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Economic Impacts of the 1997 EU Energy Tax: Simulations with Three EU-Wide Models

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Abstract. In March 1997 the European Commission adopted a proposal that increases existing minimum levels of taxation on mineral oils by around 10 to 25% and introduces excises for other energy products. This paper analyses the macroeconomic impacts of the proposal. It employs three models: HERMES, GEM-E3, and E3ME. All models confirm that the proposal will have positive macroeconomic impacts when the tax revenues are used to reduce social security contributions paid by employers. For the EU as a whole, both GDP and employment are expected to be higher and CO_2 emissions are 0.9 to 1.6 percent lower. The positive EU-wide effects can be observed in practically all member states. The sector impacts are modest, with the energy sector expected to face the most negative impacts. Differences between model results are due to the model type (general equilibrium or macro-econometric), the EU countries covered and the way tax exemptions were handled. Crucial assumptions to obtain the "double dividend" are the modelling of the labour market and the impacts on EU external trade. The sensitivity of the results for the use of tax revenues, tax exemptions and tax rate increases is assessed.

Key words: carbon dioxide, double dividend, employment, energy tax, EU, environmental policy

JEL classification: H30, Q25, Q48

1. Introduction

In March 1997, the European Commission adopted a proposal for a directive restructuring the Community framework for the taxation of energy products (European Commission 1997a and 1997b). The motivation for the proposal is threefold. Firstly, it updates an older directive (92/82/EEC) which sets minimum excise rates for mineral oils. The revision is mandated in the old directive and also follows the observation that the existing minimum excise rates are no longer in line with general developments in energy taxation. For motor fuels in particular, the minimum rates constitute only a fraction of the lowest actual rate. For this reason, the existing rates no longer contribute to the better functioning of the internal market. Secondly, the Commission was asked by the European Council to put forward a new proposal in the field of energy taxation, as a consequence of the political blockage of the existing CO_2/energy tax proposal of May 1995 (European Commission 1995a). Thirdly, following requests by the European Parliament and the Economic Committee, the Commission is trying to put the system of minimum excises into a more coherent framework. The aim of the proposal is to strengthen the internal market. In addition, it encourages member states to shift the burden of taxation away from employed labour towards the use of energy. Under the new proposal, the Community minimum levels of taxation on mineral oils are revised upwards and minimum levels are introduced for energy products other than mineral oils. The proposal contains mandatory and optional exemptions for energy intensive industries.

The Directive is thus a practical attempt to attain a "double dividend": a cleaner environment and a less distortionary way to raise taxes with the aim to increase employment. The existence of a double dividend depends on whether the efficiency losses caused by the tax interaction effect of increasing taxes (raising output prices and reducing real wages and labour supply) are outweighed by the revenue recycling effect of reducing other taxes and the Pigovian effect of reduced environmental damages. In theory the results seem to depend mainly on the following key factors (Carraro and Sinisalco 1996; Bovenberg 1997; Goulder et al. 1997):

- how tax revenues are recycled (towards the undertaxed production factor, to those inside or outside the labour force (on skilled or unskilled labour));
- substitution possibilities (one/more production factors);
- pre-existing labour tax rates (degree of existing inefficiency);
- labour supply elasticity (higher elasticity implies a greater substitution between consumption and leisure in response to real wages rates and larger tax effects).

The more empirically oriented literature (Majocchi 1996; Hourcade et al. 1998; Repetto and Austin 1997) finds that the existence of a double dividend depends critically on:

- model type (dynamic/static: CGE/optimisation or Keynesian);
- ways of returning tax revenues (lump sum, reducing indirect taxes and who pays (workers, non-workers, skilled/unskilled));
- scope for substitution (production factors, number of sectors and energy sources, capital stock treatment);
- labour's market adjustments (wage price dynamics, wage indexation and labour supply elasticity);
- tax shock compared to the baseline and pre-existing labour tax rates;
- treatment of international trade and financial flows (i.e. of unilateral domestic actions).

In addition to these factors, the effect of reduced environmental damage (both as primary and secondary or auxiliary benefits) is relevant but usually not captured in theoretical or empirical assessments.

Against this background this paper analyses the macroeconomic and sectoral impacts of the Commission's proposal based on the results of three EU-wide model simulations, using the models HERMES, GEM-E3, and E3ME. The results are new since for the first time three different multi-country models are employed with detailed sector splits to analyse the same policy and the results are based on actual rather than theoretical tax proposals. In describing the results, the paper will critically analyse the results obtained as well and the underlying assumptions to gain insights on the "if and when" of "double dividends". The paper has the following structure. Section 2 summarises the proposed directive. Section 3 provides a description of the three models. Section 4 presents detailed results for the EU as a whole, for specific EU countries and sectors, and sketches the mechanisms through which the proposed tax changes will affect the overall economies. This means that the paper also evaluates the sensitivity of the results for changes in the assumptions on how member states react, on how revenues are recycled and on whether or not energy-intensive industries are exempted. Section 5 concludes.

2. The Proposed Directive

The proposed directive attempts to strike a balance among at least six policy objectives: 1. Deepening of the Internal Market; 2. Enabling flexibility in the tax structure among member states; 3. Protection of the environment; 4. Movement towards sustainable transport; 5. Preservation of Europe's international competitiveness; and 6. Enabling tax reform to reduce unemployment.

For this purpose, the new proposal contains the following four key elements. Firstly, tax adjustments take place on a broader base than in the previous directive. The scope of the tax is extended from being geared solely towards mineral oils and is expanded to include more products.

Secondly, the proposal contains a three-step phase-in of increased rates to increase planning security. Table I shows that the proposal contains three rates for each energy type. One valid from 1.1.1998, one from 2000 onwards and one from 2002. The 2002 step is not mandatory but indicative. For transport, the existing rates for gasoline (leaded and unleaded), diesel, kerosene, and LPG are adjusted upwards. The adjustment contains three components. Firstly, there is a simple inflation adjustment (old rate times GDP deflator). In addition, the minimum excise rate is increased across the board by the same absolute amount (50 ECU per 1000 litres). The proposal is intended to reduce by a small amount (economically unjustified) preferential treatment, in particular of diesel vis-à-vis gasoline. Thirdly, the separate (lower) tax category for unleaded gasoline disappears. Fuels used in industry (diesel, kerosene, LPG) are already taxed in the existing directive. The tax for LPG will be adjusted for inflation only; those for gasoline and kerosene will be brought into line to reflect energy content. For fuels used for heating purposes, relatively small adjustments are proposed for the rates for heavy heating oil and diesel, which are already part of the excise system. However, more products will be included, notably coal and natural gas, but also kerosene, liquefied petroleum gas (LPG), lignite, anthracite and peat. These will be taxed according to their energy

Table I. Proposed minimum level of taxation (ECU per specific unit).

	Unit	Existing national rates	Existing EC-minima	1998	2000	2002
Motor fuels						
Petrol	kl	366–583	337	417	450	500
Gas oil	kl	254–458	245	310	343	393
Kerosene	kl	–	245	310	343	393
LPG	tn	–	100	141	174	224
Natural gas	Gj	–		2.9	3.5	4.5
Motor fuels used for certain industrial and commercial purposes Article 7, paragraph 2						
Petrol	kl	–	18	32	37	41
Kerosene	kl	–	18	30	35	39
LPG	tn	–	36	41	48	53
Natural gas	Gj	–		0.3	0.6	1.1
Heating fuels						
Heating gas oil	kl	5–390	18	21	23	26
Heavy fuel oil (low-sulphur <1%)	tn	6–37	13	18	23	28
Heavy fuel oil (high sulphur >1%)	tn	14–47	13	22	28	34
Kerosene	kl	–	0	7	16	25
LPG	tn	–	0	10	22	34
Natural gas	Gj	6–50		0.2	0.45	0.7
Solid fuels	Gj	–		0.2	0.45	0.7
Electricity	MWh	1–15		1	2	3

– = no data available

equivalent (0.7 ECU per Gigajoule in 2002). For electricity production, a minimum excise level is introduced at 1 ECU per MWh. Derogation's are possible for electricity from renewable energy. Table I shows that the proposed rates increase the existing minimum rates by 10 to 25% for the most important fuels. It also makes clear that the proposed rates are not always higher than existing national rates.

Thirdly, the proposal foresees mandatory and optional tax derogation's. Mandatory exemptions are the following. Enterprises whose non-transport energy costs constitute more than 20 percent of production costs are to be exempted from taxes paid on energy consumption beyond 10 percent of their production costs. However, in any case total taxes paid must be at least equal to 1 percent of sales. In addition, feedstocks, inputs for electricity production (unless the tax is introduced for environmental purposes), and commercial aviation will not be taxed. Non-mandatory exemptions can be total or partial. The proposal permits member states to reimburse completely or partially taxes paid for energy consumption exceeding 10 percent of production costs. Exemptions or lower rates are also possible for renewable energies (such as hydropower, solar, wind, biomass), environmentally benign transport (rail, inland shipping), and for investment in energy saving technologies.

Finally, the proposal permits member states to differentiate taxes on environmental grounds by means of a simple information procedure with the European Commission, as long as the applied tax rate stays above the minimum excise rate. A country can, for example, apply different rates for high and low sulphur fuels.

3. The Models Used

Three different macroeconomic models were employed to assess the economic impacts of the directive: HERMES (Harmonised European Research for Macrosectoral and Energy Systems), GEM-E3 (General Equilibrium Model for Economy-Energy-Environment), and E3ME (Energy-Environment-Economy Model for Europe). While having a number of points in common, these models cover a broad scope of economic modelling approaches, thus allowing insights into the robustness of the results obtained.

The choice of these particular models reflects the fact that they fulfil a dual need. Firstly, all three contain detailed modules for the energy sector. As the proposal will not affect all energy carriers and sectors alike, this is evidently crucial for an analysis. Furthermore, this disaggregation allows the impact of the directive on CO_2 emissions in particular to be assessed. Secondly, all three are macro-economic models covering a number of EU countries. E3ME is a macro-econometric model, HERMES consists of macro-econometric country models that are linked, and GEM-E3 is a computable general equilibrium model. This means that they are able to integrate economic feedback mechanisms. This is particularly important in the context of tax analysis, because it is clear from the ongoing discussion on the existence of a "double dividend" that the tax shifting effect is as important as the tax interaction effect.

Beyond these similarities, there are a number of differences in the model structure that are summarised in Table II. This paragraph describes those characteristics of the model that are most important for determining the existence of a double dividend:

- model type;
- scope for substitution;
- labour market adjustments;
- treatment of international trade and financial flows;
- ways of returning revenues (plus handling exemptions);
- tax shock compared to the baseline.

The first four elements are part of the "hardware" of the model. The last two points are more specific to the proposed policy and will therefore be described in section 4 of this paper.

Table II. Key characteristics of the three models.

Feature	HERMES	GEM-E3	E3ME
Type	Linked econometric models	Dynamic general equilibrium	Econometric sectoral
Sectors	9	18	30
Energy products	8	4, more detailed pre-analysis run with MIDAS[a]	11
No. of EU countries included	EU-6[b]	EU-14[c]	EU-11[d]
Labour market	Nominal wages indexed to inflation, depend on unemployment (Philips curve) and (depending on the country) productivity[e]	Real wage rate depends on demand and slope of supply curve with relatively high wage rate elasticity of supply[f]	Real wage rate depends on unemployment rate, prices and productivity[g]
Handling of exemptions	Intermediate goods in all countries	Metals, chemicals, other energy intensive industries, differentiated by country, if energy costs >10%.	Various energy-intensive industries; rail, air navigation; electricity inputs; gas in PO, ES.

[a] MIDAS is an energy-system planning and forecasting model covering the whole energy system, including energydemand, by sector and fuel, imports and energy-market prices. It includes all EU-countries separately.

[b] Belgium, France, Germany, Italy, the Netherlands and the UK.

[c] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain,Sweden and the UK

[d] Belgium, Denmark, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and UK

[e] Bossier et al. (1997)

[f] Labour supply depends on utility-maximising consumer behaviour, including free time

[g] European Commission (1995b)

HERMES is a macrosectoral econometric model (Italianer et al. 1993; Bossier et al. 1995, 1997). It is a dynamic, annual model used for making short and medium term forecasts (two to eight years). The model is "neo-keynesian"; short-term dynamics depend on final demand affecting production and production capacity utilisation rates. These in turn influences the supply side such as production price determination, allocation of production factors, energy products, consumer products and imports. In terms of dynamics, business cycle data and utilisation rate influence investment and employment with certain time lags. Price elasticities are higher on the long run due to the "putty-clay" energy production function used. In terms of substitution, the production functions distinguish vintages locking in output technologies once investment has been made. The production function comprises 3 to 4 factors (energy, capital, labour and intermediate demand). Energy and capital are complementary and together act as supplement for labour. The model has nine sectors. Eight energy products are covered: coal, coke, crude oil, petroleum products, natural gas, derived gas, electricity and other forms of energy. Labour supply is related to employment variations within specific sectors. Labour supply increases if employment goes up (encouraging workers to demand jobs). The model is particularly sensitive to the Philips curve effect. Nominal wages are indexed to consumer prices of the current and previous year as well as productivity changes. The model incorporates similar models for six EU countries, linked by bilateral trade flows. All in all, 19 countries or zones are included (including remainder of the EU, the United States and Japan). International trade and financial, bilateral flows are partly covered. Foreign trade is linked to (endogenous) world demand and competitive prices. Exchange rates (as well as interest rates) are exogenous.

GEM-E3 is a computable general equilibrium model for European Union member states that links the macro-economy with details of the interaction with the environment and the energy system (Capros et al. 1996 and 1996a; Capros et al. 1997; Capros and Georgakopoulos 1997). The model calculates the equilibrium prices of goods, services, labour and capital that simultaneously clear all markets following the Walras law. It is a multi-period model, involving dynamics of capital accumulation and technological progress. This process is sector specific through investment and scrapping. GEM-E3 is an optimisation model with equilibrium with closure through the rate of return for investment. If rates of return on capital are lower than expected, sectoral capital stocks are scrapped until a steady-state solution is approached (with equal sectoral rates of return). It includes 18 sectors and different economic agents. The model covers four energy products: solids, oil, gas and electricity. For this study GEM-E3 was exogenously linked to MIDAS to supply more detail. MIDAS is an energy-system planning and forecasting model covering the whole energy system, including energy demand, by sector and fuel, imports and energy-market prices. The labour market is influenced by the slope of labour supply (decided by households together with leisure and consumption). This model version has a relatively high real wage elasticity of labour supply. Supply is not totally elastic reflecting the bargaining power of those employed. GEM-E3 includes 14 EU-countries. The multi-country model treats each of the 14 EU member states separately and links them through endogenous bilateral trade of goods and services. The exchange rate is fixed. Exports by the EU to the rest of the world depend on relative prices. Imports by the EU are satisfied without constraints (EU is a non-price maker in exports and price-taker in imports). The behaviour of the rest of the world is exogenous.

E3ME is a regionalized, sectoral model of the EU (Barker 1998 and 1998a; Barker and Gardiner 1996; Cambridge Econometrics and Chambre de Commerce et d'Industrie de Paris 1997). It is a disaggregated time-series cross-section econometric model. It differs from other econometrics models (such as HERMES) however since it is capable of aggregating equation estimates and results to a European level. In terms of substitution possibilities energy demand depends on relative energy prices. In contrast to energy price increases relative prices decreases have no effect since the capital stock is in place and technical change is not reversible. The model covers 30 sectors. The energy products included are coal, heavy fuel oil, gas, electricity and other forms of energy. The model covers 11 EU countries. The demand for labour is influenced by: output, real labour costs, average hours worked, energy prices and technical progress. Technical progress depends on gross investments and changes in R&D stocks. Wage rates are set in a bargaining process. The real wage depends on the wage in other industries in the same region, wage rates in other regions in the same industry, as well as the unemployment rate. Trade is treated as taking place within a European "pool" rather than bilateral. Trade volumes depend on income and relative prices. Certain commodities, such as crude oil, have prices set exogenously, but the majority of prices are set by producers as mark-ups on costs in oligopolistic markets. Exchange rates and interest rates are fixed.

4. Results

4.1. Introduction

An evaluation of the proposed changes in the EU framework for taxing energy products depends on the response of member state governments. Formally, the proposal implies a mandatory increase in the level of indirect taxation on energy products in those countries where the new minimum levels of taxation are higher than the existing tax rates. However, an economic analysis cannot limit itself to the formal regulatory requirements, but needs to make assumptions in three key areas: size of the tax shock, way of using revenues and the handling of tax exemptions.

The first assumption concerns how member states will adapt their tax rates to the new minimum level proposals. Two extreme possibilities can be envisaged. Firstly, member states implement only what is strictly required by the new minimum rates: the tax increase is the difference between the nominal rates in the proposal and the national rates adjusted for inflation. Secondly, insofar as tax competition might have constrained the tax rates of individual member states, it could be conceivable that an increase in the minimum rates would lead to a proportionate increase in existing levels of taxation, even if they are already above the existing minimum rates. This would leave relative tax differentials among member states in each product group constant. The results presented below generally abstract from this possibility. It is assumed that only those tax increases that are compulsory take place, because any further tax increases cannot be directly attributed to the proposed directive and fall within the realm of member states' sovereignty.

The second assumption concerns the purpose for which member states will use the additional revenues. In principle, member states could use the revenues to reduce budget deficits or they could recycle the revenues and for example reduce taxes elsewhere. The economic simulations consider mainly that the revenues are used to decrease social security contributions paid by employers. The proposed directive clearly suggests fiscal neutrality in the member states and the use of revenues to reduce labour costs. This follows established Community goals to alleviate the tax burden on labour. The EU-wide impact of using tax revenues to cut the budget deficit is, however, also briefly summarised.

A third assumption pertains to the question of derogations for energy-intensive industries. The directive is clear about the criteria according to which enterprises qualify for such a derogation. However, for a macro-economic evaluation a problem arises because modelling takes place not at the level of firms but at the level of sectors. Sectors encompass a large number of very heterogeneous enterprises, some of which might qualify for a derogation while others do not. As the sectoral definitions of the three economic models differ, this effectively means that every research team had to handle this question in a somewhat different manner (see Table II).

In the remainder, the analysis will mainly focus on the results for the case where Member States adapt their levels to exactly meet the minimum rates proposed, tax revenues are recycled to cut social security contributions paid by employers (as proposed in the directive) and the tax exemptions for energy intensive industries apply. Firstly, EU wide impacts are described. Secondly, country specific results are given. Thirdly, sector specific results are discussed and compared. Finally, the sensitivity for changes in the assumptions on how member states react, how revenues are recycled and of exempting energy intensive industries are also discussed.

4.2. EU-WIDE RESULTS WITH RECYCLING TO REDUCE SOCIAL SECURITY CONTRIBUTIONS

Given the differences in the nature of the models, it would be surprising to arrive at identical projections concerning the impact of the proposed directive. Nevertheless, a look at the summary results in Table III (showing results for 2005) reveals that, for the EU as a whole, relatively solid conclusions can be drawn. All figures presented below are in comparison to a baseline scenario, where current tax levels change with the level of inflation over the analysis period.

Firstly, in absolute terms, all impacts are relatively small. The size of the economic "shock" of the tax adjustment stays well below what under normal circumstances is a measurable impact. Secondly, despite its relative smallness, the impact of the proposal on GDP is positive, and lies between 0.02 and 0.20 percentage points. In absolute terms the figures correspond to an EU-wide increase in annual GDP between ECU 1.6 and 16.2 billion. Thirdly, the inflationary shock (measured in terms of consumer price changes) is small. Fourthly, the proposal has a small but positive impact on employment. Estimates are between 146.000 and 335.000 jobs created. Finally, the relative increase in energy taxes leads to an EU-wide reduction in CO_2 emissions of 0.9 to 1.6 percent compared to the baseline. The emissions of a number of other pollutants (such as sulphur dioxide, nitrogen oxides and particulate matter) will also decrease, so that secondary benefits can be expected.

Table III. Summary of EU-wide model results in the year 2005.[a]

	HERMES	GEM-E3 (2004)	E3ME
GDP	+0.06%[b]	+0.02%	+0.20%[b]
Consumer prices	+0.04%	+0.08%	+0.10
EU-15 employment	+146,000[c]	+155,000	+335,000[d]
Real wages	+0.12%	+0.40%	+0.1%
Energy consumption	−0.52%	−0.89%	−0.70%
CO_2	−1.6%	−1.47%	−0.87%

[a] In percent change from baseline unless defined otherwise.
[b] Not all member states are included.
[c] Not all member states are included.
[d] The model results for employment have been scaled up. In doing so it is assumed that omitted countries experience the same effect as the average of those included in the model.

The models also provide results for the impact over time (see Figure 1). The E3ME model shows that both GDP and employment steadily increase over time, reaching their highest level in 2010, reflecting the gradual increase in tax rates. A similar trend can be observed from the results of the HERMES model. According to the GEM-E3 model, the positive impacts on GDP and employment level off in 2002 (when tax rates are no longer increased) to remain more or less stable over time. The higher substitution possibilities in GEM-E3 than in the two other models ensures that a stable solution is reached rather quickly. This is a typical characteristic of CGE models compared to macro-models.

Clearly, the net results point to a net improvement in Europe's economic performance (GDP), while contributing to a mitigation of two important problems: unemployment and environmental problems. The results thus confirm the possibility of a "double dividend". Two key elements can be distinguished to explain these results.

One impact of taxation is on the structure of the economy. As the tax makes energy consumption relatively more expensive and the employment of labour cheaper, the economy as a whole becomes more labour-intensive and less energy-intensive. Consequently, energy consumption (volume) decreases and CO_2 emissions decrease as well. A secondary effect of this labour-energy substitution is a shift in the sectoral structure of Europe's economy.

A second impact of the energy tax (given the assumed recycling) is to increase, on balance, economic growth. This is the result of two factors working in opposite directions. Firstly, the increased energy costs reduce disposable household income and reduce the competitiveness resulting from the rise in production costs. Secondly, the use of tax revenues counteracts the negative impact the tax increase would otherwise have. As the government uses the revenues to reduce social security contributions paid by employers, it stimulates the economy by making labour

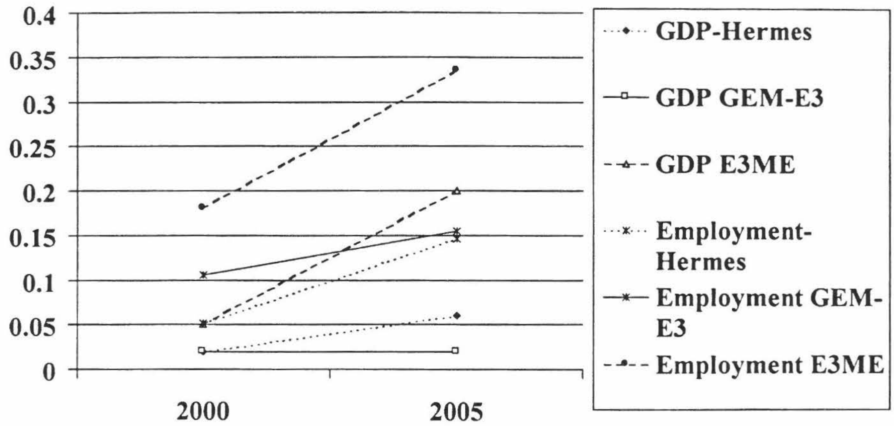

Figure 1. Impacts over time (% for GDP and 1 million person years for employment).

cheaper and reinjecting income into the economy. This partially offsets the reduction in CO_2 emissions resulting from the energy tax increase. The reduced labour costs increase the substitution in favour of labour, thus increasing employment. The rise in employment and the indexation of wages to inflation (or the increased demand for labour itself) gradually lead to real wage increases, a rise in private consumption and economic activity.

While some very energy-intensive industries may find themselves having to pay higher taxes, the revenue recycling reduces production costs for the economy as a whole. To explain this, it has to be kept in mind that only a minor part of the increased tax burden falls on industry itself. More than two thirds of the tax revenue arises from taxation of products used by households. By contrast, the revenue recycling benefits mostly industry, which now enjoys lower wages (gross of taxes). This means that, on average, the reduced wage bill more than compensates the increased energy taxes. These reduced production costs imply that the proposal (including recycling) poses no threat to international competitiveness of the European economy as a whole, although some sectors will face a small loss in competitiveness.

To recapitulate, the increase in energy prices coupled with a reduction in labour costs implies that labour substitutes energy but also capital (technology shift or supply side effects). On the demand side, the impact on the production costs differs per sector due to different labour and energy intensities. After production cost changes have been reflected in prices, changes in final and intermediate demand will occur. Increases in real wages increase consumption, but investments and exports shrink. Imports decrease slightly. In sum, the positive impacts on demand are found to be greater than the negative impacts from trade, and consequently overall GDP is higher.

The combined impact of increased energy prices and increased GDP leads to a net decrease in energy consumption of 0.5 to 0.9% in 2005 (depending on the model) which causes CO_2 emissions to decline. This also leads to a small reduction in the tax base over time. In the GEM-E3 model the related reduction in social security contributions is adjusted downward ex-post so as to keep the public deficit unaffected. In the HERMES model this is not the case and the budget deficit slightly increases over time (+0.02%), which partially explains the more positive impact on GDP. In the E3ME model a similar procedure is followed as in HERMES.

In spite of the similarities in results these are also significant differences especially between GEM-E3 on the one hand and both HERMES and E3ME on the other hand. The differences in results between HERMES and E3ME are mainly caused by the fact that HERMES covers only 6 countries and especially does not cover Spain and Ireland that would face high energy tax increases under the proposal. This is amplified by the absence of resulting indirect effects through EU-trade on other countries.

The major difference, however, is between GEM-E3 on the one hand and both E3ME and HERMES on the other hand. This can be explained by the model type and the substitution possibilities. The higher substitution possibilities in GEM-E3 than in E3ME are part of the explanation for this. This is a general feature of general equilibrium versus econometric models (Repetto and Austin 1997). In addition, feedbacks between output, consumption and investment are weaker in GEM-E3 so that the increase in GDP in E3ME (and HERMES) is more significant. The fact that HERMES gives exemptions to more sectors than the other models and covers less countries implies that overall effects are smaller than for both other models.

4.3. COUNTRY RESULTS FOR THE BASE-CASE

Figures 3 and 4 and Table IV provide more detailed modelling results for individual countries for the base-case/tax increase assumption which taxes increasing up to rates proposed by the Commission. Unfortunately, no model includes all 15 Member States. However, the overall results are fairly consistent across models. The EU-wide effects for the case of reducing labour costs can be observed in practically all Member States. The differences between the countries mainly reflect the *ex ante* differences in the energy tax increases. Figure 2 clearly shows that the energy tax revenues as % of GDP are fairly small for countries such as Denmark, Italy, and the Netherlands, where initial energy tax rates are already relatively high. The initial impulse and the subsequent effects are higher for countries such as Belgium, Ireland, Spain and United Kingdom that have relatively low energy tax levels.

E3ME effects are an order of magnitude larger than those of the other two models, but the model shows less effect on CO_2 emissions for all countries since GDP growth cancels out part of the reduction of CO_2 emissions. Also, E3ME shows more of a phase-in of the effects, while the impact in GEM-E3 is practically

Table IV. Consumer price and CO_2 changes (percentage change from baseline).

Country	Consumer price			CO_2 emissions		
	HERMES (2005)	GEM-E3 (2004)	E3ME (2005)	HERMES (2005)	GEM-E3 (2004)	E3ME (2005)
Austria		0.12			−0.76	
Belgium	0.14	0.25	0.30	−1.51	−3.19	−1.47
Denmark		0.00	−0.02		−0.14	−0.30
Finland		0.18			−1.14	
France	0.09	0.03	0.06	−2.14	−0.63	−2.70
Germany	0.07	−0.01	−0.06	−1.63	−1.28	−0.97
Greece		0.05			−0.43	
Ireland		0.19	0.41		−3.16	−1.23
Italy	−0.30	−0.06	0.00	−1.33	−1.49	0.06
Luxembrg.			−0.01			−1.51
Netherlands	0.11	−0.10	0.01	−0.81	−0.05	−0.87
Portugal		−0.01	−0.02		−1.46	−0.49
Spain		0.13	0.52		−1.56	0.54
Sweden		0.13			−0.41	
UK	0.27	0.41	0.23	−2.16	−2.68	−1.42
EU average	0.04	0.08	0.10	−1.60	−1.47	−0.87

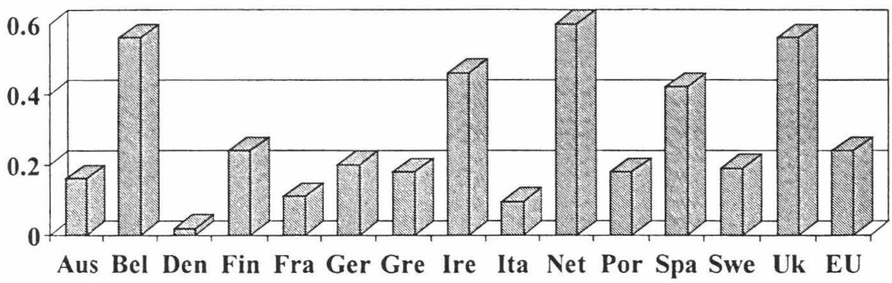

Figure 2. Tax revenues (% of GDP in 2005).

instantaneous. However, the latter can be attributed largely to the characteristics of computable general equilibrium models that tend to overestimate the short-term impacts.

For some countries (Austria, Belgium, the Netherlands) (Figure 3) GEM-E3 and E3ME predict a small net negative impact on GDP in 2005. The GEM-E3 model, for example, shows negative results for Belgium, because the energy tax increase in this country is higher than the EU average, which leads to a loss of competitiveness and export volume which overcompensates the increase in domestic demand resulting from increased private consumption. This negative impact also appears

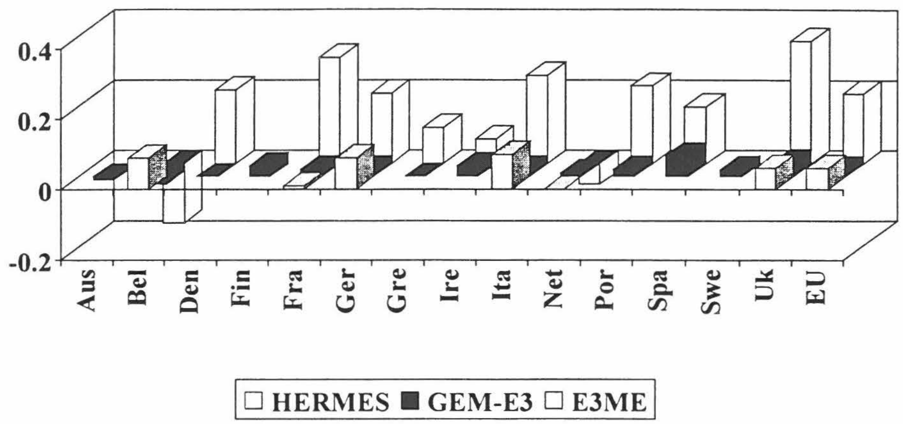

Figure 3. Impacts on GDP (% from baseline in 2005).

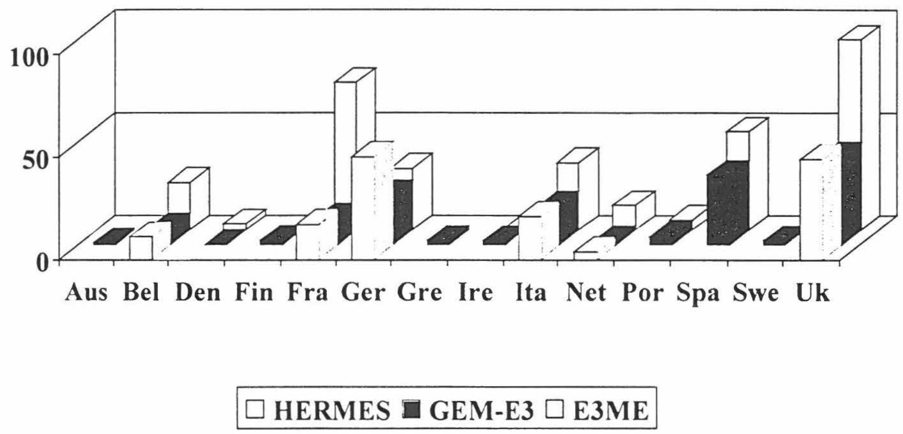

Figure 4. Impacts on employment (in 1000 person years in 2005).

in E3ME. This is also the case for the Netherlands and Austria. When negative impacts occur, the order of magnitude is generally small.

Figure 4 clearly shows that the impacts on employment are positive in all EU countries. Since CO_2 emissions are declining, with few exceptions, a double-dividend is obtained in nearly all EU countries (Table IV). Although employment increases in Luxembourg, CO_2 emissions are also slightly higher in 2000. Although fuel consumption is lower in 2000 in Luxembourg consumption shifts in favour of more CO_2-intensive fuels. Table IV shows that consumption price changes vary from country to country. GEM-E3 and HERMES results confirm for several countries the deflationary impacts also expected by E3ME for some countries. HERMES shows that as an EU-wide average consumption prices might be slightly lower in 2000 than in the baseline. Any differences in observations on price changes might also be due to different assumptions on pre-existing national tax levels and on the way tax exemptions were handled in the different models. In

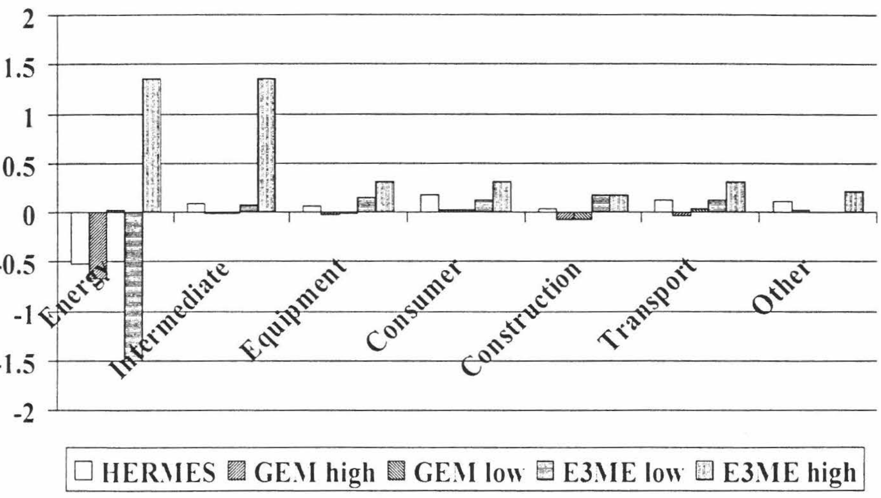

Figure 5. Sector impacts (% change from baseline in 2005).

spite of this, the inflationary impacts of the proposed directive appear to be very small, if not absent, for all countries.

4.4. Sectoral Results

Figure 5 shows that while the proposal leads to some structural change, the impacts are rather small at the level of the individual production sector (with the exception of energy itself). Enterprises will be partially able to cushion the impact of the tax by either substituting the energy source, or by installing energy-efficient equipment. Impacts are, therefore, either positive (for agriculture, equipment goods industry, consumer goods and services) or only slightly negative (for energy intensive goods and transport).

The HERMES model suggests positive impacts of up to 0.2% of sectoral value added (see Figure 5). GEM-E3 points to smaller increases in production levels of up to 0.05% whereas E3ME expects, not surprisingly in view of the more significant EU overall impacts, increases in gross output of up to 1.5% (Figure 5). The average EU results are relatively robust among the different models, with the energy sector, especially in the ferrous and non-ferrous and the gas distribution sectors, expected to face the most significant but still modest negative impacts. HERMES predicts a loss of value added in the energy sector of around 0.5% whereas GEM-E3 forecasts a maximum loss of production of 0.7% in the ferrous, non-ferrous and metal sector. E3ME expects a significant reduction in gross output in the gas distribution sector, which is linked to the relative increase in gas price expected compared to competing fuels (heavy fuel oil and coal), and a reduction in the coal and coke sector. The sectoral impacts are a combination of positive demand side effects and mixed supply side impacts (higher energy prices and lower labour costs). For example the positive GEM-E3 results for the chemical products sector are caused by the fact that, on balance, domestic production becomes cheaper (labour costs are cut more than energy prices increase, partly because the sector benefits from the exemption). The competitiveness of this sector improves and exports increase, as does domestic production. In E3ME the rubber and plastic industry shows an increase in gross output in spite of the fact that unit energy costs rise. Output increases, because demand for intermediate goods produced in the rubber and plastic industry increases, because GDP rises. Given that the figures represent EU averages they must be interpreted with caution since not all sectors in all countries might face positive impacts and the aggregate result for a specific sector might be a mix of positive and negative impacts, depending on the country. The most salient feature in the results is the small order of magnitude of the impacts on all sectors. In addition, the E3ME model, which has more detail, shows that within the energy-intensive sector important differences might occur which are masked by models (such as HERMES) which have a less detailed structure.

4.5. Sensitivity analysis

The model results depend, among other things, on the recycling of tax revenues, the actual tax rate increases by the EU member states and the tax exemptions for energy intensive industries. On the basis of some of the modelling results (carried out partially for draft versions of the proposal), it is possible to indicate the sensitivity of the results for changes in these assumptions.

The models were also used to assess the impact of using tax revenues to reduce budget deficits instead of lowering labour costs. In this case in the GEM-E3 model the current account per unit of GDP was fixed at the level obtained in the case of reducing social security contributions (reported in the previous section) and the real interest rate was assumed to adjust. If Member States increase their fuel excise rates to the minimum EC rates proposed, the results can be summarised as follows. The HERMES model shows that, without recycling, both GDP and employment would be negatively rather than positively affected. Consumer prices would also increase more substantially. CO_2 emissions would, however, be reduced further than with recycling (since GDP is lower). The GEM-E3 model results, however, show that in this case GDP would still increase, but employment increases would be smaller while the CO_2 emission reductions would be the same. In this case, energy becomes more expensive while capital becomes cheaper which induces higher investments. The resulting long-term positive impacts on GDP outweigh the short run competitiveness loser due to increased energy costs, according the GEM-E3 model. It appears that when tax revenues are used to cut budget deficits, no firm statement is possible on the final impact on GDP and employment, although CO_2 emissions would tend to decrease further.

The above results assume that member states adapt their tax rates only if they are below the proposed minimum levels. Analysis has also been carried out on the effects of member states increasing their effective rates with the same growth rates as the new EC minimum levels. The model results available indicate that in this case, assuming that tax revenues are used to reduce labour costs, the positive impact on GDP could be four to seven times higher and that on consumer prices six to eight times higher. The positive impact on employment could be three to four times higher, and that on CO_2 emissions two to ten times higher.

The impact of exempting energy-intensive industries has also been analysed. Analysis with HERMES and GEM-E3 suggest that, without the tax exemptions specified in the proposal, the positive impact on GDP would be slightly higher (around 25%), on employment somewhat higher (around 10%) but the impact on consumer prices would be insignificant. The impacts on CO_2 emissions would be slightly more significant in this case (around 1.7 to 1.8% instead of 1.5 to 1.6%). From a purely macroeconomic perspective these exemptions seem therefore to be less meaningful.

5. Concluding Observations and Discussions

The purpose of this paper was to analyse the macroeconomic and sectoral impacts of the directive on energy production proposed by the European Commission in 1997. The analysis was based on three different models. The results suggests that from a macroeconomic perspective implementation of the proposed directive is likely to confirm the possibility of a double dividend if tax revenues are used to reduce the social security contributions paid by employers. Compared to economic projections under present energy tax rates the proposed tax is expected to lead to GDP and employment increases and CO_2 emission decreases. All three models confirm this but GEM-E3 has smaller impacts on GDP and more significant reductions in CO_2 reflecting the higher substitution possibilities in the model and the smaller linkage between output, investment and employment.

The positive EU-wide impacts are generally valid for all countries. A few countries, however, are left with small losses in GDP, even with recycling. Employment impacts are, however, positive in all countries. Induced structural change is relatively minor, with no particular sacrifices imposed on any country or industrial sector. The loss of production, or value added, in the sectors most negatively affected (gas distribution, energy-intensive industries) is expected to be between 0.5 and 1.5% compared to the baseline. The more detailed sector model E3ME shows that this level of detail gives important additional insights in sectoral impacts.

Sensitivity analysis shows that on an EU-wide level the use of the additional tax revenues to reduce budget deficits (and indirectly reduce interest rates) might not imply a double dividend. Although the CO_2 reductions obtained would be higher, employment impacts are smaller and might even be negative.

If member states increased their rates in proportion to the increases proposed by the Commission, more significant position impacts on GDP, employment and

CO_2 reductions could be obtained (if tax revenues were recycled to cut labour costs). From a macro-economic perspective the exemptions for energy intensive industries are less efficient (given recycling of tax revenues to cut labour taxes) since the positive impacts on GDP, employment and CO_2 reduction are slightly smaller.

Simulation results are robust across models. Differences can be largely explained by three factors. These are the model-types used: general equilibrium or macro-econometric, the number of countries covered and the way exemptions were handled in the models. Crucial assumptions to obtain these results are the modelling of the labour market and the impacts on EU external trade. Areas for further analysis might include the impact of exchange rate changes, dual labour market considerations and the effect of energy price changes of oil exporting countries in response to terms of trade loss.

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