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CAN EUROPE REDUCE UNEMPLOYMENT THROUGH ENVIRONMENTAL TAXES?

A General Equilibrium Analysis

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Abstract

The paper develops a dynamic multisectoral general equilibrium model (EUROGEM) for the European Union which is used in the analysis of the effects of a CO_2/energy tax. The focus of the analysis is on the energy sector and the labor market with the specific intention of answering the question of whether a change in the tax system can simultaneously reduce carbon dioxide emissions and diminish unemployment in the European Union. EUROGEM is used for the analysis of the effects of a CO_2/energy tax of $10. The simulation results show clearly that the introduction of a CO_2/energy tax would have substantial effects on the European economy and on the structure of the foreign trade. Results clearly indicates the effectiveness of a tax policy in reducing pollution and energy consumption. This may be considered as the first dividend. It also appears that a second dividend may be obtained from environmental taxes. A cut in social security contributions financed by the carbon/energy tax may generate strong positive effects on employment in agriculture, energy intensive industries and other industries and services, but as the wage bargaining model shows, this positive effect diminishes in time due to the fact that the decline in the unemployment rate exerts an upward pressure on real wages.

Key words: environment, general equilibrium, multisectoral modeling

1. Introduction

Of all the recent environmental policy issues facing the European Union and the international community, the most widely publicised has been the threat of global warming from increased emissions to the atmosphere. The precise causes, likely extent, and consequences of global warming continue to be debated. However, it is clear that, if the more pessimistic 'do-nothing' scenarios were to be realised, the resulting environmental and economic consequences would be of enormous scale. In these circumstances, the precautionary policy response has been to set target levels which should not be exceeded for the main emissions believed to contribute to global warming, and then to determine, and hopefully reach political agreement on, the best ways of achieving these.

The major type of emission believed to contribute to global warming is CO_2. In October 1990 the Council of Ministers of the European Union undertook to stabilise CO_2 emissions in the EU at 1990 levels by the year 2000. In order to achieve these targets, the EU proposed a package of measures which include a combined energy and carbon tax. The revenues generated by the carbon/energy tax would be used to reduce other taxes (e.g. personal income taxes, social security charges, etc.) so as to achieve budget neutrality. Considerable concern is expressed, indeed, about the likely economic consequences of stricter environmental controls. The fear is that increased expenditure on such controls will raise the general level of production costs and prices, lower the competitiveness of exports, reduce the growth rate, and raise the level of unemployment which is already very high in the European Union.

Attempts have been made to model the macroeconomic consequences of particular policy measures (such as the carbon/energy tax) in a number of OECD countries. An OECD survey examined the macroeconomic effects of the pollution abatement and control expenditures (OECD 1985). The economic consequences including effects on output and unemployment were assessed to be low. More recently a task force of the European Commission used the HERMES econometric model to predict the likely effects of increased expenditure on environmental controls, equivalent to 1 per cent of

GDP, in each of five Member States (Belgium, Germany, France, Greece, and the United Kingdom) (Task Force 1990). On the basis of a combined scenario (introduction of the carbon/energy tax and reduction in the social security contributions) it was predicted that growth and unemployment changes would be relatively small. Similar results have been obtained by a recent simulation exercise with the QUEST model of the European Commission (European Economy 1994). The available simulation results show that if a wage-price spiral can be avoided then a CO_2/energy tax has the potential of improving employment (on the order of 0.5%) if the revenues are used for a cut in the social security contributions.

The present paper develops a dynamic general equilibrium model[1] for the European Union to be used in the analysis of the effects of a CO_2/energy tax. The focus of the analysis is on the energy sector and the labour market with the specific intention of answering the question of whether a change in the tax system could simultaneously reduce carbon dioxide emissions and increase employment in the European Union.

2. Overview of the model

EUROGEM is a dynamic multi-sector general equilibrium model for the European Union. The main focus of the model is on the energy sector and the labour market. The model distinguishes the following nine branches:

Table 1: Sectors in EUROGEM

1) Agriculture
2) Coal mining
3) Crude oil
4) Natural gas
5) Refined oil
6) Electricity, gas, water
7) Energy intensive industries
8) Other industries and services
9) Public services

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[1] For some recent general equilibrium models applied to environmental questions see for exemple Bergman (1990), Burniaux and al. (1992), Goulder (1992), Jorgenson and Wilcoxen (1990 and 1993), Kimbell and Fisher (1989), Whalley and Wigle (1989 and 1991).

EUROGEM considers the European Union as a fully-fledged economic area without distinguishing different member countries. Trade relations with the rest of the world are modelled through export and import functions without detailed modelling of the rest of the world.

EUROGEM has a recursive dynamic structure composed of a sequence of several temporary equilibria in which current savings determine future capital accumulation and the growth rate of the economy. The model can be run over variable time horizons with variable time intervals between subsequent equilibria. For the simulation exercises analysed in this paper the model is solved for thirty years with intervals of five years.

The model describes the economic behaviour of five blocks: firms, consumers, the government, the foreign sector and the labour market. All economic agents have an optimising behaviour under relevant budget constraints. All the markets operates in perfect competition with the exception of the labour market where a bargaining model explains the wage outcome. We describe below the most interesting features of the production block and of the labour market.

2.1. Production block

The private production block includes eight sectors. Five of them - coal mining, crude oil, natural gas, refined oil and electricity, gas, water - concern the supply and distribution of conventional energy. The remaining three sectors - agriculture, energy-intensive industries, other industries and services - concern the production of goods and services.

Production has a nested structure in all the sectors. At the outer nest, producers are assumed to choose the optimal mix between intermediate inputs and a composite good including labour, capital and energy (KLE). At a second stage, producers choose the optimal level of labour input (L) and capital-energy composite (KE). The optimal level of capital (K) and energy (E) is determined at the third stage. At the fourth stage, producers allocate the energy bundle between coal, natural gas, crude oil, refined oil and electricity. All intermediate inputs and energy inputs are composites of domestic and foreign goods. This complex nested structure and the functional forms used in the private production sectors are summarised in figure 1.

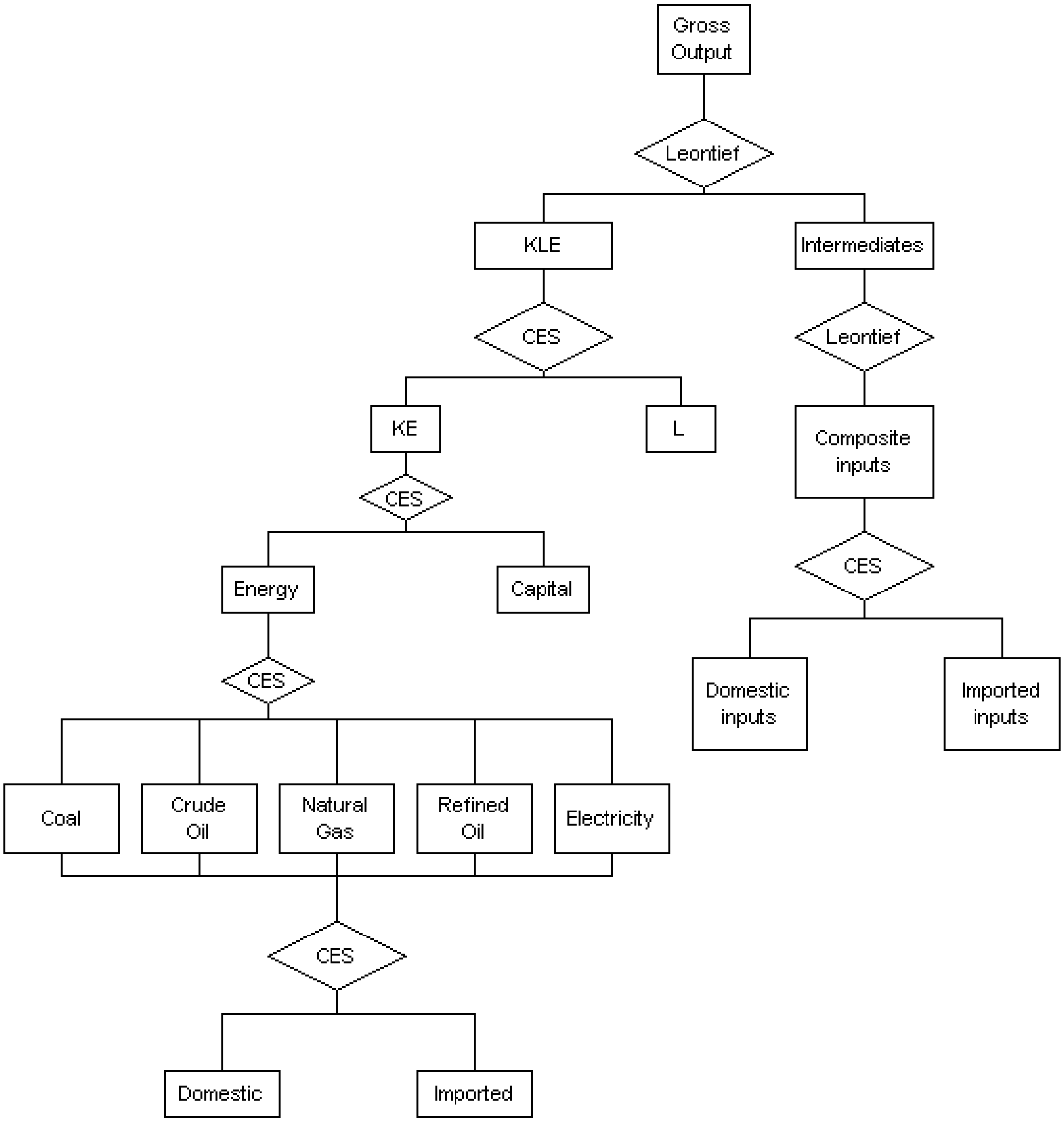

Figure 1: Production structure

Figure 1 indicates that we parameterize production substitution possibilities by assuming CES functions for capital-labour-energy composite (KLE), capital-energy composite (KE), energy composite (E) and Leontief functions between intermediates and KLE composite and across non-energy intermediates. However, within each non-energy intermediate sector, a CES function describes substitution possibilities between the domestically produced intermediate and the competing foreign-produced intermediate. This is the well known Armington assumption in foreign trade modelling. The substitution possibilities are given by CES functions. CES functions describe also the substitution possibilities for energy inputs within all sectors. In addition, CES functions describe substitution possibilities between domestically produced energy inputs and imported energy inputs.

The nested CES-Leontief structure described above allows consequently different substitution opportunities at different stages of the production process. The first stage describes the gross output:

Q_d = min(KLE, V)

where

Q_d is domestic gross output

KLE is capital-labour-energy composite

V represents intermediate inputs

V_j=min(X_{1j}/a_{1j},...,X_{nj}/a_{nj}) n = i, n (non-energy sectors)

where

X_{ij} are non-energy intermediate inputs

a_{ij} are the technical coefficients.

KLE is a CES aggregation of labour and capital-energy composite:

$$KLE = A_1\left[a_1 L^{r1} + \left(1 - a_1\right) KE^{r1}\right]^{1/r1}$$

where

A_1 is a shift parameter,

L is labour,

KE is the capital-energy composite,

α_1 is the share parameter,

σ_1 is the elasticity of substitution between L and KE,

$\rho_1 = 1 - 1/\sigma_1$.

The producer determines the optimal demand of KE and L by minimising the cost of producing one unit of KLE:

$$PKE \cdot KE + (1 + t_L) \cdot PL \cdot L$$

where

PKE is the price of the KE bundle,

τ_L is the social security contributions rate,

PL is the wage rate.

Forming and maximising the Lagrangian give - after some algebra from the first-order conditions - the optimal demand for labour and for the capital-energy composite.

The following stage determines the optimal choice of capital demand and energy demand. KE is a CES composite of capital and energy:

$$KE = A_2 \left[a_2 K^{r2} + \left(1 - a_2\right) E^{r2} \right]^{1/r2}$$

where

A_2 is a shift parameter,

E is the energy composite demand,

α_2 is the share parameter,

σ_2 is the elasticity of substitution between capital and energy,

$\rho_2 = 1 - 1/\sigma_2$.

The producer minimises the costs to determine the capital and energy demand. Costs are given by the equation:

$$PE \cdot E + (1 + t_{K}) \cdot PK \cdot K$$

where

PE represents the price of the energy bundle,

E is the energy composite bundle,

τ_K is the corporate income tax rate,

PK is the capital rent rate.

Forming and maximising the Lagrangian give the optimal demand for capital and energy.

Energy inputs are determined through minimisation of the energy costs under the unit aggregation constraint. Energy costs are given by:

$$\sum_{i=1}^{5} (1 + te_i) \cdot P_i \cdot EI_i$$

where

i = coal, crude oil, natural gas, refined oil, electricity,

τe_i is the tax rate on the energy input *i*,

P_i is the price of the energy input *i*,

EI_i is the energy input *i*.

The energy demand bundle is a CES aggregation of different energy inputs:

$$E = A_3 \left[\sum_{i=1}^{5} a_{3i} \ EI_i^{r_3} \right]^{1/r_3}$$

where

A_3 is a shift parameter,

α_{3i} represents share parameters for different energy inputs *i*,

σ_3 is the elasticity of substitution across energy inputs,

$\rho_3 = 1 - 1/\sigma_3$.

Finally, all energy and non-energy intermediate inputs are CES aggregations of domestic and foreign goods. For each composite good X we have therefore:

$$X = A_a \left[\alpha_a DX^{\rho_a} + \left(1 - \alpha_a\right) MX^{\rho_a} \right]^{1/\rho_a}$$

where

A_a is a shift parameter,

α_a is a share parameter,

DX represents domestically produced input,

MX represents imported input,

σ_a is the elasticity of substitution between domestic and imported goods,

$\rho_a = 1 - 1/\sigma_a$.

In order to determine the optimal level of domestic and foreign intermediates the producer minimises costs:

$$PD \cdot DX + PM \cdot MX$$

where

PD is the price of the domestically produced good,

PM is the after-tax price of the imported good.

Once again, forming and maximising the Lagrangian give the optimal demands.

2.2. Labour Market

Most general equilibrium models operate within perfectly flexible markets and prices so that there is no disequilibrium. This pure Walrasian framework would be very restrictive for a European model given the high level of unemployment rate and would not allow us to elucidate the effects of economic policies on unemployment.

A distinguishing feature of EUROGEM is that the labour market does not clear. The model generates endogenous unemployment through a collective bargaining process which prevents wages from being wholly flexible.

The objective of the union associated with the bargaining is assumed to be given by a Stone-Geary utility function:

$$T=L^{\beta}((1-t)PL/CPI-A/CPI)^{1-\beta}$$

where

L is employment,

PL is the nominal wage rate,

τ is the marginal tax rate,

CPI is the consumer price index,

A is the alternative income for a worker who looses his job.

The expected alternative income is given by:

$$A=(1-p)\left[mw^{m}+(1-m)\,Prod\cdot CPI\right]+p\,l\,w^{m}$$

where

π is the probability of remaining unemployed during the period if the job is lost. π is endogenous and increases with the unemployment rate,

w^m is the macro wage rate the worker can get elsewhere,

Prod is a macro productivity index,

μ is a share parameter,

λ is the replacement ratio.

Employers' utility (E) is given by their profits per unit of capital. Assuming Cobb-Douglas technology, this gives:

$$E = \left(\frac{1-\kappa}{\kappa}\right)\left(\frac{\kappa P}{(1+\tau_L)PL}\right)^{\frac{1}{1-\kappa}}(1+\tau_L)PL$$

where

κ is the Cobb-Douglas exponent,

τ_L is the social security contributions rate,

P is the net value-added price.

The outcome of the bargaining process is given by the maximisation of the Nash maximand:

$$N = T^{\phi} E$$

The bargained wage must satisfy the first-order condition:

$$\partial \log N / \partial w = (\phi / T)(\partial T / \partial w) + (1 / E)(\partial E / \partial w) = 0$$

3. Simulation Results

This section presents the results of a dynamic simulation realised with EUROGEM. In this experiment a CO_2/energy tax[2] of \$10 per barrel of oil is introduced and the tax

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[2] Tax rates are differentiated according to the energy source and its use.

revenue is recycled through reductions in the social security contribution rates keeping the total tax revenue constant in real terms with respect to its benchmark amount. The model is solved for thirty years with intervals of five years between equilibria.

The simulation results clearly show that the introduction of a CO_2/energy tax would have substantial effects on the European economy and on the structure of the foreign trade. Table 2 puts into light the sectoral effects of the carbon/energy tax. Domestic production would drastically diminish in energy sectors and in energy intensive industries. The reduction is tremendous in the long run in coal mining and is quite important in the other energy sectors as well.

Table 2: Domestic production (variation in % to benchmark)

	Year 1	Year 6	Year 11	Year 16	Year 21	Year 26	Year 31
Agriculture	-0.1	0.2	-0.6	-0.9	-0.6	-0.8	-0.7
Coal	-7.4	-23.9	-40.4	-41.1	-42.2	-41.1	-41.0
Crude oil	-0.2	-3.7	-7.7	-6.6	-9.5	-6.1	-6.0
Natural gas	-3.7	-9.7	-18.1	-18.1	-19.1	-17.9	-17.9
Refined oil	-6.8	-10.7	-15.9	-15.9	-16.1	-15.9	-15.8
Electricity	-8.9	-13.7	-19.6	-19.8	-19.6	-19.8	-19.7
Energy intensive	-4.7	-4.4	-5.5	-6.0	-3.9	-6.0	-5.9
Other	0.6	1.0	0.2	-0.2	-0.0	-0.2	-0.1

From table 3 it also appears that the carbon/energy tax would be effective in reducing the polluting activities. Table 4 confirms this. Domestic sales of energy products would considerably decrease after the introduction of the carbon/energy tax and CO_2 emissions would drop by 16% in the long run.

Table 3: CO_2 Emissions

Year 1	Year 6	Year 11	Year 16	Year 21	Year 26	Year 31
-5.0	-9.8	-16.0	-16.2	-16.1	-16.1	-16.0

Table 4: Domestic sales (variation in % to benchmark)

	Year 1	Year 6	Year 11	Year 16	Year 21	Year 26	Year 31
Agriculture	0.4	0.8	0.1	-0.2	-0.1	-0.2	-0.1
Coal	-9.5	-25.5	-41.3	-41.7	-41.7	-41.7	-41.7
Crude oil	-5.7	-9.5	-14.4	-14.3	-14.2	-14.1	-14.1
Natural gas	-8.2	-13.6	-21.2	-21.3	-21.2	-21.2	-21.2
Refined oil	-3.1	-7.3	-13.0	-13.2	-13.1	-13.1	-13.1

Electricity	-8.2	-13.1	-19.1	-19.3	-19.3	-19.3	-19.2
Energy intensive	-1.7	-1.2	-2.1	-2.6	-2.5	-2.6	-2.5
Other	0.3	0.9	0.3	-0.1	0.0	-0.0	0.1

This reduction in domestic energy sales is of course explained by the fall in energy demand (see tables 5 and 6) by firms and households following the considerable rise in after-tax energy prices.

Table 5: Energy use by non-energy sectors (variation in %)

	Year 1	Year 6	Year 11	Year 16	Year 21	Year 26	Year 31
Agriculture	-3.1	-11.3	-21.9	-22.2	-22.1	-23.1	-22.1
Energy intensive	-7.2	-14.9	-24.6	-24.9	-24.8	-25.0	-24.7
Other	-2.9	-12.5	-23.7	-23.8	-23.8	-24.5	-23.7

Table 6: Consumption demand (variation in %)

	Year 1	Year 6	Year 11	Year 16	Year 21	Year 26	Year 31
Food	0.3	0.6	0.6	0.4	0.5	0.5	0.5
Energy	-8.7	-8.2	-7.9	-8.0	-7.9	-7.9	-7.9
Transp & commun	-0.9	-0.3	-0.4	-0.6	-0.5	-0.5	-0.5
Other	0.5	1.1	1.0	0.6	0.7	0.7	0.8

Results presented above clearly indicates the effectiveness of a tax policy in reducing pollution and energy consumption. This may be considered as the first dividend. What about the second?

It appears from the simulation results that a second dividend may indeed be obtained from environmental taxes. Table 7 reproduces the evolution of the unemployment rate.

Table 7: Unemployment rate in % (benchmark 11%)

Year 1	Year 6	Year 11	Year 16	Year 21	Year 26	Year 31
10.8	8.6	8.8	9.8	9.7	9.8	9.8

A cut in social security contributions financed by the carbon/energy tax produces a favourable impact on unemployment. This policy generates initially a very small effect on employment. The unemployment rate declines by only 0.2 points after the introduction of a tax of $10 per barrel of oil equivalent. It diminishes by 2.4 points after 5 years and by 2.2 points after 10 years. But the trade-off is rather small in the long run (-1.2 points). This is explained by two interesting factors:

— The introduction of a carbon/energy tax produces considerable amounts of tax revenue at the beginning given that firms have very small possibilities of substitution in the very short run between energy sources and between capital and energy. So the reduction in the social security contributions will be important in the short run. But in the long run firms proceed to the necessary substitutions in order to reduce their tax liabilities. This means that the carbon/energy tax revenue and the reduction in the social security contributions declines in time, and the incentive to substitute labour to capital falls in the long run.

— In addition to this first element, a second factor is at work. We observe an upward push on real wages with the reduction in unemployment (see table 13). The rise in real wages put a brake on labour demand, whereas the labour supply continues to increase. This shows that the government has to supplement the carbon/energy tax policy with income policies in order to moderate real wage increases which can reduce labour demand.

Table 8: Sectoral employment (variation in % to benchmark)

	Year 1	Year 6	Year 11	Year 16	Year 21	Year 26	Year 31
Agriculture	0.6	2.9	2.4	1.3	1.4	1.2	1.3
Coal	-7.4	-23.9	-40.4	-41.1	-41.0	-41.1	-41.0
Crude oil	-0.2	-3.7	-7.7	-6.6	-6.5	-6.1	-6.0
Natural gas	-3.7	-9.7	-18.1	-18.1	-18.0	-17.9	-17.9
Refined oil	-6.8	-10.7	-15.9	-15.9	-15.9	-15.9	-15.8
Electricity	-6.3	-1.5	0.8	-0.3	-0.2	-0.3	-0.2

Energy intensive	-3.1	3.1	7.0	5.9	6.0	5.8	5.9
Other	1.2	3.5	3.3	2.3	2.4	2.2	2.3

Table 9: Capital use (variation in % to benchmark)

	Year 1	Year 6	Year 11	Year 16	Year 21	Year 26	Year 31
Agriculture	0.3	1.6	2.7	2.6	2.7	2.7	2.8
Coal	-7.4	-23.9	-40.4	-41.1	-41.0	-41.1	-41.0
Crude oil	-0.2	-3.7	-7.7	-6.6	-6.5	-6.1	-6.0
Natural gas	-3.7	-9.7	-18.1	-18.1	-18.0	-17.9	-17.9
Refined oil	-6.8	-10.7	-15.9	-15.9	-15.9	-15.9	-15.8
Electricity	-6.9	-6.6	-5.9	-5.7	-5.7	-5.6	-5.5
Energy intensive	-3.7	-1.6	1.1	1.2	1.3	1.4	1.5
Other	0.6	0.5	0.8	1.0	1.1	1.2	1.3

Tables 10 and 11 confirm the importance of international co-ordination in environmental policies. Without this co-ordination the European Union would have to face drastic disruption in its foreign trade flows. Given considerable changes in the domestic relative price structure (see table 12) and increases with respect to the world prices which remain constant without policy co-ordination, exports would significantly decrease in agriculture, energy intensive industries, refined oil and electricity sectors. Imports would substantially increase in these sectors.

Table 10: Imports (variation in % to benchmark)

	Year 1	Year 6	Year 11	Year 16	Year 21	Year 26	Year 31
Agriculture	3.0	3.8	3.8	3.3	3.4	3.2	3.3
Coal	-14.7	-27.9	-40.2	-40.1	-40.0	-40.0	-40.0
Crude oil	-7.2	-10.8	-15.7	-15.9	-15.9	-15.9	-15.8
Natural gas	-12.7	-17.1	-23.4	-23.6	-23.6	-23.7	-23.7
Refined oil	11.5	7.0	-0.8	0.4	0.5	0.4	0.4
Electricity	82.9	70.8	57.7	57.4	57.5	57.3	57.4
Energy intensive	7.5	8.2	8.3	8.1	8.2	8.2	8.3
Other	-2.1	-0.5	1.0	1.0	0.9	1.0	1.0

Table 11: Exports (variation in % to benchmark)

	Year 1	Year 6	Year 11	Year 16	Year 21	Year 26	Year 31
Agriculture	-4.3	-4.9	-6.0	-5.7	-5.7	-5.5	-5.5
Coal	6.0	3.3	-1.8	-2.7	-2.7	-2.8	-2.7
Crude oil	4.6	4.3	4.5	5.7	5.7	6.1	6.1
Natural gas	7.2	5.9	4.0	4.3	4.4	4.6	4.6
Refined oil	-12.3	-12.5	-12.9	-12.7	-12.7	-12.6	-12.6
Electricity	-40.6	-40.0	-39.6	-39.6	-39.6	-39.6	-39.6

Energy intensive	-14.1	-14.4	-16.0	-16.4	-16.4	-16.4	-16.4
Other	2.6	1.5	-0.7	-1.1	-1.0	-1.0	-1.1

Table 12: Domestic prices (variation in % to benchmark)

	Year 1	Year 6	Year 11	Year 16	Year 21	Year 26	Year 31
Agriculture	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coal	-3.3	-2.7	-1.4	-1.0	-1.0	-1.0	-1.0
Crude oil	-2.9	-3.0	-3.4	-3.3	-3.7	-3.8	-3.8
Natural gas	-3.7	-3.5	-2.3	-3.3	-3.3	-3.3	-3.3
Refined oil	3.0	2.8	2.6	2.6	2.6	2.6	2.6
Electricity	17.2	16.6	15.9	16.0	16.0	16.0	16.0
Energy intensive	3.7	3.6	3.8	4.1	4.1	4.2	4.2
Other	-2.7	-2.4	-1.7	-1.4	-1.4	-1.4	-1.4

Table 13: Miscellaneous variables (variation in % to benchmark)

	Year 1	Year 6	Year 11	Year 16	Year 21	Year 26	Year 31
Real GDP	-0.0	1.2	0.9	0.4	0.5	0.5	0.6
Real disposable income	-0.4	0.2	0.1	-0.1	-0.1	-0.1	-0.0
Real capital income	-2.1	-2.4	-3.4	-3.9	-3.8	-3.8	-3.7
Real transfers	-0.2	-2.6	-2.4	-1.3	-1.4	-1.2	-1.3
Real wage	0.7	2.1	2.7	2.6	2.7	2.8	2.8
Real return to capital	-2.1	-2.6	-3.8	-4.4	-4.4	-4.5	-4.2
Wage/return to K	1.029	1.048	1.067	1.073	1.074	1.076	1.077
Real savings	-0.6	0.5	0.3	-0.2	-0.0	-0.1	0.1
Labour supply	0.2	0.3	0.3	0.4	0.4	0.4	0.4

4. Conclusion

The double dividend issue has recently been widely debated in Europe. The simulation results from EUROGEM broadly confirms the results obtained elsewhere. A carbon/energy tax would indeed be effective in reducing carbon dioxide emissions in the medium-run. But a tax rate equivalent to $10 per barrel of oil would be insufficient to achieve the goal of stabilising CO_2 emissions. In order to stabilise or reduce pollution, the government would have to increase the tax rate in time. This would have tremendous effects on the structure of production in Europe and on international trade patterns. International policy co-ordination is therefore indispensable in this field.

As to the second dividend, there seems to be no ground for great optimism, either. The very particularity of a carbon/energy tax is that the tax base should gradually diminish as firms and households switch to less polluting energy sources and reduce their energy consumption. This means that the tax revenues recycled to reduce the social security contributions would also diminish in time, and firms would have less incentives to substitute labour to capital and energy. On the other hand, even if unemployment would decrease in the medium-run, real wages and labour supply would increase, putting a break on or even reversing the process. These factors which influence both labour supply and labour demand would reduce the effectiveness of an environmental policy to reduce unemployment in the long-run if it is not combined by an income policy.

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