Government
Institute for
Economic Research

Research Reports 162

The effects of energy taxes on energy consumption in Finland between 1995 and 2004 – An historical analysis using the VATTAGE-model

Juha Honkatukia

Kimmo Marttila

Research Reports 162 January 2011

VATT RESEARCH REPORTS

162

The effects of energy taxes on energy consumption in Finland between 1995 and 2004 – An historical analysis using the VATTAGE-model

Juha Honkatukia
Kimmo Marttila

Valtion taloudellinen tutkimuskeskus
Government Institute for Economic Research
Helsinki 2011

ISBN 978-951-561-961-7 (nid.)
ISBN 978-951-561-962-4 (PDF)

ISSN 0788-5008 (nid.)
ISSN 1795-3340 (PDF)

Valtion taloudellinen tutkimuskeskus

Government Institute for Economic Research

Arkadiankatu 7, 00100 Helsinki, Finland

Email: etunimi.sukunimi@vatt.fi

Oy Nord Print Ab

Helsinki, January 2011

Graphic design: Niilas Nordenswan

The effects of energy taxes on energy consumption in Finland between 1995 and 2004 – An historical analysis using the VATTAGE-model

Government Institute for Economic Research
VATT Research Reports 162/2011

Juha Honkatukia – Kimmo Marttila

Abstract

This study evaluates the effects of changes in energy taxes on energy consumption between the years 1995 and 2004 using an applied, general equilibrium model for a historical simulation. 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 on the users of electricity and fuels. We find that while the sharp increases in energy prices since 1995 have significantly restricted the growth of energy demand, energy taxes have also been effective in curbing the growth of energy and especially electricity consumption. For transport fuels, the effective tax rate actually fell as the price net of tax increased over time. Nevertheless, for petrol and light fuel oil we do find the taxes to have slowed down overall demand growth.

Key words: energy taxes, emission, economic growth

Tiivistelmä

Tässä tutkimuksessa selvitetään, miten energiaverotuksessa tapahtuneet muutokset ovat vaikuttaneet energiankulutukseen vuosina 1995–2005. Tutkimuksessa sovelletaan yleisen tasapainon mallia toteutuneen talous-kehityksen ja energiankäytön selittämiseen. Tutkimuksen keskeinen tulos on, että vuonna 1998 toteutettu energiaverouudistus, jossa siirryttiin energiasisällön ja hiilidioksidipäästöjen mukaan määräytyvästä panosverosta sekä polttoaineiden että sähkön verottamiseen, hillitsi energiankulutuksen kasvua. Etenkin sähkönkulutuksen kasvu olisi ilman sähköveron käyttöönottoa ollut selvästi – kymmenisen prosenttia – korkeampi. Fossiilisten polttoaineiden voimakas hinnannousu 1990-luvun lopulla ja tämän vuosituhannen alussa hillitsi niiden käyttöä verotusta enemmän. Kuitenkin bensiinin ja kevyen polttoöljyn verotus rauhoitti niiden käytön kasvua.

Asiasanat: energiaverotus, emissio, talouskasvu

Summary

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

We find that the sharp increases in energy prices since 1995 have restricted the growth of energy demand in very significantly way. Energy taxes, on the other hand, while subject to major nominal increases, 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 and fuel oils, the effective tax rate has actually fallen as the price net of tax has increased over time due to the rising price of crude oil that occurred during the late 1990s and the beginning of this millennium. 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 in curbing the growth of demand.

The main reasons for these findings are twofold. Firstly, the 1997 tax reform 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 onwards witnessed significant increases in the world prices of fossil fuels, unit taxes were not raised at the same rate as the world prices, leading to a de facto decrease in the effective tax rates for fossil fuels. This explains the negligible or even positive contributions of fuel taxes that we find in many – but not all – cases.

Contents

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, all subsequent energy tax schemes have included the idea of taxing emissions. 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 liberalized 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 modeling. 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, 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 the 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.

Chapter two of the study gives 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, which is described in section 2.5.

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. This data in described in chapter three of the study.

It is a useful exercise to study the overall development of the economy and the changes that have occurred, in order to get to grips with the more specific effects of energy taxes. This is the subject of chapter four, which also explains the decomposition of the overall effects into the contributions of several factors.

Finally, the main results of the study are given in chapter five. 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 chapter of the study concludes.

2. The VATTAGE model

2.1 Introduction

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.

Several factors explain the popularity of MONASH. The main ones are the advanced and user-friendly software packages that facilitate data handling and the set-up of complicated policy simulations, and that also allow a very detailed post-simulation analysis of the simulation results. MONASH-type models are also very adaptable to the analyses of different types of policies and different time frames. In forward-looking policy analysis, MONASH-type models offer a disciplined way to forecast the baseline development of the economy. Last, but not least, they also allow the user to replicate and explain the historical development of an economy in great detail, which is not true for most AGE models.

VATTAGE contains many advanced, dynamic features. There are three types of inter-temporal links connecting the consecutive periods in the model: (1) accumulation of fixed capital; (2) accumulation of financial claims; and (3) lagged adjustment mechanisms, notably in the labour markets. Different fiscal rules for the balancing of the public sector budgets can also be specified. The model can be run either in a recursive mode or under forward-looking (rational) expectations.

The dynamics of the model lead to gradual adjustment away from the baseline as due to policies or external shocks to the baseline development of the economy. The speed of this adjustment depends on several parameters: 1) the rates of depreciation of capital at the industry level; 2) the rate of adjustment of returns to capital; and 3) the rate of adjustment of real wages (when sluggish wage adjustment is assumed). These parameters can be derived from national accounts data and econometric studies of, notably, the labor markets.

This chapter gives a general outline of VATTAGE. The chapter is divided into three sections. In section 2.2, we describe the VATTAGE database. Section 2.3 gives an overview of the AGE theory behind demand, government finances and labor demand. Section 2.4 is devoted to the dynamic mechanisms of VATTAGE. Section 2.5 explains the different closures of VATTAGE and shows how the model is used in the historical context.

2.2 The VATTAGE database

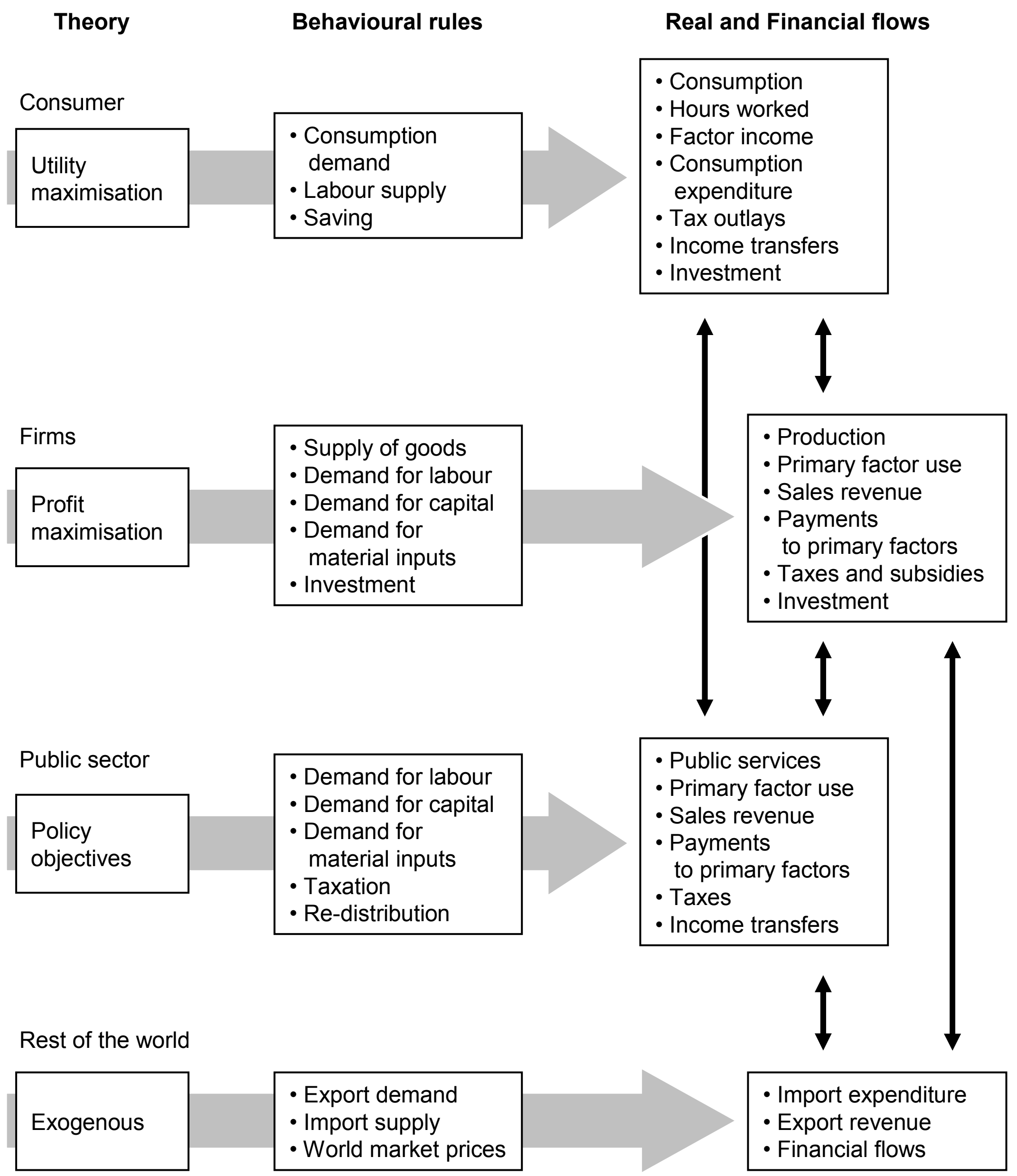
The model is based on an extensive database that describes the transactions between different agents in the economy. In the core of the model are optimization problems of the agents that result in the demand and supply functions of goods and primary factors. The transactions covered by the database and the model are illustrated in figure 2.1.

The VATTAGE database collects information about the structure of the Finnish economy derived from the national accounts, arranged in a presentation reflecting the theoretical structure of the model. The database also contains the behavioral parameters that are used to operationalise the behavioral assumptions made in the model. National accounts collect data on the use goods and services by industry and by product, but it also contains accounts for production as well as financial positions by institutional sector. (Euro stat 1997, 1) The institutional sectors are viewed as independent decision-makers (Statistics Finland 2000, 11.), and it is the behavior of these decision-makers that the model parameters and coefficients derived from the data describe and control.

A large part of the database consists of input-output data that captures the structure of demand for intermediate goods and primary factors by industries, the final good consumption by consumers, the public sector, and the rest of the world. However, input-output data does not contain data on income flows, which must be obtained from other sources in national accounts.

A large part of the transactions in the economy take place between the institutional sectors of the economy. In the database, transactions take place both between domestic sectors, and between domestic and foreign sectors. The domestic sectors are divided into three domestic subcategories whereas the foreign sectors represent foreign countries and multinational and international organizations. These institutional sectors are mutually exclusive and their role in the economy can thus be unequivocally presented. For example, export demand is final demand for domestic goods and services by the foreign sectors.

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.

2.3 An overview of the AGE theory of VATTAGE

2.3.1 Demand for intermediate goods and primary factors

VATTAGE models production as consisting of two broad categories of inputs: intermediate inputs and a primary factor-energy bundle (referred to as the KLE-bundle). Firms are assumed to choose the mix of inputs which minimizes the costs of production for their level of output. They are constrained in their choice of inputs by a three-level nested production technology. At the first level, intermediate-input bundles and primary-factor bundles are used in fixed proportions to output. These bundles are formed at the second level. Intermediate input bundles are combinations of international imported goods and domestic goods. VATTAGE also recognizes two sources for imports, namely, the EU and the rest of the world. The primary-factor bundle is a combination of labor, capital, energy and land. At the third level, the input of labor is formed as a combination of inputs of labor from five different occupational categories. 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.

At the bottom level of the intermediate good nest are the demands for commodities from various sources. The firms decide on their demands for the domestic commodities and the foreign imported commodities under a CES assumption, which amounts to the standard Armington assumption that where domestic commodities are imperfect substitutes to foreign varieties. Figure 2.3 illustrates the structure giving rise to the demand for the composite goods and individual commodities. We use the well-known GTAP-database as a source for the Armington elasticities.

In figure 2.2, an item called other cost tickets is also included. Other costs are costs not related to the use of primary factors or material and energy inputs. In industries with high profitability they often explain profits not directly related to rates of return to capital.

Figure 2.2 Top-level of the input mix

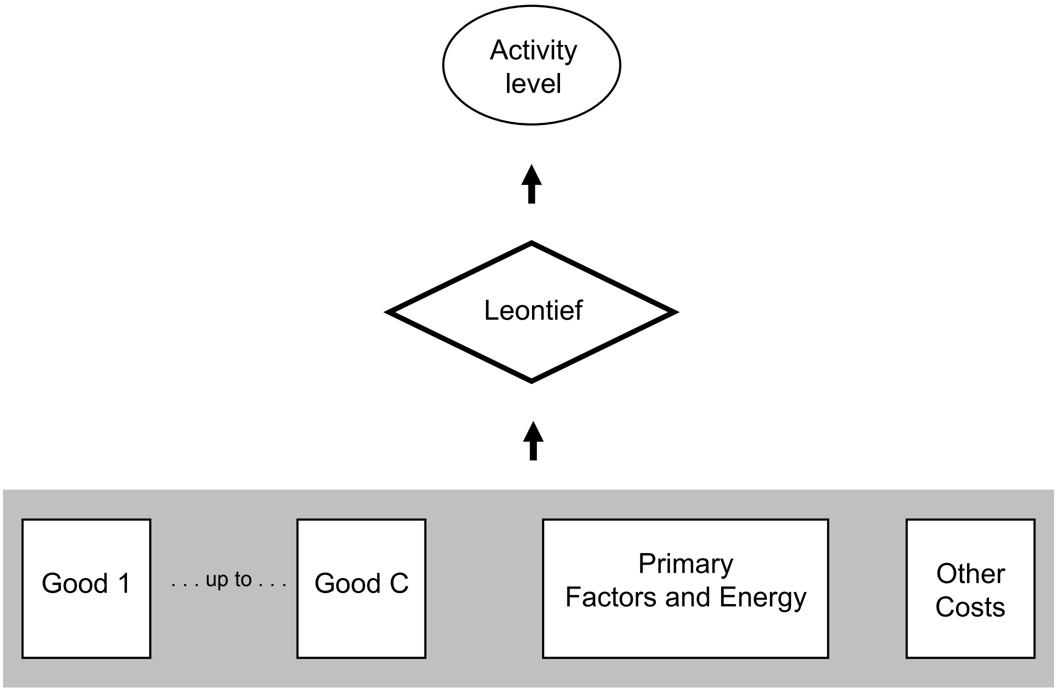
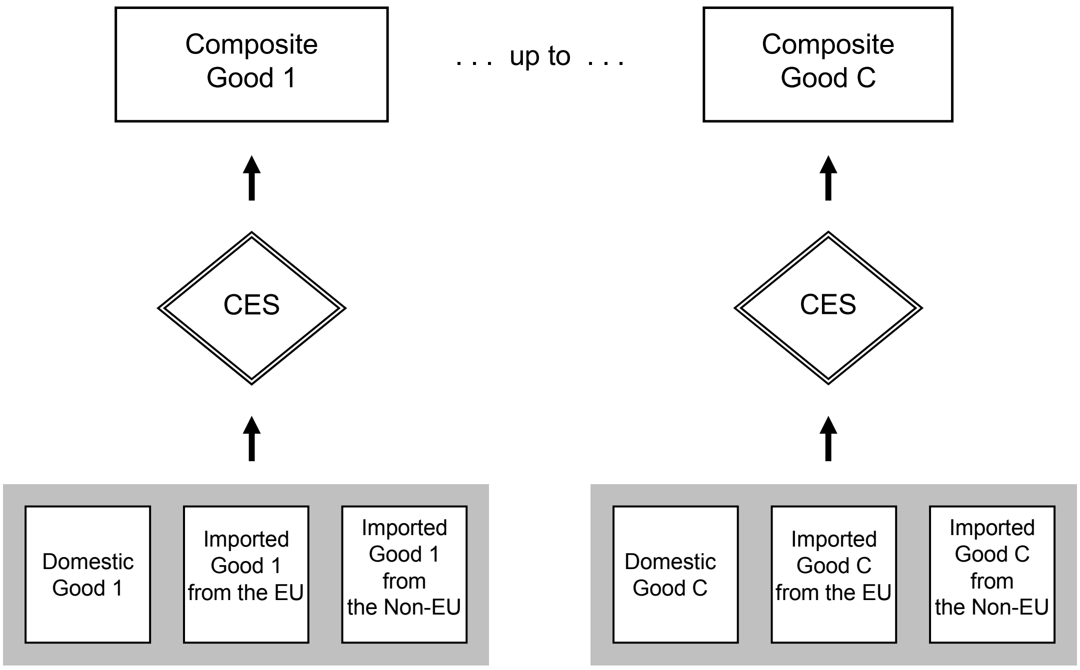
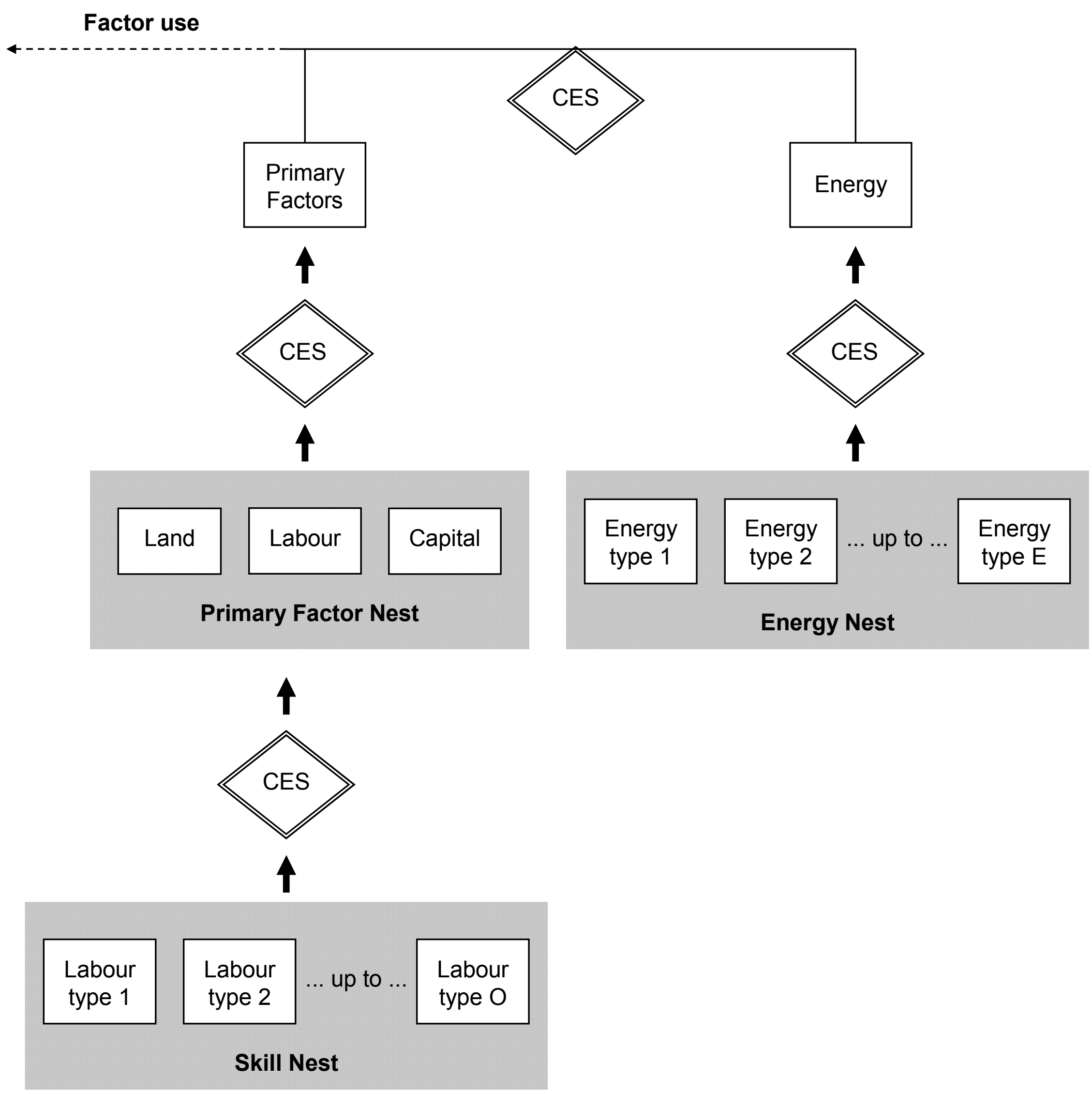


Figure 2.3 The sourcing of inputs in VATTAGE



The demand for primary factors and energy composite are determined by the top nest in figure 2.2. Primary factors and energy are assumed to be combined with energy to form a primary factor-energy nest, often called the KLE-nest, as depicted in figure 2.4 below. The demands for labor of different skills, capital, and energy are derived from this structure. An important characteristic of this structure is that energy and primary factors can be substituted for each other in many industries. Without this assumption, it would be pointless to study the effects of policies involving changes in the relative prices of energy and other inputs over time. At the same time, it is clear the elasticity summarizing this substitutability have a potentially large impact on the model's results. We rely on literature for substitution elasticity. The elasticity of substitution between primary factors has been covered in a number of Finnish studies.

Figure 2.4 The primary factor-energy composite in VATTAGE



2.3.2 Multiproduct industries and multi-industry products

In the VATTAGE database, most products are produced by several industries and many industries also produce multiple products. This is most notably the case for energy products, where several petroleum products stem from refining. An energy-related example of products stemming from several industries is wood and wood residue used for heating and energy production, which can stem from several industries.

The model allows for the possibility that industries are affected by the relative prices of their respective products when deciding their output mix. This decision is modeled as a profit maximization problem under the assumption of CET transformation technologies between possible outputs. In a historical simulation, changes in the mix of output turn out to be important for many industries.

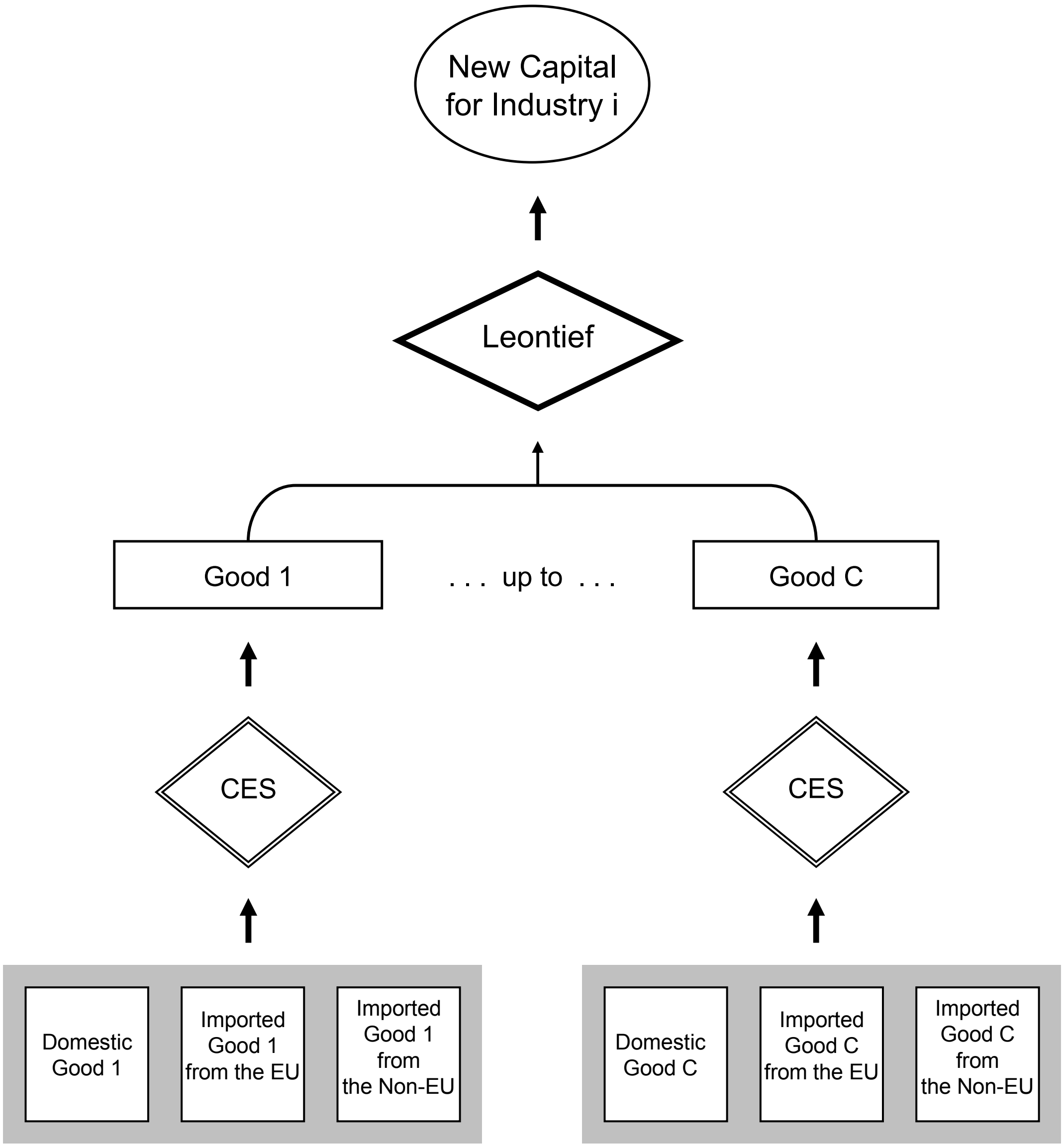
2.3.3 Demands for inputs to capital creation and the determination of investment

VATTAGE follows standard AGE practice in modeling the production of capital goods with an investment sector, whose task it is to combine inputs to form units of capital. In choosing these inputs they minimize costs subject to a Leontief technology. Figure 2.5 shows the nesting structure for the production of new units of fixed capital.

Capital is produced with inputs of domestically produced and imported commodities. No primary factors are used directly as inputs to capital formation. The use of primary factors in capital creation is recognized through inputs of the commodities, for example, construction services.

Where VATTAGE differs from most AGE models is in the description of the capital goods themselves. In VATTAGE, capital is genuinely sector specific, in other words, the commodity inputs for capital to each industry are unique. This means that capital is not malleable but that it will only adjust slowly, over time.

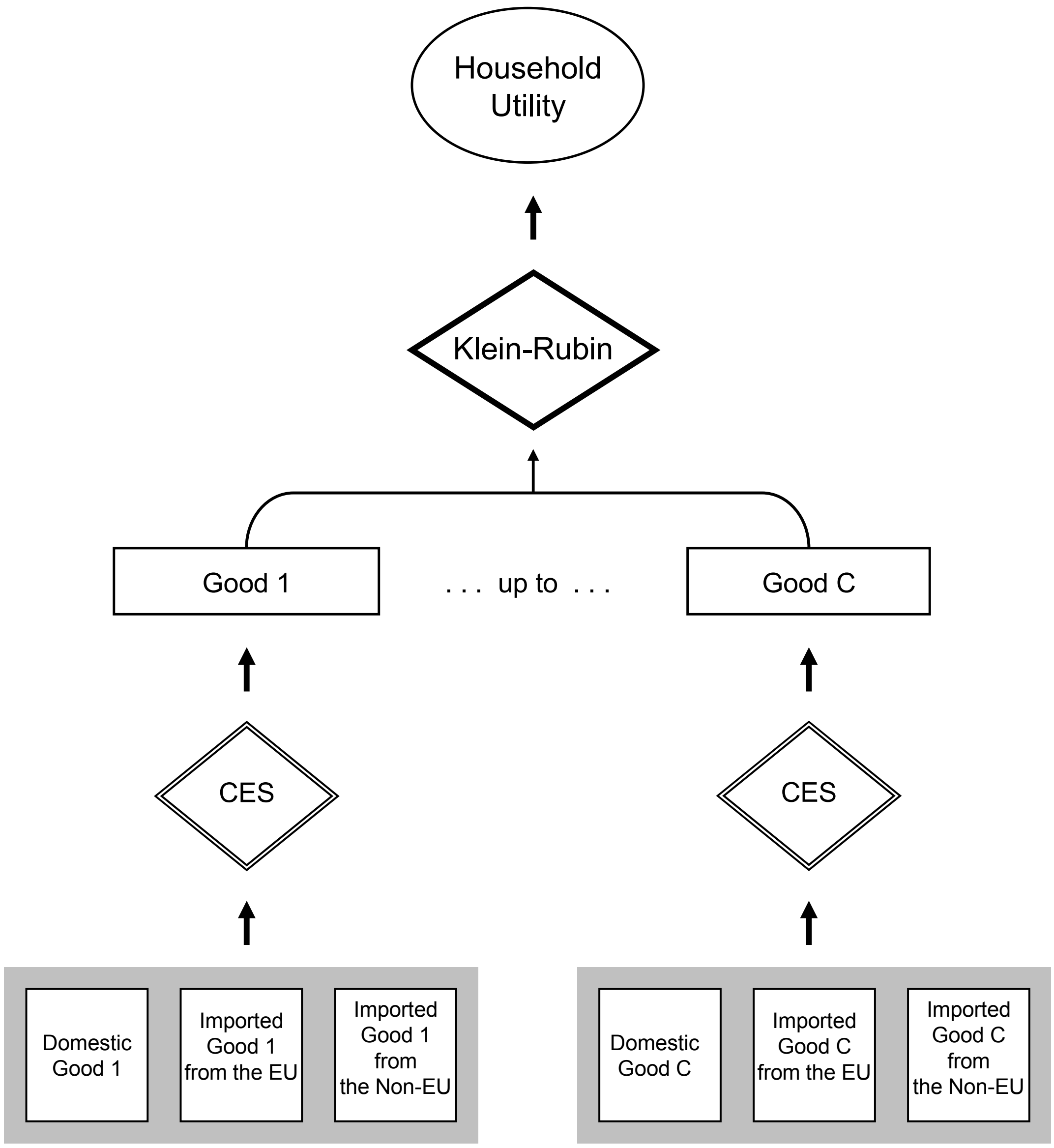
Figure 2.5 Production of investment goods in VATTAGE



2.3.4 Household demand

In VATTAGE, households are assumed to be the recipients of factor incomes. They also possess assets and liabilities abroad and domestically, which implies that a part of domestic incomes will be channeled abroad. A Keynesian consumption function then determines the level of household expenditure as a function of household disposable income, while the demands for individual goods are modeled as a utility maximization problem subject to a household expenditure constraint. Whether we treat the average propensity to consume as constant depends on the application. When the model is used to accommodate an outside forecast for the macro economy, for example, the propensity to consume is endogenous, allowing the model to capture the forecast path of household consumption, whereas in policy applications is usually exogenous. However, there are also instances where outside information on changes in the propensity to consume, stemming from studies of consumption patterns, can be used in the construction of baseline scenarios. The structure of the utility function is shown in figure 2.6.

Figure 2.6 The structure of household demand in VATTAGE



2.3.5 Export demand

Export demand is modeled by price-sensitive export demand functions. However, there are several possibilities to refine this basic set-up in VATTAGE. First, export demands in VATTAGE can be used to distinguish between traditional and collective exports. For traditional export sectors, each export good faces its own downward-sloping foreign demand curve. Thus a shock that improves price competitiveness of an export sector will result in increased export volume, but at a lower world price. The non-traditional, or collective, exports, on the other hand, face a single export demand function, that is, these exports move together. The composition of collective export demand is also exogenous. The distinction between traditional and collective exports can be used to rule out feedbacks from world prices to domestic prices, which may be of relevance for the service sectors. However, most commodities are modeled with the individual export demand functions. Finally, the supply decision to domestic and exports markets can also be modeled as being price dependent on the relative prices in these markets under the assumption of a CET technology.

2.3.6 Government demands for commodities

Commodities are demanded by the government (sectors). There are several ways of handling these demands, including: (i) endogenously, by a rule such as moving government expenditures with household consumption expenditure or with domestic absorption; (ii) endogenously, as an instrument which varies to accommodate an exogenously determined target such as a required level of government deficit; and (iii) exogenously, by assuming they follow forecasts stemming from outside of the model. In VATTAGE baseline simulations, the last assumption is often used, with official estimates of government spending giving the path that government expenditures take.

2.3.7 Indirect taxes and margin demands

In VATTAGE, supply and demand of commodities are determined through optimizing behavior of agents in competitive markets. The assumption of competitive markets implies equality between the producer's price and marginal cost in each regional sector. Demand is assumed to equal supply in all markets. However, indirect taxes and margins affect the purchaser’s prices.

The government imposes ad valorem sales taxes on commodities, income and payroll taxes on labor incomes, and capital taxes on capital income. The government also sets production taxes and collects tariffs from imports. These taxes place wedges between the prices paid by purchasers and prices received by the producers. The model recognizes margin commodities (e.g., retail trade and road transport freight) which are required for each market transaction (the movement of a commodity from the producer to the purchaser). The costs of the margins are included in purchasers' prices.

2.4 An overview of VATTAGE dynamics

VATTAGE is a dynamic model that allows the economy to adjust over time to changes in the economic environment or in policies. The most important determinant of this adjustment process is the accumulation of physical capital via investment or disinvestment, and the accumulation of financial assets over time. However, sluggish wage adjustment can also be specified, and there may be an element of sluggishness in policy responses to changes in employment. This section describes the dynamics in general terms.

An integral part of dynamic applications of VATTAGE is the baseline, or forecast, scenario of the economy. The baseline forms the reference, to which the effects of changes in policies are compared. In most applications, the baseline is formed on the basis of medium term forecasts and long run scenarios of the development of the macro economy that stem from outside of the model. The baseline uses forecasts for industry-specific historical trends in productivity, taste changes and the like that stem from the process of updating the model's database. This latter process in effect ensures that the model traces the development of the economy during the past few years. However, in constructing the baseline, it is also possible to introduce industry-specific expert forecasts for particular industries, a feature that has often been used for the large export industries, for the energy sector, and for the sectors producing public services.

2.4.1 Capital stocks, investment and the inverse-logistic relationship

In each year of year-to-year simulations, we assume that industries' capital growth rates (and thus investment levels) are determined according to functions which specify that investors are willing to supply increased funds to industry j in response to increases in j's expected rate of return. However, investors are cautious. In any year, the capital supply functions in MONASH limit the growth in industry j's capital stock so that disturbances in j's rate of return are eliminated only gradually.

The VATTAGE treatment of capital and investment in year-to-year simulations can be compared with that in models recognizing costs of adjustment. In costs-of-adjustment models, industry i's capital growth (and investment) in any year is limited by the assumption that the costs per unit of installing capital for industry i in year t are positively related to the i's level of investment in year t. In VATTAGE, the level of j's investment in year t has only a negligible effect (via its effects on unit costs in the construction and other capital supplying industries) on the costs per unit of i's capital. Instead of assuming increasing installation costs, we assume that i's capital growth in year t is limited by investor perceptions of risk. In the MONASH theory, investors are willing to allow the rate of capital growth in industry j in year t to move above j's historically normal rate of capital growth only if they expect to be compensated by a rate of return above i's historically normal level.

2.4.2 Asset dynamics

Financial assets – liabilities and deficits – provide another inter-temporal link in VATTAGE. The model recognizes current account deficits, with the related foreign liabilities, and public sector deficits, which in turn are related to government debt. These deficits are described in detail, and the dynamics depicting the accumulation of the related financial assets.

2.4.3 Labor market dynamics

VATTAGE allows for different treatments of the labor markets. The labor market equations relate population and population of working age, and define unemployment rates in terms of demand and supply of labor.

In dynamic simulations, labor supply is typically taken as exogenous, while wages adjust only gradually and unemployment is determined endogenously.

VATTAGE allows for different specifications of the labor markets. In a dynamic setting, it is not unreasonable to assume that there is an element of sluggishness in real wage adjustment. In Finland, this was very much the case until very recently, when wage setting has become more decentralized. The basic set-up of VATTAGE captures the idea that wage setting may be centralized.

2.4.4 Government finances

VATTAGE contains a detailed database on indirect taxes, payroll taxes and income taxes. Indirect taxes on commodities are modeled as *ad valorem* rates of tax levied on the basic price of the underlying flow. The basic price is the price received by the producer. VATTAGE allows for differentiation of indirect taxes to environmental taxes and other taxes for certain commodities. Production taxes are modeled as part of value added, while payroll taxes are directly levied on wages. Income taxes are levied on labor and capital incomes. Finally, import duties are levied as ad valorem taxes on imports.

VATTAGE includes revenue equations for income taxes, sales taxes, and excise taxes, taxes on international trade and for receipts from government-owned assets. As described already, the model accounts for public expenditures on commodities (or services). It also contains outlay equations for transfer payments to households (e.g., pensions, sickness benefits and unemployment benefits). The specification in VATTAGE of government finances makes the model a suitable tool for analyzing the effects of changes in the fiscal policies.

2.5 Closures and condensation instructions

In dynamic mode, VATTAGE contains hundreds of thousands of equations. It is not practical to solve directly equations systems of this size. The problem is made manageable in two ways: by omitting arrays of exogenous variables that are not shocked and by substituting out arrays of endogenous variables that are not of interest. The arrays that are targeted for these treatments typically have large numbers of components.

An example of an array that is usually omitted is

fa1mar (c, s, i, m) for c∈COM, s∈SOURCE, i∈IND and m∈MAR.

This is an array of technical change shifters concerned with the usage of margin commodity m to facilitate the flow of commodity c from source s to industry i for the purpose of current production. The array is occasionally useful in simulating technical changes but in most applications it is set exogenously on zero. Thus, in most applications it can be deleted. Alternatively, if fa1mar (c, s, i, m) is endogenous, it can be substituted out, which means that it is replaced by the variables determining it in equation

E_fa1mar (c, s, i, m) in the model code.

The concept of closure is central to simulations performed with GEMPACK. By closure we mean the specification of variables as exogenous and endogenous. The need for a closure specification arises from several reasons. First, VATTAGE does not contain explicit equations for all of its variables. For example, shifts in technology or tastes are typically treated as exogenous. Secondly, closure changes provide a practical way of modifying the model to suit to specific applications.

The concept of closure can be illustrated by considering the solution to the model. For each year, the solution takes the form

$$F(X) = 0$$

Where F is an m-vector of differentiable functions of n variables X, and $n>m$ The variables X include prices and quantities applying for a given year and the m equations impose the usual AGE conditions such as: demands equal supplies; demands and supplies reflect utility and profit maximizing behavior; prices equal unit costs; and end-year capital stocks equal depreciated opening capital stocks plus investment. It is important to realize that there always exists a solution ($X_{initial}$) derived mainly from input-output data for a particular year. In simulations we compute the movements in *m* variables (the endogenous variables) away from their values in the initial solution caused by movements in the remaining *n* – *m* variables (the exogenous variables) away from their values in the initial solution. By closure we mean 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.

VATTAGE recognizes four types of closures:

- decomposition closure,
- historical closure,
- forecasting closure and
- Policy closure

In a decomposition closure, we include in the exogenous set all naturally exogenous variables that are variables not normally explained in an AGE model. These may be observable variables, such as tax rates, or unobservable, such as technology and preference variables.

Historical closures include in their exogenous set two types of variables: observables and assignable. 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.

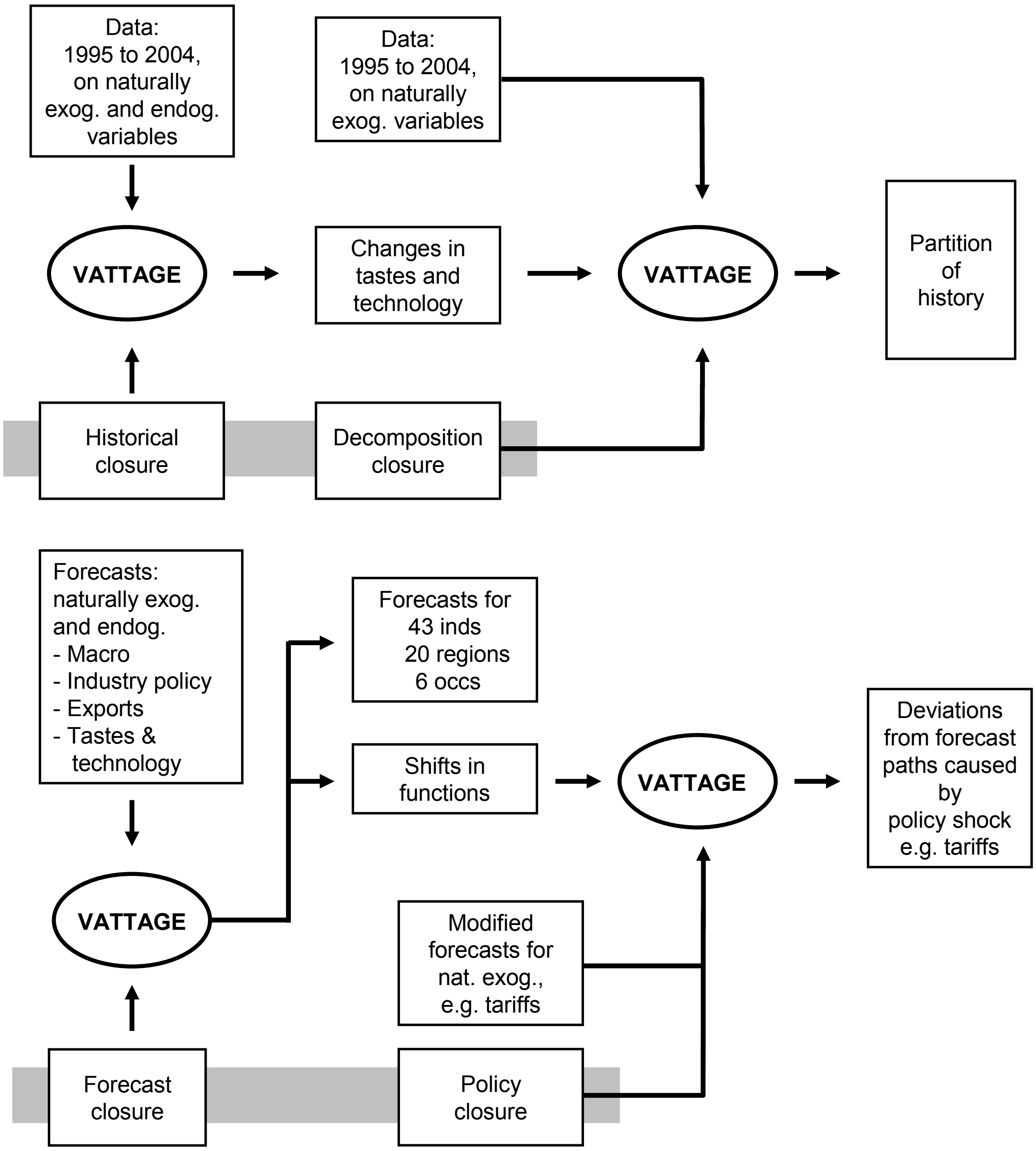
Forecasting closures are close in philosophy to historical closures. Instead of exogenising everything that is known about the past, in forecasting closures we exogenise everything that we think we know about the future. Thus in forecasts, we exogenise numerous naturally endogenous variables, including, for example, export volumes (where outside forecasts or scenarios are available), and most macro variables (where medium and long term forecasts prepared by ministries or the EU can be used). To allow these variables to be exogenous, a number of naturally exogenous variables need to be endogenised, for example the positions of foreign demand curves, the positions of domestic export supply curves, and many macro coefficients such as the average propensity to consume.

Policy closures are similar to the decomposition closures. In policy closures naturally endogenous variables, such as exports and macro variables, are endogenous, since they must be allowed to respond to the policy change under consideration. Correspondingly, in policy closures naturally exogenous variables, such as the positions of foreign demand curves, the positions of domestic export supply curves and macroeconomic coefficients, are exogenous, and are set at the values that they have in the forecasts.

The relationship between forecasting and policy simulations is similar to that between historical and decomposition simulations. Historical simulations provide values for exogenous variables in corresponding decomposition simulations. Similarly, forecasting simulations provide values for exogenous variables in corresponding policy simulations. However there is one key difference between the relationships. An historical simulation and the corresponding decomposition simulation produce the same solution. This is because all the exogenous variables in the decomposition simulation have the values they had (either endogenously or exogenously) in the historical solution. In a policy simulation, most, but not all, of the exogenous variables have the values they had in the associated forecast solution. The policy variables of interest are set at values that are different from those they had in the forecasts. Thus policy simulations generate deviations from forecasts.

The relationship between the forecast and policy simulations is illustrated in figure 2.7.

Figure 2.7 Historical and Decomposition Simulations

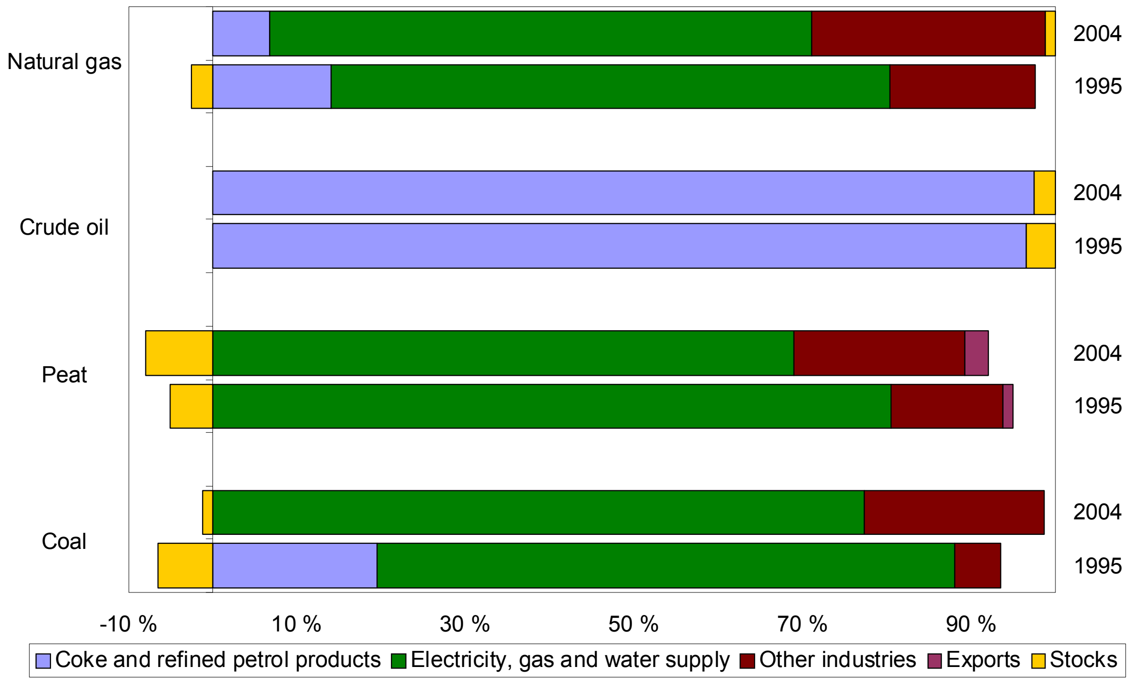


3. Changes in energy use and energy taxes from 1995 to 2004

This chapter 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 deeply 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*



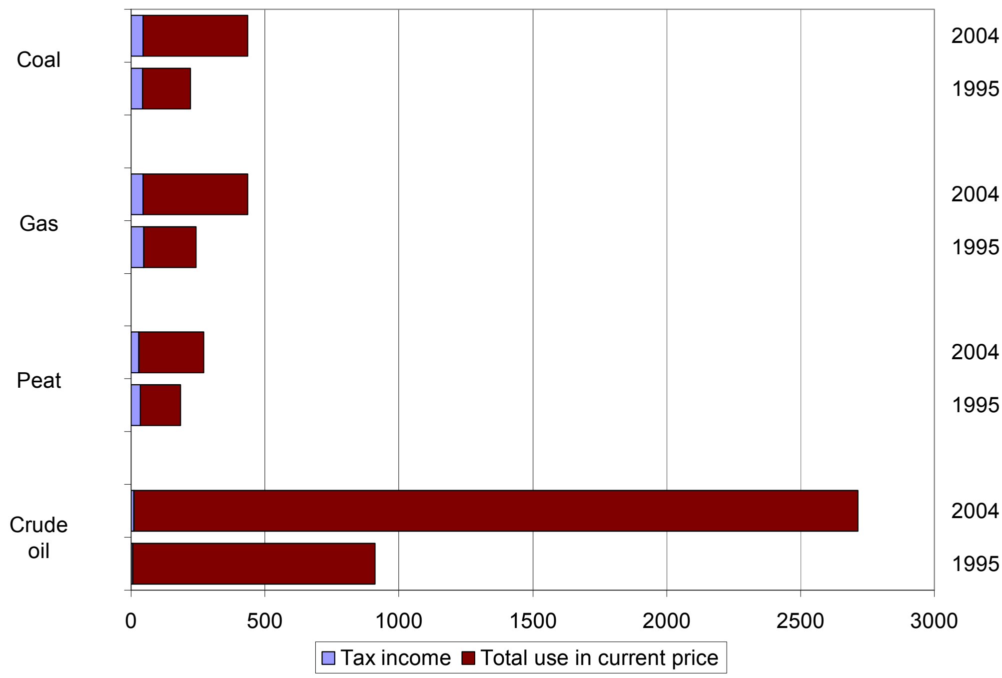
Finnish energy taxation was fundamentally revised in 1997. Whereas the old energy tax law put the taxes directly on the use of fuels (to which we count solid fossil energy carriers as well), the new law exempted electricity generation from fuel taxes but introduced a tax on electricity in its stead. 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. For the 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 applies, but the unit taxes have been revised several times since then. Table 3.1 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
1.1.1998	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 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 nor the kerosene used in airplanes was liable to taxation, nor methane, liquid gas and petrol used in shipping. 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 taxes 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.

Table 3.2 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
1.1.1998	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

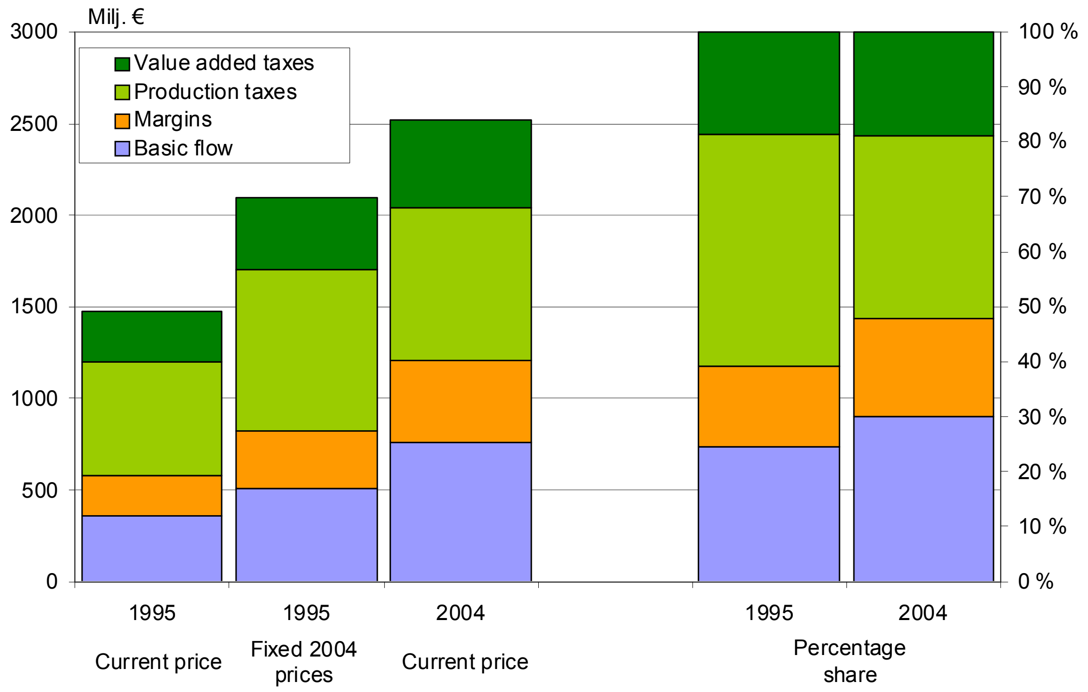
* Fee is doubled if the vessel has a single bottom.

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

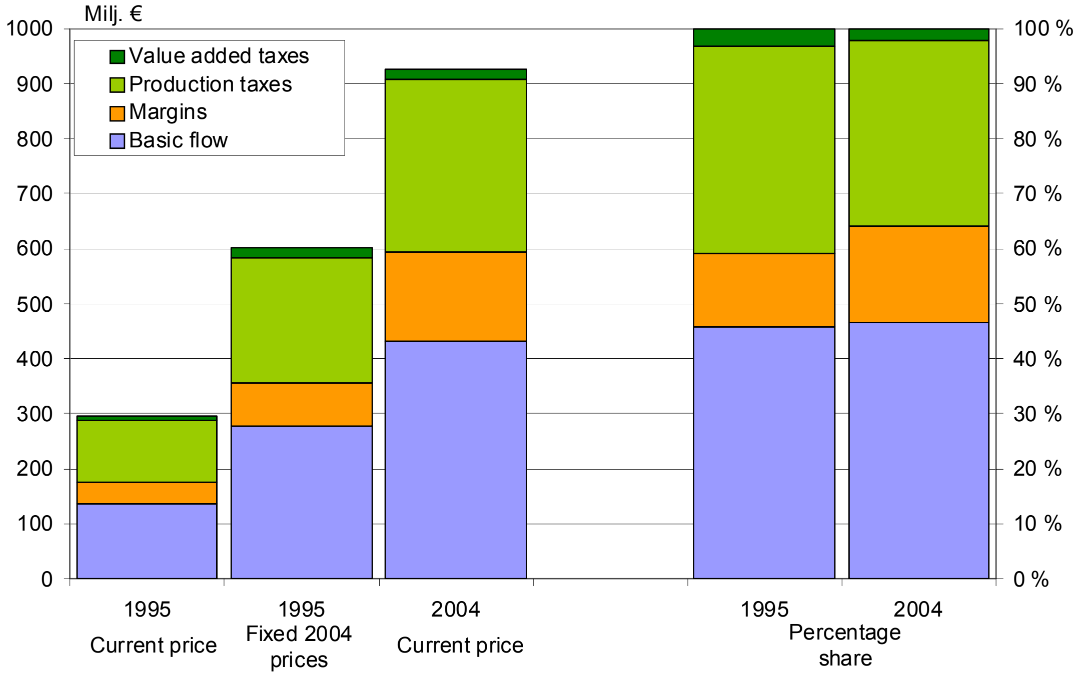
Figure 3.3 shows that the value of household consumption of petrol has increased by almost a half from 1995 to 2004. Again, the figure shows clearly that the effective share of taxes has decreased rather than increased.

Figure 3.3 *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 neither but quite so much as with petrol. This may due to the fact that the 1997 CO2-tax is heavier for diesel than for petrol.

Figure 3.5 Household consumption of diesel oil, percentage shares in purchaser value (left-hand scale) and total use in fixed and current value (right-hand scale).

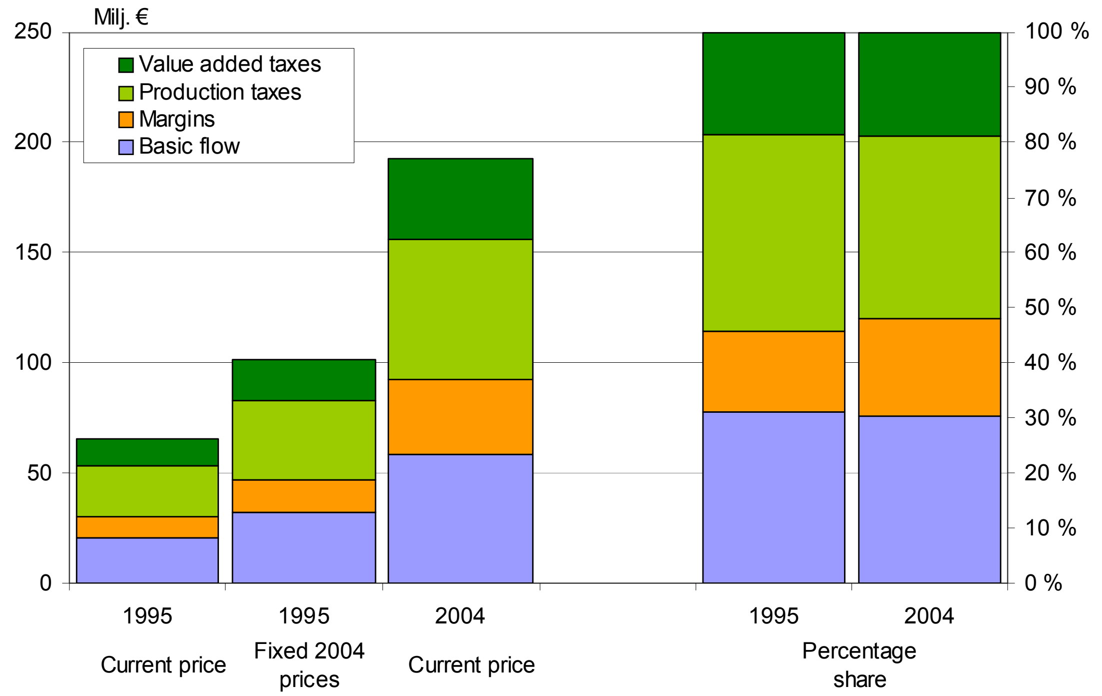
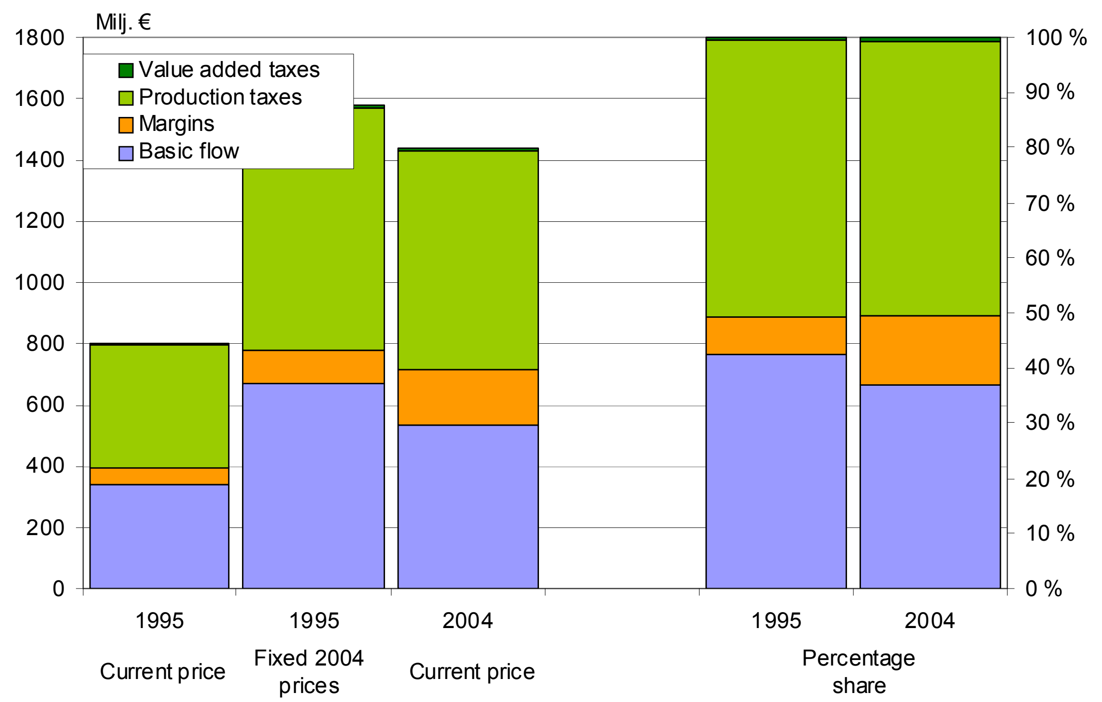


Figure 3.6 Intermediate use of diesel oils, percentage share of purchaser price (left-hand scale) and total use in fixed and current value (right-hand side).



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 clears 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).

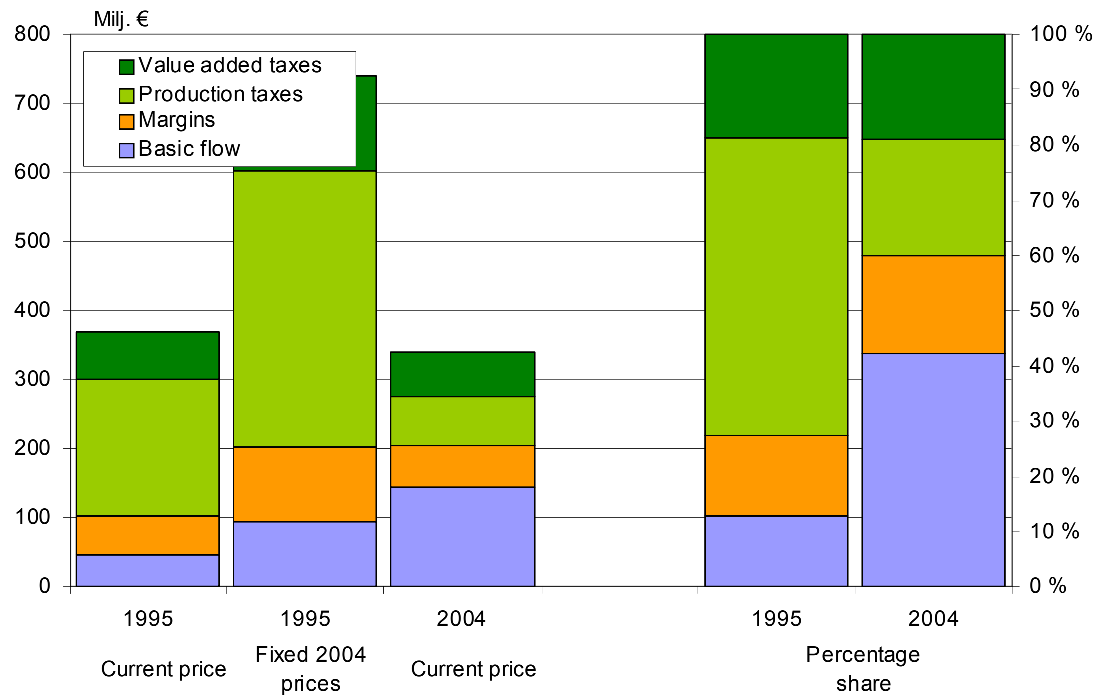
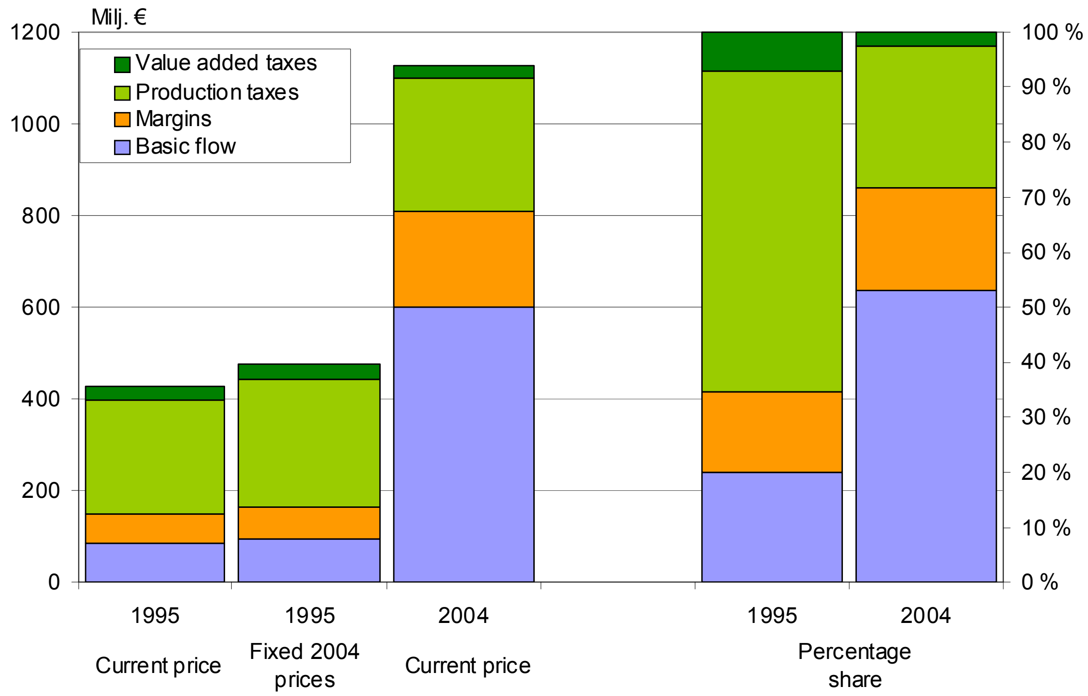


Figure 3.8 *Intermediate use of light fuel oils, percentage share of purchaser price (left-hand scale) and total use in fixed and current value (right-hand side).*



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).

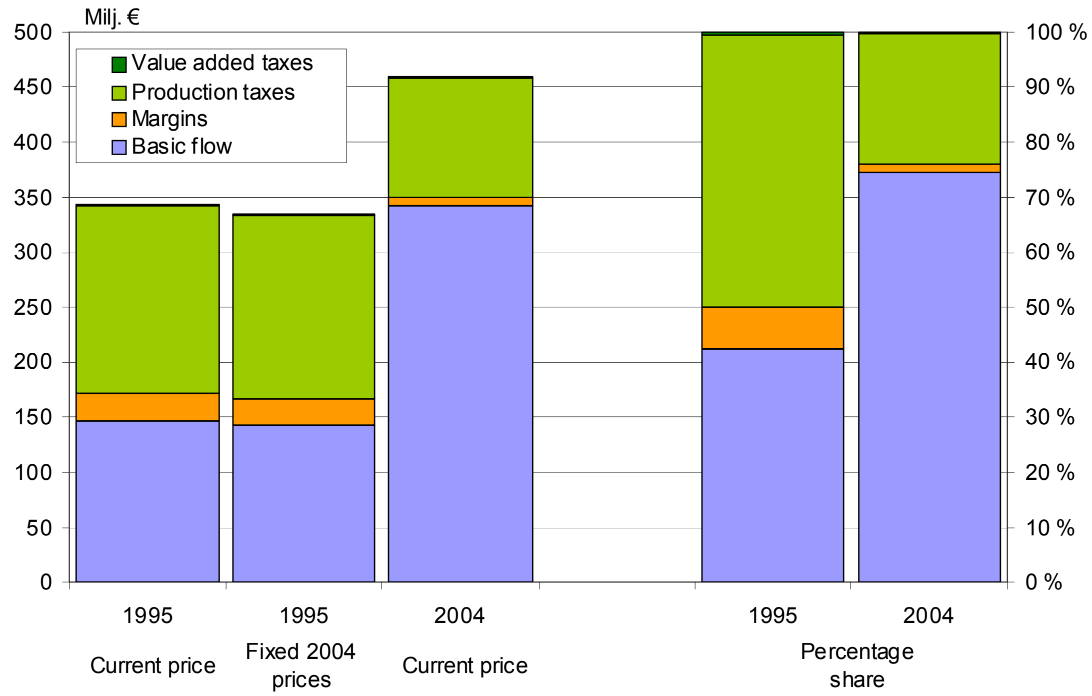


Table 3.4 shows the changes in electricity taxes from 1995 to 2004. As noted earlier, the energy tax law adopted in 1997 was the most important energy tax revision during the period. Whereas the 1994 taxation was based on inputs used in electricity generation, the 1997 tax reform put the tax on electricity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

Table 3.4 Revisions in electricity taxation

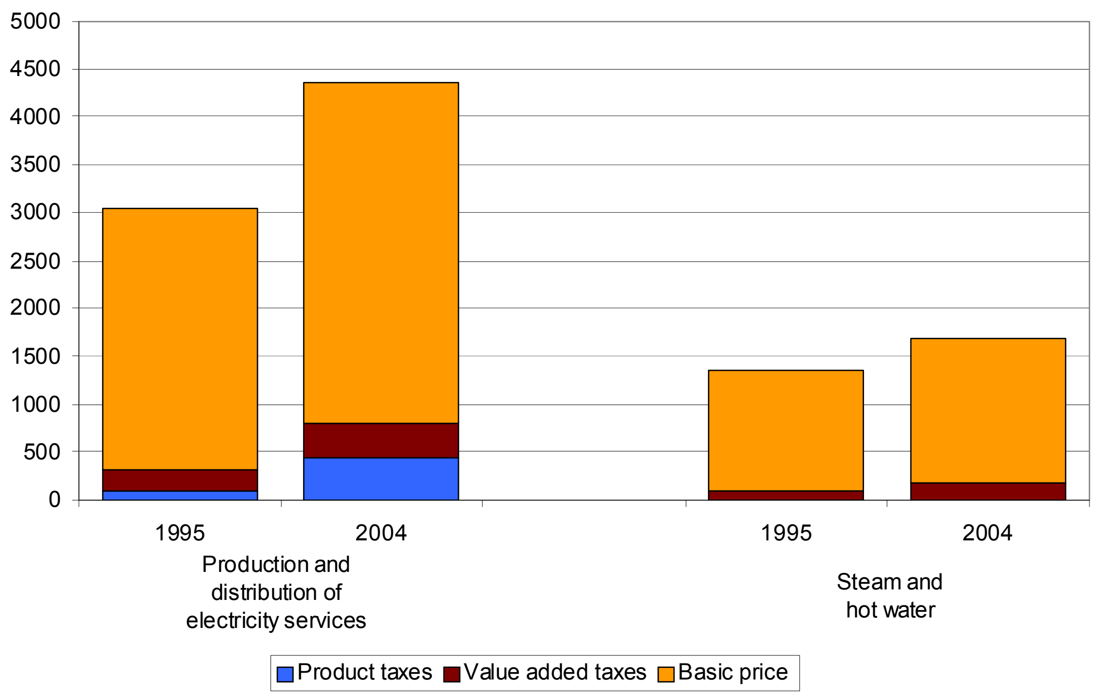
Date of imposition	Use*		Supply		
	Electricity I c/kWh	Electricity II c/kWh	Nuclear power c/kWh	Hydropower c/kWh	Import c/kWh
1.1.1995	–	–	0,4	0,07	0,37
1.1.1996	–	–	0,4	0,07	0,37
1.1.1997	0,4	0,4	–	–	–
1.4.1997	0,56	0,24	–	–	–
1.1.1998	0,56	0,34	–	–	–
1.9.1998	0,69	0,42	–	–	–
1.1.2003	0,73	0,44	–	–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

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

The 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.

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 2000). 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 labor 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 analyzed 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 three types of taxes; product taxes, product subsidies and value added taxes. Also tariffs are included. This column is important for analyzing 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/labor ratio and shifts in export technology.

The sixth set includes taste changes within the household utility function. In the historical simulation, price and volume changes 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 macroeconomic 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 an 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 labor 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.

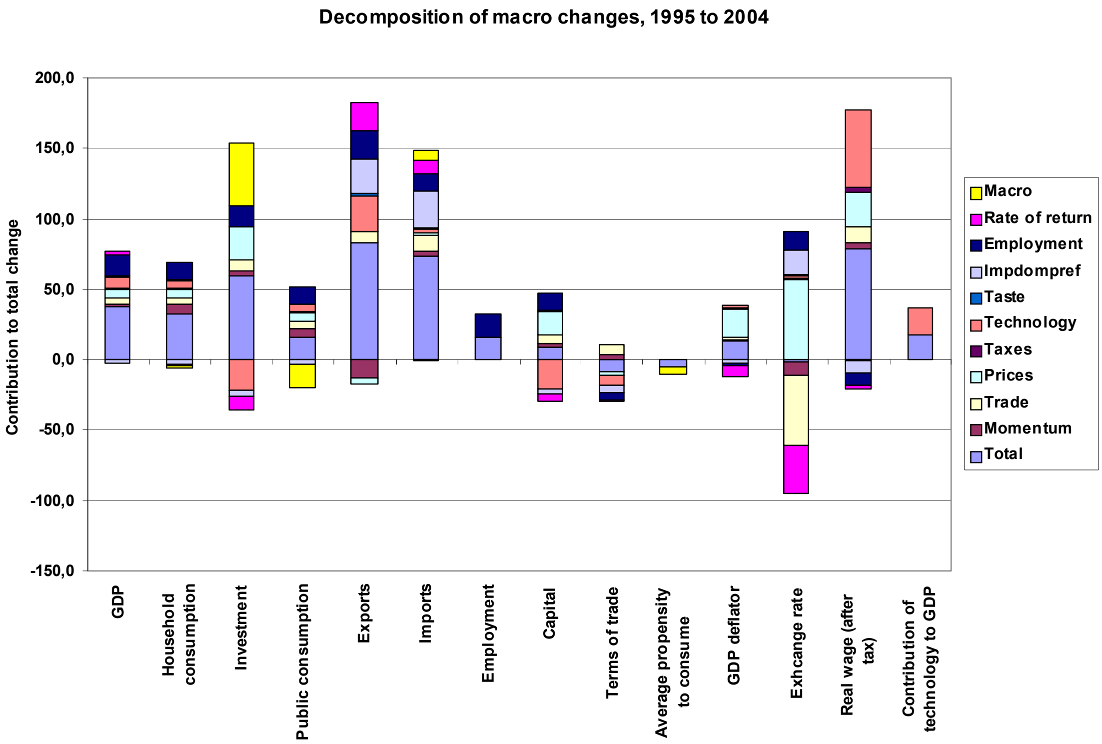
At the same time, imports of intermediate goods also increased rapidly, benefiting from falling prices elsewhere. There was a trade-favoring shift also in household demand, which shows up both in exports and in the rapid growth of imports. These changes are captured by the overall price changes given 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	Momentun	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 con	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 4.2 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 4.2 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	Momentun	Trade	Prices	Taxes	Technolog	Taste	Impdompre	Employ	Rate of ret	Macro
Agriculture	-10,0	-1,6	-12,2	7,8	-3,5	-17,0	0,2	11,2	9,1	-3,8	-0,1
Forestry	36,7	-14,0	-44,9	6,4	-1,4	29,4	6,3	42,9	27,8	-22,7	7,1
Extraction of peat	6,0	-17,8	-127,7	44,0	4,2	-9,6	3,4	14,2	43,9	50,9	0,4
Mining and quarrying	18,2	-5,2	4,2	-6,0	-1,2	1,6	0,7	-25,3	14,0	27,8	7,7
Food products	25,3	0,1	-4,1	5,1	0,3	31,0	-3,6	-16,9	10,1	4,0	-0,8
Textiles	-22,6	-7,5	-34,7	7,2	-1,9	-5,1	-0,3	-36,6	18,8	36,4	1,2
Wood products	107,3	-7,7	-36,7	-16,2	-2,2	108,7	0,8	20,9	21,8	7,6	10,3
Newsprint	12,7	-7,7	-35,6	-17,0	-1,9	45,1	1,6	13,8	13,4	1,0	-0,1
Fineprint	59,8	-12,4	-5,4	-2,1	0,4	84,2	1,7	21,6	21,9	-50,6	0,4
Pulp and other paper products	23,7	-8,4	-44,4	-17,7	0,2	16,8	1,0	9,2	14,6	52,2	0,2
Paperboard	4,2	-5,8	-37,9	2,7	-0,6	12,7	0,3	4,1	15,2	13,3	0,3
Publishing and printing	20,3	2,4	4,3	1,9	-0,5	4,9	10,5	-15,3	14,2	-1,0	-1,0
Refined petroleum products	-60,6	1,4	92,7	-23,7	4,3	-123,8	1,9	-14,9	3,0	-1,6	0,0
Chemicals and chemical prod	33,5	-9,5	1,3	-5,1	6,0	55,9	1,5	-10,6	19,0	-25,2	0,3
Rubber and plastic products	51,5	-7,8	5,1	3,5	-0,2	1,0	1,0	3,5	21,9	18,3	5,3
Non-metallic mineral products	44,3	-1,0	9,6	6,8	-1,3	29,2	-0,7	0,4	16,0	-31,6	16,9
Basic iron and steel and of fe	74,0	-2,7	52,6	-56,4	1,9	7,1	0,5	-51,7	6,4	112,9	3,2
Basic metals n.e.c.	53,3	0,1	9,3	-67,6	-6,4	-8,5	-0,1	-71,9	0,9	196,0	1,4
Fabricated metal products	80,6	-9,3	-6,0	5,7	-2,9	36,7	0,5	-2,2	24,2	20,6	13,1
Machinery and equipment n.e	33,2	-16,6	-47,9	30,3	-1,1	1,8	1,3	9,8	29,5	19,1	7,0

Table 4.4 Aggregate energy use by industries

	Total	Momentun	Trade	Prices	Taxes	Technolog	Taste	Impdompre	Employ	Rate of ret	Macro
Electrical and optical equipme	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 sup	-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 buildi	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, ro	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 p	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 trans	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 busin	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 spo	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. Electricity 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 the 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	Technology	Taste	Impdompre	Employ	Rate of retu	Macro
Wood	13,1	-8,7	-29,0	-7,3	-1,1	10,3	4,7	20,5	19,3	-2,0	6,4
Coal	37,8	8,1	26,9	-34,4	11,1	16,4	1,4	-50,2	11,0	45,8	1,7
Peat	21,8	-14,4	0,2	52,7	5,9	-85,7	3,4	6,2	40,6	12,4	0,5
Crude oil	178,6	13,1	119,0	-128,6	17,1	210,1	7,1	-77,9	3,0	15,6	0,1
Natural gas	257,3	9,2	19,1	-58,0	9,4	274,5	1,6	-43,3	7,5	36,0	1,4
Petrol	25,0	-3,9	10,3	-25,0	-1,1	-10,4	0,5	-28,7	10,7	67,1	5,6
Diesel oil	-0,4	5,9	1,4	7,0	10,0	30,6	2,3	-10,1	4,5	-51,4	-0,5
Light fuel oil	-23,1	0,9	13,0	-14,8	-2,0	-68,4	3,0	-6,2	11,2	39,6	0,6
Heavy fuel oil	-21,8	2,0	-16,1	2,4	-22,4	9,5	7,6	-6,1	9,8	-8,3	-0,3
Other oil products	46,3	-5,1	-24,0	9,6	84,5	-23,4	-7,2	4,2	20,7	-13,9	0,8
Electricity	11,0	1,5	13,5	-7,5	-11,7	-13,7	1,5	7,0	9,8	9,9	0,7
Electricity,distribution	9,7	-2,4	1,5	13,4	1,6	-9,3	1,7	-6,4	15,7	-6,0	0,0
Steam and hot water supply services	15,0	0,5	1,1	6,8	-0,2	3,3	1,5	-0,6	13,5	-9,7	-1,2

Figure 4.2 summarizes 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*

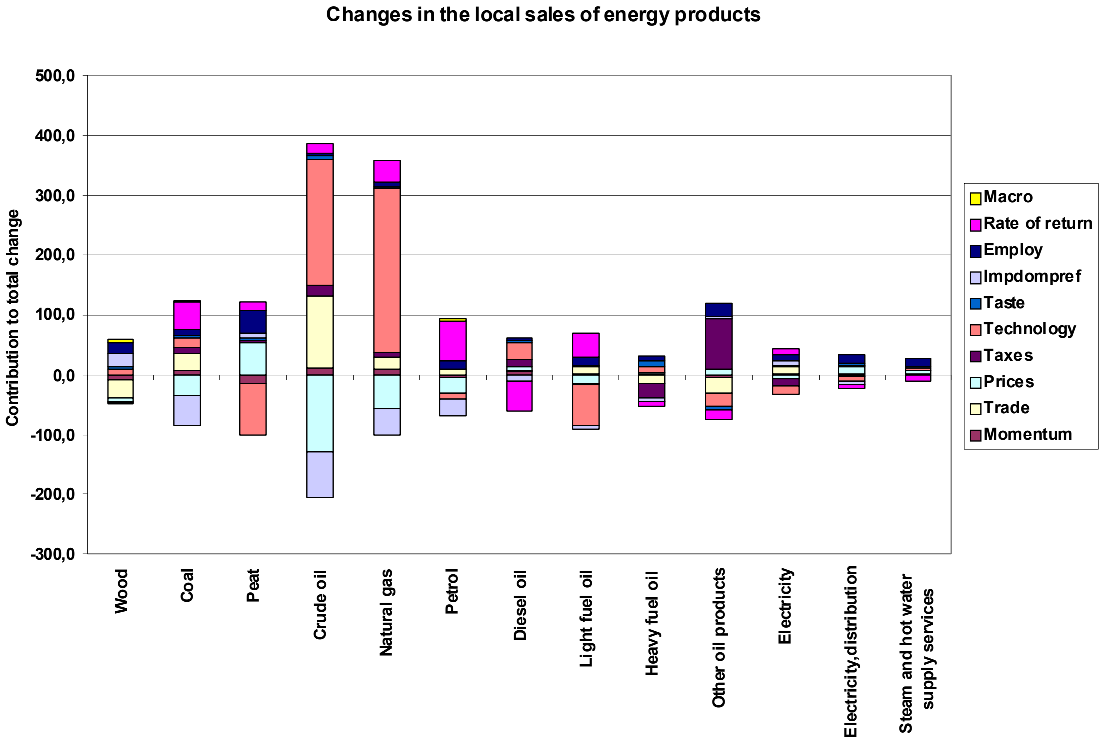
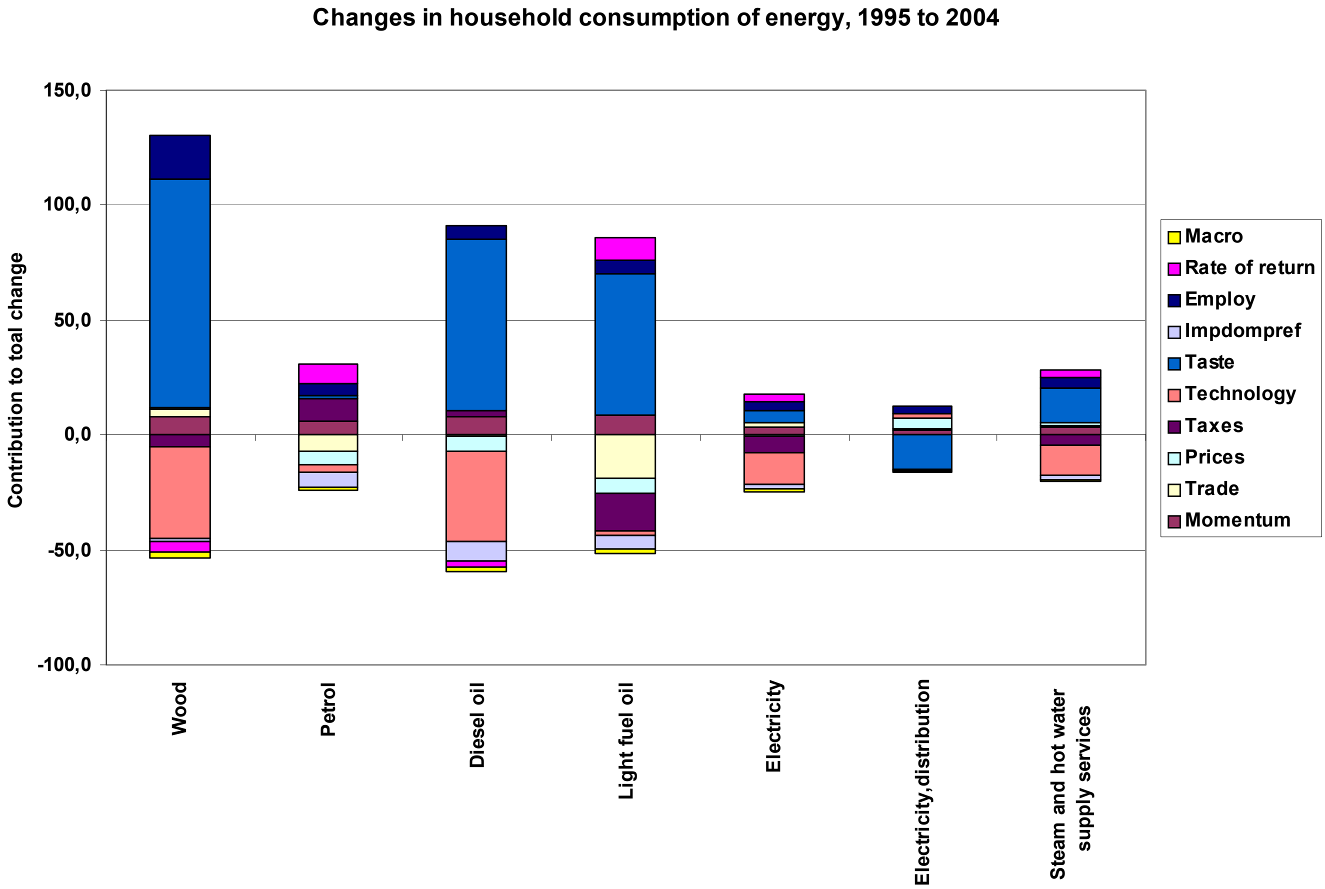


Table 4.6 reports the changes in household demand for energy. The demand for almost all energy except electricity has risen from 1995 on, driven by employment growth, and, more significantly, by changes in consumption patterns. Here, the effects of two of the changes of the 1997 energy tax law can clearly 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 favor 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 4.6 *Household demand for energy*

	Total	Momentum	Trade	Prices	Taxes	Technology	Taste	Impdompre	Employ	Rate of ret	Macro
Wood	76,5	8,0	2,9	1,0	-5,4	-39,3	99,5	-1,3	18,8	-5,1	-2,8
Petrol	6,4	6,3	-7,3	-5,4	9,6	-3,9	1,3	-6,3	5,2	8,2	-1,3
Diesel oil	31,5	8,3	-0,6	-6,7	2,5	-39,0	74,3	-8,4	6,0	-2,8	-2,0
Light fuel oil	34,3	8,4	-19,2	-6,2	-16,6	-1,7	61,4	-6,1	6,4	9,6	-1,8
Electricity	-6,5	3,7	2,0	-0,5	-7,1	-13,8	4,7	-2,3	3,9	3,8	-0,9
Electricity,distribution	-3,8	1,9	1,1	4,4	0,1	1,9	-14,8	-0,9	3,0	0,0	-0,5
Steam and hot water supply s	7,7	3,1	1,0	1,0	-4,3	-13,3	15,5	-2,1	4,5	3,1	-0,8

Figure 4.3 *Household demands 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 rates 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.

References

Dixon P. – Rimmer M. (2002): Dynamic General Equilibrium Modelling for Forecasting and Policy. Contributions to Economic Analysis 256 North-Holland Publishing Company, Amsterdam.

Dixon P. – Rimmer M. (1999): Changes in Indirect Taxes in Australia: A Dynamic General Equilibrium Analysis, The Australian Economic Review, vol 32., no.4, pp. 327–48.

Euro stat (1997): European System of National Accounts, ESA95. Eurostat, Brussels -Luxenbourg, 1996, in Finnish 1997, available at: http://circa.europa.eu/irc/dsis/nfaccount/info/data/ESA95/en/titelen.htm.

Giesecke J. (2004): The Extent and Consequences of Recent Structural Changes in the Australian Economy: 1997–2002: results from Historical/Decomposition simulations with Monash, General Working Paper No. G-151, Centre of Policy Studies, Monash University, Melbourne, available at: http://www.monash.edu.au/policy/ftp/workpapr/g-151.pdf.

Harrison J.W. – Horridge, J.M. – Pearson K.R. (2000): Decomposing Simulation Results with Respect to Exogenous Shocks. Computational Economics, Volume 15, 227 - 249.

Honkatukia J (2009): VATTAGE – A Dynamic, Applied General Equilibrium Model for the Finnish Economy, VATT Research Reports 150, July 2009, Helsinki, available at: http://www.vatt.fi/file/vatt_publication_pdf/t150.pdf.

VATT TUTKIMUKSET -SARJASSA ILMESTYNEITÄ
PUBLISHED VATT RESEARCH REPORTS

150. Honkatukia Juha: VATTAGE – A dynamic, applied general equilibrium model of the Finnish economy. Helsinki 2009.

151. Räty Tarmo: Julkaisujen vaativuus tieteenaloittain. Helsinki 2009.

143:3. Perrels Adriaan – Nissinen Ari – Sahari Anna: Reviewing key building blocks of an integrated carbon footprinting and consumer purchases' monitoring & reward system – interaction with the consumer. Climate Bonus project report (WP4). Helsinki 2009.

143:4. Hyvönen Kaarina – Saastamoinen Mika – Timonen Päivi – Kallio Arto – Hongisto Mikko – Melin Magnus – Södergård Caj – Perrels Adriaan: Kuluttajien näkemyksiä kotitalouden ilmastovaikutusten seuranta- ja palautejärjestelmästä. Climate Bonus -hankeraportti (WP5). Helsinki 2009.

143:2. Usva Kirsi – Hongisto Mikko – Saarinen Merja – Nissinen Ari – Katajajuuri Juha-Matti – Perrels Adriaan – Nurmi Pauliina – Kurppa Sirpa – Koskela Sirkka: Towards certified carbon footprints of products – a road map for data production. Climate Bonus project report (WP3). Helsinki 2009.

152. Kirjavainen Tanja – Kangasharju Aki – Aaltonen Juho: Hovioikeuksien käsittelyaikojen erot ja aluerakenne. Helsinki 2009.

153. Kari Seppo – Kerkelä Leena: Oman pääoman tuoton vähennyskelpoisuus yritysverotuksessa – Belgian malli. Helsinki 2009.

143:5. Perrels Adriaan – Nissinen Ari – Sahari Anna: The overall economic and environmental effectiveness of a combined carbon footprinting and feedback system. Climate Bonus project report (WP6). Helsinki 2009.

154. Honkatukia Juha – Ahokas Jussi – Marttila Kimmo: Työvoiman tarve Suomen taloudessa vuosina 2010–2025. Helsinki 2010.

155. Junka Teuvo: Valtionyhtiöt 1975–2008. Helsinki 2010.

156. Harju Jarkko – Kari Seppo: Yritysveropohjan harmonisoimisen vaikutus Suomen yhteisöverotuottoon. Helsinki 2010.

157. Riihelä Marja – Sullström Risto – Tuomala Matti: Trends in top income shares in Finland 1966–2007. Helsinki 2010.

158. Perrels Adriaan – Veijalainen Noora – Jylhä Kirsti – Aaltonen Juha – Molarius Riitta – Porthin Markus – Silander Jari – Rosqvist Tony – Tuovinen Tarja: The implications of climate change for extreme weather events and their socio-economic consequences in Finland. Helsinki 2010.

159. Kangasharju Aki – Pääkkönen Jenni: Mainettaan parempi tuottavuusohjelma? Katsaus valtion virastojen ja laitosten työn tuottavuuteen ja työhyvinvointiin. Helsinki 2010.

160. Kangasharju Aki – Mikkola Teija – Mänttäri Tuomas – Tyni Tero – Valta Maija: Vaikuttavuuden huomioon ottava tuottavuus vanhuspalveluissa. Helsinki 2010.

161. Ahokas Jussi – Honkatukia Juha: Politiikkatoimien vaikutukset työvoiman tarpeeseen Suomen taloudessa 2010–2025. Helsinki 2010.

VALTION TALOUDELLINEN TUTKIMUSKESKUS
STATENS EKONOMISKA FORSKNINGSCENTRAL
GOVERNMENT INSTITUTE FOR ECONOMIC RESEARCH

Valtion taloudellinen tutkimuskeskus
Government Institute for Economic Research
P.O.Box 1279
FI-00101 Helsinki
Finland

ISBN 978-951-561-961-7
ISSN 0788-5008