IS THERE A ROLE FOR DOMESTIC ENERGY TAXES UNDER EMISSION TRADING?

Juha Honkatukia
Government Institute for Economic Research VATT

Juha Forsström
Eero Tamminen
Government Centre for Technological Research VTT

Abstract: Energy taxes do not necessarily improve the cost efficiency of emission trading, if they introduce price signals that differ from those caused by trading. This article studies the use of domestic energy taxes in the trading sectors in connection with EU-wide emissions trading in Finland. The study evaluates three distinct tax scenarios that progressively switch further away from current fuel taxes and compensate the initial loss of revenue by raising either income taxes or electricity taxes. Emission trading is studied for the period 2008-12. Currently, the initial allocation of permits for this period is yet to be determined; in the study, grandfathering is assumed to base on estimated domestic reductions that would result either from raising current energy taxes or from introducing a complete carbon dioxide tax. The results indicate that macroeconomic effects are highest if revenue neutrality is maintained with income tax increases. It makes less of a difference on the macroeconomic level if current energy taxes are retained in the trading sectors or if they are abolished and electricity taxes raised to compensate for lost revenue. At the sectoral level, however, the electricity tax alternative is less costly for the trading sectors. Grandfathering has a large impact on the effects of abatement, since it determines the required reductions for the non-trading sectors. If the goal for the non-trading sectors is too strict, macroeconomic costs are raised regardless of emission trading. Trading also has an effect on the use of renewable energy. High permit prices are required to encourage wind power, whereas the use of wood increases in all cases.

1 Introduction

This article studies the use of domestic energy taxes in the trading sectors in connection with EU-wide emissions trading during the Kyoto Period. The starting point of the study is the idea that energy taxes do not necessarily improve the cost efficiency of emission trading, if they introduce price signals that differ from those caused by trading. Given the current energy taxes with all their exceptions and exemptions in use in most EU-countries, this is very likely the case. This applies to Finland as well; while the country was the first to introduce a CO2-tax, the tax is not uniformly applied. Consequently, it will distort the price signals introduced by emission trading. A remedy for this problem would be to harmonise or give up current taxes. However, if energy taxes are lowered or removed in the trading sectors, tax revenue will inevitably be lost and might have to be compensated by increases in other taxes. The study evaluates three distinct tax scenarios that progressively switch further away from current fuel taxes and compensate the initial loss of revenue by raising either income taxes or electricity taxes.

The European emission trading scheme is based on mandatory grandfathering of most of the emission permits. The grandfathering schemes are yet to be finalised, however. For the purposes of this study, grandfathering is assumed to base on those domestic emission reductions that would result from the application of either the current energy tax structure or under carbon dioxide taxes.

The tax and grandfathering scenarios are compared to a baseline with no abatement of greenhouse gases in 2010. The cost estimates thus reflect the combined effects of cutting greenhouse gases and doing so with the help of emission trade. The primary goal of the study is in finding the most cost-effective combinations of energy taxes and initial allocations.

While energy taxes are studied primarily from the point of view of climate change policies it is recognised that energy taxes have been used to further other aims as well. Security of supply considerations have affected the structure of Finnish energy taxes, as has the promoting of the use of renewable energy sources. The other main goal of the study is in finding out the combined effects of emission trading and energy taxes on the structure of the Finnish energy sector, especially on the use of renewables.

The study utilises both engineering models of the energy system and computable general equilibrium models of the economy. The EFOM energy system model approaches climate policies by fixing the demand for energy services and then optimising the energy system to produce the required services at the least cost, given the emissions target and available technologies and efficiency improving investments. The EV model of the Finnish economy, on the other hand, takes the baseline developments of the energy system as a starting point and optimises the whole production structure of the economy. The EV model is a hybrid that combines elements of engineering-type energy system models with top-down economic models and actually produces estimates of the energy system as well.

2 The model

The EV-model is a detailed description of the Finnish economy, combining traditional elements from economic CGE-models to engineering approaches for certain key sectors of the economy.

The key modelling target in setting up the model has been to capture the essential process-level features and peculiarities of Finnish energy use. The model thus relies heavily on engineering data about the details on fuel use, the often fuel-specific processes that are used in the production of heat and electricity as well as in process industries. Production in these industries is modelled along bottom-up, or engineering, descriptions of the processes. The model also makes a distinction between different electricity and heat generation technologies. This is essential for the analysis of the Finnish energy sector, which contains a lot of combined heat and power generation, as well as communal district heating.

The basic data for the model is input-output data, which for Finland is available for 1995. For the less energy-intensive industries, this data has been used as such, but for the energy-intensive process industries and for the energy sectors, engineering data has been used for disaggregating the IO-data to a sufficiently detailed level.

The description of production structures in the non-process industries follows for standard CGE-practice. For most industries, production follows a nested CES-structure, where output consists of energy-value added and intermediate good–composites, which in turn consist of composites of electricity and heat; value added; and domestic and import commodities. The model makes the standard Armingtonian assumption of imperfect substitutability between domestic and import goods.

Fuels covered by the model

The model covers most of the fuels used in Finland. One of the key features of the country is that all of the fossil fuels used in Finland have to be imported. The only domestic fuels are wood and peat. Oil products are either imported directly or refined from crude oil in Finland. For natural gas and coal the only source is imports.

Roughly 40 % of the output of the Finnish oil refineries consist of diesel oil and light fuel oil, with gasoline accounting for another 40 per cent and heavy fuel oils for the rest. The product strategy of Finnish refineries has for a long time reflected a specialisation in the production of reformulated gasolines and reformulated diesel fuels.

All in all, the EV-model takes explicitly into account the following fuels:

- Wood fuels, chopping residue, industrial wood residue
- Peat
- Refined oil products
  - Gasoline
  - Diesel oil
  - Light fuel oil
  - Heavy fuel oil
  - LPG (Liquefied petroleum gas)

- Coal
- Natural gas
- Coke

The indigenous production of wood fuels has so far been almost entirely linked to forest industries and their wood residues. To an extent, however, biomass is already being produced for fuel use at an earlier stage, in the form of chopping residues.

Forest industries

Forest industries consist of mechanical and chemical forest industries, which differ very much from each other with respect to the processes they use and also with respect to their energy use. The EV-model contains relatively much detail about these sectors, since they have a particularly large share in the Finnish energy system.

Mechanical forest industries comprise sawmills and board mills (particle and fibreboard, plywood). They are both intense users of electricity, but also contribute to the use of biomass in that their wood residues can be used both as fuels and as inputs in pulp manufacturing. They do not use biomass for energy production themselves, however. The EV-model takes the residual flows into account but assumes that they make up a fixed proportion of output. The process heat consumption of mechanical forest industries is only 5 per cent of forest industry total, and, since most production units are small, CHP is not usually profitable; thus process heat for mechanical forest industries is mainly generated with industrial heat centres.

The overall heat consumption of the forest industries is around 70 per cent of total industry consumption and its electricity consumption 60 per cent. However, forest industries only purchase around half of their electricity form the energy sector and account for 85 per cent of industrial CHP. Remarkably, only a third of their fuel consumption is made up of fossil fuels and peat, with wood fuel and black liquor accounting for the other two thirds. Thus forest industries, while being extremely energy intensive, are also a major source of bioenergy.

Chemical forest industries are responsible for most of the heat and electricity generation. These industries comprise the production of pulp and paper. The energy mix of chemical forest industries depends heavily on the type of their product. The main products of the sector are newsprint paper, SC-paper, LWC-paper, fine paper, other papers, paperboard and market pulp. The model includes all the above mentioned products with one exception: paperboard and market pulp are combined to form a residual product.

The actual product selection both reflects current demand and represents a result of conscious effort to increase the share of value added for the industry as a whole. Especially the investments in mechanical pulping and papers (SC and LWC) follow a strategy of making the most out of the Finnish resources. Mechanical pulping needs only half of the raw wood per ton of pulp compared to that of chemical pulping. This is only possible at the expense of increased use of electricity. In chemical pulping half of the wood is used as fuel and the energy inputs from outside the mill are not needed – actually a modern chemical pulp mill produces energy as a by-product!

Table 1 Forest industries	
X3411	Newsprint
X3412	SC-paper
X3413	LWC-paper
X3414	Fine paper
X3415	Paperboard and pulp

Basic metal industries

Finnish basic metal industries can be broken down to three different ”production lines”: steel production, stainless steel production and production of other metals. This basic structure is reflected in the chosen structure of the model.

Currently, the two major steel-making technologies use either the basic oxygen furnace (BOF) or the electric arc furnace (EAF) or some combination of the two. Although the end product is the same, the production processes are totally different: The EAF uses electricity and scrap as inputs whereas the BOF process uses coal (coke) and iron ore.

Stainless steel is produced in Finland perhaps mainly because one of the largest ferro-chromium deposits in the world is situated in the country. Ferro-chomium is the main ingredient in the stainless steel production. The production of stainless steel has grown to one of the main products in Finnish metal industries from its beginning in the 1970s.

The third branch of the basic metal industries consists of non-ferrous metals like copper and nickel.

The sectors defined in the EV-model are given in table 2.

Table 2 Basic metal industries	
X3711	Basic oxygen furnace steel
X3712	Electric arc furnace steel
X3713	Stainless steel
X372	Non-ferrous metals and ferrochromium

Electricity and heat generation

The EV-model distinguishes between several processes for electricity and heat generation. The basic distinction is made according to the fuel used, which is of significance in that the thermal efficiency of generation processes is to an extent dependent on the fuel choice. More importantly, however, the model defines distinct processes for condensing plants that only generate electricity; district heat processes that only generate heat; and combined heat and power generation processes that generate both heat and electric power. The large-scale use of the latter is a distinguishing feature of the Finnish energy sector and its inclusion is therefore one of the essential elements of the model. The model combines the electricity and heat generated from the various processes either following the technology-bundle described in the introduction or with the full-fledged engineering approach.

District heat has some features that distinguish it from most other goods and services. Specifically, it cannot be transmitted over long distances; it is therefore both locally produced and consumed, and it is the local demand for district heat that dictates the choice of generation method. When the demand for district heat in some network area is sufficiently high, the energy-efficient combined heat and power production becomes feasible. For small heat loads local boiler plants are the most economic choice. Even with high demand in large networks, it is more economical to use heat stations for peak loads than to build excess CHP capacity.

Small district heat networks use only heat stations. However, 80 per cent of district heat is produced in large cities where CHP is profitable. In Finnish data, demand for district heat is shown as a separate entity so it is easy to capture the dependence of heat and CHP production on demand.

Electricity is more of a normal good in that it is homogenous and can be transmitted over long distances. Since in Finland there are practically no transmission capacity bottlenecks, it is reasonable to assume that all generation forms are in competition.

The heat load determines production level in a CHP plant. Electricity output is proportional to heat generation. Typically, the output of electricity is about half the heat generation (in TWh) in coal-fired plants (or in plants using other solid fuels) and equal to heat generation in natural gas-fired combined-cycle plants.

Engineering data exist on practically all generation units operating in the electricity and heat sector, and it has been relatively straightforward to include this information in the model database at a sufficient level of detail.

Table 3 displays the power generation processes in the EV-model.

Table 3 Electricity and heat production	
X40111	Hydropower, wind
X40114	Nuclear
X40122	Distribution of heat and electricity
x401291	Peat-fired condensing plants
x401292	Coal-fired condensing plants
x401293	Natural gas-fired condensing plants
x4013534	Oil-fired condensing plants
X40212	Wood-fired CHP
x402291	Peat-fired CHP
x402292	Coal-fired CHP
x402293	Natural gas-fired CHP
x4023534	Oil-fired CHP
x40312	Wood-fired district heat
x403291	Peat-fired district heat
x403292	Coal-fired district heat
x403293	Natural gas-fired district heat
x4033534	Oil-fired district heat

Public sector

The emphasis of the EV-model is more on analysing the effects of policy instruments than on the production of public services. The production structure for the public services is therefore taken to be rigid, with substitution being possible only between domestic and foreign goods at commodity level. Neither is there an attempt to include measures of the utility the consumers may enjoy from public services. However, the commodity tax structure and energy tax structures are modelled fairly comprehensively. This allows the model to be used for analysing changes in the tax structure. The energy use of the public sector is also comprehensively covered. Most of it stems from heating and lighting of buildings.

Households

The treatment on households in the model follows the typical representative consumer approach. The labour supply decision can be assumed to stem from either utility maximisation or from the decisions of a labour union.

Investment

The production of investment goods is also modelled with Leontief-technologies. Two basic closures for investment can be studied, along the lines of the ORANI-assumptions on short-run (fixed capital stock) and long-run (fixed real interest rate).

Foreign trade

The model makes the standard Armington assumption with respect to exports and imports. The rest of the world is thus mostly covered by assumptions about world prices and world demands. An assumption about constant trade surplus closes the model.

Parameters

The model relies on exogenous estimates for elasticities of substitution. We have chosen to use GTAP-estimates to ensure some degree of comparability with results obtained from models utilising the GTAP-data base. In addition, estimates for key parameters that are specific to Finland have been obtained from relevant Finnish studies.

3 The scenarios

Baseline

The baseline scenario assumes that industrial production continues to grow at an average annual rate of 3.5 to 2010, the reference year for the impact evaluations. However, even the baseline predicts large differences between industry branches. The electronics industry is predicted to grow faster than the traditional Finnish export industries, forest and basic metal industries. Some of the more domestically oriented industries are also expected grow relatively briskly, as are the service sectors, reflecting increasing regional concentration, stimulating construction and related industries, as well as the ageing of the population.

Overall energy efficiency is expected to improve by 2 per cent for fossil fuels, but again, there are important sectoral differences. The increase is expected to be especially high in the transport sector, reflecting the effect of the EU gas mileage target, whereas in the energy sector, increases to the already high average efficiency are much harder to come by with. The energy efficiency of housing is also expected to improve fast, but this effect is more pronounced for electricity and heat consumption than for fossil fuels.

The simulations reported here do not attempt to take into account the effects of climate policies on world demand, nor on export prices. This approach can be justified by noting that estimates on these effects are not available at the required level of detail, but it does imply that the export demand reaction to the cost increases in exporting sectors maybe somewhat exaggerated, as are the resulting domestic structural changes.

Energy taxes and emission trading

The study considers three main alternatives for using domestic energy taxes in connection with emission trading. The underlying idea is that since emission trading will take care of emissions in the trading sectors, it is necessary to raise taxes only in the non-trading sectors, which otherwise might not meet their reduction target. But since energy taxes are already in use in the emission trading sectors, there may be overlapping and possibly contradicting economic incentives created by the combination of the existing taxes and permit trade. However, if energy taxes are lowered or removed in the trading sectors, tax revenue will inevitably be lost and might have to be compensated by increases in other taxes.

The tax scenarios are:

ET1: Present tax structure. Current fuel and electricity taxes are retained at present also in the trading sectors. In the non-trading sectors, current taxes are raised by the amount necessary for the non-trading sectors to meet their reduction target, which is implied by the national target and the allocation of grandfathered permits to the trading sector.

ET2: No energy taxes. Fuel and electricity taxes are no longer applied in the trading sectors. In the non-trading sectors, current taxes are raised by the amount necessary for the non-trading sectors to meet their reduction target, which is implied by the national target and the allocation of grandfathered permits to the trading sector. Moreover, income taxes and employers' social security payments are raised to cover the loss of revenue caused by the removal of energy taxes in the trading sectors.

ET3: Only electricity taxes. Fuel taxes are retained in the trading sectors at their present level. In the non-trading sectors, current taxes are raised by the amount necessary for the non-trading sectors to meet their reduction target, which is implied by the national target and the allocation of grandfathered permits to the trading sector. Electricity taxes are raised by the amount necessary to cover the loss of revenue caused by the removal of fuel taxes in the trading sectors.

Emission permits are assumed to be grandfathered, with the allocations replicating the reduction targets implied by domestic go-alone policies implemented either by raising present energy taxes, as assumed in the National Climate Strategy (thus we have tax-grandfathering schemes ET1A, ET2A, ET3A), or by introducing carbon dioxide taxes for all sectors and all uses of fossil fuels (which gives the schemes ET1B, ET2B, ET3B). The latter alternative comes close to what in some studies of European emission trading has been called ”optimal” allocation but with one, very significant, difference: here, the carbon tax–based allocation of permits has to take place prior to trading, and there is no guarantee whatsoever that this allocation would be optimal when trading commences. But to calculate the optimal allocation taking trade into account would necessitate knowing the traded amounts and the market price in advance, and this study makes no pretence of possessing that information.

The allocations are shown in figure 2 below. The results indicate that a carbon tax-based allocation puts a stricter reduction target on the trading sectors than an allocation based on the current tax structure, reflecting certain present loop-holes. The carbon-tax-based allocation is clearly the more cost-efficient alternative. It is also possible to see that electricity generation would face the highest burden for achieving this overall efficiency.

Figure 1 shows the corresponding effects of abatement on the domestic economy. The carbon tax –scheme results in much lower overall effects than the present tax structure would. Interestingly, these differences persist under emission trading, where the carbon tax –based allocation produces markedly lower effects on the economy. This result points to a major drawback of the emission trading scheme: while the differences in grandfathering within the trading sector should not be of importance, the efficiency of the burden sharing between the trading and non-trading sectors is important. If there is a misallocation of reduction goals between these sectors, there is nothing trading can do to alleviate the problem for the non-trading sectors.

Macroeconomic effects

This section summarises the aggregate effects of cutting emissions by introducing emissions trade and the various tax schemes. Figure 3 shows the estimated effects on GDP, consumption, investments and employment when permit price is 10 €/t CO2, and figure 4 for the permit price 20 €/t CO2. The macroeconomic effects clearly indicate that the no taxes-scheme (ET2) has the highest macroeconomic costs, which is due to the harmful effects of the raise in income taxes necessitated by the requirement of revenue neutrality. The present tax (ET1) and electricity tax alternative (ET3) differ from each other much less, but the electricity tax alternative is usually the more cost-efficient alternative. At the macroeconomic level, it is easy to see that emission trading per se is clearly beneficial, since the effects of abatement are smaller than they are in the go-it-alone cases reported in figure 1. However, some of the differences between the alternatives are more marked at industry level and it is also likely that their effects on income distribution are different.

The effects on GDP range from a fall of 0.2 – 0.4 per cent from baseline under the 10 euro permit prices to 0.4 – 0.8 under the more expensive permits in 2010. The fall in GDP is mostly due to a fall in consumption, driven by price increases caused by the introduction of emission permits, and also by the negative effects on income stemming from reduced economic activity in the economy. The effect on employment ranges from a fall of 0 – 0.4 per cent from baseline under 10-euro permits to 0.2 – 0.7 per cent from baseline under 20-euro permits. The largest effects are obtained in the unrealistic ET2-tax scheme, whereas the differences between the other two tax schemes are small. Assuming a baseline employment of 2.25 million in 2010, the employment effects thus can range from approximately 1000 to more than 10000 jobs in the year 2010.

Sectoral effects

The industry level effects are presented in figures 4 and 5. At the industry level, the present tax-scheme intuitively (ET1) induces larger changes in production in the trading sectors than the other alternatives, whereas in the other alternatives, the other sectors of the economy bear a larger burden. Trading per se also has a large effect on process industries whose process emissions are included in trading, changing their cost structure very markedly. But emission trade also affects the price of electricity, which raises energy costs for electricity users as well. Thus the sectoral effects reflect, to a great extent, the cost shares of fossil fuels, processes, and energy.

The results also depend on assumptions concerning export demand responses. This study assumes that world prices do not change even though emission trade is introduced. The assumption produces fairly strong export responses, as it is taken that export depend on the relative prices of Finnish exports in the world markets – the price competitiveness of Finnish export industries, in other words. In a related study, a global trade model was used to estimate the effects of emission trade in relative export prices. The results of the study indicated that emission trade would raise export prices in other countries participating in emission trading as well, which would dampen the export reaction to these countries, but not to countries that do not participate in emission trade and emission reductions.

Effects on energy use

Emission trading changes the relative prices of fuels in the energy sector fairly dramatically. Currently, no carbon taxes are imposed on fuels used for electricity generation, and consequently the introduction of the permits will have a significant impact especially in this part of the energy sector. Emission trading would also have an effect on the use of renewable energy. If permit prices are fairly high – the study takes permit prices of 10€ and 20€/tCO2 into consideration – wind power tends to benefit from trading. However, the outcome depends on the tax scheme as well: if energy taxes are not applied in the trading sectors, the relative gain for wind is smaller and its growth will remain more subdued. In any case, the overall share of wind power is expected to remain low. Wood use, on the other hand, is already at a very high level and emission trading will likely increase its use further. Under the lower of the two permit prices, retaining present taxes in the trading sectors boosts the use of wood, but under higher permit prices, the tax schemes no longer differ significantly. Figure 7 reports the overall effect of emission trade on the use of the main fuels.

Figure 1

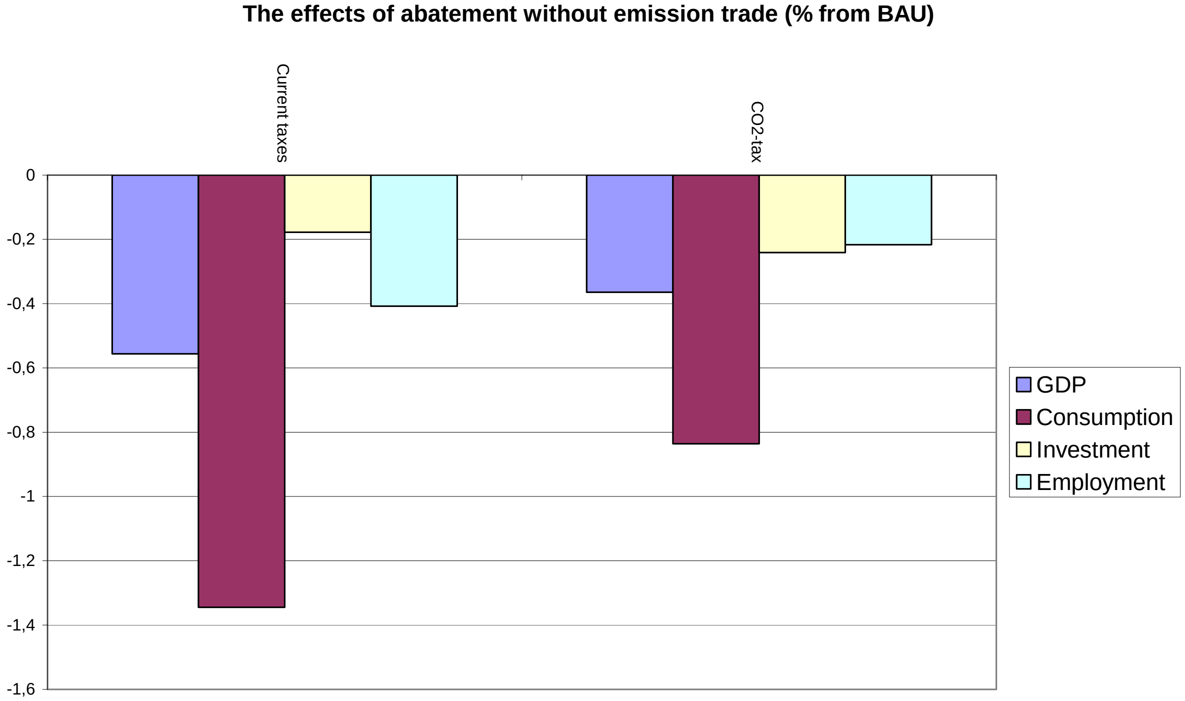


Figure 2

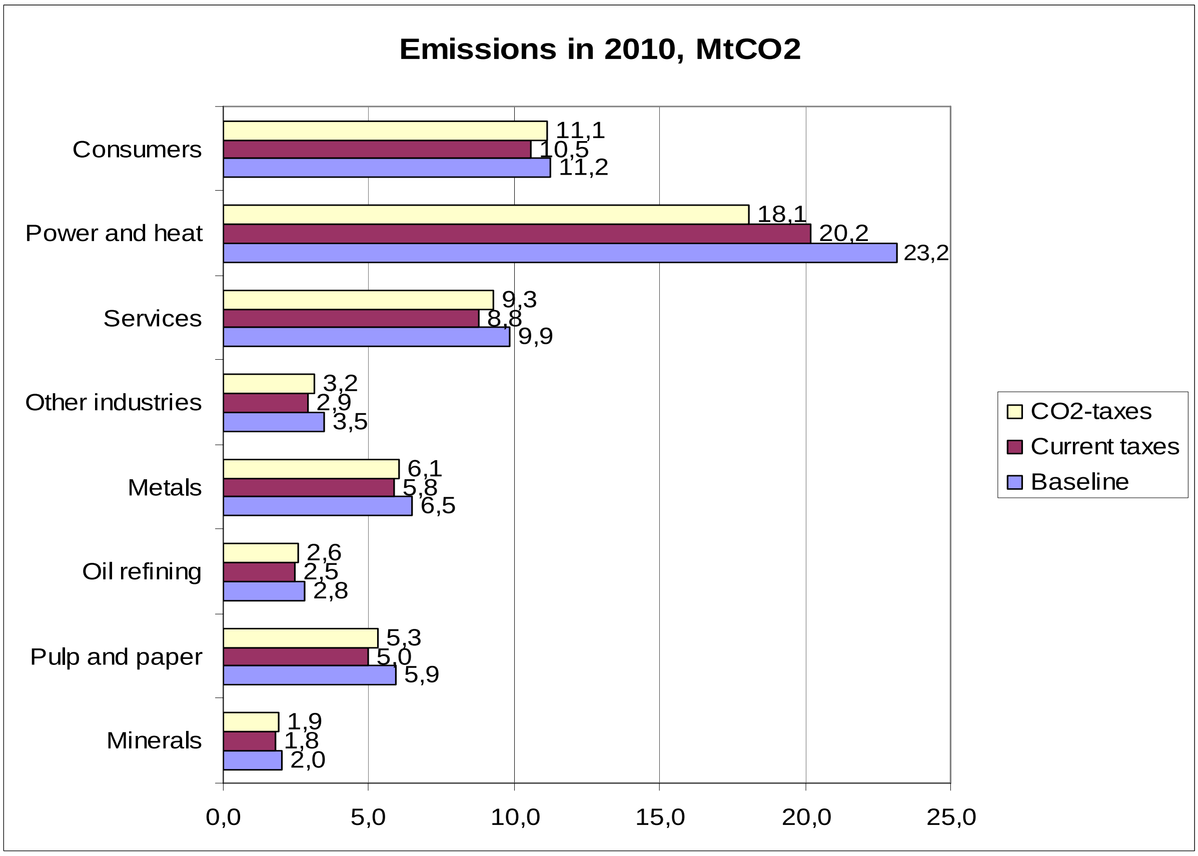


Figure 3

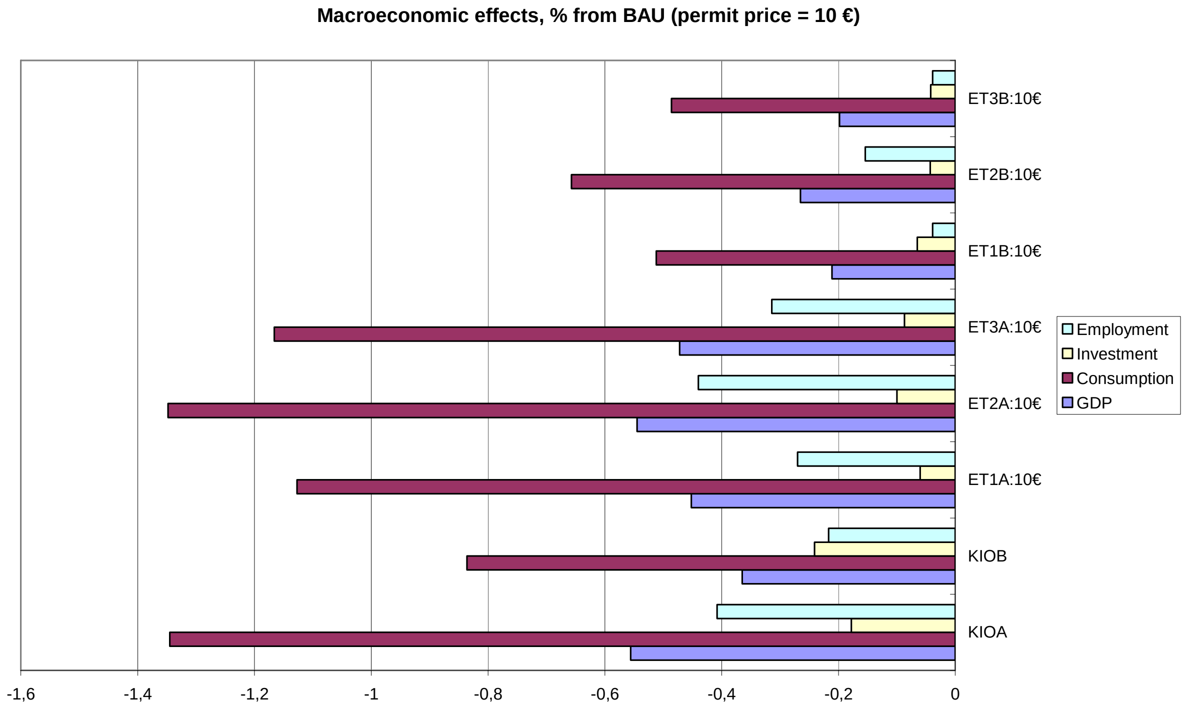


Figure 4

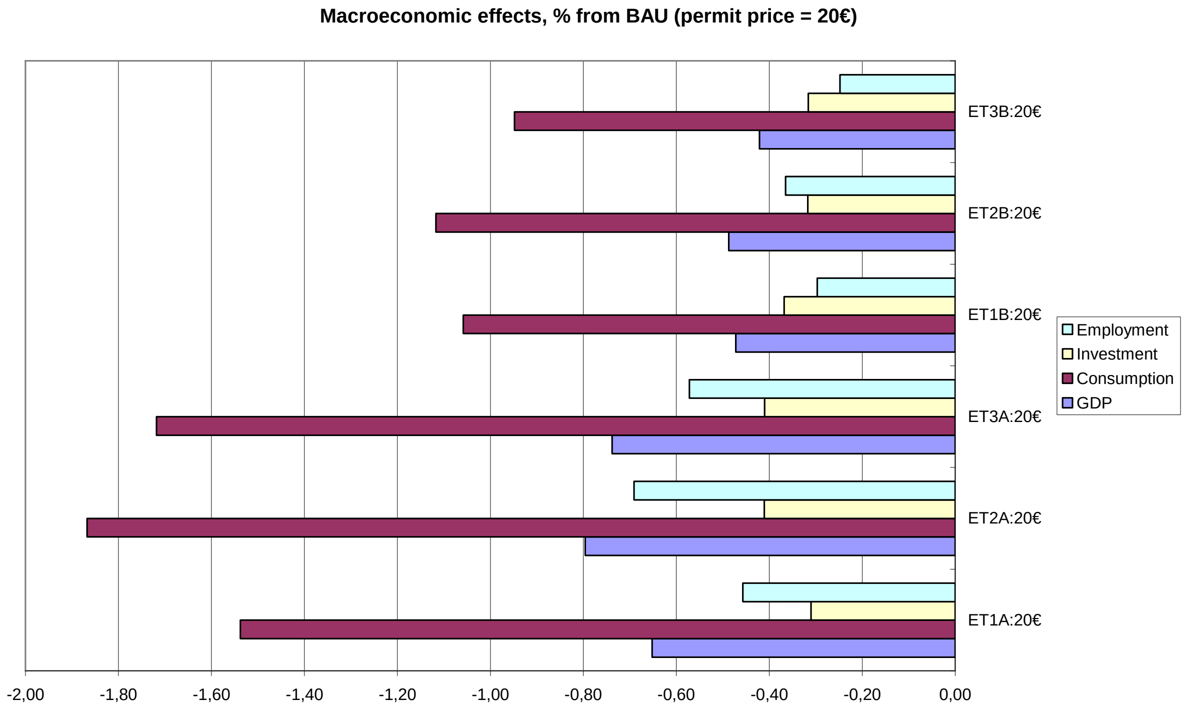


Figure 5

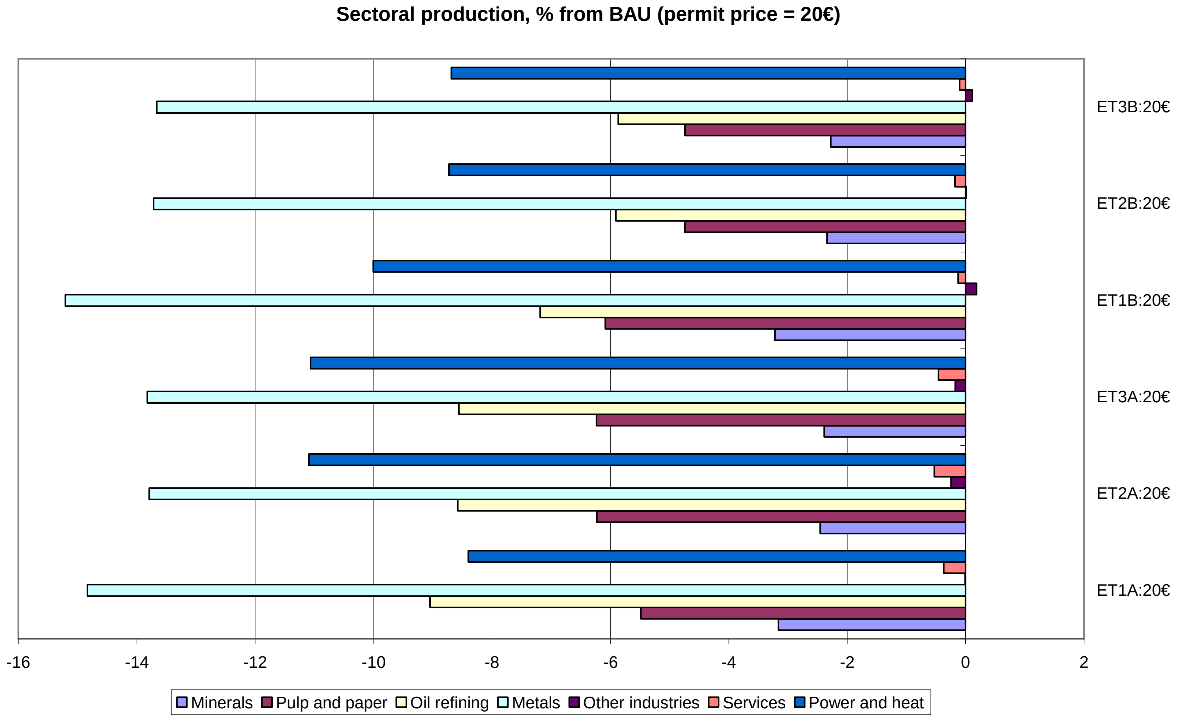


Figure 6

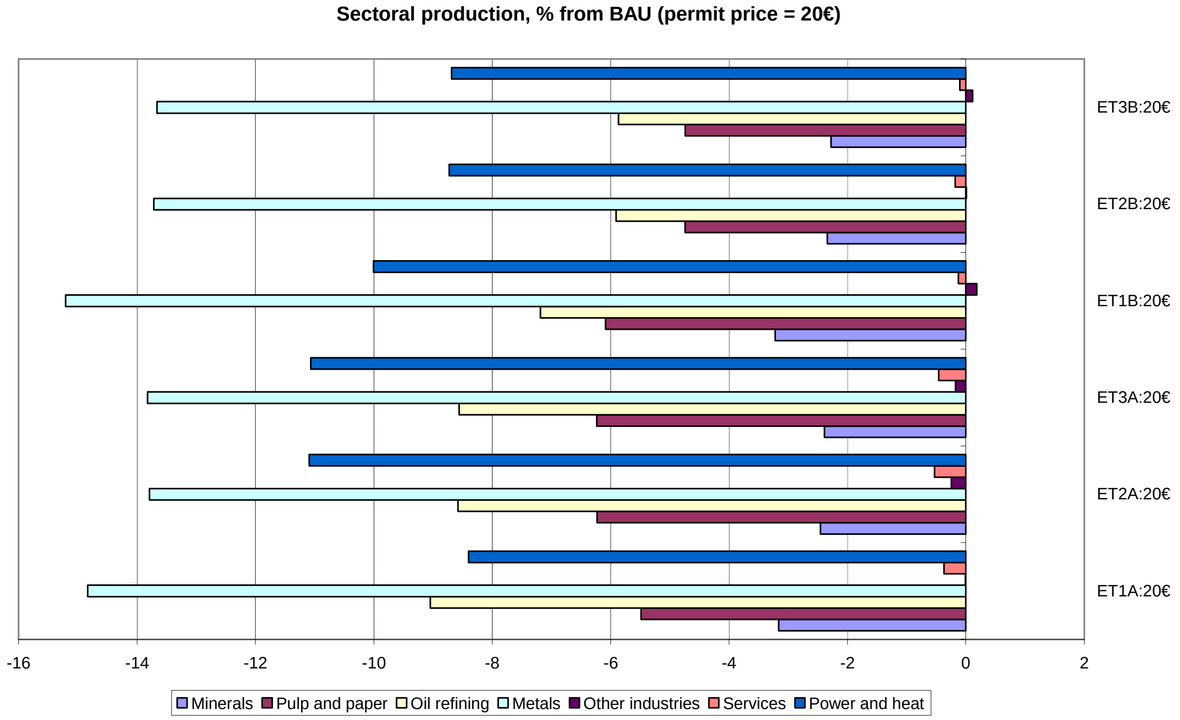
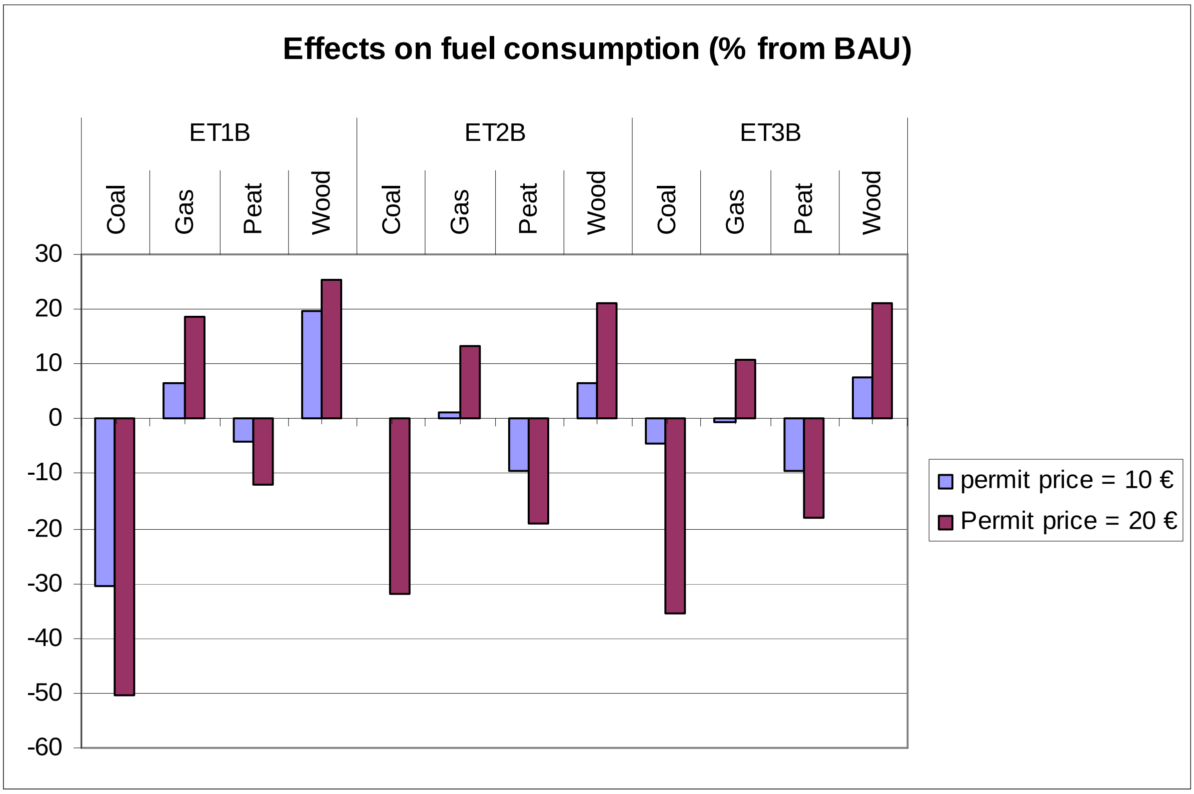


Figure 7



4. Conclusions

This article has studied the use of domestic energy taxes in the trading sectors in connection with EU-wide emissions trading during the Kyoto Period. The study has considered the idea that energy taxes do not necessarily improve the cost efficiency of abatement under emission trading, since they introduce price signals that differ from those caused by trading. In Finland in particular, there are numerous exceptions in the current energy tax code, which tend to give conflicting signals from the point of view of abatement policies.

A remedy for this problem would be to harmonise or give up current taxes. However, if energy taxes are lowered or removed in the trading sectors, tax revenue will inevitably be lost and might have to be compensated by increases in other taxes. The study has evaluated three distinct tax scenarios that progressively switch further away from current fuel taxes and compensate the initial loss of revenue by raising either income taxes or electricity taxes.

We find that the tax schemes do have different implications for the overall costs of abatement as well as their sectoral distribution. The largest macroeconomic effects occur when diminishing energy tax revenues in the trading sector are compensated by increasing income taxes. At the sectoral level, retaining present energy taxes even under emission trading induces larger changes in production than would occur if they were removed, but this happens at the cost of the non-trading sectors, which would have to bear a larger burden.

Trading per se also has a large effect on process industries whose process emissions are included in trading, changing their cost structure very markedly. But emission trade also affects the price of electricity, which raises energy costs for electricity users as well. Thus the sectoral effects reflect, to a great extent, the cost shares of fossil fuels, processes, and energy.

At the macroeconomic level, however, it is clear that emission trading can enhance the cost efficiency of abatement.

References

Commission of the European Communities: Proposal for a Directive of the European Parliament and of the Council establishing a framework for greenhouse gas emissions trading within the European Community and amending Council directive 96/61/EC, Brussels, COM(2001)581, 23-10-2001.

European Commission: Replies to some frequently asked questions on the EC emissions trading proposal, http://europa.eu.int/comm/environment/climat/emission.htm

Goulder, L.H., I.W.H. Parry, R.C. Williams, D. Burtraw (1999): The Cost effectiveness of alternative instruments for environmental protection in a second-best setting, Journal of Public Economics, Vol.72.no3. pp.329-360.

Groenenberg, H., and K. Blok (2002): Benchmark-based emission allocation in a cap-and-trade system, *Climate Policy,* 2002 (forthcoming).

Harrison, D., D.B. Radov (2002): *Evaluation of Alternative Initial Allocation Mechanisms in a European Union Greenhouse Gas Emissions Allowance Trading Scheme*, Study for the European Commission, National Economic Research Associates, 2002.

Sijm, J., K. Smekens, T. Kram, M. Boots (2002): *Economic Effects of Grandfathering* CO_2 *Emission Allowances*, ECN C-02-022, 2002.