Population Ageing and Fiscal Sustainability: An Integrated Micro-Macro Analysis of Required Tax Changes

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Population ageing and fiscal sustainability: An integrated micro-macro analysis of required tax changes

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Abstract
Most studies on the economic consequences of ageing rely on Computable General Equilibrium (CGE) models that account for feedback mechanisms through changes in relative prices, tax bases etc. However, since individual labour supply behaviour is considered to be a key element in CGE-analyses of fiscal sustainability problems, the results of these analyses may depend crucially on how the labour supply behaviour is modelled. The current practice of combining a simplified representation of the tax and transfer system with the labour supply behaviour of a few representative agents may render a misleading description of incentives and revenue effects. The purpose of this paper is to demonstrate the importance of using an alternative strategy by integrating a detailed microeconometric model of labour supply, which is sufficiently flexible to capture a large variety of labour supply responses, with a large-scale CGE model. The integrated micro-macro CGE model is employed to explore how endogenous household labour supply behaviour affects and interacts with sustainability problems in Norway. The empirical results suggest that the required increase in the future tax burden is less dramatic when the analysis accounts for heterogeneity in the labour supply behaviour. Moreover, by replacing the current progressive tax system with a flat tax system it is found that the pressure on future public finances is significantly reduced.

Keywords: Population Ageing, Fiscal Sustainability, Labour Supply, Computable General Equilibrium

JEL classification: D58, H31, H50, J22

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1. Introduction

Most industrial countries will experience a substantial change in the age structure of their populations over the next fifty years that is first and foremost due to an increasing life expectancy and a slowdown in fertility. Ageing of the population is expected to have a major consequence for the economy since it may affect labour supply, capital accumulation and growth, the composition of demand, foreign trade and capital accounts as well as public expenditures and incomes[1]. The policy debate has focused most on the effect on public finances. The combination of ageing and welfare state schemes has strong direct effects on the government expenditures related to public old-age pensions, health services and care for the elderly, whereas the number of taxpayers may stagnate or even decrease. The current fiscal policy is not sustainable in most OECD countries; governments must sooner or later cut expenditures or raise taxes in order to keep the public budget balanced in the long run. This conclusion does also apply to Norway despite the fact that ageing in Norway is expected to be less rapid and dramatic than in other OECD countries[2], and moreover that the Central government is the owner of a petroleum wealth estimated to be twice the GDP in 2003[3]. Projections made by OECD[4] demonstrate that Norway actually faces one of the sharpest increases in government expenditures as a share of GDP in the OECD-area. The main reasons are the maturing of the pension system, and that pension expenditures are currently relatively low. According to projections in the Government's National Budget 2004 government expenditures related to old-age and disability pension benefits increase from 9 percent of GDP in 2002 to about 20 percent in 2050. The sustainable use of the petroleum wealth can finance less than 25 percent of these expenditures in 2050.[5] As the expenditures on welfare state related arrangements are largely financed on a pay-as-you-go basis, maintenance of the existing arrangements may require a larger rise in the tax burden than what will be accepted by the majority of the electors. Thus, an important challenge is to provide a good

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1 See Siebert (2002) for an overview.

2 United Nations (2001).

3 Statistics Norway (2003). This estimate of the petroleum wealth includes the present value of the net cash flow from the petroleum sector and the estimated capital in the Government Petroleum Fund by the end of 2003. The relative importance of the government petroleum revenues can alternatively be expressed in terms of the sustainable use of this wealth. According to the fiscal policy rule adopted from 2002 most of the current petroleum revenues collected by the government is saved as financial assets in the Central government Petroleum Fund. On average only the expected real return (4 percent at present) can be used each year. The fund is expected to increase from 54.2 to 93.2 percent of GDP from 2003 till 2010, reflecting a rapid transformation of petroleum wealth into financial wealth. The fiscal policy rule implies that the current use of petroleum wealth increases gradually to the permanent income level as the petroleum reserves are depleted. Measured as a share GDP the annual use of the petroleum wealth is then projected to reach a maximum of not more than 5 percent around 2030.

4 Antolin and Suyker (2001).

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projection of the future tax burden and examine to what extent the tax burden can be relaxed by introducing an appropriate income tax reform.

Evaluation of the long run economic consequences of ageing and policy adjustments requires development and use of Computable General Equilibrium (CGE) models capturing resource constraints, incentives and feedback mechanisms through changes in relative prices, tax bases etc.[6] However, to be tractable the labour supply behaviour of the CGE models normally relies on a few representative agents and rough and simple approximations of the tax and transfer system. Simplifications are of course inevitable in economic modelling. However, the aggregate "representative agent" style of modelling labour supply implies obvious drawbacks in studies concerning fiscal sustainability, since responses to tax- and social security reforms are key mechanisms in the public budget effects. Heterogeneity in behavioural responses may seriously violate the autonomy of aggregate labour supply functions. The lack of accuracy in the formal description of the tax- and transfer systems also makes it hard to evaluate proposed tax reforms. Moreover, aggregate models obviously limit the scope for distributional evaluations.

Empirical research on labour supply behaviour has been dominated by microeconometric work. This research has identified substantial heterogeneity in both supplied man-hours and the wage- and income elasticities. Thus, microeconometric models used to study labour supply responses of tax- and transfer reforms, typically provide a very detailed description of heterogeneous individuals constituting representative samples of the population. Heckman (1974) is probably the first exercise that performs an explicit structural modelling of preferences and budget constraints in order to simulate the effects of a reform of family-related benefits. Heckman took full account of the non-linearity of the budget constraint in the estimation and simulation of the microeconometric model. The problem addressed was an evaluation of a child related welfare policy that made significant complications in the budget set. Heckman proposed a particular method of recovering preferences by using the conditions to be fulfilled by the marginal rate of substitution for the labour supply function to be located on a particular point of the budget set. Shortly after, Burtless and Hausman (1978) proposed a method specifically addressed to piece-wise linear budget constraints. Both Heckman (1974) and Burtless and Hausman (1978) work through the implications of the Kuhn-Tucker conditions. These contributions account for complex budget sets but at the cost of using very simple and restrictive functional forms for utility functions or behavioural functions. Alternatively, very flexible and complex preference or behavioural functions are adopted (e.g. Blundell and Meghir 1985) but at the cost of replacing the exact budget sets by simplified approximations or in some cases even by linear subsets. Computational feasibility is

[6] Examples of recent projection studies of ageing and fiscal sustainability based on CGE models include Kotlikoff, Smetters and Walliser (2001) for the US, Pedersen and Trier (2000) for Denmark, Westerhout *et al*. (2000) and Beetsma, Bettendorf

the main reason for these choices. Most of these models are based on the "marginalist" version of the standard neo-classical model of leisure-income choice, where the derivation of a behavioural function (labour supply) involves comparisons between marginal variations of utility. The extension of the basic framework with constant marginal wage to more complex cases with non-linear and kinked budget sets is theoretically straightforward but computationally burdensome. The focus on these problems has first and foremost generated econometric research on estimation and computation problems and may explain why most behavioural models have been complemented with mainly illustrative policy simulation exercises based on some representative typology of households or using aggregate measures of welfare change such as average compensating or equivalent variation. During the last decade a novel approach has emerged, making use of models that allow for a representation of different degrees of availability of the opportunities in the choice set. For example, in a certain country, part-time jobs might be relatively difficult to find (maybe with differences from household to household). More generally, jobs of any kind might be more or less difficult to find (relative to non-market opportunities) in different countries, or regions, and/or for different individuals. These new models belong to the multinomial logit family or some extension of it (see e.g. Ben-Akiva and Watanatada 1981). They differ from the standard labour supply models by characterizing behaviour in terms of a comparison between utility levels rather than between marginal variations of utility. Eamples of applications to labor supply are Dickens and Lundberg (1993), Aaberge, Dagsvik and Strom (1995), van Soest (1995), and Aaberge, Colombino and Strom (1999). These studies do not model choice by means of a more or less simple formula representing the reduced form behavioral function (e.g. an equation expressing chosen hours of work as a function of wage, other income and socio-demographic characteristics). Instead, in a way, they mimic the actual process of choice by checking the alternative with the highest utility. Without entering here technical details that can be found in the references above, among others, the benefits of this novel approach are notable: the resulting models are fully structural and specify a flexible direct utility function to describe the preferences of single individuals or married couples. Moreover, they allow for any type of complexity in the choice set, including fixed costs of labor market participation, quantity constraints and different availability of different types of jobs and piecewise linearity of the budget constraints. Although the labour supply models that we use are strictly speaking *supply* models and do not contain an explicit representation of the (labour) demand side, they nonetheless permits taking into account employment/unemployment effects.

However, when the multinomial logit type of models are used as a basis for simulating the effects of policy changes, such as tax reforms, the partial equilibrium nature of these behavioural models is a

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and Broer (2003) for the Netherlands. Recent Norwegian studies are Ministry of Finance (2001) and Holmøy, Fredriksen and Heide (2003).

drawback. They ignore possible feedback effects from changed behaviour due to changes in constraints, since prices, wages and quantity constraints are kept fixed. Since the CGE studies lack what the microeconometric models highlight, and vice versa, these strands of research are complementary. Thus, the integration of the two approaches is certainly important, given that the purpose of empirical studies is to provide as realistic results as possible by exploiting all relevant available information. This paper meets this challenge. It demonstrates how a CGE model and a detailed micro econometric labour supply model can be integrated and used to provide new insight on the fiscal sustainability problems in Norway. More specifically, we discuss the following question: What is the required tax increase in a future situation characterised by a much older population, provided that 1) the current welfare state arrangements are maintained; 2) the current fiscal policy rule for using the petroleum wealth is maintained? Given our long run perspective, we find it relevant to consider adjustments in broad based tax rates and estimate the required change in the payroll tax when the current income tax system is maintained. Since labour supply responses are the driving forces behind the growth in the tax bases, we will get useful information from an evakuation of how the fiscal sustainability assessment is affected by a hypothetical flat tax reform. In this alternative reform we assess the necessary pay-as-you-go adjustments in a flat tax rate levied on all types of personal income. The effects of the flat tax reform become clear when we compare them with the results of the reform based on pay-as-you-go adjustments of the payroll tax rate.

The paper is organised as follows. Section 2 provides a brief description of the modelling framework, i.e. the macroeconomic CGE-model, the microeconometric labour supply model and how these models have been integrated in a joint simulation framework. Section 3 discusses three different long run scenarios: (i) A base line scenario in which individual labour supply is fixed; (ii) a scenario based on the same assumptions as in (i) except that individual labour supply responds according to the microeconometric model and (iii) a scenario where the existing income tax system is replaced by an endogenous flat tax rate. The two former scenarios use the payroll tax as tax instrument; i.e. the payroll tax is changed in order to keep the time path of the public budget surplus consistent with the fiscal policy rule. The third scenario examines to what extent our results depend on the design of income tax system. We focus on the equilibrium adjustments of labour supply, tax bases, public expenditures and the endogenous tax instruments. The interpretation emphasizes what can be learned from taking account of a detailed model of labour supply rather than an aggregate representation, the relative importance of the various general equilibrium effects, as well as the contribution to the labour supply effect from changes in real wages and non-labour income. Section 4 summarizes the conclusions and briefly discusses further research projects.

2. The integrated micro-macro model framework

2.1. The CGE Model

The CGE model, MSG6, of the Norwegian economy has been developed with a focus both on long run projections and analyses of tax policy and other structural policies.[7] It includes a detailed account of government expenditures and revenues. Specifically, the model determines equilibrium adjustments in the determinants of individual labour supply, i.e. consumer real wage rates, real non-labour income and tax rates. It is therefore relevant for our study. The following exposition focuses on the aspects of the model that are considered to be the most relevant for the present study. The most important equilibrium mechanisms are explained in Section 2.3 and in Section 3, where the simulation results are reported and discussed. Appendix 2 describes formally the macroeconomic structure of the model, and provides a more thorough explanation of the mechanisms behind the results in this paper.[8]

The model assumes that the Norwegian economy is too small to affect world prices in NOK[9] and interest rates. All agents have access to international markets for financial capital. Supply equals demand in all markets in all periods, which implies no unemployment. The resource constraints on the economy as a whole include the time endowment of the labour force, the technology of firms and an intertemporal budget constraint, which ensures that the net foreign debt does not explode.[10] In practice, macroeconomic growth is dominated by exogenous assumptions on growth in, respectively, Total Factor Productivity (TFP) in private business industries and labour productivity in government sectors. *Aggregate labour supply is exogenous in the CGE model as the microeconometric labour supply model determines this variable*. Goods and services, including those from labour and capital, are perfectly mobile across industries, and fixed capital is malleable.

By specifying 60 commodities, 32 private business industries and 7 government sectors, MSG6 provides a rather detailed description of indirect taxes, taxes of private companies in different industries and various industry subsidies. Compared to a more aggregate model, this contributes to make the calculations of government budget effects more accurate. Government employment, the

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[7] Statistics Norway has been engaged in CGE modelling since the late 1960s, and this work has resulted in several generations of MSG models. MSG6 should be regarded as a family of models, which differ with respect to closure rules etc. All of these versions differ radically from older MSG-generations. Depending on the issue, different model versions have been applied in Holmøy and Vennemo (1995), Fæhn and Holmøy (2000, 2003), Bye (2002). The Norwegian Ministry of Finance has regularly used different versions of the model to generate long run projections.

[8] We refer to Heide, Holmøy, Lerskau and Solli (2004) for a detailed description of the model and its empirical content.

[9] The exchange rate is fixed. This is an innocent assumption in a CGE model like MSG6, since the pass-through of exchange rate changes to all nominal prices is immediate and complete, leaving relative prices unchanged. The exchange rate can therefore be interpreted as a numeraire in the model.

government purchases of goods and services measured in fixed prices, and transfers before indexation are exogenous. In the simulations presented in this paper the public budget constraint is satisfied by endogenous adjustments of alternatively: a) the payroll tax rate, which works like a broad flat tax on labour income; b) a hypothetical flat tax rate on wages, capital income and transfers.

Most imported products are considered as close but imperfect substitutes for the corresponding domestic products. Thus, the import shares of these tradables fall as the import price increase relatively to the price of the corresponding domestic product[11]. Output and input in an industry can change both because of changes at the firm level and as a result of entry or exit of firms, which are heterogeneous with respect to productivity. Managers of private firms have model consistent expectations, and maximise present after tax value of the cash flow to owners. Producers allocate their output between the domestic and the foreign market. In most industries it is costly to change the composition of deliveries to these two markets. Whereas world prices of exports are exogenous, domestic producers of manufactures and services engage in monopolistic competition in their home markets[12]. The production functions at the firm level between output and a composite variable input factor exhibits decreasing returns to scale. The scale elasticities range from 0.85 - 1.00.[13]

2.2. The microeconometric labour supply model

The labour supply model used in this study can be considered as an extension of the standard multinomial logit model, and is designed to allow for a detailed description of the labour market[14]. The modelling approach for labour supply used in this study differs from the traditional marginal criteria models of labour supply in several respects. First, it accounts for observed as well as unobserved heterogeneity in tastes and choice constraints, which means that it is able to take into account the presence of quantity constraints in the market. Second, it includes both single person households and married or cohabiting couples making joint labour supply decisions. A proper model of the interaction between spouses in their labour supply decisions is important as most of the individuals are married or

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[10] This intertemporal national budget constraint reflects that households and the government obey their intertemporal budget constraints. The corporate sector is assumed to distribute all after tax profits to the owners of the companies, which include the households, the government and foreigners.

[11] The price elasticities of importshares rely on Naug (1994).

[12] This aspect of the technology is captured by assuming that output is a Constant Elasticity of Transformation (CET) function of deliveries to the export market and deliveries to the domestic market. Aukrust (1970) and Bowitz and Cappelen (1994) find empirical evidence supporting the view that Norwegian firms behave more like price takers on the export market than they do in the domestic markets. The mark-up ratios between the price of domestic deliveries and marginal costs are consostent with the econometric evidence in Klette (1999).

[13] Klette (1999) estimates decreasing returns to scale at the firm level in Norwegian manufacturing industries.

[14] Examples of previous applications of this approach are found in Aaberge, Dagsvik and Strøm (1995), and Aaberge, Colombino and Strøm (1999, 2000). The modeling approach used in these studies differs from the standard labour supply models by characterizing behaviour in terms of a comparison between utility levels rather than between marginal variations of utility. These models are close to other recent contributions adopting a discrete choice approach such as Dickens and Lundberg (1993), van Soest (1995) and Euwals and van Soest (1999).

cohabiting. Third, by taking all details in the tax system into account the budget sets become complex and non-convex in certain intervals. For expository simplicity we consider in what follows only the behaviour of a single person household.

In the model agents choose among jobs characterized by the wage rate *w,* hours of work *h* and other characteristics *j*. The problem solved by the agent looks like the following:

(2.1) $$\max_{(w,h,j)\in B} U(y,h,j)$$

subject to the budget constraint $y = f(wh,m)$, where *h* denotes hours of work, *w* is the pre-tax wage rate, *j* indicates other job and/or household characteristics, *m* is the pre-tax non-labour income (exogenous), *y* is disposable income, *f(.,.)* comprises the tax rule that transforms pre-tax incomes (*wh,m*) into net income *y*, *B* denotes the set of all opportunities available to the household (including non-market opportunities, i.e. a "job" with $\mathrm{w} = 0$ and $\mathrm{h} = 0$).

Agents can differ not only in their preferences and in their wage (as in the traditional model) but also in the number of available jobs of different type. Note that for the same agent, wage rates (unlike in the traditional model) can differ from job to job. As analysts we observe the chosen *h* and *w*, but we do not know exactly what opportunities are contained in *B*. Therefore we use a probability density function to represent *B*. Let $p(h,w)$ denote the density of jobs of type (h,w). By specifying a probability density function on *B* we can for example allow for the fact that jobs with hours of work in a certain range are more or less likely to be found, possibly depending on agents' characteristics; or for the fact that for different agents the relative number of market opportunities may differ. We assume that the utility function can be factorised as

(2.2) $$U\left(f(wh,m),h,j\right) = V\left(f(wh,m),h\right)\varepsilon(h,w,j)\,,$$

where *V* and ε are the systematic and the stochastic component, respectively. Moreover, we assume that ε is i.i.d. according to:

(2.3) $$\Pr\left(\varepsilon \le u\right) = \exp\left(-u^{-1}\right)$$

The term ε is a random taste-shifter that accounts for the effect on utility of all the characteristics of the household-job match observed by the household but not by us. It can be shown that under the assumptions (2.1), (2.2) and (2.3) we can write the probability density function of a choice (h,w) as[15]:

$$\varphi(h,w) = \frac{V\left(f(wh,m),h\right)p(h,w)}{\iint_{qz} V\left(f(zq,m),q\right)p(q,z)dqdz}, \tag{2.4}$$

which is analogous to the continuous multinomial logit model. The intuition behind expression (2.4) is that the probability of a choice (h,w) can be expressed as the relative attractiveness – weighted by a measure of "availability" *p(h,w)* – of jobs of type (h, w). The tax rule, however complex, enters the expression as it is, and there is no need to simplify it in order to make it differentiable or manageable as in the traditional approach. While the traditional approach derives the functions representing household behaviour on the basis of a comparison of marginal variations of utility, our approach is based on comparison of discrete levels of utility.

To account for the fact that single individuals and married couples may face different choice sets and exhibit different preferences over income and leisure separate models for single females and males and married/cohabitating couples have been introduced. The parameters of the models have been estimated on the basis of data for individuals between 25 and 62 years old from the 1995 Survey of Level of Living[16] by the method of maximum likelihood after choosing convenient but still flexible parametric forms for V and *p(h,w)*. We have restricted the ages of the individuals to be between 25 and 62 in order to minimize the inclusion in the sample of individuals who in principle are eligible for retirement, since analysis of retirement decisions is beyond the scope of this study. For a more detailed description of the data and definition of variables we refer to the appendix. The empirical specifications of V and *p(h,w)* and the estimation results are given in Aaberge et al (2006).

The behavioral implications of empirical labour supply models is normally displayed in terms of wage and income elasticities The elasticities of the random utility models given by (2.2) – (2.4) are computed by means of stochastic simulations of the model since - alluded to above- we (as analysts) do not observe all variables affecting preferences and opportunity sets. Draws are made from the distributions related to preferences U and opportunities B. Given the responses of each individual we then aggregate over the individuals to get the aggregate elasticities. Tables 2.1 and 2.2 report these

[15] See Dagsvik (1994) and Aaberge et al. (1999), who provide two alternative methods for deriving (2.4).
[16] For further details on the microdata we refer to Aaberge and Colombino (2006).

elasticities[17]. Since many individuals in this model of discrete choice will not react to small exogenous changes, the elasticities in Tables 2.1 and 2.2 have been computed as an average of the percentage changes in labour supply from a 10 percent increase in the wage rates.

Table 2.1. Aggregate labour supply elasticities with respect to wage for single and married individuals. Norway 1994

Family status	Type of elasticity	Female elasticities		Male elasticities	
		Own wage elasticities	Cross elasticities	Own wage elasticities	Cross elasticities
Single females and males	Elasticity of the probability of participation	0.12		0.04	
	Elasticity of the conditional expectation of total supply of hours	-0.09		-0.02	
	Elasticity of the unconditional expectation of total supply of hours	0.02		0.02	
Married females and males	Elasticity of the probability of participation	0.21	-0.19	0.23	-0.11
	Elasticity of the conditional expectation of total supply of hours	0.31	-0.23	0.16	-0.13
	Elasticity of the unconditional expectation of total supply of hours	0.52	-0.42	0.39	-0.23

The third and sixth rows of Table 2.1 give the unconditional elasticities of labour supply, which means that both the impact on participation and hours supplied is accounted for. Table 2.1 demonstrates that all own wage elasticities of married females and married males are clearly positive, whereas single females and males on average will only respond weakly positive to a wage increase. Second, we observe that all aggregate cross wage elasticities are negative due to the income effect. Thus, an increase in, say, the wage rates for males imply that the labour supply of his spouse goes down. The negative cross wage elasticities means that an overall wage increase give far weaker impact on labour supply, both for males and females, than partial wage increase for the two gender.

[17] Detailed income-dependent elasticities are reported in Aaberge and Colombino (2006). These elasticities show a sharp decline with respect to income.

Note also that hours supplied (given participationis) for married/cohabitating females are by far more responsive than participation. This result is a reflection of the flexibility of the Norwegian labour market, where jobs with part-time working hours are rather common. Moreover, rather generous maternity leave arrangements and subsidised kindergartens makes it is attractive for women to combine the raising of children and participation in labour market activities. By contrast, for single females we find that participation increases when wages increase, whereas hours supplied (given participation) decrease. A similar, but weaker, effect is found for single.

The simulated income elasticities are reported in Tables 2.2. Since the income elasticities are household specific, the aggregate labour supply response to a shift that involves changes in non-labour income, is the result of a complex calculation. Our simulations on capital income and cash transfers are unevenly affected by the general economic growth and the tax rate adjustments. Table 2.2 shows how the elasticity of labour supply with respect to changes in these income categories is estimated to depend on gender and household type.

Table 2.2. Aggregate labor supply elasticities with respect to non-labor income for single and married individuals. Norway 1994

Family status	Type of elasticity	Female elasticities			Male elasticities		
		Non-labour income (cap. income + cash transfers)	Capital income	Cash trans-fers	Non-labour income (cap. income + cash transfers)	Capital income	Cash trans-fers
Single females and males	Elasticity of the probability of participation	-0.79	-0.20	-0.71	-0.19	0	-0.08
	Elasticity of the conditional expectation of total supply of hours	-0.09	-0.03	-0.06	-0.05	-0.15	-0.02
	Elasticity of the unconditional expectation of total supply of hours	-0.89	-0.23	-0.77	-0.23	-0.16	-0.09
Married females and males	Elasticity of the probability of participation	-0.20	-0.11	-0.09	-0.23	-0.12	-0.10
	Elasticity of the conditional expectation of total supply of hours	-0.09	-0.04	-0.02	-0.10	-0.04	-0.05
	Elasticity of the unconditional expectation of total supply of hours	-0.30	-0.15	-0.11	-0.32	-0.16	-0.15

The major feature of the estimated labour supply elasticities can be summarised as follows:

- Labour supply of married women is far more elastic than for married men.

- Individuals belonging to low-income households are much more elastic than individuals belonging to high-income households.

As demonstrated by the review of Røed and Strøm (2002) these findings are consistent with the findings in many recent studies.[18]

Once the parameters have been estimated, we can simulate the labour supply effects of changes in the set of wage rates, non-labour income and tax rules. The simulation procedure works as follows. First, for each household we simulate the opportunity set with 200 points: one is the chosen alternative, the other 199 are built by drawing from the estimated *p(h,w)* density. Second, for each household and each point in the opportunity set, we draw a value ε from the distribution (2.3). Third, for each household we solve problem (2.1).

Aaberge and Colombino (2006) have demonstrated that the estimated random utility models used in this study reproduce the observed 1994 distributions of hours of work and disposable income rather precisely. To evaluate the prediction performance of the models estimated on Norwegian 1994 data Aaberge and Colombino (2006) used these models to predict the distributions of disposable income for couples, single females and single males in 1979 and 2001 by accounting for changes in taxes as well as in the composition of the population. The results of the out-of-sample predictions reported show that the models perform rather well[19].

2.3. Integrating the CGE model and the partial labour supply model

The micro-macro modelling framework works as follows: For given values on the after-tax real wage rate and non-labour income the micro-econometric model simulates the households' labour supply for a representative sample of households. The assessed percentage change in the supply of man-hours is inserted into the CGE model, in which labour supply is exogenous. The CGE model then computes the equilibrium adjustments in the real wage rate, the revenue neutral tax rate and non-labour income. Next, the changes in these variables are used as basis for changing the associated variables in the microeconometric model, which then produces new values for households' labour supply. The process continues until equilibrium values in the labour market are reached. Figure 2.1 illustrates the exchange of information in the iteration process.

[18] Of particular interest when it comes to the responsiveness of the low-wage workers is a randomised experiment in Canada, the Canadian Self-Sufficiency Project. Blank, Card and Robbins (1998) report an almost doubling of employment rates for person offered in-work benefits compared to a control group.

[19] See also Aaberge et al. (2006), who provide an evaluation of how the representation of choice sets in models of labour supply affect prediction performance of the models..

The iteration approach faces the problem of exchanging the comparative statics results derived from the microeconometric labour supply model with the time paths derived from the dynamic CGE model. In practice, it is not feasible to carry out the iteration process in every year within the time horizon (2050). Our solution to this problem has been to interpret our results as stationary long run effects. To this end we compute what we call a stationary equilibrium associated with the projected situation characterising the year in focus, say 2050. This is achieved by letting all exogenous variables be constant at their 2050-levels. The CGE model then computes a transition path where the stocks of real and financial assets converges to their stationary solutions, whereas resources used to produce the capital goods are gradually reallocated from production of capital goods to consumption goods industries. It is in this computation of stationary 2050-equilibria that we use both the CGE-model and the partial labour supply model iteratively. We discuss the problems related to iteration between a static and a dynamic model further in Appendix 3.

Figure 2.1. The interaction between the CGE model and the partial labour supply model

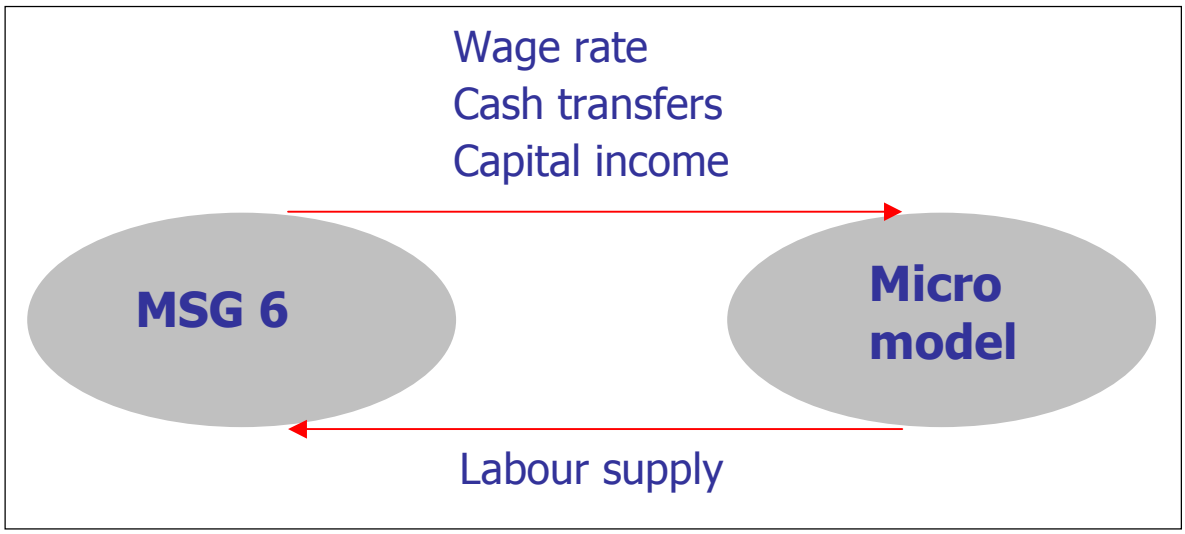
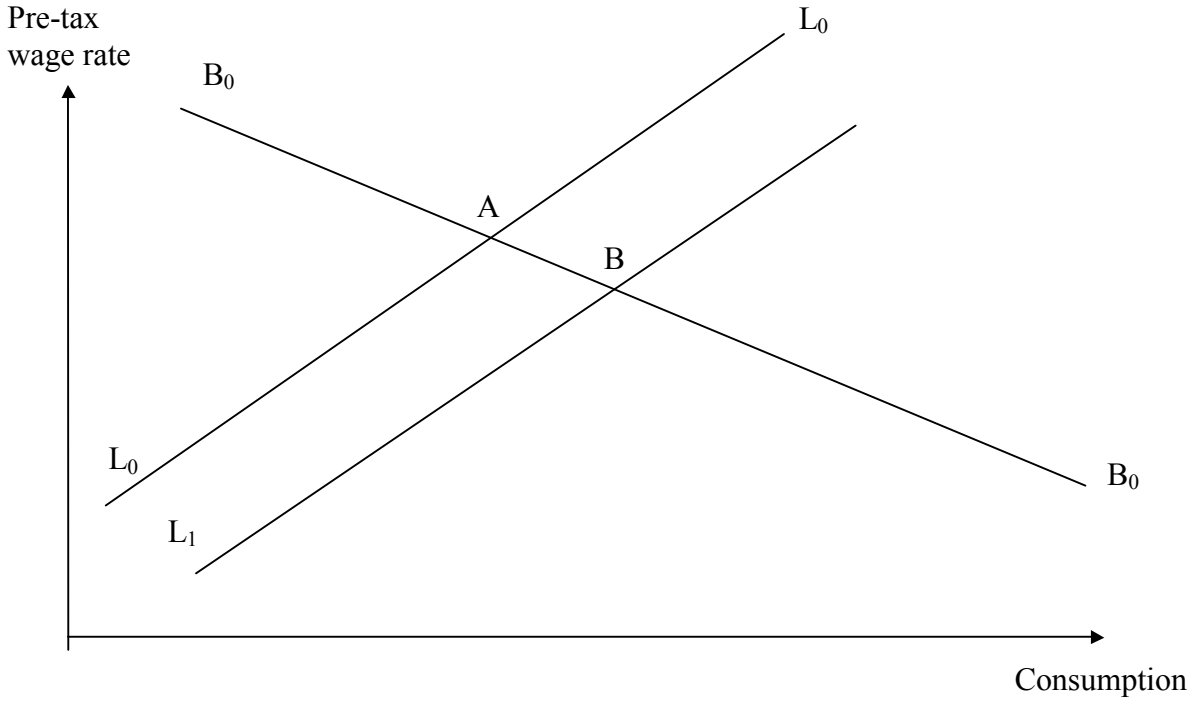


Figure 2.2 illustrates the equilibrium adjustment of the real wage cost per hour to a given increase in labour supply generated by the micro model. The LL- and the BB-locus describe reduced form long run equilibrium relationships between the producer wage rate and private consumption that are consistent with, respectively, labour market equilibrium and the budget constraint for the total economy implied by the external balance requirement. Since the loci capture reduced form equilibrium relationships, they account the equilibrium adjustments of all other endogenous variables as well. The point where the two loci intersect represents the stationary general equilibrium.

Figure 2.2. Equilibrium adjustments of the consumption level and wage rate caused by an exogenous increase in labour supply in MSG6



The *LL-locus* is upward sloping for the following main reasons: A partial increase in private consumption implies excess demand for labour. Increasing the wage rate restores labour market equilibrium because 1) firms substitute labour for other factors of production, and 2) changes in the industry structure reinforce the fall in aggregate labour demand. The latter effect can be explained as follows: The surge in the unit cost functions depends positively on the cost shares of labour. Higher costs deteriorate the international competitiveness of Norwegian producers. In particular export supplies are sensitive to higher costs. The result is a negative scale effect on labour demand. In addition, households will face an increase in the relative price of the most labour intensive products, and substitution effects contribute to a reallocation of resources from the most labour intensive to less labour intensive industries.

The main reason why *BB-locus* is downward sloping is that a partial increase in private consumption raises imports. The wage rate must fall in order to boost exports and reduce import shares so that the external balance is restored.

An exogenous increase in labour supply shifts the LL-locus from LL_0 to LL_1, since the wage rate must fall in order to raise labour demand for a given level private consumption. The BB-locus is unaffected by changes in labour supply. Thus, the new equilibrium (B) is characterised by higher private

consumption and a lower wage cost per hour compared to the initial one (A). Rybczynski effects are at work in MSG6, but they are modified by the changes in large labour intensive non-traded goods sectors and by decreasing returns to scale. In result, the labour supply expansion is not completely absorbed through a reallocation of resources in favour of the most labour intensive industries. Decreasing returns to scale necessitates a reduction of the wage costs, which induces firms to choose more labour intensive input combinations.

Note that although the real producer wage rate must fall, the consumer real wage may increase if direct taxes on labour income or indirect taxes on consumption are used to endogenously restore the government budget constraint. The reason is that the surge in employment, other inputs, output and demand expands most direct and indirect tax bases. The net budget effect of the changes in the wage rate is less important since both tax bases and government consumption are negatively affected. Assessments of the empirical importance of the various budget effects require a relatively detailed CGE model.

From the equilibrium adjustments in the wage rate and private consumption it is rather straightforward to explain the general equilibrium effects on other variables, see Holmøy et al. (1999). Focusing on labour supply decisions the changes in households' non-labour income deserve special interest. Capital income is increasing in labour supply since profits and output are positively related. Indexation is the only endogenous element in the cash transfers. From the discussion above the nominal consumer wage rate may increase if the decrease in the taxes levied on labour income is sufficiently strong.

3. Long run macroeconomic scenarios

3.1. A reference scenario with fixed individual labour supply

Our starting point is a reference projection of the Norwegian economy to 2050 in which behavioural effects on labour supply are neglected. This projection is based on the same assumptions as used in Fredriksen *et al*. (2003), which in turn relies heavily on the Norwegian Ministry of Finance (2001). The subsequent overview of exogenous assumptions is confined to the most important determinants of the endogenous payroll tax rate and of the individual labour supply responses simulated in the subsequent sections.

Key exogenous assumptions

Demography and resources: We rely on the projections in the middle alternative of the population projections in Statistics Norway (1999). The *labour force* is assumed to increase by 0.5 percent per year until 2010. Thereafter the labour force stays roughly constant throughout the scenario. Due to demographic changes measured in man-hours has increased by 12.8 percent from 1995 to 2050. The old-age dependency ratio, defined as those 67 and older relative to those of working age 20-66, rises from 22 percent in 2002 to 40 percent in 2050. Over the same period the ratio of people 80 years or older to those of working age will rise from 7.2 percent to 13.8 percent, and the number of old-age pensioners grows by 78.7 percent.

TFP grows by 1.3 percent per year in private business sectors. Taking decreasing returns to scale into account, this is in line with long run historical trends. In 2002 the export share of *petroleum* products was 42 percent, and taxes and petroleum revenues amounted to approximately 27 percent of total Central Government income. Estimates of the future petroleum revenues are of course very uncertain. Our assumptions are the same as those used in the Governmentss Long Term Programme 2002-2005, see Norwegian Ministry of Finance (2001). In our scenarios the net cash flow measured in current prices, declines from 170 billion NOK in 2002 to 128 billion NOK in 2010 and to 110 billion NOK in 2050. As Norway, especially the government, accumulates financial assets, the international interest rate is important for the national and government income. The nominal interest rate is 5.5 percent throughout the scenario, whereas all world prices, except petroleum prices, measured in NOK grow annually by 1.5 percent. A 4 percent real interest rate, measured in international purchasing power, is also the assumption underlying the present fiscal policy rule adopted in Norway in 2001.

Government expenditures: The time path of the government budget surplus is determined by the fiscal policy rule explained in Section 1. It is realised by endogenous adjustment of the payroll tax rate. The exogenous projections of Government consumption, in particular employment in Government sectors, are based on various models developed in Statistics Norway. First, government consumption within the sectors *health care* and *education* has utilised a model that decomposes changes in the input of labour and intermediate inputs into a) changes in the size of different age groups who differ in their use of public services; b) changes in the service and standards; c) changes in coverage ratios. We have made the rather cautious assumption that no changes take place in standards and coverage ratios beyond already approved reforms. A plausible interpretation is then that a scenario characterised by further growth in private consumption per capita involves privatisation of services traditionally provided by the government sector. Ageing alone implies an annual growth in government employment of 0.6 percent from 2002 to 2020, 1.1 percent in 2021-2030 and 0.8 percent in 2031-2040. Thereafter government employment grows by 0.3 percent per year.

The government expenditures related to public pension benefits have been projected by simulations on a detailed dynamic micro simulation model[20], designed for this purpose. This model simulates entry into public pension schemes based on old age, disability, widow(er)hood and early retirement. The relevant transition rates have been estimated on historical data. The total number of pensioners in 2050 is projected to be 57.8 percent higher than in 2002. The model also includes a detailed description of how the public pension schemes determine the individual pension entitlements. Government pension expenditures will also grow for the following reasons:

- According to political intention public pension benefits are indexed to wages, rather than, say, inflation.
- The public pension system, implemented in 1967, is still maturing as the number of pensioners entitled to supplementary pensions is still increasing. Measured in terms of unindexed benefits, the average old-age public pension benefit is projected to increase by about 20 percent from 1999 to 2050.[21] An important reason is the growth in female labour income.
- The scheme for occupational pensions guarantees employees in the government sector two thirds of previous earnings.
- The number of early retirees will grow during the next decades as it did in the 1990s. The early retirement benefits are partly financed by the government.[22]

Macroeconomic growth

Table 3.1 shows how the macro economic key variables grow from 1995 to 2050. The combined effect of exogenous growth in employment and TFP, as well as endogenous capital deepening, expands GDP by 1.7 percent per year as an annual average over the period 1995-2050. On average private consumption per capita can grow by an annual rate equal to about 2.5 percent without breaking the intertemporal constraint on net foreign debt. This implies a doubling of private consumption per capita in about 28 years. The deviation between the growth rates of private consumption and GDP is partly due to the moderate growth in government consumption, which may be interpreted as a higher degree of privatisation of services traditionally provided by the government sector. Also it reflects that a part of the present value of the private consumption is financed by the initial petroleum wealth.

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[20] See Fredriksen (1998) for a detailed description of this model (called MOSART) and of some applications.

[21] The unit of measurement in the Norwegian National Insurance System is the "Basic Pension Unit" (BPU). The average old-age pension benefit from the NIS is projected to increase from 2.1 to 2.8 BPUs from 1999 to 2050. More on this, see The Pension Commission (2002).

[22] A main reason to this has been the pension arrangement referred to as AFP (an abbreviation for the Norwegian term *Avtalefestet pensjonsordning*). Currently, AFP covers the entire public sector, employing about one third of all employees, and about 43 percent of private sector employees. This arrangement provides strong incentives to retire at the age of 62 years.

Table 3.1. Long run macroeconomic development with fixed individual labour supply and endogenous payroll tax rate. Variables are measured in fixed prices, except where indicated

	Simulated 1995-levels, Billions NOK	The ratio between 2050- and 1995-levels
Private consumption	418.6	5.3
Government consumption	195.4	1.6
Gross fixed capital formation	209.2	1.4
Exports	383.3	1.5
Imports	358.4	2.4
GDP	848.1	3.0
Real Average consumer after-tax wage rate	145.2	3.1
Real cash transfers received by households, net of old-age pensions	92.9	3.1
Real capital income received by households	294.2	2.8
Employment, mill. man hours	2975.3	1.1
Payroll tax rate, percent	13.1	2.0

A conclusion that turns out to be robust with respect to individual labour supply behaviour is that the expected ageing in Norway will *not* represent any strong drag on aggregate economic growth over the period 1995-2050. As mentioned in Section 2, the sustainable growth in consumption possibilities is determined almost solely by productivity growth, which is driven by the exogenous TFP-growth set in line with historical trends. The unique role of productivity as the fundamental growth determinant is not an artefact of our particular CGE model, but reflects common knowledge about economic growth. In particular, compared to variations in the TFP-growth rate, plausible variations in age structure of the population are of minor importance.[23]

Determinants of labour supply

The average annual growth in the nominal pre- and after-tax wage rate is found to be 4.2 percent when individual labour supply responses are ignored. It reflects the growth in the producer value of the marginal product of labour in the traded goods sector[24], which is primarily a result of the TFP-growth, reduced labour intensity in the input composition, and a growth in the world prices of 1.5 percent per year. The resulting annual growth in the pre-tax consumer real wage rate averages 2.2 percent. All tax rates but the payroll tax rate, are fixed along the base line scenario. This implies that the after-tax consumer real wage rate in 2050 is simulated to become 3.1 times the 1995-level. Non-labour income includes cash transfers from the government and capital income. Deflated by the consumer price

[23] The importance of productivity growth for the long run living standards is pointedly discussed in Krugman (1992, p.9), who declares: "*Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker.*"

[24] Note that it follows from the general equilibrium conditions that the traded goods sector is large enough to ensure that foreign trade is balanced in the long run. The size of the traded goods sector affects the value of the marginal productivity of the input factors because the model assumes decreasing returns to scale in most industries.

index, capital income and total transfers (net of old-age pension benefits which are not received by the labour force) would in 2050 be, respectively, 2.8 and 3.1 times the 1995-level.

Future tax burden

Ageing in Norway causes a substantial increase in the future tax burden. The payroll tax rate has to be increased from 13 percent today to nearly 26 percent in 2050 in order to meet the public budget constraint determined by the fiscal policy rule. This result is first and foremost due to the fact that the public old-age pension benefits are projected to increase from the current 7 to 20 percent of GDP in 2050. In 2050 old-age pension benefits grow to become 5 times as high as in 1995.

The increase in the payroll tax is almost completely shifted from firms to labour. This incidence works through two channels. First, as pointed out in Section 2.3, the wage cost per hour is basically determined by the producer value of the marginal labour productivity in a *sufficiently large* traded goods sector. Thus, in the new general equilibrium the increase in the payroll tax rate results in a reduction of the wage rate of roughly the same order of magnitude. The second channel of incidence is the pass-through of wage costs to the prices of non-traded goods.

The simulated figures illustrate a general insight: productivity growth in the private sector will not ease the pressure on public finances, provided that (i) public pension benefits and other public transfers are indexed by the wage growth; (ii) employment is unaffected by productivity growth. In Norway, the opposite is true. Those believing that productivity growth will ensure fiscal sustainability without increases in taxes or cut in government expenditures, should recognize the following mechanisms: The general equilibrium effect of a positive shift in TFP will be an increase in the wage rate in all sectors of approximately the same order as the endogenous increase in labour productivity. The resulting surge in household incomes and consumption will expand most of the tax bases by about the same proportion. An important exception in Norway is the petroleum revenue collected by the government. However, *cet. par.*, government expenditure also increases approximately proportionally to the wage rate because government consumption is dominated by wages, and because transfers are indexed to wages. Since the Norwegian government runs a fiscal deficit when petroleum net revenues are excluded, this non-oil fiscal deficit will increase as a result of TFP growth and reinforce the pressure on public finances.

3.2. Projections accounting for endogenous labour supply

Table 3.2 displays the predicted change in the key variables when we take into account endogenous individual labour through our integrated model framework. In the new stationary equilibrium in 2050 employment is 4.6 percent higher compared to the 2050-equilibrium base case, where labour supply

was supposed to change exclusively due to demographic changes. The behavioural effects come on top of the 12.8 percent employment growth from 1995 to 2050 caused by demographic changes. The isolated effects of endogenous labour supply on the estimates of GDP and private consumption in 2050 are somewhat smaller than the percentage increase in employment, 4.0 and 4.2 percent, respectively. This is due to decreasing returns to scale in the private business industries and to a small reduction in the overall capital intensity in production. The reduction of the average capital-labour ratio is due to a decrease in the hourly wage cost relatively to other factor prices.

Section 2.3 explained why increased labour supply must lead to lower real wage cost per hour in order to keep the economy within the intertemporal foreign debt constraint when the private sector production functions exhibit decreasing returns scale. However, the endogenous reduction of the payroll tax is strong enough to give room for an increase in the wage rate facing workers. When individual labour supply is endogenous rather than fixed, the endogenous payroll tax in 2050 is reduced from 26 to 21 percent due to expansion of the tax bases. However, an increase in the broadly defined payroll tax rate from the present 13 percent to 21 percent still makes it adequate to regard the Norwegian fiscal sustainability problem as severe.

Table 3.2. Comparison of long run macroeconomic development with fixed and endogenous individual labour supply (L) and endogenous payroll tax rate. Variables are measured in fixed prices, except where indicated

	Ratio between 2050- and 1995-levels		Effect of endogenous L in 2050. Percentage deviations from base line
	Exogenous L	Endogenous L	
Private consumption	5.3	5.6	4.2
Government consumption	1.6	1.6	-0.8
Gross fixed capital formation	1.4	1.5	3.6
Exports	1.5	1.5	3.8
Imports	2.4	2.4	2.3
GDP	3.0	3.2	4.0
Real average consumer after-tax wage rate	3.1	3.1	0.8
Real cash transfers per capita received by households, net of old-age pensions	3.1	3.1	1.9
Real capital income per capita received by households	2.8	2.9	0.9
Employment, mill. man-hours	1.1	1.2	4.6
Payroll tax rate, percent	2.0	1.6	-19.2

Given that the consumer real wage rate would be 209.3 percent higher in 2050 than in 1995, the increase in labour supply of 4.6 percent may at first glance seem surprisingly small. A weighted average of the individual wage elasticities of labour supply reported in Table 3.3 equals 0.12. Note, however, that this is a local measure of the aggregate wage elasticity. A first-order approximation of the *wage effect* on labour supply from 1995 to 2050 would be to multiply this elasticity by the 209.3 percent growth in the consumer real wage rate. Such an approximation suggests that the wage growth contributes to a growth in labour supply by 25.1 percent. However, the growth in non-labour income must also be accounted for. A rough first-order approximation is that of the non-labour income effect on labour supply from 1995 to 2050 would multiply the aggregate labour supply elasticity with respect to non-labour income, which equals –0.17, by the 190 percent growth in total non-labour income from 1995 to 2050. Such an approximation suggests that growth in non-labour income contributes to a *reduction* of labour supply by 32.3 percent. The net effect of the two approximations is a reduction in aggregate labour supply by roughly 7.1 percent. By contrast, the simulated effect is a 4.6 percent increase. Thus, a first order approximation based on the local properties of the microeconometric labour supply model produces a very misleading impression of the effects of the large changes projected over the period 1995-2050.

In order to explain the deviation between the simulated effects and the first order approximation based on the local elasticities, it is necessary to take the global properties of the microeconometric model into account. Two global properties emerge as most important in this respect. . First, the wage elasticity rises by 17 percent when it is computed at the income levels projected in 2050 compared to the one computed in 1995, see Table 3.3. Secondly, the labour supply elasticity with respect to non-labour income is reduced (in absolute value) by income growth; in the 2050 situation it is about two thirds of the corresponding 1995-level. Taking into account the gradual changes in the relevant elasticities, the 4.6 percent increase in labour supply is well within what might be expected from a back-of-the-envelope check of the simulated results.

The aggregate labour supply elasticities may vary for two reasons: i) The micro elasticities are not fixed structural parameters but sensitive to changes in labour and non-labour income; ii) changes in the composition of aggregate labour supply between individuals with different elasticities. The latter effect clearly contributes to explain the increase in the average wage elasticity. The most wage elastic individuals increase their shares in aggregate labour supply. This positive correlation between changes in weights and wage elasticities raises the average wage elasticity. Although the outcome of the microeconometric model simulations are sensitive to the change in the income level, the pattern of negative correlation between labour supply elasticities and income is maintained; i.e. low-income families respond more strongly to changes in economic incentives than high-income families.

Table 3.3. Labour supply elasticities in 1995 and 2050. 1995 tax system

Labour supply elasticity w.r.t.	1995	2050
wage	0.12	0.14
non-labour income	-0.17	-0.12
wage and non-labour income	-0.07	0.04

General equilibrium effects also affect labour supply. As pointed out in Section 2.3, a positive shift in labour supply cannot be absorbed unless the real wage cost per hour declines in order to restore both labour market equilibrium and the intertemporal external balance constraint. As noted above, this adjustment takes place despite the increase in the real consumer wage rate due to the endogenous decline in the payroll tax rate. The increase in the wage rate facing workers implies an increase in the government cash transfers to households since they are indexed by wages. In addition, higher employment also raises the optimal capital stock and capital income. However, Table 3.2 shows that the general equilibrium effects that arise from changes in the labour supply behaviour account for minor modifications of the effects caused by 55 years of economic growth. The consumer real wage rate increases by 0.8 percent, whereas the cash transfers and capital income to households increase by 1.9 and 0.9 percent, respectively.

3.3. The effect of replacing the 1994 tax system by flat taxation

Is it possible to ease the future tax burden through tax reforms? This important question can only be given a tentative answer within the scope of this paper. We restrict our study to simulate the outcome of e the progressivity of the tax structure. More precisely, we simulate the equilibrium in 2050, when all personal income tax rates in the 1995 system is replaced by a flat tax tax rate levied on all labour market earnings, as well as cash transfers and capital income. on all income. Under this hypothetical system the government budget constraint is met through endogenous adjustments of the flat tax rate, instead of the payroll tax rate. In 1995 the revenue collected from the direct income taxes amounted to 24 percent of labour income, capital income and cash transfers.

The difference between the equilibrium in 2050 and the initial equilibrium in 1995 is now a result of a) growth effects between 1995 and 2050 accounted for in Sections 3.1 and 3.2, and b) the flat tax reform. Here we confine the discussion to examine the sensitivity of our projections in 2050 for those variables most relevant for the future tax burden. Table 3.4 and 3.5 shows how the effects of allowing for endogenous individual labour behaviour are affected by the tax system. Table 3.4 compares three different equilibria in 2050 with the corresponding 1995-levels. The first and second columns are identical to the second columns in, respectively, Table 3.1 and Table 3.2. In the third column, the 2050 projections in the scenario with endogenous individual labour supply and endogenous adjustments in the flat tax rate are compared with the corresponding observed 1995-levels. In Table 3.5 the first two

columns report the percentage deviations measured in 2050 between the two scenarios with endogenous individual labour supply and the base line scenario. The third column shows the equilibrium effects of implementing the flat direct income tax system in 1995 in terms of percentage deviations between the new equilibrium and the base line 1995-levels. Thus, the difference between the results of the second and the third columns captures how the pure growth effects work under a flat tax system.

The overall impression from comparing the results in Tables 3.2, 3.4 and 3.5 is that a flat tax reform would boost labour supply and cause a substantial increase the government net revenue. Endogenous labour supply behaviour under a flat tax regime generates a 16.7 percent increase in employment in 2050 compared to the projection based on fixed individual labour supply. The flat tax rate would have to increase from 24 percent in 1995 to 32 percent in 2050 in the case where individual labour supply was assumed to be fixed and not responsive to incentives. Relaxing this assumption and allowing for endogenous labour supply behaviour imply that the flat tax rate can be set equal to 22.9 percent in 2050. A flat tax rate of 18.3 percent provided sufficient tax revenue in 1995. Thus, the combined effects of population ageing and economic growth require an increase in the flat tax rate of approximately 5 percentage points from 1995 to 2050.

Table 3.4. Long run macroeconomic development with endogenous individual labour supply (L) under the 1995 tax system and a flat tax system. Ratios between 2050-levels and base case 1995-levels. Variables are measured in fixed prices, except where indicated

	1995 tax system, endogenous payroll tax rate		Flat tax system, endogenous flat tax rate
	Exogenous L	Endogenous L	Endogenous L
Private consumption	5.3	5.6	6.1
Government consumption	1.6	1.6	1.6
Gross fixed capital formation	1.4	1.5	1.6
Exports	1.5	1.5	1.7
Imports	2.4	2.4	2.6
GDP	3.0	3.2	3.5
Real consumer pre-tax wage rate	3.1	3.1	3.1
Real consumer after-tax wage rate	3.1	3.1	4.2
Real cash transfers per capita received by households, net of old-age pensions	3.1	3.1	3.2
Real capital income per capita received by households	2.8	2.9	3.0
Employment, mill. man-hours	1.1	1.2	1.3
Payroll tax rate	2.0	1.6	1.0

Flat tax rate	-	-	1.0

Table 3.5. Macroeconomic changes caused by endogenous individual labour supply responses in 2050. Deviations in percent from base line. Variables are measured in fixed prices, except where indicated

	2050, 1995 tax system	2050, Flat tax system	1995, Pure effect of flat tax reform
Private consumption	4.2	14,3	12.4
Government consumption	-0.8	-2,9	-1.7
Gross fixed capital formation	3.6	10,7	6.3
Exports	3.8	14,3	8.7
Imports	2.3	8,5	9.4
GDP	4.0	13,7	7.8
Real consumer pre-tax wage rate	0.8	-10.3	-8.6
Real consumer after-tax wage rate	0.8	1.7	-1.1
Real cash transfers per capita received by households, net of old-age pensions	1.3	-7.0	-5.6
Real capital income per capita received by households	0.4	15.7	17.4
Employment, mill. man-hours	4.5	16.7	10.4
Payroll tax rate	-19.2	-	-
Flat tax rate	-	-28.4	-23.8

* Billions NOK in fixed 1995-prices, when nothing else is indicated.

Table 3.5 demonstrates that about two thirds of the employment expansion can be attributed to the flat tax reform. The pure employment effect of the growth from 1995 to 2050 is approximately 6 percent under the flat tax regime. Recall that the corresponding employment effect was 4.6 percent when the 1995 tax system was maintained. Thus the pure growth effect on labour supply is slightly stronger under the flat tax system than when the payroll tax rate is increased under the 1995 tax system. A main reason for this difference is that the workers exclusively pay the increase in the payroll tax, whereas the increase in the flat tax rate is shared between workers, capital owners and transfer recipients. Thus, the negative impact on the consumer real wage rate is reduced, and heavier taxation of non-labour income has a positive effect on labour supply.

4. Concluding remarks

We have developed an integrated Micro-Macro CGE model and employed it to explore how endogenous individual labour supply behaviour affects and interacts with fiscal sustainability problems in Norway caused by ageing combined with the maintenance of an ambitious welfare state policy. In particular, the existing pay-as-you-go financed pension system will bring about a sharper

increase in the ratio of government expenditures to GDP in Norway than in most other countries up to 2050. The results of the simulation exercise discussed in this paper present a rather differentiated picture, depending on the methodology employed and the hypothesis made upon the tax system.

The standard procedure underlying long run CGE-studies of ageing is to let a few representative agents determine the aggregate labour supply responses. Specifically, previous projections of the Norwegian economy have been based on exogenous assumptions of labour supply, and no responses to changes in the wage rate, non-labour income and taxes. In our first projection we repeat this approach by simulating the CGE model simulations without accounting for the behavioural responses coming from the microeconometric model of household labour supply, and keeping the tax system unchanged. The resulting perspectives are indeed worrying: fiscal sustainability would require doubling the payroll tax rate (from 13.0 percent to 26.0 percent). However, if we take endogenous labour supply into account, the picture starts to look better, the required payroll tax rate in 2050 being 21.0 percent instead of 26.0 percent.

Since labour supply seems so important, it makes sense to hypothesise a reformed tax system that gives better incentives to work. The simplest idea consists in introducing a Flat Tax. In this case we use directly the flat tax rate - instead of the payroll tax rate - as the instrument to balance the public budget. For the sake of comparison, let us start by keeping labour supply exogenous. Then, in 1995 we would need a 24.0 percent flat tax rate in order to generate the same total tax revenue as obtained with the actual tax system; in 2050, the rate would be 32.0 percent. Now, allow endogenous labour supply: The required flat tax rates are then 18.3 percent in 1995 and 22.9 percent in 2050. The results can be summarised in Table 4.1.

Table 4.1. Equilibrium tax rates. (The average payroll tax rate was 13.0 percent in 1995.)

		Tax system		
		Current (instrument: payroll tax rate)	Flat Tax (instrument: flat tax rate)	
		2050	1995	2050
	Exogenous	***26.0***	***24.0***	***32.0***
Labour Supply	Endogenous	***21.0***	***18.3***	***22.9***

As a tentative conclusion, it appears that fiscal sustainability problems expected in the future decades is reduced to manageable dimensions provided the tax system is reformed in order to improve the

incentives to labour supply. Two qualifications are in order at this point. First, there are of course many other ways to stimulate labour supply that might be alternative or complementary to reforming the tax system. The results in Fredriksen, Heide, Holmøy and Solli (2005) suggest that a pension reform is perhaps the most important candidate in this respect. Other policies might also work, although they might be more expensive (such as improving public substitutes for parental childcare etc). Second, even confining ourselves to tax reforms, the flat tax rule itself - besides its advantages in term of simplicity - is not necessarily the best one in order to get the desired effects: for example, it is likely to increase income inequality. Alternative tax rules might produce similar efficiency effects without increasing income inequality[25]. More generally, the pattern of labour supply elasticities (Table 3.1) reveals that what matters in order to bring more people into the labour market is increasing the net wage for individuals living in low- and average-income households. This would suggest - rather than a pure Flat Tax - a reduction of progressivity focussed on low and average income brackets.

From the methodological point of view, the exercise shows very clearly the importance of both general equilibrium effects and the effects captured by a detailed microeconometric model of labour supply behaviour in heterogeneous households, as well as of their interactions. Moreover, it would be hard to decide which one is less harmful to ignore as a simplifying strategy - if we had to. Their relative importance seems to vary depending on the point in time and the policy environment considered by the simulation exercise.

A criticism often raised against large and complex empirical models is that they are black boxes, leaving outsiders with small opportunities to check the logic and the driving forces behind the results. Integrating *two* large models make us vulnerable to such a criticism. However, we want to emphasize that we give priority to realistic assessments rather than to numerical illustration of particular effects. It is then inefficient to neglect available information about mechanisms of potential empirical significance because they complicate the analysis. In this respect it is interesting to note that recent research on labour supply, human capital and social policy evaluation literature has augmented CGE models with a more detailed description of the heterogeneity in behaviour.[26] A "cost-benefit" evaluation of which effects that should be given priority in empirical assessments should be based on experiences with rich models, rather than on *ex ante* conjectures. In particular, such evaluations should

[25] For example, a flat tax coupled with a Negative Income tax or a workfare mechanism may produce a favourable result (Aaberge, Colombino and Strøm, 2001).

[26] Heckman, Lochner and Taber (1998) includes a parametric distribution of heterogeneity in abilities in policy analyses of human capital accumulation; CGE studies in the international trade and public economics literature have been complemented with microsimulation modules to allow detailed distributional analyses, see e.g. Bourguignon, Robilliard and Robinson (2001); OLG models addressing ageing issues and effects of tax- and social security reforms have recently been expanded by including a larger number of representative individuals in order to capture both more details of the tax- and social security systems and distributional effects, see Kotlikoff, Smetters and Walliser (1998, 2001), Fehr (1999), Broer (2001), Fehr and Steigum (2002) and Fehr, Sterkeby and Thøgersen (2003).

- in economics as in other quantitative disciplines - take advantage of the dramatic improvement in computational methods, rather than cling to the same constraints available to Ricardo and Marshal.[27]

References

Aaberge, R., J.K. Dagsvik and S. Strøm (1995): Labour Supply Responses and Welfare Effects of Tax Reforms, *Scandinavian Journal of Economics*, 97, 4, 635-659.

Aaberge, R., Colombino U. and S. Strøm (1999): "Labour Supply in Italy: An Empirical Analysis of Joint Household Decisions with Taxes and Quantity Constraints", *Journal of Applied Econometrics*, 14, 403-422.

Aaberge, R., U. Colombino and S. Strøm (2000): "Labour Supply Responses and Welfare Effects from Replacing Current Tax Rules by a Flat Tax: Empirical Evidence from Italy, Norway and Sweden", *Journal of Population Economics*, 13, 595-621.

Aaberge R., Colombino U. and S. Strøm (2001): Do more equal slices shrink the cake? An empirical evaluation of tax-transfer reform proposals in Italy, CHILD Working Paper 19/2001 (http://www.child-centre.it/)

Aaberge, R, U. Colombino and T. Wennemo (2006): Evaluating Alternative Representations of the Choice Sets in Models of Labour Supply, IZA Discussion Paper No. 1986.

Aaberge, R. and U. Colombino (2006): Estimation and Prediction Performance of a Structural Random Utility Model for Labor Supply, Statistics Norway, Mimeo.

Antolin, P. and W. Suyker (2001): How should Norway respond to ageing?, Working Paper 296 in *OECD Economics Department Series,* OECD.

Aukrust, O. (1970): PRIM 1. A Model of the Price and Income Distribution Mechanisms of an Open Economy, Review of Income and Wealth 16, 51-78.

Beetsma, R., L. Bettendorf and P. Broer. The Budgetary and Economic Consequences of Ageing in the Netherlands, *Economic Modelling*, forthcoming.

[27] See Judd (2001) for an expert discussion of the usefulness of computational methods in economics.

Ben-Akiva, M. and Watanatada, T. (1981): “Application of a Continuous Spacial Choice Logit Model”, in Manski, C. F. and McFadden D. (eds.) *Structural Analysis of Discrete Data with Econometric Applications*, MIT Press, 1981.

Blundell, R. and C. Meghir (1986): Selection Criteria for a Microeconometric Model of Labour Supply, *Journal of Applied Econometrics*, **1**, 55-80.

Bourguignon F., A.-S. Robilliard and F. Robinson (2001): Crisis and Income Distribution: A Micro-Macro Model for Indonesia, Mimeo.

Bowitz, E. and Å. Cappelen (1994): Price Formation and Factor Demand in Norwegian Industries. Social and Economic Studies 85, Statistics Norway. (In Norwegian).

Broer, D. P. (2001): Growth and welfare distribution in an ageing society: An applied general equilibrium analysis for the Netherlands, *De Economist* 149, 81-114.

Burtless, G. and J. Hausmann (1978): The Effects of Taxation on Labour Supply, *Journal of Political Economy*, 86, 1103-1130.

Bye, B. (2002): Taxation, Unemployment and growth: Dynamic Welfare Effects of "Green" Policies. *Journal of Environmental Economics and Management* 43, 2002, 1-19.

Dagsvik, J.K. (1994): Discrete and Continuous Choice, Max-Stable Processes and Independence from Irrelevant Attributes, *Econometrica*, 62, 1179-1205.

Dickens, W. and S. Lundberg (1993): Hours Restrictions and Labour Supply, *International Econonomic Review*, 34, 169-191.

Euwals, R. and A. van Soest (1999), Desired and actual labour supply of unmarried men and women in the Netherlands, *Labour Economics*, 6, 95-118.

Fehr, H. (1999): *Welfare effects of dynamic tax reforms*, Mohr Siebeck.

Fehr, H. and E. Steigum (2002): Pension funding reforms in a small open welfare state. In Fossati, A. and W. Wiegard (eds.): *Policy evaluation with computable general equilibrium models*, Routledge Applied Economics, pp. 232-248.

Fehr, H. W. I. Sterkeby and Ø. Thøgersen (2003): Social security reforms and early retirement, *Journal of Population Economics* 16, 345-361.

Fredriksen, D. (1998): *Projections of Population, Education, Labour Supply and Public pension benefits. Analyses with the Dynamic Simulation Model MOSART*, Social and Economic Studies 101, Statistics Norway.

Fredriksen, D., K.M. Heide, E. Holmøy and N. M. Stølen (2003): Makroøkonomiske virkninger av endringer i pensjonssystemet. Reports 2003/13, Statistics Norway.

Fredriksen, D., K.M. Heide, E. Holmøy and I. F. Solli (2005): Macroeconomic effects of proposed pension reforms in Norway. Discussion Paper 417, Statistics Norway.

Fæhn, T. and E. Holmøy (2000): Welfare Effects of Trade Liberalization in Distorted Economies: A Dynamic General Equilibrium Assessment for Norway, in Harrison, G.W., S.E. Hougaard Jensen and T. Rutherford (2000): *Using Dynamic General Equilibrium Models for Policy Analysis*, North Holland.

Fæhn, T. and E. Holmøy (2003): Trade liberalisation and effects on pollutive emissions to air and deposits of solid waste. A general equilibrium assessment for Norway. Economic modelling 20 (2003), 703-727.

Heckman J. (1974): Effects of Child-Care Programs on Women's Work Effort, *Journal of Political Economy*, 82, 2-II, 136-163.

Heckman J, L. Lochner and C. Taber (1998): General Equilibrium Treatment Effects: A Study of Tuition Policy, *American Economic Review*, 88, 2, 381-386.

Holmøy, E., D. Fredriksen and K. M. Heide (2003): Effects of some suggested reforms of the Norwegian pension system: An integrated dynamic micro-macro assessment, Manuscript.

Holmøy, E. and H. Vennemo (1995): A general equilibrium assessment of a suggested reform in capital income taxation, *Journal of Policy Modelling*, 17 (6), 531-556.

Holmøy, E. and T. Hægeland (1997): Aggregate Productivity Effects of Technology Shocks in a Model of Heterogeneous Firms: The Importance of Equilibrium Adjustments, Discussion Paper 198, Statistics Norway.

Holmøy, E., B. Strøm and T. Åvitsland (1999): Empirical characteristics of a static version of the MSG-6 model, Notater 99/1, Statistics Norway.

Judd, K. (2001): Computation and economic theory: Introduction, *Economic Theory* 18 (1, 2001), pp 1-6.

Klette, T.J. (1999): Market power, scale economies and productivity: Estimates from a panel of establishment data. Journal of Industrial Economics, 47, 451-76.

Kotlikoff, L., K. Smetters and J. Walliser (1998): The economic impact of privatising social security. In Siebert, H. (ed.): Redesigning social security, Mohr Siebeck.

Kotlikoff, L., K. Smetters and J. Walliser (2001): Finding a way out of America's demographic dilemma, *NBER Working Paper 8258*.

Krugman, P. (1992): *The age of diminished expectations*, Cambridge MA: MIT Press.

Naug, B. (1994): En økonometrisk analyse av utviklingen i importandelene for industrivarer 1968-1990, *Social and Economic Studies* 84, Oslo: Statistics Norway.

Norwegian Ministry of Finance (2001): Long Term Programme 2002-2005, St. melding no.30 (2000/2001) (In Norwegian).

OECD (2002): OECD National Accounts, Main Aggregates Vol. 1, Paris: OECD.

Pedersen, L.H. and P. Trier (2000): Har vi råd til velferdsstaten, *DREAM Working Paper Series 2000:4*.

The Pension Commission (2002): *Preliminary report*, Oslo: Norwegian Ministry of Finance.

Poterba, J. (ed.) (1996): *Tax policy and the economy*, vol. 10, Cambridge MA: MIT Press.

Shoven J.B. and J. Whalley (1984): Applied General Equilibrium Models of Taxation and International trade: An Introduction and Survey, *Journal of Economic Literature*, 22, 1007-1051.

Siebert, H. (ed.) (2002): *Economic Policy for Ageing Societies*, Berlin: Springer-Verlag.

Statistics Norway (2002): Befolkningsframskrivinger. Nasjonale og regionale tall, 2002 - 2050. www.ssb.no/emner/02/03/folkfram/ 05.12.2002.

Thøgersen, Ø. (2001): Reforming social security: Assessing the effects of alternative funding strategies, *Applied Economics*, 33, 1531-1540.

United Nations (2001): *World Population Prospects: The 2000 Revision.* (Database).

van Soest A. (1995): Structural Models of Family Labour Supply: A Discrete Choice Approach, *Journal of Human Resources*, 30, 63-88.

Westerhout, E., et. al. (2000): Ageing in the Netherlands, *Special Publication*, CPB Netherlands Bureau of Economic Policy Analysis.

Appendix 1
Structure and properties of the CGE model (MSG6)

A1.1 A stylised one-sector version of the CGE model (MSG6)

Consumer behaviour

A representative price taking consumer with perfect foresight decides on consumption, savings and labour supply. The intertemporal utility function has the additively separable CES form:

(1) $$W_0 = \int_0^\infty e^{-\rho t} U(D, T-L)^{1-\frac{1}{\sigma}} dt$$

The felicity function, U, is a homothetic CES function, D is consumption, T is the hours that can be allocated to leisure or labour, L, per year. T-L is leisure. The ideal CES price index for U takes the general form

(2) $$P_U = P_U\left((1-t_W)W, (1+t_C)P\right),$$

where W is the pre-tax wage rate, t_W is the marginal tax rate on wage income, P is a price index for consumption, t_C is the indirect tax on consumption. The consumer and firms consider imports to be an imperfect substitute for the domestic product. The ideal price index for the composite of imports and the domestic product is given by the CES price index

(3) $$P = P\left(P_H, (1+t_I)P_I\right),$$

where P_H is the price index for the domestic product, t_I is the tariff rate and P_I is the cif price of imports. The consumer consider the product supplied by different domestic firms within the same industry to be imperfect substitutes, which can be aggregated into a composite via a CES function as in the Dixit-Stiglitz model of monopolistic competition. Assuming a continuum of domestic product variety, the price index for the domestic differentiated product takes the form

(4) $$P_H = \left[\int_0^n \left(P_{iH}\right)^{1-\upsilon} di\right]^{\frac{1}{1-\upsilon}},$$

The consumer maximizes the intertemporal utility function subject to the intertemporal budget constraint

(5) $$\int_0^n e^{-(1-t_\pi)r}\left[(1+t_C)PD + (1-t_W)W(T-L) + (1-t_\pi)\pi + Y\right]dt = V_0$$

where $D = D(D_H, D_I)$ is the volume index (sub utility) of the composite of domestic varieties, D_H, and imports, D_I. π is profits, all of which is distributed to the consumer in this stylized exposition of the model. t_π is the tax rate on profits, which in this exposition is levied on all types of capital income. Y is net transfers from the government and V_0 is the net wealth at time 0. r is the interest rate, here assumed constant. The consumer takes the wage rate

Choosing units so that preferences are symmetric at the nests in the utility function, utility maximization yields the following demand functions

(6) $$U = \left(\mu P_U\right)^{-\sigma_C},$$

(7) $$D = \left(\frac{(1+t_C)P}{P_U} \right)^{-\sigma_F} U ,$$

(8) $$L = T - \left(\frac{(1-t_L)W}{P_U} \right)^{-\sigma_F} U ,$$

(9) $$D_H = \left(\frac{P_H}{P} \right)^{-\sigma_I} D ,$$

(10) $$D_I = \left(\frac{(1+t_I)P_I}{P} \right)^{-\sigma_I} D ,$$

(11) $$D_{iH} = \left(\frac{P_{iH}}{P_H} \right)^{-\nu} D_H ,$$

where μ is the shadow price of total wealth owned by the consumer, which is equal to the inverse of the intertemporal ideal price index of welfare. Note that μ is an endogenous constant. D_{iH} is the demand for the domestic variety i.

Behaviour of firms and aggregate industries

MSG6 is designed to allow for productivity heterogeneity among firms within the same industry. This heterogeneity is represented by a simple formal structure for the sake of tractability. The model also captures the fact that most firms sell their products in several markets in which they have different market power. Especially, it is assumed that the export market and the domestic market are segmented from each other. The form is a prices taker in all factor markets and in the export market, whereas the domestic market is characterised by monopolistic competition. Each firm has perfect foresight and maximizes the firm value, which equals the present value of the after-tax cash flow. Neglecting here the input of intermediaries, physical capital depreciation and the details of the taxation, the value of the i'th firm at time 0 is

(12) $$V_{i0} = \int_0^\infty e^{-(1-t_C)rt} \left(\pi_i - P\dot{K} - F \right) dt ,$$

where $\dot{K}$ is investment and F is a fixed cost associated with entry. Operating profits are defined as

(13) $$\pi_i = P_{iH} X_{iH} + P_W X_{iW} - (1 + t_L) w L_i ,$$

where X_{iH} is output delivered to the domestic market, X_{iW} is exports and P_W is the common exogenous world price of exports.

The perceived demand function facing each firm is consistent with the large group case of monopolistic competition:

(14) $$X_{iH} = E(P_{iH})^{-\nu} ,$$

where E is a demand parameter regarded by the firm as given.
The transformation function between outputs and inputs has the separable structure

(15) $$\left[(X_{iH})^{\rho} + (X_{iW})^{\rho}\right]^{\frac{1}{\rho}} = \left[A_i f(L_i, K_i)\right]^s ,$$

where s<1. Tractability is considerably increased by assuming $1/\rho = s$. The variable cost function of a firm then takes the form

(16) $$C_i = c_i \left[(X_{iW})^{\frac{1}{s}} + (X_{iH})^{\frac{1}{s}} \right],$$

where c_i is the dual price index of the composite CES- nput of labour and capital

(17) $$c_i = \frac{1}{A_i} \left[((1 + t_L) W)^{1-\sigma_K} + ((1 + t_K)(rP - \dot{P}))^{1-\sigma_K} \right]^{\frac{1}{1-\sigma_K}} .$$

where A_i is total factor productivity (TFP) and t_K is the effective tax rate of capital services, which captures non-neutral capital income taxation. Firms are ranked according to decreasing TFP. The structure of TFP-heterogeneity is formalised by

$A_i = A_0 e^{-ti}$, $t>0$.

After integrating (by parts) (12) and appropriate substitutions the dynamic maximization problem of the firm can be transformed into a sequence of static problems where the firm maximizes

$$\pi'_i = P_{iH} X_{iH} - c_i \left(X_{iH}\right)^{\frac{1}{s}} + P_W X_{iW} - c_i \left(X_{iH}\right)^{\frac{1}{s}} - F$$

with respect to P_{iH} and X_{iW}. The export supply function becomes

$$X_{iW} = \left(\frac{sP_W}{c_i}\right)^{\frac{s}{1-s}} \tag{18}$$

The exponential structure of TFP heterogeneity implies the following relationship between export supplies from firm i and the most efficient firm, $i = 0$, respectively:

$$X_{iW} = X_{0W} e^{\frac{-sti}{1-s}}. \tag{19}$$

Optimal price setting for domestic deliveries implies the mark-up rule

$$P_{iH} = \frac{mc_i}{s} \left(X_{iH}\right)^{\frac{1}{s}-1} \tag{20}$$

where $m = v/(v-1)$ is the mark-up factor. Consistency between perceived demand and supply for product i implies

$$P_{iH} = \frac{mE^{\frac{1}{s}-1} c}{s} e^{ti} \left(P_{iH}\right)^{-v\left(\frac{1}{s}-1\right)}. \tag{21}$$

Inserting the relative product price structure back into the perceived demand function yields the relationship between domestic deliveries from different firms:

$$X_{iH} = X_{0H} e^{\frac{-mti}{m/s-1}}, \tag{22}$$

where the mark-up formula has been used. $X_{0H} = \left(\frac{mc}{s}\right)^{-\left(\frac{m}{m/s-1}\right)} E^{\frac{m-1}{m/s-1}}$.

For a given number, n, of firms and products the industry output variables are easily calculated. Defining $h_H = \frac{m/s-1}{t}$ and $h_W = \frac{1/s-1}{t}$, we get

(23) $$X_H = \int_0^n X_{iH}\,di = X_{0H}\frac{h_H}{m}\left(1-e^{\frac{-mn}{h_H}}\right) \approx X_{0H}\frac{h_H}{m}$$

(24) $$X_W = \int_0^n X_{iW}\,di = X_{0W}h_W\left(1-e^{\frac{-n}{h_W}}\right) \approx X_{0W}h_W$$

The approximations at the end of the expressions are better the greater are the number of active firms. They are not made in the real MSG6, but will be used in the subsequent exposition for the sake of simplicity. It corresponds to an infinite number of firms. Since the share of output and input of a firm i decreases with i due to the ranking and heterogeneity, the difference between the finite and infinite integrals is small when n is large, see Holmøy and Hægeland (1997) for a detailed discussion of this approximation.

Equilibrium

In the real MSG6, the number of firms is determined by the standard absence of entry/exit condition, which can be written

(25) $$\left(\frac{m}{s}-1\right)c_n\left(X_{nH}\right)^{\frac{1}{s}} + \left(\frac{1}{s}-1\right)c_n\left(X_{nW}\right)^{\frac{1}{s}} = F\ .$$

Employing the approximation defined above, the price index of the composite domestic good can be written

(26) $$P_H \approx bP_{0H}\ ,$$

where $0 < b = \left(\frac{t}{m/s-1}\right)^{m-1} < 1$ due to the "love of variety" preferences, which dominates the effect of including higher prices than P_{0H} in the ideal index. Moreover, the perceived domestic demand function can now be written

(27) $$X_{0H} = b^{\nu} E(P_H)^{-\nu}.$$

Equilibrium in the domestic product market requires $X_{iH} = D_{iH} + J_{iH}$, where $J_{iH} = \left(\frac{P_{iH}}{P_H}\right)^{-\nu}\left(\frac{P_H}{P}\right)^{-\sigma_I}\dot{K}$ is the investment of the i'th domestic variety. This equilibrium condition can be written:

(28) $$X_{0H} = b^{\nu}\left(\frac{P_H}{P}\right)^{-\sigma_I}\left(D + \dot{K}\right).$$

Aggregate demand for capital and labour becomes

(28) $$K = \left(\frac{(1+\tau_K)(rP - \dot{P})}{c}\right)^{-\sigma_K}\left[h_H (X_{0H})^{\frac{1}{s}} + h_W (X_{0W})^{\frac{1}{s}}\right],$$

(29) $$L = \left(\frac{(1+\tau_L)W}{c}\right)^{-\sigma_K}\left[h_H (X_{0H})^{\frac{1}{s}} + h_W (X_{0W})^{\frac{1}{s}}\right],$$

Labour market equilibrium implies

(30) $$T - \left(\frac{(1-t_L)W}{P_U}\right)^{-\sigma_F} U = \left(\frac{(1+\tau_L)W}{c}\right)^{-\sigma_K}\left[h_H (X_{0H})^{\frac{1}{s}} + h_W (X_{0W})^{\frac{1}{s}}\right].$$

Net foreign wealth, B, develops according to

(31) $$\dot{B} = rB + P_W X_W + O - P_I (D_I + J_I),$$

where O is the value of oil and gas exports and J_I is the investment of imported goods, which is given by $J_I = \left(\frac{(1+t_I)P_I}{P}\right)^{-\sigma_I}\dot{K}$.

The following transversality condition on net foreign wealth accumulation implies a national intertemporal budget constraint for the economy as a whole:

(32) $$\lim_{t\to\infty} Be^{-rt} = 0$$

The exogenous variables are: r, P_I, P_W, O, T. In addition the tax rates are exogenous if a public budget constraint is met through endogenous lump sum transfer. If transfers are exogenous, one of the tax rates is endogenous.

A1.2 Empirical properties of the CGE model (MSG6)

Below we explain key properties of the CGE model by analsing the simulated long run effects of 10 percent exogenous increases in, respectively, 1) the level of total factor productivity (TFP) in all private industries, and 2) the labour force. TFP growth is the main determinant of economic growth, whereas equilibrium adjustments to exogenous shifts in labour supply is at the heart of the results in this paper. The exposition is based on Heide, Holmøy, Lerskau and Solli (2004).

It should be noticed that the following results depend on the aggregate and standard endogenous labour supply behaviour within the MSG6 model. A credo of the present paper is that an aggregate standard description of labour supply behaviour may result in aggregate labour supply responses significantly different from what is derived from a complex detailed description, even if the aggregate description is well calibrated.

Effects of increasing total factor productivity

The productivity parameters of all production factors in all private industries are increased permanently by 10 percent from period 0. The shift is unanticipated. In the reference scenario, only about 2/3 of the total employment works in these sectors. Table 3.4.1 summarizes the most important effects, measured as percentage deviations from the corresponding paths in the reference scenario.

Table A1.1. Long run macroeconomic effects of a permanent unanticipated 10 percent increase in total factor productivity (TFP). Percentage deviation from reference scenario

Constant Prices:	
Private consumption	12.5
General government consumption	-0.9
Gross fixed investment	1.2
Exports	4.8
Import	9.1

GDP	9.1
GDP, mainland	9.4
Fixed capital stock	3.8
Total employment, man-hours:	-2.5
Government sector	0.1
Private business sector	-3.8
Manufacturing	-8.0
Price indices:	
Hourly wages	19.1
Consumer price index	2.8
Price of capital goods	2.2
Percent of GDP:	
Trade surplus	3.5
Current account	31.8
Net foreign wealth, Norway	3.4

The main effect of an increase in TFP is general growth: Out of a given volume of input factors, output increases and consumers reach a higher level of welfare with more consumption and leisure. At the same time, the productivity shift affects incentives, especially relative prices, and the economy undergoes complex adjustments in order to benefit from the additional resources implied by the shift. For example, a substantial real wage increase leads, *cet. par.*, consumers to increase their labour supply and benefit from the higher wealth by a further surge in private consumption. An implicit part of the story is that with perfect foresight and access to international capital markets, consumers correctly expect that income will remain high, and choose a consumption level in accordance with the present value of future income. The permanent increase in consumption combined with the temporary increase in investments at the beginning of the scenario, are financed through reduced net financial investments abroad. Over time, parts of the expanded capacity are used to pay back interest and loans, so that the intertemporal constraint on net foreign debt is met.

The nominal wage rate increases by 19 percent in the long run. The *main* mechanisms can be explained by reference to the text-book model of a Small Open Economy (SOE) or the Scandinavian Model of Inflation: Since export prices are given, producer real wages are determined by the

productivity in the export sector. When technologies exhibit constant returns to scale, an increase in labour productivity will be carried over to wages in its full magnitude. Furthermore, the additional revenue per produced unit due to higher productivity of *all* factors is carried over to wages. The reason is that competition drives net rate of return to fixed capital down to the exogenous interest rate corrected for non-neutrality in the capital income taxation. Technical complementarity between labour and other inputs implies that the marginal labour productivity increases both with increased productivity and with more input of capital and intermediates.

In MSG6, this line of reasoning serves only as an approximation of the full picture, since decreasing rather than constant returns to scale makes the wage determination more complex. Increased total demand increases imports according to the import shares. The rise in domestic prices contributes further to raise imports through substitution away from domestic deliveries. In present value terms the rise in imports has to be financed by a corresponding growth in exports, in order not to violate the intertemporal budget constraint on foreign debt. The expanded export production reduces the marginal productivity of all inputs, which in turn modifies the effect on the wage rate compared to the exogenous productivity increase. The effect on wages of increased productivity of all other factors is, as explained above, valid also in MSG6. Due to the input of fixed capital and intermediaries the cost share of labour averages 50 - 60 percent in most manufacturing industries. This magnifies the increase in the wage rate compared to the increase in the productivity of labour.

The rise in the consumer real wage rate of immediately 20 percent has a positive effect on labour supply, since the positive substitution effect dominates the negative income effect in MSG6.[28] However, *ex ante* equilibrium adjustments in the wage rate, consumers want to reduce their labour supply because of the income effects caused by the increase in profits distributed to the consumers. The combination of various income effects dominates the substitution effect of the increase in the real wage rate, and employment is reduced by 2.5 percent in the long run.

The rise in wages makes labour relatively more expensive than other production factors, since the increase in the wage rate is only partly carried over to the prices of capital goods and material inputs as they include imported products. This change in relative factor prices induces substitution in favour of capital and material inputs, and increases the capital-labour ratio at the firm level. Substitution in consumption raises the aggregate capital intensity even more by a reallocation of resources in favour

[28] It should be recalled that an endogenous lump sum transfer is adjusted to meet the given development of the public budget surplus. If the public budget constraint is met by adjustments in a distortionary tax rate, e.g. the payroll tax rate, there may be significant feed back effects on relative prices and resource allocation, see e.g. Fredriksen *et al.* (2003).

of the more capital intensive sectors. In the long run, the capital stock has increased by 3.8 percent compared to the reference scenario.

In the long run, GDP has increased by about 9 percent. This reflects that the volume of inputs is basically unchanged in physical units, although the composition has changed in favour of capital and material inputs. An increase in productivity is, however, equivalent to an increase in inputs measured as effective units. The magnitude of the output growth corresponds to this, modified by decreasing returns to scale. On average the scale elasticity is close to 0.9, implying that the output expansion will be 90 percent of a proportional increase in all inputs.

Dynamics: Producers and consumers are forward looking and equipped with model consistent expectations. In accordance with the intertemporal substitution possibilities consumers postpone consumption till periods when the cost of living index is relatively low. *Cet. par*, firms increase their investment if they foresee that the prices of capital goods will be higher in future periods. In the simulation the increase in TFP results in initially higher prices than in the reference scenario, but the positive shift in the price indices is diminishing. After some years, however, the prices increase again, which can be traced back to a substantial increase in the price of electricity.

The logic behind the strong increase in the price of electricity exemplifies the importance of mutual dependencies between different markets for the general equilibrium outcomes. It has two main elements. First, the supply of electricity is determined differently in the reference scenario than in the shift simulations. In the reference scenario the domestic electricity production grows according to exogenous political decisions on expansion of the hydro power- and the gas power capacity. In addition, electricity is imported to balance the market at a level consistent with electricity prices growing at roughly the same rate as other prices. In the shift simulations, however, the net import of electricity is exogenous and follows the reference path. Moreover, the technology in domestic electricity production is characterised by a strong degree of decreasing returns to scale. The general increase in demand caused by the 10 percent TFP shift raises the electricity demand. The electricity market is balanced by raising the price along the steep supply curve. The pressure in the electricity market grows over time as the growth in the reference path implies that a gradually increasing resource base is subject to the TFP-shift. This explains why the change rate of the electricity price increases over time.

The broad picture of the new investment path is a substantial increase from the reference path in the first years after the shift is instigated. An important dynamic feature is that although the capital stock technically could be adjusted to the optimal level immediately after the shift, investments are

smoothed out over some years for two reasons: First, decreasing returns to scale is a feature of the technology also in the industries producing capital goods (most notably *Buildings and Construction*, *Machinery and Metal Products*). This has the same modifying effect on investments as convex adjustment costs in standard macroeconomic models: The increased demand for investment goods has to be supplied by a relatively small fraction of the economy. As resources are reallocated into production of investment goods, marginal costs in these industries increase substantially and are by far not outweighed by the reduced marginal costs in the remaining large part of the economy where resources are drawn from.[29] Second, the temporary high investment demand tightens the labour market. The wage rate increases to restore labour market equilibrium, and brings about a relatively stronger increase in prices in the investment period than in subsequent periods. Thus the combination of high capital goods prices and negative expected capital gains leads firms to postpone investments.

Changing the wage level to adjust international competitiveness is an important dynamic mechanism in MSG6. Since producers of export deliveries face given prices, changes in nominal wages equal changes in producer real wages for completely export oriented firms. The rise in the nominal wage rate is initially higher than in subsequent years. This is required to meet the temporary increase in investment demand: To accumulate capital up to the new desired capital intensity, investments crowd out exports in the periods following the shift by reallocating resources into production of investment goods. In addition, the high demand for investment goods is partly met by higher imports, adding to the decrease in net exports. As the capital stock is expanding, demand for (domestic and imported) investment goods declines, nominal wages fall and producers find it profitable to expand exports.

The result of the wage and price dynamics is that production of traded goods, especially of the highly price sensitive export supplies, is crowded out by the temporary increase in investment. Note that the reduction in the net exports during the investment period must be reversed in later periods in order to keep the economy within the intertemporal budget constraint. Thus, the accumulation of fixed capital in domestic industries is to a great extent financed by a reduction in the net foreign wealth.

Consumption is continuously falling from 16 percent above the reference scenario in the short run down to 12.5 percent in the long run, whereas labour supply is falling from 1 percent below the reference scenario in the short run to 2.5 percent in the long run. The dynamics of consumption and labour supply result from the intra- and intertemporal substitution effects, reflecting the time profiles of the consumer price index and the wage rate. The relative change rate of the consumer price index

[29] The price effects on products from the manufacturing industries producing machinery etc illustrate the point: Due to expanded production, the drop in the prices of these products is smaller than the drop in most other prices. Without the smoothing of investments over the first couple of years, the difference in price reductions would be even bigger.

follows a U-shaped curve, whereas the increases in the wage rate equals 22.3 percent initially, falling gradually to 19.1 percent in the long run. The consumer real wage rate is initially 20 percent above the reference scenario, but drops gradually down to 16.3 percent. This real wage dynamics induce substitution over time in favour of leisure and less consumption. In addition the intertemporal effect induces consumers to postpone consumption and leisure from the first periods. However, this effect is small, due to a low intertemporal rate of substitution, i.e. strong preferences for consumption smoothing.

Effects of increasing the labour force

In this experiment the labour force is permanently increased by 10 percent relative to the reference scenario from period 0. Note that the labour force is exogenous in MSG6, whereas the individual labour supply is endogenous. Table 3.5. summarizes the macroeconomic effects.

Table A1.2. Long run macroeconomic effects of a permanent unanticipated 10 percent increase in the labour force. Percentage deviation from reference scenario

Constant Prices:	
Private consumption	8.0
General government consumption	-1.7
Gross fixed investment	8.6
Exports	10.4
Import	6.0
GDP	8.1
GDP, mainland	8.3
Fixed capital stock	6.3
Total employment, man-hours:	9.1
Government sector	0.1
Private business sector	13.7
Manufacturing	21.1
Price indices:	
Hourly wages	-7.4
Consumer price index	-2.5
Price of capital goods	-3.6

Percent of GDP:	
Trade surplus	-3.6
Current account	-17.3
Net foreign wealth, Norway	-3.6

1) General equilibrium feed-back on employment:

The 10 percent increase in the labour force results in a 9 percent increase in employment. This is due to a drop in real wages, which makes it relatively less attractive to work and increases the demand for leisure. The mechanisms behind the drop in wages cannot be explained without recognizing the strong impact of the wage rate on the accumulation of foreign assets. At the initial relative prices, the output produced by the extra man-hours has to be absorbed by consumption and investments, which raises imports according to the import shares. The resulting increase in net imports in every year violates the intertemporal budget constraint on net foreign debt. To restore the long run external balance, the present value of net exports must rise. However, producers do not find it profitable to raise exports at the initial relative prices due to decreasing returns to scale. A drop in the wage rate is required. The marginal cost curves then shift downward, depending on the direct and indirect cost shares of labour, and results in expanded production of export deliveries at given world prices. Lower wages also reduce the prices of Norwegian products relative to the given prices of close but imperfect imported substitutes, and both firms and consumers substitute domestic products for imports. Moreover, the fall in the wage rate induces factor substitution away from capital and other material inputs, which are partly imported. Both substitution effects have a negative impact on imports.

Mark-up pricing of domestic deliveries implies that the decline in the consumer real wage rate is modified compared to the drop in the nominal wage rate (which, in relative terms, equals the drop in the producer real wage rate in completely export oriented firms). As mentioned above, the drop in consumer real wage rate reduces individual labour supply.[30] This explains why the equilibrium adjustment in aggregate employment is less than the exogenous 10 percent increase in the labour force.

It should be recalled that an endogenous lump sum transfer is adjusted to meet the given development of the public budget surplus. If the public budget constraint were met by adjustments in a distortionary

[30] Note that the substitution effect of a change in the wage rate dominates the income effect in the *partial* labour supply model implemented in MSG6. However, the exposition mentions the substitution effect only, because the income effect of changes in the wage rate is almost ruled out by general equilibrium effects. The reason is that the additional wage income generated by a higher wage rate implies lower profits in export production and higher prices of domestic deliveries. In addition, changes in capital income received by the households complicates the story.

tax rate, e.g. the payroll tax rate, there may be significant feed back effects on relative prices and resource allocation, see e.g. Fredriksen *et al*. (2003). Alternatively, the government consumption, e.g. employment, is adjusted to meet the public budget constraint. This procedure is often followed in policy analyses by the Norwegian Ministry of Finance. Implications of this closure rule are discussed in HSÅ99.

2) The Rybczynski theorem does not hold in MSG6

The decline in the real wage rate is not in accordance with the standard textbook theory for a small open economy (SOE). In the simplest SOE model the economy absorbs changes in factor endowments by adjusting the industry structure. Provided that the initial optimal factor intensities span the aggregate factor intensities, the new equilibrium is feasible without changes in relative factor prices and factor substitution at the micro level. The drop in real wages as a result of an increase in the labour force, illustrates the complexity of MSG as compared to the simple model of a SOE: With decreasing returns to scale, an expansion in any sector implies higher marginal costs for given prices. Profitable expansion of exports can only be brought about through a reduction in real wages. However, the possibilities for import substitution make domestic demand for traded goods quite price elastic. The price elasticity of export supply is even greater as the scale elasticities are in the vicinity of 0.9. Therefore, although the Rybczynski theorem does not hold in its strict sense, the "Rybczynski effect", i.e. factor substitution in macro through changes in the industry composition, is indeed an important determinant also in MSG6 of how the additional labour is absorbed by the economy. Summing up, the additional labour is absorbed by a combination of output expansion (growth effect), as well as increased aggregate labour intensity caused by both factor substitution within firms, and the Rybczynski effect.

3) Growth in GDP:

The long run GDP expansion is less than the exogenous increase in the labour force. In the long run GDP ends up about 8 percent higher than in the reference scenario, whereas employment and capital increases by, respectively, 9 and 6.3 percent from their reference paths in the long run. Hence, MSG6 deviates from a simple Solow growth model, in which all quantity variables grow at the same rate as the growth rate in effective labour in steady state. There are two main reasons for this deviation between the simple Solow model and MSG6. First, the production function exhibits constant returns to scale in the Solow model, whereas there are decreasing returns to scale in most private industries in MSG6. On average the scale elasticity is close to 0.9, which means that the output expansion will be 90 percent of a proportional increase in all inputs. Second, the relative increase in the capital stock will be smaller than the equilibrium growth in employment. As explained above, this is due to both endogenous factor substitution both at the micro level, as well as changes in the industry structure.

Note that the increase in private consumption affects the aggregate capital intensity, especially through the increased consumption of the extremely capital intensive housing services.

4) Dynamics:

Producers and consumers are forward looking and equipped with model consistent expectations. According to the intertemporal substitution possibilities, consumers postpone consumption till periods when the cost of living index is relatively low. *Cet. par.* firms increase their investment if they foresee that the prices of capital goods will be higher in future periods. In the simulations the increase in the labour force causes the prices of consumption and capital goods to decline continuously over the entire time path.

The broad picture of the investment path is a substantial increase the first years after the shift is instigated, in order to equip the additional labour with the optimal capital-labour ratios. After a drop in the midst of the period, investments again increase, reflecting that a higher capital stock requires more replacement investments. An important dynamic feature is that although the capital stock technically could be adjusted to the optimal level immediately after the shift, investments are to some extent smoothed out over some years out of two reasons: First, decreasing returns to scale is a feature of the technology also in the industries producing capital goods (most notably *Buildings and Construction*, *Machinery and Metal Products*). This has the same modifying effect on investments as convex adjustment costs in standard macroeconomic models: The increased demand for investment goods has to be met by supplies from a relatively small fraction of the economy. As resources are canalised into the industries producing capital goods, marginal costs increase substantially in these industries. Mark-up pricing of domestic deliveries shifts transmits higher costs into higher prices. This price effect is by far not outweighed by the reduced marginal costs in the remaining large part of the economy where resources are drawn from.[31] Secondly, the temporary high investment demand tightens the labour market. The wage rate increases to restore labour market equilibrium, and brings about a relatively stronger increase in prices in the investment period than in subsequent periods. Thus the combination of high capital goods prices and negative expected capital gains leads firms to postpone investments.

The result of the wage and price dynamics is that production of traded goods, especially of the highly price sensitive exports is crowded out. Moreover, consumption is postponed. Note that the reduction in the net exports during the investment period must be reversed in later periods in order to keep the economy within the intertemporal budget constraint. Thus, the accumulation of fixed capital in

[31] The price effects on products from the manufacturing industries producing machinery etc illustrate the point: Due to expanded production, the drop in the prices of these products is smaller than the drop in most other prices. Without the smoothing of investments over the first couple of years, the difference in price reductions would be even bigger.

domestic industries is to a great extent financed by a reduction in the net foreign wealth. The increasing trend in private consumption (and leisure) reflects a modest increase in private savings in the first part of the simulation period, but most of the fixed capital investment reflects a change in the portfolio of assets held by the Norwegian economy.

The intertemporal effects on consumption are rather small. From an initial increase in consumption of 7.8 percent, consumption rises only 0.2 percentage points further until 2050, despite a continuous fall in prices and rise in real wages after the initial drop. The small effect is due to a low intertemporal rate of substitution, and strong preferences for consumption smoothing. This high and smooth consumption path implies that the increase in investments turns out to have no crowding out effect on consumption. With perfect foresight and access to international capital markets, consumers expect correctly that income will increase over time, and choose a consumption level in accordance with the present value of future income streams. The high consumption and investment levels in the beginning of the scenario are financed through reduced net financial investments abroad, resulting in a significant negative current account balance. Over time, parts of the expanded capacity are used to pay back interest and loans, contributing to restore balance at the current account.

Regarding the effects on the wage level to improve international competitiveness, the dynamic mechanisms play a substantial role. Since producers of export deliveries face given world marked prices, the relative change in the nominal wage rate equals the relative change in the producer real wage rate in a (hypothetical) purely export oriented industry. The initial cut in nominal wages is not sufficient to raise exports to such an extent that the external balance is restored. By limiting expansion in export industries, resources can be canalised into production of investments goods, which face a substantial but temporary increase in demand. While investments gradually slow down as the capital stock is accumulating, nominal wages continue dropping and export industries continue expanding, until the external balance is restored.

Appendix 2: Combining the Labour supply model and the CGE model

The MSG6-model captures several dynamic aspects of a small open economy, including fixed capital investment, financial investment, intertemporal substitution and forward looking behaviour. On the other hand, the microeconometric labour supply model is static. The complexity of the labour supply model does allow us to merge the two models into one big CGE-model with a very detailed description of individual labour supply behaviour and the tax system. Our iterative procedure is a

second-best alternative. However, the iterative approach faces the fundamental problem of combining consistently the solution of a static model with the time paths resulting from the dynamic MSG6 simulations.

In principle, the final solution in every year within the time horizon (2050), should be the result of iterations between the two models. In practice, such a procedure is not feasible. Nor is it well defined until the solution of the static model is carefully interpreted. In particular it must be decided whether the labour supply responses should be interpreted as long run solutions, or as responses consistent with a temporary equilibrium. The cross section data underlying the estimation of the labour supply model makes it most appropriate to interpret the estimated behaviour as long run responses. In the dynamic model stock flow dynamics associated with accumulation of real and financial assets makes the immediate equilibrium response different from the long-run response. Thus, along a typical simulated growth path the endogenous variables change between the years t and $t+1$ for two reasons: First, there are short run responses to the changes in the exogenous variables from t to $t+1$. Second, the dynamic properties of the model structure makes the solution in year t+1 dependent on changes in both exogenous and endogenous variables in year t-1, t-2,…. . Along such a growth path it is not obvious how the long-run results from the labour supply model should be implemented.

Our solution to this principal and practical problem has been to focus on the long run effects. To this end we compute what we call a stationary equilibrium associated with the projected situation reached in 2050. This is achieved by letting all exogenous variables be constant at their 2050-levels. The model then computes a transition path where the stocks of real and financial assets converges to their stationary solutions, whereas resources used to produce the capital goods are gradually reallocated from production of capital goods to consumption goods industries. It is in this computation of stationary 2050-equilibria that we use both the CGE-model and the partial labour supply model iteratively.

An element of inconsistency implied by this procedure arises since the development between the base year 1995 and 2050 does not account for endogenous supply responses. However, we conjecture that the path dependence of the stationary 2050 equilibrium is relatively weak. The path dependency work primarily through the national financial wealth accumulated in 2050. Higher employment from 1995 till 2050 would have resulted in higher consumption possibilities in 2050 since parts of the additional national income would have been saved. Thus, private consumption and capital income would have been higher than in our computation. This would, *cet. par.* modify the increase in labour supply, but this modification is likely to be small.