“Le Progrès Technologique Pour la Compétitivité et l’ Emploi”

Conference organised by

The European Commission and the Chambre de Commerce et de l’ Industrie de Paris

Paris, 1 December 1995

Utilisation du modèle GEM-E3 à l’étude du problème de Double Dividende
Using the GEM-E3 Model to study the Double Dividend Issue[1]

by

P. Capros, T. Georgakopoulos (National Technical University Athens)

D. Van Regemorter, S. Proost (CES/ Catholic University Leuven)

Résumé: Le papier présente les premiers résultats de l’utilisation du modèle d’équilibre général calculable ***GEM-E3*** des 12 pays membres de l’Union Européenne, qui sont liés par du commerce international endogène. Le problème de la Double Dividende, comme defini dans le papier, concerne l’analyse des politiques qui visent à obtenir simultaneusement de l’environnement plus propre et de l’ emploi plus élevé. Le papier analyse la politique qui combine une taxe sur le carbone (pour réduire les émissions de CO_2) avec une réduction des charges de sécurité sociale versées par les employeurs (pour réduire le cout de travail). Le papier analyse ce problème selon l’aspect de la faisabilité de la double dividende et de la comparaison d’une application coordonnée vis-à-vis d’une application non coordonnée aux pays de l’Union Européenne. Dans tous les cas étudiés, les résultats confirment l’importance des effets distributionels, concernant les pays, les secteurs économiques et les agents économiques. Des conclusions positives sont généralement obtenues pour la possibilité d’obtenir globalement une double dividende. L’exercise de modélisation montre en particulier la pertinence du modèle ***GEM-E3*** pour ce type d’analyse de politique économique et illustre la richesse de l’information que l’on puisse obtenir.

Abstract: The paper presents first results obtained by using the computable general equilibrium model ***GEM-E3*** for 12 member-states of the European Union, linked together through endogenous trade. The double dividend issue, as conceived in the paper, regards analysis of policies that aim at achieving simultaneously cleaner environment and higher employment. The paper analyses a policy that combines a carbon tax (for reduction of CO_2 emissions) and a decrease of social security charges (for reduction of labour cost bore by firms). The paper deals with this issue with concern about the feasibility of a double dividend and the coordinated versus non coordinated application of the combined policy in the EU member states. In all cases studied, the results confirm the importance of distributional effects of the policy, regarding countries, sectors and economic agents. Positive conclusions are generally drawn about the possibility of achieving an overall double dividend. The modeling exercise also signifies the relevance of the ***GEM-E3*** model in this kind of policy analysis studies and illustrates the richness of information and insights obtained through its use.

[1] The views expressed in this paper do not engage the European Commission. The paper and the numerical results must be considered as an outcome of scientific research and are subject to modelling and data limitations. They also are subject to revision. The paper does not conclude with a firm policy recommendation, but contributes to the policy analysis debate. The construction of the GEM-E3 model and its use, as presented in this paper, are partially financed by the European Commission DG-XII/F1. The model construction involved several teams, including NTUA, KUL, University of Mannheim, IDEI, University of Strathclyde and CORE.

1. Introduction[2]

In recent years, there is a growing interest in analyzing combined policies that address complex economic issues. The motivation of policy makers is of course to take advantage of win-win policy cases, if such cases exist in reality. For example, an important issue is whether or not the internalization of environmental externalities can be beneficial for other policy areas as well. For example, the revenues from pollution taxes could be used to cut other distortionary taxes. The combined policy may, then, imply a double dividend, that is not only a better environment but also benefits associated with lower distortionary taxes (see [7], [8] and [24]).

The non environmental dividend can be defined in various ways. Given the important unemployment problems, the European Union has given priority to the analysis of distortionary circumstances in the labour market that might explain persisting unemployment. Within this perspective, the European Commission's White paper on "Growth, Competitiveness and Employment" encouraged to use the revenues from environmental taxation for a reduction of social charges weighing down the labour market.

Regarding environmental taxation, the European Commission considered carbon taxes as an important instrument to achieve reduction (or stabilisation) of CO_2 emissions. However, since the May 1992 initial proposal to use a 10 $/bbl carbon-energy tax, the different member states have never reached the necessary unanimity to introduce this tax. In December 1994, a new proposal[3] has been advanced that allows the different member states to install unilaterally or jointly an energy carbon tax. What is common for all the member states is a set of guidelines for use and target values if they decide to use an energy-carbon tax. Apart from a general coordination problem that arises in the European Union regarding the application of a carbon tax, there is also strong argumentation in favour of exempting the energy intensive industry. For these reasons, some analysts proposed a system of CO_2 tradable permits as a more effective way of solving the coordination and sectoral allocation problems through market mechanisms.

The present paper reviews and explores in depth one of the recent applications of the computable general equilibrium model ***GEM-E3*** (see also [10], [11], [12] and [14] for a discussion of all or some of the aforementioned issues) used to study the feasibility of a double dividend for environment and employment.

The paper starts with a brief presentation of ***GEM-E3*** model. Then it presents model results for the above issue.

---

[2] This paper is fourth in a series of papers on the same subject (see references). Compared to previous versions, this paper provides new numerical results based on an improved version of the model and its data.

[3] Com (92) 226 final

2. The *GEM-E3* model

2.1 Introduction

GEM-E3 is an computable general equilibrium model, for the European Union member states, that provides details on the macro-economy and its interaction with the environment and the energy system. It is an empirical, large-scale model, written entirely in structural form. The model computes the equilibrium prices of goods, services, labour and capital that simultaneously clear all markets under the Walras law. In brief, the model can be characterised as follows:

- It is a multi-country model, treating separately each EU-12 member-state and linking them through endogenous trade of goods and services.
- It includes multiple industrial sectors and economic agents, allowing the consistent evaluation of distributional effects of policies.
- It is a multi-period model, involving dynamics of capital accumulation and technology progress, stock and flow relationships and backward looking expectations.

In addition, the model covers the major aspects of public finance including all substantial taxes, social policy subsidies, public expenditures and deficit financing, as well as policy instruments specific for the environment/energy system. A financial/monetary sub-model complements the real side of the model and operates as an overall closure, following the IS-LM methodology (on the role of closures in CGE models, see [19]). Therefore, this macro-closure is combined with a micro-economic representation of agents' behaviour and market clearing.

The model determines the optimum balance of energy demand and supply, atmospheric emissions and pollution abatement (for acid rain emissions), simultaneously with the optimising behaviour of agents and the fulfillment of the overall equilibrium conditions. In this sense, the model analyses the interactions between the economy, the energy and the environment systems.

The results of the model include projections of full input-output tables by country, national accounts, employment, capital, monetary and financial flows, balance of payments, public finance and revenues, household consumption, energy use and supply, and atmospheric emissions. The computation of equilibrium is simultaneous for all domestic markets of all EU-12 countries and foreign trade links.

A major aim of the model in supporting policy analysis, is the consistent evaluation of distributional effects, across countries, economic sectors and agents. The burden sharing aspects of energy supply and environmental protection are fully analysed, while ensuring that the European economy remains at a general equilibrium condition.

2.2 Model design principles

The ***GEM-E3*** model includes a detailed representation of production structures and consumption patterns, with fully flexible coefficients, as in the D. W. Jorgenson’s tradition (see [21], [22], [25], [3] and [14]). It also integrates energy and environment within production costing and the Input-Output structure (see also [4]).

The model is largely inspired by the computable general equilibrium models that are extended with an IS-LM closure (see for example Bourguignon, Branson, De Melo, [5], [6], [9], [16]). The model implements the so-called macro-micro approach that combines a micro-economic representation of demand and supply behaviour with a macro-economic consistent framework.

In addition, it formulates endogenous international trade and detailed treatment of taxation, as in other trade-oriented general equilibrium models (see for example Shoven and Whalley, [27] and [28]).

The model is based on a Social Accounting Matrix framework and is calibrated for a base year, as in World Bank models (see for example [15], [17], [18]). The model runs dynamically by solving a system of simultaneous non-linear equations in each period.

2.3 Model components

The appendix provides a stylised (but simplified) presentation of the equations of the ***GEM-E3*** model. It also describes the model’s nomenclature.

Domestic production is defined by sector following the sectoral decomposition of the Input-Output table. It is assumed that each sector produces a single good, following a constant returns of scale technology. It is also assumed that perfect competition conditions prevail in all markets for goods. The sectoral firm decides, under profit maximisation, its supply of good or service given its selling price and the prices of production inputs. The firm can change its stock of capital only in the next year, by investing in the current year. Since the stock of capital is fixed within the current year, the supply curve of domestic goods is upwards sloping and exhibits decreasing return of scale. All production inputs are considered as production factors. The firm adjusts flexibly the entire mix of production inputs.

The desired stock of capital for the next year is derived from profit maximisation seeking to achieve an optimal level of long run rate of return of capital, given expectations about future user’s cost of capital. The optimal long-run rate of return of capital is derived according to Ando-Modigliani formula (see [1]) involving the real interest rate augmented by the depreciation rate. Sectoral investment is therefore obtained through partial adjustment of current to desired stock of capital.

The behaviour of the representative household is derived on an inter-temporal model (see [23]). The model has to determine household’s decision regarding his labour supply and the allocation of revenues into consumption, investment and savings. This decision is conceived for a given wage rate (derived from the labour market), interest and discount rates. Labour supply depends on the allocation of fixed time resources of households into leisure and work. The computed demand for leisure indirectly determines total expenditure and savings of households. Given households’ total spending in investment (dwellings) and consumption of goods, the model determines the derived demand for goods and services. The allocation mechanism is flexible, price dependent and considers durable and non durable goods. Non durable goods are associated to consumption purposes (food, culture etc.). Durable goods include cars, heating systems and electric appliances, and their use involves demand for non durable goods, for example energy (see [13]).

Government behaviour is largely exogenous. The government demands for consumption goods and services and for capital goods to form public investment. Following the SAM definitions, the model distinguishes between several categories of public revenues, depending on a variety of taxation and other policy instruments. Public transfers to economic agents are also represented according to the SAM definitions. For example, government allocates transfers for social policy and receive social security contributions.

The demand of products by the consumers, the producers and the public sector (for consumption and investment) constitutes total domestic demand.

This domestic demand is allocated between domestic products and imported products, following the Armington specification (see [2]). In this specification, sectors and consumers use, under cost minimisation, a composite commodity which combines domestically produced and imported goods, which are considered as imperfect substitutes. The minimum unit cost of the composite good determines its selling price. This is formulated through a CES unit cost function, involving the selling price of the domestic good, which is determined by goods market equilibrium, and the price of imported goods, which is taken as an average over countries of origin. By applying Shephard’s lemma (see [26]), we derive total demand for domestically produced goods and for imported goods. In ***GEM-E3*** imports are further allocated by country of origin, depending on their relative export prices. Dual unit-cost formulation, is used throughout.

The supplier of domestically produced goods faces two markets: the domestic and the foreign ones. Therefore, in order to maximise his profits, we assume that he can apply different tariffs according to the nature of these two markets. We introduce an export supply function to reflect the producer's decision on the optimal mix of goods offered to the domestic market and goods offered to the world market, following a Constant Elasticity of Transformation (CET) function operating under profit maximisation.

The model is not covering the whole planet and thus the behaviour of the rest of the world (ROW) is left exogenous: imports demanded by the rest of the world depend on export prices set up by the European Union countries, while exports from the rest of the world to the EU are sold at an exogenous price.

The imports demanded by the ROW are flexibly satisfied by exports originating from the European Union (EU) countries. The latter consider the profitability of exporting to the ROW, exporting to EU or addressing the goods to their domestic markets. Via these profitability considerations, the EU countries set their export prices, as mentioned above. Within the European Union, exports are considered homogeneous. This means that the producer sets a single export price for European Union countries and another export price for the rest of the world.

Imports demanded by the EU countries from the ROW are supplied by the latter flexibly. However, the EU countries consider the optimal allocation of their total imports over the countries of origin, according to the relative import prices. Each country buys imports at the prices set by the supplying countries following their export supply behaviour. Of course, the supplying countries may gain or loose market shares according to their price setting. When importing, the EU countries compute an index of mean import price according to their optimal allocation by country of origin. This mean import price is then compared to the domestic prices in order to allocate demand between imports and domestic production (this corresponds to an Armington assumption).

The model verifies analytically that the balance of the trade matrix in value and the global Walras law are verified in all cases. A trade flow from one country to another matches, by construction, the inverse flow. The model ensures this symmetry in volume, value and deflator.

Income flows between agents, following the SAM definitions as mentioned before, and the market equilibrium conditions complete the model. The equilibrium conditions in the markets of goods serves to determine domestic production prices.

For the labour market it is postulated that wage flexibility ensures full employment. On the demand side we have the labour demanded by firms (as derived from their production behaviour), while on the supply side we have the total available time resources of the households minus the households' desire for leisure (which is derived from the maximisation of their utility function). The equilibrium condition serves to compute the wage rate.

At the equilibrium point, the economic agents either achieve maximum profit (equal to zero) or completely use their budget constraint. The model then verifies the Walras law at the global level.

The model evaluates the energy-related emissions of CO_2, NO_X and SO_2 as a function of the energy consumption and the abatement level per sector. For SO_2 and NO_X we specify abatement costs which will increase the cost of using pollution intensive inputs. The cost of energy, as considered in optimising behaviour of producers and consumers, consists of the cost of acquiring energy inputs, the costs of abatement equipment and the costs (or revenues) from transacting CO_2 emission rights. Therefore, environmental decisions of economic agents (regarding energy, abatement and pollution permits) are taken simultaneously with non environmental (that is economic) decisions.

3. Double Dividend analysis for EU-12

As mentioned in the introduction, we used the full version of ***GEM-E3*** to run a double dividend application for EU-12 member-states regarding the environment (CO_2) and employment. This version considers full competitive equilibrium in all markets, including goods markets, labour and capital markets.

3.1 Model Assumptions

Being within a competitive equilibrium regime, the labour market is influenced by the slope of labour supply (as decided by households simultaneously with consumption and leisure). In this sense, the model assumes that the entire unemployment is voluntary. However, the model also assumes that, if the economic conditions are favourable, the households can supply more labour force, since they have spare time. This concept is used to reflect unemployment that prevails in European countries, which is further represented by a relatively high real wage rate elasticity of labour supply. *In other terms, we assume that additional labour force is available to enter the market with some flexibility, but under competitive equilibrium conditions.*

The labour supply is not, nevertheless, totally elastic. This elasticity can be thought of, as representing the bargaining power of the already employed people. A high bargaining power would entail that an increase of the labour demand, would lead to an important increase in the wage rate, without any additional employment. The other extreme would be for the wage rate to remain constant and the employment to increase to cover the whole labour demand. The elasticity used in the model, falls between these two extremes. This elasticity can be also interpreted as a measure of the distortion of the labour market and the double dividend policy seeks to partly decrease the initial distortion of the market. The assumption about the prevailing labour market regime turns out to be a critical assumption for the results, as we shall see.

The model allows for a free variation of the balance of payments, while the exchange rate is kept fixed; this is equivalent of closing the monetary system through the adjustment of the central bank's reserves in foreign currency. In the current EU-linked model version, the demand for imports by the rest of the world (non EU-12) is flexible, depending on relative prices; however, the demand for imports by EU-12 addressed to the rest of the world is satisfied by the latter without constraints; thus, we assume that the balance of payments of EU-12 as a whole may also vary, while the exchange rates remain fixed. This assumption is equivalent to the small open economy[4] hypothesis for the EU-12 taken as a whole, vis-à-vis the rest of the world.

The model runs dynamically until it approaches a steady-state solution (approximately after more than 10 years). The model formulates a sector-specific dynamic process of capital accumulation through investment and scrapping. There is no instantaneous adjustment of the sectoral rates of return of capital to the optimal long run rates. The rate of investment, separately in each sector, is affected by the discrepancy of effective and optimal rates of return of capital. If, after a distributional policy such as the double dividend, a sector obtains a rate of return of capital that is lower than the optimal one, it will gradually reduce the capital stock through a fixed rate scrapping. The model exhibits long run properties where the sectoral rates of return of capital tend to equalize.

3.2 Scenario Assumptions

The CO_2-tax pattern follows the proposal of the European Commission of end of 1992. In that, the tax is a 50-50% mix of carbon and energy tax, globally at the level of 10$/barrel of oil equivalent. So, the imposition differs by fuel according to the related CO_2 emissions only partially. Electricity taxes applicable directly to electricity sold to users concern only the fraction of electricity produced from hydroelectric and nuclear plants, so they differ across countries. Power generation, however, has to deal with taxes imposed to the fossil fuels burned. The utilities may then reflect those higher costs to end-user electricity prices. This is left to the model, so the impacts on prices may be lower if utilities can alter the fuel mix. The tax is imposed gradually over three model periods (3.3$/barrel, 6.6$/barrel and 10$/barrel), and kept constant for the rest of the model simulation.

---

4 Namely, that each EU member state is price taker in imports and non price maker in exports.

The CO_2-tax takes the form of an excise tax. Thus, the impact on prices differs according to the level of pre-existing excise taxes on the energy products. To compute that, we used detailed engineering information involving energy prices for the base year, that are converted via physical energy balance sheets to changes in the end-user prices of energy products. The implied changes of these prices, if considered in percentage, differ by sector and country. **Table 1** shows the energy taxation scenario as calibrated in physical units.

Table 1 : Percent change in fuel prices inflicted by the Carbon-energy tax

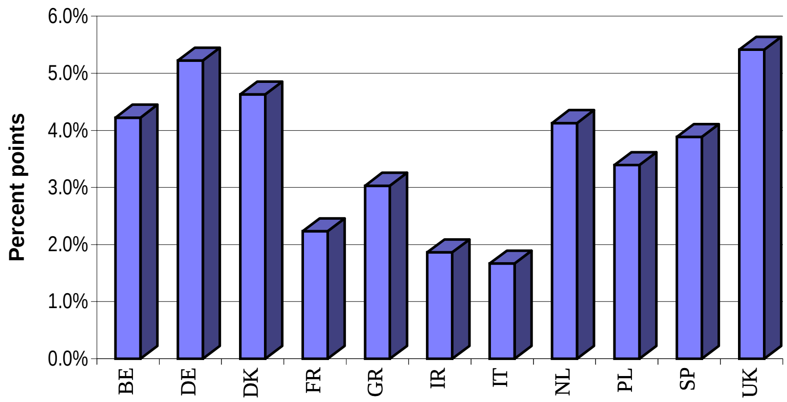
	Countries										
	Belgium	Germany	Denmark	France	Greece	Ireland	Italy	Nether-lands	Portugal	Spain	United Kingdom
Industry											
Coke	78.2%	71.4%	58.1%	114.1%	81.2%	65.1%	69.1%	48.5%	70.2%	76.9%	65.2%
lingnite	236.9%	135.8%	158.1%	193.5%	246.0%	177.3%	227.0%	214.2%	161.3%	137.6%	177.5%
Hard Coal	80.8%	46.3%	53.9%	66.0%	75.4%	60.5%	77.4%	73.0%	55.0%	46.9%	60.5%
Refined Oil	32.4%	30.6%	32.4%	29.8%	30.4%	25.0%	30.0%	30.8%	31.2%	28.1%	28.1%
Diesel Oil	20.0%	20.2%	19.7%	15.0%	18.7%	16.6%	15.6%	20.5%	12.6%	18.3%	19.9%
Electricity	3.4%	1.8%	0.0%	5.8%	0.6%	0.3%	1.0%	0.4%	2.4%	2.4%	1.1%
Nat. Gas	32.1%	30.7%	94.0%	31.7%	31.4%	21.2%	34.3%	36.2%	32.6%	22.7%	38.9%
Transports											
Diesel Oil	11.5%	10.4%	15.2%	11.1%	19.3%	8.4%	12.5%	12.5%	12.6%	13.6%	9.0%
Gasoline	7.5%	9.0%	7.9%	7.3%	9.3%	6.5%	6.2%	7.4%	6.9%	8.4%	7.8%
Domestic											
Hard Coal	24.6%	16.6%	28.0%	14.2%	28.3%	30.4%	23.8%	19.7%	20.3%	33.2%	29.2%
Diesel Oil	17.1%	17.8%	14.1%	14.0%	18.7%	15.2%	13.2%	15.9%	12.6%	18.3%	17.1%
Electricity	1.4%	1.0%	0.0%	2.3%	0.4%	0.2%	0.7%	0.2%	1.8%	1.3%	0.8%
Nat. Gas	17.0%	18.9%	15.2%	15.2%	17.8%	13.3%	17.3%	23.2%	16.4%	13.8%	27.3%

Regarding the accompanying reduction of the rate of social security contribution of employers, we note the following:

- We consider that this reduction operates uniformly in all sectors, independently of their relative labour costs or the pre-existing level of the rate.
- We determine *ex-post* the level of reduction of the rate of social security contribution of employers that is necessary to compensate exactly the additional revenues from the CO_2-tax. The model iterates among the possible values of rate reduction and determines the one needed in the new equilibrium achieved.

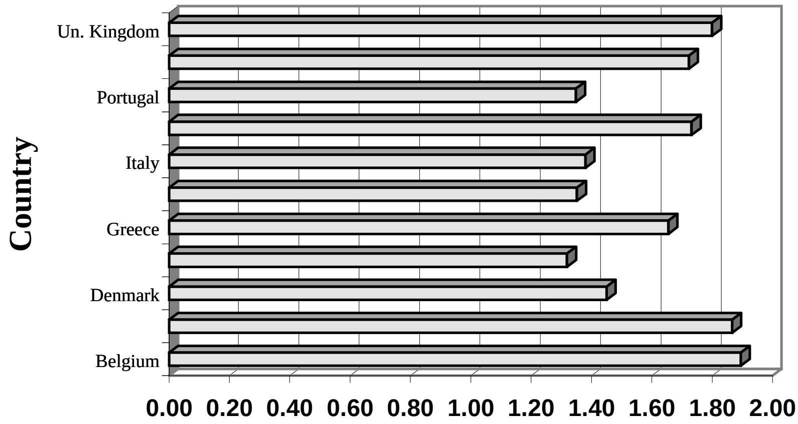
Figure 1 shows the ex-post values obtained.

Figure 1 : Reduction of social security rate



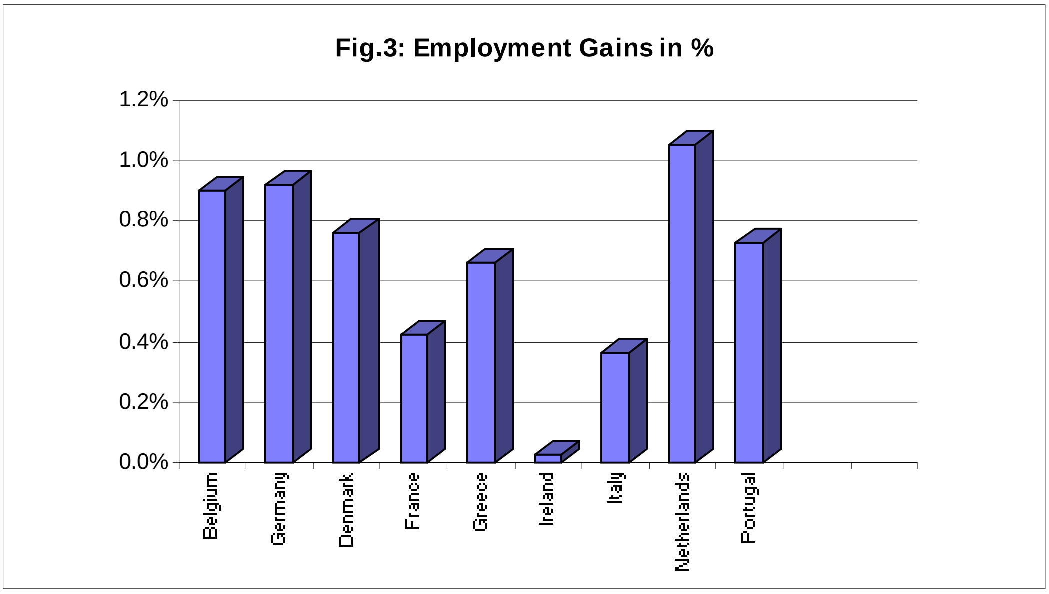
To provide an order of magnitude of the importance of the taxation scenario, **fig. 2** shows total revenues from the above CO_2-tax as a % of GDP. These range from about 1.4 to 1.9% of GDP.

Fig.2 : Revenues of the Carbon-energy tax (% of GDP)



3.3 Is there a positive double dividend?

Figures 3 and 4 show the main finding, namely a positive double dividend in all EU-12 member-states. As expected, the benefits for the environment (measured by the reduction of CO_2 emissions) are by far larger than the benefits for the employment. In the EU-12, total employment increases by around 800.000 persons, while total CO_2 emissions decrease by 9.5 % in the steady-state. In addition, NO_x and SO_2 emissions also decrease, namely by 12 % and 13 % respectively. This is not due to abatement technology, but can be explained by the improvement of energy efficiency and the adjustment of fuel mix.



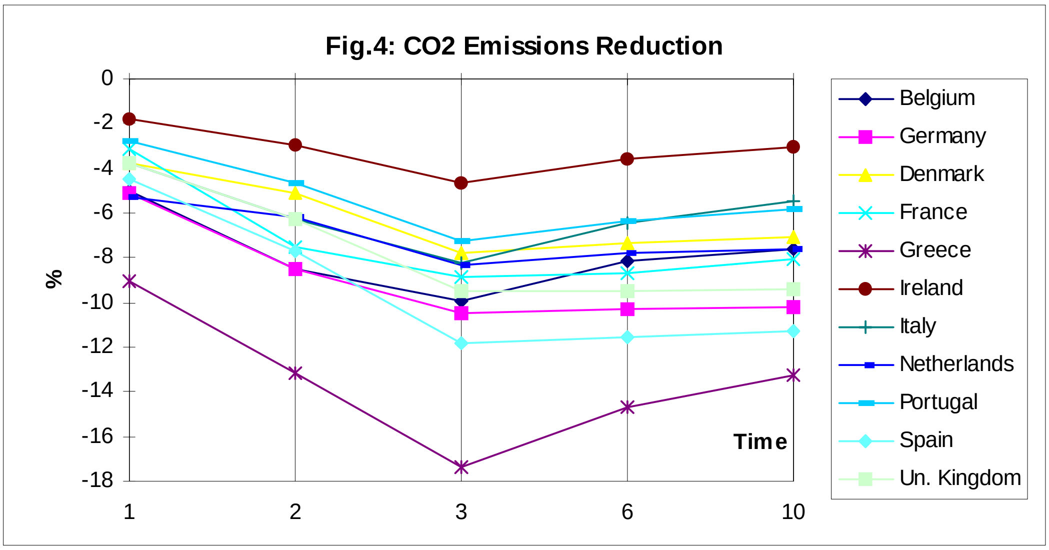


Table 2: Energy consumption and emissions

Total Energy Consumption

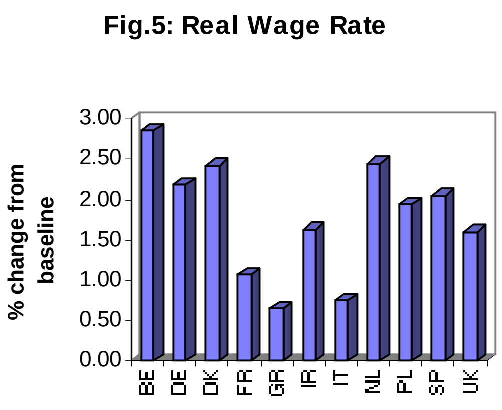
	1	2	3	6	10
Belgium	-1.71	-2.90	-4.39	-3.74	-3.43
Germany	-2.37	-4.00	-6.12	-6.05	-5.98
Denmark	-2.37	-3.10	-4.80	-4.86	-4.90
France	-0.91	-2.32	-3.60	-3.46	-3.37
Greece	-2.16	-4.77	-7.57	-6.84	-6.38
Ireland	-1.06	-1.57	-2.57	-2.28	-2.08
Italy	-1.82	-3.22	-5.12	-4.13	-3.62
Netherland	-2.08	-2.81	-4.61	-4.92	-4.93
Portugal	-1.92	-3.24	-5.20	-4.47	-4.09
Spain	-1.83	-2.76	-4.58	-3.93	-3.58
Un. Kingd	-2.16	-4.34	-6.87	-6.45	-6.27

Total Emissions for the European Union as a whole

	1	2	3	6	10
CO2	-4.37	-6.98	-9.96	-9.75	-9.67
NOX	-5.23	-8.94	-13.08	-12.46	-12.13
SO2	-5.53	-9.47	-13.85	-13.20	-12.86

The application of the double dividend policy, as defined above, initiates an increase in energy prices coupled with a reduction in labour costs. Prices of production factors change non-uniformly, resulting in substitutions in favour of labour and away from energy, hence we obtain substantial savings on energy consumption and emissions of pollutants. Energy demand decreases more in the sectors that are heavy consumers of energy (up to -15% in that sector, in the third period). The indirect effects on electricity prices, because of higher costs, are rather low of the order of 3-4%. In general, electricity and gas substitute the other energy forms, as expected.

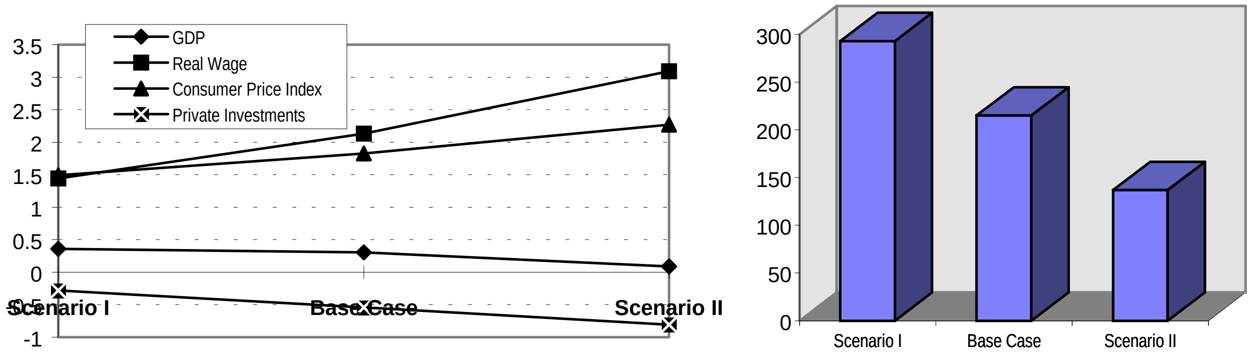
The fuel switching is however moderate in all sectors. Total energy consumption decrease, differs by country ranging from 3% to 6%. The corresponding decrease of CO_2 emissions is of the order of 9.5% in the steady state solution, while substantial gains on the other pollutants calculated by the model (SO_2 and NOx) are also effected. **Table 2** shows total energy consumption and total emissions of pollutants.



The firms, by their optimising behaviour, demand more labour and less energy. Within a competitive labour market regime, the implied shift of the aggregate labour demand curve would imply a re-evaluation of the real wage rate (**figure 5**). The degree of such an increase would then depend on the slope of the labour supply curve. A high increase can even cancel the positive effects on employment.

A rigid labour supply, interpreted as the existence of labour unions with a significant bargaining power, acts as a resource constraint in the economy, upwards pushing the real wage rate, and triggering the inflation spiral. On the contrary, a flexible labour supply, reflecting the availability of people that could enter the labour market, allows for gains in supply potential of the firms, that could compensate the inflationary pressure. The assumption about the slope of the labour supply curve is critical for the sign and hence the qualitative interpretations of results. This is a major condition for the quantitative results of the double dividend. **Figure 6** gives selected results of a sensitivity analysis under three alternative assumptions about the prevailing labour market regime.

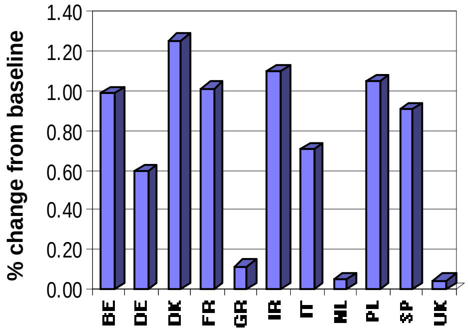
Figure 6 : Impact of the labour supply elasticity on the double dividend.



Scenario I reflects a 50% higher labour supply elasticity (compared to the base case assumption) while Scenario II an elasticity 30% lower. The left diagram shows GDP, real wage rate, consumer's price index and private investments (% changes from the baseline), while the right shows the changes in employment in thousand persons. It is clear from the above diagrams, that an inelastic labour supply leads to price increases and additional competitiveness losses, which in turn lead to the deterioration of the economy. An elastic labour market on the other hand, allows a more smooth adjustment of the economy and maximises employment gains. These sensitivity analysis results shown, concern Germany.

The surplus or deficit of public budget remains unchanged, by construction of the simulation run, as explained before. Thus, the policy application does not alter, in a first approximation, income distribution and does not imply any need for public budget financing (or any new financing capacity from the public budget). Income distribution is effected indirectly, through the re-evaluation of labour compared to other factors and the implied mechanism of income distribution, through the Social Accounting Matrix of the model.

Figure 7: Terms of Trade

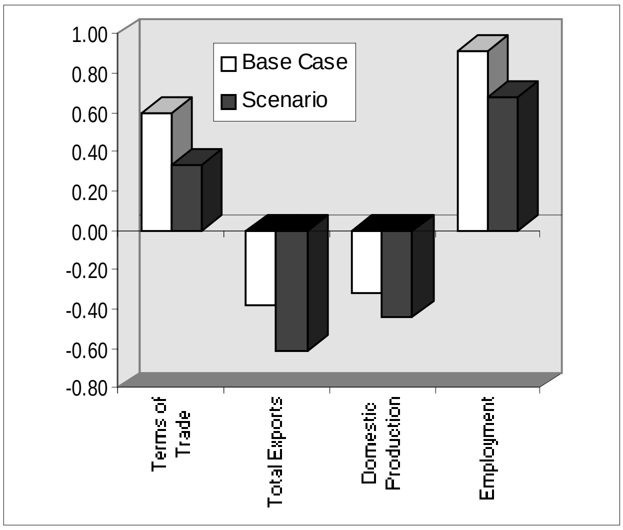


As mentioned, the current account at the country level can adjust (is not fixed). The EU member-states are interdependent through flexible bilateral trade flows. The behaviour of the rest of the world (RW) is assumed exogenous. Then the EU countries, by definition, do not face a price reaction of the RW when they demand more imports. The EU countries do so because of higher production costs that are due to imperfect adjustment of production technology to the changes of relative production factor prices. The absence of readjustment of RW imports combined with the unchanging RW export prices, entail a revaluation of EU exports that will increase more than the value of imports. The latter can even decrease, depending on the elasticities and the flexibility of shifting away from energy, which is basically imported in the EU. This imply an improvement of the terms of trade [5] for the EU (**figure 7**), or in other terms a willingness of the RW to accept a deterioration of their terms of trade. It turns out that this willingness is a necessary condition for a double dividend.

---

[5] Terms of trade are defined here (as it is standard in the literature), as the ratio of export price over import price.

Fig. 8 : Exposure to competition in the export market (% change from baseline)



A sensitivity analysis, to that respect, consisting of increasing the export elasticities addressed to the rest of the world, illustrated the importance of the exposure to foreign competition. The more competitive the export market, the less possible is an improvement in the terms of trade vis-à-vis the rest of the world. Firms operating on a competitive export environment face a decreasing export demand (effected from the domestic price increases induced by the tax) which leads to a shrinking of the market available to the firm and a general slowdown of the economic activity. Exports decrease more than in the base case and money inflow from the rest-of-the-world is now much lower. Domestic prices adjust to the decrease of the export demand, stabilising at a lower level than before, which leads to some augmentation of domestic compared to the base scenario. Employment benefits are reduced (**figure 8** gives sensitivity results for Germany, with the scenario reflecting increased elasticities of the import demand of the rest of the world). Of course there is a limit in the import demand elasticity of the rest of the world, above which, the reduction in exports (and hence domestic production and demand for production factors) would overcompensate the reduced labour cost, leading to no employment dividend at all.

3.4 Indirect and Equilibrium Effects

As mentioned, the assumed double dividend policy entails a change of relative costs of production factors. The unit cost of labour decreases, while the cost of energy increases. Labour becomes more competitive, not only compared to energy, but also with respect to other production factors including capital. Thus, labour substitutes for energy but also for capital. This implies a diminishing rate of return of capital and a slowdown of investment.

To this effect (technology optimisation), one must add a demand effect. The production costs bear different charges by sector, due to different energy and labour intensities. These varying costs, after being reflected into prices, will imply substitutions both in final and intermediate demand.

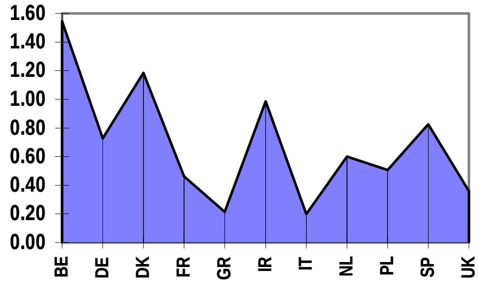
Therefore, those sectors that face a diminishing market, have an additional reason to invest less: due to the limited substitutability of the factors and the fixed capital constraint the rate of return on capital tends to further decrease.

The sectors, on the other hand, that see their market augmenting will tend to invest more, since they will attribute a higher shadow price to their capital stock as they desire more production capacity. In this case, the demand effect has the opposite sign from the substitution effect, so the outcome, regarding investment, is uncertain. In the current model however it tends to be positive for most sectors (especially consumer industries and private services).

The increase in real wages pushes private income and consumption, which keeps up domestic demand. Because of higher production costs, as explained above, competitiveness of domestic firms tend to deteriorate and the volume of exports shrinks (**Table 3**). The volume of non energy imports from the RW increases.

Table 3: Private Consumption (right) and investments (left) for each EU member states (% change from baseline)

	Agriculture	Energy Intensive	Industry Equipment goods	Consumer goods	Transport/ Communication	Private Services
Belgium	0.13	-0.19	-0.34	0.19	-0.07	0.80
Germany	0.22	-1.03	-0.80	-0.13	0.08	0.11
Denmark	0.15	-0.82	-0.42	0.05	-0.42	0.39
France	0.25	-0.57	-0.58	-0.02	-0.15	0.04
Greece	-0.26	-2.42	-2.07	-0.56	-0.50	-0.50
Ireland	-0.09	-0.07	0.01	-0.02	-0.33	0.46
Italy	-0.21	-0.74	-0.44	-0.31	-0.29	0.11
Netherlanc	0.15	-0.14	-0.36	-0.03	-0.28	0.06
Portugal	0.17	-0.69	-0.12	0.04	-0.85	0.22
Spain	0.23	-0.89	-0.42	0.01	-0.24	0.25
Un. Kingd	0.16	-0.62	-1.19	-0.24	1.68	-0.35



Shifts of total domestic demand (**table 4**) are then uncertain, since they are positively influenced by private consumption and negatively influenced by trade. Shifts of total investment is also uncertain, for the reasons explained above.

Table 4: Domestic Demand (% change from baseline)

	Agriculture	*Energy Intensive Industries*	*Equipment goods industries*	*Consumer goods industries*	*Transport/ Communication*	*Private Services*
Belgium	0.61	0.20	0.37	0.94	0.76	0.00
Germany	0.16	-0.40	-0.40	0.26	0.27	0.06
Denmark	0.24	0.20	0.31	0.62	-0.04	0.09
France	0.19	-0.26	-0.07	0.27	0.06	0.04
Greece	-0.09	-0.75	-0.85	-0.21	-0.51	-0.01
Ireland	0.01	0.16	0.25	0.47	0.54	0.13
Italy	-0.05	-0.43	-0.14	-0.08	-0.23	0.00
Netherlands	0.13	-0.11	0.02	0.26	0.14	0.07
Portugal	0.21	-0.17	0.12	0.25	0.19	0.02
Spain	0.21	-0.29	0.14	0.34	0.02	0.10
Un. Kingdom	0.01	-0.53	-0.64	0.00	-0.26	0.25

Households consider simultaneously the propensity to invest more in durable goods because of higher income, but also the operating costs of durable goods that become higher because of higher energy costs. This combination turns out to be negative (in this model application) for the demand of durable goods. This effect must be added to the effect from the slight slowdown of total investment (as explained), entailing a slowdown of the demand for equipment goods. This explains the negative effects on the equipment goods industry.

Of course, the energy intensive industries suffer the most, facing the highest decrease of their market. Non energy intensive sectors face, on the other hand, an increasing demand (both in the intermediate goods market and through final demand) resulting from the substitution effects of both industry and consumers.

Total imports remain unchanged or decrease, because the shift from a mostly imported good - energy - compensates the increase of non energy imports, which is due to competitiveness losses. As explained in the previous section, the combined changes in foreign trade leads to improved terms-of-trade for the EU, compared to the RW [6].

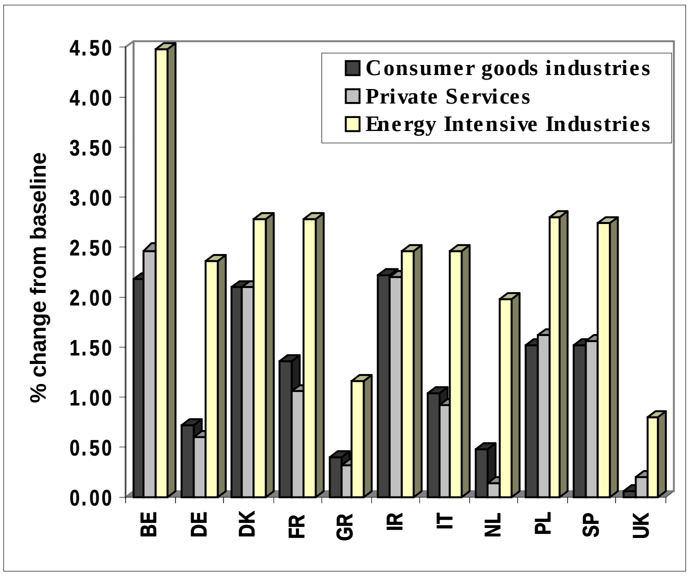
Since prices increase all over the European Union, it is understandable that intra-EU volume of trade decreases much more than the marginal (0.55% as compared to 0.15%) reduction of the exports of the rest-of-the-world to the EU. The result of this, is a small increase in the import dependency of the EU. The decrease of intra-EU trade is, once again, not uniform across countries and sectors. The different export prices set by each sector in every country, lead some to become more or less competitive and thereby increase or decrease respectively their export shares. The country that benefits the most from the adjustments of trade is the United Kingdom (see also footnote 6), which minimises its export losses. Total imports and exports by sector are given in **table 5**.

[6] Greece and the Un. Kingdom are exceptions to this rule for different reasons:

Greek consumers get a considerable proportion of their income through transfers from the rest of the world which is considered exogenous in the model and hence, in the case of an increase in prices, decreases in real terms affecting the disposable income.

The UK on the other hand is a producer of oil. In the model we make the assumption that exports cannot be completely redirected from the EU to the rest of the world, and so the oil sector in the UK faces a smaller demand. So the profit rate of this sector (which makes up a big proportion of the total value added of the industry) dimishes affecting the rest of the economy considerably.

Figure 9 : Unit cost of domestic production



The combined effects from supply, domestic demand and unit costs of labour may compensate each other. As a matter of fact, we observe small increases of domestic prices (**figure 9**) and inflation (**table 6**). Demand push is moderated by the flexibility of labour supply, while demand contraction in some sectors moderates price increases due to cost increases.

Table 5 : Volume of exports and imports by sector (% change from baseline)

	Exports						*Imports*					
	Agriculture	Energy Intensive Industries	Equipment goods industries	Consumer goods industries	Transport/ Communication	Private Services	Agriculture	Energy Intensive Industries	Equipment goods industries	Consumer goods industries	Transport/ Communication	Private Services
Belgium	-0.43	-0.80	-0.31	-0.27	-0.80	-0.57	1.03	-0.22	0.07	0.85	0.63	1.16
Germany	-0.47	-0.82	-0.20	0.02	-0.39	-0.09	0.57	0.20	-0.36	0.78	1.04	0.73
Denmark	-0.47	-0.95	-0.39	-0.55	-1.18	-0.55	1.01	0.77	0.27	0.35	1.11	0.83
France	-0.17	-0.93	-0.44	-0.20	-0.70	-0.30	0.71	0.38	0.16	0.75	1.11	0.61
Greece	0.40	-0.45	-0.21	0.31	-0.34	0.28	-0.57	-0.89	-0.87	-0.90	-0.02	-0.25
Ireland	-0.46	-0.63	-0.32	-0.72	-0.69	-0.69	0.53	0.02	-0.05	1.12	1.32	1.01
Italy	-0.06	-0.86	-0.43	-0.24	-0.76	-0.29	0.14	0.20	0.08	0.06	0.63	0.23
Netherlands	-0.04	-0.42	-0.10	0.16	-0.48	0.11	0.33	-0.15	-0.01	0.88	1.59	1.24
Portugal	-0.44	-0.93	-0.35	-0.24	-1.01	-0.47	0.78	0.42	0.13	1.15	1.52	0.94
Spain	-0.33	-0.96	-0.36	-0.29	-0.85	-0.38	0.91	0.45	0.30	1.46	2.05	1.50
Un. Kingdom	-0.06	-0.19	-0.01	0.25	0.06	0.24	0.08	-0.69	-0.75	0.13	0.18	0.09

Table 6 : Consumer's price index and GDP (% change from baseline)

	Consumer's price index					**GDP in factor prices**				
	1	**2**	**3**	**6**	**10**	**1**	**2**	**3**	**6**	**10**
Belgium	0.85	1.81	2.93	2.51	2.23	0.22	0.37	0.52	0.47	0.43
Germany	0.45	0.92	1.63	1.76	1.83	0.16	0.25	0.35	0.32	0.30
Denmark	1.26	1.85	2.99	2.91	2.84	0.19	0.26	0.38	0.39	0.39
France	0.48	1.38	2.22	2.24	2.24	0.06	0.14	0.20	0.18	0.17
Greece	0.41	0.16	0.26	0.50	0.62	0.05	0.09	0.09	0.04	0.00
Ireland	0.78	1.38	2.30	2.37	2.49	0.03	0.05	0.07	-0.02	-0.07
Italy	0.59	1.08	1.73	1.75	1.77	0.10	0.16	0.23	0.12	0.07
Netherlands	0.46	0.67	1.17	1.47	1.63	0.28	0.35	0.52	0.43	0.38
Portugal	0.72	1.31	2.16	1.96	1.84	0.14	0.24	0.36	0.30	0.27
Spain	0.82	1.40	2.34	2.28	2.25	0.17	0.26	0.39	0.34	0.31
Un. Kingdom	0.22	0.32	0.60	1.09	1.28	0.22	0.44	0.63	0.51	0.44

Regarding effects on total activity, the positive effects of demand are found to over-compensate negative effects from trade and thus GDP in factor prices is slightly augmenting.

3.5 Summary of conditions for a Double Dividend

The results and sensitivity analyses confirm the following points:

- The positive double dividend result, is achieved everywhere. We obtain more employment (although small in magnitude) coupled with an increased real wage rate, and significantly less energy consumption, hence fewer emissions not only for CO_2 but for other pollutants as well.
- The magnitude of the employment dividend depends crucially on the labour market regime. An inelastic labour supply minimises the gain in employment and will also lead to higher competitiveness losses and inflationary pressures.
- Distributional effects across sectors are important. The energy intensive industry suffers the most, followed by the equipment goods industry. On the other hand, consumer goods and services are favoured from the redirection of demand towards them, a shift that has long-term implications.
- The decrease in competitiveness of the EU-12, reflected in the decrease of both intra-EU trade and of the volume of exports to the rest-of-the-world, is overcompensated by the significant improvement of the EU terms of trade, leading to an increase in the money inflow from exports.
- A double dividend is only obtained if the rest-of-the-world accepts the deterioration of its terms of trade (is, in other words, willing to buy more expensive products) with the EU member states, so as to support the amelioration of the current account of the EU.

The effects differ significantly by country. This is attributed to the different structure of the economies, mainly regarding:

- the flexibility of the labour market (demand and supply)
- the degree of exposure of sectors to foreign trade and the dependence of the economy on sectors that are affected by the policy
- the pre-existing level of energy-related excise taxes
- the flexibility of the energy supply system (mainly power generation) to adapt and the possibilities for fuel switching (in particular for natural gas).

Sensitivity analysis confirmed that the differences are rather due to the structure of the economy of the countries, than to the values of any particular elasticities. In any case, the distributional effects to countries are not neutral, so they must be seriously considered if the policy is to be implemented at the European Union level.

4. References

[1] Ando A., F. Modigliani, R. Rasche and S. Turnofsky (1974): “On the role of expectations of price and technological change in investment function”, International Economic Review, Vol. 15, No 2, June, pp. 384-414.

[2] Armington, P.S. (1969): “A theory of demand for products distinguished by place of production”, International Monetary Fund Staff Papers, IMF, Washington DC.

[3] Bergman, Lars (1988): “Energy Policy Modeling: A Survey of General Equilibrium Approaches” Journal of Policy Modeling, 10 (3), pp. 377-399.

[4] Bergman, Lars (1990): “General equilibrium effects of environmental policy: a CGE-approach”, Discussion Paper, Stockholm School of Economics, Stockholm.

[5] Bourguignon, F., J. de Melo and A. Suwa (1991): “Distributional Effects of Adjustment Policies: Simulations for Archetype Economies in Africa and Latin America”, The World Bank Economic Review, Vol 5, No 2, pp. 359-366.

[6] Bourguignon, F., W.H. Branson and J. De Melo (1989): “Macroeconomic adjustment and income distribution: a macro-micro simulation model”, Working Paper, appeared also as “Adjustment and Income Distribution”, Working Paper, The World Bank, May.

[7] Bovenberg, L. and Van der Ploeg (1994): “Environmental Policy, public finance and the labour market in a second best world”, Journal of Public Economics, 55, 349-390.

[8] Bovenberg, L. and Van der Ploeg (1994) “Green Policies and public finance in a small open economy”, Scandinavian Journal of Economics, 96, 343-363.

[9] Capros, P., P. Karadeloglou and G. Mentzas (1991): “Market Imperfections in a General Equilibrium Framework: An Empirical Analysis”, Economic Modelling, January.

[10] Capros, P., T.Georgakopoulos, S. Zografakis, D. Van Regemorter, S. Proost (1995): “Co-ordinated versus uncoordinated European carbon tax solutions analysed with GEM-E3 linking the EU-12 countries”, paper presented at a symposium on “Economic Aspects of environmental policy making in a federal system”, Leuven, 14-16 June.

[11] Capros, P., T.Georgakopoulos, S. Zografakis, S. Proost, D. Van Regemorter, K. Conrad, T. Schmidt, and Y. Smeers (1996): “Double Dividend Analysis: First results of a General Equilibrium Model (GEM-E3) linking the EU-12 countries”, in “Environmental fiscal reform and Unemployment”, eds. C. Carraro and D. Siniscalco, Kluwer Academic Publishers.

[12] Capros, P., T.Georgakopoulos (1996): “Using the GEM-E3 model to study the double dividend issue”, in Proceedings of the 51st International Conference of the Applied Econometrics Association (AEA) on “Econometrics of Environment and Transdisciplinarity”, eds. A. Baranzini, F. Carlevaro, Vol II, 680-711, Lisbon, 10-12 April.

[13] Conrad, K. and M. Schröder (1991): “Demand for durable and nondurable goods, environmental policy and consumer welfare”, Journal of Applied Econometrics, vol. 6, pp. 271-286.

[14] Conrad, K. and T. Schmidt (1995): “National economic impacts of an EU environmental policy: an applied general equilibrium analysis”, paper presented at a symposium on “Economic Aspects of environmental policy making in a federal system”, Leuven, 14-16 June.

[15] De Melo, J. (1988): “Computable General Equilibrium Models for Trade Policy Analysis in Developing Countries: A Survey”, Journal of Policy Modeling, 10 (4), pp. 469-503.

[16] De Melo, Martha, M. Leduc and S. Razmara (1989): “A Policy Model for Tunisia with Real and Financial Flows”, Working Paper, The World Bank, January.

[17] Decaluwe, B. and A. Martens (1987 and 1988): “Developing Countries and General Equilibrium Models: A Review of the Empirical Literature”, Report of the International Development Research

Center, University of Montreal, June, published also by the Journal of Policy Modeling, 10 (4), 1988.

[18] Dervis, K., J. De Melo and S. Robinson (1982): "General Equilbrium Models for Development Policy", Cambridge University Press, Cambridge.

[19] Dewatripont, M. and G. Michel (1987): "On closure rules, homogeneity and dynamics in applied general equilibrium models", Journal of Development Economics, Vol. 26, No 1, June, pp. 65-76.

[20] Fuss, M., McFadden D., eds., (1978): "Production Economics", North Holland, Amsterdam.

[21] Hudson, E. and D.W. Jorgenson (1974): "US Energy Policy and Economic Growth, 1975-2000", Bell Journal of Economics and Management Science, Vol. 5, No. 2, Autumn, pp. 461-514.

[22] Jorgenson, D.W. and P.J. Wilcoxen (1989): "Environmental regulations and U.S. economic growth", presented at the MIT Workshop on "Energy and Environmental Modeling", July 31-Aug. 1, also published in Rand Journal of Economics, Summer 1990.

[23] Lluch, C. (1973): "The Extended Linear Expenditure System", European Economic Review, 4, pp. 21-31.

[24] Oates, W. (1991): "Pollution Charges as a Source of Public Revenues", Discussion Paper, Resources of the Future, Washington.

[25] OECD (1994): "GREEN - The Reference Manual", Economics Department, Working Papers No 143, OECD, Paris.

[26] Shephard R.W. (1953): "Cost and Production Functions", Lecture Notes in Economics and Mathematical Systems, Springer-Verlag, Berlin, New York.

[27] Shoven J.B. and J. Whalley (1974): "On the computation of competitive equilibrium on international markets with tariffs", Journal of International Economics, Vol. 4, No. 4, November, pp. 341-355.

[28] Shoven J.B. and Whalley J. (1984): "Applied General Equilibrium Models of Taxation and International Trade: An Introduction and Survey", Journal of Economic Literature, Vol. XXII, September, pp. 1007-1051