj}^H \leq P_{Zj}$ or $P_{Zj}^H \geq P_{Zj}$, the results achieved in terms of efficiency of environmental policy would be sub-optimal at a national level, but optimal at an aggregate level. To show this sub-optimality condition, in fact, equation (8) would take the form:

$$\frac{\partial \Pi Q_i}{\partial Z_i} = P_{Qi} \frac{\partial Q_i}{\partial E_{ei}} \frac{\partial E_{ei}}{\partial Z_i} = P_{Zi}^H + P_{Zj}^H \quad (10)$$

where $P_{Zi}^H = P_{Zj}^H$ but $P_{Zi}^H \neq \mathrm{P_{Zi}}$ or $P_{Zj}^H \neq \mathrm{P_{Zj}}$.

3.1.2 The consumer structure

[5] First Order Conditions. Here FOCs with respect to polluting activities are considered such that governments internalise pollution with specific emission taxations. Therefore the shadow price for pollution assumes positive values such that $P_{Zi} > 0$.

Figure 2 shows the consumer structure.

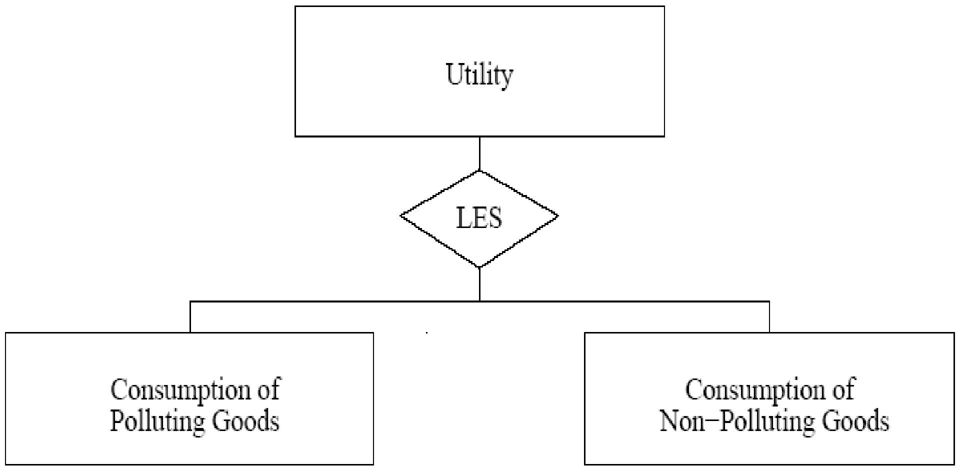

Figure 2. The Consumer Structure

As shown in Figure 2, the consumer's utility function assumes a LES[6] function. It is necessary to distinguish specific considerations. In the view of an Heckscher-Ohlin model agents' preferences should be identical across countries. However, to be consistent with the case study considered, while utility functions are identical across countries, different income levels would justify EU states preferences to consume less polluting goods relative to ACs. Under analytical terms, a Stone-Geary type utility function addresses the above considerations[7]. Consumption of polluting goods is treated as dis-utility and pollution in turns depends by consuming such goods. The relative notation for the utility function is the following:

$$U_i = (CN_i - \overline{CN}_i)^{\alpha ih}(CP_i - \overline{CP_i})^{(\beta_i - \phi_i)} \tag{11}$$

where CN_i and CP_i are the consumption of non-polluting and polluting goods, respectively, while $\overline{CN}_i$ and $\overline{CP}_i$ are the subsistence level of non-polluting and polluting goods, respectively; α_i, β_i denote the elasticity of substitution parameters, while $(\beta_i - \phi_i)$ is the elasticity parameter for consuming polluting goods net of the dis-utility caused from pollution. This implies that consumer's decisions of spending their income on polluting goods are net of pollution effect. Finally, the usual restrictions for this type of utility function apply: $\alpha_i, \beta_i, \phi_i < 1$; $\alpha_i + (\beta_i - \phi_i) = 1$; $CN_i > \overline{CN}_i \geq 0$; and $CP_i > \overline{CP}_i \geq 0$.

[6] Linear Expenditure System.

[7] A Stone-Geary utility function is a quasi-homothetic form of utility of the LES specification. Its use overturns the constraint of unitary constant income elasticity. In this context, in fact, this constraint would not allow the demand for less-polluting goods to increase relative to non-polluting goods.

3.1.3 *The trade structure*

Figures 3 and 4 show the imports and exports structure, respectively.

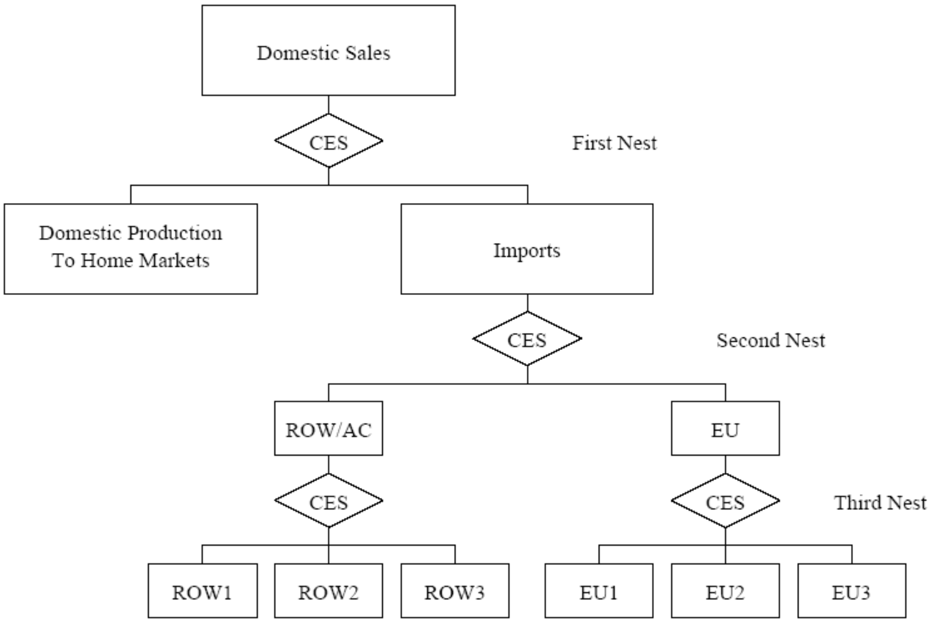

Figure 3. The Imports Structure

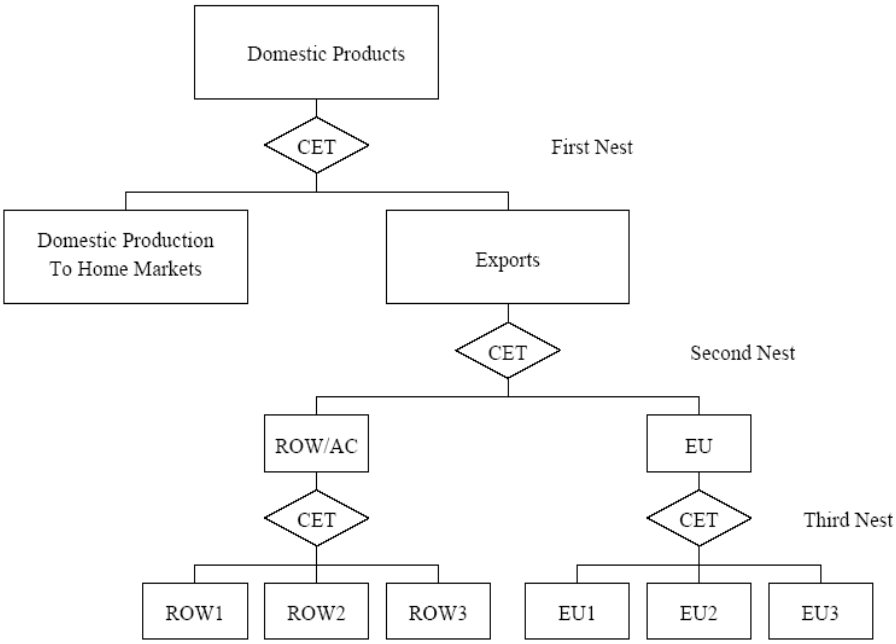

Figure 4. The Exports Structure

Both imports and exports structures illustrate a nested function type. In the *first* nest of the imports structure a composite consumption commodity QQ_i is obtained through an Armington CES[8] function of imports QM_i and domestic commodity QD_i. In the *second* nest, composite imports is obtained via an Armington CES function of imports from outside EU, QM_{ROWi} and imports from within the EU, QM_{EUi}. Finally in the *third* nest imports from within and outside EU are obtained by combining an Armington CES of imported commodities sourced from region *1* to *n*. The corresponding analytical terms are given in the following equations:

$$QQ_i = G_{1i}\left[\delta_{1i}QM_i^{\sigma_{c1i}} + (1-\delta_{1i})QD_i^{\sigma_{c1i}}\right]^{\left(\frac{1}{\sigma_{c1i}}\right)} \tag{12}$$

$$QM_i = G_{2i}\left[\delta_{2i}QM_{ROWi}^{\sigma_{c2i}} + (1-\delta_{2i})QM_{EUi}^{\sigma_{c2i}}\right]^{\left(\frac{1}{\sigma_{c2i}}\right)} \tag{13}$$

$$QM_{ROWi} = G_{3ai}\left[\delta_{3ai}QM_{ROW1i...ROWni}^{\sigma_{c3ai}}\right]^{\left(\frac{1}{\sigma_{c3ai}}\right)} \tag{14}$$

$$QM_{EUi} = G_{3bi}\left[\delta_{3bi}QM_{EU1i...EUni}^{\sigma_{c3bi}}\right]^{\left(\frac{1}{\sigma_{c3bi}}\right)} \tag{15}$$

where $G_{1i,2i,3ai,3bi}$ are efficiency parameters, $\delta_{1i,2i,3ai,3bi}$ are share parameters[9] and $\sigma_{1i,2i,3ai,3bi}$ denote elasticises of substitution[10].

Imports are minimised such that:

$$\begin{aligned} MinTC_{QQi} = P_{QQi}QQ_i(QM_i(QM_{ROWi}(QM_{ROW1i}...QM_{ROWni}),\\ QM_{EUi}(QM_{EU1i}...QM_{EUni})), QD_i) + \text{costs} \end{aligned} \tag{16}$$

where TC_{QQi} is the total cost of imported commodities.

On the exports side, the *first* nest is a composite quantity QX_i produced via a CET[11] function abroad QE_i and domestically QD_i. In the *second* nest, composite exported goods are demanded, again with a CET function, to satisfy rest of the world market, QE_{ROWi} and the EU, QE_{EUi}. In the *third* nest exported commodities to the above markets are obtained by combining a CET function of exported commodities sold to regions *1* to *n*.

The corresponding analytical terms for exports functions are given in the following equations:

$$QX_i = H_{1i}\left[\gamma_{1i}QE_i^{\omega_{c1i}} + (1-\gamma_{1i})QD_i^{\omega_{c1i}}\right]^{\frac{1}{\omega_{c1i}}} \tag{17}$$

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8 The Armington CES assumption is applied to overcome the overspecialisation problem featured in the Hecksher-Ohlin theory. "The Armington assumption implies that goods with the same statistical classification but different countries of origin are treated as non-perfect substitutes" (De Lucia, 2007, pag. 68).

9 $\delta_{1i,2i,3ai,3bi} + (1-\delta_{1i,2i,3ai,3bi}) = 1$.

10 $0 < \sigma_{1i,2i,3ai,3bi} < \infty$.

11 Constant Elasticitt of Transformation.

$$QE_i = H_{2i}\left[\gamma_{2i} QE_{ROWi}^{\;\omega_{c2i}} + (1-\gamma_{2i}) QE_{EUi}^{\;\omega_{c2i}}\right]^{\frac{1}{\omega_{c2i}}} \tag{18}$$

$$QE_{ROWi} = H_{3ai}\left[\gamma_{3ai} QE_{ROW1i...ROWni}^{\omega_{c3ai}}\right]^{\frac{1}{\omega_{c3ai}}} \tag{19}$$

$$QE_{EUi} = H_{3bi}\left[\gamma_{3bi} QE_{EU1i...EUni}^{\omega_{c3bi}}\right]^{\frac{1}{\omega_{c3bi}}} \tag{20}$$

where $H_{1i,2i,3ai,3bi}$ and $\gamma_{1i,2i,3ai,3bi}$ are efficiency and share parameters[12] respectively, while $\omega_{1i,2i,3ai,3bi}$ denotes elasticises of substitution[13].

Exports are maximised such that:

$$\begin{aligned} MaxTR_{QXi} = P_{QXi} QX_i (QE_i (QE_{ROWi} (QE_{ROW1i} ... QE_{ROWni}),\\ QE_{EUi} (QE_{EU1i} ... QE_{EUni})), QD_i) + \text{revenues} \end{aligned} \tag{21}$$

where TR_{QXi} is the total revenues of exported commodities.

4. MODEL SIMULATION AND REGIONAL ANALYSIS

The empirical CGE model has been developed by following a Social Accounting Matrix (SAM) approach (De Lucia, 2007). This consists of accounts and sub-accounts considering the following: Commodity accounts; Activity accounts; Factor accounts; Government accounts; Capital accounts; Trade accounts. The data set used is the GTAP v.6.0, which considers SAM data for the year 2001. This was further extended to address Environmental accounts in physical terms. In particular, local and transboundary pollution of SO_2 and NO_X were considered. The transboundary matrix was obtained by the EMEP project (Tarrasón et al., 2003), while emission factors were taken by the RAINS model developed at IIASA (1998). Finally, energy inputs data and energy prices at 2001 market prices were taken from the OECD Energy Balance and Energy Statistics Tables. Emissions tax rates for EU and AC are taken form the Regional Environmental Center (2001).

4.1 Model simulation analysis and country results levels

For the purpose of this article simulation analysis aims at answering the following two main questions:
1) What are the environmental implications of the enlargement, a non-simultaneous and a simultaneous change in elimination of trade barriers in Accession Countries and the implementation of a harmonised system of environmental taxation in EU27?”[14]
2) ““What are the implications of the enlargement, a non-simultaneous and a simultaneous elimination of trade barriers and adoption of a harmonised system of environmental taxation on the structure of the economy in Italy and Apulia?

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12 $\gamma_{1i,2i,3ai,3bi} + (1-\gamma_{1i,2i,3ai,3bi}) = 1$.

13 $0 < \omega_{1i,2i,3ai,3bi} < \infty$.

14 De Lucia, 2007, pag. 169.

To answer question 1, the following policy simulation exercises are carried out:

- **“MinTx** Emission taxes harmonised at minimum current level.
- **AvgTx** Emission taxes harmonised at average current level.
- **MaxTx** Emission taxes harmonised at maximum current level.[..]
- **MinTxEnlarg** Emission taxes harmonised at minimum current level and elimination of imports and export tariffs in Accession Countries.
- **AvgTxEnlarg** Emission taxes harmonised at average current level and elimination of imports and export tariffs in Accession Countries.
- **MaxTxEnlarg** Emission taxes harmonised at maximum current level and elimination of imports and export tariffs in Accession Countries”[15].

Tables 1 and 2[16] show results for existing member states and AC countries.

Table 1. Country level results for EU15

		aut	bel	deu	dnk	esp	fin	fra	gbr	grc	irl	ita	lux	nld	prt	swe
WELFARE	MinTx	0.13	-0.14	-1.29	-2.54	0.20	-0.55	-0.99	0.23	0.04	-0.03	0.79	-0.03	0.01	-0.05	0.58
	AvgTx	0.27	-0.42	1.44	-2.31	-0.33	-0.60	-0.48	-0.07	0.00	0.41	-0.13	0.28	-0.24	-0.02	0.87
	MaxTx	0.88	-1.81	13.74	-0.90	-3.12	-0.85	0.22	-1.28	-0.20	2.57	-5.32	2.06	-1.46	0.10	2.22
	Enlarg	0.30	0.16	1.65	0.09	0.17	0.07	0.53	0.32	0.18	0.08	0.82	0.01	0.22	0.03	0.06
	MinTxEnlarg	0.43	0.02	0.36	-2.45	0.37	-0.48	-0.46	0.55	0.23	0.05	1.61	-0.02	0.24	-0.02	0.64
	AvgTxEnlarg	0.57	-0.27	3.09	-2.22	-0.16	-0.53	0.05	0.25	0.18	0.48	0.69	0.29	-0.02	0.01	0.92
	MaxTxEnlarg	1.19	-1.68	15.40	-0.82	-2.96	-0.78	0.75	-0.93	-0.01	2.64	-4.50	2.08	-1.23	0.12	2.29
TAX_{IMP}	MinTx	1.00	1.01	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.03
	AvgTx	1.00	1.00	0.99	1.04	1.00	1.00	1.00	0.99	1.00	1.00	1.00	0.98	1.00	1.00	1.03
	MaxTx	0.97	0.94	0.95	0.99	0.97	0.98	0.99	0.94	0.97	0.97	0.99	0.86	0.98	0.97	1.01
	Enlarg	0.89	0.98	0.93	0.98	0.97	0.97	0.98	0.99	0.93	0.99	0.94	0.98	0.97	0.98	0.96
	MinTxEnlarg	0.89	0.99	0.94	1.00	0.97	0.98	0.98	0.99	0.93	0.99	0.94	0.99	0.97	0.98	0.99
	AvgTxEnlarg	0.89	0.98	0.93	0.99	0.97	0.97	0.98	0.98	0.92	0.99	0.94	0.96	0.97	0.98	0.98
	MaxTxEnlarg	0.87	0.92	0.88	0.95	0.94	0.96	0.96	0.93	0.91	0.96	0.93	0.85	0.95	0.95	0.96
TAX_{EXP}	MinTx	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.02
	AvgTx	1.00	1.00	0.99	1.00	0.99	1.00	1.00	0.99	1.00	1.00	1.00	0.99	1.00	1.00	1.02
	MaxTx	1.00	0.93	0.97	0.99	0.96	0.98	0.99	0.95	0.98	0.97	0.99	0.96	0.98	0.98	1.01
	Enlarg	0.74	0.93	0.90	0.91	0.93	0.95	0.96	0.94	0.87	0.96	0.92	0.96	0.96	0.97	0.90
	MinTxEnlarg	0.74	0.93	0.90	0.92	0.93	0.95	0.95	0.94	0.87	0.96	0.92	0.97	0.97	0.97	0.92
	AvgTxEnlarg	0.74	0.92	0.90	0.91	0.93	0.95	0.95	0.94	0.87	0.96	0.92	0.96	0.96	0.97	0.92
	MaxTxEnlarg	0.74	0.86	0.87	0.90	0.90	0.93	0.95	0.89	0.85	0.93	0.91	0.92	0.95	0.95	0.92
TAX_{Z}	MinTx	*1.00*	*1.00*	*1.00*	0.01	*1.00*	*1.00*	0.23	*1.00*	*1.00*	*1.00*	0.12		*1.00*	*1.00*	0.00
	AvgTx	*16.44*	*24.65*	*24.47*	0.19	*24.49*	*22.52*	5.37	*21.80*	*23.83*	*23.16*	2.98		*21.07*	*23.22*	0.06
	MaxTx	*24.39*	*128.65*	*141.35*	1.06	*138.47*	*128.70*	30.50	*126.80*	*135.15*	*129.45*	17.17		*117.39*	*148.41*	0.34
	Enlarg	*0.00*	*0.00*	*0.00*	1.00	*0.00*	*0.00*	1.00	*0.00*	*0.00*	*0.00*	1.00		*0.00*	*0.00*	1.00
	MinTxEnlarg	*1.00*	*1.00*	*1.00*	0.01	*1.00*	*1.00*	0.23	*1.00*	*1.00*	*1.00*	0.12		*1.00*	*1.00*	0.00
	AvgTxEnlarg	*16.49*	*24.68*	*24.80*	0.19	*24.50*	*22.53*	5.37	*21.81*	*23.87*	*23.15*	2.99		*21.09*	*23.22*	0.06
	MaxTxEnlarg	*24.68*	*128.78*	*141.82*	1.06	*138.52*	*128.78*	30.52	*126.82*	*135.22*	*129.58*	17.20		*117.49*	*148.48*	0.34
DEP_{NO_X}	MinTx	1.00	1.00	1.01	1.04	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.00	1.08
	AvgTx	0.99	1.00	1.00	1.03	0.99	1.03	0.99	1.00	0.99	1.00	0.99	1.00	1.00	0.99	1.07
	MaxTx	0.95	0.96	0.96	0.99	0.96	0.99	0.96	0.98	0.94	0.98	0.96	0.97	0.96	0.96	1.02
	Enlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MinTxEnlarg	1.01	1.01	1.01	1.04	1.00	1.04	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.00	1.08
	AvgTxEnlarg	1.00	1.00	1.00	1.03	0.99	1.03	1.00	1.00	0.99	1.00	0.99	1.00	1.00	0.99	1.07
	MaxTxEnlarg	0.96	0.96	0.96	0.99	0.96	0.99	0.96	0.98	0.94	0.98	0.96	0.97	0.96	0.96	1.02
DEP_{SO_2}	MinTx	1.01	1.00	1.00	1.15	1.00	1.07	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.35
	AvgTx	0.99	0.98	0.99	1.13	0.98	1.05	0.99	0.99	0.98	0.99	0.99	0.99	0.99	0.99	1.32
	MaxTx	0.93	0.89	0.93	1.03	0.91	0.97	0.91	0.96	0.90	0.93	0.91	0.92	0.91	0.92	1.19
	Enlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MinTxEnlarg	1.01	1.00	1.01	1.15	1.00	1.07	1.00	1.00	1.00	1.00	1.01	1.01	1.00	1.00	1.35
	AvgTxEnlarg	0.99	0.98	0.99	1.13	0.98	1.05	0.99	1.00	0.98	0.99	0.99	0.99	0.99	0.99	1.32
	MaxTxEnlarg	0.93	0.89	0.93	1.03	0.91	0.97	0.91	0.96	0.90	0.93	0.91	0.92	0.92	0.92	1.20

[15] *ibid.*

[16] Blank values refer to zero values including those of the base case scenario. Italicised values refer to zero base case values. In these cases the starting point values for simulations are those of MinTx.

Table 2. Country level results for ACs

		row	bgr	cyp	cze	est	hun	ltu	lva	mlt	pol	rom	svk	svn
WELFARE	MinTx	1.61	0.01	-0.03	0.05	0.00	0.06	0.01	0.01	0.01	0.12	0.01	0.03	0.01
	AvgTx	1.82	0.02	-0.03	0.10	0.05	0.12	-0.01	0.01	0.08	-0.08	-0.21	-0.02	0.02
	MaxTx	5.27	0.12	-0.01	0.38	0.36	0.44	-0.12	0.01	0.48	-1.02	-1.05	-0.24	0.11
	Enlarg	0.33	-0.49	-0.48	-1.50	-0.16	-0.41	0.06	-0.02	-0.21	-0.64	-0.46	-0.16	-0.90
	MinTxEnlarg	1.95	-0.48	-0.51	-1.45	-0.16	-0.36	0.08	-0.01	-0.20	-0.51	-0.45	-0.12	-0.89
	AvgTxEnlarg	2.15	-0.47	-0.50	-1.39	-0.11	-0.30	0.05	-0.01	-0.13	-0.71	-0.67	-0.18	-0.88
	MaxTxEnlarg	5.60	-0.36	-0.47	-1.08	0.20	0.01	-0.06	-0.01	0.28	-1.67	-1.52	-0.42	-0.78
TAX_{IMP} %	MinTx	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.00
	AvgTx	1.00	0.96	1.00	0.97	0.94	0.99	0.99	0.97	0.97	0.99	0.97	0.97	0.98
	MaxTx	1.00	0.79	0.98	0.84	0.70	0.93	0.94	0.83	0.86	0.96	0.88	0.83	0.91
	Enlarg	1.00	0.26	0.57	0.15	0.19	0.59	0.56	0.44	0.41	0.61	0.33	0.15	0.29
	MinTxEnlarg	1.00	0.26	0.57	0.15	0.19	0.59	0.56	0.45	0.40	0.61	0.33	0.15	0.29
	AvgTxEnlarg	1.00	0.25	0.57	0.15	0.18	0.58	0.56	0.43	0.39	0.61	0.33	0.14	0.28
	MaxTxEnlarg	1.00	0.20	0.56	0.12	0.13	0.55	0.52	0.35	0.34	0.60	0.30	0.12	0.23
TAX_{EXP} %	MinTx	1.00	1.00		1.01	1.01	1.00	0.92	1.00	1.00	0.99	1.00	1.01	1.00
	AvgTx	1.00	0.96		0.97	0.97	1.01	0.85	0.96	0.99	0.99	0.98	0.96	0.98
	MaxTx	1.02	0.84		0.84	0.81	1.08	0.57	0.80	0.94	1.01	0.89	0.74	0.90
	Enlarg	1.00	1.19		0.19	0.11	2.29	-0.16	0.82	0.84	3.34	1.18	-1.43	-0.02
	MinTxEnlarg	1.00	1.19		0.19	0.11	2.29	-0.16	0.82	0.84	3.36	1.18	-1.45	-0.02
	AvgTxEnlarg	1.00	1.14		0.18	0.10	2.29	-0.18	0.78	0.82	3.32	1.15	-1.40	-0.02
	MaxTxEnlarg	1.02	0.95		0.13	0.09	2.27	-0.22	0.62	0.78	3.15	1.03	-1.21	-0.04
TAX_Z %	MinTx		*1.00*	*1.00*	0.27	1.00	*1.00*	0.43	0.38	*1.00*	0.07	*1.00*	0.14	*1.00*
	AvgTx		*24.02*	*24.82*	6.46	23.39	*24.95*	10.98	9.12	*24.22*	1.62	*24.38*	3.45	*24.60*
	MaxTx		*113.91*	*182.73*	31.97	108.36	*141.04*	52.50	48.14	*127.44*	8.77	*114.56*	16.76	*141.70*
	Enlarg		*0.00*	*0.00*	1.27	1.05	*0.00*	1.01	1.28	*0.00*	1.02	*0.00*	1.20	*0.00*
	MinTxEnlarg		*1.20*	*1.01*	0.34	1.05	*1.04*	0.44	0.48	*1.22*	0.07	*1.12*	0.16	*2.31*
	AvgTxEnlarg		*28.55*	*24.75*	8.14	24.58	*25.90*	11.11	11.59	*29.48*	1.65	*27.30*	4.12	*55.62*
	MaxTxEnlarg		*130.96*	*154.56*	38.90	112.37	*146.25*	53.07	58.94	*151.75*	8.93	*126.47*	19.44	*291.69*
DEP_{NOX}	MinTx	1.00	1.00	1.00	1.01	1.03	1.01	1.05	1.05		1.02	1.00	1.01	1.00
	AvgTx	1.00	0.98	1.00	0.99	1.02	0.99	1.03	1.03		1.00	0.98	0.99	0.99
	MaxTx	1.00	0.92	0.99	0.95	0.98	0.93	0.97	0.97		0.95	0.90	0.93	0.95
	Enlarg	1.00	1.00	0.95	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00
	MinTxEnlarg	1.00	1.00	0.95	1.01	1.03	1.01	1.05	1.05		1.02	1.01	1.01	1.00
	AvgTxEnlarg	1.00	0.99	0.95	1.00	1.02	1.00	1.04	1.03		1.01	0.98	1.00	0.99
	MaxTxEnlarg	1.00	0.92	0.95	0.95	0.98	0.93	0.97	0.98		0.95	0.90	0.94	0.96
DEP_{SO_2}	MinTx	1.00	1.01	0.99	1.01	1.05	1.01	1.05	1.07		1.03	1.01	1.01	1.01
	AvgTx	1.00	0.98	0.99	0.99	1.03	0.99	1.01	1.05		1.01	0.98	0.99	0.99
	MaxTx	1.01	0.88	1.01	0.92	0.94	0.91	0.88	0.97		0.93	0.86	0.91	0.93
	Enlarg	1.00	1.00	0.95	1.00	1.00	1.01	1.00	1.00		1.00	1.00	1.01	1.00
	MinTxEnlarg	1.00	1.01	0.94	1.01	1.05	1.02	1.05	1.08		1.03	1.01	1.02	1.01
	AvgTxEnlarg	1.00	0.98	0.95	0.99	1.03	1.00	1.01	1.06		1.01	0.98	1.00	0.99
	MaxTxEnlarg	1.01	0.89	0.97	0.92	0.95	0.91	0.88	0.97		0.93	0.86	0.91	0.93

Results from Tables 1 and 2, show implications for welfare, imports (TAX_{IMP}) and export taxes (TAX_{EXP}), emission taxes (TAX_Z) and depositions of SO_2 (DEP_{SO2}) and NO_X (DEP_{NOX}).

Welfare. The most interesting result to notice (in Enlarg) is that AC present a loss when entry the EU. This loss is minimum in Latvia (-0.02 billion US dollars), but high for countries such as the Czech Republic (-1.50) or Slovenia (-0.90). On the other hand, Lithuania is the country to gains welfare (0.06) from elimination of trade barriers. Existing member states all gain from the enlargement process. Germany gains most (1.65 billions) followed by Italy (0.80). When environmental taxation is harmonised across all levels of taxation considered in the simulation analysis, results vary. In AC, welfare gains are in the range of 0.01 billion US dollars in Latvia, Lithuania, Bulgaria and Slovenia to 0.48 billions in Malta; in EU 15 welfare gains are insteas in the range of 0.01 billion dollars in Portugal to 13.74 billion dollars in Germany. When environmental and trade policies are put into place simultaneously, an average welfare loss of 0.55 billion US dollars is present in AC, whereas this value doubles in EU15

TAX_{IMP}. Results from the use of an harmonised environmental policy (MinTx, AvgTx and MaxTx) presents a relatively low effect on imported taxes in both group of countries. This is a 1% reduction in EU15 and 5% in AC. The elimination of trade barriers for the enlargement process reduces imports taxes in AC on average by 62%. The figure goes down to 85% in the Czech Republic and Slovakia. In AC, the scenario for a simultaneous implementation of environmental and trade policies presents an average reduction of 64% , which is almost the same as the enlargement simulation's result. In EU15 this figure reaches just about 5% reduction of import tariffs.

TAX_{EXP}. Results from the implementation of an harmonised environmental policy has the same effects in both AC and EU in the figure of a 5% reduction relative to the base case. Negative values express subsidy rates. Important results to notice are the relative changes to the base case in the figure of just about 84% reduction in Lithuania and 98% in Slovenia. Hungary, Poland, Bulgaria and Romania show the highest changes in export taxes under the Enlarg hypothesis. The figures are in the range of 118%- 334%. For the EU15 results under the same hypothesis suggest an average reduction in export subsidies by 9%. The simultaneous use of trade and environmental policies is similar as the Enlarg result for the EU15, Lithuania, Slovakia, Slovenia, Hungary, Poland and Romania.

TAX_Z In both MinTx and MinTxEnlarg simulations, relevant changes of 77% and 88% decrease in Italy and France are observed, respectively. In simulations AvgTx and AvgTxEnlarg an average of 83% and 19% decrease in EU15 and AC is obtained, respectively. When considering only the implementation of an harmonised environmental policy in MaxTx, SO_2 and NO_X emission taxes decrease by an average of 27% of total emission taxation for France, Italy and Sweden; whereas for the remaining countries an average increase by 33% is present. For countries like Lithuania, Latvia, Poland and Slovak SO_2 and NO_X emission taxes decrease by an average figure of 69%. Almost the same figure is recorded in these countries when both trade and environmental policies are taken into account simultaneously. For the remaining AC countries, in contrast, a 46% increase under the same simulation is observed. Finally, in simulation Enlarg, relevant results emerge only for the Czech Republic, Estonia, Lithuania, Latvia, Poland and Slovak where the average figure across these countries is an 14% increase from the base case.

DEP_{NOX} Highest decrease values for NO_X depositions in AC are present in MaxTx by a 5% figure. In the EU15 the general trend is a small reduction of 3%, on average, in simulations MaxTx and MaxTxEnlarg.

DEP_{SO2} In the EU15 and AC, almost the same scenario applies to SO_2 depositions reduction as for NO_X under the MaxTx hypothesis. Here the figure of 5% reduction is also present in MaxTxEnlarg. In contrast, under the MinTx and MinTxEnlarg simulations SO_2 depositions increase by 4% in EU and by a small 2% in AC.

4.2 Model simulation analysis and country results levels

To answer the second question addressed in section 4.1 under the same simulations exercises the results on the economic structure in Italy are discussed. Table 3 illustrates the results obtained. The industries considered in Table 3 are those whose changes from the base case are relevant[17].

[17] For full details of all sectors, see De Lucia (2007).

Table 3. Sectoral Results for Italy

		Agr		ely		fml		foo		gas		Mtl		oil		teq		tex		TOTAL	
		Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P
EXP_{EU}	MinTx	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	0.99	1.00	1.00	1.00	1.00	1.00	1.00
	AvgTx	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.00	0.95	1.01	1.00	1.00	1.00	1.00	1.00	1.00
	MaxTx	0.99	1.00	0.99	1.05	0.99	1.01	0.99	1.00	1.01	1.00	0.99	1.00	0.71	1.10	0.98	1.00	0.98	1.00	0.98	1.00
	Enlarg	0.99	1.00	1.00	1.00	0.99	1.00	0.99	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MinTxEnlarg	0.99	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.02	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00
	AvgTxEnlarg	0.99	1.00	0.99	1.00	0.99	1.00	0.99	1.00	1.02	1.00	1.00	1.00	0.95	1.01	1.00	1.00	1.00	1.00	1.00	1.00
	MaxTxEnlarg	0.99	1.00	0.99	1.05	0.99	1.01	0.98	1.00	1.02	1.00	0.99	1.00	0.70	1.10	0.98	1.00	0.98	1.00	0.98	1.00
EXP_{AC}	MinTx	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	0.99	1.00	1.00	1.00	1.00	1.00	1.00
	AvgTx	1.00	1.00	1.02	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	1.01	1.00	1.00	1.00	1.00	1.00	1.00
	MaxTx	1.00	1.00	1.20	1.09	1.04	1.02	0.98	1.00	1.00	1.00	1.00	1.00	0.81	1.12	0.98	1.00	0.99	1.00	0.98	1.00
	Enlarg	1.32	1.05	1.02	1.00	1.05	1.01	1.31	1.05	1.02	1.00	1.09	1.01	1.08	1.01	1.07	1.01	1.07	1.01	1.06	1.01
	MinTxEnlarg	1.32	1.05	1.01	1.00	1.05	1.01	1.31	1.05	1.02	1.00	1.09	1.01	1.09	1.01	1.07	1.01	1.07	1.01	1.06	1.01
	AvgTxEnlarg	1.32	1.05	1.04	1.01	1.05	1.01	1.30	1.05	1.02	1.00	1.09	1.01	1.05	1.03	1.07	1.01	1.07	1.01	1.06	1.01
	MaxTxEnlarg	1.32	1.05	1.22	1.09	1.09	1.03	1.28	1.04	1.02	1.00	1.09	1.01	0.89	1.13	1.05	1.01	1.05	1.01	1.04	1.01
IMP_{EU}	MinTx	1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.04	0.99	1.00	1.00	1.00	1.00	1.00	1.00
	AvgTx	1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	1.01	1.00	1.00	1.00	1.00	1.00	1.00
	MaxTx	1.01	1.00	1.03	1.03	1.01	1.00	1.01	1.00	1.04	1.00	1.01	1.00	0.73	1.08	1.01	1.00	1.01	1.00	1.01	1.00
	Enlarg	0.99	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MinTxEnlarg	0.99	1.00	1.00	1.00	1.00	1.00	0.99	1.00	0.99	1.00	1.00	1.00	1.04	0.99	1.00	1.00	0.99	1.00	1.00	1.00
	AvgTxEnlarg	0.99	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	0.98	1.01	1.00	1.00	1.00	1.00	1.00	1.00
	MaxTxEnlarg	1.00	1.00	1.03	1.04	1.00	1.00	1.00	1.00	1.04	1.00	1.01	1.00	0.73	1.08	1.01	1.00	1.01	1.00	1.01	1.00
IMP_{AC}	MinTx	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	AvgTx	1.00	1.00	0.97	1.01	0.97	1.00	1.00	1.00	0.99	1.00	0.99	1.00	0.87	1.02	1.00	1.00	1.01	1.00	1.00	1.00
	MaxTx	1.00	1.00	0.84	1.07	0.85	1.03	1.01	1.00	0.88	1.00	0.96	1.00	0.48	1.11	1.01	1.00	1.04	0.99	1.00	1.00
	Enlarg	1.37	0.96	0.97	1.01	1.26	0.96	1.52	0.93	0.84	1.01	0.97	1.00	1.00	1.00	1.03	1.00	1.02	1.00	1.03	1.00
	MinTxEnlarg	1.37	0.96	0.97	1.00	1.25	0.96	1.52	0.93	0.85	1.01	0.97	1.00	0.99	1.00	1.03	1.00	1.02	1.00	1.03	1.00
	AvgTxEnlarg	1.37	0.96	0.94	1.02	1.22	0.97	1.53	0.93	0.83	1.01	0.96	1.01	0.86	1.02	1.03	0.99	1.02	1.00	1.03	1.00
	MaxTxEnlarg	1.37	0.96	0.82	1.07	1.07	0.99	1.54	0.93	0.74	1.01	0.93	1.01	0.48	1.11	1.05	0.99	1.06	0.99	1.03	1.00
GDP	MinTx	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	0.99	1.00	1.00	1.00	1.00	1.00	1.00
	AvgTx	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	1.01	1.00	1.00	1.00	1.00	1.00	1.00
	MaxTx	1.00	1.00	0.99	1.05	0.99	1.01	1.00	1.00	1.00	1.00	0.99	1.00	0.75	1.13	0.99	1.00	0.99	1.00	1.00	1.00
	Enlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MinTxEnlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	0.99	1.00	1.00	1.00	1.00	1.00	1.00
	AvgTxEnlarg	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	1.02	1.00	1.00	1.00	1.00	1.00	1.00
	MaxTxEnlarg	1.00	1.00	0.99	1.05	0.99	1.01	1.00	1.00	1.00	1.00	0.99	1.00	0.76	1.13	0.99	1.00	0.99	1.00	1.00	1.00
DOMSUP	MinTx	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	0.99	1.00	1.00	1.00	1.00	1.00	1.00
	AvgTx	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	1.02	1.00	1.00	1.00	1.00	1.00	1.00
	MaxTx	1.00	1.00	0.99	1.05	0.99	1.01	1.00	1.00	1.00	1.00	0.99	1.00	0.77	1.13	0.99	1.00	0.99	1.00	1.00	1.00
	Enlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MinTxEnlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	0.99	1.00	1.00	1.00	1.00	1.00	1.00
	AvgTxEnlarg	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	1.02	1.00	1.00	1.00	1.00	1.00	1.00
	MaxTxEnlarg	1.00	1.00	0.99	1.05	0.99	1.01	1.00	1.00	1.00	1.00	0.99	1.00	0.77	1.13	0.99	1.00	1.00	1.00	1.00	1.00
DEM_K	MinTx	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	AvgTx	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MaxTx	1.00	1.00	0.99	1.00	0.99	1.00	1.00	1.00	1.00	1.00	0.99	1.00	0.75	1.00	0.99	1.00	0.99	1.00	1.00	1.00
	Enlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MinTxEnlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.01	1.00	1.00	1.00
	AvgTxEnlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MaxTxEnlarg	1.00	1.00	0.99	1.00	0.99	1.00	1.00	1.00	1.00	1.00	0.99	1.00	0.76	1.00	0.99	1.00	0.99	1.00	1.00	1.00
DEM_L	MinTx	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	AvgTx	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MaxTx	1.00	1.00	0.99	1.00	0.99	1.00	1.00	1.00	1.00	1.00	0.99	1.00	0.76	1.00	0.99	1.00	0.99	1.00	1.00	1.00
	Enlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MinTxEnlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	AvgTxEnlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MaxTxEnlarg	1.00	1.00	0.99	1.00	0.99	1.00	1.00	1.00	1.00	1.00	0.99	1.00	0.76	1.00	0.99	1.00	0.99	1.00	1.00	1.00
DEM_E	MinTx	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	0.99	1.00	1.00	1.00	1.00	1.00	1.00
	AvgTx	1.00	1.01	1.00	1.01	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	0.97	1.01	1.00	1.01	1.00	1.01	0.99	1.01
	MaxTx	1.00	1.12	0.99	1.06	0.99	1.01	1.00	1.05	1.00	1.00	0.99	1.04	0.75	1.13	0.99	1.07	0.99	1.05	0.94	1.10
	Enlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MinTxEnlarg	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	0.99	1.00	1.00	1.00	1.00	1.00	1.00
	AvgTxEnlarg	1.00	1.01	1.00	1.01	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	0.97	1.02	1.00	1.01	1.00	1.01	0.99	1.01
	MaxTxEnlarg	1.00	1.12	0.99	1.06	0.99	1.01	1.00	1.05	1.00	1.00	0.99	1.04	0.76	1.13	0.99	1.07	0.99	1.05	0.94	1.10
$EM(NO_X,SO_2)$	MinTx	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.00
	AvgTx	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	0.97	1.00	1.00	1.00	1.00	0.99	0.99
	MaxTx	1.00	1.00	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00	0.99	0.99	0.75	0.75	0.99	0.99	0.99	0.99	0.96	0.91
	Enlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	MinTxEnlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.01
	AvgTxEnlarg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	0.97	1.00	1.00	1.00	1.00	1.00	0.99
	MaxTxEnlarg	1.00	1.00	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00	0.99	0.99	0.76	0.76	0.99	0.99	0.99	0.99	0.96	0.91

From Table 3 the following comments can be drawn. In the agricultural sector, relevant changes from the base case are found for imported and exported commodities from/to Accession Countries. 32% and 63% increases relative to the base case for imported and exported commodities are obtained, on average, across Enlarg, MinTxEnlarg, AvgTxEnlarg simulations. The corresponding price for imported goods however decreases by 4%; while a 5% increase is observed for relative prices of exported commodities.

In the electricity sector, relevant changes from the base case for imported and exported commodities from/to Accession Countries are again obtained in simulations MaxTx and MaxTxEnlarg. A corresponding 16% average decrease across these simulation exercises despite a 7% increase in relative imported prices is recorded. For exported electricity commodities, average increases of 20% and 9% are found in quantity and relative export price respectively.

In the food sector, bilateral trade with Accession Countries increases in simulations in which enlargement is modelled. In simulations Enlarg, MinTxEnlarg and AvgTxEnlarg both exports of and imports from food to Accession countries increases by 30% and 53% on average respectively. The relative price of the imported commodities fall slightly while export prices rise.

A decrease in imports of gas commodities from Accession Countries occurs in simulations where enlargement occurs or where the maximum tax rate is applied. For simulations MaxTx, Enlarg, MinTxEnlarg and AvgTxEnlarg an average decrease of 14% is observed. When both factors occur simultaneously, MaxTxEnlarg, a larger decrease of 26% occurs.

For the oil sector, major changes occur in both simulations in which tax is at the highest rate considered. Exports to the Accession Countries and EU15 decrease significantly, by 15% and 30% respectively, while prices increase by 13% and 10%. Imports are also decreased, by over half from Accesion Countries and by 27% from the EU15. Import prices from Accesssion countries rise by 11% and by 8% from the EU15. Massive decreases are also seen in sectoral GDP, domestic supply, emissions, and demand for labour, capital and energy. These are of a magnitude of 23-25%.

Trade of non-ferrous metals, transport equipment and textile with Accession countries is effected in simulations Enlarg, MinTxEnlarg, AvgTxEnlarg. Export quantities of these commodities to Accesion Countries increases by 7-9%, though there is little increase in the relative prices charged.

4.3 Model simulation analysis and regional results

In this section an analysis for the Apulia region is carried out. The main aim here is to answer to how the real data available at the Italian Bureau of Statistics (ISTAT) for Apulia would change given the change observed in the Italian level result. The methodology employed is the same across results for trade, GDP, demand for labour (DEM_L), demand for capital (DEM_K) and emissions.

Trade. Because of the difficulty to harmonise the classification of goods between ISTAT and the GTAP v.6.0 data base, comparisons for trade were possible for Agriculture, Oil and electricity sectors. The following steps are implemented:

a) First, data of trade from/to AC were computed by subtracting trade values of EU27 to EU15;
b) Second, shares of trade values between Apulia and Italy were computed as shown in Table 4;

Table 4. Shares for Trade Apulia / Italy

Sectors	IMP_{EU}	IMP_{AC}	EXP_{EU}	EXP_{AC}
Agr	0.037	0.126	0.176	0.241
Oil	0.003	0.222	0.028	0.019
Ely	0.000	0.000	0.000	0.000

c) Finally, model simulation results for Italy were multiplied by the shares computed in b). The obtained results for Apulia are then shown in the following Table:

Table 5. Simulation Results for Apulia

Simulations	Sectors	IMP_{EU}	IMP_{AC}	EXP_{EU}	EXP_{AC}
Enlarg, MinTxEnlarg, AvgTxEnlarg	Agr	1.040			1.152
MaxTx, MaxTxEnlarg	Oil	0.991	0.992	0.992	0.997
MaxTx, MaxTxEnlarg	Ely	1.000	1.000	1.000	1.000

As shown in Table 5, no changes would occur in the electricity sector for simulations MaxTx and MaxTxEnlarg. This is due because of zero values occurring in the ISTAT data set for trade in this sector.

In the agriculture sector, according to average simulations results for Enlarg, MinTxEnlarg and AvgTxEnlarg, a 15% increase occurs for exported commodities to AC countries, while a small increase of 0.04% is observed for imported commodities from EU countries.

In the oil sectors, decreases in trade values are mostly of the same magnitude. This assumes a significant small figure between 0.8%-0.9%.

GDP, DEM_L and DEM_K. Table 6 shows results obtained in the oil sector. The most noticeable result from Table 6 is the decrease of employment levels at regional scale. The corresponding figure is in the region of 4%. While, the relatively small decreases of 0.004% and 0.007% are obtained in the regional GDP and demand for capital, respectively.

Table 6. Apulia Results for GDP, DEM_K, DEM_L

OIL Sector	Shares Apulia/Italy	Simulations MaxTx and TaxTxEnlarg
GDP	0.019	0.995
DEM_K	0.030	0.992
DEM_L	0.157	0.961

Emissions of SO_2 and NO_X. Computations for emissions at regional level were carried out similarly to those obtained in the environmentally extended SAM of the model under study. To obtain estimates of regional SO_2 and NO_X emissions, GDP values were multiplied by emission factors[18] for the use of oil, coal and gas in the oil sector. The corresponding model simulation results for Apulia are illustrated in the table below.

Table 7. Results for SO_2 and NO_X in Apulia

EMISSIONS	Emission factors			Emission Shares	Simulations
	Oil	Coal	Gas	Apulia / Italy	MaxTx and TaxTxEnlarg
SO_2	1.60	1.00	0.00	0.019	0.995
NO_X	0.11	0.21	0.12	0.193	0.951

The obtained regional results for emissions clearly show that when trade policy and harmonised environmental taxation are implemented both simultaneously e non-simultaneously with the highest emission tax rate, major decreases for the Apulia region occur for NO_X emissions. These have a magnitude of around 5%. A small decrease of around 0.5% is given for the case of SO2 emissions.

5. POLICY DISCUSSION

In this section the two questions developed in the previous section are revisited in the light of policy implications that can be drawn from the obtained results.

What are the environmental implications of the enlargement, a non-simultaneous and a simultaneous change in elimination of trade barriers in Accession Countries and the implementation of a harmonised system of environmental taxation in EU27?

Before the entry in the EU, Accession Countries were heavily subsidising its exported commodities; whereas, on the import side these countries were suffering from high import tariffs rates. The figures were totally different with the entry in the EU. Generally, the abolition or reduction of trade tariffs directly affects relative prices of commodities. Likewise, substitution effects between imported and domestically produced goods take place. Trade creation, where goods and services are reallocated across countries, improves domestic and international efficiency and productivity. This has been particularly noticed in the food and agricultural sector. As a consequence, the intra-EU trade in these sectors has substantially increased. The side effects of these major changes such as trade diversion were different from country to country. In Italy, major sectors affected were agriculture, electricity, ferrous and non-ferrous metal, food, gas, oil, transport equipment and textile sectors. Households' welfare was undoubtedly affected by these changes. Primary welfare effects on Accession Countries were a loss in the range of 0.02-1.50 billion US dollars. This was merely due to an increase in relative prices in domestic supply, which in turn was caused by the relative increase in exported commodities to the EU. This is the main reason why welfare gains instead occur in existing member states.

The implementation of a coordinated environmental policy under a harmonised system of SO_2 and NO_X emissions taxation shows that changes in welfare vary from country to country. Though welfare gains are higher in existing member states some countries endure a welfare

[18] IIASA (1998).

loss. Furthermore, high harmonised emission tax rates would have greater impact on energy intensive sectors such as chemicals, ferrous and non ferrous metals and transportation. This is because in countries in which energy intensive sectors exhibit lover emission factors, increases in harmonised emission tax rates would cause a lower impact on these industries. This would cause a these industries to be more relatively competitive on the international market. "Furthermore, welfare effects of the application of a harmonised emission tax system must be considered in connection to other tax mechanisms that each member states have at their disposition, such as for example income taxes. The structure and income tax levels would affect households' propensity to consume polluting and non-polluting goods, whether or not these are demanded domestically or in other EU countries. In addition, the practicability of a harmonised emission tax is decided on available information to the central and local government administrations. Model simulations assume this information being already available and therefore welfare effects would claim that the feasibility of a harmonised emission tax system has been exogenously established"[19]. "The most interesting result to note from the welfare perspective is that the change in welfare which occurs under the conditions of introducing an harmonised emission taxation and a simultaneous removal of trade barriers is identical to the sum of welfare changes due to each policy being implemented individually. This implies that in terms of welfare the interaction between the two policies would be minimal. In other words, the changes that affect consumer utility which occur due to EU enlargement would be disjoint from the changes that would exist in the case that emission taxation were harmonised". [20]

What are the implications of the enlargement, a non-simultaneous and a simultaneous elimination of trade barriers and adoption of a harmonised system of environmental taxation on the structure of the economy in Italy and Apulia?

Major implications of a simultaneous implementation of a harmonised system of emissions taxation and the elimination of trade barriers mainly occur in the agriculture, food, oil, gas, and electricity sectors. A decrease appears in the production of these commodities. This obviously occurs when industries are more polluting. Patterns of trade are also affected. An increase in exported commodities to the Accession Countries is present because of the use of cleaner technologies. Therefore, the simultaneous effects of trade and environmental policies would favour the international competitiveness of commodities which are produced in countries and regions where industries make use of less polluting energy factors. The so-called "linkages effects are relevant in the context of using cleaner technologies. A linkage effect rely on the possibility of value added in related industries being amplified or contracted by linking input and output activities. As such, green technology diffusion may take place within industries based on these linkages"[21].

A deeper examination of the simultaneity effects of these policies should also consider the evolution of each industry's competitiveness, the trends of domestic production and foreign demand, the characteristics of the labour market and so on. This goes beyond the scope of this work. Nonetheless, the obtained results suggest a direction of the effects of the interactions between trade and environmental policies under study. In Apulia region, for example, a considerable employment reduction in the oil sector would take place and the most affected areas would obviously be those in Taranto or Brindisi. Major effects on emissions also take place. At Italian level a noticeable 23-25% reduction would occur in SO_2 and NO_X emissions

[19] De Lucia, 2007, pag. 221.
[20] *Ibid*, pag. 223.
[21] *Ibid.*

in the oil sector. As such, the relative figure in Apulia would be around 5% for NO_X, against a small decrease by 0.5% in SO_2 emissions. Finally, "these findings contribute to narrow the policy makers' strategic model of coordination of domestic policies. In general, after the policy makers establish their policy objectives they have several instruments at their disposal to reach their goals. The results obtained in the case under study, with the use of two political economic instruments (the elimination of trade tariffs and the use of a harmonised environmental taxation) to reach one domestic policy objective (household's welfare) policy makers would obtain, *ceteris paribus*, a unique solution to the strategic model of coordination of domestic policies. (Timbergen, 1952)."[22]

6. CONCLUDING REMARKS

In this paper, economics and environmental effects between the implementation of a harmonised SO_2 and NO_X emission taxation at EU level and trade policies are examined. These are carried out through the use of a CGE model across EU and AC countries. Simulation results obtained at sectoral Italian level are used to question how real data from ISTAT can change if they were applied to study the Apulian case.

In section 2, a review of traditional trade and environmental policy regulation was presented. In section 3, a review of major empirical CGE modelling was illustrated. Furthermore, a simple analytical model of optimal environmental regulation of transboundary pollution on the structure of an economy was presented. In section 4, model simulation results at EU and AC and Italian case were illustrated. While some general trends were noted for all countries, sectoral results were seen to vary from country to country dependent on the features of each country's economy. The implementation of high harmonised emission tax rates would have greater impact on energy intensive sectors such as chemicals, ferrous and non ferrous metals and transportation. Finally, in section 5 a discussion of policy implications was addressed. The most interesting result found from a welfare perspective was that the interaction between the two policies would be minimal.

Based on the Italian results, a regional analysis for Apulia was also performed. Major implications of a simultaneous implementation of a harmonised system of emissions taxation and the elimination of trade barriers mainly occurred in the agriculture, food, oil, gas, and electricity sectors. In the oil sector, a side effect would be a considerable employment reduction. This would undoubtedly affect areas such as Taranto or Brindisi provinces. Finally, emission reductions would take place in the figure of 23-25% for SO_2 and NO_X at Italian level. Major result in Apulia would occur for NO_X emissions, against a small decrease for SO_2 emissions. A deeper analysis of the simultaneity effects of the policies under study would suggest considering the evolution various economic trends. The static nature of the model has prevented to do so. Nonetheless, the obtained results suggest a direction of the effects of the interactions between trade and environmental policies under study.

[22] De Lucia, 2007, pag. 223.

Bibliography

Anderson, K. and Blackhurst, R. (1992) The Greening of World Trade Issues. Harvester Wheatsheaf, Hemel Hempstead, UK.

Arrow, K. J. and Debreu, G. (1954) Existence of an Equilibrium for a Competitive Economy. *Econometrica*, 22, 265-290.

Barrett, S. (1994) Strategic Environmental Policy and International Trade, *Journal of Public Economics*, 54:325{338.

Bergman, L. (1990) The development of computable general equilibrium modeling. In Bergman, I., Jorgenson, D. W., and Zalai, E., editors, *General Equilibrium Modeling and Economic Policy Analysis*. Blackwell, Oxford.

Burniaux, J.-M., Martin, J. P., and Oliveira-Martins, J. (1992) Green: A Global Model for Quantifying the Cost of Policies to Curb CO_2 Emissions. *OECD Economic Studies*, 19,141-165.

Capros, P., Georgakopoulos, T., Van Regemorter, D., Proost, S., Conrad, K., Schmidt, T.,Smeers, Y., Ladoux, N., Vielle, M., and McGregor, P. (1995) *The GEM-E3 model: Reference manual*.

Carraro, C. and Siniscalco, D. (1992) Environmental Innovation Policy and International Competition. *Environmental and Resource Economics*, 2(2),183-200.

Conrad, D. (1992) *Optimal Environmental Policy for Oligopolistic Industries in an Open Economy*. Mimeograph, University of Mannheim, Germany.

d'Arge, R. C. (1972) Customs Unions and Direct Foreign Investments: A Correction and Further Thoughts, *Economic Journal*, 81(322), 352-355.

d'Arge, R. C. and Kneese, A. V. (1972), Environmental Quality and International Trade. *International Organization*, 26(2):419{465.

De Lucia C., Leonida L., (2002) The Evidence of the Environmental-Economic Transition Hypothesis: a Semi-Parametric Approach, Planum European Journal of Planning – *Urbanistica* - n.117.

De Lucia, C., (2007) Integrating Local and EU Environmental Policies, Trade and Transboundary Pollution in an Enlarged Europe: A Computable General Equilibrium Model". *PhD Thesis*, University of York.

European Union (1996). Framework of air quality directives, *96/62/EC*.

Giersch, H. (1974) The International Division of Labour: Problems and Perspectives. In J. C. B. Mohr (Paul Siebeck), Tubingen.

Istat, National and Territorial accounts, 2001. www.istat.it

Kakutani, S. (1941). A Generalization of Brouwer's Fixed Point Theorem. *Duke Mathematical Journal*, 8,457-459.

Lopez, R. (1994) The environment as a factor of production: the effects of economic growth and trade liberalization, *Journal of Environmental Economics and Management* 27, 163-184.

Manne, A. S. and Richels, R. (1992) Buying Greenhouse Insurance: The Economic Cost of CO_2 Emission Limits. MIT Press, Cambridge, Mass.

Markusen, J. R., Morey, E. R., and Olewiler, N. D. (1993) Environmental Policy when Market Structure and Plant Locations are Endogenous. *Journal of Environmental Economics and Management*, 24, 69-86.

McGuire, M. C. (1991). Regulation, factor rewards, and international trade. *Journal of Public Economics*, 17, 335-354.

Newberry, D. M. (2001). Harmonizing Energy Taxes in the EU. *University of Cambridge*, Cambridge, UK.

Nordhaus, W. D. (1994) *Managing the Global Commons: The Economics of Climate Change*. MIT Press, Cambridge, Mass.

Nordhaus, W. D. and Yang, Z. (1996) A Regional Dynamic General-Equilibrium Model of Alternative Climate Change Strategies, *American Economic Review*, 86(4),741-765.

Panayotou, T. (1993) Empirical test and policy analysis of environmental degradation at different stages of economic development, *Working Paper* WP 238, Technology and Employment Programme, International Labour Office, Geneva.

Rauscher, M. (1993) Environmental Regulation and International Capital Allocation. *Working Paper*.

Regional Environmental Center (2001).Environmental Taxes in an Enlarged Europe.

Ricardo (1817) On the Principles of Political Economy and Taxation.

Siebert, H. (1977). Environmental Quality and the Gains from Trade. *Kyklos*, 30, 657-673.

Tarrasón, L., Jonson, J. E., Fagerli, H., Benedictow, A., Wind, P., Simpson, D., and Klein, H. (2003). Transboundary acidificaton, eutrophication and ground level ozone in Europe. Source-Receptor relationships. *EMEP/MSC-W Norwegian Meteorological Institute. Status Report 1/2003. Part III.*

Ulph, A. (1997) Environmental Policy and International Trade when Governments and Producers Act Strategically. *Working paper, University of Southampton*.

Xie, J. and Saltzman, S. (2000) Environmental policy analysis: An environmental computable general equilibrium model for developing countries. *Journal of Policy Modeling*, 22(4),453-489.

Yang, Z., Eckaus, R. S., Ellerman, A. D., and Jacoby, H. D. (1996) The MIT Emissions Predictions and Policy Analysis (EPPA) model. *Report 6. MIT Joint Program on the Science of Global Change*.

Whalley, J. and Wigle, R. (1990) Cutting CO_2 Emissions: the Effect of Alternative Policy Approaches, *The Energy Journal*, 12(1).