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The Effects of Energy Taxes on Energy Consumption in Finland between 1995 and 2004 – An Historical Analysis using the VATTAGE-Model

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1. Introduction

In 1990, Finland was the first country in the world to introduce an energy tax based on CO2-emissions. While energy taxation has been revised several times since then, the idea of taxing emissions has been carried over to all subsequent energy tax schemes. There is a widespread consensus that energy taxes have restricted the growth of energy use; yet few studies have considered the effectiveness of energy taxes in detail.

The present study evaluates the effects of energy taxes on energy use in the period 1995 to 2004. The choice of the period is affected by several factors: there were considerable increases in energy taxes between 1995 and 2004; the emphasis on taxation also changed between the two years from an up-stream tax on primary energy and fossil fuels in 1995 to a mixed system with taxes placed both on primary energy carriers as well as electricity and fossil fuels in 2004; finally, after 2004, the EU emission trading system lead to yet another change in effective energy taxation, lending comparisons to earlier years more difficult. The 1995 and 2004 energy taxes are described in detail in chapter three of the study.

The difficulty in assessing the impacts of the taxes lies in distinguishing the effects of energy taxes from other developments in the energy markets and in the economy as a whole. The Nordic electricity markets were liberalised in the mid-1990s; there have been large fluctuations in the prices of most fossil energy sources; and it is also clear that the economic growth in itself has been connected to increased energy use, at least in the past. This calls for a methodology that can separate these overall effects from the specific changes in the tax system.

The methodology used in this study is one of Applied General Equilibrium modelling. AGE models are capable of dealing with both the macroeconomic and the specific changes that have occurred in the period under study, since they contain a full description of the structure of the economy at a very detailed commodity and industry level. In a historical simulation, we start from data for 1995 and use the observed changes between 1995 and 2004 in a large number of variables as inputs in the model to carry the economy to 2004. The changes in the model's structural parameters can then be used to explain the contributions of each of the observed changes to the differences between the 1995 and 2004 economy, and to decompose the otherwise intangibly overall effects into contributions of several factors – taxes being chief among them. It is clear that explaining history this way involves changes in all of the economy, not just the energy sector. But the advantage of using an AGE model is that it allows us to dismiss changes that are not due to the energy markets and energy taxes themselves.

The paper is organised as follows. Section gives a brief description of the model and explains the general idea behind the historical simulation. In particular, the central idea of a historical simulation is related to the mix of exogenous and endogenous variables in the model.

Chapter three gives the background for the observed changes in energy use and prices, and in energy taxation in particular.

Finally, the main results of the study are given in chapter five. A historical simulation involves the introduction of a large set of data on the observed changes in production, the use of inputs by the industries, final demand, prices, and, finally, taxes. To get to grips with the more specific effects of energy taxes, it useful to first study the overall development of the economy. This is the subject of the first part of section four, which also explains the decomposition of the overall effects into the contributions of several factors. The second part of the section deals with energy. To anticipate, we find that the sharp increases in energy prices since 1995 have restricted the growth of energy demand in a very significant way. Energy taxes, on the other hand, while raised markedly in nominal terms especially in the late 1990s, have had a more mixed record. They have been effective in curbing the growth of electricity consumption and, in many industries, the overall growth of energy consumption. However, in the case of transport fuels, the effective tax rate has actually fallen as the price net of tax has increased over time. For these fuels, it is the price increase rather than the taxes that seem to have slowed down consumption.

The final section makes some concluding remarks.

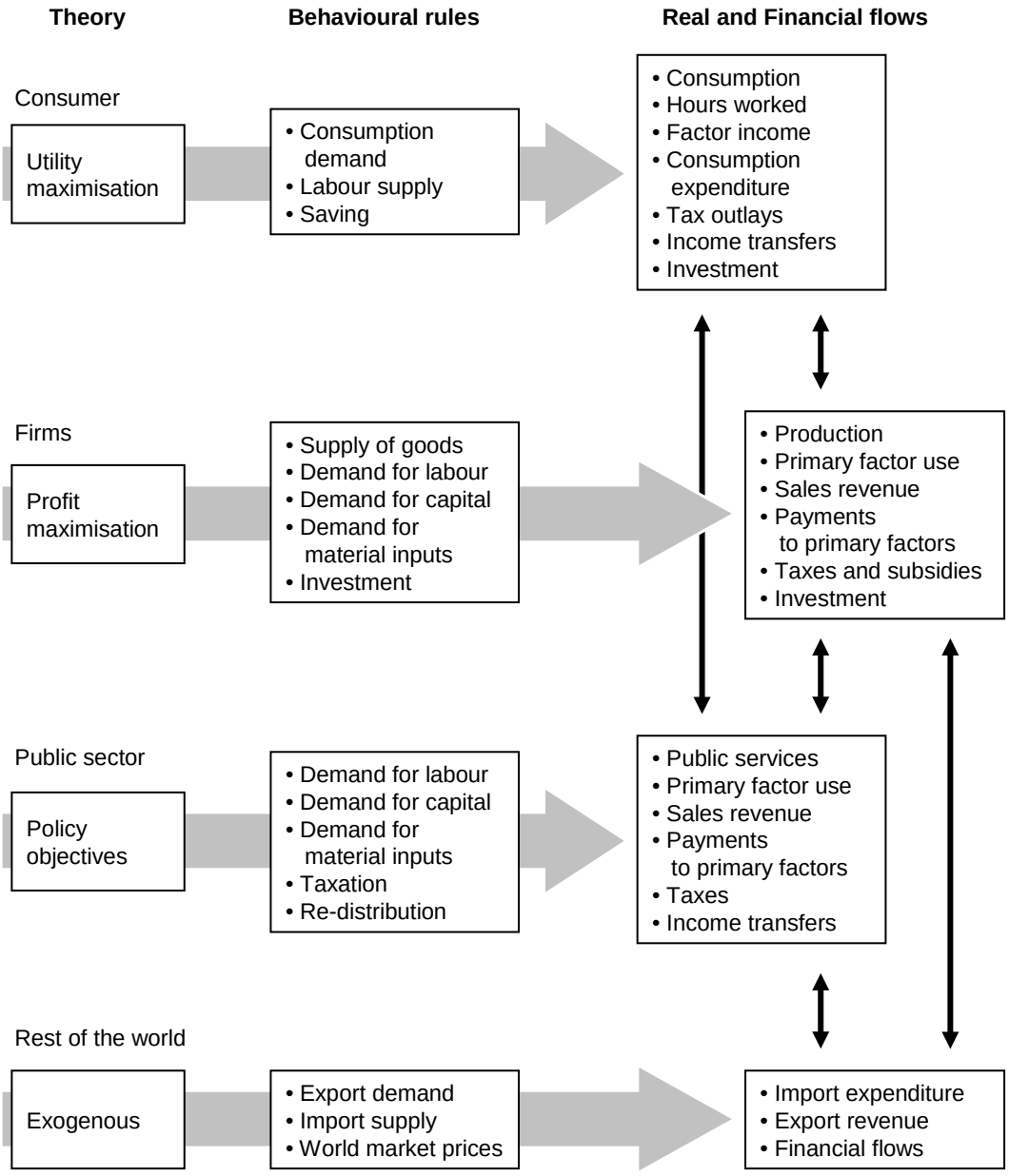
2. A historical simulation with VATTAGE

VATTAGE is a dynamic, applied general equilibrium (AGE) model of the Finnish economy. It can be applied to study the effects of a wide range of economic policies. The VATTAGE database contains detailed information about commodity and income taxes as well as the expenditures and transfers of the public sector and thus covers most policy instruments available to the government.

VATTAGE is based on the dynamic model developed at the Centre of Policy Studies in Monash University. MONASH-type models are used in countries ranging from China and South Africa to the United States (Dixon and Rimmer, 2002) In Europe, models based on MONASH have been developed for Denmark, Finland, and the Netherlands. VATTAGE is documented in Honkatukia (2009), but it is useful to describe some of the features of the model that are relevant to our application here.

In a historical simulation, attention is focused on the structural changes in the economy. These are captured by the parameters describing the evolution of factor productivity, tastes, the composition of trade, and intermediate input augmenting technical change. In figure 1 below, these parameters capture the change that occurred in the historical flows once the data on actual volumes and prices is introduced in the model.

Figure 2.1. The structure of an Applied General Equilibrium model

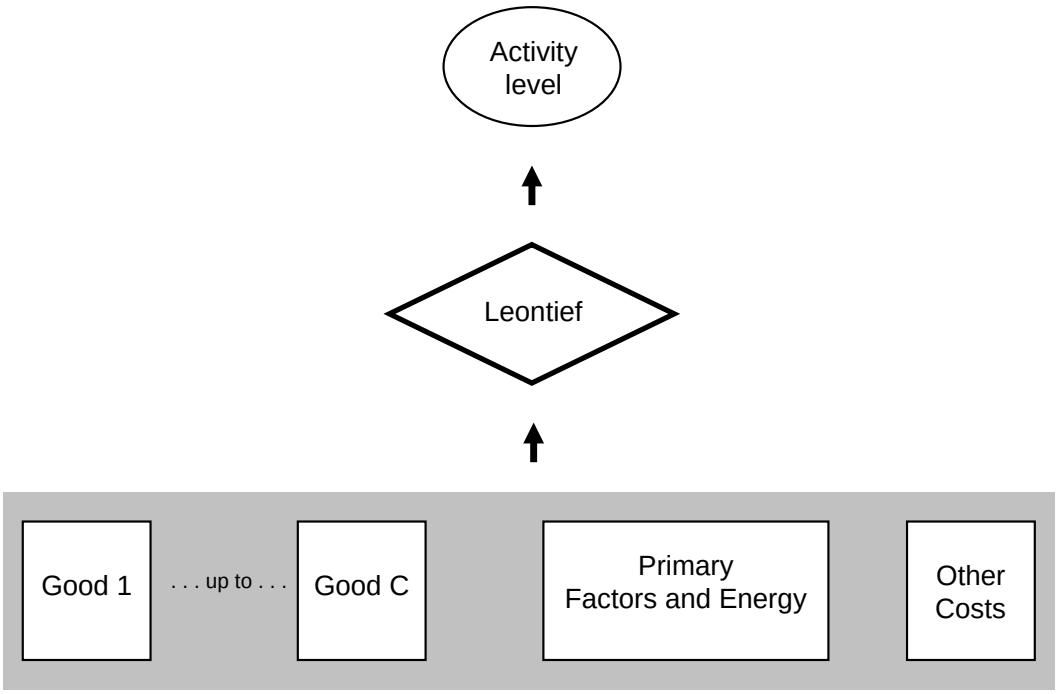


VATTAGE models production with conventional, nested production functions. The idea behind industrial classification is to group activities whose production processes or the products they make are similar. However, VATTAGE also allows for multi-production of commodities. The VATTAGE database uses the national industrial classification TOL 2002, basing on NACE 2002 and ISIC Rev. 3.1, to classify industries, and the CPA-classification to group products. The detailed data on commodities allows us to study the production of goods almost at a process level.

To pick an example of the structure of VATTAGE, figure 2 depicts the structure of factor demand in VATTAGE. The share of intermediates in each industry, as

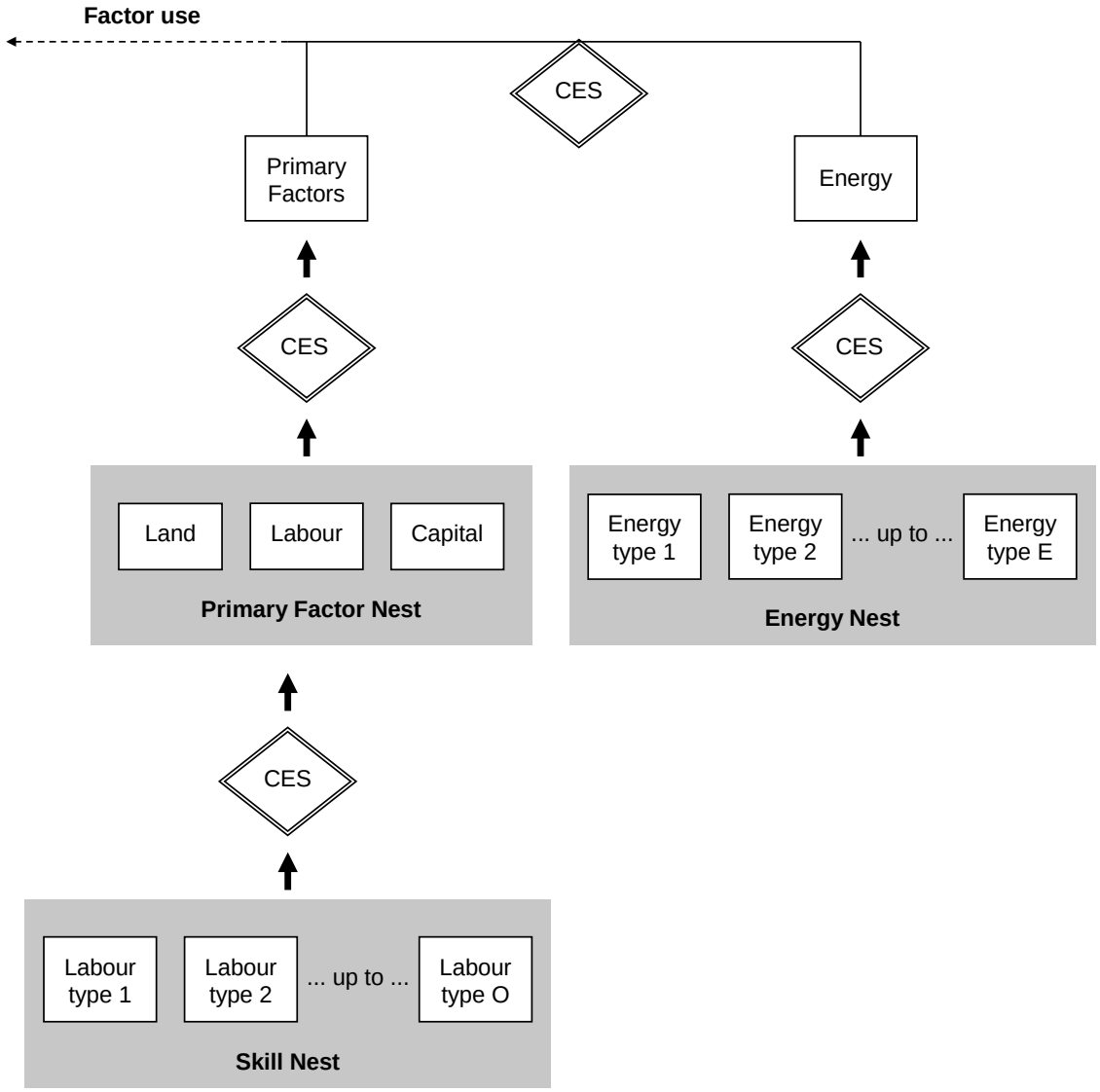
well as the domestic/import composition of each intermediate good can be allowed to change in a historical simulation to better capture the structural changes in the economy.

Figure 2.2. Top-level of the input mix



Of particular interest in this study is the evolution of energy use. Figure 3 shows the KLE-nest in VATTAGE. The energy goods covered by VATTAGE include the basic fossil fuels, refined petroleum products divided into different transport fuels, peat, and also wood, which has a very large share in Finnish primary energy consumption (historically, roughly a quarter).

Figure 2.3. The primary factor-energy composite in VATTAGE



The historical simulation bases on a particular closure for the model. The model closure consists of the division of the model's variables into endogenous and exogenous. There is no single way to do this. Instead, the closure depends largely on the application.

In MONASH fashion, VATTAGE recognises four types of closures:

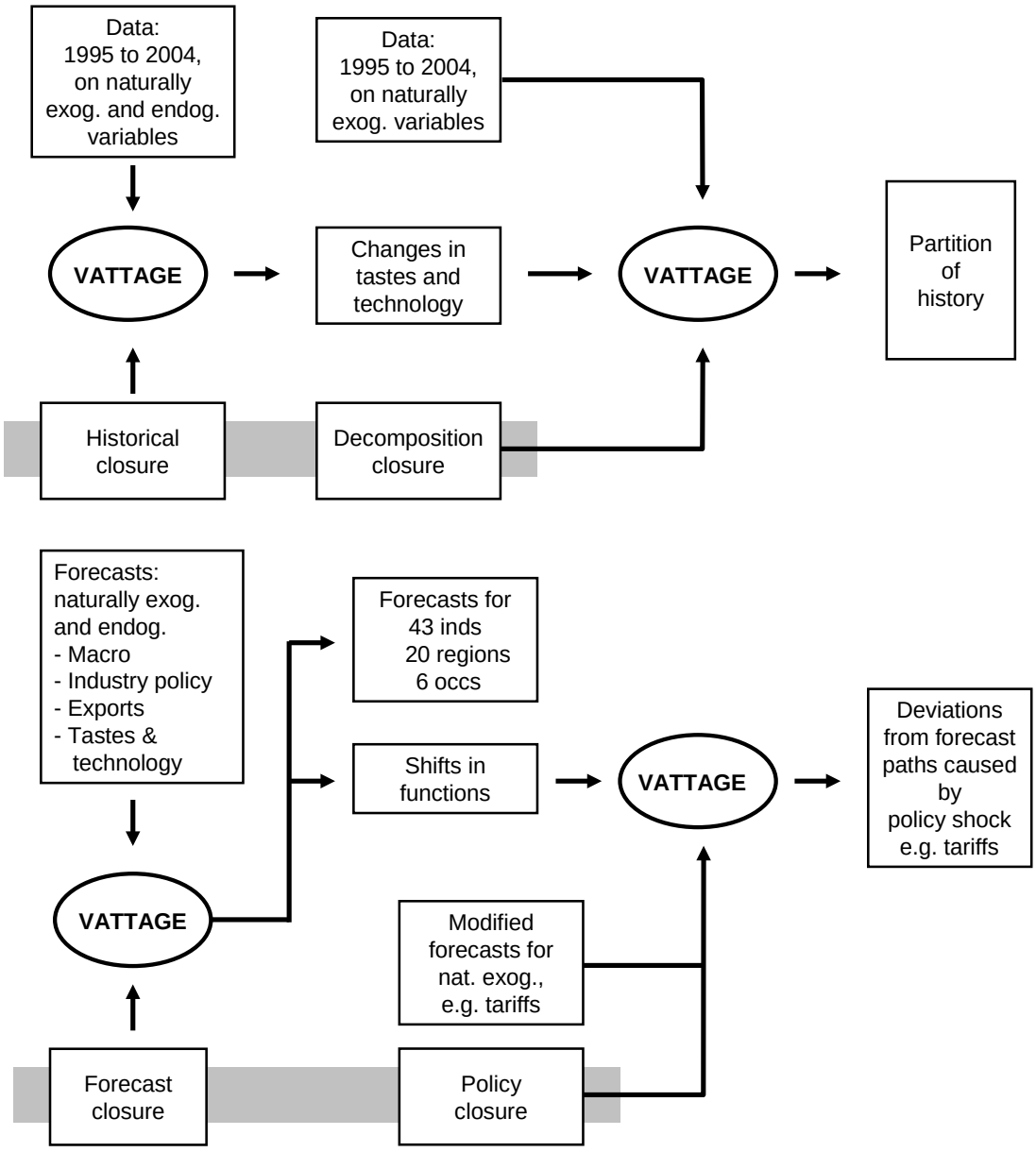
- decomposition closure,
- historical closure,
- forecasting closure and
- policy closure,

of which only the first two are relevant here. In a decomposition closure, we include in the exogenous set all naturally exogenous variables, that is variables not normally explained in a AGE model. These may be observable variables, such as tax rates, or unobservables, such as technology and preference variables.

Historical closures include in their exogenous set two types of variables: observables and assignables. Observables are those for which movements can be readily observed from statistical sources for the period of interest. Historical closures vary between applications depending on data availability but typically include a wide array of macro and industry variables, as well as intermediate input flows between industries.

The relationship between the historical and decomposition closures is illustrated in Figure 3.

Figure 3. VATTAGE closures

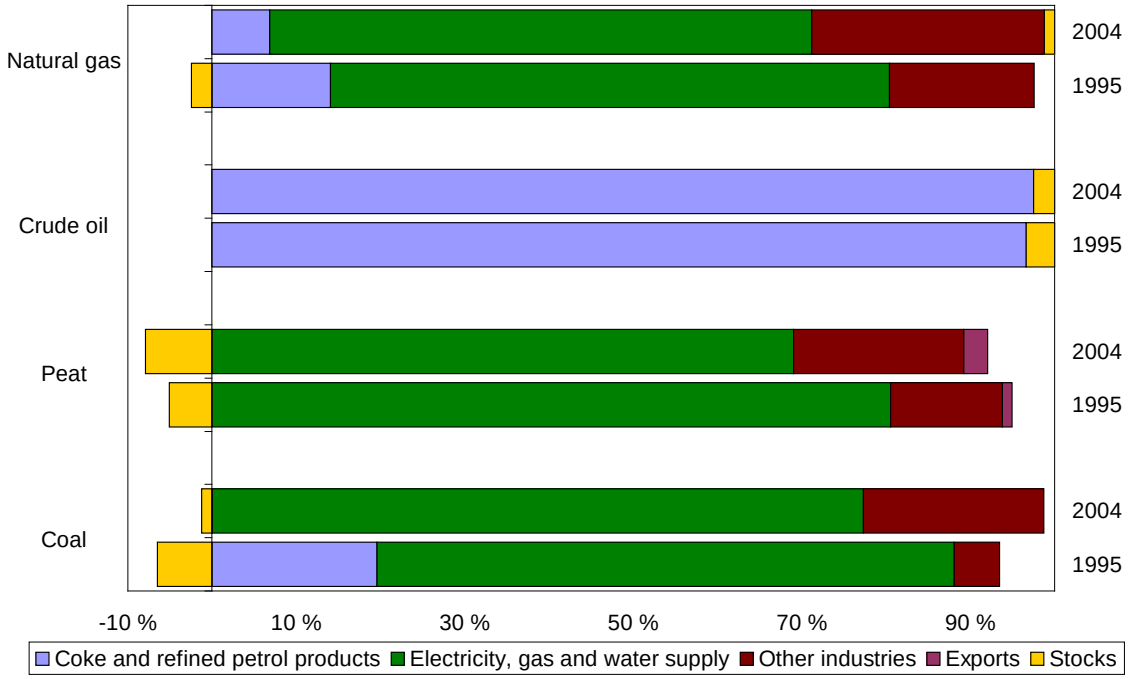


3. Changes in energy use and energy taxes from 1995 to 2004

This section gives an overview on the changes in energy use and energy prices in the Finnish economy from the year 1995 to 2004. The period was a very turbulent one for the Finnish economy, as a whole; the country was recovering from a severe recession, and overall economic growth was very rapid. This involved a deep structural change, which was also reflected in the energy sector in the form of rapid growth in investments. During the period, the Finnish economy grew more deelply integrated into European markets, both through Finland's EU accession, and via the integration and deregulation of the Nordic energy markets during the latter half of the 1990's. The energy sector was also affected by the boom of the world economy, which saw energy prices rise to new, higher levels towards the end of the 1990s. In the VATTAGE database, energy products include, peat, crude oil, coal, natural gas, several petroleum products, and electricity and heat. In the following, we study the taxation of each of these.

Figure 3.1. below shows the use of primary energy in 1995 and 2004. It is clear that the energy sector itself is the largest user of primary energy in heat and power generation. Crude oil is used almost solely in the refining of petroleum products. Coke is used by some industries directly in the coking processes for example, partly it is used for coke production by refineries, but mostly, it too provides energy for the heat and power sector.

Figure 3.1. Primary energy use by user type, per cent.



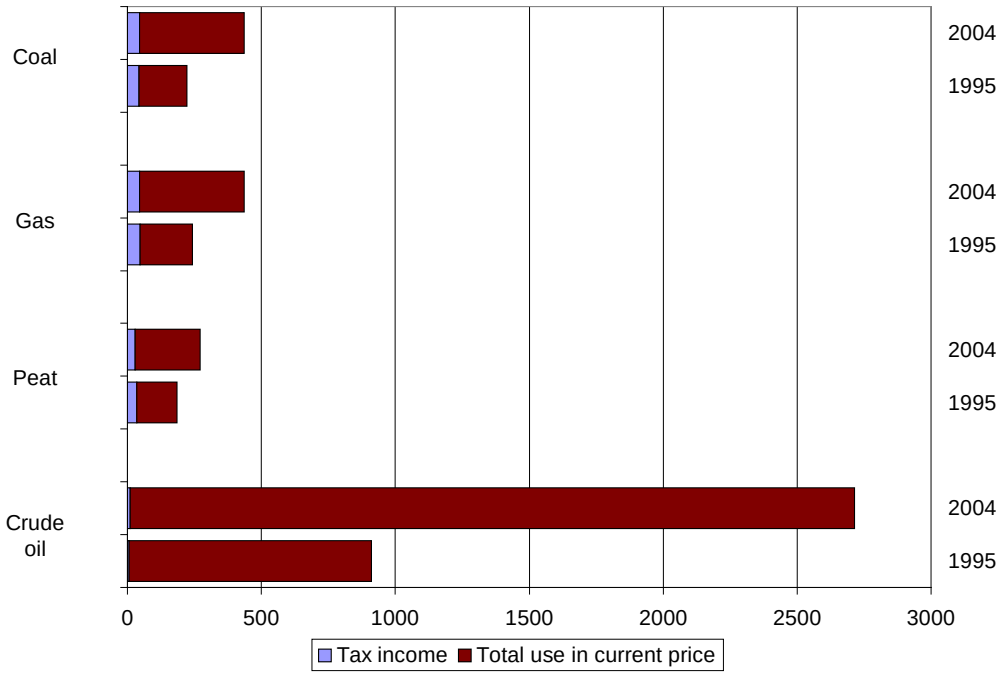
Finnish energy taxation was fundamentally revised in 1997. Whereas the old energy tax law put the taxes directly on the use of fuels (to which we count solid fossil energy carriers as well), the new law exempted electricity generation from fuel taxes but introduced a tax on electricity in its stead. The main reason for this change was that the old tax law was seen to distort competition between domestic and foreign electricity generators, which had become an issue with the integration of the Nordic electricity markets. Forthe generation of heat, however, fuel taxes continued to be applied as before.. The law also changed the role of the CO2 tax. In the old, 1994 energy tax law, the unit tax was based both on energy content and CO2 emissions. In the new law, the CO2 part remained, although it was not applied at a uniform rate for all fossil fuels, but the energy content part was transformed into a basic tax. The 1997 structure basically still apllies, but the unit taxes have been revised several times since then. Table 3 below gives the changes to unit taxes after 1995 in current prices.

Table 3.1. Revisions in unit taxes between years 1995-2004.

Date of imposition	Coal €/t	Natural gas c/nm3	Peat €/MWh
1.1.1995	19,53	0,94	3,12
1.1.1996	19,53	0,94	3,12
1.1.1997	28,42	1,195	3,72
1.4.1997	28,42	1,195	3,72
1.1.1998	33,4	1,4	4,34
1.9.1998	41,37	1,73	5,4
1.1.2002	41,37	1,73	5,4
1.1.2003	43,52	1,82	5,68

Figure 3.2 below compares the revenue from unit taxes to the value of energy use in 1995 and 2004. It is clear that the effective tax rates have fallen for all three of the major primary energy carriers. For example, the share of taxes in the total use of coal decreased from 65 per cent to 55 between 1995 and 2004. This is largely a consequence of the erosive effect on the tax tax base of the 1997 tax reform.

Figure 3.2. Tax revenue and total use of different energy sources.



The tax revenue from the primary energy carries in 1995 was roughly at same level as in 2004, but the total use of energy (value change) had increased substantially. Crude oil forms an exception, as no taxes are levied on its use, but rather on refined petroleum products.

The energy tax law[1] related to liquid fuels was established in 1994. The law in question concerned only petrol, diesel oil, light oil and heavy oil. Neither petrol and the kerosene used in airplanes were liable to taxation, nor methane, liquid gas and petrol used inshipping. First revision was made in 02006 when recyclable waste oil was liberated from taxes. Refined petrol products used in energy production became tax-free in 1997. Table 3.2 presents revisions in product tax and table 3.3 presents revisions in tax-type fees for petrol products. Notably, the base tax for heavy fuel oil was cancelled in 1997.

Table3.2. Product taxes between 1995 and 2004.

	Petrol c/l			Diesel fuel c/l			Light fuel oil c/l			Heavy fuel oil c/kg		
Date of imposition	Base tax	Additional tax	Excise tax	Base tax	Additional tax	Excise tax	Base tax	Additional tax	Excise tax	Base tax	Additional tax	Excise tax
1.1.1995	43,06	2,07	45,13	25,23	2,07	27,3	0,72	2,3	3,02	0,43	2,69	3,12
1.1.1996	49,78	2,07	51,85	25,23	2,07	27,3	0,72	2,3	3,02	0,43	2,69	3,45
1.1.1997	48,96	2,76	51,72	24,37	3,13	27,5	1,75	3,13	4,88		3,72	3,72
1.4.1997	48,96	2,76	51,72	24,37	3,13	27,5	1,75	3,13	4,88		3,72	3,72
1.1.1998	52	3,21	55,21	26,36	3,67	30,03	1,83	3,67	5,5		4,34	4,34
1.9.1998	51,2	4,02	55,22	25,5	4,52	30,02	1,83	4,54	6,37		5,4	5,4
1.1.2002	51,19	4,02	55,21	25,5	4,52	30,02	1,83	4,54	6,37		5,4	5,4
1.1.2003	53,85	4,23	58,08	26,83	4,76	31,59	1,93	4,78	6,71		5,68	5,68
1.9.2004	56,5	4,23	60,73	29,48	4,76	34,24	1,93	4,78	6,71		5,68	5,68

Table 3.3. Tax type fees for petrol products.

Date of imposition	Motor gasoline	Diesel fuel	Light fuel oil	Heavy fuel oil
Strategic stockpile fee				
1.7.1984	0,723	0,387	0,387	0,320
1.1.1997	0,673	0,353	0,353	0,286
Harbour fee for goods				
1.1.1994 **	0,042–0,074	0,049–0,084	0,049–0,084	0,057–0,099
Compensation fee for oil pollution damages				
1.1.1992 *	0,028	0,031	0,031	0,037
1.1.2003 *	0,045	0,050	0,051	0,060

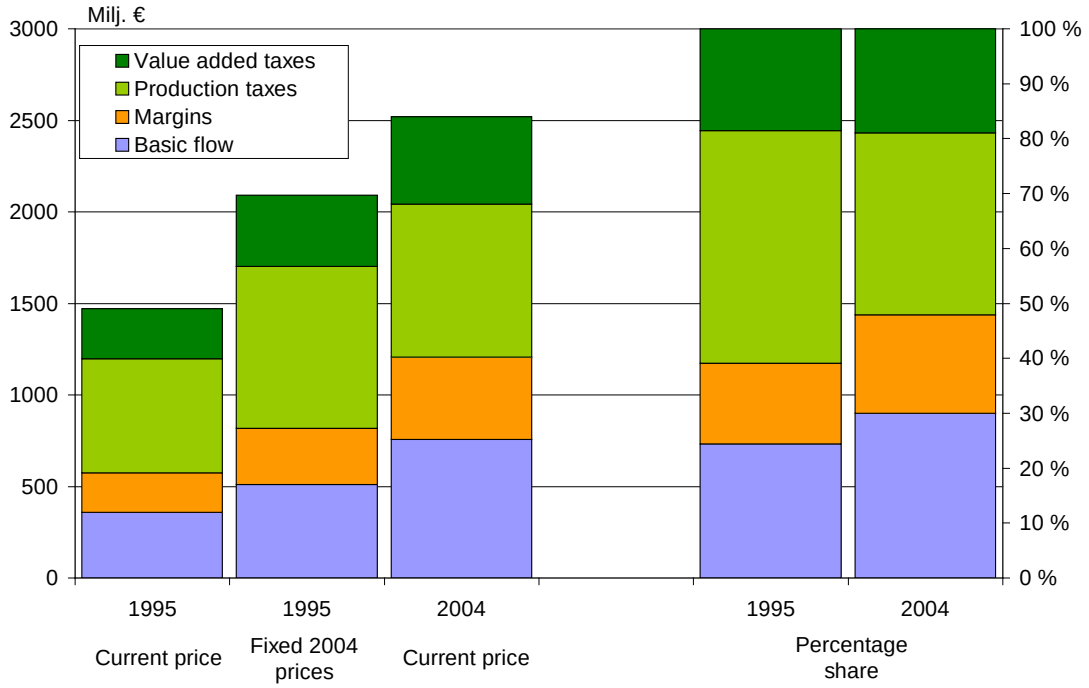
* Fee is doubled if the vessel has a single bottom.

** Tax fee recommended by Finnish port association, actual size can be harbour accommodation

[1] New tax for liquid fuels is called Laki nestemäisten polttoaineiden valmisteverosta 29.12.1994/1472 is available in Finnish at http://www.finlex.fi/fi/laki/ajantasa/1994/19941472

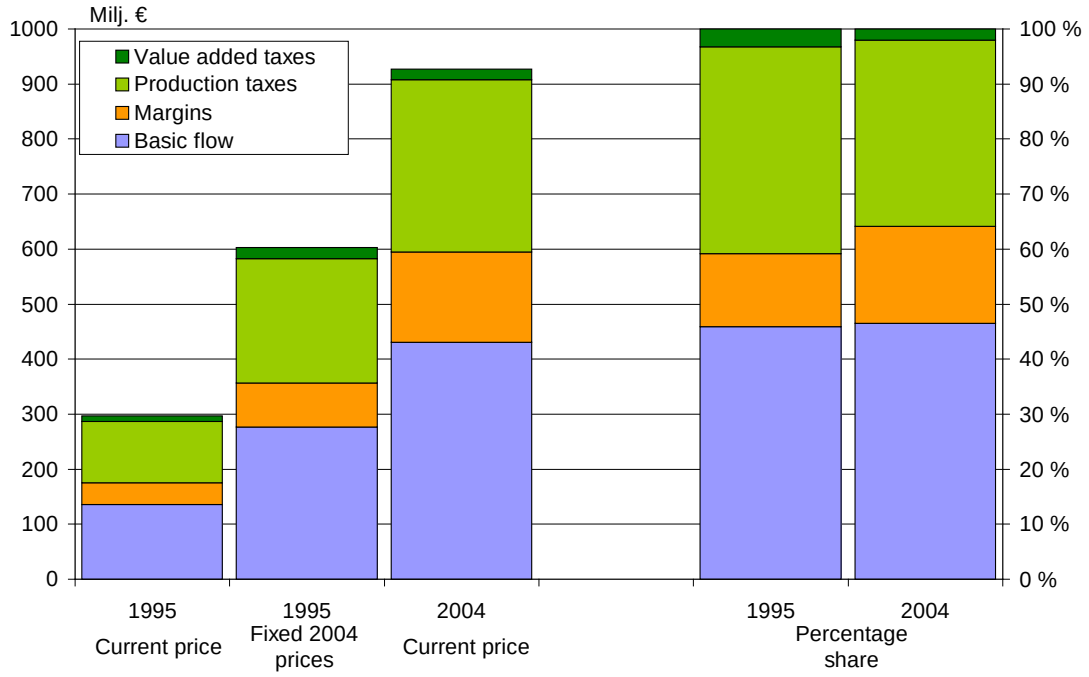
Figure 3.3 shows that the value of household consumption of petrol has increased by almost a half from 1995 to 2004. Again, the figure shows clearly that the effective share of taxes has decreased rather than increased.

Figure3.3. *Household consumption of petrol by households percentage shares in purchaser's value (left-hand scale) and total use in fixed and current value (right-hand side).*



Petrol is also used as an intermediate input by many industries. Figure 3.4 shows the value of intermediate use of petrol in 1995 and in 2004.

Figure 3.4. Intermediate use of petrol, percentage share of purchaser price (left-hand scale) and total use in fixed and current value (right-hand scale).



Figures 3.5 and 3.6 give the value of household consumption and intermediate of diesel oil and the breakdown to the shares of basic prices, taxes and margins. For diesel oil, the share of taxes has also decreased but nor quite so much as with petrol. This may due to the fact that the 1997 CO2-tax is heavier for diesel than for petrol.

Figure3.5. *Household consumption of diesel oil, percentage shares in purchaser value (left-hand scale) and total use in fixed and current value (right-hand scale).*

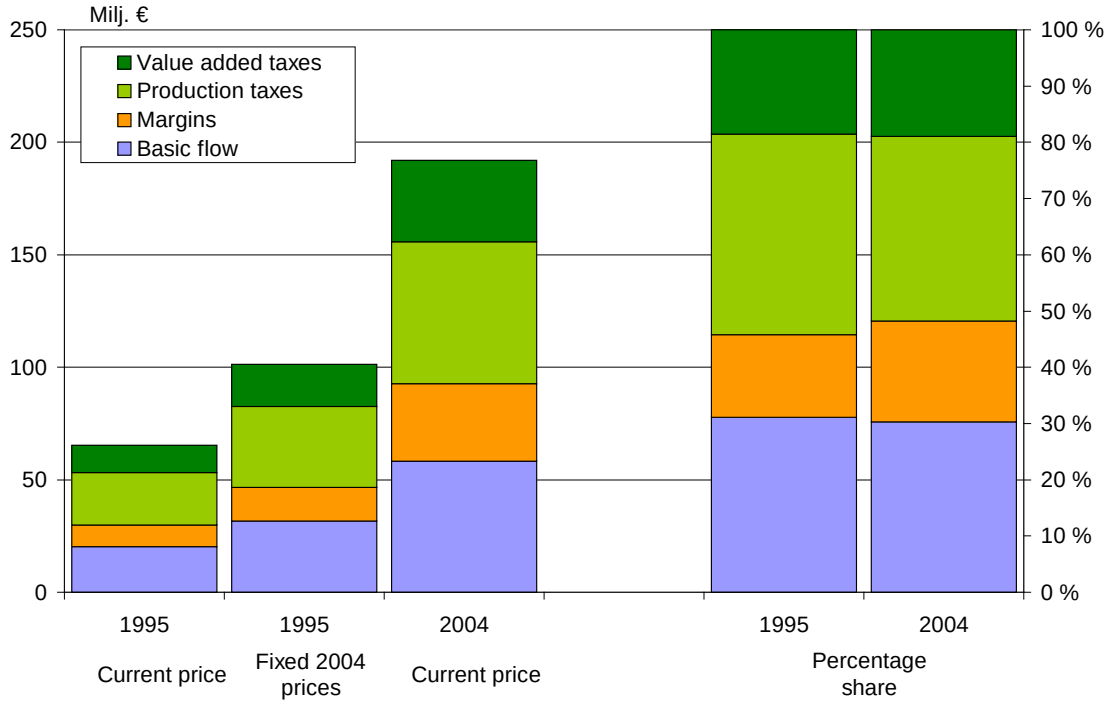
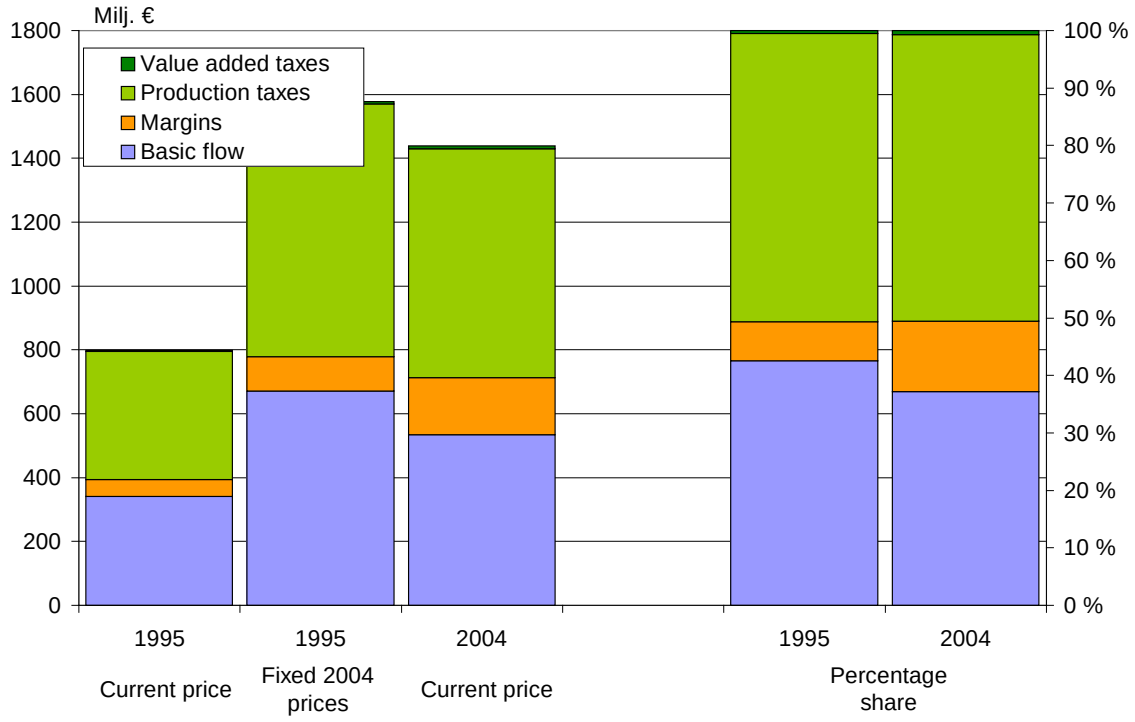


Figure3.6. *Intermediate use of diesel oils, percentage share of purchaser price (left-hand scale) and total use in fixed and current value (right-hand side).*



Light fuel oils have mainly been used for heating, although certain sectors – chief among them agriculture – have been entitled to use light fuel oils also as a transport fuel. Light fuel oils have a significantly lower basic tax than petrol and diesel. It clear from figures 3.7 and 3.8 that the share of the tax has decreased markedly between 1995 and 2004.

Figure 3.7. *Household consumption of light fuel oils used by households, percentage shares in purchaser value (left-hand scale) and total use in fixed and current value (right-hand scale).*

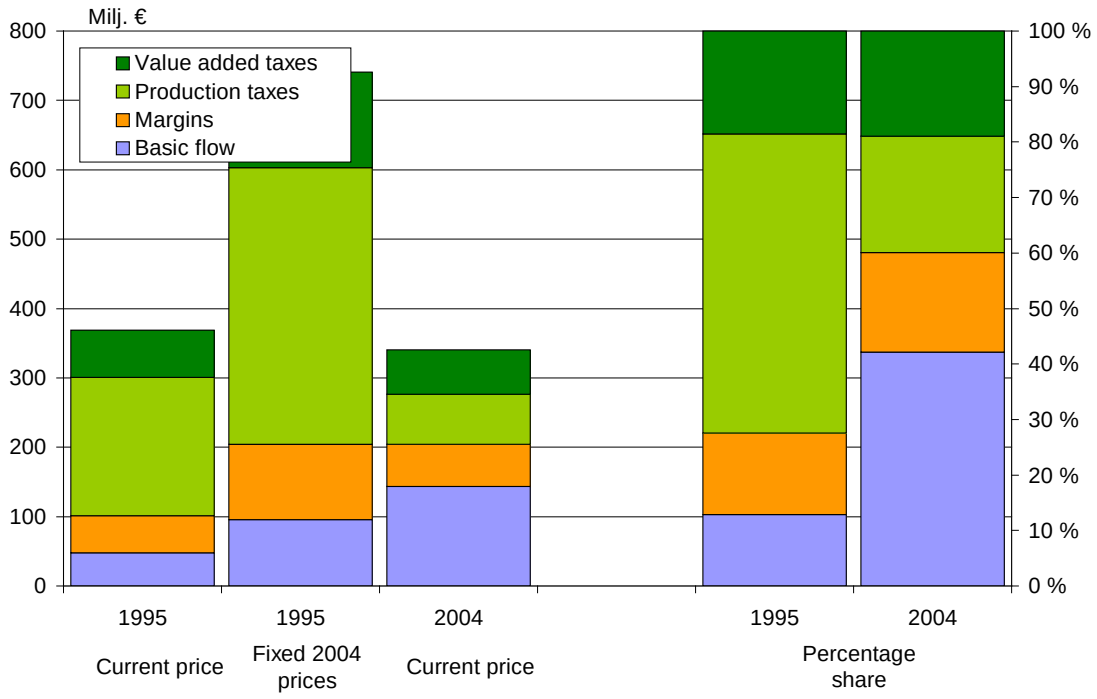
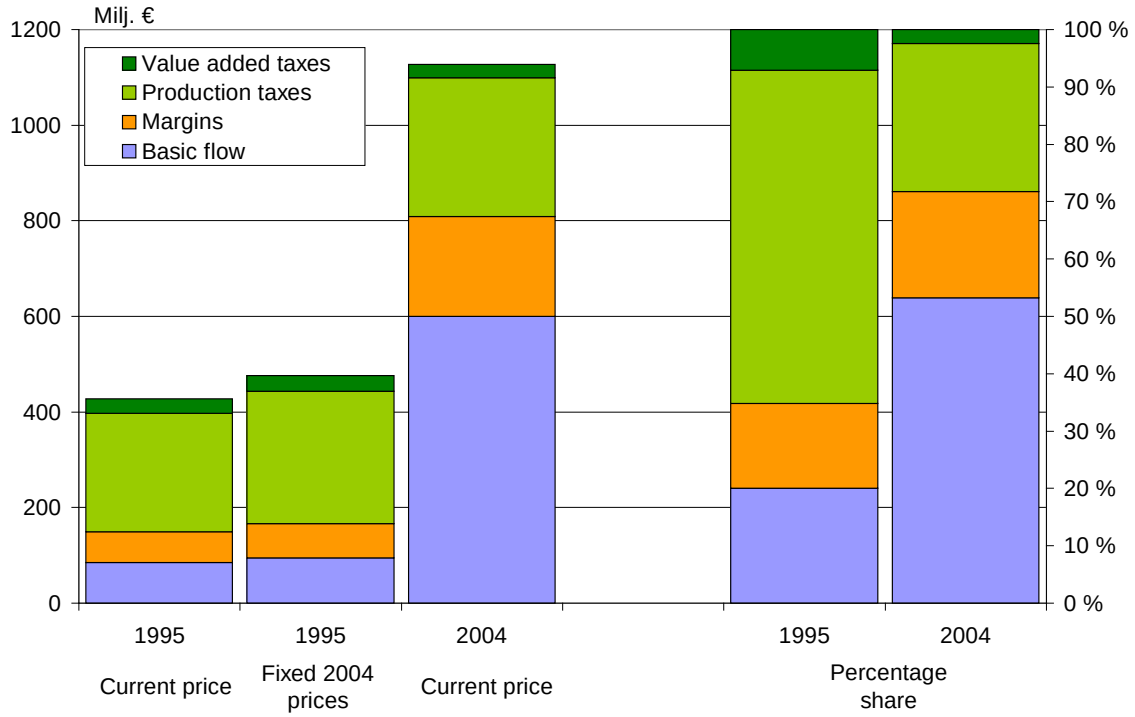


Figure 3.8. *Intermediate use of light fuel oils, percentage share of purchaser price (left-hand scale) and total use in fixed and current value (right-hand side).*



Heavy fuel oils are mainly used for heating and electricity production and also in the transport sector. Figure 3.9 gives the use of heavy fuel oils, and show that also with them the share of taxes has fallen between 1995 and 2004. To an extent, this is due to the 1997 tax law, since a major user of heavy fuel oil was electricity generation, which under the 1994 tax law had to pay a tax on its use of heavy oil. This was no longer the case after 1997.

Figure 3.9. *Intermediate use of heavy fuel oils, percentage share of purchaser price (left-hand scale) and total use in fixed and current value (right-hand side).*

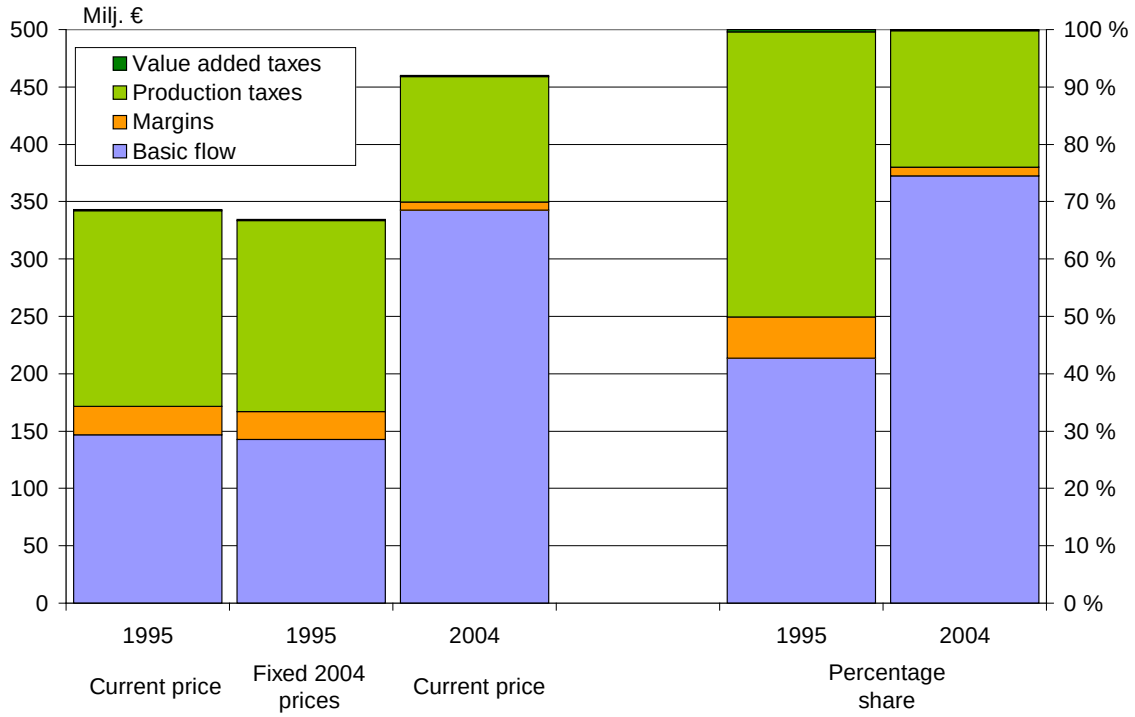


Table 3.4 shows the changes in electricity taxes from 1995 to 2004. As noted earlier, the energy tax law adopted in 1997 was the most important energy tax revision during the period. Whereas the 1994 taxation was based on inputs used in electricity generation, the 1997 tax put the tax on electricity consumption, shifting the burden of the tax towards users of electricity. It also concerned industrial establishments producing electricity.

The 1997 law also introduced, two tax classes for different users of electricity. In addition, a strategic stockpile fee of 0,013 c/kWh was defined for both user groups. The first group consists of electricity used in manufacturing industries and in green-houses. The second group contains the rest of electricity users. For example, private consumption and electricity used in commercial buildings are in the second tax group.

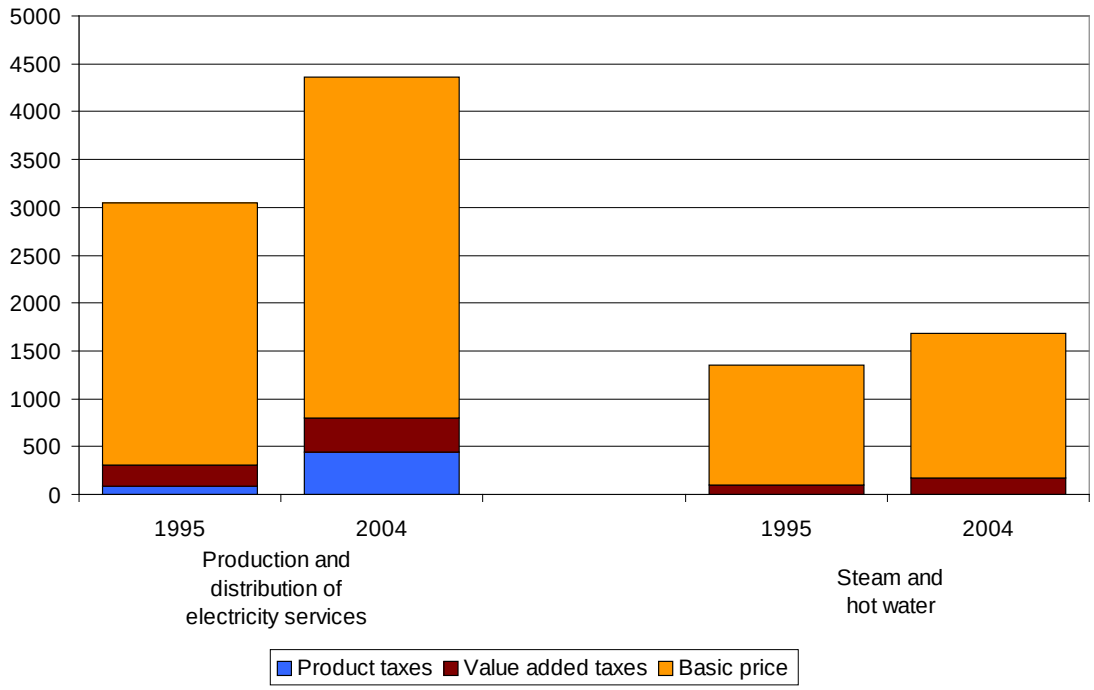
Table 3.4 Revisions in electricity taxation.

Date of imposition	Use*		Supply		
	Electricity I c/kWh	Electricity II c/kWh	Nuclear power c/kWh	Hydropower c/kWh	Import c/kWh
1.1.1995	–	–	0,4	0,07	0,37
1.1.1996	–	–	0,4	0,07	0,37
1.1.1997	0,4	0,4	–	–	–
1.4.1997	0,56	0,24	–	–	–
1.1.1998	0,56	0,34	–	–	–
1.9.1998	0,69	0,42	–	–	–
1.1.2003	0,73	0,44	–	–	–

* Tax class II consist of electricity used in manufacturing and professional greenhouses, rest of users are in tax class I.

The total electricity tax revenue as a share of total use is presented in Figure 3.10. The effect of the tax revision is clearly visible. Value added taxes stayed at the same level compared to total use for both products. The changes in electricity taxation towards final use have led to a significant increase in the share of product taxes in the total value of electricity use.

Figure 3.10. Tax revenue and total use of electricity and heat at purchaser's prices.



4. Results from the historical simulation

This section presents the main results of the study. We commence by giving the results at the macroeconomic level. This is followed by an analysis at the level of overall energy use; of energy by industry; and of energy use by households.

In a historical simulation, the observed changes in the economy are explained with the help of the model, as explained in section 2.5. We can then decompose the observed changes into effects stemming from different sources (Harrison, Horridge and Pearson 2002). These sources are here divided into sets:

- Momentum; effects stemming from wealth and assets
- Foreign demand and import prices; changes in world markets and prices
- Domestic prices; effects stemming from domestic price level
- Indirect taxes; changes in indirect taxation
- Technical change; changes in output mix, and in intermediate and primary factor productivity
- Household tastes; changes in domestic consumption patterns
- Import / domestic preferences; changes towards domestic or imported commodities
- Employment growth; changes due to increased use of labour inputs
- Rates of return; here, shifts in taxes affecting the rate of return
- Macro variables; shifts if investment to capital ratio and the average propensity to save

The second set in the above list describes changes in international trading conditions. Finland is a small open country and it has to adapt to e.g. changes in international business cycles, inflation and relative prices in the rest of the world. Variables related to these changes are included in second column. Because imports and exports are interrelated, those are analysed simultaneously.

The third set includes the effects of the overall domestic price level. This set is included mostly to distinguish between foreign market and domestic effects.

The fourth set includes variables related to changes in net indirect taxes. Indirect taxes consist of tree types of taxes; product taxes, product subsidies and value added taxes. Also tariffs are included. This column is important for analysing indirect effect of taxes in total economy.

The fifth set describes technical changes in the Finnish economy. To be exact, it consist variables describing industry specific commodity input demand in current productivity and capital formation, industry specific primary factor productivity, technical changes in effecting capital/labour ratio and shifts in export technology.

The sixth set includes taste changes basing on used consumption variables from household utility function (see Honkatukia, 2009; Honkatukia, et al. 2009). In the historical simulation, price and volume changes combined with estimated parameter values from household behaviour are used to calculate shifts in household tastes towards specific commodities. The decomposition simulation includes tastes as endogenous.

The shifts between import and domestic preferences are included in seventh set. Imports are divided in two sources; imports from EU members and imports from non-EU countries different Domestic preferences and technical change in current productivity, primary factor productivity by industry.

The eighth set isolates variables related to employment and population growth over the simulation period.

The decomposition of rates of return is presented in the ninth set. It includes exogenous variables affecting the rates of return, here, mainly changes in production subsidies.

The last set includes a miscellaneous group of variables affecting the economy at the amcroeconomic level. For example, it contains aggregate shifts in the investment capital ratio, aggregate shifts in government demand, and shifts between public and private consumption..

Finally, the first set shows momentum effects. It explains what would have happened to Finnish economy if there had not been any changes in the exogenous variables. Primarily, it includes the effects of returns to financial assets, which would have affected the economy regardless of other changes.

4.1 Decomposition of main macroeconomic changes

The decade from 1995 on was a turbulent one for the Finnish economy. The country was recovering from the worst recession in decades, and the structure of the economy underwent major structural changes. This resulted in one of the fastest sustained growth periods in Finnish history.

Table 4.1 illustrates the changes in the main macroeconomic variables between 1995 and 2004. the first column in the table gives the total change in each of the macroeconomic variables during the decade. As can be seen, imports and exports increased rapidly during the period. Total exports grew by 82.6 per cent from year 1995 to 2004, or at an average 6.9 per cent annually. Imports increased by 74 per cent, or at an annual trend of 6.3 per cent. The rapid growth in exports pulled the domestic economy to healthy growth rates as well. Household consumption grew by 31,8 per cent, or at annual rate of 3,2 per cent, whereas investment grew at a whopping annual rate of 5,3 per cent, and closer to

60 per cent overall. Employment also grew rapidly, especially in the latter part of the 1990's.

The consequent columns in table 4.1 below give the decomposition of the underlying factors for each of the variables. From the table, it can be seen that GDP grew by 37.3 per cent from 1995 to 2004. The largest contribution to this change stemmed from employment, which alone would have explained a 15.7 per cent increase in GDP. Technological change – mainly primary factor productivity growth – explains an 8.3 per cent GDP growth. Trade and domestic prices together explain more than 10 per cent's worth of GDP growth.

Household demand grew by 31.8 per cent. Again, employment is the largest factor behind this growth. Investment contributed to a growth in GDP by almost 60 per cent. Here, there are several explaining factors. Trade and prices together explain half of investment growth, and employment half of the remainder. Technology contributed negatively, however, which is due mainly to a tendency towards more labour intensive production in many industries. Macroeconomic variables played a major role in investment. Chief among them was an overall rise in investment capital ratio in the economy. Public consumption grew by close to 16 per cent. Since it is closely related to employment and population growth, these explain two thirds of public consumption growth.

The rapid growth of the Finnish economy coincided with an expansion of the world economy and world trade. Arguably, trade facilitated the marked productivity improvements in many industries, which was reflected in falling prices in many of Finland's export products. This is reflected in the very rapid export growth from 1995 to 2004 in table 4.1. Technological change and increased employment contributed largely to this, as did rapid growth in the world market demand for most exports.

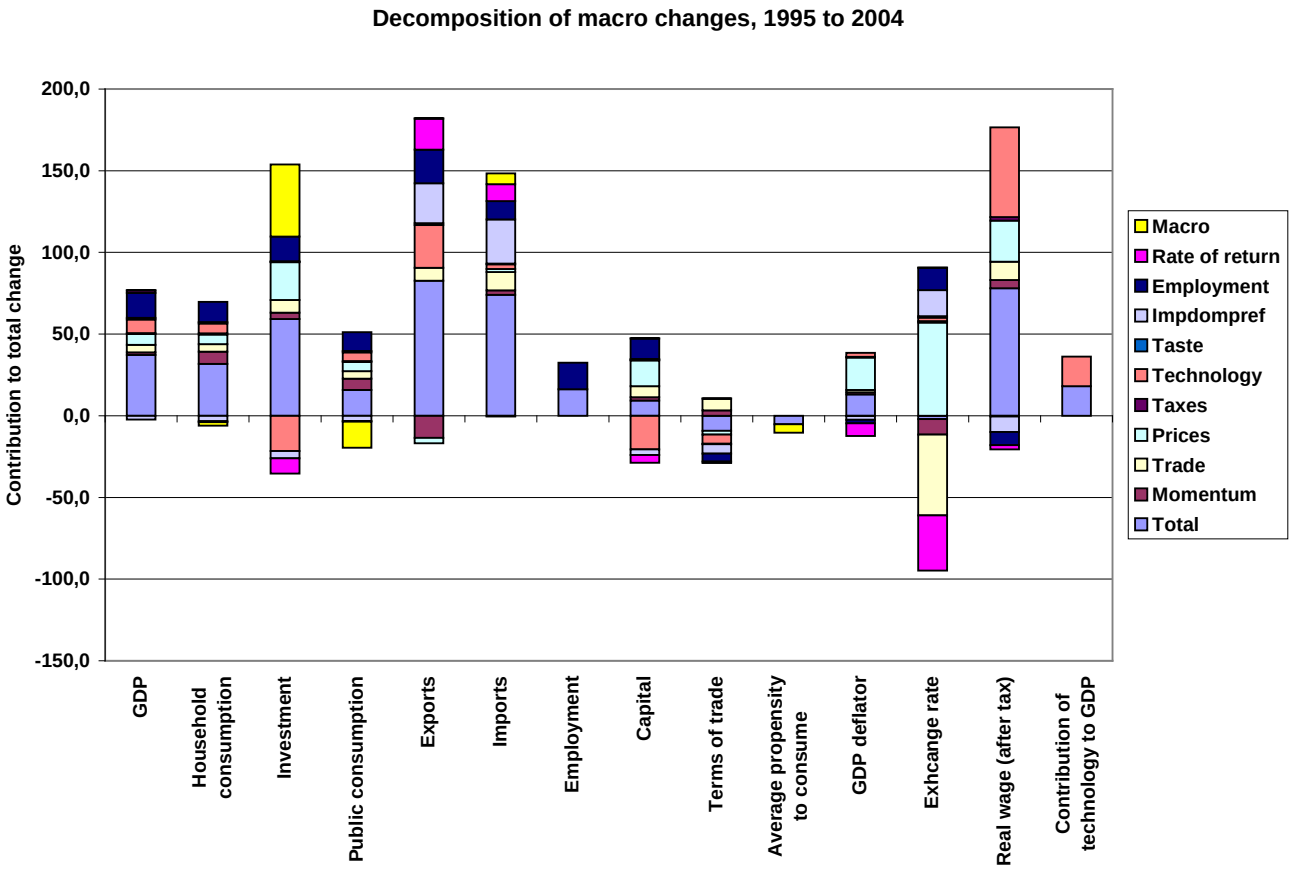
At the same time, imports of intermediate goods also increased rapidly, benefiting from falling prices elsewhere. There was a trade-favoring shift also in household demand, which shows up both in exports and in the rapid growth of imports. These changes are captured by the overall price changes given in Table 4.1.

An interesting change that occurred in the decade starting in 1995 was also the deterioration of the terms of trade, which can be attributed partly to technology, partly to changes in the trade patterns. At the same time, real wages increased, also due mainly to technology – rapid productivity growth. The overall contribution of technological change to GDP was 18 per cent, that is, half of GDP growth can be explained by productivity growth alone.

Table 4.1. Decomposition of changes in macro variables, 1995 to 2004

	Total	Momentum	Trade	Prices	Taxes	Technology	Taste	Impdompre	Employme	Rate of ret	Macro
GDP	37,3	1,5	4,6	6,6	0,6	8,3	1,0	-2,3	15,2	1,4	0,3
Household	31,8	7,4	4,6	5,9	0,6	6,0	0,9	-3,4	12,4	-0,5	-2,1
Investment	59,2	3,9	7,8	23,2	0,0	-21,5	0,5	-4,5	15,0	-9,4	44,2
Public cons	15,8	6,9	4,5	5,6	0,6	5,3	0,8	-3,2	11,6	-0,5	-15,9
Exports	82,6	-13,6	8,0	-3,2	0,0	26,1	1,2	24,4	20,6	19,0	0,3
Imports	74,0	2,7	11,3	1,8	-0,4	2,9	0,4	27,1	11,2	10,4	6,6
Employme	16,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	16,2	0,0	0,0
Capital	9,3	2,0	6,8	15,8	0,2	-20,6	0,7	-3,4	12,5	-4,7	0,1
Terms of tr	-9,2	3,3	7,2	-2,4	0,0	-5,6	-0,3	-5,7	-4,8	-0,9	0,0
Average pr	-5,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-5,2
GDP deflat	13,1	1,3	1,4	19,9	0,5	2,5	-0,1	-2,4	-2,0	-7,9	0,0
Exhcange	-2,1	-9,4	-49,5	57,0	0,9	2,1	0,8	16,1	13,6	-33,8	0,1
Real wage	78,0	5,1	11,2	25,2	2,0	55,0	-0,4	-9,5	-8,1	-2,5	0,0
Contributio	18,1	0,0	0,0	0,0	0,0	18,1	0,0	0,0	0,0	0,0	0,0

Figure 4.1 shows the decomposition of the macroeconomic changes, demonstrating that the largest changes occurred in exports, imports and investment. At the same time, domestic purchasing power also benefitted from the changes and grew almost as rapidly as exports.



4.2 Decomposition of changes in energy use

This section gives our main findings on energy use. We report the observed changes in energy use and decompose the change into contributions by the underlying factors just as we did with the macroeconomic variables.

The analysis uses the observed changes in energy taxes and prices to evaluate their specific effects in each of the sectors. This involves as a first step an evaluation of the other changes in taxes. In effect, changes in energy taxes have to be distinguished from other changes in taxation. VATTAGE takes into account all indirect taxes, whereby it is important to distinguish between the overall changes and the changes in energy taxes. By reducing product subsidies from the total tax income, we can calculate net taxes as described in Table 2 below. Taxes on imports (tariffs) are not included in taxes from domestic

sources. In Table 4.2, the overall revenue from indirect taxes in current prices has grown by 47.9 per cent between the years 1995-2004, or at an annual rate of 4.5 per cent. Revenue from intermediate use has increased by 81.8 per cent , or by 6.9 per cent per annum. As can be seen, the share of specific product taxes grew smaller over the period, as revenue from product taxes grew at a slower rate than that of other indirect taxes. This reflects the fact that most specific taxes – such as the CO2 tax – are defined in unit terms, as opposed to the proportional – or ad valorem – rates for most other indirect taxes.

Table 2.2 Changes in indirect tax revenue between years 2004 and 1995.

	Total Value at year 2004 M€	%-change from 2004 to 1995	%-change from 1995 to 2004	Annual %-changes based on trend between 1995 and 2004
Net indirect taxes (subsidies included)				
- from consumption	12611	-32,40	47,94	4,45
- from intermediate use	4895	-45,00	81,83	6,87
Value added taxes				
- from consumption	8192	-36,89	58,44	5,25
- from intermediate use	3087	-42,10	72,70	6,26
Production taxes				
- from consumption	4537	-21,79	27,85	2,77
- from intermediate use	2709	-35,14	54,18	4,93

The results on energy use at industry level are given in Tables 4.3 and 4.4. The tables show the decomposition of changes in aggregate energy use at the level of individual industries. From the table it can be seen that energy use grew in most industries between 1995 and 2004. The price of imported energy – a key element in the trade-column – dampened the growth in most industries, Export growth, on the other hand, increased the demand for energy in many export industries. The effects of taxes were much smaller, but mostly negative. It would appear that the introduction of electricity taxes did have the effect of slowing down overall energy demand growth, since overall growth is mostly negatively affected in electricity-intensive industries. The two-tier electricity tax should have had a larger effect on service industries, where the tax is higher than in export industries, and this appears indeed to be the case. Interestingly, the effects of taxes were also negative in two of the three transport industries, reflecting most likely the effects of increases in the taxes of diesel fuels and fuel oils.

Table 4.3 Aggregate energy use by industries

		Total	Momentum	Trade	Prices	Taxes	Technolog	Taste	Impdompre	Employ
I_01	Agriculture	-10,0	-1,6	-12,2	7,8	-3,5	-17,0	0,2	11,2	9,1
I_02	Forestry	36,7	-14,0	-44,9	6,4	-1,4	29,4	6,3	42,9	27,8
I_103	Extraction of peat	6,0	-17,8	-127,7	44,0	4,2	-9,6	3,4	14,2	43,9
I_13_4	Mining and quarrying	18,2	-5,2	4,2	-6,0	-1,2	1,6	0,7	-25,3	14,0
I_15	Food products	25,3	0,1	-4,1	5,1	0,3	31,0	-3,6	-16,9	10,1
I_17_9	Textiles	-22,6	-7,5	-34,7	7,2	-1,9	-5,1	-0,3	-36,6	18,8
I_20	Wood products	107,3	-7,7	-36,7	-16,2	-2,2	108,7	0,8	20,9	21,8
I_21121	Newsprint	12,7	-7,7	-35,6	-17,0	-1,9	45,1	1,6	13,8	13,4
I_21125	Fineprint	59,8	-12,4	-5,4	-2,1	0,4	84,2	1,7	21,6	21,9
I_21129	Pulp and other paper products	23,7	-8,4	-44,4	-17,7	0,2	16,8	1,0	9,2	14,6
I_212	Paperboard	4,2	-5,8	-37,9	2,7	-0,6	12,7	0,3	4,1	15,2
I_22	Publishing and printing	20,3	2,4	4,3	1,9	-0,5	4,9	10,5	-15,3	14,2
I_23	Refined petroleum products	-60,6	1,4	92,7	-23,7	4,3	-123,8	1,9	-14,9	3,0
I_24	Chemicals and chemical produ	33,5	-9,5	1,3	-5,1	6,0	55,9	1,5	-10,6	19,0
I_25	Rubber and plastic products	51,5	-7,8	5,1	3,5	-0,2	1,0	1,0	3,5	21,9
I_26	Non-metallic mineral products	44,3	-1,0	9,6	6,8	-1,3	29,2	-0,7	0,4	16,0
I_271	Basic iron and steel and of ferr	74,0	-2,7	52,6	-56,4	1,9	7,1	0,5	-51,7	6,4
I_271_5	Basic metals n.e.c.	53,3	0,1	9,3	-67,6	-6,4	-8,5	-0,1	-71,9	0,9
I_28	Fabricated metal products	80,6	-9,3	-6,0	5,7	-2,9	36,7	0,5	-2,2	24,2
I_29	Machinery and equipment n.e.	33,2	-16,6	-47,9	30,3	-1,1	1,8	1,3	9,8	29,5

Table 4.4 Aggregate energy use by industries

	Total	Momentum	Trade	Prices	Taxes	Technology	Taste	Impdompre	Employ	Rate of ret	Macro
Electrical and optical equipmer	107,5	-12,8	-41,5	16,2	-1,5	11,5	1,5	37,7	22,6	69,1	4,7
Transport equipment	41,5	-18,4	3,1	35,4	-2,6	110,3	0,7	-1,5	32,7	-122,0	3,7
Manufacturing n.e.c.	28,7	-5,3	-30,9	8,8	-4,3	62,9	-6,4	-4,0	21,0	-17,3	4,3
Electricity, gas and water supp	-2,8	-0,6	-2,7	10,4	3,6	-16,9	1,2	-7,3	10,8	-1,3	0,0
General construction of buildin	56,0	8,4	6,9	32,3	-2,8	-1,6	0,0	-5,6	13,0	-26,8	32,3
Construction of motorways, roa	33,0	3,6	6,9	13,5	-0,8	-20,2	0,5	-9,4	11,5	-3,2	30,6
Wholesale and retail trade	21,4	6,1	5,3	1,1	-1,5	-6,6	7,4	-2,8	9,6	1,0	1,7
Hotels and restaurants	49,6	9,0	5,0	4,4	1,6	134,4	-102,0	-5,8	12,7	-6,7	-3,0
Land transport; transport via pi	5,8	-1,6	1,6	-20,9	-3,5	-64,6	-4,2	-3,6	16,1	86,4	0,2
Water transport	-22,8	0,7	-15,2	6,7	-9,9	16,9	1,5	-0,3	3,2	-26,7	0,2
Air transport	-2,0	11,2	23,9	66,0	6,1	217,8	4,7	-20,4	-7,2	-304,4	0,3
Supporting and auxiliary transp	13,0	3,1	12,0	3,5	-2,5	32,6	-6,0	-14,1	10,7	-19,9	-6,4
Post and telecommunications	74,2	4,1	9,8	3,3	5,6	22,3	18,7	-5,5	14,9	0,8	0,2
Financial intermediation	3,3	4,2	3,5	4,3	-1,8	-14,6	-6,5	0,1	12,1	2,7	-0,7
Real estate, renting and busine	3,1	7,0	0,6	15,6	-5,4	10,6	0,1	-3,4	11,3	-31,3	-1,9
Buying and selling of own real	58,0	2,4	43,0	8,2	0,0	8,6	-0,6	-23,1	14,5	-3,6	8,6
Public administration	17,9	7,0	4,0	3,3	-2,6	5,9	2,4	-4,7	10,5	5,0	-13,0
Education	18,4	8,2	2,4	4,8	-3,0	7,7	1,4	-4,4	10,2	5,8	-14,6
Health and social work	22,9	8,7	4,0	4,4	-3,3	6,0	1,3	-4,8	12,3	8,0	-13,5
Recreational, cultural and spor	32,2	7,8	2,5	3,6	0,7	5,5	5,3	-1,5	12,4	-0,4	-3,6

Table 4.5 shows the changes in aggregate domestic sales of energy products. Electrity use grew by 11 per cent between 1995 and 2004. The largest factors contributing to this growth were trade (13,5 per cent), and employment and rate of return with close to ten per cent each. Electricity prices slowed the growth down with a contribution of -7,5 per cent, and electricity taxes by -11,7 per cent. Were it not for higher prices and taxes, in other words, electricity consumption would have grown almost 20 per cent more. For the other fossil fuels, the increase in their prices has been much more significant in lowering the rate of growth of their use than taxes; in fact, the contribution of taxes has been positive

in many cases. This is due to the fact that in relative terms, taxes have actually grown smaller over the period, even though the absolute unit taxes have in most cases been raised.

Table 4.5 Aggregate sales of energy in Finland

		Total	Momentum	Trade	Prices	Taxes	Technolog	Taste	Impdompre	Employ
C_02	Wood	13,1	-8,7	-29,0	-7,3	-1,1	10,3	4,7	20,5	19,3
C_101	Coal	37,8	8,1	26,9	-34,4	11,1	16,4	1,4	-50,2	11,0
C_103	Peat	21,8	-14,4	0,2	52,7	5,9	-85,7	3,4	6,2	40,6
C_11101	Crude oil	178,6	13,1	119,0	-128,6	17,1	210,1	7,1	-77,9	3,0
C_11102	Natural gas	257,3	9,2	19,1	-58,0	9,4	274,5	1,6	-43,3	7,5
C_13_4	Petrol	25,0	-3,9	10,3	-25,0	-1,1	-10,4	0,5	-28,7	10,7
C_232011	Diesel oil	-0,4	5,9	1,4	7,0	10,0	30,6	2,3	-10,1	4,5
C_232012	Light fuel oil	-23,1	0,9	13,0	-14,8	-2,0	-68,4	3,0	-6,2	11,2
C_232013	Heavy fuel oil	-21,8	2,0	-16,1	2,4	-22,4	9,5	7,6	-6,1	9,8
C_232014	Other oil products	46,3	-5,1	-24,0	9,6	84,5	-23,4	-7,2	4,2	20,7
C_4011	Electricity	11,0	1,5	13,5	-7,5	-11,7	-13,7	1,5	7,0	9,8
C_4012	Electricity,distribution	9,7	-2,4	1,5	13,4	1,6	-9,3	1,7	-6,4	15,7
C_403	Steam and hot water supply se	15,0	0,5	1,1	6,8	-0,2	3,3	1,5	-0,6	13,5

Figure 4.2 summarises the changes in the sales of energy products in Finland. Two major changes are evident from the picture: there has been a major increase in the use of natural gas, and there has also been a big increase in the imports of crude oil, reflecting increased domestic refining capacity. The contribution of taxes has mostly been modest, and it has effectively cut only the demand for electricity. This is not surprising given the shift towards taxation of electricity use in 1997, and given that the effective fuel tax rates have grown lower as the price of energy has fallen. However, the price and tax effects together have had the effect of dampening energy demand growth in most industries.

Figure 4.2 Domestic sales of energy products

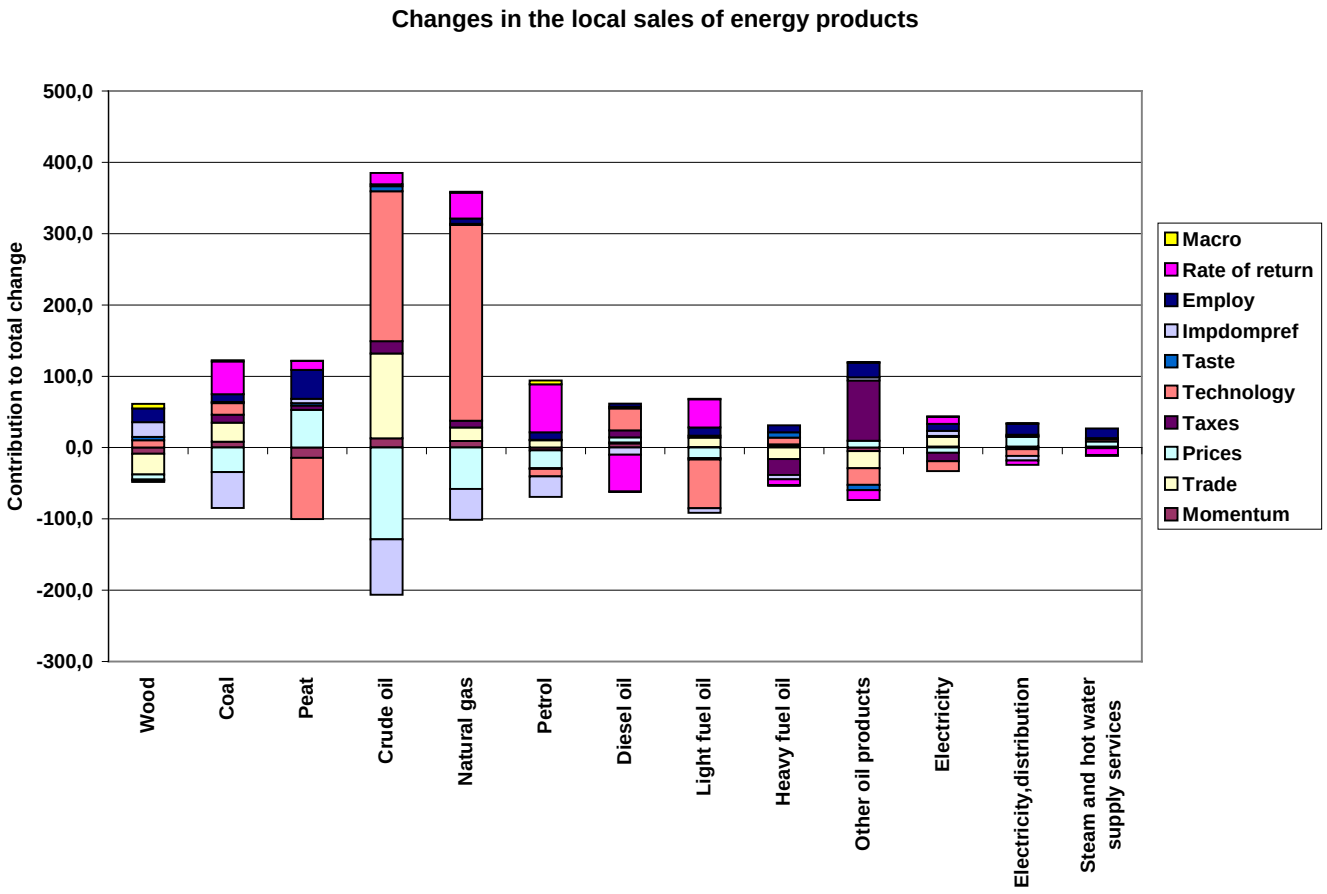
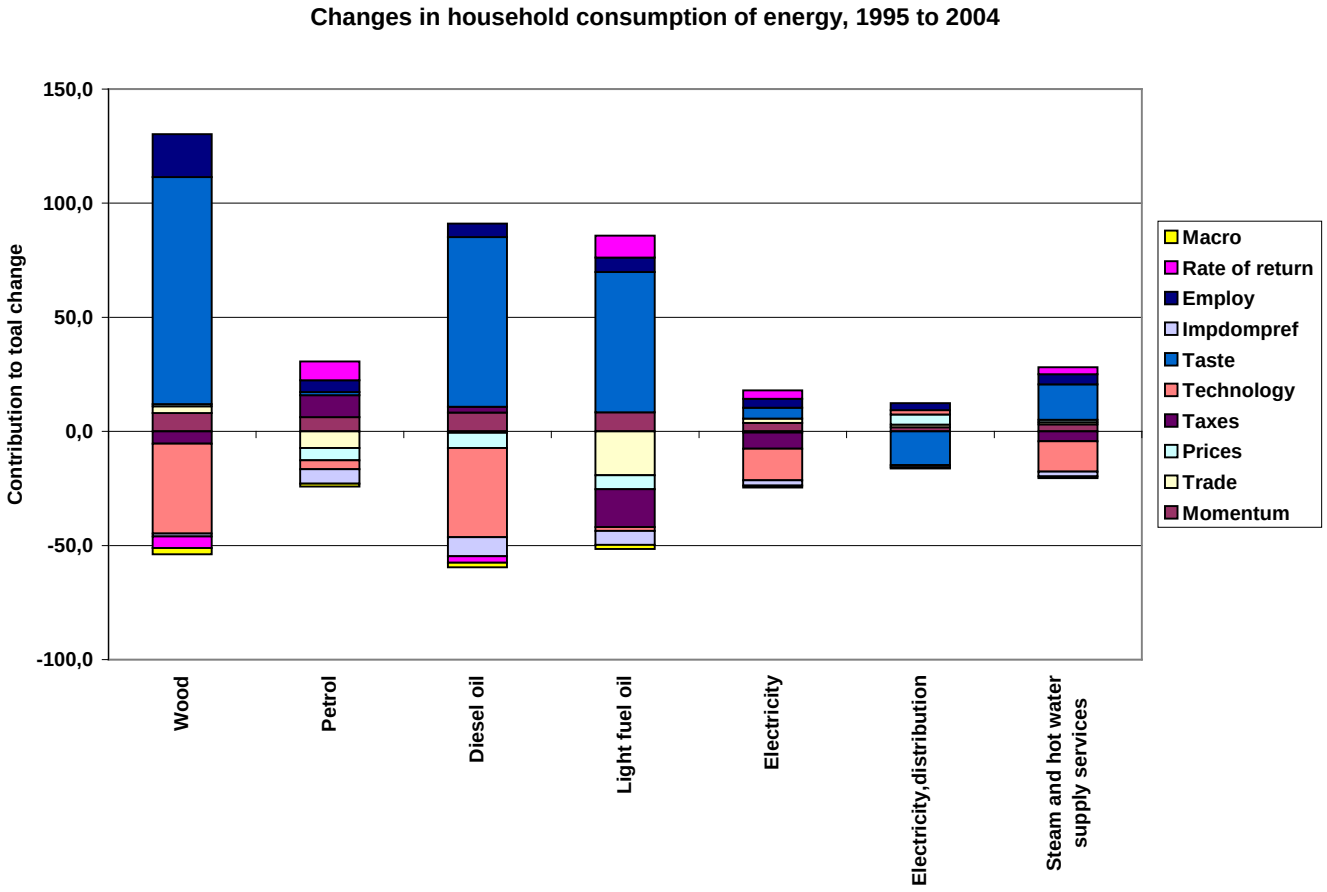


Table 4.6. reports the changes in household demand for energy. The demand for almost all energy except electricity has risen from 1995 on, driven by employment growth, and, more significantly, by changes in consumption patterns. Here, the effects of two of the changes of the 1997 energy tax law can clearly be seen. The first is the negative effect on light fuel oil demand caused by the marked rise in the taxes on light fuel oil; the second, the negative overall effect of the electricity tax on the demand for electricity. For most of the petroleum products, however, it is rather the effect of rising prices than the taxes that has dampened demand growth, which nevertheless has grown, mostly fuelled by changing consumption patterns, which have tended to favour diesel – for motoring – and light fuel oil – for heating. Interestingly, there has also been an increase in the demand for wood, although here, our data does not allow a distinction to be made between the uses of wood by the consumers.

Table 4.5 Household demand for energy

		Total	Momentum	Trade	Prices	Taxes	Technolog	Taste	Impdompre	Employ
C_02	Wood	76,5	8,0	2,9	1,0	-5,4	-39,3	99,5	-1,3	18,8
C_232011	Petrol	6,4	6,3	-7,3	-5,4	9,6	-3,9	1,3	-6,3	5,2
C_232012	Diesel oil	31,5	8,3	-0,6	-6,7	2,5	-39,0	74,3	-8,4	6,0
C_232013	Light fuel oil	34,3	8,4	-19,2	-6,2	-16,6	-1,7	61,4	-6,1	6,4
C_4011	Electricity	-6,5	3,7	2,0	-0,5	-7,1	-13,8	4,7	-2,3	3,9
C_4012	Electricity,distribution	-3,8	1,9	1,1	4,4	0,1	1,9	-14,8	-0,9	3,0
C_403	Steam and hot water supply se	7,7	3,1	1,0	1,0	-4,3	-13,3	15,5	-2,1	4,5

Figure 4.3 Household demand for energy, 1995 to 2004



5. Conclusions

This study has evaluated the effects of changes in energy taxes on energy consumption between the years 1995 and 2004. During this period, Finnish energy taxation was fundamentally changed, going from an up-stream, emission and energy content based approach to one with a mixed fuel and electricity tax. The change put the burden more closely to the user of electricity and fuels.

Our main finding is that changes in the energy taxes have had a marked effect on the sales of electricity, but a much smaller one the sales fossil fuels. Only in the case of petrol and light fuel oil do we find the taxes to have slowed down overall demand growth. For the other fossil fuels, however, the effects of increases in their prices have been much more significant.

The main reason for these findings is, firstly, that the 1997 genuinely shifted the tax burden towards electricity, and even though it also introduced a two-tier unit tax, it still made electricity more expensive to most of its users; secondly, while the period from mid-1990's on saw significant increases in the world prices of fossil fuels, the unit taxes were not raised at the same rate as the world prices, leading to a de facto decrease in the effective tax raes for fossil fuels, which explains the negligible or even positive contributions of fuel taxes that we find in many cases. It is noteworthy, though, that fuel taxes did have an effect on the consumption of some fuels, most notably light fuel oil, directing demand away from light fuel oil.

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