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

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, that 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 allows for a flexible representation of 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 projection of the future tax burden and examine to what extent the tax burden can be relaxed by introducing an appropriate income tax reform.

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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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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. Burtless and Hausman (1978) present a fairly general and very popular approach to modelling individual behavioural responses to complicated changes in the budget constraint due to tax reforms. More general and flexible procedures have been developed by for example Dickens and Lundberg (1993), Aaberge, Dagsvik and Strøm (1995) and van Soest (1995). However, when simulating the effects of policy changes, such as tax reforms, the partial equilibrium nature of these behavioural models is a 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.

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

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. We also examine the sensitivity of our results with respect to choice of tax instrument by estimating the required tax increase when a flat tax system is supposed to replace the current income tax system.

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. Holmøy, Strøm and Åvitsland (1999) provide a comprehensive description of the model and its empirical properties. Appendix 2 describes formally the macroeconomic structure of the model. 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 we interpret our simulation results.

The model assumes that the Norwegian economy is too small to affect world prices in NOK[8] 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.[9] 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

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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] 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.

[9] 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.

make the calculations of government budget effects more accurate. Government employment, the 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. 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. 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.[10]

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[11]. 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 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.

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

[11] 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).

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:

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

subject to the budget constraint $y = f\left(wh,m\right)$, 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

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

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

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

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[12]:

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

[12] See Dagsvik (1994) and Aaberge et al. (1999), who provide two alternative methods for deriving (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.

The parameters of the model have been estimated by maximum likelihood after choosing convenient but still flexible parametric forms for *V* and *p(h,w)*. The model is used to estimate the labour supply behaviour of the making individual between 20 and 62 years old, i.e. the most active individuals in the labour market. The empirical specifications of the model and the estimation results, based on Norwegian tax return data for married couples and single females and males, are given in Appendix 1. 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).

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.

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

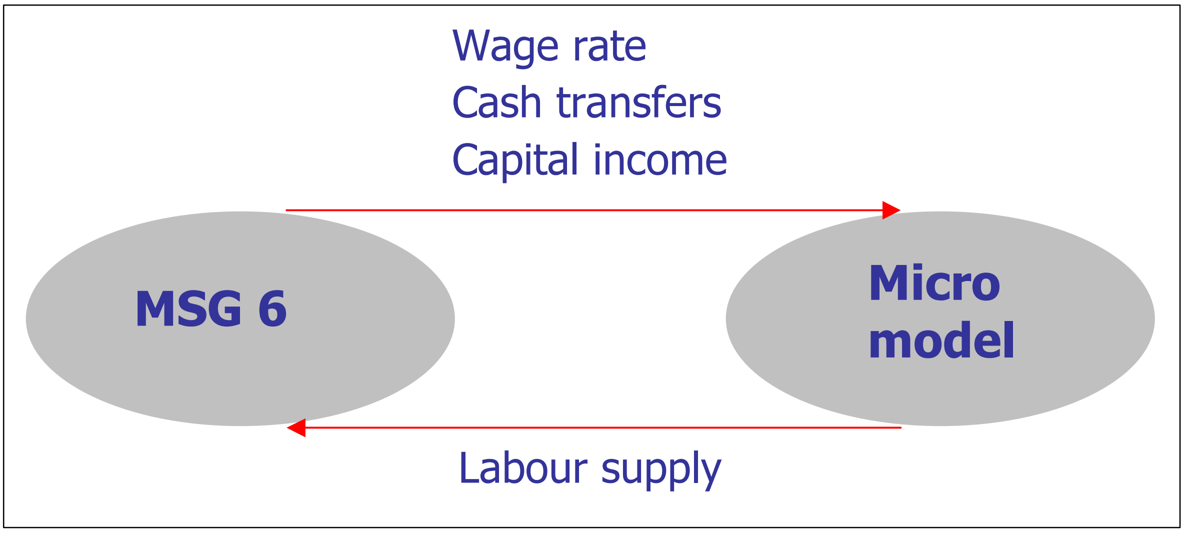
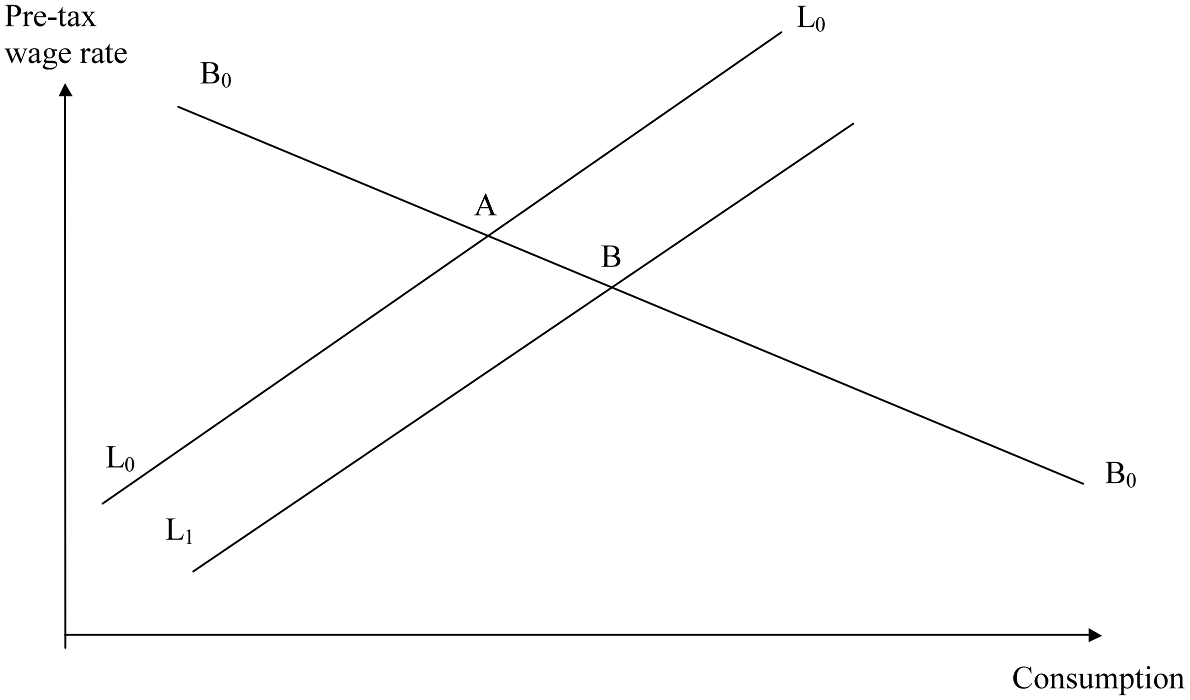


Figure 2.2 illustrates the equilibrium adjustment of the real wage cost per hour to a given increase in labour supply generated by the micro model. The figure contains a simplified reduced form of MSG6 that captures the essential parts of the determination of the stationary long run levels of the real wage cost and private consumption. The LL- and the BB-locus describe combinations of 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. 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. 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. 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.

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[13], 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.[14] 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.[15]

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

[14] 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).

[15] 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

	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
Average consumer real after-tax wage rate, NOK per hour	145.2	3.1
Cash transfers received by households, net of old-age pensions	92.9	3.1
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.[16]

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[17], 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 has become 3.1 times the 1995-level. Non-labour income includes cash transfers from the government and capital income. Deflated by the consumer price index, capital

[16] 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.*"

[17] 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.

income and total transfers (net of old-age pension benefits which are not received by the labour force) have in 2050 become, 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 have 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 has grown by 4.6 percent 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.

	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
Average consumer real after-tax wage rate, NOK per hour	3.1	3.1	0.8
Cash transfers per capita received by households, net of old-age pensions	3.1	3.1	1.9
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 has become 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.

An examination of the global properties of the microeconometric model reveals two patterns, which largely account for the deviation between the simulated increase in labour supply and the first order approximation based on the local elasticities. 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 in this paper since we restrict our study to simulate the outcome of the equilibrium in 2050, when the 1995 system of direct income taxation is replaced by a flat tax system. Under this hypothetical system the government budget constraint is met through endogenous adjustments of the flat tax rate, instead of the payroll tax rate. The flat tax is levied on all labour market earnings, as well as cash transfers and capital income. 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

	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
Consumer real pre-tax wage rate, NOK per hour	3.1	3.1	3.1
Consumer real after-tax wage rate, NOK per hour	3.1	3.1	4.2
Cash transfers per capita received by households, net of old-age pensions	3.1	3.1	3.2
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

	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
Consumer real pre-tax wage rate	0.8	-10.3	-8.6
Consumer real after-tax wage rate	0.8	1.7	-1.1
Cash transfers per capita received by households, net of old-age pensions	1.3	-7.0	-5.6
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 the following Table.

Equilibrium tax rates

		Tax system			
		Current (instrument: payroll tax rate)		Flat Tax (instrument: flat tax rate)	
		1995	2050	1995	2050
	Exogenous	***13.0***	***26.0***	***24.0***	***32.0***
Labour Supply	Endogenous	***13.0***	***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 Holmøy, Fredriksen and Heide (2003) 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[18]. 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.[19] 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 - 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.[20]

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[18] 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).

[19] 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).

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

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The micro-model - Empirical specification and estimation results

The modelling approach of this paper differs from the traditional textbook model by treating the utility function as a random variable and analyzing labour supply as a random utility maximization problem. This framework can be considered as an extension of the standard mutinomial logit model; see Dagsvik (1992) and Aaberge et al. (1999) for further details. For the sake of completeness we give a brief outline of this modelling framework.

To account for the fact that single individuals and married couples may face different choice sets and exhibit different preferences over income and leisure we estimate separate models for single females and males and married couples.

A.1. Single females and males

The structural part of the utility functions for single females and males is assumed to be of the following form

(A1)

$$\log v\left(C,h\right)=\alpha_2\left(\frac{C^{\alpha_1}-1}{\alpha_1}\right)+\left(\alpha_4+\alpha_5\log A+\alpha_6\left(\log A\right)^2+\alpha_7 Pu+\alpha_8 Ch_1+\alpha_9 Ch_2+\alpha_{10}Ch_3+\alpha_{11}PuCh_1+\alpha_{12}PuCh_2+\alpha_{13}PuCh_3\right)\left(\frac{L^{\alpha_3}-1}{\alpha_3}\right)$$

where $C=f\left(wh,I\right)$ is disposable income (income after tax) measured in 100 000 NOK, L is leisure, defined as $L=1-\left(h/8736\right)$, A is age, Pu is a dummy variable that takes the value one if the individual is employed in the public sector and zero if the individual is employed in the private sector,

Ch_1, Ch_2, and Ch_3 are number of children below 3, between 3 and 6 and between 7 and 14 years old, respectively. Note that the children terms are abandoned in the utility function for single males because very few children lived separated from their mothers.

We assume that the density of pairs of offered hours and wages in the market is given by

(A2)
$$p\left(h,w\right)=\begin{cases}g_0 g_1(h)g_2(w) & \text{if} \quad \left(h,w\right)>0\\ 1-g_0 & \text{if} \quad \left(h,w\right)=0\end{cases}$$

where g_0 is the proportion of market opportunities in the opportunity set, and g_1 and g_2 are the densities of hours and wages, respectively. Except for a possible peak in the full-time job interval <1846,2106> we assume that the distribution of offered hours is uniformly distributed. Thus, g_1 is given by

(A3)
$$g_1(h) = \begin{cases} \gamma & \text{if} \quad h \in [52, 1846] \\ \gamma\pi & \text{if} \quad h \in \langle 1846, 2106 \rangle \\ \gamma & \text{if} \quad h \in [2106, 3640] \end{cases}$$

where 3640 is the maximum hours observed in the sample.

The density of offered wages is assumed to be lognormal with mean that depends on length of schooling (S) and on past potential working experience (E), where experience is defined to be equal to age minus length of schooling minus five,

(A4)
$$\log w = \beta_0 + \beta_1 S + \beta_2 E + \beta_3 E^2 + \eta$$

where η is standard normally distributed.

The estimation of the models for single individuals and married couples is based on data from the 1995 Survey of Level of Living. For a more detailed description of the data and definition of variables we refer to the appendix. We have restricted the ages of the individuals to be between 18 and 54 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.

The parameters appearing in expressions (A1)-(A4) are estimated separately for single females and males by the method of maximum likelihood. The likelihood functions are equal to the products of the individual-specific labour supply densities for single females and males, respectively. The estimates of the preference and job opportunity parameters are reported in Table A1.

Table A1. Estimates of the parameters of the utility functions for single females and males[*)]. Norway 1994

Variable	Coefficient	Single females		Single males	
Preferences:					
Consumption	α_1	-0.59	0.28	0.24	(0.33)
	α_2	4.37	(0.52)	2.27	(0.44)
Leisure	α_3	0.65	(0.92)	0.76	(0.99)
	α_4	498.50	145.18	337.40	(128.84)
	α_5	-265.77	(79.22)	-180.89	(70.63)
	α_6	36.36	(10.89)	24.81	(9.75)
	α_7	-2.97	(0.87)	-2.20	(0.90)
	α_8	3.62	(7.87)		
	α_9	-0.36	(2.43)		
	α_{10}	-2.24	(1.42)		
	α_{11}	-7.29	(7.46)		
	α_{12}	-1.02	(2.10)		
	α_{13}	1.15	(1.10)		

[*)] Standard deviations in parentheses.

A2. Married couples

The labour supply model for married couples accounts for both spouses' decisions through the following specification of the structural part of the utility function for couples

(A7)

$$\log v(C,h_M,h_F)=\alpha_2\left(\frac{C^{\alpha_1}-1}{\alpha_1}\right)+\Big(\alpha_4+\alpha_5\log A_F+\alpha_6(\log A_F)^2+\alpha_7 Pu_F+\alpha_8 Ch_1+\alpha_9 Ch_2+\alpha_{10}Ch_3+\alpha_{11}Pu_F Ch_1+$$
$$\alpha_{12}Pu_F Ch_2+\alpha_{13}Pu_F Ch_3\Big)\left(\frac{L_M^{\alpha_3}-1}{\alpha_3}\right)+\Big(\alpha_{15}+\alpha_{16}\log A_M+\alpha_{17}(\log A_M)^2+\alpha_{18}Pu_M+\alpha_{19}Ch_1+\alpha_{20}Ch_2+\alpha_{21}Ch_3+$$
$$\alpha_{22}Pu_M Ch_1+\alpha_{23}Pu_M Ch_2+\alpha_{24}Pu_M Ch_3\Big)\left(\frac{L_F^{\alpha_{14}}-1}{\alpha_{14}}\right)+\alpha_{25}\left(\frac{L_M^{\alpha_3}-1}{\alpha_3}\right)\left(\frac{L_F^{\alpha_{14}}-1}{\alpha_{14}}\right).$$

where the leisure L_i is defined as $L_i=1-(h_i/8736)$, i = F, M. We allow for sector- and gender-specific job opportunities in accordance with the functional forms ((A2)-(A6)) that were used for single females and males. The estimates of the model parameters for couples are reported in Table A2.

Table A2. Estimates of the parameters of the utility function for married/cohabitating couples.[*)] Norway 1994

Variable	Coefficient	Estimates
Preferences:		
Consumption	α_1	0.14 (0.09)
	α_2	6.49 (0.43)
Wife's leisure	α_3	-3.81 (0.43)
	α_4	194.89 (28.53)
	α_5	-107.09 (15.88)
	α_6	15.14 (2.23)
	α_7	0.34 (0.31)
	α_8	1.31 (0.31)
	α_9	1.70 (0.26)
	α_{10}	-0.95 (0.30)
	α_{11}	0.40 (0.33)
	α_{12}	0.39 (0.32)
	α_{13}	-0.97 (0.24)
Husband's leisure	α_{14}	-1.01 (039)
	α_{15}	222.99 (41.03)
	α_{16}	-116.55 (22.34)
	α_{17}	15.85 (3.06)
	α_{18}	-0.60 (0.51)
	α_{19}	-0.08 (0.40)
	α_{20}	-0.30 (0.35)
	α_{21}	-0.15 (0.25)
	α_{22}	-0.16 (0.39)
	α_{23}	-0.93 (0.31)
	α_{24}	-0.16 (0.25)
Leisure interaction between spouses	α_{25}	4.84 (1.12)

[*)] Standard deviations in parentheses.

A.3. Wage elasticities

The wage elasticities 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 and opportunities. Given the responses of each individual we then aggregate over the individuals to get the aggregate elasticities. Tables A3 and A4 report these elasticities. Since many individuals in this model of discrete choice will not react to small exogenous changes, the elasticities in Tables A3 and A4 have been computed as an average of the percentage changes in labour supply from a 10 percent increase in the wage rates.

Table A3. Labour supply elasticities with respect to wage for single females, single males, married females and married males by deciles of household disposable income*. 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	I	0.59		0.00	
		II	0.45		0.00	
		III	0.06		0.06	
		IV	0.00		0.00	
		V	0.00		0.00	
	Elasticity of the conditional expectation of total supply of hours	I	-0.17		0.77	
		II	-0.04		0.00	
		III	-0.08		-0.08	
		IV	-0.07		0.00	
		V	0.00		0.00	
	Elasticity of the unconditional expectation of total supply of hours	I	0.42		0.77	
		II	0.42		0.00	
		III	-0.02		-0.02	
		IV	-0.07		0.00	
		V	0.00		0.00	
Married females and males	Elasticity of the probability of participation	I	1.03	-0.28	0.90	-0.23
		II	0.35	-0.14	0.79	0.00
		III	0.14	-0.23	0.13	-0.10
		IV	0.12	-0.12	0.06	-0.06
		V	0.07	0.00	0.06	-0.19
	Elasticity of the conditional expectation of total supply of hours	I	1.51	-0.01	0.87	0.11
		II	0.62	-0.53	0.38	-0.08
		III	0.27	-0.24	0.18	-0.14
		IV	0.08	-0.22	0.02	-0.09
		V	0.19	-0.10	-0.02	-0.23
	Elasticity of the unconditional expectation of total supply of hours	I	2.54	-0.29	1.77	-0.12
		II	0.97	-0.67	1.17	-0.08
		III	0.41	-0.47	0.31	-0.24
		IV	0.20	-0.34	0.08	-0.14
		V	0.26	-0.10	0.05	-0.42

* I = the lowest decile in the distributions of observed after-tax income for single females, single males and couples, respectively. II = the second decile, III = the third to eight decile, IV = the ninth decile and V = the tenth decile.

Table A4. 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 the sixth panel of Tables A3 and A4 give the unconditional elasticities of labour supply, which means that both the impact on participation and hours supplied is accounted for.
Table A5 demonstrates that all own wage elasticities of married females and married males are positive, whereas single females and males located in the central part of the income distribution will respond weakly negative to a wage increase. Second, we observe that almost all cross wage elasticities are negative due to the income effect. Thus, an increase in, say, the wage rate for males implies 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. For couples belonging to the ninth decile of the couples' income distribution this counteracting effect is so strong that labour supply of these couples declines from an overall wage increase. From the two the first two rows in each of the panels of Table A3 we observe that the labour supply of the 10-20 percent poorest are far more responsive to changes in economic incentives than the 10-20 percent richest. For single females and males in the 3-8 deciles of their corresponding income distributions we observe backward bending labour supply curves as income effects dominate over substitution effects.

By comparing the fourth and fifth panel of Table A3 we see for married/cohabitating females that hours supplied (given participation), in particular for those belonging to the poorest couples, is 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 males with medium high incomes.

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.[21]

A.4. Income elasticities

The estimated income elasticities are reported in Tables A5 and A6. Non-labour income comprises several income categories, which are unevenly distributed among households and do not change uniformly in our simulation experiments. Since the income elasticities are household specific, the aggregate labour supply response to a shift which involves changes in non-labour income, is the result of a complex calculation. Our simulations capital income and cash transfers are unevenly affected by the general economic growth and the tax rate adjustments. Table A6 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 A.5. Aggregate labour supply elasticities with respect to non-labour 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

[21] 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. Card and Robbins (1998) report an almost doubling of employment rates for person offered in-work benefits compared to a control group.

Table A.6. Labour supply elasticities with respect to non-labour income for single females, single males, married females and married males by deciles of household disposable income*. Norway 1994

Family status	Type of elasticity		Female elasticities: Non-labour income (cap. income + cash transfers)	Female elasticities: Capital income	Female elasticities: Cash transfers	Male elasticities: Non-labour income (cap. income + cash transfers)	Male elasticities: Capital income	Male elasticities: Cash transfers
Single females and males	Elasticity of the probability of participation	I	-0.59	0.59	-0.59	0	0	0
		II	0	0	0	0	0	0
		III	-0.71	-0.13	-0.64	-0.12	-0.12	-0.06
		IV	-1.38	-0.34	-1.38	-0.33	0	-0.33
		V	-1.33	-1.00	-1.00	-0.83	-0.83	0
	Elasticity of the conditional expectation of total supply of hours	I	0.43	-0.16	0.43	0	0	0
		II	0	0	0	0	0	0
		III	0.08	0.02	0.09	0.05	0.05	0.05
		IV	-0.21	-0.04	-0.21	0.05	0	0.05
		V	-0.51	0.16	-0.47	-0.42	0.01	-0.40
	Elasticity of the unconditional expectation of total supply of hours	I	-0.18	0.42	-0.18	0	0	0
		II	0	0	0	0	0	0
		III	-0.63	-0.11	-0.56	-0.07	-0.07	-0.01
		IV	-1.56	-0.22	-1.42	-0.29	0	-0.29
		V	-1.81	-0.86	-1.42	-1.22	-0.82	-0.40
Married females and males	Elasticity of the probability of participation	I	0	0	0	0	0	0
		II	0	0	0	0.07	0.14	0.07
		III	-0.16	-0-06	-0.11	-0.17	-0.17	-0.10
		IV	-0.23	-0.12	0	-0.46	-0.29	-0.17
		V	-0.81	-0.54	-0.27	-0.82	-0.57	-0.25
	Elasticity of the conditional expectation of total supply of hours	I	0	0	0	0	0	0
		II	-0.05	-0.10	-0.10	-0.08	0.01	-0.12
		III	-0.05	0.01	-0.03	-0.03	0	-0.03
		IV	-0.14	-0.06	0	-0.01	-0.01	0.03
		V	-0.22	-0.22	0.10	-0.32	-0.13	-0.13
	Elasticity of the unconditional expectation of total supply of hours	I	0	0	0	0	0	0
		II	-0.05	-010	-0.10	-0.01	0.16	-0.04
		III	-0.21	-0.05	-0.13	-0.20	-0.07	-0.13
		IV	-0.37	-0.18	0	-0.47	-0.30	-0.14
		V	-1.01	-0.75	-0.17	-1.11	-0.69	-0.38

* I = the lowest decile in the distributions of observed after-tax income for single females, single males and couples, respectively. II = the second decile, III = the third to eight decile, IV = the ninth decile and V = the tenth decile.

Table A.7. The distribution of observed labour and non-labour household income by family status. Norway 1994

Family status		Household income, NOK 1994			
		Earnings	Cash transfers	Capital income	Gross income
Single males (M)	I	47628	24877	9796	82300
	II	86569	13213	5429	105212
	III	158998	14273	12033	185304
	IV	261927	19849	25129	306905
	V	288260	15139	158675	462074
	VI	163806	15861	27026	206694
Single females (F)	I	43351	36240	4093	83684
	II	69078	29817	7032	105927
	III	133800	32565	10536	176901
	IV	194107	43013	24647	261767
	V	256523	52515	14732	323771
	VI	136595	35708	11375	183677
Couples	I	146076	27060	16544	189680
	II	201199	33697	22404	257300
	III	329398	32169	37479	399046
	IV	473665	34986	71892	580544
	V	507850	33207	287367	828424
	VI	330517	32197	62281	424994

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:

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

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

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

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

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

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

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

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

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

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

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

(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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Labour market equilibrium implies

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

Net foreign wealth, *B*, develops according to

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

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.

Combining a dynamic and a static 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.

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