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A General Equilibrium Evaluation of Aggregate Welfare Effects from Improved Sectoral Efficiency

Empirical Evidence for Norway

Abstract:

This paper discusses and shows how a CGE model can be used to assess welfare effects of structural policy reforms targeting inefficiency problems at micro levels that normally are not captured in operational CGE-models. The CGE approach allows computation of shadow prices which are generally both unobservable due to various price distortions, and endogenous. Moreover, the paper discusses how static measures of sectoral inefficiency can be implemented in a CGE-model that accounts for real world dynamics. Results from CGE-simulations suggest that general equilibrium effects have substantial influence on welfare, at least when the initial waste of resources is as large as reported in sector studies for Norway. More precisely, compared to the CGE-estimate a partial equilibrium approach overestimates the welfare gain by more than 30 percent.

Keywords: Structural reform, Efficiency gains, General equilibrium effects

JEL classification: C68, C81, H50, L70, L98

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1. Introduction

The development of Computable General Equilibrium (CGE) models over the last decades has resulted in a large literature which estimates welfare effects of various structural policy reforms affecting the incentives facing producers and consumers in a market economy. Foremost, CGE models have been used to evaluate the welfare effects of reforms of the tax system and protective trade policies. However, as noted in e.g. Vennemo (1992), and Krugman (1992), the estimated welfare gains from both actual and more hypothetical reform proposals are typically rather low, ranging between 0 and 5 per cent of the initial consumption possibilities. These results suggest that the welfare potential from structural reform policies is of the same order of magnitude as normal economic growth over one or two years. Provided that the estimates are unbiased, such policies should of course still be implemented, but policy advisers should be careful not to create too optimistic expectations about the welfare gains.

However, one might suspect that these estimates include a negative bias because CGE-models are in general not able to capture distortions creating inefficiency at the micro level. Anecdotal evidence of waste of resources and X-efficiency at the micro level abound. In particular, there are lots of «horror stories» about what is going on in sectors directly or indirectly controlled by the government[1]. On the other hand, in order to be operational, even the largest CGE-models, are confined to analyse reallocations of resources between relatively aggregated sectors of the economy. Thus, the hypothesis emerges that a major source of welfare improvement lies in inefficiency at a much more detailed level of aggregation than the ones that can be described in operational CGE-models. Information about such inefficiency problems can only obtained by detailed sector studies, and one might argue that a partial equilibrium analysis is the most relevant approach for assessing the potential welfare loss associated with the inefficiency.

Compared with CGE assessments, the partial equilibrium approach is, however, burdened with three well known shortcomings. First, partial equilibrium assessments assume that the shadow prices can be measured by observable market prices, but the equality between these price concepts are violated by distortive taxes and market imperfections. With such distortions correct shadow prices can in general not be calculated analytically. Thus, shadow prices are more realistically evaluated by a CGE-model

[1] Every issue of the Norwegian financial magazine «Kapital» includes an article about how the government sectors waste money.

than by a partial equilibrium approach. Second, if the potential efficiency improvements are substantial rather than marginal, the assumption of constant shadow prices is unlikely to hold as an acceptable approximation. Such endogenous adjustments of shadow prices may be due to both large efficiency improvements in a single industry or a result of simultaneous improvements in several industries. A consistent account of the endogeneity of the shadow prices requires a CGE-model.

On this background the most fruitful approach may therefore be to assess the potential aggregate welfare gain from efficiency improvements within different sectors by combining detailed sector studies of inefficiency with a CGE-analysis of the aggregate welfare effects. This paper discusses the methodology and the results from a project following such a strategy when assessing the scope for improved efficiency in the Norwegian economy. The report from this project, see Norman, Førsund, Holmøy, Mørkved and Sørensen (1991), concluded that the order of magnitude of the welfare potential was as large as 29 - 31 per cent of the GDP level in 1987[2]. This paper will not discuss the realism of the sectoral inefficiency estimates which of course are the basic determinants of the aggregate welfare effect. The primary aim of the paper is rather to use the sectoral results to demonstrate and explain that the CGE-analysis may improve the estimate of the aggregate welfare gain significantly compared to the partial equilibrium approach. As a matter of fact, the paper shows that a partial equilibrium approach overestimates the welfare gain by more than 30 per cent compared to the general equilibrium estimate. On the methodological side, the paper discusses how one should design and interpret the CGE-model simulations of the particular kind of information offered by the sector studies. Special attention is given to the problem of how estimates derived from a static framework should be interpreted and used in a dynamic model.

The paper is organised as follows. Section 2 presents the estimates of potential efficiency improvements reported in the sector studies. Section 3 describes how these are converted into appropriate shifts in exogenous variables in MSG-5. In addition, Section 3 presents a non-technical overview of MSG-5, as well as an explanation of the particular way in which the model has been simulated. Section 4 presents the MSG-5 estimate of the welfare gain and discusses the main reasons why this estimate is considerably lower than the sum of partial equilibrium estimates over sectors. Section 5 concludes.

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[2] This estimate should not be interpreted as a measure of the *net* welfare effect. In several cases, as e.g. the question regarding the start of schooling, there may be good reasons for maintaining the present regime. Consequently, the welfare gains presented in this paper should rather be interpreted as a price tag on some existing conditions.

2. Efficiency Gains Identified in Partial Sector Studies

In 1989-90 a commission was set up by the Norwegian government with the task to identify and quantify the welfare loss generated by inefficiency in government sectors and private sectors heavily controlled by the government authorities. The commission interpreted its mandate in a rather broad way, so the measure of total inefficiency included:

- Inefficiency within sectors producing public services (Education, Health services and Government administration)
- Inefficiency within private production sectors directly controlled by the Government (Domestic transport, Electricity supply)
- Inefficiency within private production sectors heavily regulated through Government Assistance (Agriculture, Fishery)
- Inefficiency caused by Government transfers (the Social security system, Foreign aid)
- Dead-weight losses due to excessive tax distortions of the price system
- Inefficiency caused by unemployment

For each of these "sectors" a report was written by selected experts, which contained three key elements: i) a description of the underlying reasons to the existing inefficiency, ii) a quantitative assessment of the potential for efficiency improvement, and iii) recommendations of policy reforms that, if implemented, would bring about realisation of the estimated potential for efficiency improvement. These sector studies were critically examined and extensively utilised in the final commission report, see Norman *et al.* (1991). As noted in the introduction, this paper will not question or repeat the rationalisations provided in these reports of the assessments of the potential sectoral efficiency gains. The relevant conclusions drawn in Norman *et al.* (1991) concerning the magnitude of these gains, are therefore just listed in Table 1 below. A brief account of the sources underlying these efficiency improvements is given in Appendix A[3].

The following two general remarks apply to the interpretation of all sector studies. First, most of the estimates found in the sector studies were substantially reduced before they were used as inputs in Norman *et al.* (1991). This was due to a risk averse attitude to the large degree of uncertainty associated with most of these estimates. Second, in order to transform the estimates of wasted labour, capital and other material inputs into corresponding estimates of potential welfare gains, explicit

[3] MSG-5 is not sufficiently detailed to capture the efficiency improvements due to reallocations of electricity from energy intensive industries to other consumers, deregulations of transport markets and additional investments in the road system. The gains associated with these improvements are therefore not calculated in the MSG-5 analysis, but the gain estimates made in the corresponding sector studies has been included in Norman *et al.* (1991).

shadow prices have to be associated to the resources. In the partial equilibrium assessments, the fixed shadow prices reflected average market prices in 1987. The shadow price of labour was set equal to the average wage cost per man year, i.e. NOK 186 000[4]. If producers behave rationally, this wage cost reflects the average marginal productivity of a man year in the Norwegian economy. The shadow price of real capital was set to 8 per cent, which reflects several estimates of the average real rate of net return to capital in the Norwegian business sector. The shadow value of released material inputs was assumed to be equal to the market value actually paid by the sectors releasing these goods and services. The total welfare gain from eliminating inefficiency in a sector is computed by the formula

Value of released resources (1987-prices) =

released man years x 0,186 bill. NOK/man year

\+ market value of released real capital x 0,08 per cent

\+ market value of released material inputs.

The first three columns in Table 1 report the estimated waste of the labour, real capital and material inputs respectively. The fourth column includes the partial equilibrium evaluation of the potential welfare gain from use of these resources. The fifth column measures these absolute gain estimates relative to GDP in 1987. The figures are substantial, especially when compared to the 0-5 per cent gain typically found in the CGE-literature on structural policy reforms, see e.g. Krugman (1992) and Vennemo (1992). The subsequent sections discusses whether and to what extent this large partial equilibrium estimate includes a positive bias due to neglecting of general equilibrium effects.

[4] One man year was defined as 1725 hours.

Table 2.1. Summary of the partial sector estimates of potential efficiency gains

	References to partial sector studies	Waste of resources			Estimated welfare gain, fixed 1987 factor prices	
		1000 Man years	Real capital, bill.	Mat. input, bill.	Released resources, bill.	Total gain, per cent of GDP
Public services						
Education	Robertsen and Friestad (1990), Øvereng (1990), Andersen (1990)	93,3	15,0	0,7	19,3	3,3
Health	Grund (1990)	21,0			3,9	0,7
Administration	Johnsen (1990)	12,4		2,0	4,3	0,7
Regulated sectors						
Transport	Hiorth (1990)	16,0	8,5	3,2	6,9	1,2
Transfers						
Fishery	Hanneson (1990)	23,0	5,5		4,7	0,8
Agriculture	Aanesland (1990)	70,0	15,0		14,2	2,4
Social security	Rødseth (1990)	138,0			25,7	4,4
Foreign aid	Pedersen (1990)				4,6	0,8
Unemployment	Norman *et al.* (1991)	140.0			26.0	4.5
SUM		513,7	44,0	5,9	109,6	19,7

3. A CGE-assessment of the Welfare Gain of all Reform Proposals

3.1. A brief overview of the MSG-5 model

Relevance

The numerical model MSG-5[5] was used to estimate the total welfare gain of a simultaneous elimination of the inefficiency identified by the sector studies. Being a CGE-model, MSG-5 has two general properties that makes it relevant for such an analysis: First, contrary to macroeconometric models in the Keynesian tradition, the model treats resources as scarce in the sense that each one has a positive shadow price. The idea that resources can be wasted and that *gains* can be obtained from efficiency improvements, depends fundamentally on the conception that resources are *scarce* in the

[5] MSG-5 is an abbreviation for the fifth generation of the Multi Sectoral Growth model. The first version of the MSG is described in Johansen (1960). Over the last 30 years the model has been regularly developed and used at Statistics Norway. A complete description of the equation structure and parameter estimates of MSG-5 is given in Holmøy, Nordén and Strøm (1995).

economy. Second, the model has a consistent micro theoretical foundation. In particular this applies to the determination of marginal utilities and productivities, which are the basic determinants of the shadow prices of the specified resources. An important point in this respect is that the model describes explicitly how taxes and market imperfections cause shadow prices to deviate from the corresponding market prices. In the model computations welfare gains have been measured by the growth in the real value of consumption. Hence, the shadow price of a resource equals the increase in consumption caused by a marginal increase in the supply of the resource.

A final point is that MSG-5 is operational for this concrete project because the sectors covered by the sector studies are specified individually in the model. However, although quite disaggregated with respect to industry and commodity classification, MSG-5 could not be used to check the primary estimates of waste reported in the sector studies. As stated above, the role of the model was confined to improve the evaluation of the welfare gains from reallocation of wasted resources[6].

Structure

The following paragraphs present some key features of the MSG-5 model. A more comprehensive description is given in Appendix B, whereas a complete description of the model is given in Holmøy, Nordén and Strøm (1995).

The model specifies 41 commodities and 28 private production sectors. For most manufactures and for some services, which jointly cover about fifty per cent of total exports, each commodity is an Armington composite of a domestic and a foreign variety, which are regarded as imperfect substitutes. Thus, for these tradables import shares are price dependent. Import prices are exogenous, and the exchange rate is normalised to unity. Since the Armington assumption is supposed to hold also for foreigners, Norwegian manufacturing firms face export demand functions that are decreasing in the ratio between the domestic price and the exogenous world market price. Production of resource based commodities like primary industry products, crude oil and Natural gas, is determined by exogenous supply side conditions, and the prices of these product are assumed to be equal to the corresponding exogenous world prices. The model specifies five input factors including labour, capital, electricity, fuels and other material inputs, which are optimally combined.

[6] In addition, the systematic use of a CGE-model turned out to be a useful diciplinating framework for how to extract the most relevant information from the sector studies. For example, many of these studies did not originally have estimates for the increase in the productivity of other factors than labour.

Competition ensures that domestic producer prices equal total unit costs which are independent of production levels due to the general assumption of constant returns to scale. Domestic prices will in general deviate from the corresponding world market prices for tradables considered to be imperfect substitutes for corresponding foreign products. The model includes a detailed description of how indirect taxes and subsidies create wedges between producer and purchaser prices, and the user cost of each capital good is augmented to include a detailed description of capital income taxation. The assumption of constant returns to scale, combined with exogenous output determination in those sectors where economies to scale is regarded essential, make prices independent of the demand side of the economy.

Household demand is derived from utility maximising behaviour. A separable structure of Stone-Geary and CES-utility functions impose strong restrictions on the Slutsky matrix and gives a recursive demand system. However, important features of the household's ability to substitute between specific activities are retained.

Labour supply is exogenous in MSG-5. Two additional resource restraints were imposed by letting the aggregate stock of real capital and the current account be exogenous. The capital market and the exogenous current account are balanced by endogenous adjustments of the shadow price of capital and the wage rate. The resource restraints imply that the aggregate private consumption level is determined basically from the supply side.

3.2. Model application and interpretation of the results

Implementing efficiency improvements from sector studies in MSG-5

The sector studies estimate the reductions of inputs that would follow from efficiency improvements while implicitly assuming the industry specific output levels to be fixed. The released resources are employed in a hypothetical sector where their social values are constant and equal to their average market prices, cf. Section 2. In MSG-5 the relevant implementation is to shift factor specific productivity coefficients in the model. Since the sector studies focused on the inefficient use of labour, the following explanation of the transformation of sector study estimates into relevant exogenous shifts in the MSG-5 simulations is confined to labour only. To the extent that real capital and material inputs have been changed, the same lines of reasoning apply to these factors.

In the government sectors Education, Health Services and Administration, no independent measures of output exist. The MSG-5 model follows the practice in the NA where the output value is set equal to costs. Moreover, the activity levels and the input composition in these sectors are exogenous in MSG-5 due to well known problems of modelling the behaviour in government sectors. The labour productivity improvements in these sectors have been implemented by keeping the levels of government consumption equal to the exogenous initial reference level, whereas the input coefficients have been adjusted in order to bring about input reductions in accordance with the sector estimates. In this way, the effect of these shifts is equivalent to an increase in the total labour supply without reducing government consumption. In education the main part of the efficiency potential was found to be due to not allowing children start school at six rather than at the age of seven, as well as waste of schoolchildren's and students' time during the years within the education system. Elimination of both kinds of excess time consumption, as well as the potential employment from reforming the social security system, has been implemented in the MSG-5 simulations as a further expansion of the total labour supply.

Elimination of excessive employment in Agriculture, Fishery and the domestic transport sector has been implemented in MSG-5 as exogenous reductions of the input coefficient for labour so that the base year output levels can be produced by the employment estimated in the sector studies. The consumption growth from reducing foreign aid is captured in the MSG-5 simulations through an increase in the value of net imports within the constraint of a fixed current account surplus.

Design of the policy experiments and interpretation of estimated gains

In practice, implementation of the proposed reforms and the completion of their effects is likely to take considerable time. In principle, the dynamics associated with the policy reforms call for a comparison between time paths rather than comparative statics. The reference, or pre-reform, path should be a "neutral" projection with no efficiency improvements. The alternative post-reform path should have the same exogenous input as the reference path except that the productivity in e.g. agriculture is increased. The gain from the reforms should be calculated as the present value of changes in the instantaneous welfare measure, which is real private consumption pr. year in MSG-5 analyses.

However, there are several reasons why this ideal approach is impossible to follow. First, the sector studies made no assessments of neither the time profile of the implementation of the reform, nor of the dynamic effects of the reforms. Instead their approach were completly static, and the efficiency gain

estimates were interpreted as long-run effects feasible within an unknown time horizon. Accordingly, these studies provide no guidelines for specifying a realistic dynamic development for the changes in the relevant exogenous variables in MSG-5. Second, although MSG-5 generates dynamic paths due to capital accumulation, which is described in terms of year-to-year development of the variables, the model is not able to calculate comparative dynamics in a realistic way. Being a CGE model, it is not formulated with the ambition of giving a realitic description of the speed of adjustment and tatonnement processes. Rather, the standard interpretation of these models is that they are confined to provide a relevant suggestive description of different long run equilibria. Consequently, even in the hypothetical case where the sector studies provided information about the dynamics of the productivity effects of the reforms, the unrealistic equilibrium dynamics in MSG-5 makes it hard to utilise this information to improve the gain estimates compared to the case of only static information about the productivity effects. In particular, the fact that MSG-5 neglects all kinds of disequilibrium problems during the transition period, implies that the simulated welfare gains in these years are likely to have a positive bias. The bias of the present value of the welfare effects is strengthened through the discounting by an *annual* discount rate. Operational equilibrium models describing the true dynamics of an economy have not been developed yet. The focus in both the sector studies and in Norman *et al*. is on the potential gains provided that the market mechanism brings about new employment opportunities of the released resources. Such a focus implies that the analysis emphasises the long-run effects. One may say that this view has been taken to its extreme since both the partial and the general equilibrium analyses are confined to the stationary long run effects only.

One might argue that the model would be improved if individual intertemporal behaviour based on perfect foresight were built into the model[7]. I would not agree with this view. Although, such intertemporal models facilitates the interpretation of the model results, the distinction between *short run* and *long run* effects in intertemporal models, is relevant only as a characterisation of the dynamics within the model itself. It does not follow that the simulated dynamics, in particular the short run effects, represent a good description of what will actually happen in the short run measured by true calendar time.

When the analysis is restricted to focus on the stationary long run effects, it is not obvious how a relevant reference situation describing the pre-reform economy should be specified. In the partial sector studies, the situation in 1987 was taken as the reference point. But assessment of the long run

[7]See e.g. Turnovsky (1991) for an introduction to intertemporal macroeconomic modelling based on rational individual behaviour.

effects rather warrants that the reference situation is chosen as a long-run equilibrium point on the simulated pre-reform scenario. The case of efficiency improvements in agriculture serves as a good example of how the choice of reference situation may generate misleading results. It is widely expected that technology improvements will contribute to a further gradual reduction of the use of resources in this sector even if no explicit policy reform takes place. If exit of farms is motivated by profitability considerations, it is likely that such a development will have a positive effect on the average productivity of the sector[8]. Then the basis for potential efficiency gains will be reduced along a realistic reference scenario compared to the hypothetical potential in 1987.

In spite of this argument, the general equilibrium assessment of the potential gains has been made relative to a reference point which was constructed on basis of the situation in 1987. One reason for this choice was to make the general equilibrium results comparable to the results in the sector studies. More fundamentally, it is indeed not easy to see how the information in the sector studies can be exploited unless the reference point is the same in the two approaches. In order to justify the estimates as long run gains, the choice of reference situation has, however, been supported by a more abstract and counterfactual interpretation of both the partial and the general equilibrium estimates. We interpret the results as a measure of the potential efficiency gains to be exhausted in 1987 if an alternative policy had been followed over a sufficiently long period prior to this year. This approach is motivated by the normative character of our study. All kinds of welfare measurements imply a choice of how the benefits are exhausted. Our approach implies a hypothetical assessment of how much it would have been possible to raise current private consumption if the sector reforms had been implemented a sufficiently long time ago.

To make the results from simulating MSG-5 consistent with such an interpretation, the model simulations were designed in a particular way, which is quite different from the approach typically followed when tracing out "realistic" long term projections for the Norwegian economy. In short, the design aimed at producing results that could be given a comparative statics interpretation applying to two hypothetical descriptions of the Norwegian economy in 1987. First, we constructed a reference scenario describing a hypothetical base year (1987) situation for all simulation periods, in which no efficiency improvements had taken place. This was done by fixing all exogenous variables at their 1987-level[9]. Such a pre-reform scenario eventually becomes stationary after a transition period, in

[8] Strictly, this effect presupposes a positive correlation between profitability and productivity at the individual farm level, which may be violated if Government assistance is too strongly directed to the least productive farms.

[9] In some sectors the level of gross investment is exogenous. These levels were set equal to the level of real capital depreciation ensuring that the capital stocks in these sectors were constant along the simulated paths.

which resources are reallocated from production of capital goods. This reallocation of national income from savings, i.e. future consumption, to current consumption accounts for the main differences between the simulated hypothetical stationary base year situation and the observed 1987 situation. The alternative post-reform equilibria were simulated after perturbation of the exogenous variables mentioned above by the constant long run shifts, while keeping other exogenous variables at the same level as in the reference simulation. After some simulation periods the alternative scenarios also become stationary. Each one of these is interpreted as the hypothetical post-reform equilibrium in 1987 if the reform policy had been followed historically. Thus, when comparing the post- and pre-reform levels of private consumption, both figures should be interpreted as measures of a hypothetical maximal sustainable consumption level in 1987.

Note that our approach ensures that the hypothetical 1987-situation in the pre-reform scenario does not include any effects of the reform proposals suggested in the sector studies. If a more realistic projection had been chosen as a reference scenario, it is likely that such a scenario would incorporate parts of the potential efficiency improvements found in the sector studies. The general equilibrium estimate of the efficiency gain would then include some degree of double counting.

4. The general equilibrium assessment of the total potential for efficiency improvements

4.1. Interpretation of macroeconomic equilibrium effects

As explained in the previous section, the consumption effects are basically due to simultaneous positive shifts in labour supply and factor productivities. In order to interpret the numerical results, it is useful to provide an intuitive explanation of the key macroeconomic effects of partial changes in these exogenous variables.

Increased labour supply

To see why relative prices must change when the labour supply increases, consider the hypothetical case where all prices are constant. Then exports, import shares and the input composition in each industry would also stay constant. The increase in labour demand necessary to balance the labour market, would be followed by a roughly proportional increase in the demand for real capital[10]. However, the MSG-5 simulations do not allow the capital stock to relative to the pre-reform scenario,

[10] The deviation from exact proportionality would have been due to different capital intensities in the different industries.

and equilibrium in the capital market commands an increase in the shadow price of capital. In the product markets the supplies produced by the additional labour supply, are absorbed by an increase in private consumption as long as exports, investment and Government consumption remains constant.

Turning to the impacts on the current account, the increase in private consumption and intermediate inputs would cause imports to grow, thus violating the fixed current account constraint. Restoring the external balance requirement calls for a decrease of the Norwegian price level relative to the exogenous world prices through a fall in the wage rate. Notice that the adjustment of the wage rate must also compensate for the endogenous rise in equilibrium costs of capital. The economy becomes more labour intensive due to the reduction of the real wage rate for two different reasons. First, factor substitution takes place within the individual industries. Second, the price sensitivity on the demand side causes expansion of the relatively most labour intensive industries and contraction of the most capital intensive industries. Holmøy (1992) provides a more comprehensive analytical description of the various substitution effects in MSG-5.

In the new equilibrium the increase in production capacity has been absorbed by higher private consumption. Imports have increased since, empirically, the decline in the price sensitive import shares represents a weaker effect than the income effect on import demand. The import growth has been financed by a rise in exports made possible by a depreciation of the real exchange rate, i.e. the ratio between Norwegian and international price levels. However, this effect, which follows from the Armington specification of foreign trade, implies that the benefits from the growth in the labour endowment can not be enjoyed without a loss in terms of trade. Accordingly, the consumption possibilities increases by less than GDP.

Positive productivity shifts

Improved labour productivity implies an increase of the effective labour supply. There is also an additional effect working through the reduction of unit costs in domestic production. Competition forces prices to follow the reductions of unit costs. These price effects are spread through the economy by the input-output structure that links domestic prices to each other. Thus, prices of produced factors of production, including real capital, are reduced relatively to the wage rate. Moreover, the international competitiveness of Norwegian industries improves resulting in export growth and lower import shares.

Since the capital stock is not allowed to adjust, the positive shift in the demand for capital must be neutralised through a rise in the equilibrium rate of return. The impact on the equilibrium wage rate is ambiguous. The negative price effect of the productivity calls for a higher wage rate in order to re-establish the necessary international competitiveness. On the other hand, the positive income effect on net imports, as well as the price effect of the rise in capital, implies a downward pressure on the wage rate.

4.2. Simulation results

The results from the MSG-5 simulations are presented in table 4.1 below. The simulated welfare gain in terms of consumption growth equals NOK 94.0 bill. when measured in 1987 prices. A small fraction of the consumption growth is due to reduced gross investment. This is due to a negative covariance between the reallocations of the fixed aggregate stock of capital and the industry and asset specific rates of capital depreciation. The negative covariance implies that the aggregate capital stock is reallocated in a way which reduces the average rate of depreciation.

Table 4.1. Macroeconomic effects of all sector reform proposals. Volumes in bill. 1987-prices

Consumption	*94.0*
Net exports	0.9
Exports	18.4
Imports	17.5
Gross investment	- 3.3
GDP	91.6

The corresponding partial equilibrium estimate, obtained by adding gain estimates from the partial sector studies, equals NOK 109.6. bill. In other words the latter estimate includes a positive bias equal to 100 x (109.6 - 94.0)/94.0 = 16.6 per cent. The subsequent paragraphs discusses the main reasons behind the discrepancy between the two estimates. The discussion is organised according to the points mentioned in Section 3.1.

Choice of Shadow Prices

First it is principally and empirically important to make clear that the price concepts underlying the evaluation of the welfare gains are not the same in the partial and the general equilibrium approach. The subsequent discussion explains why a consistent evaluation based on a common set of shadow prices increases considerably the upward bias of the partial equilibrium estimate.

The partial equilibrium estimate uses average factor prices paid by the producers as shadow prices. Assuming competitive behaviour, these factor prices equal the value of the marginal product of the factor when employed in a sector paying average factor prices. However, the precise value concept in this context is production evaluated at *producer prices*. Consequently, the partial equilibrium estimate of the total welfare gain measures the *producer value* of the output produced by re-employment of wasted resources.

On the other hand, the estimate of the total welfare gain obtained by simulating MSG-5, equals the growth in consumption, which is measured in fixed *consumer* prices. Indirect taxation makes the aggregate consumption evaluated at consumer or market prices substantially higher than the corresponding volume evaluated at producer prices. A rough estimate of this difference can be obtained by comparing GDP evaluated at the two set of prices. For 1987, the producer[11] value of GDP equals 88 per cent of the consumer value of GDP. Since both the reference and the alternative scenarios in our calculations differ from the observed situation in 1987 with respect to the composition of GDP, this ratio will take on a somewhat different value in the simulations. However, it is suggestive for the order of magnitude. If anything, the average tax wedge between consumer and producer prices in our computations is likely to be even higher because the GDP share of consumption, which is taxed higher than other final delivery components in GDP, is larger in our simulations than the observed share. The sum of partial gain estimates can be approximately evaluated at consumer rather than producer prices by multiplying the reported estimate by the factor 1/0.88 = 1.14. The resulting sum of partial gain estimates then becomes NOK 109.6 x 1.14 = 124.5 bill. in 1987- consumer prices. Consequently the reduction of this estimate due to general equilibrium effects increases to 124.5 - 94.0 = 30.5 bill. Alternatively, *compared to the MSG-5 calculations the sum of partial gain estimates includes a positive bias equal to 100 x 30.5/94.0 = 32.4 per cent when both estimates are measured in consumer prices.* This bias is substantial.

Endogenous prices and marginal productivities

There are two main reasons why the general equilibrium effects contributes to a reduce the estimated total welfare gain. First, there is diminishing returns to partial increases in the production factors. The strong increase in labour supply relative to the increase in the supply of other factors can not be absorbed without reducing the marginal productivity of labour. Second, the negative income effect on

[11] Strictly, the National Account concept «basic prices» rather than producer prices has been used in this comparison. However, the choice between theese price concepts has no empirical significance.

the trade balance can not be neutralised by increasing Norwegian market shares in foreign and domestic demand unless the prices of Norwegian tradables are reduced relatively to the fixed world prices. The empirical importance of both effects are, however, crucially dependent on the degree of openness of the Norwegian economy. This point justifies a more careful examination of the implications of the modelling of foreign trade in small open economies.

For the sake of reference, a Small and completely Open Economy (SOE) can be defined as an economy that produces tradables only, and all product prices are fixed world prices. The reason why the SOE represents an interesting reference case, is that the factor prices will be independent of changes in factor endowments under some restrictions on production functions and the changes in endowments, see e.g. Woodland (1982). The SOE will absorb the changes in labour supply by reallocating resources from the least to the most labour intensive sectors (the Rybczynski effect). Accordingly, the closer a CGE-model is to the SOE-model, the less sensitive will the marginal factor productivities and the factor prices be to changes in factor supplies. It follows that the accuracy of the partial equilibrium approach will be improved the more equal the actual economy is to the SOE.

Compared to the SOE the degree of openness of the Norwegian economy, as described by MSG-5, is restricted in several respects. Most importantly, industries producing either non-tradables or tradables subject to protective trade policies employ a much larger share of the production factors than industries exposed to international competition. In addition, MSG-5 like several other CGE-models, adopts the Armington hypothesis, according to which tradables produced in the Norwegian exposed industries are close but imperfect substitutes for corresponding products from other countries. Thus, export growth and lower import shares require a reduction in Norwegian prices relative to the corresponding world prices.

However, although MSG-5 is widely different from the stylised SOE model, modified Rybczynski effects still play a role in the model. For example, when the increase in labour supply brings about a reduction in the wage rate, the price of labour intensive products[12] will decline relative to other products. As long as the price elasticities of the demand for these products is not particularly low relative to other products, labour intensive industries will crowd out production in other industries. Although the Armington specification excludes infinite price elasticities, tradables are much more price sensitive than sheltered commodities. The resulting contribution in favour of a more labour

[12] Factor intensities should be measured after correction for the indirect use of primary factor through the input-output system.

intensive industry structure modifies the need for downward adjustment of the wage rate and the marginal productivity of labour. In MSG-5, however, the Rybczynski effects are modified and often dominated by several other equilibrium adjustments. The most important ones were described in Section 4.1. A more elaborate discussion is given in Holmøy (1992).

The modification of the total efficiency gain caused by lower export prices can be approximated by the change in the fixed prices value of net exports[13]. That is, exports evaluated to NOK 0.9 bill in 1987 prices could have been consumed if export prices were constant. This figure accounts for 5.6 per cent of the discrepancy between the general equilibrium estimate and the added partial estimates of the total efficiency gain. This figure is not an exact measure of the negative terms-of-trade effect on welfare. The primary reason is that if commodities are consumed rather than exported, they are evaluated at consumer prices, which exceed export prices by the effective indirect tax rate on consumption. Consequently, export prices underestimates consumers' willingness to pay for the exported products.

One might expect that the endogenous adjustments of marginal productivities and prices would have been less significant if the capital stock were allowed to increase in order to equate the marginal return to capital to the world market interest rate. However, simulations on MSG-5 with the appropriate closure rule show that this is not the case as far as the stationary long-run results are concerned. Under this alternative closure rule the capital stock would have grown by roughly the same proportion as employment as long if the wage rate were constant. The capital accumulation crowds out private consumption during the first periods and yields a return in terms of a stronger long run growth in private consumption compared to the case where the capital stock is kept constant. The expansion of the economy implies a positive income effect on imports compared to the simulations based on a fixed capital stock. Consequently, the equilibrium reduction of the wage rate must be stronger under this closure rule in order to raise exports by a sufficient amount, and there is a stronger modification of the welfare gain through the terms of trade effect.

As to the impact on the estimate of the welfare gain, endogenous capital formation requires that the changes in consumption in the different periods are weighted together in a dynamic welfare measure. As MSG-5 has not incorporated intertemporal behaviour such an evaluation can only be done by additional ad hoc calculations. As shown in Norman *et al*. a first order approximation of the welfare

[13] In Norman et al. (1991) the estimated welfare loss due to reduced export prices is equal to NOK 5.9 bill., which is much larger than the figure used in the text.

gain indicates that allowing the capital stock to adjust has minor influence on the estimated welfare gain. The same conclusion is derived in Vennemo (1992).

5. Conclusions

This paper has made a case for the use of CGE-models in the evaluation of welfare effects of structural policy that targets inefficiency problems at the micro level, even if this level can not be described in an operational CGE-model. The CGE approach solves the problems that correct shadow prices are unobservable in practice. The effect on the welfare estimate due to endogenous shadow prices is more significant the more serious are the initial inefficiency. On the other hand, if elimination of inefficiency basically generates an increase in factor supplies, the CGE modifications of the partial equilibrium estimates will be smaller the more equal the textbook model of a small open economy. The approach taken in this paper suggests that general equilibrium effects have substantial influence on the estimated welfare gain, at least when the initial waste of resources is as large as reported in the sector studies for Norway.

The paper has also discussed how static measures of inefficiency, derived from detailed sector studies, can be implemented in a CGE-model that recognises at least parts of the real world dynamics. The discussion reveals that it is not straightforward to design the model simulations appropriately. The solution suggested in this paper implies a much higher degree of abstract interpretation of the simulation experiment than is usually required when CGE-models are employed for long-run projections of economic growth. Neither is it obvious how partial sector assessments of efficiency improvements should be interpreted.

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Appendix A.

A summary of the identification and quantification of potential efficiency improvements in partial sector studies

A.1. Public services

Education

Three sector studies, covering respectively *Primary and secondary schools*, *Junior colleges* and *Universities and colleges*, estimated to what extent it was possible to reduce the input of time spent by pupils, students and teachers without reducing the quality of the educational system.

Primary and secondary schools:

Robertsen and Friestad (1990) applied a micro simulation model of the cost structure in the primary and secondary schools teaching children ageing from 7 to 15 years. This model can be used to estimate how input of resources is affected by different assumptions about how these schools are being operated. The calculations used in Norman *et al.* (1991) are based on an alternative where neither the working time for teachers nor the average size of schools is in conflict with any official standard requirements in Norway. The increased efficiency implies that the pupil/teacher ratio rises from the 1989-level of 10.7 to 15.8, which is equal to the Norwegian average in the mid-seventies. The corresponding ratio was 17 in both Netherlands and West Germany, which equals the ratio for Norway in 1970. Robertsen and Friestad points out that only half of the decline in the Norwegian pupils/teacher ratio can be attributed to various reforms in the Norwegian schools system during 1970-1989. Furthermore, there is no evidence indicating that Norway has "better" schools than these countries.

A far more significant source of potential efficiency improvements is to let children start school at the age of six rather than at seven. Such a reform would bring Norway in line with most other countries with respect to the age when children start school[14]. *Cet. par.* the long run effect would be an increase in the labour force by one cohort, i.e. about 2.5 per cent or 60.000 man years. Norman *et al.* (1991) judged the historical reasons for starting school at seven rather than at the age of six not to be valid anymore. The final assessment took into account that the reduction in the average age of children in

[14]In fact, the reform in 1997 implies that children start schooloing at the age of six.

the primary school requires an increase in the teacher/pupil ratio. On the other hand, such a reform will reduce the amounts of resources used on nursery.

Junior colleges:

Øvereng (1990) identifies the following possibilities for cost reductions: 1) An increase of the size of classes where this is not in conflict with pedagogical principles, would reduce the number of teachers by 6 per cent; 2) Reducing the number of optional subjects to be chosen by the students would save 1 per cent of the teachers. Accordingly, the total number man years used for teaching in Junior colleges could be reduced by 7 per cent. This was considered to be a very cautious estimate since it did not include the effects of capacity problems, especially pronounced within vocational training, causing Junior college students to waste time on irrelevant courses and/or relatively unproductive work.

Universities and high schools:

According to Andersen (1990), the main problems in higher education appear to be that too many students leave before finishing their education, and that the average student uses too much time in order to obtain his final exam. Resources could therefore be saved if the academic institutions promote exits at an earlier stage or if they could increase the share of students who finished their studies through positive efforts. The report mentions three major reasons to excessive time consumption at Universities: 1) Waiting in queues as a way of allocating the limited capacity within different branches of study to students; 2) Students finance part of their consumption by taking irrelevant work due to borrowing constraints; 3) Insufficient pedagogical support from the institutions[15]. The report points out some measures which could be used to provoke earlier desertions and reduce the students' time consumption. In order to assess the net benefit from such changes, one should in principle subtract the utility of just being a student. Such information is not available. On the other hand, it has not been taken into account that the social value of time is higher after graduation than before.

Health services

Grund (1990) points out that the institutions within the health system probably have managed to increase their cost efficiency during the last years. However, he still calculates a substantial potential for further cost efficiency improvements, see Table 2. This potential is related to very significant differences in efficiency, measured by unit costs, between relatively similar institutions. In short,

[15] Andersen (1990) mentions that the representative student in the late 1980ies is occupied with irrelevant paid work 10 hours a week, whereas the number of hours used on studies were only 26. The average age of graduates has increased since 1970 for all subjects in the Universities. On average the increase has been from 26,5 to 28 years. For humanistic subjects the increase has been from 29 to 35 years.

Grund estimates that 12,5 per cent of the labour input in health services can be saved if the best practice technology is implemented everywhere. However the implementation of the best practice technologies is not costless. On the other hand Grund has not considered the possibilities of a better utilisation of the capital stock within the institutions. No quantitative information is available about these two effects. As a "neutral" assumption Grund's estimate was chosen.

Administration in the government sectors

Johnsen (1990) examined the potential for efficiency gains within internal administration in the government sector. From comparative studies of Sweden and Denmark, and of different public institutions in Norway, Johnsen estimates that 12,5 per cent of the Government employment is occupied with unnecessary internal administration of zero social value. In health care and education the share of the employed occupied with internal administration is lower, and we assume a potential equal to 10 per cent of the man years for these two sectors. The potential for reduction in material inputs was assumed to be of the same relative order.

A1.2. Sectors strongly regulated by the government[16]

Domestic transport

The composition of transport services in Norway, reflects partially the topological characteristics of the country and location of the population. The relative importance of transportation by sea, air and car is greater than in other countries. However, Hiorth (1990) argues that Norway could benefit from further adjustments to these characteristics. Based on Hiorth's study, Norman *et al.* (1991) recommends

- a shift in long distance transport of passengers and goods from least profitable parts of the railroad system to road transport and aircraft,
- replace parts of the existing ferries and ships used in coast traffic by more modern ones,
- a shift from the use of private cars to bus and train in and outside the large cities,
- deregulation of different transport markets (busses, ferries, ships, aircrafts).

[16] Norman et al. (1991) includes the electricity sector in this group of sectors. Bye and Johnsen (1990) estimates inefficent allocation of hydro power between different consumer groups. Such kind of inefficiency was not possible to describe in MSG-5 when the calculations were undertaken. Consequently, inefficiency in this sector has been omitted in the present paper.

Hiorth calculates the yearly loss caused by too low investments in the road system, to be about NOK 2,9 bill. in 1987 prices. A major share of this figure can be attributed to suboptimal financing of the road investments.

A comparison with the Swedish truck sector shows that the Swedish efficiency is 31 per cent higher than the Norwegian. Hiort attributes most of this gap to unnecessary slack in capacity utilisation. Norman *et al.* (1991) considered a 10 per cent increase in efficiency to be a cautious estimate of the potential. In fixed 1987 prices the partial equilibrium estimate of the welfare gain from eliminating this slack would be NOK 2,6 bill.

It should be noted that the welfare estimate in Norman *et al.* (1991) did not include any benefits from changes in taxation from the present system which taxes car *investment* to a system taxing the *use* of cars. The present system makes it optimal to keep the cars too long causing excessive costs related to maintenance and repairs.

A1.3. Efficiency losses caused by the transfer system

The transfer system includes transfers between urban and rural regions organised through assistance to the primary production sectors agriculture and fishery, transfers between domestic households through the social security system, and international transfers through foreign aid.

Fishery

The government transfers to fishery can be traced back to the mid-fifties. The support was initially intended to be limited to years with exceptional low catches and to be of transitory character. However, it became a permanent and important income source for the sector peaking in 1981 when it accounted for 90 per cent of its factor income. In the late 1980's the direct government transfers equals about 20 per cent of the sector's value added. This is really a paradox since Norwegian fishery is based on some of the world's richest natural resources and fishermen and equipment of high quality. In other countries, e.g. Iceland, where the natural resources are quite equal to the Norwegian, the fisheries contribute a lot more to GDP. Hanneson (1990) explains the paradox as a result of a policy that has generated

- permanent large excess capacity,
- maintenance of an inefficient industry structure,
- excessive exploitation of the fish resources,

- an administration giving first priority to a maximum of employees and security against bank ruptcy.

Hanneson shows that the consequences of implementing the best practice techniques and structure in the various kinds of fishery would reduce the number of active fishermen by about 66 per cent (22.500 man years) and the number of employees in the processing industry by 50 per cent (7.000 man years). And this could be done without significant reduction in the sector's output. In addition, Hanneson estimates a reduction in the number of bureaucrats working in institutions administrating various supportive transfers to the fishery sector.

Efficiency improvement would also reduce the input of real capital and this effect is likely to dominate the need for new investment which is necessary when new technologies are to be implemented. Norman *et al.* (1991) considered a relative reduction in the capital equal to 50 per cent of the relative reduction of employment to be a cautious estimate.

In order to obtain these gains, Hanneson recommends a new policy based on the following principles. The role of the government is to find the optimal level of exploitation of the reproducible fish resources and to look after that the stocks of fish are not subject to excessive exhaustion by the fishery sector. The role of the fishery sector is to maximise the pure rent of these resources. The simplest and most effective way to achieve this goal is to replace the existent system of detailed regulations by a system of marketable quotas.

Agriculture

Through negotiations with the government the farmers have obtained arrangements which guaranty an average income level among farmers equal to the average for wage earners in manufacturing industries. This implied that the sector was subsidised by about 60 per cent or NOK 15 bill. per year at the end of the 1980's.

There are two main sources to efficiency gains in the agricultural sector. First, the historical and present output level of food products can be supplied by less input of factors[17]. Second, Norwegian consumers could benefit from trade liberalisation and free import of agricultural goods. Norman *et al.* (1991) confined the quantification of potential efficiency gains to the first source only. The reason for

[17] In addition, the calculations include the effiency gains from shutting down the (relatively small) part of production which is sold on the world market at strongly subsidized prices.

neglecting benefits from raising imports was of course not that it was considered to be empirically insignificant. Rather it was a consequence of serious problems in measuring the relevant shadow prices. In principle, import prices should be used as shadow prices in a free trade regime. However, in practice drastic reductions of the agricultural sector is not a flexible reversible process. Thus, the products should be evaluated by a set of import prices over a sufficiently long period. The actual observable world prices are unlikely to be representative indicators of their long run levels because world markets for agricultural products are heavily distorted through various kinds of government assistance, causing observed world prices to lie well below unit costs. This limitation of the potential efficiency gains introduces a negative bias to the estimated figures.

The estimated waste of resources was based on Aanesland (1990), who calculates the resource savings from eliminating inefficient excess supply and implementation of best practice technologies that were already in use in Norway in 1989. This methodology results in an estimated annual labour requirement equal to 19 400 man years. This figure should be compared to the actual number of farmers which are likely to have an alternative value as employees with normal productivity in other sectors. Based on official data (from «Budsjettnemda»), this number was 78.000. Implementation of the productivity improvements would therefore imply that the number of farmers can be reduced by ca. 58.000, or 74 per cent. In addition, a reform giving first priority to efficiency would also reduce the administrative bureaucracy both within the government sector and within the farmer's own organisations. Aanesland estimated that this effect would imply that as many as 12 000 man years could be re-employed in other sectors. Consequently, the total potential labour saving then becomes (58.000 + 12.000) = 70.000 man years.

The capital stock can not be reduced by the same proportion as labour. First, the new operating units will be more capital intensive compared to the current average. Second, parts of the capital stock in agriculture are types of consumption capital. As cautious estimate compared to Aanesland’s assessments, the report suggested that 16 per cent of the capital stock could be allocated to alternative purposes. Measured in 1987-prices, the total value of resources released for alternative purposes exceeds NOK 14 bill.

- The most important elements in a reform policy would be:
- Gradual, but significant increase in the official efficiency standard requirements that entitle farms to government transfers.

- Cancellation of the concession arrangements for greater and more efficient farms within the production of pork and poultry.
- Elimination of production limitations.
- Abolition of the income guaranty arrangements.

The social security system

Expenditures related to the social security system is the largest single category in the Norwegian government budgets. Outlays increased much faster than the general income level; from 7.9 per cent of GDP in 1967 to 15.3 per cent in 1987. The expenditure growth is due to both growth in the real value of transfers per recipient, and the inclusion of new categories of legitimate recipients. As a matter of fact, the total number of recipients entitled to long-term benefits increased from 476.000 persons in 1967 to 879.000 in 1987, that is 44 per cent of the labour force.

A large international literature concludes that economic incentives, depending on the design of the social security system, affect unemployment, absence due to illness, the number of receiving disablement benefits and the choice of retirement date. This literature defines the concept "*equivalent social security benefit*" as the level of the benefit which, combined with no paid work, gives the individual the same welfare as it has when working. Normally the equivalent benefit is lower than, but increasing in income from paid work. Only when the actual social security benefit is below the equivalent benefit, misuse of the system will not occur. The Norwegian system includes several benefits that are likely to exceed the equivalent level. In particular, illness benefits stands out in this respect.

Rødseth (1990) has estimated the loss of labour force which is likely to be generated by the design of the Norwegian social security system. He has done this separately for three kinds of social security benefits; unemployment, illness and disability. The results will necessarily depend on what the alternatives are to the present system. The alternative considered by Rødseth, is a privately funded system without public benefits.

Rødseth estimates that 25.000 man years per year are “lost” as a consequence of the present system of illness benefit payments instead of the alternative. The corresponding estimate for the system of unemployment benefits is 30.000 lost man years, and the number of lost employment caused by the rules for disablement benefits lies in the interval 105.000 - 138.000. Norman *et al.* (1991) regarded the upper bound of this interval to the most realistic point estimate.

Norman *et al.* (1991) included unemployment exceeding the NAIRU level as waste of resources. The report does however not point to any concrete policy reforms that can be used in order to achieve full employment. Any estimate of the NAIRU rate for Norway in the late nineteen eighties will be uncertain. Based on an estimate of 1.5 per cent, elimination of inefficient unemployment would imply additional labour supply equal to 140 000 man years in 1989.

Foreign aid

The foreign aid offered through the public budgets amounted to 1.1 per cent of national income in 1987, and Norway is therefore among the nations that offer relatively most aid to the developing countries. Of this amount 10 per cent was spent on temporary expedients. The rest, NOK 5.8 bill. was given as development aid, distributed between bilateral aid (3.2 bill.), multilateral aid (2.4 bill.) and administration (0.2 bill.).

Based on the arguments and documentation in Pedersen (1990), Norman *et al.* (1991) pronounce a very negative judgement on the effects of the part of the Norwegian foreign aid that is given for development purposes. Whereas there is no reason to suspect that the effects of temporary expedients offered to areas hit by catastrophes e.t.c. can be improved, recipients would be equally well off without any of the bilateral aid and half of the multilateral aid. In this case the administration too is waste of resources. The total value of wasted resources then becomes NOK 4,6 bill.. The relevant interpretation of “resources” in this case is net imports; a cut in the foreign aid would improve the Norwegian current account by the same amount without reducing Norwegian net wealth.

Appendix B.

A non-technical overview of the structure of MSG-5

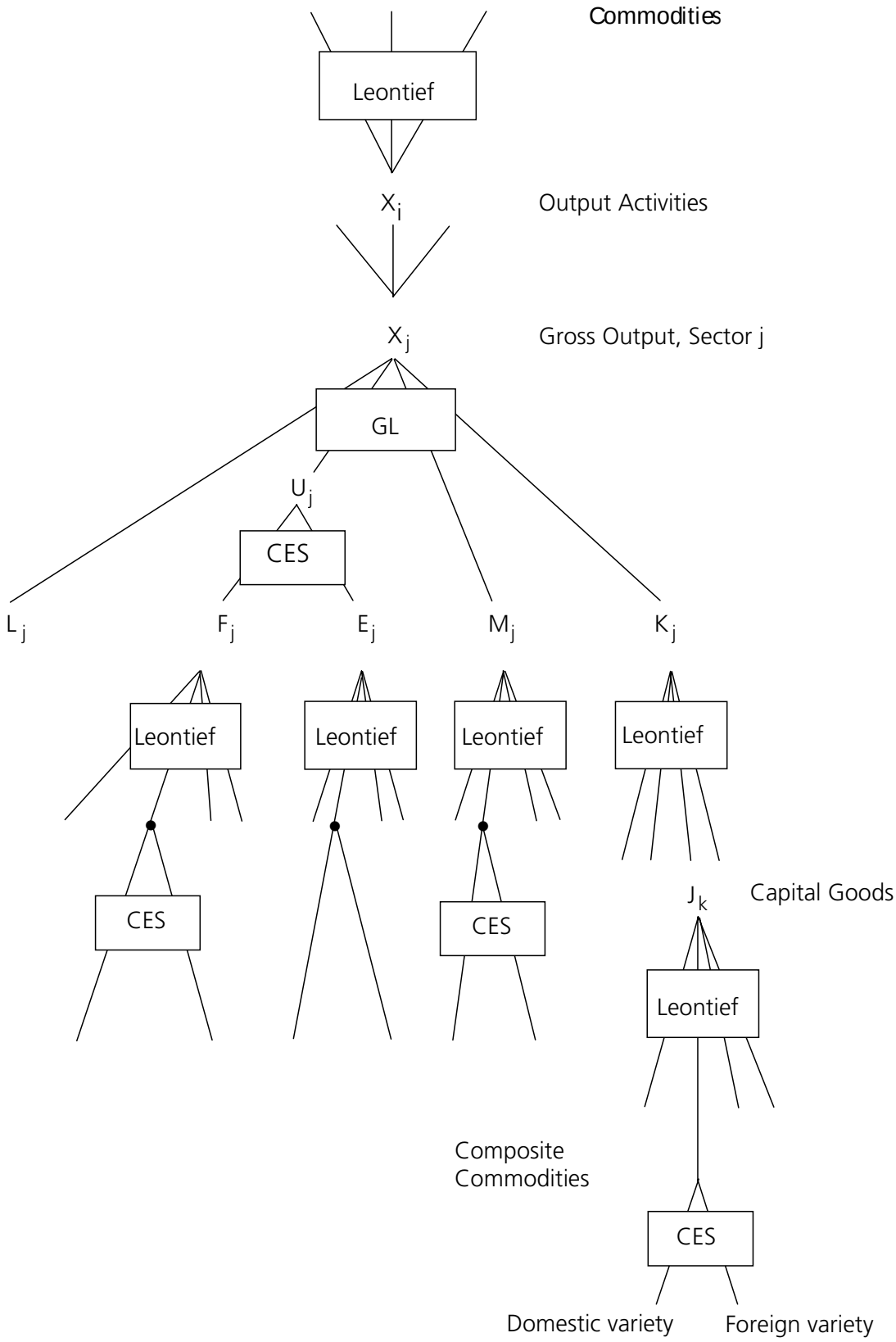
Commodity classification

The model specifies 41 commodities, of which 9 are non-competing imports and 4 are public goods. Except for non-tradable commodities and for non-competing imports, each commodity is a composite of a domestic and a foreign variety. Constant Elasticity of Substitution (CES) functions with constant returns to scale are used to aggregate a domestic and foreign variety of each commodity into a corresponding Armington composite. For each composite the elasticity of substitution is uniform across different sources of absorption. The share parameters in the CES-functions, which are calibrated to the National Accounts (NA) in the base year, vary both across commodities and by source of absorption.

Production structure and producer behaviour

28 private production sectors are specified. Firms within these sectors are assumed to behave competitively on both output and input markets. In general, each sector produces several commodities. With some exceptions, the output composition is fixed corresponding to the description given by the NA in the base year. The demand for inputs follows a two stage budgeting procedure, see Figure 1. At the "top" level the four input factors labour, capital, energy and other material inputs are optimally combined according to a constant returns to scale technology. The technology is specified in dual terms by Generalised Leontief (GL) cost functions estimated by Bye and Frenger (1992). Different kinds of technical progress can be studied through exogenous parameter shifts. At the "bottom" level, demand for energy is further divided into electricity and fuels according to a constant returns CES production function estimated by Mysen (1991).

Figure 1. The Structure of Production



Material inputs, electricity and fuels in each sector are sector specific Leontief-aggregates of the basic commodities. The capital stock in each sector is also a sector specific Leontief-aggregate of eight capital goods. Each capital good is a Leontief-aggregate of the basic composite commodities in the model. The user cost of each capital good takes the standard neo-classical user cost form augmented to include those parts of capital income taxation relevant to the producer decisions, see Holmøy and Vennemo (1995) and Holmøy, Larsen and Vennemo (1993) for detailed expositions.

Determination of prices

Prices are determined in MSG-5 according to the long-run equilibrium condition, which requires all entry/exit incentives to have vanished. Thus domestic producer prices equal unit costs, adjusted by net subsidies, in each industry. Due to the assumption of constant returns to scale, combined with exogenous output determination in those sectors where economies to scale is regarded essential, unit costs are independent of the scale of production. The only exception from this rule is hydro power electricity where diseconomies to scale implies a long-run supply function that is increasing in the electricity price. The relevant prices of commodities are purchaser prices including indirect taxes and trade margins.

Through the price-cost relations in the model, all endogenous domestic prices become functions of primary cost components. These are the sectoral wage rates, capital costs per NOK invested, import prices, productivity parameters, indirect tax rates and domestic prices of public services. Due to decreasing returns in the electricity sector, the domestic prices are in principle also dependent on the activity level in the economy through the electricity demand. However, the practical importance of this quantity effect is empirically negligible for most domestic prices.

The exchange rate is the numeraire in the model. Due to the assumption of domestic and foreign varieties being imperfect substitutes, domestic prices of tradables need not be equal to the corresponding world market prices. Exceptions from this rule are the prices of products from extractive and primary industries[18]. These products are assumed to have perfect foreign substitutes, so their prices equal the corresponding exogenous world prices.

Household consumption

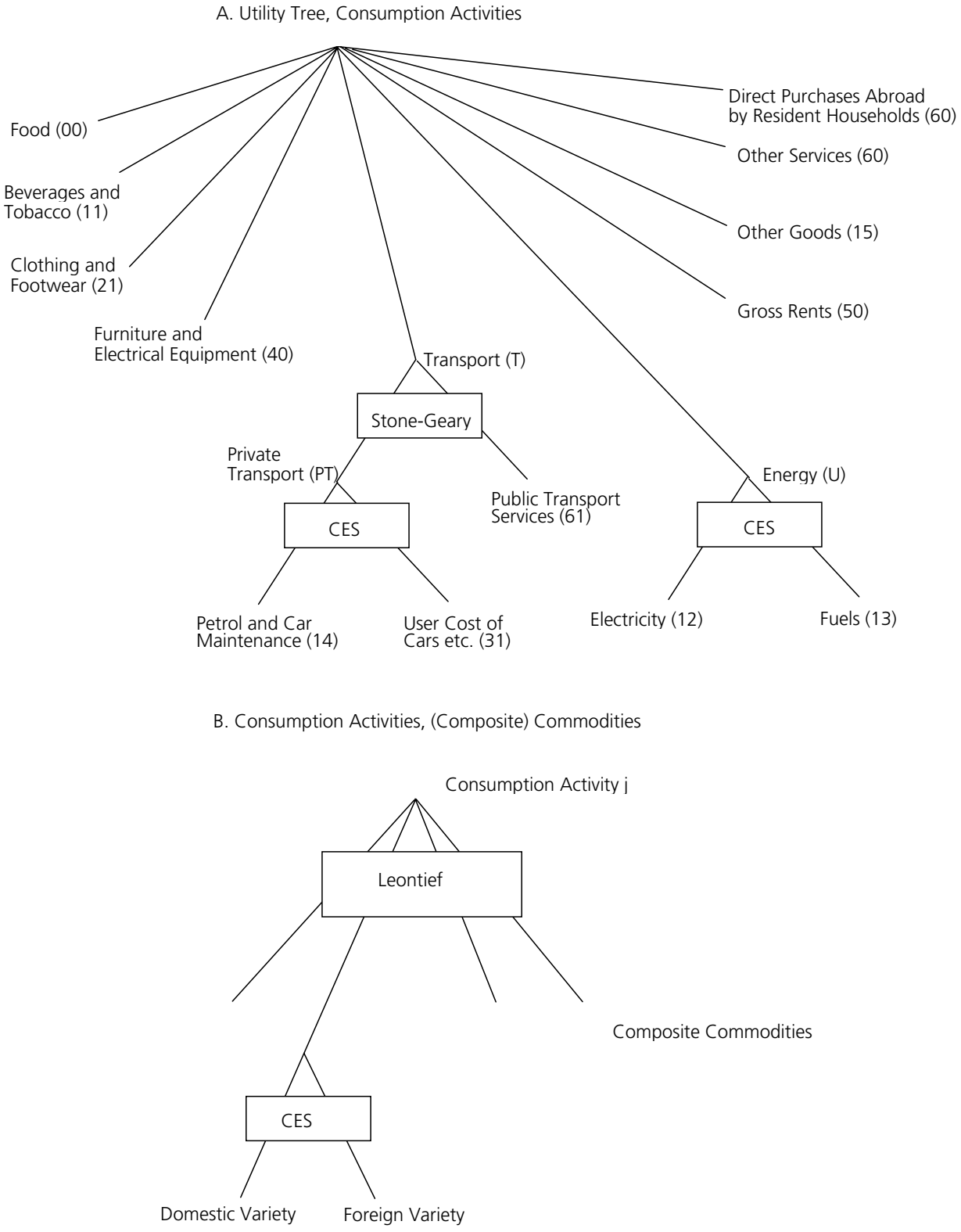
Household consumption demand is derived from utility maximising households. 14 household groups are specified, distinguished by socio-economic and demographic characteristics. The

[18] This include the products *Crude Oil, Natural Gas, Oil and Gas pipeline Transport,* and *Oil and Gas Exploration and Drilling, Leasing of Oil Drilling Rigs and Ocean Transport.*

mapping from various income categories to households is generated by data from the Norwegian Income Statistics.

As for the structure of the utility functions, weakly separable non-homothetic preferences are introduced (see Figure 2). At the top level, the households allocate total consumption expenditure to 10 consumption goods according to a non-homothetic linear expenditure system (LES) derived from Stone-Geary utility functions. At the intermediate level, consumption of transport services is allocated to private and public transport services according to a non-homothetic LES-system. At the bottom level both private transport services and energy are linearly homogenous CES-aggregates. A given level of private transport services requires services from the stock of cars and petrol and from car maintenance in proportions which are not necessarily fixed. The demand for energy can be satisfied by different combinations of electricity and fuels. The parameters are transformed from the microeconometric work described in Aasness, Biørn and Skjerpen (1988). The transformation procedure is discussed in detail in Aasness and Holtsmark (1993a, 1993b), where the properties of the household demand system are also discussed in more detail. *Commodity demand* follows from the assumption of fixed commodity-by-activity coefficients, see the second part of Figure 2.

Figure 2. Household Demand Structure in MSG-5



While the structure imposed implies strong restrictions on the Slutsky matrix and gives a recursive demand system, important features of the household's ability to substitute between specific activities are retained. Since the LES-system is a Gorman polar form, it also allows for perfect aggregation of the demand systems across households. Hence, aggregate consumer demand for each consumption good is a function of prices, aggregate consumption expenditure, the number of children, the number of adults less elderly in public institutions and the estimated levels of minimum consumption for the individual household types.

Foreign trade

The modelling of exports and imports is quite similar to what is implemented in the MODAG-model, see Cappelen (1991). Export demand is endogenous for most manufactures and for some services, which jointly cover about fifty per cent of total exports. For these commodities, Norwegian firms face export demand curves which depend negatively on the ratio between the domestic price and the exogenous world market price. In addition, an index for world market demand can shift this demand function. The export demand functions were estimated by Lindquist (1991). In MSG-5 the econometric relations are static and use the long-run parameters that can be deduced from the dynamic equations in MODAG. For the rest of the commodities, most notably *Crude Oil, Natural Gas, Oil and Gas pipeline Transport* and *Oil and Gas Exploration and Drilling, Leasing of Oil Drilling Rigs and Ocean Transport,* export demand is fixed by the model user. The same is true for exports of second-hand real capital.

Production of resource based commodities like primary industry products, crude oil and Natural gas, is exogenous and assumed to be determined by supply side conditions. Thus, for these commodities, the model only determines *net* exports as producers are assumed to be price takers on the world markets. Consequently, gross imports are determined residually as the difference between total demand and domestic supply. Except for non-competitive ones, imports of each of the remaining commodities are determined via import shares. The import shares are both commodity specific and, in general, depend on the demand component. For manufactured goods, which cover more than half of total imports, the import shares increase endogenously if the domestic price is raised relative to the corresponding import price. Formally, the import shares follow from Shephard's lemma as the derivative of the price of the composite good with respect to import price. However, the relative price dependence of the import shares is only commodity specific and does not vary across different kinds of domestic use. The substitution parameters are estimated by (1994). For services, except *Domestic Transport Services*, the import shares are exogenous.

Closure rule

Labour supply is exogenous in MSG-5. Two additional resource restraints were imposed by letting the aggregate stock of real capital and the current account be exogenous. The capital market and the exogenous current account are balanced by endogeneous adjustments of the shadow price of capital and the wage rate. The resource restraints imply that the aggregate private consumption level is determined basically from the supply side.

This closure rule implies somewhat artificial restrictions to the Norwegian economy. A more satsifactory model would allow intertemporal consumer behaviour to influence the total consumption time path, as well as endogeneous adjustments of the total real capital stock. Moreover, agents would take advantage of international capital markets implying a greater degree of separability betwen the dynamics of domestic demand and the domestic production possibilities. However, consistent incorporation of endogeneous accumulation of real capital and foreign debt in normative analyses, requires a fully intertemporal model. Unfortunately, it was not feasible to implement and solve an intertemporal version of the MSG model at the time when the simulations reported in Norman *et al.* (1991) were undertaken[19]. The chosen closure rule seems to be the most attractive one among the operational alternatives because it simplifies the normative interpretation of the model simulations. Consumption effects are basically due to efficiency gains, and not to growth in the resource base at the expense of future consumption reductions that is not accounted for in the simulations.

[19]Intertemporal behaviour has been incorporated in a new version of the MSG-model.