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Abstract:
Welfare analysis of energy taxes typically shows that systems with uniform rates perform better than differentiated systems. However, most western countries include some exemptions for their energy-intensive export industry, and hence, avoid this potential welfare gain. Böhringer and Rutherford (1997) find that compared to a differentiated system, uniform taxation in combination with a wage subsidy preserve jobs in these industries at a fraction of the potential welfare gain in the German economy. This result holds in this Norwegian study where a more broad based subsidy scheme, represented by production dependent subsidies, is used to protect jobs in the Norwegian energy-intensive industry. However, the welfare cost per job preserved by this subsidy scheme amounts to about 60 percent of the wage cost per job, suggesting that these jobs are expensive to preserve.

Keywords: Energy taxes, Political feasibility, Competitiveness, CGE models

JEL classification: F41, H21, Q43, Q48

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1. Introduction

Though discriminatory energy taxation may to some degree be legitimized for welfare reasons (see e.g. Richter and Schneider, 2003), most of the empirical literature find that the existing exemptions and tax rebates tend to be costly compared to uniform systems (Ballard and Shoven, 1987, Böhringer and Rutherford, 1997, Bye and Nyborg, 2003). In spite of these findings, several countries have exempted, energy-intensive export industries from energy taxation; see OECD (1995). The potential loss of competitiveness, and hence down scaling of industry, create a political pressure aimed at preserving these exemptions. Studies of the tradeoff between overall economic efficiency and political pressure aimed at preserving the energy industry, find that a modest share of the welfare gain generated by imposing uniform energy taxation or removing existing tax exemptions is lost when subsidy and transfer schemes are used to preserve equity values in the energy industry; see Bovenberg and Goulder (2001) for the US case, Vollebergh, De Vries and Koutstaal (1997) for the EU case, and Bjertnæs and Fæhn (2004) for the Norwegian case. The main explanation is that an energy tax to a large extent is shifted on to other economic agents hence substantial amounts of revenue generated can still be used to cut other distorting taxes. In several European countries, political pressure from unions, local governments, and political parties, are aimed at preserving employment in different industries or regions, rather than preserving equity values. Studies of the tradeoff between overall efficiency and political pressure aimed at preserving employment in the energy industry find that uniform energy taxation combined with a wage subsidy scheme outperform a differentiated energy tax system in terms of efficiency; see Böhringer and Rutherford (1997) for the German case, and Felder and Schleiniger (2002) for the Swiss case. The main explanation is that the more targeted wage subsidy schemes generates smaller distortions between sectors, compared to a differentiated energy tax system, and at the same time reduces the distortion in the labor market.

However, national energy tax systems are under pressure from other holds as well. EU pressure against any discriminatory policy tends to reduce the scope for national policy. Both discriminatory energy taxation and sector specific wage subsidies are tools that are under pressure within the EU system. More general subsidy schemes, like subsidies for transport and other transitory schemes, seem to face less resistance. Faced with fewer, and less accurate national policy measures, the welfare cost of job preserving subsidy schemes are likely to increase. This study contributes to the literature by analyzing the tradeoff between efficiency gains from a uniform electricity tax reform and local employment concerns, when a more general subsidy scheme preserves employment in the electricity intensive industry. A CGE model of the Norwegian economy quantifies the welfare gain of extending the current electricity tax base to include electricity consumption in the manufacturing industry. The reform is accompanied by production dependent subsidies designed to preserve the initial level of employment in the electricity-intensive industry. The revenue generated by the electricity tax reform is used to finance the subsidy scheme, while the remaining part of the revenue is recycled through a percentage cut in the payroll tax rate to all firms. The introduction of the electricity tax contributes to increase welfare by removing one of several favorable policy measures in this industry. However, the production subsidies constitute a new favorable measure, which contribute in the opposite direction. About half of the revenue generated is recycled through a reduction in the payroll tax. This contributes to lower the substantial tax wedge in the labor market, and hence increase welfare. All in all, the welfare increases. Hence, a uniform electricity tax combined with production dependent subsidies preserve jobs at a lower welfare cost compared to the current differentiated electricity tax system.

Natural retirement, voluntary exit, and creation of new jobs, are factors that tend to relieve the political pressure aimed at preserving employment in the electricity-intensive industry in the long run. Hence, a scheme designed to preserve jobs for a limited period of time might be sufficient to neutralize the political pressure aimed at preventing a uniform energy tax reform. This study illuminates this further by analyzing a scenario where the electricity tax reform is accompanied by job preserving production dependent subsidies that, after one decade, is gradually removed the following decade. As less revenue is used to finance this subsidy scheme, more revenue is recycled through a percentage cut in the payroll tax rate, which contributes to a further reduction in the labor market distortion. The resulting welfare increase is larger in this scenario, compared to the scenario with an infinite subsidy scheme.

However, it is not clear whether these jobs are worth preserving. The welfare cost of introducing a job preserving subsidy scheme may exceed the welfare cost of alternative policies designed to relieve local and regional employment concerns. The functioning of the local labor market is crucial in this respect. Completely flexible local markets where workers and other resources are freely allocated into other sectors without incurring additional costs would solve temporary local unemployment caused by a uniform electricity tax reform. The reallocation of workers and recourses into other sectors also contributes to the welfare gain associated with such a reform. On the other hand, restrictions in the mobility of labor in the energy industry, combined with wage rigidity, is likely to erode most of the potential welfare gain associated with a uniform CO_2 tax reform in the Norwegian economy, Bye (2000). The main explanation being that labor from the energy industry is reallocated into unproductive unemployment. Hence, both the welfare gain of a uniform energy tax reform, and its effect on the local labor market depend crucially on the flexibility of the local labor market. However, the functioning of local labor markets is complex. Fehr and Hjørungdal (1999) find that flexibility in local labor markets in combination with government actions are likely to result in modest job search costs in most local communities in case of an electricity price increase in the Norwegian electricity-intensive industry. In this study, I assume completely flexible markets in all communities, and zero transaction costs connected to inflexible capital and labor markets. Consequently, there is no local unemployment, and the reported welfare gain due to the electricity tax reform do not include transaction costs connected to inflexible capital and labor markets. However, excluding transaction costs connected to an inflexible local labor market do not affect the conclusions in this study, as relevant reform scenarios preserve employment in the electricity intensive industry.

To illuminate further on the tradeoff between efficiency and local/ regional employment concerns, this study calculate the potential welfare gain of imposing the uniform electricity tax reform without preserving employment in the electricity-intensive industry. The resulting welfare gain is divided by the number of full time job years allocated away from the industry. The resulting welfare gain per full time job (year) removed from this industry is 432.000 NoK, or 1,5 times the average wage cost. The welfare gain of removing the production dependent subsidy scheme is calculated by using the scenario where the uniform electricity tax reform is combined with the subsidy scheme as a benchmark. The resulting welfare gain of removing the subsidy scheme, divided by the number of full time job years removed from the electricity-intensive industry, amounts to approximately 200.000 NoK. These potential gains are substantial, suggesting that these jobs are expensive to preserve, even though transaction costs connected to inflexible capital and labor markets are not included into the calculations. In contrast, Böhringer and Rutherford (1997) report a welfare gain per job preserved by their wage subsidy scheme. However, in their analyzes, costs connected to raising revenue to finance the wage subsidy scheme are not included. Such costs are included in this study where part of the revenue generated by the extended electricity tax base are used to finance the subsidy scheme, instead of being recycled through uniform percentage cuts in the payroll tax rate.

The paper is organized as follows; Section 2 presents some background information, and the methodological aspects of the analysis, including the basic feature of the computable general equilibrium model. Section 3 outlines and explains the results, while section 4 concludes.

2. Method

2.1. Background

The main objective of this analyzes is to calculate the welfare effect of a subsidy scheme designed to preserve employment in the Norwegian electricity-intensive industry when a uniform electricity tax is introduced. Previous analyses indicate that the trade-off issue between efficiency and political feasibility is relevant for the Norwegian electricity policy. Bye et al (1999) find that imposing uniform electricity price would improve welfare, but at the expense of the electricity-intensive sectors. Thus, the gain presumes frictionless reallocation of resources. The electricity-intensive sectors comprising the industries *Manufacture of Metals*, *Manufacture of Pulp and Paper Articles*, and *Manufacture of Industrial Chemicals*, is responsible for almost 1/3 of total electricity consumption in Norway, and it generates about 10-15 percent of the total export revenues (including oil and gas). At present, it enjoys several favorable policy measures, including low payroll taxes due to rural location[1], low electricity prices according to favorable long-term power contracts, and exemptions from energy taxes; both the consumer tax on electricity and the CO_2 tax. As the sectors basically use hydropower, this analysis focuses on the electricity tax system.[2] In the present system, final consumers, primary industries, and service industries, including transportation and construction, pay an electricity tax rate of 0.095 NOK/KWh[3], while all manufacturing industries are exempted.

2.2. The design of the analysis

All reform scenarios are changes from a business-as-usual (BAU) scenario. The BAU is a projection of the Norwegian economy, where all exogenous variables are set in accordance with the reference scenario in the Long Term Program of the Norwegian government; See Norwegian Ministry of Finance (2001). Policy variables are kept at their (real) 1999 levels.

In the *reference reform* scenario the current electricity tax exemptions of the manufacturing industries are abolished. Compared to the BAU scenario, the *reference reform* consists of two components:
i) The electricity tax component: The manufacturing industries are faced by an electricity tax at the same level as the tax already imposed on households and remaining industries,

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[1] This type of differentiation is included into this study because EU is likely to accept this type of policy from 2007.

[2] Compared to CO_2 taxes, the arguments in favor of taxing electricity in Norway are less based on environmental reasoning and more a question of raising public revenue.

[3] This equals approximately 1.2 Eurocents/KWh when 1 EUR = 7.92 NOK.

ii) The electricity tax revenue recycling component: The revenue is recycled back to the representative consumer through a uniform percentage pay roll tax rate decrease for firms in all sectors.

In the *job-preserving reform* scenario, the same electricity tax reform is accompanied by production dependent subsidies designed to preserve employment within the energy-intensive export sector. Thus, compared to BAU, the *job-preserving reform* scenario will also influence through two additional components.

iii) The production subsidy component: The production in the energy-intensive export industry is subsidized to preserve the BAU level of employment in this sector.

iv) The subsidy financing component: The revenue from the electricity tax is shortened in order to finance the production subsidy scheme. This results in a smaller percentage pay roll tax rate decrease (compared to the decrease in the reference reform).

The two components in the subsidy scheme are decomposed by simulating the *subsidy financing* scenario, where the electricity tax reform in the *reference reform* scenario is accompanied by the subsidy financing component. The extra revenue is transferred lump sum to the representative consumer, instead of being used to finance the production subsidy scheme. Hence, the reform consists of components *i), ii),* and *iv).* The objective of this scenario is to quantify the costs of raising revenue to finance the subsidy scheme.

Finally, I simulate the *time constrained job-preserving reform* scenario, which consists of the electricity tax reform, i.e. component i) and *ii),* in addition to a time constrained subsidy scheme. This scheme consists of introducing component *iii)* and *iv)* the first decade, and gradually removing these two components the subsequent decade. The electricity tax reform components are included for an infinite period of time. Components included in the various reforms are presented in table 2.1.

Table 2.1: Reforms and components.

Reform: **Component:**	*Reference reform*	*Job-preserving reform*	*Subsidy financing scenario*	*Time constrained job-preserving reform*
The electricity tax component	x	x	x	x
The electricity tax revenue recycling component	x	x	x	x
The production subsidy component		x		x*
The subsidy financing component		x	x	x*

*two decades

2.3. Basic features of the computable general equilibrium model

2.2.1. General features

The numerical intertemporal general equilibrium model for the Norwegian economy gives a detailed description of the structures of economic policy, production, and consumption in the Norwegian economy. The model has 41 private and 8 governmental production activities; see Table A.1. Fæhn and Holmøy (2000) give a more extensive verbal description of the model, while Heide et al. (2004) present a formal, one-sector version.

2.2.2. Consumer behaviour

Consumption, labour supply, and savings result from the decisions of an infinitely lived representative, forward-looking consumer, who maximises present value of utility subject to an intertemporal budget constraint. Utility originates from material consumption and leisure consumption, according to an Origo-adjusted Constant Elasticity of Substitution function (OCES); see Bye (2003) and Bye and Holmøy (1997), and the material consumption is allocated across 26 different consumer goods in a nested OCES function (see figure 2B, appendix B) The OCES specification allows the income elasticities to vary among goods.

2.2.3. Producer behaviour, technology and product markets

Producer behaviour is generally specified at the firm level. The structure of the production technology is represented by a nested tree-structure of CES-aggregates. All factors are completely mobile and malleable[4]. The manager of the firm is assumed to be rational and forward-looking and maximise the present value of the cashflow to owners; see details in Holmøy, Larsen and Vennemo (1993) and Holmøy, Nordén and Strøm (1994).

The domestic market structure is assumed to be a large group case of monopolistic competition, where each firm has some market power in their respective home markets. According to evidence on markup pricing by Norwegian firms (Klette, 1999 and Bowitz and Cappelen, 2001), market power is small; in most industries markups are set to 5 percent. Each firm produces a variety of a product that is an imperfect substitute for other varieties of this product (represented by Spence-Dixit-Stiglitz preferences). The elasticity of substitution among the varieties of a product is calibrated to be consistent with the estimated markup ratios.[5]

World prices are assumed to be unresponsive to domestic demand and supply. The export markets and the home markets are assumed segregated, due to firms' adjustment costs of reallocating deliveries between the two markets. Domestic and imported products are imperfect substitutes according to the Armington hypothesis. The production technology is described by the CES tree structure in figure B.1. in the appendix. There is decreasing returns to scale in the composite factor input. An entry/exit condition determines the number of firms in an industry.

The only net-export price that responds to changes in domestic behaviour is the electricity price. The Norwegian electricity market is part of a Nordic, competitive market where domestic supply and demand affect the common Nordic market price. The relation between the Nordic electricity price, and Norwegian net import, is consistent with a numerical Nordic electricity market model[6]; a net import increase of 1 TWh increases the Nordic price by 0.03 eurocents/KWh. The Norwegian supply of electricity is based on hydropower, which is assumed to be exogenously, and gas power, which is implemented as a backstop technology.

2.2.4. The government

The government collects taxes, distributes transfers, and purchases goods and services from the industries and abroad. Overall government expenditure is exogenous and increases at a constant rate.

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[4] On exception is the production of electricity, see Holmøy et al. (1994).

[5] In order to maximize profits, the firm sets the markup ratio equal to $\sigma/(\sigma-1)$, where σ is the substitution elasticity among varieties.

[6] Aune and Hansen (2004) document the estimations, while Johnsen (1998) documents the Nordic electricity market model. See Holmøy et al. (1994) for a detailed description of the domestic supply and demand for electricity.

The model incorporates a detailed account of the government's revenues and expenditures. In the policy experiments it is required that the nominal deficit and real government spending follow the same path as in the baseline scenario, implying revenue neutrality in each period.

3. Results

3.1. The Reference Reform: Effects of equalizing the electricity tax

This section outlines the main effects of the *reference reform*, while a more detailed descriptions is given in Bjertnæs and Fæhn (2004).

The direct increase in the input prices of electricity of 0.095 NOK/KWh, measured in 1999 NOK, represents a price increase in most manufacturing industries of about 30 percent along the path. For the energy-intensive export industries the percentage price increase is larger, as they initially enjoy low electricity prices, partly due to lower distribution costs per KWh, and partly due to favorable long-term price contracts with the government. In the first year, the direct, price increase averages 60 percent for the energy-intensive export sector, while the increase is 47 percent on average in the long run. The initial effect of the revenue recycling is to reduce the payroll tax rate by about 6 percent, i.e. from 13,1 percent to about 12.3 percent.

The macroeconomic responses to these reform elements are described in Bjertnæs and Fæhn (2004). Table 3.1 reports the resulting changes in the economy. The downscaling of the energy-intensive export sector and the gas power generation has strong implications for capital demand, as these sectors are highly capital-intensive. Thus, investments fall. The aggregate capital stock falls by 0.38 percent in the long run. This, along with a reduction of labor supply of 0.06 percent due to the wage fall, explains the long-run GDP fall of 0,35 percent. The GDP fall only constitutes about 1/5 of the reduction in gross production, while 4/5 of the fall originates from a fall in intermediate goods. This mostly takes place in the energy-intensive export sector, while other industries, including several manufacturing industries, increase their output. All industries, except the energy-intensive export sector, face cost reductions due to a lower wage cost, reduced prices of capital goods and intermediates, and reductions in the Nordic electricity price. The latter takes place as a consequence of the downscaling of the energy-intensive export sector, which leads to a substantial reduction in electricity demand.

Net export of electricity increases in the short run, and compared to the BAU scenario, the production of gas power is reduced, and the introduction is postponed by 5 years (from 2012 to 2017). This reduces the Nordic price of electricity in the short run, while it remains unaffected in the long run. The long run price of electricity is determined by the costs of gas power, which is hardly affected by this reform.

The cost reductions are shifted on to prices in the domestic markets according to fixed mark up pricing. The price increase on electricity used in the manufacturing industry has lead firms in the electricity-intensive industry to substitute electricity intensive machinery, for labor. This contributes to explain why their percentage fall in employment only constitutes about half of their percentage fall in production. The reduction in the Nordic price of electricity moderates both this substitution effect, and the downscaling effect. A price increase on domestic electricity-intensive goods also tends to moderate the downscaling effect. All in all, about 2400 full time jobs are reallocated away from the electricity intensive industry in 2010, increasing to approximately 3600 in 2030.

The welfare gain of this *reference reform* measured as the present value of utility changes in all periods is 0.04 percent, which is substantially lower than the long-run impact on the utility level. The reduction in consumer prices on leisure and material consumption is more modest in the earlier periods, hence, a substitution of consumption of leisure, goods and services towards later periods takes place.

The small welfare effect is due to both small effects on resource allocations as well as various allocation effects pulling in opposite directions. The main contributions are reductions of two tax wedges in the economy, which, in isolation, tend to improve welfare. The first is the initial electricity price discrimination between different industries; the second is the reduction of the, initially considerable, taxation of labour income. The reform is also associated with a modest terms-of-trade loss in the electricity market that pulls the welfare gain downwards. As Norway is a net exporter of electricity in the reference reform scenario, the Nordic price decrease of electricity generates a terms-of-trade loss.

Table 3.1: Effects of the reference reform, the job-preserving reform, and the subsidy financing reform, % changes from the BAU scenario

	Reference reform			Job-saving reform			Subsidy financing reform		
Year	**2010**	**2030**	**Steady st**	**2010**	**2030**	**Steady st**	**2010**	**2030**	**Steady st**
GDP	-0.02	-0.17	-0.35	-0.02	-0.12	-0.16	-0.06	-0.26	-0.44
Material cons.	0.03	0.09	0.09	0.03	0.05	0.04	-0.04	-0.01	-0.01
Labor supply	0.07	-0.02	-0.06	0.04	-0.02	-0.00	0.02	-0.13	-0.13
Full* consumption	-0.005	0.056	0.077	-0.008	0.030	0.029	-0.022	0.038	0.048
Wage rate, consumers	-0.33	-0.63	-0.70	-0.11	-0.25	-0.22	-0.56	-0.94	-0.94
Price, mater. cons.	-0.52	-0.74	-0.77	-0.26	-0.31	-0.29	-0.53	-0.72	-0.76
Export	-0.87	-2.22	-4.20	-0.54	-1.18	-1.81	-0.91	-2.36	-4.28
Import	-1.00	-1.52	-1.26	-0.54	-0.76	-0.54	-1.05	-1.59	-1.3
Payroll tax rate	-5.2	-7.0	-5.6	-2.8	-3.2	-2.8	-2.8	-3.2	-2.8
Labor force, Manu.metals	-7.1	-13.3	-21.1	0	0	0	-7.1	-13.5	-21.2
Gross prod. Manu.metals	-14.4	-21.5	-27.6	-9.2	-11.5	-11.9	-14.4	-21.6	-27.6
Electr. price Manu.metals	36.3	49.9	49.6	38.5	50.5	50.4	36.2	49.9	49.6
Electr. use Manu.metals	-30.4	-40.8	-46.1	-25.8	-39.8	-45.9	-30.4	-40.9	-46.2

*Full consumption constitutes a composite of material consumption and leisure.

3.2. The job-preserving reform scenario: Effects of the subsidy scheme

3.2.1. Effects of the subsidy scheme

Two additional components, *the production subsidy component (iii) and the subsidy financing component iv))* are added in the *job-preserving reform* scenario, in addition to the components in the *reference reform* scenario. Comparing the welfare level in these two scenarios reveal the total welfare cost of preserving the BAU-level of employment in the energy-intensive industry with the implemented subsidy scheme.

The simulations reveal that the welfare gain of the *job-preserving reform* scenario amounts to 60 percent of the welfare gain of the *reference reform* scenario. Hence, 40 percent of the welfare gain generated by the electricity tax reform is lost when the subsidy scheme is introduced.

The *subsidy financing* scenario decompose the effects of the subsidy scheme by comparing this scenario with the *reference reform* scenario and the *job-preserving reform* scenario, respectively. The *subsidy financing* scenario includes the electricity tax reform components in addition to the *subsidy financing component*. The latter component consists of setting the payroll tax rate decrease identical to the payroll tax rate decrease in the *job-preserving reform* scenario, and transferring the remaining revenue lump-sum to the representative consumer. Hence, no subsides are introduced to prevent a fall in employment in the electricity-intensive industry in this scenario. The effects of the electricity tax reform components are analyzed in section 3.1, and will not be repeated.

3.2.2. Effects of the subsidy financing component:

A comparison of the *subsidy financing* scenario, with the *reference reform* scenario, reveal the effects of the *subsidy financing component*. This component consists of a higher over all payroll tax rate, where the subsequent higher revenue is transferred lump-sum to the representative consumer.

The first round effect of the higher payroll tax rate in the *subsidy financing* scenario is a cost increase of labor, which reduces production, especially in exports where product prices are exogenously determined in the world market. The cost increase is shifted on to domestic prices, inducing substitution towards imports. These effects lead to a current account deficit, and excess labor supply. Comparing simulations of the *subsidy financing* scenario with the *reference reform* scenario shows that the general equilibrium effect on the steady state wage rate is a reduction of 0,24 percent (0,94 percent -0,70 percent see table 3.1), and most of the cost increase due to the higher payroll tax rate is neutralized. The price on material consumption is almost unaffected, and hence, the real wage rate is reduced. This results in a modest reduction in the aggregate labor supply, which contributes to restore equilibrium in the labor market. The cost decrease due to the wage rate reduction contributes to reduce the cost increase resulting from the higher payroll tax rate, which contributes to restores the international competitiveness. Some of the cost decrease is shifted on to domestic prices, which leads to substitution of imports for domestic goods. The external balance is restored at a slightly lower level of both exports and imports.

A comparison of the welfare level in the *subsidy financing* scenario, with the welfare level in the *reference reform* scenario, shows that the welfare cost of raising revenue through uniform payroll tax increases to finance the subsidy scheme, amounts to 44 percent of the welfare gain in the *reference reform* scenario. The reduction in labor supply in combination with a large tax wedge between material consumption and leisure contributes to explain this welfare cost[7].

The revenue recycling effect is crucial for the welfare effects of the subsidy scheme, as 44 percent of the welfare gain in the *reference reform* is lost when approximately half of the revenue generated is no longer recycled as percentage cuts in the payroll tax rate. The magnitude of production subsidies needed to preserve employment in the electricity-intensive industry determines the amount of revenue needed to finance the subsidy scheme. The level of production subsidies needed to preserve employment in the electricity intensive industry are determined by the employment effects from the electricity tax reform, as well as effects from the subsidy scheme. The electricity tax reform has lead firms in the electricity intensive industry to substitute away from electricity intensive machinery, and towards more labor-intensive production. The pre tax price decrease of electricity in early decades has moderated the down-scaling effect, and hence, the fall in employment. The fall in the electricity price generates a substitution effect away from labor towards electricity intensive machinery. However, the latter effect is weaker, and the reduction in employment is more modest in early decades, compared to later decades. Consequently, the need for subsidies is more modest in early decades, and a smaller part of the revenue generated by the electricity tax reform is redistributed in the subsidy scheme in early decades. These effects have moderated the percentage employment decrease in these industries, which only amounts to a little more than half of the percentage fall in production. This contributes to explain why only about half of the revenue generated by the electricity tax reform is recycled through the subsidy scheme, while the remainder is recycled through cuts in the payroll tax rate.

3.2.3. Effects of the production subsidy component:

The effects of the *production subsidy component* financed by lump sum taxation are found by comparing the *job-preserving reform* scenario, with the *subsidy financing* scenario. Both the electricity tax reform, and the payroll tax rate decrease, is identical in both scenarios. The only difference between the scenarios is the *production subsidy component* in the *job-preserving reform* scenario, while the equivalent amount of revenue is transferred lump sum in the *subsidy financing* scenario.

In the *job-preserving reform* scenario, the production dependent subsidies are introduced to neutralize the adverse employment effects in the energy-intensive industry. The first round effect of introducing

[7] The elements in this tax wedge are a marginal tax on labor income, approximating 40 percent on average, indirect consumer taxes, including the VAT averaging 22 percent, and the payroll tax, averaging about 13 percent (in the BAU system), and a 5 percent markup in the domestic industry.

production dependent subsidies in the electricity-intensive industry is a cost reduction, and a subsequent up-scaling of production, which result in excess labor demand and accumulation of foreign assets. The resulting steady state wager rate increase is found by comparing the *job-preserving reform* scenario with the *subsidy financing* scenario. It shows that the steady state wage rate increases by 0,72 percent (0,94-0,22, see table 3.1). There is a marginal decrease in steady state full consumption, although present value welfare increases slightly. The wage rate increase contributes to restore the external balance by reducing export and raising import shares. The wage increase also reduces the excess labor demand through both supply and demand effects.

The welfare effect of the *production subsidy component* (with lump-sum financing) amounts to only 4-5 percent of the welfare gain in the *reference reform* scenario. The increase in supply of labor contributes positively because of the large tax wedge between leisure and material consumption. However, the substantial expansion of the electricity-intensive industry contributes negatively because of favorable taxation, long-term power contracts, low payroll taxes motivated by its peripheral location and exemption from the CO_2 tax on process-related emissions.

3.3. Preserving employment for a limited period of time

This section study effects of a time constrained subsidy scheme, where employment in the electricity-intensive industry is preserved for a limited period of time. The *time constrained job-preserving reform* scenario consists of the electricity tax reform components, in addition to the two subsidy scheme components the first decade, and where these two components are gradually removed the following decade. Effects of this time constrained subsidy scheme are analyzed by comparing this scenario, with the *reference reform* scenario. The effects of introducing these components are discussed in the previous sections, hence it will not be repeated. However, the time constrained durations of these components limits their effects on the economy. Revenue generated in periods after the components are removed, is recycled as payroll tax rate decreases.

The welfare cost of this time constrained subsidy scheme amounts to 18.6 percent, calculated as a percentage of the welfare gain in the *reference reform* scenario. This again amounts to about half of the welfare cost generated by the subsidy scheme where employment in the electricity-intensive industry is preserved in all future periods. The main factor that contributes to explain this difference is a lower need for revenue to finance the time constrained subsidy scheme. Consequently, more revenue is recycled through a reduction in the payroll tax rate. This generates a welfare gain that contributes to explain the difference in welfare costs.

The long-term power contracts, which expire within 2010, contribute to lower the social marginal product of labor in the electricity intensive industry in the short run. This contributes to increase the welfare cost of preserving jobs in these industries in the short run, compared to preserving jobs in the long run. On the other hand, the subsidy schemes contribute to increase demand for electricity, and hence, increase the Nordic price of electricity in the short run. This generates a terms of trade gain in the short run which lowers the welfare cost of the time constrained subsidy scheme relative to the infinite subsidy scheme.

Table 3.2. Effects of the time constrained job-saving reform, percentage changes from the BAU scenario

Year	2010	2030	2100
GDP	0.01	-0.17	-0.36
Private consumption	-0.01	0.09	0.09
Labor supply	0.10	-0.03	-0.06
Full consumption	-0.034	0.059	0.079
Wage rate to workers	-0.19	-0.62	-0.70
Price, material consumption	-0.37	-0.73	-0.76
Export	-0.44	-2.23	-4.22
Import	-0.66	-1.52	-1.25
Payroll tax rate	-3.7	-7.0	-5.5
Labor force, Metal	-0.7	-13.3	-21.1
Production, Metal	-9.7	-21.5	-27.6
Electricity price, Manu. Metal	38.2	49.9	49.6
Electricity use, Metal sector.	-26.3	-40.8	-46.1

3.4. Potential welfare gain of reallocating jobs

The welfare cost of introducing a job preserving subsidy scheme may exceed the welfare cost of alternative policies designed to relieve local and regional employment concerns. A reallocation of labor into other sectors is one alternative. However, the functioning of the local labor market is crucial in this respect. Completely flexible markets where workers and other resources are freely allocated into other sectors without incurring additional costs would solve local employment concerns connected to a uniform electricity tax reform. On the other hand, restrictions in the mobility of labor in the energy industry, combined with wage rigidity, is likely to erode most of the potential welfare gain associated with a uniform CO_2 tax reform in the Norwegian economy, see Bye (2000). To illuminate further on the tradeoff between efficiency and local/ regional employment concerns, this study calculates the potential welfare gain of imposing the uniform electricity tax reform when all markets are assumed to be completely flexible. Transaction costs connected to reallocating workers and other resources to other sectors are not included, however, the calculated welfare gain per job-year reallocated away from the electricity-intensive industries generates some useful insights.

The welfare gain of the *reference reform* is divided by the number of full time jobs reallocated away from the electricity-intensive industry as a result of the reform. Future full time jobs are weighted with the discount factor of the economy, to get a welfare measure per full time job reallocated away from the electricity-intensive industry to other sectors. The resulting welfare gain per full time job amounts to 432.000 NoK, which is about 1.5 times the average wage cost.

The welfare cost of the subsidy scheme introduced in the *job-preserving reform* scenario is divided by the number of (weighted) full time jobs reallocates back to the electricity-intensive industry. This amounts to 174.000 NOK per full time job preserved in the electricity-intensive industry. The welfare cost per full time job preserved in the electricity-intensive industry by the subsidy scheme in the *time constrained job-preserving reform* scenario amounts to 194.000 NoK, which, compared to the subsidy scheme in the *job-preserving reform*, is a little higher. Two factors contribute to explain this difference in welfare cost per full time job preserved by these reforms. First, the long-term power contracts that are terminated in 2010 contribute to lowering the social marginal product of labor in the energy-intensive industry in the short run. This contributes to increase the cost per job year saved in the first decade. Second, the subsidy scheme increases demand for electricity, which increases the Nordic price of electricity in early decades. The following cost increase tends to lower production, and hence demand for labor. This effect increases the level of subsidies needed to preserve one full time job, and hence, the subsidy financing cost per job preserved this period. On the other hand, substitution from electricity intensive machinery towards more labor-intensive production tends to neutralize this effect. A terms of trade gain contributes in the opposite direction.

4. Conclusions

Welfare analyses of energy taxes typically show that systems with uniform rates perform better than differentiated systems. However, most western countries include some exemptions for their energy-intensive export industry, and hence, avoid this potential welfare gain. Studies of the tradeoff between overall efficiency and political pressure aimed at preserving employment in the energy industry find that uniform energy taxation combined with a wage subsidy scheme outperform a differentiated energy tax system in terms of efficiency; see Böhringer and Rutherford (1997) for the German case, and Felder and Schleiniger (2002) for the Swiss case. This study contributes to the literature by analyzing the tradeoff between efficiency gains from a uniform electricity tax reform and local employment concerns, when production dependent subsidies preserve employment in the Norwegian electricity-intensive industry, and finds that a uniform electricity tax combined with production dependent subsidies preserve jobs at a lower welfare cost compared to the current differentiated electricity tax system. However, preserving these jobs is found to be costly, as the potential welfare gain per job reallocated away from the electricity intensive industry due to the electricity tax reform amounts to about 60 percent of the wage cost per job. In contrast, Böhringer and Rutherford (1997) report a welfare gain per job preserved by their wage subsidy scheme. However, they do not include costs connected to raising revenue to finance the wage subsidy scheme. Note that the subsidy scheme in this study increases both profit and export in the electricity-intensive industry. Hence, shareholders and pressure groups concerned with export revenue benefit by supporting the subsidy scheme. However, preserving existing tax exemptions is even better for these groups.

EU does not object to an electricity tax system that exempts all sectors. Removal of sector specific exemptions this way might enhance efficiency without eroding jobs in the energy-intensive industry. However, welfare effects of more lenient energy taxation are beyond the scope of this paper.

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Appendix A

Table A.1: Production Activities in MSG-6

MSG-6 Code	Production Activities
11	Agriculture
12	Forestry
13	Fishing
14	Breeding of Fish
21	Fish Products
22	Meat and Dairy Products
16	Grain, Vegetables, Fruit, Oils, etc.
17	Beverages and Tobacco
18	Textiles, wearing Appeal and Footwear
26	Furniture and Fixtures
27	Chemical and Mineral Products, incl. Mining and Quarrying
28	Printing and Publishing
34	Manufacture of Pulp and Paper Articles
37	Manufacture of Industrial Chemicals
41	Gasoline
42A	Diesel Fuel
42B	Heating Fuels, Paraffin, etc.
43	Manufacture of Metals
46	Manufacture of Metal Products, Machinery and Equipment
47	Hired Work and Repairs
48	Building of Ships
49	Manufacture and repair of oil drilling rigs and ships, oil production platforms etc.
55	Construction, excl. of Oil Well Drilling
60	Ocean Transport - Foreign
63	Finance and Insurance
66	Crude Oil
67	Natural Gas
68	Services in Oil and Gas Exploration
69	Pipeline Transport of Oil and Gas
71	Production of Electricity
72	Power Net Renting
73	Sales and Distribution of Electricity
75	Car and Other Land Transportation
76	Air Transport
77	Railroads and Electrical Commuters

Table A.1 (cont.)	
MSG-6 Code	Production Activities
78	Ocean Transport - Domestic
79	Post and Tele Communication
81	Wholesale and Retail Trade
83	Dwelling Services
85	Other Private Services
89	Imputed Service Charges from Financial Institutions
	Government Input Activities
	Central Government
92C	Defense Exclusive of Military Submarines and Aircraft
92U	Military Submarines and Aircraft
93S	Central Government Education and Research
94S	Central Government Health-Care and Veterinary Services etc.
95S	Other Central Government Services
	Local Government
93K	Local Government Education and Research
94K	Local Government Health-Care and Veterinary Services etc.
95K	Other Local Government Services

B.1 Consumer behavior

In year t the representative consumer chooses a path of "full consumption", F, by maximizing intertemporal utility given by

$$\text{(B.1)} \qquad U_t = \sum_{s=t}^{\infty} (1+\rho)^{t-s} \frac{\sigma_F}{\sigma_F - 1} F_s^{\frac{\sigma_F - 1}{\sigma_F}}$$

subject to the intertemporal budget constraint, see Bye and Holmøy (1997) for further details. σ_F is the intertemporal elasticity of substitution in full consumption. The intertemporal utility maximization gives the demand for full consumption

$$\text{(B.2)} \qquad F_s = \left[\frac{1 + r(1 - t^D)}{1+\rho} \right]^{\sigma_F t} (\lambda PF_s)^{-\sigma_F},$$

where r is the world market interest rate on financial wealth, t^D is the tax rate on capital income, λ is the marginal utility of wealth and PF is the ideal price index of full consumption. Full consumption is a CES-composite of material consumption, C, and leisure, LE. The corresponding ideal price index is given by

$$\text{(B.3)} \qquad PF_s = \left[\alpha_C PC_s^{(1-\sigma_C)} + (1-\alpha_C) \left(\frac{PLE_s}{1+g} \right)^{(1-\sigma_C)} \right]^{\frac{1}{1-\sigma_C}},$$

where PC is the price index of material consumption and PLE is the price of leisure (net of tax wage rate) measured in efficiency units such as labor, implying that the price of leisure must be adjusted with g, the factor augmenting technical change. σ_C is the elasticity of substitution between material consumption and leisure, and α_C is the intensity parameter for material consumption. In each period full consumption is distributed between leisure and material consumption, see Bye (2003) for further details.

B.2 Intertemporal equilibrium

A necessary condition for reaching a steady state solution is

$$\text{(B.4)} \qquad 1 + r(1 - t^D) = (1+\rho)(1+g)^{\frac{1}{\sigma_F}}$$

which is a "razor's edge" condition since r, t^D, ρ and g which determines the long run (steady state) growth rate of the economy, are all considered as exogenous. In the analyses, equation (B.4) is assumed to hold at all points in time.

B.3 Data and parameters

The model is calibrated to the 1999 national accounts. For the production functions the elasticities of substitution between machinery and energy, the elasticity of substitution between the energy-machinery aggregate and labor and the elasticity of substitution between the modified real value added and various material inputs (see figure B.1.), are adjusted to parameters of a Generalized Leontief (GL) cost function estimated on time-series data from the national accounts, see Alfsen et al (1996). The elasticities of substitution between electricity and fuel oil in the energy aggregate are based on CES-function estimates on time series data by Mysen (1991). Most of these elasticities of substitution are smaller than 1. The elasticities of substitution between non-polluting and polluting transports, and the corresponding elasticities between the modified real value aggregate and various material inputs are set to 0.5, for all industries.

In the model of producer behavior the elasticities of transformation between deliveries to the domestic and foreign market are set equal to 4. The elasticities of scale in different industries are then calibrated to 0.83, given the elasticities of transformation. The elasticities of substitution between domestic products and imported goods are partly based on estimated parameters (see e.g. Svendsen (1990)), but adjusted upwards such that all are around 4. For further details of the calibration of the model of producer behavior, see Holmøy and Hægeland (1997).

In the consumer model the intertemporal elasticity of substitution, σ_F, equals 0.3, Steigum (1993). Econometric estimates of σ_F vary considerably between different sources, and 0.3 is in the lower end of the range of the estimated parameters. The uncompensated wage elasticity of labor supply is 0.1 percent, which is based on estimates of labor supply for married women and men on micro-data by Aaberge, Dagsvik and Strøm (1995). This is consistent with the calibrated elasticity of substitution between material consumption and leisure of 0.6, and the share of leisure in the full consumption aggregate of 0.4, see also Bye, Holmøy and Strøm (1999) for details. The calibration of the parameters in the complete demand system for material consumption is based on detailed econometric studies using both micro and macro data, see Wold (1998).

Figure B.1. Production technology

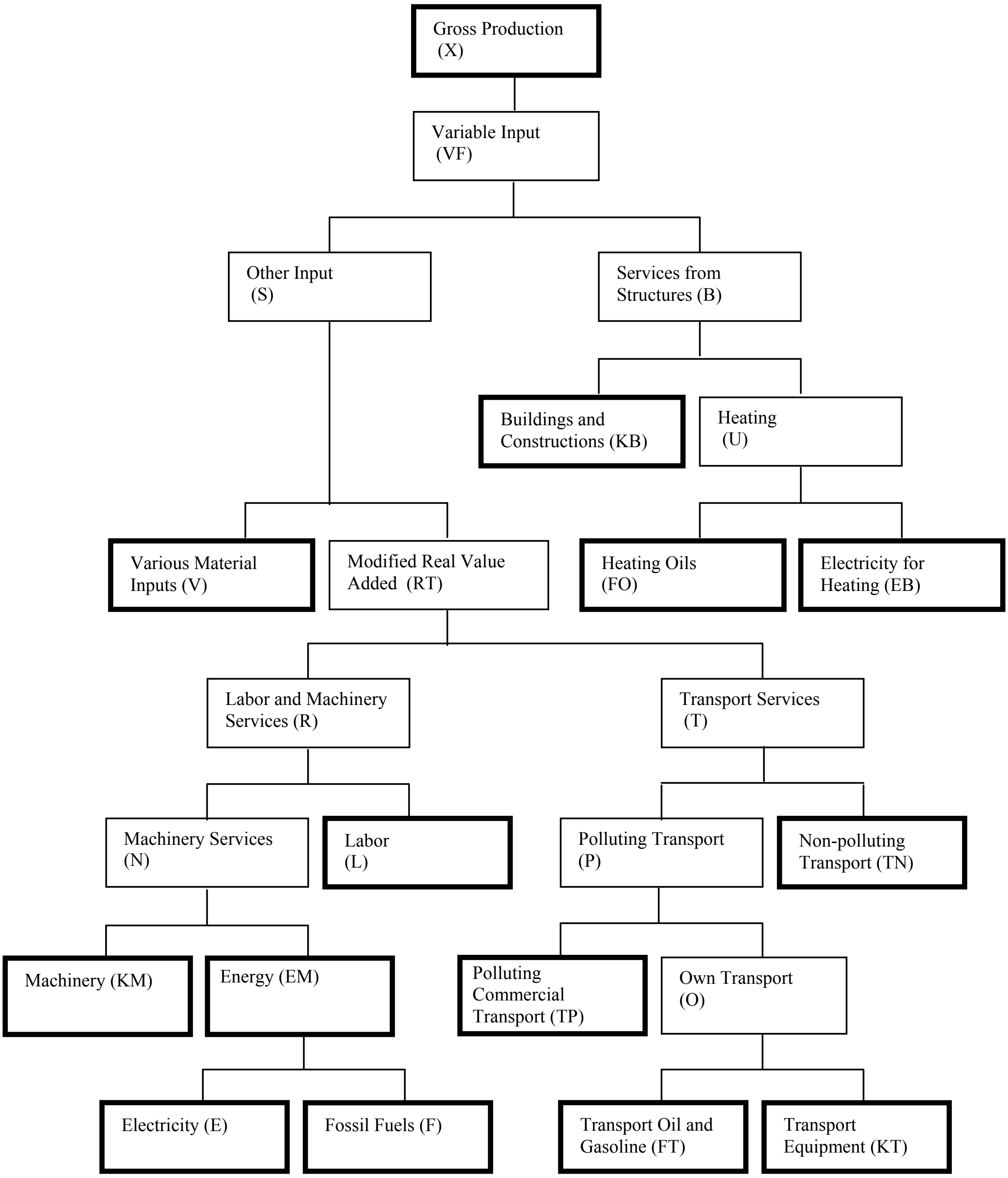
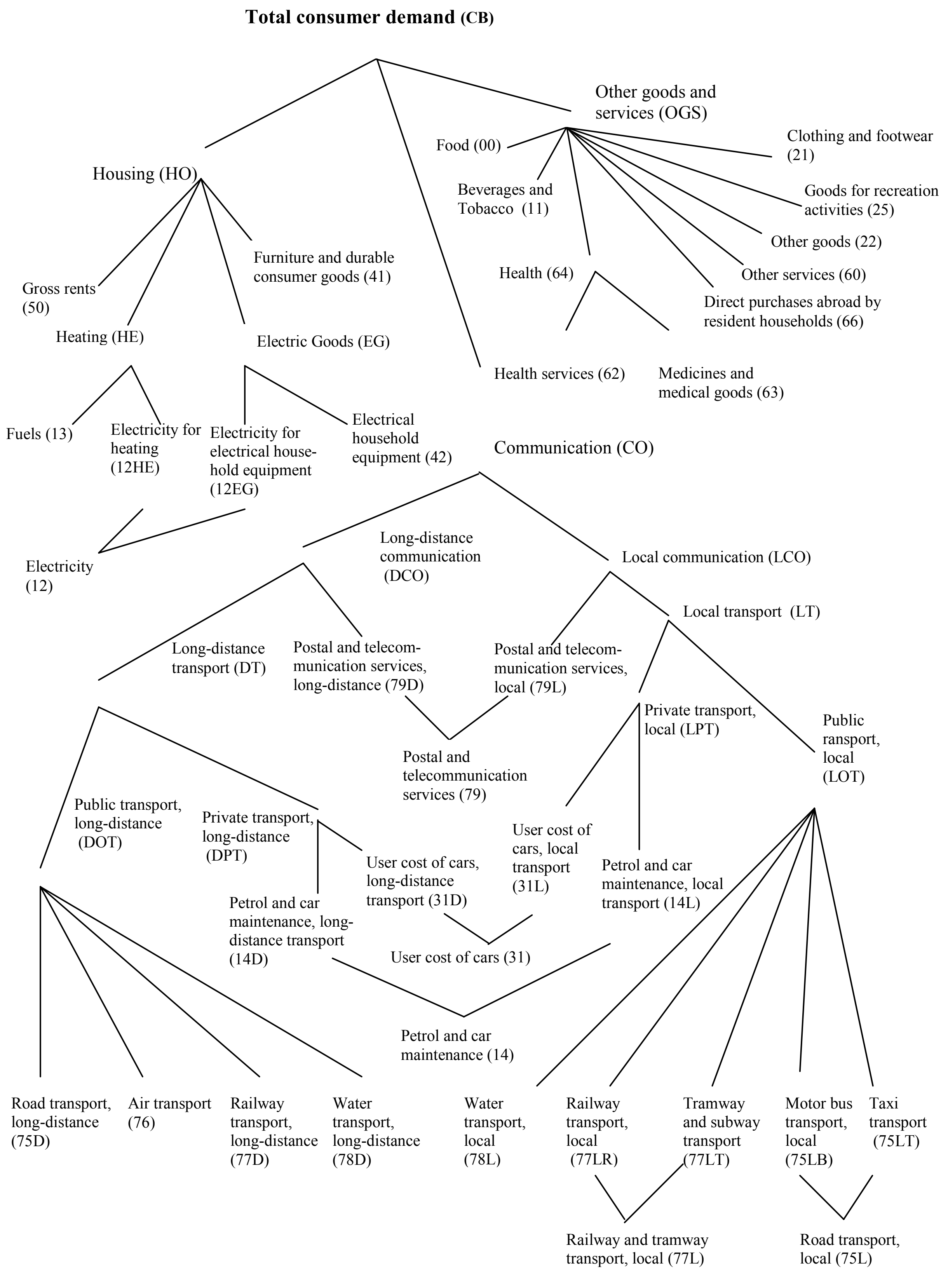


Figure B.2. Material Consumption



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