STUDY ON THE RELATIONSHIP BETWEEN ENVIRONMENTAL/ENERGY TAXATION AND EMPLOYMENT CREATION

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Task 1: Literature Review and Evaluation of The Structure of Existing Models

This task involved a review of the theoretical literature on the double dividend, followed by an assessment of some empirical models (*HERMES, EUROGEM, GEM-E3*, *E3ME, LEAN-TCM,* and *HONKATUKIA*). Main references are European Commission (1993), Bayar (1998), Capros et al. (1996), Cambridge Econometrics (1998), Welsch (1996), Honkatukia (1997). Some these models have been used by the European Commission to provide estimates of the likely consequences of a proposed carbon/energy tax. The models looked at in this review are all applied to the European Union, or various parts of it.

1.1 Theoretical Literature

The theoretical literature relevant to the relationship between environmental taxation and employment creation is centred on the suggestion by Pearce (1991) that environmental taxation could lead to a "double dividend". The idea behind this suggestion is that environmental taxes not only produce improvements in the environment but also generate substantial amounts of government revenue. This new government revenue would allow governments to reduce the rates of other taxes in the economy while maintaining a constant level of total revenue and expenditure. As these other taxes are generally regarded as distortionary (interfering with the efficient functioning of markets), the reduction in their rates can be seen as improving efficiency and thus producing a second benefit from the adoption of environmental taxes.

The connection between the double dividend and employment creation arises because one possible distortionary effect of taxation is the reduction of employment. Such a reduction in employment could result from taxes that are obviously related to employment, such as income tax and social security taxes, but also from taxes that affect the real value of workers' wages, such as value added tax and excise duties. Thus one aspect of the double dividend could be an increase in employment that follows from a reduction in one or more of these taxes.

The way by which such tax reductions might increase employment depends crucially on whether or not the labour market is in equilibrium, with demand equal to supply. If there is disequilibrium in the labour market, with supply greater than demand and consequent involuntary unemployment, employment creation requires an increase in labour demand. This could be achieved by reducing the cost of employing labour, for example by reducing employers' social security taxes.[1]

On the other hand, if the labour market is in equilibrium, with demand equal to supply and no involuntary unemployment, an increase in employment requires an increase in labour supply. This could be achieved by increasing the returns to work, by reducing

[1] It is important to note that any increase in employment from this policy does not necessarily imply a reduction of unemployment by the same amount (or at all), because the increased availability of jobs may induce additional people to enter the labour force. The figures for employment creation that are quoted in this report should be interpreted with this point in mind.

direct taxes on labour income or by reducing sales taxes on goods that workers wish to buy, provided that workers respond positively to such increased incentives.

Although the focus of the policy discussion has been mainly on employment, it is important to note that a double dividend could arise without any change in employment, simply by reducing the distortions in consumer choice that result from sales taxes. Indeed, a large part of the theoretical double dividend literature does not address issues of employment: it assumes that there is no involuntary unemployment and places no particular value on additional employment creation.[2] The part of the theoretical literature that has dealt explicitly with employment has concentrated mainly on the case of involuntary unemployment, and the double dividend that is created in this case is often referred to as the "employment double dividend".

This report does not attempt to cover all the details of the double dividend literature. Instead, it presents and explains the main conclusions that may be drawn from this literature, paying particular attention to factors that could be relevant to the construction of empirical models. It first deals with some important general points that apply whether or not labour markets are in equilibrium. It then presents an analysis of the employment double dividend, dealing with the case of labour market disequilibrium, as this is generally assumed to be the situation in most of Europe. Finally it considers how the analysis has to be changed when the labour market is in equilibrium, and there is no involuntary unemployment.

1.1.1 General Principles

The primary purpose of environmental taxes is to reduce damage to the environment by increasing the costs of harmful actions, such as the burning of fossil fuels that produces carbon dioxide. The idea is that consumers and firms will then be forced to take account of the effects of their actions on the environment. For this to work properly, the size of the taxes should equal the monetary value of the environmental damage that the actions cause. Taxes that meet this requirement are sometimes referred to as 'Pigouvian' taxes.

If the revenue from such Pigouvian environmental taxes were sufficiently large to fund all government expenditures, the existing distortionary taxes could be completely removed. Then the economy would be undistorted by either taxation or environmental externalities. The double dividend would be a reality.

However, most European governments have expenditure levels that are more than 40% of their GDP, and Pigouvian taxes will not raise that level of revenue. It is therefore necessary to consider the effect of environmental taxes as *reducing* rather than entirely *replacing* other taxes. This means that the interaction between environmental taxes and other taxes has to be considered, and it is this fact that causes the analysis to be so complicated.

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[2] The idea is that there is very little gain in individual welfare in moving somebody from voluntary unemployment into employment, in contrast to the very substantial gains in moving somebody from involuntary unemployment into employment. Of course, both types of employment creation can improve tax revenue, and that effect is captured in the theoretical literature even when issues of employment are not addressed.

In order to understand this interaction, it is helpful to follow Goulder's (1995) distinction between the "weak double dividend" hypothesis and the "strong double dividend" hypothesis. The weak double dividend is simply concerned with what is done with the revenue from environmental taxes, saying that it is better to use this revenue to reduce the rates of distortionary taxes than to provide lump-sum payments to citizens. The strong double dividend says that the replacement of some existing taxes with environmental taxes will reduce the distortionary cost of raising the current level of government revenue.

The weak double dividend has been shown to hold in almost all models. The most important exception is when the lump-sum payments are markedly better than tax reductions at raising the incomes of poor households.[3] However, the details of these results are not worth discussing here because the weak double dividend is simply about how to spend the environmental tax revenue. It says nothing to enhance the case for environmental taxation. It is the strong double dividend that needs to be true in order to claim that environmental taxes can contribute to the efficiency of the economy in other ways than improving the environment. Unfortunately, the conditions for the truth of the strong double dividend require more sophisticated analysis, and there is a wider range of disagreement.

Because the strong double dividend is concerned with reducing the distortionary cost of the tax system, the analysis can only be fully understood in the context of the theory of optimal taxation: a theory that deals with the problem of minimising the distortionary costs of a tax system that generates a given level of government revenue.

The first important fact to be aware of is that the theory of optimal taxation typically does not concern itself with environmental issues. It is simply concerned with raising revenue efficiently, and so we can refer to such taxes as "revenue-optimal". **Thus a revenue-optimal set of taxes is one that minimises its effect, as measured by a "distortionary cost", on the actions of market participants, without regard to their environmental effect.[4]** If a country has adopted a revenue-optimal set of taxes, there is no possible change to those taxes that will raise the same revenue at a smaller distortionary cost. In particular, the imposition of a higher rate of tax on a good that damages the environment cannot reduce the distortionary cost of the tax system, and can generally be expected to increase it. This implies that the strong double dividend cannot be true in an economy where the taxes are revenue-optimal.

Of course, this does not mean that there is never a strong double dividend, because it is unrealistic to suppose that countries currently have revenue-optimal taxes. What it does mean is that a strong double dividend exists when (and only when) the imposition of an environmental tax moves the tax structure closer to the revenue-optimum. Thus, those parts of the literature that claim to show the existence of a strong double dividend are based on presumed situations in which the existing taxes are not revenue-optimal and environmental taxes produce a move towards the

[3] As this sentence illustrates, the theory can also take account of the distributional effects of taxes. However, these have not been paid much attention in the double dividend literature and so will not be emphasised here.

[4] This concept of revenue-optimal taxes takes account of all the effects of tax changes, including those that result from the shifting of the tax burden between different groups in society.

revenue-optimum. In contrast, the papers that show the absence of a strong double dividend assume either that taxes are already revenue-optimal or that the environmental tax does not move the system towards revenue-optimality. Which of these situations applies to any particular country is, of course, an empirical question and this is where the computer simulation models are useful.

Nonetheless, the theory of optimal taxation can help provide some general insight by indicating the likely structure of revenue-optimal taxes, and thus whether the introduction of environmental taxes is likely to reduce the distortionary effects of taxation in a typical EU country. In the following two sections we use the key results from the theory of optimal taxation to assess the likelihood of additional a double dividend arising that includes employment creation. We deal first with the situation that is currently thought to represent the situation in Europe most closely, the case with involuntary unemployment. We then move on to consider the case without involuntary unemployment.

1.1.2 The Case with Involuntary Unemployment

In the context of the theoretical general equilibrium models used to analyse the double dividend in the presence of involuntary unemployment, the unemployment is caused by the wage being higher than its market clearing value. This leads to a situation where the demand for labour is less than its supply, and the result is involuntary unemployment. In this situation, the only way to create additional employment is to increase the demand for labour. This section analyses how the use of environmental taxes to partly replace existing taxes might be able to achieve such a demand increase.

There are several possible explanations of this "high" wage, including trades unions and various models of asymmetric information, but the analysis is easier if we start by simply taking the real after-tax wage as fixed[5] and only later look at the implications of how it is determined. Taking this approach, the important aspect of the unemployed economy is the distortion of the wage, and the standard response from optimal tax theory is to look for ways to reduce that distortion either by direct subsidy or by introducing taxes elsewhere that offset it.

It might be thought that the distortion of the wage could be reduced directly by reducing social security (payroll)[6] taxes, while imposing environmental taxes to replace the lost revenue. However, it must be recognised that the environmental taxes will increase the cost of goods that workers buy, thus tending to reduce the real wage. This means that workers will demand wage increases to restore the previous value of the real wage and this will offset the effects of the reduced payroll taxes. In other words, the move from payroll taxes to environmental taxes has not reduced the taxation of workers; it has simply rearranged it.

In order for a move from payroll taxes to environmental taxes to increase employment, the taxation of workers must be reduced. This can be achieved in two

[5] This is based on the idea that workers are interested in what they can buy with their (after-tax) earnings, and that they can enforce a particular minimum level of this.
[6] In principle, cutting income tax would also reduce labour costs by reducing the before-tax wage rates that workers demand.

possible ways: (i) the shifting of the tax burden from workers to other groups, (ii) the improvement in the efficiency of the tax system. We deal with these two possibilities in turn.

1.1.2.1 Shifting the Tax Burden

One case in which the approach of moving from payroll taxes to environmental taxes could work is when some consumers are not workers. For example, imagine that some consumers live entirely (or much more than average) on capital income. The imposition of a sales tax on an environmentally damaging good that was used to reduce labour taxes would move some of the tax burden from workers to non-workers, and so reduce the distortion of the labour market, provided that the non-workers did not emigrate as a result. In other words, the revenue raised from the sales taxes would be more than sufficient to generate a subsidy that reduces the cost of labour to employers, and so encourage employment. This would create the employment double dividend, but at a cost to non-working consumers. The double dividend has arisen by shifting the tax burden from workers to non-workers.

It is worth noting that the same effect can apply with two other groups of non-workers. The first are people on state benefits, but only provided that the benefit is not increased to compensate for the increased price of the environmentally damaging good. The second are people in other countries if the good, or products made with the good, are exported and the country has sufficient market power that the other countries are unable to switch their source of supply.

Another form of tax shifting is the taxation of goods whose production uses a particularly large amount of an under-taxed factor of production, with the revenue being used to subsidise (or, at least, reduce the taxation of) employment. If environmentally damaging goods make heavy use of under-taxed factors, then their taxation could produce an employment double dividend. To see this, consider a factor that is inelastically supplied (in the sense that the same quantity would be supplied at a lower price) and currently taxed at less than 100%. The situation is clearly not revenue-optimal, as a higher tax on the factor would raise additional revenue without reducing its supply. A direct solution to this situation would be to increase the tax on the income to that factor. However, an indirect partial solution would be to impose some other tax that would result in a fall in the income to that factor, such as a tax on a good whose production made particularly heavy use of that factor. Thus, if capital were inelastically supplied and was currently taxed at less than 100%, and if the production of energy was particularly capital-intensive, a tax on energy could be seen as partly a tax on capital. In this case the imposition of an energy tax, which was used to finance a cut in labour taxes shifts the burden of taxation away from labour and towards capital. This would reduce the distortion of labour demand without distorting the supply of capital (which is inelastic), thus creating a strong double dividend.

In applying this analysis, it is very important to be sure that the factor really is inelastically supplied. If the capital were elastically supplied, perhaps because of the ease of moving it to countries with lower taxes on capital, the tax shifting would cause a considerable increase in the distortionary cost of the tax system in the form of capital moving abroad. In this case the benefits of the shift in terms of increased employment would be smaller[7]. Bovenberg and De Mooij (1998) have addressed this issue. The desirable level of environmental taxation depends crucially on the elasticity of capital supply and the current rates of capital taxation.

This discussion shows that the shifting of the tax burden away from labour can, in certain circumstances, produce a double dividend.

1.1.2.2 Improving the Efficiency of the Tax System

It is also interesting to ask whether an employment double dividend can be created without shifting the tax burden, in part because such tax shifting could be difficult if non-labour factors of production are elastically supplied and non-working consumers are protected from bearing the tax burden. The aim is to reduce the tax burden on workers so that labour costs can be reduced and labour demand increased.

If we rule out tax shifting by assuming that all inputs into production are elastically supplied at fixed cost (energy and capital because they are internationally mobile, and labour because the wage is fixed), it can be shown that minimisation of production costs requires that all factors are equally taxed. What is actually the case in most European countries is that labour is taxed more heavily than other factors. Thus a shift away from the taxation of labour to the taxation of other factors can be expected to reduce production costs. This will reduce the prices that workers face for the goods they wish to consume. In this case, the move from payroll taxes to taxes on other factors will not be offset by an increase in wages, and employment will increase.

This analysis looks as if it will lead to the existence of an employment double dividend for energy taxation, even without shifting the tax burden. However, the situation is not quite that simple, for two reasons. First, the argument in the previous paragraph was concerned with increasing the tax on all non-labour factors. An increase in energy taxation alone may improve the relative costs of labour and energy, but at the cost of possibly worsening the relative costs of capital and energy. Second, as energy is a produced good (although possibly imported) it may well have already been taxed, and so an additional tax on its use could lead to it being over-taxed. Thus, it is not clear that energy taxation will always lead to an employment double dividend. However, it is more likely to happen if energy is more substitutable with labour than with capital, as that would make the correction of the relative costs of labour and energy more important than the worsening of the relative costs of energy and capital.

Before concluding this discussion of employment creation when there is involuntary unemployment, it is important to note that the possible strong double dividend analysed here does not apply to all sizes of environmental tax. The arguments presented here have applied to small taxes. As environmental taxes are increased, they increase the distortionary costs of revenue raising by changing consumer choices, and this effect can outweigh reductions in the distortion of the labour market.

Finally, let us turn to the question of how the wage is determined and whether or not it would in fact be "fixed". This is important because it is possible that the policies

[7] In fact the distortionary cost of the tax system could be reduced by an environmental tax that fell on labour and was used to finance a reduction in capital taxation!

discussed here may affect the real wage. The main influence on wages discussed in the literature is trades unions, and we will concentrate on them here. In most models of trade union behaviour, a reduction in unemployment will lead to a higher wage. This will reduce the size of any possible employment double dividend, because any reduction in unemployment will increase the wage, which will in turn increase unemployment. It is, in fact, possible to produce a model in which unemployment cannot be reduced: the entire subsidy to employment is absorbed by an increase in the wage. However, in most of the literature, trades unions are shown to simply reduce the size of any employment double dividend.

1.1.3 The Case without Involuntary Unemployment

When the labour market is sufficiently flexible to ensure full employment, the emphasis in the double dividend literature moves away from employment creation and towards the general efficient functioning of markets. However, the distortion of the labour market is still a major concern, with the idea that employment taxes tend to reduce the level of labour supply below the optimal level. Hence the use of environmental taxes to partially replace other taxes could increase labour supply and increase measured employment. This section considers the scope for such changes

The cases of tax shifting discussed in the previous section continue to be possible sources of a double dividend, but through a different mechanism. Instead of a reduction in worker taxation allowing a lowering of labour costs and increased demand, we need to look at the supply side incentives to work. In this case, a reduction in labour taxation increases the rewards to working and so increases labour supply, which in a flexible labour market leads to greater employment.

In addition, as when there is involuntary unemployment, it is interesting to look at what possibilities there are without tax shifting. Such possibilities involve improving the efficiency of the tax system. However, the analysis is different in this case. The arguments of section 1.1.2.2 no longer apply as the wage is not fixed at a level that makes supply exceed demand, and so the emphasis is more on increasing labour supply than increasing labour demand.[8] Instead, it is necessary to look at the way in which taxes on workers affect their labour force participation. We now turn to an examination of this.

A simple model that is widely used in optimal tax theory is useful for illuminating this question. It is a model in which the only factor of production is labour. In this framework, the only reason for taxing some goods more heavily others is that their consumption is more closely associated with leisure than other goods (in economic terminology, these goods are said to be particularly complementary to leisure). This means that the heavier tax on these goods would implicitly tax leisure and so encourages people to work more, thus reducing the distortion to labour supply produced by the tax system as a whole. So, if an environmentally damaging good was also a good that is consumed in association with leisure, the imposition of a special

[8] Of course, increasing labour demand will increase the wage and so increase labour supply (provided that its supply is not backward bending). However, it turns out that the use of taxes to increase labour demand is an inefficient use of the tax system. Any money is better spent on direct changes to the incentives that workers face.

tax on this good in an economy with uniform sales taxes could have a double dividend.

It is worth looking at this case in more detail, as it involves a line of reasoning that is quite helpful in understanding the double dividend. One can think of raising the tax on the environmentally damaging good (let us call it energy) and using the revenue to reduce taxes on labour (such as income tax or payroll taxes[9]), as suggested in the double dividend literature. At first sight, this might appear to automatically reduce the distortion of labour supply, but things are not that simple. It is not only taxes directly on labour that reduce labour supply, but also taxes on goods that are bought with the income earned by the labour. Thus, increasing the tax on energy also reduces labour supply. However, if energy were particularly complementary to leisure, this effect would be particularly small because people who were deciding whether or not to work more would expect to spend a relatively small proportion of their extra earnings on energy. This means that the disincentive effect of the tax on energy will be less than the incentive effect of reducing taxes on labour, so labour supply would increase and a strong double dividend result.

Note that if the consumption of energy had been associated more closely with labour (had been particularly substitutable for leisure), the result would have been the opposite: the imposition of an energy tax would have reduced labour supply, because energy would have been a relatively larger part of the expenditure from the possible extra earnings. In this case, there would not be a strong double dividend. In fact, the environmental tax would have worsened tax distortions in the economy.

A case that has been highlighted in the literature is one that falls between these two possibilities: no goods are particularly associated with either labour or leisure (there is "weak separability" between goods and leisure). In this case, uniform sales taxation is optimal. A very small environmental tax will neither increase nor reduce the distortionary cost of the tax system, but any significant tax will be a move away from the optimum and so increase the distortionary cost. It is this that lies behind the main theoretical result of Bovenberg and Goulder (1996), casting doubt on the existence of a double dividend.

1.1.4 Conclusions from the Theoretical Review of the Double Dividend Literature

The following conclusions can be drawn from the review conducted above.

The literature on the double dividend distinguishes between a 'weak form' and a 'strong form'. The strong form, which is the one of interest to this project, states that a switch to environmental taxes and away from non-environmental taxes will reduce the welfare cost of raising the current level of government revenue even if their environmental effects are neglected. A strong double dividend cannot occur if the existing tax structure is revenue-optimal. If, as is likely in practice, the existing tax structure is not revenue-optimal, a strong double dividend will occur if the new environmental tax moves the tax structure in the direction of revenue-optimality.

[9] In an economy without involuntary unemployment, payroll taxes also reduce the incentive to work because they reduce the wage that employers are able to pay their workers.

Therefore, the prospects for a strong double dividend depend on the existing structure of taxation, as well as on other aspects of the economy.

The way in which a strong double dividend might be accompanied by increased employment depends on whether or not the labour market is in equilibrium. If it is in disequilibrium, with involuntary unemployment, additional employment is created if the use of environmental taxes to partially replace existing taxes results in an increased demand for labour. If it is in equilibrium, without involuntary unemployment, additional employment is created by increasing labour supply.

There are no necessary or sufficient conditions for environmental taxes to increase employment, but the theory has identified factors which make it more likely.

A. The prospects of increased employment when there is involuntary unemployment are higher if:

   (i) The environmental tax can be passed on to factors that are inelastically supplied and relatively under-taxed.

   (ii) Non-working households are large enough in numbers, and are significant as consumers of goods produced with the environmentally intensive inputs that are taxed.

   (iii) Through international market power, the environmental tax can raise the price of goods produced with a relatively intensive use of the taxed environmental input. A similar effect would arise if non-EU suppliers reduced the price of goods that were subject to environmental taxes when they entered the EU.

   (iv) Capital is relatively immobile internationally. In this case it can absorb some of the environmental tax and less falls on factors such as labour, enhancing the double dividend effect.

   (v) The elasticity of substitution between energy (the environmental input) and labour is greater than the elasticity of substitution between energy and capital.

   (vi) The real wage rises little when unemployment falls, so that the reduction in the taxes on labour are not offset by wage rises.

B. The above conclusions are based on a model with involuntary unemployment. When there is non involuntary unemployment, conclusions (i) to (iv) still hold but conclusions (v) and (vi) are replaced by:

   (vii) The environmental tax is levied on goods that are more complementary to leisure in consumption than the goods whose taxes are reduced.

These conclusions raise important implications for policy and for the design of empirical models. The empirical models are discussed in the next section, but there are two policy issues that are worth raising here.

First, the importance of capital mobility in determining the existence of an employment double dividend suggests the need for international co-operation in setting environmental taxes. If one country on its own imposes environmental taxes that reduce the return to capital, it could suffer from substantial capital movement. However, if a group of countries imposed such taxes at the same time, there would be less scope for capital to move elsewhere. To some extent, this argument applies also in considering international market power, both in terms of being able to increase the price of exports and in terms of being able to reduce the price of imports. This market power will be greater for a group of countries acting together than for a single country. However, against this, the larger is the group of countries that apply the taxes, the smaller is the remaining set of countries that will have to pay the shifted taxes and so the smaller the amount of tax that can be shifted. International co-operation may also be useful in minimising the loss of international competitiveness that could result from introducing environmental taxes. International competitiveness is not considered in the theoretical literature, which assumes that exchange rates adjust to maintain equilibrium in the balance of payments. However, it is captured in the empirical models.

Second, the literature does not specifically deal with the practical question of which taxes on labour should be reduced to get the largest employment double dividend. Should it be income tax or social security taxes? Intuitively, it seems likely that it should be social security taxes because they are more closely linked to employment than income tax, which can cover non-labour incomes and is progressive (thus bearing less heavily on the incomes of lower-paid workers). This intuition is tested below, in the section on sensitivity of the results to parameters and assumptions.

1.2 Description of the Empirical Models

We have looked at the three models used by the European Commission in their assessment of the February 1997 proposal for the taxation of energy products: *HERMES, EUROGEM, GEM-E3* and *E3ME*. We have also analysed the following other models: *HONKATUKIA*, a model constructed for the Finnish economy, and *LEAN-TCM*, a Europe-wide model on somewhat similar lines to *HERMES*. All these models are very complex, involving very many equations and sophisticated lag structures. Each is representative of their own approach to modelling, and are capable of being used to simulate many other issues apart from environmental taxation. The discussion here just summarises their important attributes for the purposes of the current study.

The *HERMES* model is an econometric model, with a fairly complex specification of macroeconomic relationships. However, it has some characteristics of a general equilibrium model in that the specifications of production, consumption and labour supply are consistent with the theoretical general equilibrium models that are typically used in analysing optimal tax and double dividend issues. It does not assume perfect competition in the product market (while most theoretical models do) and has a real wage determined by productivity growth and unemployment. The production function incorporates capital, energy, labour and intermediate goods in a two stage nested form: at the first stage, capital is combined with energy and labour is combined with intermediate goods; at the second stage, these two aggregates are combined to produce output. Full details of the model are available, although we have not had access to the software to run the model.

The *EUROGEM* model is from the same stable as *HERMES,* but is an integrated Europe-wide model. The production structure is similar to *HERMES*. The labour market is not assumed to clear, and its analysis is extended to include a union bargaining objective function, which is a function of the level of employment and the difference between the wage rate and the level of real income for an unemployed person. Union policy thus determines the real wage rate and the effective level of unemployment. This feature, along with the integrated EU-wide modelling, distinguishes it from *HERMES.*

The *GEM-E3* model is a more classical computable general equilibrium model, with more emphasis on consistency with general equilibrium theory than detailed estimation of a macroeconomic model. The production function structure is similar to that of Hermes, but a bit more complicated. The most important difference is that it assumes perfect competition in all markets, including the labour market. This means, strictly, that there is no unemployment. (see below). The model specifications in the literature are quite cursory and we have not been able to see the full set of equations, with the estimated parameter values.

The *E3ME* model is an econometric model, but is different from Hermes in having less concern for the structures of economic theory. It is similar to Hermes in having imperfect competition and a wage determination equation that incorporates productivity growth and unemployment. From the point of view of this study, it is difficult to compare with the other two models because it does not estimate a production function, only input demand functions. In some cases, production functions can be inferred from input demand functions, but this is not the case for E3ME as the input demand functions are not consistent with the constant returns to scale assumption that is made in general equilibrium models.

The *HONKATUKIA* model is a full employment, dynamic CGE model with a relatively simple production structure. Its novel feature is the treatment of firms as imperfectly competitive. With free entry and exit, firms' profits are driven to zero. It is not entirely clear what the implications of this structure are for the double dividend. The author notes that, with imperfect competition, the increase in consumer prices following tax changes will be greater, as prices are based on a mark-up on costs. Furthermore, since mark-up pricing implies inefficiency, the tax policies may reduce or exaggerate these inefficiencies. In practical terms, however, we cannot say what overall impact imperfect competition will have, unless the **degree** of competition is specifically modelled as a sensitivity parameter. The author has not done this.

The *LEAN-TCM* model also has some features that are similar to *HERMES.* The production structure is a nested one, with labour and an 'energy-capital' aggregate. The labour market again does not clear. Unlike the *EUROGEM* model, the real wage is not determined by a specific union bargaining objective function but by an equation in which the real wage increases as a function of the tightness in the labour market (difference between the actual and full employment levels of labour supply).

Table 1 below summarises the main features of these models. It is clear that one cannot choose between them purely on theoretical grounds, and that their evaluation has to be based partly on how consistent their performance is with other known and observed features of these economies. Tasks 2 and 3 are concerned with this evaluation.

Table 1: Main Features of Empirical Models Used in the European Employment/Carbon Tax Literature

Model	Key Economic Assumptions	Special Points
Hermes	CGE model with unemployment. Uses nested CES production functions. National and EU applications.	Detailed development at national level in EU. Structure is transparent. Real wages determined by productivity growth and unemployment.
EUROGEM	Similar to HERMES. National and EU applications.	U-wide model. Real wages now also depend on trade union bargaining objectives, which are a function of employment and real income differentials between workers and the unemployed.
GEM-E3	Classical CGE model with full employment. Run at EU-12 and EU-15 level	Structure has more emphasis on consistency with general equilibrium theory than with detailed estimation of structural equations. Information on model structure is cursory.
E3ME	Econometric model with less basis in economic theory. Assumes unemployment.	No production functions specified; only input demand functions with increasing returns. Cannot derive underlying productions functions from them.
HOKATUKIA	Model for Finland only. Dynamic CGE model with relatively simple structure and full employment.	Firms are imperfectly competitive, which allows some of the tax to be passed on in higher prices. Implications of environmental for overall efficiency of economy remain unclear.
LEAN-TCM	Similar structure to HERMES with unemployment.	Real wage depends on tightness of labour market

Task 2: Identification of the Key Parameters in Existing Models

2.1 Key Aspects of the Models For the Double Dividend Debate

The discussion of the theoretical literature suggests that the following features of the economy are important in assessing the likelihood of a double dividend. It is worthwhile to look at the extent to which the models capture each of these features:

1. *Existing tax structure*.
   This is captured in detail by each model.

2. *Complementarity of consumption goods to leisure.*
   This has not been captured in any of the models as they all assume separability.

3. *The pattern of factor intensities of production for different goods.*
   This has been captured in detail by each of the models.

4. *The characteristics of non-worker consumers.*
   These are not well captured in any model as they all appear to use the representative household approach. The only non-worker consumer is the rest of the world, and all models assume that the EU countries have some monopoly power in trade. This gives the models some ability to pass on energy tax increases to foreigners and thereby create a larger double dividend in the EU.

5. *International mobility of factors of production*
   This is really only an issue for capital. None of the models explicitly addresses the issue of the international mobility of capital. If capital is mobile in this way, it will seek the highest return, and investment in any one country must respond to differences between domestic and international rates of return. An increase in energy prices, which can be passed on to capital and thereby reduce the rate of return on capital, should imply a reduction in domestic investment. This reduction in turn will raise domestic rates of return until the international and domestic rates are equalised. Hence capital will not bear part of energy tax and the tax shift will not result in as big a gain in employment as when capital is immobile.

   None of models we have looked at includes an investment response of this kind. Although most have investment depending on the real after tax rate of return to capital, they do not allow for a response to differences between the domestic and world rates. HERMES does not specifically model investment as a function of domestic versus international rates of return. HERMES models capital demand differently in different countries with, for example, investment being exogenous in several sectors in France but being a function of relative prices of capital, energy and labour in Germany and some other countries. EUROGEM has a similar structure for capital demand to the German component of the Hermes model. E3ME, *HONKATUKIA, LEAN-TCM* and

GEM-E3 also have the level of investment dependent on the cost of capital and other factors but not to relative rates of return on investment.

In view of this, we believe that the **all** the models could exaggerate the impacts of a shift in taxation from labour to energy in terms of increased employment. If capital is indeed mobile the burden of increased energy taxation could not be passed on to capital and would be borne by energy and labour, reducing the size of the double dividend.

6. *The Elasticities of Substitution Between Labour, Capital and Energy*

We noted that the greater the elasticity between labour and energy, relative to the elasticity between capital and energy, the more likely it is that a double dividend will exist. This sub-section reviews the four models, which have been used in the analysis of the double dividend literature.

HERMES. In this model there is a nested production structure, as described in section 1.2. The structure determines the Allen Elasticities[10] (footnote here, not lower down) between capital and labour and between energy and labour as always equal to one. The elasticity between capital and energy, however, is free to vary. In most cases the corresponding cross price elasticity is negative, implying that capital and energy are complements. Approximate values estimated for the Allen Elasticites for France were: -0.5 (intermediate goods sector); -0.4 (equipment manufacturing sector); -3.0 (consumer goods sector). For Germany the corresponding values were -0.27, -1.77 and -0.64. Given the lags, the full effects of the elasticities will take some time to work, but estimates of short and medium run elasticities are not available. (The above figures are all long run estimates). In view of the above figures, the case for a strong double dividend effect is quite strong.

EUROGEM. The elasticities for this model were obtained from Mr. Bayar. Separate estimates are made for the short, medium and long runs. The table below gives the figures. The production structure is the same as in the HERMES model, with a composite good of energy and capital entering into a production function with labour, and different energy forms having imperfect substitution. The actual values are summarised in Table 2.

Table 2: Elasticities Used in the EUROGEM Model

Elasticity	Short	Medium	Long
Capital/Energy	-0.1	-0.5	-1.0
Labour/Composite of Energy + Capital	0.1	0.4	0.8
Between Energy Sources	0.3	1.1	2.0

The labour/composite elasticity is not that different from *HERMES* in the long run, and labour and energy elasticities are also indicative of a complementary relationship between the two inputs.

[10] If the cost function for the firm is $E = G(X_1, X_2, \ldots X_N, Y)$, where the Xs are inputs and Y is output, the Allen elasticity of substitution between inputs i and j is given by $\Phi_{ij} = \{G.G_{ij}/G_iG_j\}$. The cross price elasticity between inputs i and j is given by $E_{ij} = \Phi_{ij}M_j$, where M_j is the share of input j in total cost.

E3-ME

The E3-ME model is not estimated in terms of the production function but in terms of the input demand equations. As has already been noted, the production function cannot be inferred from these demand functions for this model. Nevertheless, something of the flavour of the substitutability of labour for energy and capital can be gleaned from the employment equations. These equations include the price of energy and the level of capital investment as explanatory variables. Increases in energy prices lower employment and, in more than half the sectors, increased investment also results in lower employment. Hence for these sectors capital and energy are likely to be complements; an increase in the price of energy is associated with lower investment. Moreover the negative relationship holds for the aggregate employment equation. On the other hand, labour and energy are also complements; an increase in the price of energy lowers employment. It is difficult to see whether the labour-energy elasticities are greater than the capital energy elasticities, but the model clearly has a smaller double dividend tendency on these grounds than HERMES or EUROGEM.

GEM-E3

A personal communication from Ms Van Regemorter informed us that this model has a complex structure of substitution between factors of production, based on a nested CES (constant elasticity of substitution) production function. At the top level, there is an elasticity of substitution between 0.3 and 0.4 (depending on the sector) between capital and all other factors. At the second level, there is an elasticity of substitution between 0.2 and 0.4 between electricity and other inputs. At the third level, the other inputs are disaggregated into materials, labour and other fuels, with an elasticity of substitution equal to 0.5. This structure implies that taxes on energy that are used to reduce taxes on labour will allow substitution between these two inputs at the second or third level of the production function, without necessarily altering the return to capital. As discussed in the theoretical section, this is the sort of pattern of substitution that will allow a double dividend because the elasticity of substitution between energy and labour is greater than the elasticity between energy and capital. However, it is worth noting that the elasticities of substititution are all rather small, suggesting that the size of the double dividend from this source would not be large.

HONKATUKIA

This model has a much more simplified production structure, with all elasticities between inputs in production being set at one. Hence there is no reason for a shift in taxes from employment to energy to favour labour relative to capital.

LEAN-TCM

Like *HERMES,* this model has a high elasticity between labour and energy and between labour and capital (from the model structure the two are equal). The actual value taken is 0.6. It also has an elasticity between energy and capital that varies by sector, ranging in most cases between -0.4 and -0.5. Thus this model appears to have a high chance of generating the double dividend, similar to that of the *EUROGEM model.*

In general, we would conclude that the estimated elasticities of labour with respect to energy and that of capital with respect to energy favour a double dividend when taxes are shifted from labour to energy. Although the magnitude of this impact, however, is still uncertain, the empirical evidence supports the case for a relatively strong double dividend effect on these grounds.

7. The Responsiveness of Labour Demand or Supply to Changes in Labour Taxes

The models analysed vary considerably in their treatment of the labour market. The *HERMES* and *EUROGEM* models do not assume perfect competition in the product market and labour markets. *HERMES* has a real wage determined by productivity growth and unemployment. EUROGEM, as noted above, has a union bargaining function whose arguments are employment and real wage less the unemployment benefit. The *E3ME* model is different from *HERMES* in that its estimated elasticities are not restricted to meet the requirements of the standard theory of the firm, but is similar to *HERMES* in having imperfect competition and a wage determination equation that incorporates productivity growth and unemployment.

The GEM-E3 model is a more classical computable general equilibrium model, with more emphasis on consistency with general equilibrium theory than detailed estimation of a macroeconomic model. It assumes perfect competition in all markets, including the labour market. This means, strictly, that there is no unemployment. However, the labour supply function is fairly elastic and it is able to capture the demand side factors of labour market, as discussed in section 1.1.2 above. This has allowed it to be used to estimate the employment creating effects of energy taxes, with the upward sloping supply curve of labour playing the same role as the union-produced relationship between unemployment and the real wage. The production function structure is similar to that of Hermes, but a bit more complicated.

A similar remark applies to the HONKATUKIA model. It assumes full employment and generates changes in the level of employment as a result of an elastic labour supply function (although the value is not reported). The value of the elasticity of labour demand is one, which makes the model probably more responsive to labour tax changes than one would expect on the basis of empirical data.

In summary, the modelling of the labour market is divided into those models that assume full employment (or voluntary unemployment) and those that assume involuntary unemployment. The former may generate a ‘double dividend’ in the sense that employment increases as the incentives to supply labour become stronger. However, as the people who have moved into employment were previously voluntarily unemployed, the benefit to society is very different from the benefit created when involuntary unemployment is reduced. The two sets of employment effects are therefore not really comparable, although they are frequently compared.

2.2 Analysis of the Impacts of the 1997 Harmonisation of Energy Taxation

Some idea of the quantitative importance of the features of the three models we have examined so far can be gained by comparing their results in a common application: the February 1997 proposal for taxation of energy products. The proposal seeks to harmonise energy taxes by setting minimum levels of excise levies on all energy products. These minimum rates are to be introduced in three stages with the last stage originally proposed for 2002. Some exemptions are offered to energy intensive industries and flexibility is allowed in respect of differentiating taxes on the basis of environmental effects, as long as minimum rates are respected. Since the actual rates vary a lot by country, the actual increases in energy taxes analysed also differ considerably. The model assumes that the taxes are recycled through reduced employers' social security contributions. The proposed minimum levels that would apply to heating fuels and electricity after the last increase are shown in Table 3 below.

Table 3: Proposed minimum level of energy taxation (ECU per specific unit)

Fuel	Unit	Min level
Gas oil	Kl	26
Heavy fuel oil (low sulphur)	tonne	28
Heavy fuel oil (high sulphur)	tonne	34
Kerosene	Kl	25
LPG	tonne	34
Natural Gas	GJ	0.7
Solid Fuel	GJ	0.7
Electricity	MWh	3

2.2.1 Methodology

The Commission contracted three modellers to analyse the impacts of such changes across the 15 EU countries. Some key summary results are given in Table 4 below. The figures for the first four variables were reported by the teams working on each model. The last two lines of the table are derived from those figures.

There are two striking features of the table. First, all the models show a positive effect on employment. Second, the E3ME projection of employment gain is nearly three times that of the other two models. However, this does not appear to result from differences in substitution assumptions, as the E3ME projections for the employment/GDP ratio and the energy/GDP ratio are not substantially different from those of the other models.

The difference is related to the very much larger increase in GDP that is predicted by the E3ME model. Some of this could be due to the increasing returns to scale feature of the E3ME model, as the tax proposal seems to have reduced the price level in this model alone, but it seems unlikely that this can be the entire explanation. The price level fall suggests that the shifting of the tax burden to the rest of the world could not have happened. This leaves the likelihood that some of this could be due to the shifting of the tax burden to capital, which Mr Barker (in personal communication) confirmed as being immobile in this model. Such backward shifting, caused by the high capital intensity of the energy industries, is given by Barker (1994) as one of the explanations for the large employment increase. This highlights the need for further investigation of the assumptions made about capital mobility in the different models.

Table 4: Model Results of Energy Tax Harmonisation in the Year 2005

	Hermes	GEM-E3	E3ME
Reported changes			
GDP	+0.06%	+0.02%	+0.20%
Consumer Prices	+0.04%	+0.08%	-0.08%
Employment	+190,000	+155,000	+457,000
Energy	-0.52%	-1.49%	-0.74%
Computed changes			
Employment/GDP	+0.08%	+0.09%	+0.10%
Energy/GDP	-0.58%	-0.91%	-0.64%

Sources: See References and Text

The choice of the time period to 2005 by the Commission's report confirms our initial belief that it is the medium to long-term properties of these models that are important, rather than their short-term properties. Most of the lags in the models cover relatively short periods, and so do not warrant further investigation. The most important long-term adjustment in these models is that of the capital stock. This needs further investigation, and is clearly related to the issue of international capital mobility, that has already been stressed.

2.3 Analysis of the 1992 EU Carbon/Energy Tax and Similar Proposals

Studies also exist, which analyse the impacts of the 1992 energy/tax proposal. In this, a 50:50% mix of carbon and energy tax is applied at the level of $3/barrel of oil equivalent in the first year and rising to $10 in seven years. The models that have been run for this option are *E3ME, GEM-E3, LEAN-TCM* and *EUROGEM.* The *E3ME* is not run for exactly the same scenario, as it increases taxes from $1 per barrel of oil equivalent to $13 in 11 years. The *LEAN-TCM also* has slightly different tax increases than the others. Finally, the E3ME model is only run for the UK. In spite of these limitations, a comparison of the results is, nevertheless instructive. Table 5 presents the main findings. The following points are worth noting:

(i) The models differ considerably in terms of their GDP increase, with *LEAN-TCM* producing the biggest increase in the final year, followed by *EUROGEM, GEM-E3* and *E3ME.* In this respect *E3ME* performs differently from Table 4, where it has the biggest final increase in GDP.

~~Table 5: Impacts of an Energy/Carbon Tax in EU12: Some Comparative Results~~

			Percentage Changes Over Baseline					
			GDP INCREASE	EMP. INCREASE	CARBON FALL	ENERGY FALL	PRICE CHANGE	EMP/GDP
	E3ME	UK ONLY	0.02%	0.12%	0.33%	N/A	0.00%	0.10%
	GEM-E3	UK ONLY	N/A	N/A	N/A	N/A	N/A	N/A
	GEM-E3	EU12	N/A	N/A	N/A	N/A	N/A	N/A
	LEAN-TCM	EU9	0.47-1.4%	0.7-2.24%	4.1-4.8%	N/A	N/A	0.2-0.8%
YEAR 1	EUROGEM	EU15	0.00%	0.20%	5.00%	N/A	N/A	N/A
	E3ME	UK ONLY	0.05%	0.47%	1.31%	N/A	-0.03%	0.42%
	GEM-E3	UK ONLY	N/A	N/A	N/A	N/A	N/A	N/A
	GEM-E3	EU12	N/A	N/A	N/A	N/A	N/A	N/A
	LEAN-TCM	EU9	N/A	N/A	N/A	N/A	N/A	N/A
YEAR 3	EUROGEM	EU15	0.60%	1.08%	6.92%	N/A	N/A	0.48%
	E3ME	UK ONLY	0.12%	2.59%	4.51%	N/A	-0.22%	2.47%
	GEM-E3	UK ONLY	0.30%	0.53%	N/A	-7.72%	2.25%	0.23%
	GEM-E3	EU12	0.15%	0.37%	10.34%	-5.08%	3.89%	0.22%
	LEAN-TCM	EU9	0.4-2.1%	0.8-3.2%	6.2-7.6	N/A	N/A	0.4-1.1%
EAR 10/1	EUROGEM	EU15	0.90%	2.20%	16.00%	N/A	N/A	1.30%

Notes:

1. E3ME analyses a carbon tax starting at $1 per b.o.e, rising to $13 in year 11
2. For E3ME AND EUROGEM, the last row of figures is for year 11.
3. GEM-E3 and EUROGEM analyse a carbon tax starting at $3 per b.o.e and rising to $10 in year 7. For GEM-E3 the last roW of figures is for year 10.
4. The year 3 value for EUROGEM is interpolated.
5. GEM-E3 EU figures are estimated from individual country data, using appropriate weights.
6. The EU12 are Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxemburg, Netherlands, Portugal, Spain and United Kingdom
7. The EU9 are the EU12 without Germany, Greece and Luxemburg.
8. The EU 15 are the EU12 plus Austria, Sweden and Finland.

Sources:

E3ME: Cambridge Econometrics (1998)
GEM-3E: Capros et al (European Commission (1997)
EUROGEM: Bayar (1998)
LEAN-TCM: Welsch (1996)

(ii) The time profile of the increases also varies. *EUROGEM* picks up much faster than *E3ME*. *LEAN-TCM* does not appear to have increased impacts over time at all. We do not have data on the time profile for *GEM-E3*.

(iii) The employment increase is greatest for *LEAN-TCM,* followed by *E3ME.* We attribute the high value in *LEAN-TCM* to the low wage elasticity with respect to unemployment. This means that when taxes are lifted and employment demand increases, the real wage does not increase by much to negate the tax advantage. The *E3ME* effect is probably due to the increasing returns to scale assumption cited earlier, and partly to a greater substitutability of labour for energy, which did not come out in Table 2. It is noteworthy that, in terms of employment, *EUROGEM* produces similar results to *E3ME* for the EU12. *GEM-E3* has a much smaller employment impact.

(iv) The employment/GDP ratios vary a great deal. *E3ME* has much the highest ratio, followed by *EUROGEM* and *GEM-E3*. This suggests that the substitution potential in the three models differs quite a lot, with *E3ME* having the greatest and *GEM-E3* the lowest.

(v) As in Table 2, *E3ME* generates a fall in prices, whereas the other two show a small increase in the price level, indicating that a shifting of the tax to the rest of the world is unlikely to be big.

2.4 Analysis of Other Models

The *HONKATUKIA* model could not be compared with the other models as it was not run for a similar set of changes in taxes. Instead it was run for a base case where taxes on carbon (with certain exemptions were set at 70FIM/tonne of carbon). This is equivalent to about $13/tonne. The model then looked at further increases of 50-200% with different ways of revenue recycling (through lump-sum transfers, through social security payment reductions and through social security payment reductions applied selectively to labour intensive sectors). The simulations also looked at two cases of overall investment; one where it was fixed in each sector and the other where it was fixed in aggregate.

The results show that the base case generates virtually no double dividend. Although it is not explained, this is possibly due to the fact that the revenues are not recycled. In the other simulations, where revenues are recycled, some employment increases are generated relative to the baseline. With aggregate investment fixed and tax increases of 50% on carbon, the employment increase is 0.05%, a figure that is much lower than the models reviewed in Tables 2 and 3. While the tax increases are not comparable, it is instructive that the impacts are smaller. This may be the result of elasticities of substitution between labour and capital/energy being the same as those between capital and energy. He model shows that constraining capital movements makes the employment effects smaller; when each sector has to keep retain its overall capital level constant, the employment effect is only 60 percent of the above. The model also shows that a discriminatory way of recycling the tax revenues is **not** desirable. The employment effect is smaller than when all sectors are treated equally. Finally the environmental benefits in all cases are very small; carbon emissions changes are negligible.

The reasons for these results are not clear, and the paper does not offer a credible explanation for all of them. Further analysis using this model is warranted.

2.5 Conclusions

The analysis in this task has shown that the models differ in a number of ways that the theoretical analysis suggested would influence the likelihood of employment creation.

It is therefore very interesting to note that all the models suggest that the use of energy taxes to partially replace taxes on labour increases employment. However, there is a considerable variation between the models in the size of this effect.

It is impossible to use theoretical analysis to determine which of the many differences between the models are responsible for the differences in predicted employment creation. Instead, we must turn to Task 3, which reports on numerical experiments to investigate which factors are most important in determining the amount of employment created.

Task 3: Estimation of the Sensitivity of the Models to the Key Parameters and Assumptions

3.1 Sensitivity Analysis

Capros *et al.* (1996) provide some idea of the sensitivity of the GEM-E3 model to some parameter variations. A selection of their results is shown in the Table 6. Unfortunately, they do not provide details of the actual parameter values they use. Nonetheless, the table gives some hints as to what might be important. The first line of the table gives the base case results. The second line reports the consequences of making the wage rate strongly dependant on the level of employment, and shows that it reverses the GDP change and eliminates the employment gain: the energy taxes have distorted production with no employment gain because of the wage rise.

The third and fourth lines show the implications of altering the elasticity of substitution between labour and materials, showing that a high elasticity promotes employment growth and reduces energy use. This is what one would expect from labour subsidies.

Table 6: Sensitivity of GEM-E3 model predictions to key parameters (for France)
Simulation of European Commission's 1992 carbon/energy tax proposal

	Change in GDP	Change in Energy	Change in Employment
Base case	0.16%	-4.40%	+91,000
Inelastic Labour	-0.14%	-4.25%	0
Low labour-materials substitution	0.07%	-1.21%	+33,000
High labour-materials substitution	0.18%	-6.42%	+116,000
Competitive exports	0.05%	-4.70%	+68,000
Low capital-labour substitution	0.16%	-4.40%	+90,000
High capital-labour substitution	0.05%	-4.70%	+68,000

The fifth line shows the effect of regarding the export market as more competitive, producing a smaller employment gain despite the continued reduction in energy use. It also shows that the GDP growth is substantially reduced. This illustrates the importance of tax shifting, in this case to the rest of the world, in producing a double dividend.

Finally, the last two lines show the effect of altering the substitutability between the capital/electricity aggregate and the labour/materials aggregate. The effects on employment are relatively modest, but interestingly show that a higher elasticity of substitution produces a smaller employment effect. This is presumably because the higher elasticity creates a greater distortionary effect between capital and (non-electrical) energy, thus reducing efficiency, as witnessed by the much smaller gain in GDP.

In addition, Ms Van Regemorter has informed us that GEM-E3 does not produce a double dividend for any country if the assumption of EU monopoly power in international trade dropped, because of its loss of competitiveness. In other words, in this model, the double dividend only exists if some of the tax can be shifted to overseas consumers. This emphasises the importance of looking carefully at the modelling of non-worker consumers, something that is frequently overlooked in the literature. However, it should be noted that EU monopoly power is not required to produce a double dividend in all the models. Mr Barker (in private communication) has confirmed that the E3ME double dividend does not depend on being able to pass on costs in export prices.

An additional source of evidence on sensitivity was provided by Mr Bayar, who kindly carried out some simulations for us with EUROGEM. The results are shown in Table 7.

Table 7: Sensitivity of EUROGEM model predictions to model assumptions
Simulating the imposition of a US $10/tonne carbon/energy tax

	Change in Employment after 20 years	Change in Carbon Dioxide after 20 years
Base Case	+ 0.61%	-17.93%
Doubling of top level elasticity: KE vs. L	+3.41%	-18.84%
Halving of top level elasticity: KE vs. L	-0.08%	-17.24%
Doubling of second level elasticity: K vs. E	-1.14%	-26.78%
Halving of second level elasticity: K vs. E	+1.25%	-12.26%
Recycling revenue through labour income tax	-2.12%	-18.55%

The first row of Table 7 reports the percentage changes to employment and carbon dioxide emissions in the twentieth year after the policy change, based on the standard model assumptions with revenue recycled through reductions in social security taxes. The second and third rows show the changes if the elasticity of substitution between labour and the capital-energy aggregate is changed. As expected from the theory, increasing this elasticity substantially increases the employment benefit, as labour substitutes more easily for energy in response to the tax changes. Halving the elasticity actually eliminates the employment double dividend completely.

The third and fourth rows of Table 7 also illustrate the theoretical results, by showing the importance of the elasticity of substitution between capital and energy. As expected, reducing the elasticity increases the employment double dividend, as the energy tax has a smaller distortionary effect on the quantity of capital used in production. Doubling the elasticity removes the double dividend.

The last row of Table 7 reports on the effect of recycling the revenue through reductions in labour income tax instead of social security taxes. This confirms the intuition of the theoretical section: social security taxes are the best form of revenue recycling for obtaining an employment double dividend.

Unfortunately, we have been unable to obtain any sensitivity results for the effect of international capital mobility, which the theoretical analysis and the results of task 2 suggest could be of considerable importance. As reported in section 2.1, the models do not represent international capital mobility directly, although some do make investment depend on the rate of return on capital. However, none of the modellers have reported the sensitivity of their results to changes in the parameters that link investment to the rate of return. We asked Mr Bayar to do this for EUROGEM but it appears that the model is not constructed in a way that makes this possible.

3.2 Conclusions

There has been little work that systematically investigates the sensitivity of model results to changes in assumptions. Unfortunately, it was not possible for us to gain access to these models and conduct sensitivity analysis of our own. We have had to rely on that conducted by the model-builders themselves.

As expected, and as emphasised in the theoretical literature, the degree of substitution between inputs is important in determining the additional employment created. The larger was the elasticity of substitution between labour and energy, the larger was the employment increase. Also, the smaller was the substitution elasticity between capital and other inputs, the larger was the employment increase. These reflect the efficiency effects of reducing the high tax on labour.

The importance of efficiency was also demonstrated in EUROGEM by the fact that the use of energy tax revenue to reduce income taxes, rather than payroll taxes, reversed the employment gain. This reflects the fact that income tax is not so closely related to employment as are payroll taxes.

The role of shifting the tax burden was also demonstrated in GEM-E3, by the fact that employment gains were reduced with increased export competition and by the fact that the employment gain disappears completely if none of the tax can be shifted abroad. Unfortunately none of the models captured the possibility of shifting taxes between different groups within society, such as those on pensions. More importantly, none of the models were able to indicate the sensitivity of the results to changes in the ability to shift the tax burden onto capital. The theoretical analysis suggests that this is very important, and the investigation of this with numerical models should be a high priority for further research.

Task 4: A Review of Practical Examples of Environmental Taxes and Revenue Recycling

4.1 General Features of Green Tax Reform

During the 1990s there has been increasing interest in green tax reform to achieve the twin benefits of reducing environmental damage whilst increasing employment. Table 8 summarises current practice across Europe.

Table 8: The double employment-environment dividend: current practice in Europe

Countries	Tax shift
Belgium	The revenue of a "special levy on energy" (introduced in 1993) is paid into a special fund to finance social security expenditures.
Denmark	New or increased environment-related taxes will increase revenues by DKr 12.2 billion by 1998, with a simultaneous lowering of income tax. Since 1996, part of the revenue of the newly increased CO_2 tax on industry has been allocated to reducing employers' social security contributions.
Finland	Starting in 1997, lower taxes on income and labour (Fmk 10-11 billion in cuts announced for the period 1999-2003), offset in part by new ecotaxes (e.g. a landfill tax, Fmk 300 million per year) and energy taxation.
Germany	From the beginning of 1999 additional taxes have been imposed on fuels with a 0.8% reduction (about 9 billion DM) in National Pension contributions.
Italy	Over half of the revenues (about 2,200 bn IL) raised in the first year from a carbon tax introduced in January 1999 will go towards reducing employment charges.
Netherlands	A large part of the revenue of the 'regulatory tax on energy' introduced in 1996 goes towards reducing employers' social security contributions.
Switzerland	Revenue from new ecotaxes on VOCs and extra-light heating fuels will be redistributed to households in the form of reduced compulsory sickness insurance contributions (1999).
Sweden	A tax reform in 1991 resulted in a SKr 15 billion tax shift to environment-related taxes, leading to a reduction inter alia in marginal income tax rates. A reduction in employers' social security contributions is being considered.
United Kingdom	Revenue from a landfill tax introduced in October 1996 (£450 million/annum) is to be used to reduce employers' social security contributions by 0.2 percentage points.

Source: updated from OECD (1997) *Environmental taxes and green tax reform*

Some of the longer running and more substantive schemes that have tried to achieve a 'double dividend' effect are described in more detail below.

4.2 Denmark[11]

Green taxes on industry were introduced in 1995. The 'energy pack', resulted in a change in the taxation and energy allocation for industry and aims to reduce CO_2 emissions by 4% (of 1988 levels) by 2005 and is therefore one of the key initiatives to reduce Danish emissions. The energy pack is specifically targeted at the industrial sector, whilst the energy sector (electricity and gas suppliers) and households are regulated through other systems. Taxes on industry were increased in 1996 and the current rates are as shown in Table 9.

Table 9: Energy Tax Rates in Denmark

Uses	Examples of use	Tax rates in 1999 (Danish Kr/tonne CO2)
Heavy industry with agreement	Energy for cement and steel manufacturing	3
Heavy industry without agreement		20
Light process	All electricity which is not heavy industrial	80
Heating	Oil, natural gas and central heating	570-950
Transport	Energy used in personal cars and vans	900-1840
Households*	Heating and lighting	570-950

Note: *Excluding transport

The level of taxes takes into account the degree of international competition facing Danish industry. Taxes are therefore lower on the more energy intensive activities and those that face the greatest competition from overseas. This means that manufacturing industry and agriculture have the lower taxes compared with other industrial sectors (Table 10).

Table 10: Danish Energy Tax Rates: Differentials by Sector

Sector	Tax (Danish Kr/GJ)	Energy Consumption (%)	Tax rate (%)
Agriculture	9	18	10
High energy intensive manufacturing industry	8	43	30
Other manufacturing industry	18	12	17
Service and trade, construction	32	27	43
All private industry (average)	13	100	100

[11] Details from the 1999 Danish Government report *Evaluating Green Taxes and Industry*

In the longer run it is intended that the energy taxes should be fiscally neutral. In 1996, the only year where historical data is available, the level of recycling was 100 million Danish Kroner lower than the taxes. However, calculations from the Danish government show by 1998 fiscal neutrality should have been achieved and from 2000 it is expected that rebates will exceed taxes.

Overall, the returns to industry have been calculated to be approximately 0.2% of GNP in 2000 and so costs to private industry are not greatly affected by the energy pack.

4.3 Germany[12]

The first stage of ‘ecological tax reform’ was introduced in Germany on 1 April 1999 and was part of a wider framework of ‘ecological tax and contribution’ policy of the current government.

The main aims of the tax reform are to:

- tax the use of energy appropriately;
- use the additional tax revenue to decrease National Pension (NP) contributions, thereby decreasing the burden of income-related costs;
- encourage investment in energy-efficient equipment, and;
- strengthen Germany’s position in the ‘green goods’ market.

The measures of the first stage are:

1. Introduction of a 0.02 DM/kWh tax on electricity use at the level of electricity retail, which will be passed on to the consumer. This includes imported electricity (e.g. from France);
2. Increase of mineral oil tax/duty of 0.06 DM/litre for transport fuels, 0.04 DM/litre for heating oil, and 0.0032 DM/kWh for natural gas;
3. Reduction of NP contributions by 0.8% (about DM 9 billion), equally shared between employers and employees. In terms of absolute National Pension (NP) and Social Insurance (SI) contributions, this is a reduction from 20.3% to 19.5% and 42.3% to 41.5%, respectively.

There are also exceptions for clean energy sources and discounts for certain industry sectors.

The key exceptions are:

- Renewable energy sources (wind, solar, geo-thermal, and hydro/waste/biomass up to 5 MW capacity) are exempt of the electricity tax.
- As there is no tax on coal for power generation, the increase of mineral oil tax has been waived for heating oil and natural gas fuels.
- The increase of mineral oil tax has also been waived for CHP generation with load factors of greater than 60%, and there is no mineral oil tax at all for CHP plants with load factors of greater than 70%.

[12] Information taken from the Finance Ministry’s Web-site (http://www.bundesfinanzministerium.de).

The main discounts and rewards are:

- Reduced rate of 20% of electricity tax (0.004 DM/kWh, or 0.13 p/kWh) for the manufacturing and agricultural industries with demand for more than 50 MWh/year;
- Reduced rate of 50% of electricity tax (0.01 DM/kWh, or 0.33 p/kWh) for urban public transport operators and domestic night/storage heating;
- Extended tax relief for natural gas vehicles to 2009.

4.4 Italy[13]

In January 1999 a carbon tax was introduced which will be increased annually from 1999 to 2004. By 2005 taxes on petrol will increase by 7%, diesel tax by 12%, coal tax by 42%, natural gas by 2%. Tax on heating oil will rise by 52% for domestic users and 61% for industry. Meanwhile, taxes on liquid petroleum gas (LPG), an alternative, low-polluting transport fuel, will fall.

Over half of the forecast revenues of 2,200 billion Lira raised in the tax's first year will be spent on reducing employment charges. Revenues raised are intended to help pay for three years of welfare contributions incurred by employers taking on new staff in Italy's poorer south. Half the pension contributions of young businessmen who change jobs will also be covered. Revenues from the tax will also be recycled to road transport professionals and residents of remote mountain areas to offset increases in diesel and heating oil prices. A further Euros 155 million will be used to finance further measures against polluting emissions

4.5 Netherlands[14]

A 'regulatory tax on energy' was introduced on 1 January 1996 with the aim of stimulating additional conservation of energy among small energy consumers. The revenues are recycled through reductions in direct taxes. The tax was initially targeted at small-scale energy consumption and then extended to larger users in January 1999, but at a much lower rate.

The tax is applicable to natural gas (usage over 800 m^3), electricity (usage over 800 kWh) and mineral oil products, which can be used a substitutes for gas by households or small businesses. The tax paid on mineral oil products in excess of a certain quantity may be refunded. Road transport fuels are not covered by the tax.. The tax rates exclusive of VAT are shown below in Table 11.

The tax was introduced in three stages in order to limit potentially undesirable economic impacts. At its 1998 level the tax had raised the gas price by 20% to 25% for smaller consumers and the price of electricity by about 15%.

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[13] Information from ENDS Daily, 19 January 1999 and personal communication with A. Goria, FEEM.

[14] Details taken from the Dutch Ministry of Housing, Spatial Planning and Environment publication, VROM (1998) *The Regulatory Tax on Energy in the Netherlands: Questions and Answers*, updated by information from the Ministry's website (http://www.minvrom.nl/environment/groene_belastingen/home.htm) and personal communication with Anthonie Henderson, VROM.

One sector that is partially exempted from the tax is the greenhouse horticulture. This sector has a very high energy/employee ratio and so it is impossible to recycle revenue back to this sector in a way that would compensate adequately for the very high burden imposed by the tax. It was therefore decided to introduce a special zero-rate on the natural gas used in greenhouses. The sector receives no special treatment as regards the tax on electricity.

Table 11: 1999 Rates of regulatory tax on energy in the Netherlands

fuel	unit	cents/unit	EUR-cents/unit
natural gas	m^3		
800-5,000		15.98	7.25
5000-170,000		10.44	4.74
170,000-1 million		0.71	0.32
electricity	kWh		
800-10,000		4.95	2.25
10,000-50,000		3.23	1.47
50,000-10 million		0.22	0.10
light fuel oil	litre	12.68	5.75
heating oil	litre	12.79	5.80
LPG	kg	15.13	6.86

The tax is expected to raise about Dfl. 2.2 billion (including the VAT paid over the tax) structurally after 1998 when the rates reach their final level. The revenues raised by the tax are recycled through relief in other taxes paid by households and businesses. The amount paid by the group ‘households’ (Dfl. 1.2 billion) is recycled to households and that paid by the group ‘businesses’ (Dfl. 1 billion) is recycled to businesses and the government sector.

Revenues are recycled back to households through three changes to the personal income tax: a reduction of 0.6 percentage points in the rate charged over the first income bracket (accounting for ca. 7% of the revenue recycled to households), a raise of Dfl. 80 in the tax free income allowance (accounting for ca. 32%) and a Dfl.100 rise in the standard deduction for senior citizens (accounting for about 1%).

For businesses, recycling is through a reduction of 0.19 percentage points in the wage component paid by employers to cover social premiums paid by employees (accounting for ca. 57% of the revenue recycled to businesses), a rise of Dfl. 1300 in the standard deduction for small independent businesses (accounting for about 25%), and a reduction of 3 percentage points in the corporate tax rate over the first 100,000 guilders of profit (accounting for the remaining 18%).

The effect of the tax and recycling on job creation is expected to be positive but fairly modest. During the preparation of the bill, the Dutch Central Planning Bureau used economic models to calculate the employment impact of a small-scale energy tax in combination with a number of different revenue recycling schemes. The employment impact was found to be dependent on several factors, of which the most important were how the revenues are recycled and how energy prices develop.

The employment effect projected therefore varies with assumptions concerning future energy price development. In a scenario with relatively high energy prices, investments take place fairly quickly following introduction of the tax and then taper off (to zero in 2010), while in a scenario with lower prices the investment impulse takes longer to work and tapers off from its high point (about 11,000 extra jobs in 2010) much later. The extra jobs created in both scenarios are largely in the construction sector and tertiary services sector.

4.6 United Kingdom

A tax on landfill was introduced on 1 October 1996[15]. Inactive waste (such as bricks) is taxed at £2 per tonne and all other waste is taxed at £7 per tonne. The tax applies to waste disposed of at landfill sites throughout the United Kingdom which, in broad terms, are licensed under environmental law. To minimise the overall impact on business costs the tax was accompanied by a reduction from 6 April 1997 to the main rate of employers' National Insurance contributions of 0.2 percentage points. The estimated net revenue yield from these measures is £450 million per year although, because precise figures about the amount of waste sent to landfill are not available centrally, the estimate is open to a greater than usual margin of error.

The UK has recently announced that a climate change levy will be introduced as of April 2001. The proposed levy will be charged on industrial and commercial use of energy. The levy will not be raised on domestic consumption, aviation fuel or public transportation. The levy will also not be applied to road transport, as this is covered by previous taxation. The levy will, however, apply to electricity, coal and its derivatives, natural gas and LPG. Those required to register and pay the levy will include: electricity, gas and energy companies; importers of energy for commercial production; and community heating schemes supplying industry. The levy will be applied as a specific rate per nominal unit of energy, using differential rates to account for different carbon contents, which are to be announced in the Finance Bill 2000. The rate charged on electricity will be uniform, reflecting the average carbon produced in electricity production. HM Customs and Excise in a consultation paper[16] indicate that, if these differential rates were derived from the 1998 Digest of Environmental Statistics and taking into account lower rates for energy intensive sectors agreeing targets for improved energy efficiency, they would be of the order of 0.21 pence per kWh for coal and gas and 0.60 pence for electricity. It is expected that revenues from the climate change levy will amount to £1.75 billion.

[15] Information taken from the web-site of the Department of the Environment, Transport and the Regions, www.detr.gov.uk

[16] HM Customs and Excise (1999) "Consultation on a Climate Change Levy", Consultation paper. March 1999. Available from HM Treasury website: www.hm-treasury.gov.uk.

Task 5: Comparison of Model Parameters and Assumptions with Real World Examples

The main parameters critical to the double dividend analysis are given in Table 12 below, with a comment on estimates from other studies not relating to this literature.

The estimates for the production function elasticities in the simulation studies are broadly consistent with the empirical literature. The HERMES model values are most closely based on the empirical estimates but the others are not far from the HERMES values.

The situation is more problematic with regard to the sensitivity of capital flows to changes in domestic rates of return and to the parameters of the labour market. For the international capital movements empirical evidence suggests that there is considerable sensitivity. Mintz (1996) cites evidence that "interest rates across countries seem to be closely related through financial arbitrage" which would imply that deviations in rates of return on capital would generate substantial international movements. The models, however, fail to take this into account. On the labour market, models that allow for unemployment take a real wage elasticity of unemployment that is generally consistent with the low value of 0.1 (Layard, Nickell and Jackman, 1991). On the supply side the empirical determination of sensitivity to the real wage is now more complex and disaggregated than these simulation models suggest. Furthermore there is disagreement between the more 'neoclassical' economists and the Keynesians, with the former suggesting much higher value for supply elasticities than the former. Nevertheless, a 'ball park' figure of around 0.7 is often used. It is not possible to say whether the estimates in the GEM-E3 and Honkatukia models are consistent with this figure, although it is likely that they are.

To conclude, apart from the sensitivity of capital flows to real rates of return, the simulation models do not appear to be inconsistent with the empirical literature. It is not always possible, however, to obtain the parameter values from the simulation models.

Table 12: Estimates of Key Parameter Values in Simulation Models and Other Literature

Parameter	**Assumed value in study**	**Assumed value in other studies**	**Models affected**
Sensitivity of international capital movements to changes in domestic rates of return	Zero.		All
Elasticities of substitution between composite of energy/capital and labour	One in long run. Eurogem has short run values of 0.1, rising to 1 in long run. Lean TCM has value of 0.6	Broadly consistent with the empirical literature	Hermes Eurogem Lean TCM Honkatukia
Elasticities of substitution between energy and capital	Hermes has various values based on empirical estimates. They vary from country to country. Lean/TCM has a similar but narrower range.	Hermes values are taken from empirical literature	Hermes Lean/TCM
Elasticities of substitution between energy types	Around 2 in long run and 0.3 in short run (Eurogem).	Consistent with empirical literature	
Elasticity between capital and other factors	0.3 to 0.4	No specific studies cited but broadly consistent with related empirical work.	GEM-E3
Elasticity between energy and other inputs	0.2 to 0.4		GEM-E3
Elasticity between all inputs other than energy	0.5		GEM-E3
Elasticity of real wages with respect to unemployment.	Values vary by country but values are at or below 0.1.	Low value of around 0.1 in literature.	Hermes Eurogem
Sensitivity of labour supply	In GEM-E3 it is stated to be fairly elastic but no actual value available. Similarly in Honkatukia it is said to be consistent with empirical estimates but value is given.	Wide range in literature, which is much more detailed in its modelling of impacts. Value of 0.7 is consistent with some studies	GEM-E3 Honkatukia

Task 6: Calculating the Employment Implications of the Proposed New System of Energy Taxation Using a Bottom-Up Methodology

6.1 Introduction

In the previous sections a number of studies have been analysed, which use macroeconomic models to examine the scope for a double dividend in the context of the Commission's proposals for a Directive restructuring the Community framework for the taxation of energy products.[17] The results from these models indicate that the economic impacts of the proposed Energy Tax Directive are small and that a double-dividend of reduced emissions and increased employment can be achieved if tax revenues are used to reduce the social security contributions paid by employers. The range of estimates is, however, quite large and there are significant uncertainties as to the magnitude of the employment and carbon reduction effects.

Although the models used in these studies (e.g. E3ME, HERMES and GEM-E3) encompass a range of different approaches, they are all top-down macro-economic models. Under this task, a completely different methodology has been developed, which makes use of a bottom-up engineering approach for calculating the employment effects of the proposed tax. The results from this approach are have then been compared to those obtained using the more traditional macro-economic models.

6.2 Methodology

In the bottom-up approach, a particular tax change is analysed for each industrial sector to which it applies. An increased tax on energy products will therefore stimulate actions at the plant level that will imply investment in energy saving equipment, as well as other adjustments in employment and output. Through a detailed knowledge of the sector and contacts with key industry representatives, these changes can be estimated, and the consequent changes in both direct and indirect employment calculated. The analysis has been carried out, initially for the manufacturing sector in the UK and then extended to the manufacturing sector in the rest of the EU. Unfortunately it has not been possible within the confines of this project to extend the formal analysis to non-manufacturing industry (e.g. mining, construction and the energy industries), services and agriculture. However, in the concluding section a rough estimate of the overall size of the employment effect across all sectors is made.

The methodology, details of which are given in Annexes I and II can be summarised as follows:

1. From a detailed knowledge of the options for reducing carbon emissions in each sector, a detailed carbon dioxide savings supply curve has been estimated for each of the seventeen sub-sectors of manufacturing industry. Analysis is

[17] A discussion of these studies may be found in the Working Paper of the Commission entitled 'Presentation of the New Community System for the Taxation of Energy Products', Part II: ' Assessment of the Impact of the Proposal'.

based on a database of around 400 energy technologies established by AEA Technology.

2. The curves, which give net present cost per tonne of CO_2 saved by technology in each of the sub-sectors has been calculated using a nominal discount rate of 25%. This high rate is justified on the grounds that manufacturing industry uses such a rate to decide on all investments, including those in carbon reduction. Examples of such curves are shown in Annex I. They start with the lowest cost options and move on to increasing cost alternatives.

3. The above modelling is more detailed for the UK than for the other countries of the EU in that the UK data provide full cost of supply estimates. For the other countries the costs of supply are based on an empirical relationship which shows that energy savings within any manufacturing sector are proportional to value added. Hence the energy savings and the CO_2 savings in the other 14 countries have been estimated.

4. The curves inevitably show that there are some options with 'negative costs' -- i.e. technologies in which the costs of adopting them generate a reduction in unit costs of production at the same time as reducing carbon dioxide emissions. This is a common feature in bottom up models and has been criticised on the grounds that, if such options exist, why are they not adopted anyway? One answer is that implementing them involves implementation costs that have not been accounted for in the calculations. For this reason, and to avoid giving too optimistic a picture of the costs of changing technologies in response to a carbon tax, it is assumed that such a tax will not necessarily result in the cost effective options being adopted in a strict net cost order. Rather it has been assumed that industry will invest in a **range** of cost-effective savings opportunities over a period of years, with the rate of uptake of individual measures over time depending on their relative cost-effectiveness. These include the negative cost options but they do not get adopted immediately and not especially in response to the tax change.

5. From the above, estimates of the costs of responding to a carbon tax have been worked out. These costs include capital and labour items. The latter can be positive or negative; the new technology may require more or less labour. Since details of the technologies are available these labour costs can be estimated and from them the changes in **direct** labour requirements. Indirect labour requirements have also been estimated from detailed knowledge about the labour inputs in the construction of the capital equipment demanded by the changes in technology. In doing this allowance has been made for the proportion of the equipment that is produced outside the EU.

6. The above calculations have been made under two assumptions: (a) that the carbon tax is an additional tax on the enterprises and (b) the tax is accompanied by a reduction in social security payments on labour by an amount equal to the total tax collection divided by the number of employees in the manufacturing sector. In order to estimate the effect of recycling the tax revenues to reduce employer labour charges, the results have been calculated assuming that each sector will use the recycled taxes to employ additional

workers such that total labour costs are constant before and after the tax is applied. This assumption of a unit elasticity of demand for labour with respect to the wage rate is not empirically proven in this context but is broadly consistent with other labour demand studies.

7. The employment effects of the Directive have been calculated assuming that the final stage of the tax has been implemented and the sectors have fully adjusted to the increases. Given the capital stock turnover and investment lead times inherent in most sectors of manufacturing industry the results are therefore presented for 2010.

6.3 Results

The effect of the proposed energy tax on the annual investment in energy saving measures, CO_2 emissions and employment are presented in Tables 13 and 14 below, both by country and by sector. Across the whole of the EU, the proposed tax stimulates manufacturing industry to invest an additional 253 M Euros per year in energy saving measures over the period 2002 to 2010. This results in CO_2 emissions being 2850 ktC lower in 2010 than they otherwise would have been and increases employment by a modest 31,000. However, if the tax revenue is recycled to reduce labour costs, then the employment benefits could be as high as an additional 118,500 jobs.

Table 13: Effects of the proposed Energy Tax Directive by Country

	Additional annual investment stimulated (M Euro)	CO_2 reduction (ktC)	Employment change	
			no recycling to reduce labour costs	with recycling to reduce labour costs
Austria	2	25	800	1,490
Belgium	12	130	730	5,300
Denmark	0	0	360	360
Finland	2	14	690	1,130
France	51	434	6,000	23,890
Germany	70	913	12,000	39,160
Greece	2	33	60	790
Ireland	4	51	350	1,480
Italy	14	173	4,950	9,150
Luxembourg	1	15	30	672
Netherlands	0	4	820	920
Portugal	4	45	300	1,700
Spain	30	364	510	10,720
Sweden	3	15	2,140	2,940
United Kingdom	58	635	1,770	18,830
EU Total	**253**	**2,850**	**31,270**	**118,540**

Most of the additional investment in energy saving takes place in the Chemicals, Food, non-metallic minerals and engineering sectors and thus the bulk of the CO_2 savings come from these sectors. However, in terms of additional employment it is the engineering sector that is by far the biggest winner with an additional 30,000 jobs. This is largely because this sector is the one that would manufacture and supply virtually all the energy saving measures stimulated by the tax.

Table 14: Effects of the proposed Energy Tax Directive by sector

	Annual investment stimulated (M Euro)	CO_2 reduction (ktC)	Employment change	
			no recycling to reduce labour costs	with recycling to reduce labour costs
Primary Metals	13	226	140	10,730
Non-metallic Minerals	47	820	0	11,470
Chemicals	64	587	160	8,390
Paper & Printing	12	108	40	3,570
Textiles & Leather	8	65	-60	12,260
Food	64	555	840	13,090
Engineering	34	386	29,800	45,120
Other	11	104	360	13,910
Total	**253**	**2,850**	**31,270**	**118,540**

If tax revenues are not recycled to reduce labour costs, then direct employment effects across all the sectors totals only an additional 2,400 jobs across the EU, with a further 28,900 jobs being created in engineering as a result of the demand for additional energy saving measures

6.4 Conclusions

The bottom-up analysis, which has considered only manufacturing industry in the EU, indicates that the proposed energy tax Directive could save 2.85 MtC (about 2% of 1990 emissions from this sector) while creating 119,000 additional jobs. Overall employment in the manufacturing sector is 20% of total employment or around 28 million for the EU15. Hence the employment effect in the bottom-up analysis in comes out at about 0.4%. In Table 2 the employment effects for the same directive, for all sectors, ranged from 155,000 to 457,000, or 0.11 to 0.33%. Hence the effect from the bottom up analysis is at the upper end but not out of line with those from the top down analysis.

As noted above, the decrease in carbon emissions from the bottom-up model is about 2% from baseline values. In Table 2, the decrease in carbon emissions is roughly 0.5 to 1.5%. So again the bottom-up model provides results, which are in the same range as the top-down models, but at the upper end.

Task 7: Conclusions

The first part of the report reviewed the theoretical literature on the double dividend and the empirical literature, as it exists for the European Union countries. The theoretical literature is complex and, even for most economists not specialising in the area, rather difficult to follow. We have attempted to provide a guide to the main results that should be comprehensible to the non-specialist economist working in this policy area. The double dividend needs some care in definition; we state it as a case where a switch in taxation towards an 'environmentally sensitive input', and away from a non-environmental input will create employment or reduce the welfare cost of raising the current level of government revenue. At the same time it will reduce the level of environmental damage.

There are several factors which, when present, make it more likely that an employment double dividend will exist. They are summarised in section 1.1.4. Prominent among them are the cases where:

(a) the environmental tax can be passed on to factors that are inelastically supplied,

(b) the tax can be passed on to non-workers,

(c) the substitutability between labour and energy is greater than that between energy and capital,

(d) real wages are not very sensitive to the level of employment.

The empirical models do not pick up on all these as much as they might. In particular they do not address (a) the elasticity of supply of one key factor of production (capital, which may be much more elastic than most models assume) and (b) the role of non-workers in determining the extent of the double dividend. **These are areas where further work is required.**

The models are quite good at modelling the different elasticities of substitution between labour, energy and capital. On these, although there are some quantitative differences, most models find that labour and energy/capital are substitutes whereas energy and capital are complements. Moreover the differences are big enough to provide strong grounds for a double dividend to be created.

There is an important divide between models that assume full employment and those that treat the labour market as being in disequilibrium, with involuntary unemployment. In the full employment models, the key assumption is the elasticity of supply of labour. The value assigned to this is not always known. This gap needs to be filled, and the models need to model labour supply in a more sophisticated way, allowing for example for different elasticities between different categories of workers (e.g. by gender). In the unemployment case, the modelling of the wage determination equation is rather *ad hoc.* A full sensitivity of the result to the parameters of this part of the model is needed.

Almost without exception the models looked at find that a switch in taxation from labour to carbon/energy will increase employment and reduce carbon emissions. At the same time they will increase GDP. Hence there is some agreement on this 'good news'. The differences are about the size of the impacts. For the 1992 proposed carbon/energy tax, which rises to $10 per barrel of oil equivalent over about 7 years, the size of the impact ranges from 0.4 to 2.6 percent by the end of that period. This is for various groupings of EU countries and has therefore to be treated with caution, but is still instructive about the range of estimates. With around 140 million people employed in the EU12, it translates into a range of half a million extra jobs to over 3.5 million. The impact on carbon reductions is also huge -- from 5 to 16 percent. The GDP values range from 0.4 to 2.2 percent.

The bottom-up analysis, which has considered only manufacturing industry in the EU, indicates that the proposed energy tax Directive could save 2.85 MtC (about 2% of 1990 emissions from this sector) while creating about 119,000 additional jobs. Overall employment in the manufacturing sector is 20% of total employment or around 28 million for the EU15. Hence the employment effect in the bottom-up analysis comes out at about 0.4%. In Table 2 the employment effects via the top down analysis, for the same directive and for all sectors, ranged from 155,000 to 457,000, or 0.11 to 0.33%. Hence the effect from the bottom up analysis is at the upper end but not out of line with those from the top down analysis. It is important to note, however, that the manufacturing sector offers more opportunities for substituting labour for energy than the other sectors.

As noted above, the decrease in carbon emissions from the bottom-up model is about 2% from baseline values. In Table 2, the decrease in carbon emissions is roughly 0.5 to 1.5%. So again the bottom-up model provides results which are in the same range as the top-down models, but at the upper end.

The robustness of the results from two very different modelling approaches would suggest some confidence in the conclusion that the introduction of the proposed energy tax would have a useful role in helping to reduce CO_2 emissions in the EU and could also have a small positive impact on employment, particularly if the revenues are used to reduce employer labour costs.

Finally, it should be noted that the terms of reference to this study were concerned with the effects of proposed environmental and energy taxes, and excluded issues connected to their actual design. Important design issues include the question of exactly which environmentally damaging activities should be taxed, the extent to which taxes should be differentiated between different activities, and the extent to which particular sectors should be exempted from such taxes. These are all issues that deserve further study.

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ANNEX I: Details of the Bottom-Up Modelling Methodology

The bottom-up approach was originally developed to examine the impacts of tax changes on UK manufacturing industry and for this study has been adapted to provide estimates for manufacturing industry across Europe.

Carbon Dioxide Savings Supply Curves

The basis of the approach is a set of detailed carbon dioxide savings supply curves, one for each of seventeen sub-sectors of manufacturing industry. The curves have been estimated for all major industrial devices, using a database of the recent pattern of distribution of energy technologies in the UK established by AEA Technology (around 400 technologies). The methodology allows for competition between energy end-use technologies on the basis of cost effectiveness, though combined heat and power is estimated separately.

The curves have been calculated using a discount rate of 25% and are presented in terms of net present cost per tonne of CO_2 saved, by technology in each of the sub-sectors. Cross cutting technologies such as boilers and CHP were considered separately. Examples of these curves are shown in Figures 1 and 2.

Figure 1: Potential National Carbon Dioxide Savings in Food and Drink 25% Discount

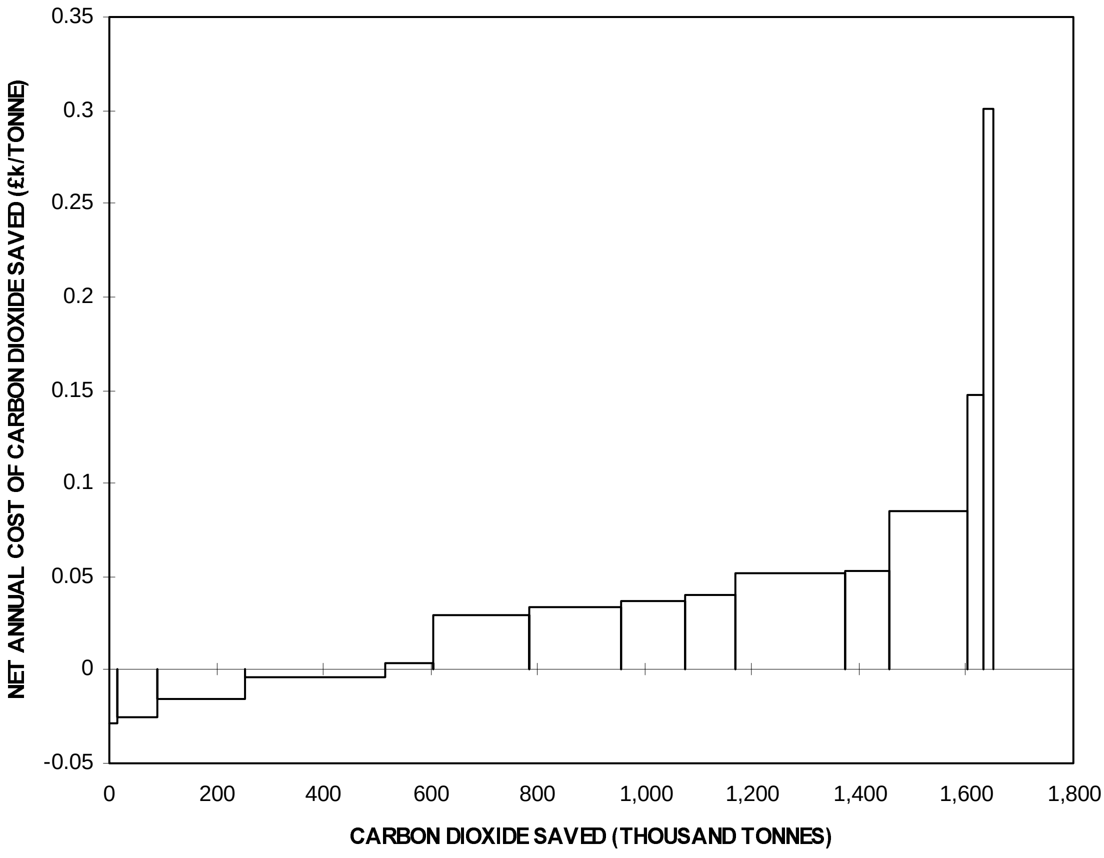
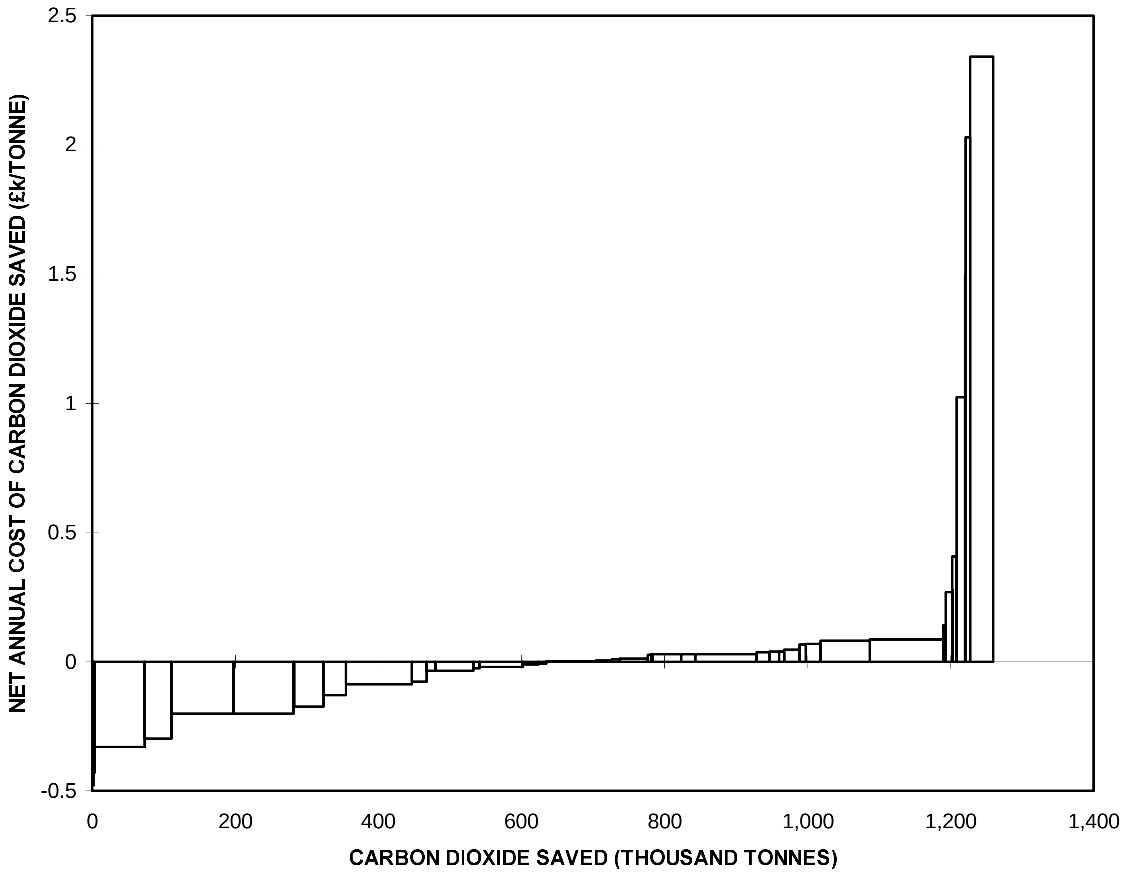


Figure 2: Potential National Carbon Dioxide Savings in Textiles
25% Discount



In deriving the curves, fixed and variable costs and other savings associated with improved product quality, maintenance and labour cost changes, throughput improvements and other non-operating costs have also been included in the analysis as well as energy savings. However, it needs to be recognised that the engineering-economic approach does not necessarily capture all of the costs and benefits that individual companies may need to take into account in investment appraisal. On the cost side these include management time, capital availability and perceived risk, with possible benefits including opportunities for better plant management and efficiency of operation, more integrated production and enhanced corporate image.

Nevertheless, the savings supply curves do indicate the existence of a large pool of investments in manufacturing industry for which the engineering economics does not impose a serious barrier to CO_2 abatement given suitable time scales for investment.

Energy Tax Model

AEA Technology have developed a simple spreadsheet model for UK manufacturing industry that uses these savings carbon dioxide savings supply curves to calculate the impact of energy taxes on energy and CO_2 savings and indicates the implied investment to achieve these savings. In the model the basic curves, described above, have been adapted and combined to reflect the actual investment behaviour of the eight major sub-sectors of industry shown in Annex II. Rather than adopting energy savings measures in a strict net cost order, it has been assumed that industry will invest in a range of cost-effective savings opportunities in a given period, with the rate of uptake of individual measures over time depending on their relative cost-effectiveness.

In a perfect market, all measures that are cost-effective for a particular set of energy prices would be taken up. Imposing a tax on energy would then stimulate investment in more expensive savings measures that have become cost effective. However, the CO_2 savings supply curves show that, even in the absence of a tax, there exists a significant cost-effective energy efficiency potential across all sectors. The model therefore assumes that the impact of a tax would be to promote extra investment in energy efficiency measures such that additional savings realised are equal to the difference between the cost-effective potentials before and after the tax is applied.

In the case of the proposed Directive on energy taxation, the change in the level of energy prices implied by the tax will vary across the European Union depending on the existing tax structure in each Member State. The effect of these price changes on the level of emissions savings will also be different, depending on the structure of manufacturing industry in each country and the fuel mix.

In order to allow for these differences to be properly accounted for it was necessary to develop 14 further spreadsheet models, one for each country in the European Union. These new models have made use of previous work, undertaken by AEA Technology for European Commission DGXVII, which examined energy savings options in the UK, Germany, the Netherlands and Portugal.[18] The results of this study showed that, for a given sub-sector, there was a good correlation between the size of possible energy savings in a particular country and the level of value added output from the sub-sector.

The new models have therefore been configured to represent the particular industrial structure in each of the Member State by assuming that for a given level of tax and sub-sector:

$$\text{Energy savings in country i} = \text{Energy savings in UK} \times \frac{\text{Value added in country i}}{\text{Value added in UK}}$$

These energy savings have then been converted to carbon dioxide emissions savings using country specific emissions factors.

Employment Effects of the Tax

As well as the energy savings that may be attributable to a particular energy efficiency investment, the carbon dioxide savings supply curves also contain data on the costs of other impacts that the measure may have. Among these other impacts are effects on employment, which may be either positive or negative. Positive employment effects can arise because the measure involves monitoring and targeting of energy use or because the equipment used requires additional staff time spent on its operation and

[18] Detailed Modelling of the Priority of Industrial Energy Efficiency Technologies for Europe, a Thermie B project for EC DGXVII by AEA Technology (UK), CCE (Portugal), FHG-ISI (Germany) and University of Utrecht (the Netherlands).

maintenance. Negative employment effects can occur if the measure involves process integration resulting in staffing efficiencies or automation. For this study these changes in employment costs have been converted into employment levels using information on wages as well as National Insurance and pension data for the different sectors. Since all the measures stimulated by the energy tax are cost effective there are no negative impacts on employment due to loss of competitiveness.

There will also be indirect employment effects in those companies that supply and install the energy saving measures. These indirect employment effects have been calculated from a knowledge of the investment costs associated with the measures and data on the labour costs and gross output per head of the supplying industries. These supply companies are assumed to all lie within the engineering sector of the economy and so this is where the indirect employment effects will be felt.

Annex II – Coverage of the Bottom-Up Analysis

Sectors
Primary Metals
Non-Metallic Minerals
Chemicals
Engineering
Food
Paper
Textiles
Other manufacturing

Categories of Energy Saving Measure	Metals	Minerals	Chem	Eng	Food	Textiles	Paper	Other
Energy Management & Good Housekeeping	✓	✓	✓	✓	✓	✓	✓	✓
Large-Scale CHP	✓	✓	✓	✓	✓	✓	✓	✓
Boilers & Heat/Steam Distribution					✓	✓		
Process Maintenance &/or Modification	✓	✓	✓				✓	
Process Control/Optimisation	✓	✓	✓		✓		✓	
Non-drying Separation Technologies			✓		✓			
Heat Recovery	✓	✓	✓		✓	✓	✓	
Drying & Evaporating Technologies		✓	✓		✓	✓	✓	
Improvement of Yield	✓					✓		
Design/Operation of Furnaces/Kilns/Ovens	✓	✓			✓			
Combustion & Firing Processes	✓	✓						
Insulation & Refractories	✓	✓						
Low Temperature Processes						✓	✓	
Aerobic/Anaerobic Digestion							✓	
Additives and Material Substitution		✓						