CHAPTER 3

Computable General Equilibrium Assessments of Fiscal Sustainability in Norway

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Abstract

The chapter demonstrates how the computable general equilibrium model MSG6, combined with special models of government expenditures, has been used to assess the long-run fiscal sustainability in Norway. The simulations suggest that Norway faces a severe fiscal sustainability problem in the long run, despite an exceptionally strong fiscal position at present. This result is found to be relatively robust to exogenous variations in productivity growth, petroleum prices, longevity, immigration and the health of the elderly. The chapter also discusses the fiscal effects of various policy responses, including the pension reform of 2011, improvements in the standards of public health services and care for the elderly, as well as a tighter fiscal policy rule. The simulation experiments demonstrate that general equilibrium mechanisms contribute significantly to the total effects.

Keywords

Population ageing, fiscal sustainability, computable general equilibrium model, dynamic microsimulation

JEL classification codes

H30, H55, H62

3.1 INTRODUCTION

Most industrial countries face fiscal sustainability challenges due to substantial increases in their demographic old-age dependency ratios after 2010. Contingent on present tax rates and welfare schemes, government expenditures are projected to grow faster than the tax base, which necessitates increases in the tax rates or cost-saving reforms of the welfare schemes. Most economies in the Organization for Economic Cooperation and Development (OECD) struggle with strained government finances already at the early stage of the ageing process of the population. The financial crisis and the expansionary fiscal measures taken to counteract it have further weakened government finances in several countries. Over the next decades, ageing will make the fiscal sustainability problems much harder to solve. The wave of pension reforms and other cost-saving reforms of

Handbook of CGE Modeling - Vol. 1 SET
ISSN 2211-6885, http://dx.doi.org/10.1016/B978-0-444-59568-3.00003-1

public welfare schemes indicate that policy making adjusts to the prospects communicated through long-run economic projections. However, the present economic and political turbulence in several indebted European economies clearly manifest that cutting public welfare and increasing the tax burden are highly unpopular policies.

The fiscal sustainability problem is likely to be particularly severe in the Scandinavian welfare states where the government provides relatively generous and highly non-actuarial pensions and most of the health and care services. As will be argued in this chapter, this is also true for Norway although Norway's present fiscal stance looks exceptionally strong. The large but temporary petroleum rents collected by the government may obscure a sound evaluation of the potential fiscal sustainability problems facing Norway as ageing sets in. Moreover, substantial budget surpluses may stimulate further expansion of an already generous welfare state, rather than cost-saving welfare reforms. Thus, long-run analyses of fiscal sustainability are particularly important in Norway.

Realistic long-run projections of government finances based on empirical models are perhaps the only way to make politicians aware of the long-run fiscal consequences of today's decisions on pay-as-you-go tax-financed welfare schemes, including health services, long-term care and public pension systems of the defined benefit type. Population ageing makes the present and future expenditure effects of given welfare standards much larger than they were when they were implemented. A long-run perspective on tax-financed welfare policies is also imperative since history shows that it is very hard to reverse such welfare improvements.

Computable general equilibrium (CGE) modeling should play an important role in working out projections relevant for evaluation of long-run fiscal sustainability problems, and there is a large literature of CGE studies of fiscal sustainability.[1] (i) The long-run perspective makes the general equilibrium assumptions of rational responses to economic incentives, flexible relative prices and market clearing appropriate. (ii) The longer the time horizon, the more will many of the exogenous variables deviate from their values today. Moreover, changes in tax bases and government expenditures reflect changes in most markets of the economy. The relevance of general equilibrium effects is increasing in the magnitude of the exogenous changes, and in the number of agents facing these changes and their repercussions. (iii) CGE models are typically constructed for policy evaluation, especially of budget-neutral combinations of changes in policy instruments. The focus on budget neutrality obviously overlaps with the focus on total budget effects in studies of fiscal sustainability.

[1] See Chauveau and Loufir (1995); OECD (2001); European Commission (2001); McMorrow and Roeger (2002); and Visco (2002) for international comparisons of quantitative assessments of the fiscal and macroeconomic consequences of ageing. Kotlikoff *et al.*, (2001); Kotlikoff (2001); and Feldstein (2005) estimate the fiscal gap in the US. Beetsma *et al.*, (2003) and The Danish Welfare Commission (2004) estimate the need for raising the tax burden in the Netherlands and Denmark, respectively. Andersen *et al.*, (2008) provide a review in English of the Danish Welfare Commission.

There is a strong tradition in Norway for using empirical large-scale models in economic planning and policy making. Bjerkholt (1998) discusses how institutional features distinguish the use of macroeconomic models in Norway from that of other countries. The shift from a high degree of central government planning in the first decades after World War II to the use of market-based mechanisms has changed, but not reduced, the use of empirical large-scale models. In particular, such models have become increasingly important in order to evaluate long-run fiscal sustainability problems. They were probably important for the wide political acceptance of the fiscal policy rule adopted in 2001, which has imposed quite tight restrictions on the annual use of the petroleum rents. They were also explicitly used in the process that provided acceptance of the cost-saving Norwegian pension reform implemented in 2011.

Empirical analyses of long-run trends and supply-side policy reforms in Norway have usually employed the model called MSG (an abbreviation of multisectoral growth) or, more precisely, one of the several versions of this family of models. Bjerkholt and Tveitereid (1985) and Schreiner and Larsen (1985) describe the use of MSG in the Norwegian planning system. In order to exploit the maximum of available information, MSG is often combined with more partial and specialized models, which determine the demographic development, labor force and public pension expenditures. Since the late 1990s, different versions of the sixth generation of MSG, MSG6, have been used, both in academic research and for policy making by the Norwegian Ministry of Finance (NMF). MSG6 has little in common with the original MSG model, MSG1, developed by Leif Johansen as an integral part of his pioneering thesis on MSG presented in Johansen (1960). According to Jorgenson (1984), MSG was the first successful implementation of a CGE model without the assumption of fixed input-output coefficients. The background and importance of Johansen's development of MSG1 is discussed in Dixon and Rimmer (2010) and Bjerkholt (2009). Holmøy (2011) also describes the CGE modeling carried out after Johansen's work within the "MSG project," focusing on how and why new generations of MSGs have been developed.

The sophistication of MSG and other CGE models have increased dramatically since 1960. The research topics are also different. However, the main motivation for the CGE approach is in principle still the same. Johansen saw that, in analyses of the expansion of several industries in a growing economy, clear and interesting results can not typically be derived analytically in general equilibrium models with more than two sectors. However, by exploiting the power of computers, instead of only pen and paper, he was able to solve much richer and more complex models. This allowed him to exploit much more of the available relevant information, which drastically improved the relevance and realism of the analysis.

However, a tradeoff between transparency and realism/relevance seems unavoidable. The lack of transparency has been a key argument for criticizing the CGE approach, and other large-scale empirical macroeconomic models, for not meeting standard criteria for good science. The main point in this criticism is that it is hard for outsiders to check the results. However, a quotation from Mankiw (2006) seems appropriate when discussing this matter:

> … *the subfield of macroeconomics was born not as a science but more as a type of engineering. God put macroeconomists on earth not to propose and test elegant theories but to solve practical problems.*

Johansen made important contributions to economic theory, but his MSG book clearly shows that he had the engineer's attitude to CGE modeling. It seems fair to say that the "engineering" attitude has dominated the CGE literature, not least the MSG project.

This chapter demonstrates how CGE modeling has been used to assess to what extent Norway faces long-running problems of fiscal sustainability. It also analyses the fiscal effects of various policy responses, including the pension reform of 2011, improvements in the standards of public health services and care for the elderly, as well as a tighter fiscal policy rule. The exposition emphasizes the importance of the general equilibrium effects. More specifically, Section 3.2 describes the structure and properties of MSG6, focusing on what is most relevant when examining fiscal sustainability issues. A more comprehensive and detailed description is relegated to the Appendix. Heide *et al.*, (2004) provide detailed explanations of how MSG6 works. Section 3.3 assesses the fiscal sustainability problem in a baseline scenario. Sections 3.4, 3.5, 3.6 and 3.7 examine how the picture of the fiscal prospects depend on, respectively, higher productivity in the private sector, the oil price, the pension system, the mortality and health of the elderly, the standard of tax-financed health services and old-age care, immigration, and the tightness of the fiscal rule. Section 3.8 makes some final remarks.

3.2 MODEL STRUCTURE

Conceptually and empirically, the system of national accounts forms the base for MSG6. The model has been constructed to analyze a wide range of issues. In addition to long-run projections of macroeconomic growth and government finances, these issues include social efficiency and reallocation effects of industry and trade policy, tax reform and the links between economic activity, energy markets and the environment. The importance of different parts of the model depends of course on the issues being analyzed. The following exposition emphasizes the parts and properties that are most relevant in studies of long-run fiscal sustainability.

3.2.1 Demography, labor force, government consumption and public pensions

The demographic development is exogenous in MSG6. It is set equal to the projection regarded by the demographic experts as the most plausible one among the latest available official demographic projections. These are provided by Statistics Norway.

MSG6 specifies six government production sectors, where the factor shares are exogenous. Following the national accounts, government consumption equals the production costs in government sectors, plus the purchases of products from private industries, minus the revenues from user fees and sales of government services. Government purchases of final goods from private industries are exogenous. The government revenues from user fees and sales depend endogenously on the demand from households and private firms. However, these revenues cover a relatively small share of the total government consumption expenditures. Labor costs are the major cost component in government consumption. These expenditures are therefore basically driven by the assumptions that determine the demand for labor in government service sectors.

Employment in the sectors *Administration* and *Defense* is assumed to grow proportionally to the total population. The other four government sectors specified in MSG6 include: *Education*, *Health services*, *Child care* and *Long-term care*. Government consumption in these sectors was 19.5% of the Norwegian Mainland-GDP[3] in 2010. These sectors are split into 12 subsectors, all producing individual services. The employment growth in each subsector is determined by the corresponding labor demand, which equals the product of changes in the following components: (i) Labor productivity, (ii) the age- and gender-specific service standard, measured by man-hours per user, (iii) the age- and gender-specific user rate, measured by the number of users relative to the relevant population, and (iv) the number of males and females, respectively, in each age group. The age- and gender-specific user rates may be used to simulate changes in the health conditions of the different age groups.

The *Old-age* and the *Disability* pensions are by far the most important public pension schemes in a long-run fiscal perspective. In 2010, the expenditures of these pensions equaled 9.0% of the Norwegian Mainland-GDP. Most fiscal sustainability studies based on MSG6, including all those presented in this chapter, have incorporated highly detailed projections of public pension expenditures. However, it would be unfeasible to incorporate calculations of public pension expenditures in MSG6 that are sufficiently realistic and detailed with respect to the pension rules and population heterogeneity, to be interesting in operational pension policy discussions. Instead, MSG6 is combined with the dynamic microsimulation model MOSART, which is especially designed for simulating individual pension entitlements, benefits and government pension expenditures (Fredriksen, 1998). MOSART has been regularly used by the government to compute government pension expenditures. In particular, the model was intensively used under the preparation of the public pension reform implemented in 2011.

MOSART includes accurate descriptions of most elements in the existing and alternative pension systems. Specifically, it accounts for the complex interplay between minimum guarantees and earnings-dependent pensions. The model simulates the

[3] The Mainland sector is equal to the total economy except the off-shore petroleum sectors and ocean transport.

economic life courses of a representative cross-section equal to 1% of the Norwegian population, using a set of transition probabilities to determine the occurrence of sociodemographic events, including births, migration, deaths, marriages, divorces, educational activities, retirement, and labor force participation. Figure 3.1 shows the structure of this model. The probabilities of transition between states over the life course are functions of individual characteristics, which are estimated from observations in a recent period, mostly cross-sectional data. In analyses of fiscal sustainability, the relevant outcome of the MOSART projections are the time paths of the number of various types of pensioners, average individual pension benefits, total public pension expenditures and the total labor force. Pension benefits and total pension expenditures are calculated in real terms, i.e., in terms of the wage rate in a base year.

Age profiles of labor market participation and labor market earnings constitute a central part of MOSART, since the age profiles of earnings are crucial for the computations of individual pension entitlements and benefits. These age profiles differ between population groups defined by *inter alia* gender, education and country background. Aggregating man-hours over the individuals in MOSART, and adjusting for the sample size, generates the total labor force, which can be interpreted as the potential labor supply.

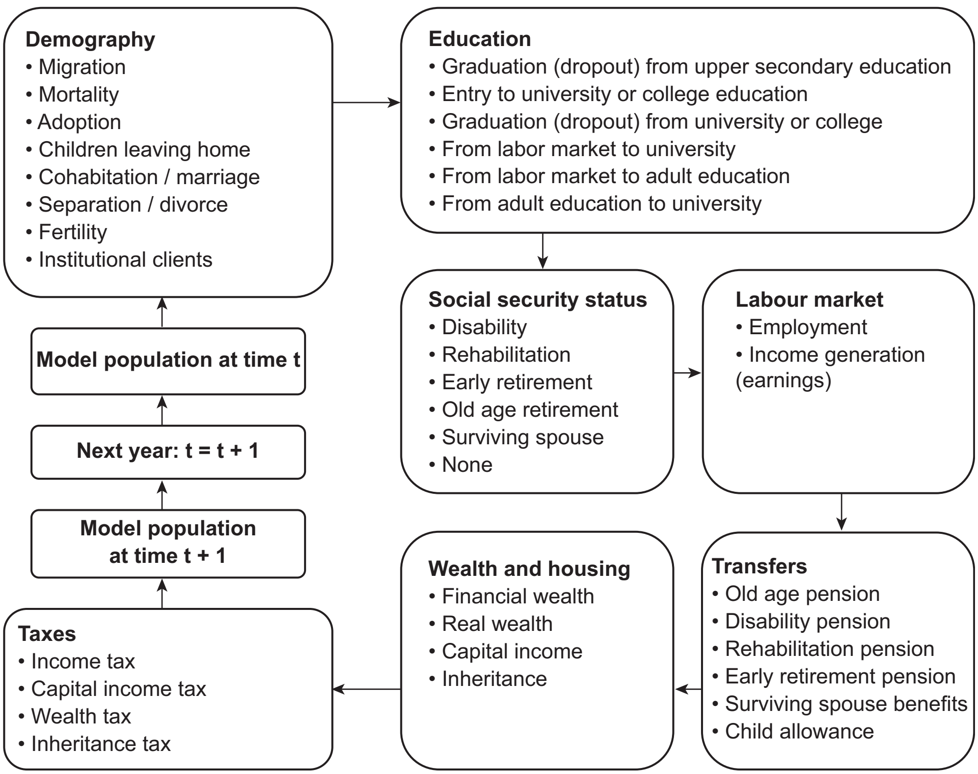

Figure 3.1 Structure of the dynamic microsimulation model MOSART.

This is an increasing function of educational attainment at both the intensive and the extensive margin. Specifically, individuals with relatively low education become disability pensioners earlier and at a higher degree compared with individuals with high education. The microsimulations capture the increasing trend of female education and labor supply, which implies a surge in the future old-age entitlements of women.

Contrary to MOSART, MSG6 includes endogenous labor supply behavior. As will be described in more detail below, a representative consumer maximizes in each year a constant elasticity of substitution (CES) utility function defined over material consumption and leisure subject to a budget constraint. This reflects the assumption that all individuals have the same labor supply response to given changes in economic incentives. Thus, MSG6 adds the real consumer wage rate, real non-labor income and taxes to the demographic labor supply determinants specified in MOSART. The MSG6 projections take the development of the labor force determined by MOSART as a starting point in the determination of aggregate labor supply. Typically, the baseline scenario of total man-hours is set equal to the MOSART projection. In this particular projection, any labor supply effects of growth in the after tax real wage rate and the real non-labor income are neutralized by changes in the utility function parameter governing "productivity" of leisure. One rationale for this procedure is to make the baseline scenario transparent and easy to explain. Moreover, the net labor supply effect of realistic growth in both the real wage rate and non-labor income is relatively small. However, when MSG6 is used to simulate other scenarios, which are compared with the baseline, preference parameters are exogenous and equal to their baseline values, whereas labor supply responds to changes in the real wage rate and non-labor income.

Except for special studies, such as the effects of a public pension reform, there is no feedback from the economic development simulated by MSG6 on the MOSART projections. This implies that one neglects the effects on public pension expenditures caused by changes in labor supply incentives, which affect employment, earnings and pension entitlements. This is a weakness. It can be mitigated by iterative simulations between MSG6 and MOSART. As a matter of fact, this has actually been done in studies of the public pension reform, see Section 3.5, where pension expenditures are at the heart of the analysis. In the other studies, we have reasons to believe that the neglected effects on pension expenditures are relatively small and highly uncertain. In our view, the gains in terms of accuracy and relevance by taking the MOSART projections into account outweigh the importance of the lack of complete consistency between the comparable projections generated by the two models.

3.2.2 Brief overview of MSG6

The calculations outlined above of the demographic development, labor force, number of pensioners, individual pension benefits and public pension expenditures *ex ante* wage indexation, and real government consumption enter MSG6 as exogenous variables. One might say that the main role of MSG6 in analyses of fiscal sustainability is to calculate the tax bases and the relative prices, especially the price element in the various government expenditure components relatively to the price element in the sources of government revenues. All tax bases are endogenous in MSG6. As the model specifies 60 commodities and 40 production sectors, the calculation of the revenue from indirect taxation of households and firms captures important details of the tax system.

Changes in the wage rate and prices will in general not be budget-neutral, since they induce disproportionate effects on the nominal tax bases and the nominal government expenditures. Specifically, the direct and indirect share of wages is higher in the expenditures than in the tax bases, even when the petroleum taxes are exempted. One of the reasons for this is that almost all cash transfers to households are indexed by the wage rate. This reflects that Norway is an egalitarian welfare state with small income differentials between employed and unemployed individuals. This property of the Norwegian economy gives rise to important general equilibrium repercussions in most of the simulation experiments presented in Sections 3.4–3.7.

MSG6 models the Norwegian economy as too small to affect world prices and the international interest rate, and the exchange rate is fixed. Goods and factors are perfectly mobile between industries. Supply equals demand in all markets in all periods. All agents have access to international capital markets. The economy as a whole obeys an intertemporal budget constraint formalized as a non-Ponzi game condition for the accumulation of foreign debt. This 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.

The standard version of MSG6 includes a submodel of intertemporal consumer behavior, where a representative consumer with an infinite time horizon and perfect foresight maximizes an additively intertemporal utility function over an infinite horizon subject to an intertemporal budget constraint and a time constraint in each period. However, such a model is irrelevant in fiscal sustainability studies, involving *inter alia* ageing and pensions. All studies summarized in this chapter ignore intertemporal consumer behavior, but they maintain the abovementioned intertemporal budget constraint for the economy as a whole. Rather, the time path of total private consumption is determined from the supply side; households consume what is left of production and net imports after the demand from firms and government sectors have been satisfied. The time profile of private consumption is reasonable compared to historic trends in our projections and changes in this profile have small effects on our evaluations of fiscal sustainability.

As noted above, consumers decide in each period on labor supply and the composition of private consumption according to standard consumer theory. The utility obtained in each period corresponds to the concept Full Consumption, which is a homothetic CES utility function in leisure and an aggregate of all types of consumer goods referred to as Material Consumption. The elasticity of substitution is set to 0.6. The initial budget share of leisure has been set to 0.5 based on studies of time spending by Norwegian households. Combined with the base year levels of non-labor income, these parameter values imply a direct Cournot wage elasticity of labor supply equal to 0.1. Such an order of magnitude is in line with the empirical properties of the micro-econometric model estimated by Aaberge *et al.,* (1995).

MSG6 distinguishes between the behavior of the individual firms and the aggregate industry behavior. Output and input in an industry can change through adjustments at the firm level and through entry or exit of firms. All private firms are run by managers with perfect foresight, who maximize the present value of cash flow. The private profitability is affected by indirect taxation of inputs, capital income taxation, and a rich menu of subsidies and government transfers. Producers of manufactures and tradable services allocate their output between the domestic and the foreign market. The cost of changing the composition of these deliveries 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.

Whereas exports are sold at fixed world prices, domestic consumers regard products from different firms within the same industry as close but imperfect substitutes. MSG6 employs the model of the Large Group case of Monopolistic Competition (LGMC) to formalize the market structure for domestic deliveries. The elasticities of substitution between the varieties in different industries are calibrated to be consistent with the estimated markup ratios between the output price and marginal costs in Klette (1999). None of the markup ratios exceeds 1.05. Entry (exit) takes place in an industry if the variable after tax profit increases (decreases) relative to the fixed entry cost. The model of monopolistic competition in MSG6 differs from the standard textbook model by allowing productivity differentials between firms within the same industry, which generates an *asymmetric* equilibrium (see Holmøy and Hægeland, 1997).

For inputs, the separability assumptions allows all inputs to be perfectly aggregated into one index of aggregate input through a system of nested constant returns to scale CES functions. Labor is homogeneous, whereas the capital goods and intermediaries are Leontief aggregates of the commodities specified in the model. The production function of the firm is assumed to exhibit decreasing returns to scale. The scale elasticities range from 0.85 to 1.00, which implies a small negative bias compared to those estimated in Klette (1999). This bias was introduced in order to avoid unrealistic specialization patterns of the industry structure.

Most imported manufactures and a few tradable services are close but imperfect substitutes for the corresponding domestic products. Thus, the import shares of these products are modeled according to the Armington assumption. Commodities produced by primary industries are assumed to be regarded as homogenous by both Norwegian and foreign consumers. In the absence of any trade restriction, the prices of these commodities would be equal to the corresponding exogenous world prices, and the model would determine only net imports as the residual between domestic production and domestic demand. Import protection is captured by nominal tariffs and non-tariff barriers modeled either as additional costs for foreign producers when exporting to the Norwegian market, or quantitative restrictions, such as import quotas.

Since all world prices of Norwegian exports and imports are exogenous, there is no scope for endogenous terms-of-trade effects caused by changes in Norwegian prices. The single wage rate is the only endogenous primary factor price. The model avoids the possibility that only one traded good sector survives the competition in the product and factor markets that ensures full exploitation of comparative advantages. This well-known “specialization problem” is avoided by the assumption of decreasing returns to scale, which causes increasing supply curves of exports. However, the price sensitivities of exports are large, and the dynamics of export adjustments are unrealistic. Table 3.1 summarizes the differences between the textbook Small Open Economy (SOE) model and MSG6. Despite the differences, the logic underlying the SOE model remains instructive when interpreting the results generated by MSG6.

In particular, this applies to the wage rate determination. Although this results from a highly complex simultaneous model structure, one may still say that the wage rate adjustment is *the* basic mechanism that ensures that the economy meets the intertemporal external balance constraint. In a long-term scenario, nominal wage growth will be close to the sum of the exogenous growth in world prices and the parameters reflecting factor productivities — a property consistent with the Scandinavian Model of Inflation. However, contrary to the textbook SOE model, MSG6 includes some interdependence between the determination quantities and relative prices. This can be exemplified by considering an exogenous increase in the labor force, raising employment. The additional income of increased employment is spent on both traded and non-traded goods. As long as exports do not change, increased demand for traded goods raises imports in all years, which violates the external balance constraint represented by the non-Ponzi game condition on net foreign debt. Recall that world prices of exports are exogenous. Thus, a real depreciation is required in order to restore the external balance. The real depreciation is obtained by a fall in the wage rate. This makes it profitable for firms to increase exports and the import shares will decline in all kinds of demand.

Table 3.1 MSG6 compared with the standard model of a SOE

SOE	MSG6
1. Firms maximize profits: exogenous world product price = marginal cost, which is independent of the scale of production, due to: a. Constant returns to scale. b. Exposed sectors with comparative advantage survive and "determine" prices of internationally immobile factors. c. Prices on non-traded goods determined by unit costs. d. Prices are independent of quantities (factor price equalization). e. "Extreme" specialization of the exposed sector.	1. Firms maximize profits, but: a. (Weakly) decreasing returns to scale. b. Imports and domestic products are imperfect substitutes. c. Prices of internationally immobile factors are *mainly* determined by the exposed sectors; downsizing increases the ability to remunerate factors. d. Prices on non-traded goods determined by markups over marginal costs. e. Less "extreme" specialization of the exposed sector, but exporting industries are sensitive to changes in costs.
2. Full employment of all resources. 3. Households receive the factor income, which is allocated on consumer goods through utility maximization. 4. Non-traded goods: domestic production = domestic demand.	2–4. As in the SOE model, but more details.
5. Balanced trade.	5. Trade is balanced in present value terms.
6. Given the set of active industries, resource rents do not affect factor prices.	6. Resource rents increase factor prices.

3.3 EVALUATING FISCAL SUSTAINABILITY

3.3.1 Key exogenous assumptions

The baseline scenario is simulated from 2006 until 2050. The focus on long-run fiscal sustainability makes the exogenous demographic development particularly relevant. The baseline scenario is based on the median alternative in the population projections from 2008 (Statistics Norway, 2008). This projection assumes:

- The fertility rate equals 1.85.
- Annual net immigration was set to 40,000 in the first years, which is about two-thirds of an average cohort of newborns. Net immigration gradually declines and equals 20,000 from 2030. The main share of immigrants is 20–39 years old.
- The average longevity of men and women increases annually by 0.14 years. Thus, over the period 2005–2050 average longevity for newborn men and women increases by nearly 6.5 years.

- The demographic dependency ratio measured by the number aged 20−66 relative to the number of those aged 67 and older will decrease from 4.7 in 2005 to 2.7 in 2050.
- With respect to changes in pension expenditures, it is particularly important that the remaining life expectancy for both men and women aged 62 years increases by 4 years from 2010 until 2050.
- The demographic dependency ratio, measured by the sum of individuals being younger than 20 years or older than 65 years divided by the rest of the population, will stay at about 68% until 2016. The ratio rises and stays at approximately 83% between 2037 and 2046. It then rises further, passing 88% around 2060.
- The public expenditures on health services and long-term care depend primarily on the number of elderly more than 80 years old. The share of this age group in the total population declines from 4.6% in 2007 to 4.1% in 2015. Then it starts to grow continuously, passing 4.6% again in 2020 and 9% in 2055.

In addition to the demographic development, the following exogenous assumptions are key determinants of the growth in macroeconomic variables and the government budget components:

(i) *Total labor supply in the baseline scenario* is determined in the dynamic micro-simulation (see Section 3.2.2) by adding up each person's labor force participation rate and expected working hours. It depends on age- and gender-specific assumptions about education, disability, early retirement, unemployment and working hours. Aggregate labor supply grows by 0.3% per year in the baseline. As mentioned in Section 3.2.2, the MSG6 simulations allow aggregate labor supply to change endogenously away from the baseline.

(ii) *Total factor productivity* (TFP) grows by 1.3% per year in private industries, which is in line with historical trends. Labor productivity in government sectors grows by 0.5% per year.

(iii) *World prices*, except prices of crude oil and natural gas, grow by 1.5% annually.

(iv) The *nominal interest rate* stays constant at 5.5%.

(v) The *government petroleum revenues* are based on the regularly updated production forecasts carried out by the Norwegian Petroleum Directorate. The oil price grows by 2% annually from the average level of 2007 of $71 (2007 dollars) per barrel. The price of natural gas follows the oil price.

(vi) The *public welfare policies* applying in the base year are prolonged, which implies no real growth in the standards of individual public welfare benefits, including both government cash transfers to individuals, as well as the role of the government in producing and financing individual welfare services, including *Health services*, *Social care* and *Education*. This assumption is probably not the most realistic one. Rather, it has been chosen for technical reasons. Especially, it provides a benchmark for analyzing the effects of the pension reform implemented in 2011, as well as other potential welfare policy changes. More precisely, the assumption means that all cash transfers are indexed by the growth in the average wage rate. It also implies prolongation of the base year age specific user ratios and the standard of the welfare services. The service standard is defined as the use of labor and other resources per user of the services.

(vii) *Employment in the sectors producing public goods*, i.e. *Defense* and *Administration*, is in per capita terms the same as in the base year. This also applies to the ratios between labor and other inputs.

(viii) The *fiscal policy* follows a strict interpretation of the fiscal rule introduced in 2001. It isolates the government petroleum revenues measured as the net cash flow (P) from the rest of the budget. The government petroleum revenues are saved in the Government Pension Fund (GPF). Among several restrictions on the investment policy, the GPF capital cannot be invested in Norwegian assets. The government is allowed an annual out-take, which should equal the expected real rate of return (r) on the GPF capital (B) as an average over the cycle. So far, this real rate has been set to 4.0%, which is assumed to equal the long-run difference between the expected nominal returns on the GPF capital (i) and the expected general growth in world prices (π). The annual public budget constraint is defined by equality between the out-take of 4% of the accumulated GPF capital and the non-petroleum primary deficit (D). Formally, the public budget constraint in year t is $D_t = (i - \pi)B_{t-1}$. Then the GPF capital accumulates according to $B_t = (1 + \pi)B_{t-1} + P_t$. Since i, π and P are exogenous variables in MSG6, the time paths of B and D are effectively exogenous.

(ix) *Endogenous pay-as-you-go adjustments of the payroll tax rate* are to used meet the public budget constraint. All other tax rates remain constant in real terms. As any choice of a budget-neutral policy response, this choice is somewhat arbitrary. It has the following motivation: (a) If the long-run scenarios are supposed to quantify the problems of fiscal sustainability, it is hard to rationalize that policies aiming at reducing the growth in specific government expenditure components should be neutralized by raising other government expenditures. (b) If taxes rather than expenditures adjust, it is rather uncontroversial that the tax burden effectively will be carried by labor in a SOE. (c) Most contributions to mandatory public or private pension schemes are formally paid by the employer as a fixed share of wages. In fact, the payroll tax was introduced as a social security premium. (d) Other taxes are more complex than the payroll tax. Changing these would imply some kind tax reforms and explaining these would take the focus away from the discussion of fiscal sustainability.

These assumptions imply an average annual growth in real GDP of 1.7%. This growth projection is weak compared to historical trends. The most important reasons are slow projected growth in the labor force and the drag on aggregate productivity growth caused by the reallocation of resources from private to government sectors.

3.3.2 Necessary fiscal adjustments

Figure 3.2 summarizes the dynamics of government finances until 2050 in terms of the pay-as-you-go adjustments of the payroll tax rate that would be necessary to meet the fiscal policy rule, given the partly hypothetical policy assumptions in the baseline. The tax rate falls (increases) when the base of government revenues increases faster (more slowly) than government expenditures. The present fiscal rule implies that the base of government revenues in a given year includes all tax bases in the Mainland economy and 4% of the capital in the GPF.

The base of government revenues grows faster than the expenditures until 2020, and the payroll tax rate can therefore be reduced from the present level of 13%.[4] Negative payroll tax rates around 2020 suggest that there is fiscal scope for cutting other taxes as well. After 2020 government expenditures outgrows the base of government revenues, and the payroll tax rate must be raised by 0.4 points every year.

The U-shaped time profile of the payroll tax rate in Figure 3.2 will reappear several times in the subsequent sections. However, the position of this curve will vary somewhat. These variations reflect that the different studies have been carried out at different

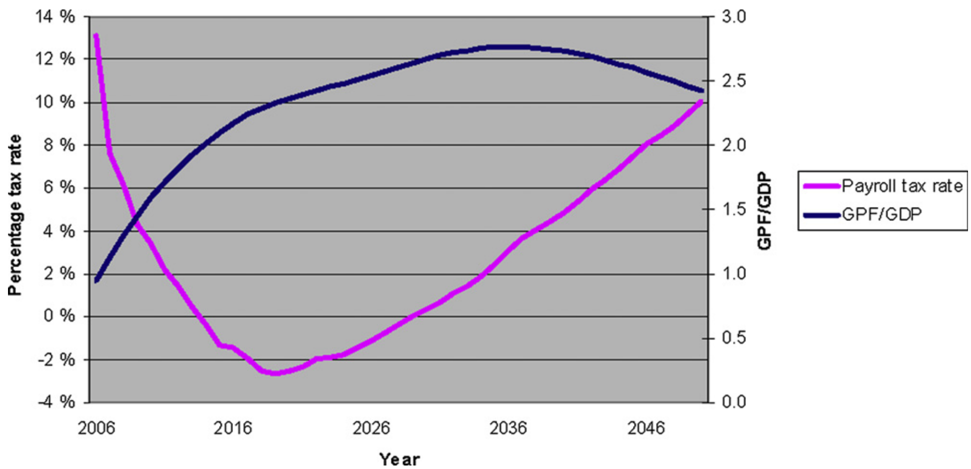

Figure 3.2 No-reform scenario: necessary payroll tax rate (left axis) and the GPF/GDP ratio measured in current prices (right axis).

4 The Norwegian payroll tax rate differs between regions. Today, the average rate is slightly above 13%.

times, and some of the exogenous assumptions have been revised. In particular, the exogenous prices of oil and the natural gas are highest in the most recent studies. Higher petroleum revenues contribute to reduce the tax burden. Also, the demographic projections have been updated, basically by increasing immigration and the average life expectancy.

The model simulations allow a closer examination of the contributions to the U-shaped time profile of the payroll tax rate. Table 3.2 reports the growth rate of the main components of the primary government expenditures and sources of revenues given the fiscal rule. Recall that fiscal rule does not allow direct spending of government petroleum revenues. Instead, 4% of the GPF can be used. Also, note that the figures do not include the effects of the endogenous adjustments of the payroll tax rate, because the point of the table is to examine the forces that contribute to make this adjustment necessary. Table 3.2 reveals the following main reasons for the U-shaped time profile of the payroll tax rate: (i) Most of profitable oil reserves are rapidly depleted before 2020 and most of the profits from the petroleum production are saved in the GPF. Thus, the capital in the GPF grows much faster "today" than it will in the future, especially after 2020, and so does the 4% out-take from the fund permitted by the fiscal rule. (ii) The growth in employment slows down. Almost all tax bases are positively

Table 3.2 Growth in government primary expenditures and sources of government primary revenues, given the baseline assumptions except adjustments of the payroll tax rate (average annual growth rates, %)

	2006–2020	2021–2050
Total expenditures	4.6	5.0
Government consumption	4.1	4.7
Employment	0.9	1.0
Health and old-age care	1.4	2.0
Labor cost per hour	4.4	4.4
Cash transfers to households	6.3	5.5
Public old-age pensions	8.1	6.3
Old-age pensioners	2.3	1.7
Average benefit *ex ante* indexation	0.7	0.0
Wage indexation	4.6	4.5
Sources of revenues	5.6	4.4
Tax bases, Mainland sector	5.3	4.6
4% of the GPF	7.0	3.0
Gap between the growth rates of expenditures and sources of revenues	−1.0	0.6
Memo		
Total employment	0.9	0.6
GDP, Mainland sector (current prices)	5.6	4.6

related to employment. (iii) The reallocation of labor from private industries to the government health and old-age care sectors implies a negative drag on the tax base, because there are no indirect taxes on public services and the effective tax payroll tax base is the wages in the private sector only. (iv) The growth in the number of elderly aged 80 or more accelerates from 2020. This group is the heaviest user of tax-financed health services and old-age care.

Figure 3.2 may be used to argue that Norway does not face severe fiscal sustainability problems. The present rather generous welfare state could be financed with a lower tax burden than today in all years until 2050. Simultaneously, the fiscal policy rule implies an unprecedented accumulation of financial assets. The GPF/GDP ratio rises from close to 1 in 2007 to a peak at 2.8 in 2036. Thus, judged by the *levels* of government expenditures and tax bases within a 40- to 50-year perspective, Norway's fiscal future looks bright. In particular, it looks much brighter than it did when the pension reform process was initiated, at that time one expected a real oil price of $25 (2004 dollars). Fiscally, Norway appears to be an outlier in the OECD.

However, Figure 3.2 can also be used to argue that Norway faces severe fiscal sustainability problems in the long run. This conclusion is based on the *growth trends* after 2020 rather than the *levels* of government revenues and expenditures within a more or less arbitrarily chosen period. After 2020, government expenditures grow faster than the total tax base. This imbalance between the growth rates of government expenditures and revenue bases is not a temporary phenomenon; no available information suggests that the necessary tax burden would stabilize if the simulation period were extended beyond 2050.

Furthermore, the projection underlying Figure 3.2 can be criticized for under-rating the future tax burden. One reason is the implausible assumption of no further growth in public service standards. The political pressure for improving standards of public health and care services will be strong when private consumption *per capita* grows by 2—3% annually. The demographic trends imply that the main users will represent a radically larger share of the voters. Thus, the scope for expansionary fiscal policy until 2020 may be used to expand spending instead of tax cuts. Indeed, this has been the policy so far. In particular, child care and old-age care have been given high priority. This policy implies that growth in the payroll tax rate starting in 2020 will be accelerated, since increases in the public spending per elderly interacts with the growth in the number of elderly (see Section 3.6).

A natural response to the U-shaped time path of the required payroll tax rate in Figure 3.2 is that the time path of the tax burden should be smoothened through more prefunding. This would require a tighter fiscal policy rule than the present one. It is questionable if it is politically feasible to increase government savings beyond the ambitious plan implied by the fiscal policy rule. Section 3.7 examines the effects on the tax burden dynamics of increased government saving.

3.4 SENSITIVITY OF THE FISCAL PROSPECTS TO VARIATIONS IN ECONOMIC GROWTH AND TERMS OF TRADE

3.4.1 Accelerated economic growth[5]

With a few exceptions, international literature leaves the impression that productivity growth in the private sector, *cet. par.*, has a positive government budget effect. The underlying logic is that higher productivity raises the tax bases, and that this effect dominates any price effects on government expenditures. This reasoning underlies the so-called OECD method of assessing fiscal sustainability, which draws on Blanchard *et al.*, (1990). This method uses the ratio between government debt and GDP to indicate the degree of fiscal sustainability. Cronin and McCoy (2000) claim that this debt ratio is the conventional indicator of fiscal sustainability.[6]

In addition, most studies based on generational accounting or CGE models find that productivity growth contributes, *cet. par.*, improves fiscal sustainability through the expansion of tax bases. For example, Gokhale and Raffelhüschen (1999) suspect budget projections for the US to be too optimistic because they find the projected productivity growth to be higher than warranted by US experience. Using a large CGE model, Kotlikoff *et al.*, (2001) find that a productivity-driven decline (increase) in the real wage growth contributes to the increase (decrease) in the future tax rates necessary to meet the intertemporal government budget constraint. With reference to these simulation studies, Kotlikoff (2001, p. 37) concludes: "A higher rate of technological progress improves, but doesn't fundamentally alter, the demographic transition." Heald (2005) reviews long-run projections for the UK (HM Treasury, 2004), which show that higher productivity reduces the future need for fiscal tightening. Cronin and McCoy (2000) find the same pattern in alternative long-run projections of the Irish economy.

These results may leave the impression that a positive correlation between productivity growth in the private sector and the fiscal stance is a robust empirical "law." Policy makers may even consider future fiscal sustainability problems to be over-rated to the extent that they regard productivity growth projections to be negatively biased.

However, government expenditures are also positively related to the productivity level in private sectors. It is a rather uncontroversial insight that competition will shift the cost-saving effect of productivity growth in an industry from the capital owners to the employees. Over time, the wage growth will be spread to other sectors, including the government sectors. In addition to the increase in the government wage bill, wage indexation of government cash transfers implies that the additional income caused by higher productivity in specific industries are automatically shared by all citizens, not only

[5] This section is a condensed exposition of Holmøy (2006b).

[6] Roux (1993); Hemming and Miranda (1991); and Cronin and McCoy (2000) represent examples of this method of measuring fiscal sustainability. Goldfajn (2002) and Bentz and Fetzer (2004) discuss the OECD method.

by the more productive workers. It is easily verified (Holmøy, 2006b) that the tax rate necessary to maintain exact primary budget balance is independent of productivity in all private sectors if total employment is fixed, all industries exhibit constant returns to scale, and all government budget components are equally affected by wage rate adjustments.

It unlikely that actual economies meet all these conditions. An important example is public debt services, which are significant in most OECD economies. These expenditures are independent of the wage rate. Eventually public debt services must be financed by a primary budget surplus. If the wage shares in all primary budget components are equal, an increase in the wage rate induces a proportional increase in the primary budget surplus. For economies where the government collects positive wage independent net revenues, the opposite results apply. This is the case in Norway and other countries where the government collects significant resource rents and interest on public wealth.

However, even if wage rate adjustments have fiscal effects, the link between the wage rate and productivity changes is not obvious. In the textbook model of the SOE the wage rate depends positively on the exogenous world prices of outputs and the productivity in the sectors producing traded goods (T-sectors), and no other variables. In particular, productivity growth in sectors producing non-traded goods (N-sectors) will not affect the wage rate. Instead, the cost effect is shifted forwards to lower product prices. Thus, the budget effect of productivity growth in N-sectors depends on the budget share of N-goods in government expenditures.

In general, the fiscal effect of productivity growth is therefore ambiguous, depending on economy specific characteristics. Such an ambiguity is a perfect challenge for CGE modeling: a multitude of interacting effects must be weighted together according to their empirical importance in the actual economy being examined. The remaining part of this section presents the results presented in Holmøy (2006b) of using MSG6 to simulate the fiscal effects of productivity changes in the Norwegian economy.

The simulation experiment considers a partial permanent 10% increase in the TFP index in a selection of T- and N-sectors. The fiscal effect is measured by the adjustment of the payroll tax rate necessary to restore the baseline path of the government budget surplus. The sectors experiencing the TFP shift are selected so that this shift affects the same base of resources in the T- and N-sectors. The simulation results reported in Table 3.3 confirm that the two TFP shifts have almost equal effects on the macroeconomic aggregates, such as private consumption, employment and the real wage rate. However, the productivity shift in the N-sector turns out to have the strongest growth effects over time. The primary reason is that the N-sector grows faster in terms of inputs than the selected T-sectors in the baseline scenario, so that the 10% TFP shift gradually affects a larger resource base than in the T-scenario. This difference is magnified by the difference in general equilibrium effects on labor supply.

Table 3.3 shows that higher TFP in private industries has an adverse fiscal effect. The endogenous increase in the wage rate turns out to have a stronger effect on government

Table 3.3 Long-run macroeconomic effects in Norway of a 10% increase in TFP in T-sectors and N-sectors (percentage deviations from the baseline scenario unless otherwise stated)

	T-scenario	N-scenario
Pay roll tax (percent)	1.5	0.5
Total revenues, of which	5.4	0.3
Indirect taxes	3.4	−0.2
Direct taxes, net of petroleum revenues	7.2	0.5
Total expenditures, of which	5.9	0.3
Government consumption	6.2	0.8
Cash transfers to households	5.2	0.3
Private consumption	1.5	1.7
Employment	−0.7	−0.4
Wage cost per hour	6.5	0.8
Wage rate	5.4	0.4
Consumer real wage rate	1.6	2.0

expenditures than on the tax bases along the baseline. This reflects primarily that the government uses a significant share of its wage independent petroleum revenues to finance government expenditures. It also reflects that the government production sectors are labor intensive and that almost all government cash transfers are indexed by the average wage growth in Norway. Andersen and Pedersen (2006a,b) obtain the same result in a similar CGE analysis for Denmark. This suggests that the MSG6 results do not only reflect that the petroleum revenues make Norway's fiscal position exceptionally strong.

When TFP is raised by 10% in traded goods sectors accounting for 6.6% of total gross production value (in 2005), the payroll tax rate must be raised from 31 to 32.5% in 2050. If the same TFP shift takes place in a non-traded goods sector of the same size, the corresponding increase in the payroll tax rate is only a third (i.e. 0.5%). Compared to the macroeconomic effects, the differences in fiscal effects are strikingly large. Especially, the effects on gross revenues and gross expenditures are much greater in the T-scenario. The wage adjustment explains most of the difference between the fiscal effects of the two TFP shifts and it demonstrates that much of the textbook logic of the SOE model also holds in MSG6. The profit effect of higher TFP in the T-sector is shifted over to the wage rate – the only immobile resource. TFP growth in the N-sector reduces the prices of domestically produced intermediaries and capital goods. This allows a relatively small increase in the competitive wage rate consistent with trade balance. In the textbook SOE model, the possibility of this wage effect is ruled out by simplifying the assumptions.

The MSG6 results suggest that equilibrium effects on labor supply are relatively small. The labor supply falls although the consumer real wage rate increases and the uncompensated labor supply elasticity is positive (0.1). The dominance of the income effects over the substitution effects reflects that the income effects include not only the higher consumer real wage, but also higher capital income and higher wage indexed cash transfers.

Higher productivity in the form discussed in this paper is manna from heaven. By definition, it allows improved average welfare in the countries experiencing it. The possible adverse fiscal effect of productivity growth does not change this. However, although productivity growth makes life easier for the average person, it is an important policy lesson that politicians cannot rely on growth to solve fiscal sustainability problems. It should be stressed that the conclusions above are confined to fiscal effects of productivity shifts in the private business sector. Obviously, productivity growth in government service production can improve the fiscal stance if it is used to reduce costs. However, according to the hypothesis underlying the term "Baumol's (cost) disease," the technological scope for productivity improvements is on average significantly lower in the service production typically provided by the government than in other sectors.

3.4.2 Increased petroleum wealth[7]

It is at least a widespread impression that the financial fundament for much of the welfare and fiscal policy in Norway hinges on the oil price. In both 2009 and 2010, petroleum share of total Norwegian exports equaled 46% and the GDP share of the sector equaled 22%. Between 85 and 90% of the net cash flow from sales of oil and gas is collected by the central government through indirect and direct taxes, surplus accruing directly to the state, and dividends from companies. The cash flow collected by the central government from the petroleum sector increased from 11 to 13% from 2009 to 2010. However, oil and gas are non-renewable resources, which should be regarded as wealth. By the end of 2007, 36.4% of the total resources had been depleted. If the present production were maintained, the oil and gas reserves would be depleted after, respectively, 6 and 22 years. Realistic production profiles imply a much longer production period.

A recurrent issue in the Norwegian policy debate is the time path for oil and gas production and the intertemporal plan of spending the petroleum wealth. The policy target has been to obtain permanent benefits from the resource rents, i.e. to avoid "Dutch Disease" problems. As explained above, the fiscal rule adopted in 2001 isolates the petroleum cash flow government petroleum revenues from the government budget. It is directly invested in the Central GPF – Global and the annual 4% out-take from the fund should equal to the non-petroleum budget deficit over the cycle.

An important premise for avoiding "Dutch Disease" is to obtain realistic estimates of the petroleum wealth and to communicate to these the public. The fiscal effect of permanent changes in the oil and gas price can be measured by the adjustments in the tax

7 The general equilibrium mechanisms discussed in this section are analyzed in a stylized analytical model in Holmøy (2006a).

burden needed to meet the annual budget constraint implied by the fiscal rule. Subsequently, these adjustments are computed by changes in the payroll tax rate. The real oil price stays at \$71 (2007 dollars) in the baseline. In order to examine non-linearity, the budget-neutral paths for the payroll tax rate have also been estimated for \$30, \$120, \$200 and \$250 (2007 dollars). The gas price changes are proportional to the oil price changes.

The empirical significance of the general equilibrium effects on the tax rate adjustments can be elucidated by comparing them with corresponding naïve estimates. The naïve estimate ignores all equilibrium effects. It simply divides the additional government revenue by the relevant tax base. The additional revenue is given by the fiscal rule as 4% of the higher capital in the GPF. The relevant base of the payroll tax is the wage sum in the private sector. The naïve estimate is based on the same projections of all relevant variables as the CGE estimate. Following this naïve procedure, it would be possible to cut the payroll tax rate by as much as 24.8 percentage points in 2050 if the real oil price stayed at \$120 rather than \$30 from 2010.

The MSG6 simulations verify the obvious result that higher oil and gas prices improves the Norwegian fiscal stance, but the positive slope of the tax rate trend after 2020 is not reduced. However, interesting information lies in the estimated orders of magnitude. Two points deserve explanation because they are substantively important and because they involve interesting general equilibrium repercussions: (i) The scope for tax cuts is much smaller than the naïve estimate and (ii) the scope for tax cuts decreases as the petroleum price increases.

The simulated payroll tax cut made possible by moving from the \$30 to the \$120 scenario is 11.3 percent in 2050 (Figure 3.3 and Table 3.4). This is less than half of the naïve estimate. Thus, general equilibrium effects imply a striking modification of the scope for tax cuts. In other words, there is a great risk of over-rating the scope for fiscal expansion that which can be financed by additional petroleum revenues if one neglects the insights from the CGE analysis.

The by far most important general equilibrium effect is the effect of wage rate adjustments, which affect government expenditures and the tax bases differently. Thus, the nature of the equilibrium effects in this simulation experiment is analogous to those induced by higher productivity growth explained in the previous section. Since Norway is a net exporter in present value terms of oil and gas, higher prices of oil and gas imply a terms-of-trade gain. A real appreciation is required in order to meet the same intertemporal external balance as in the baseline. In the case where the oil price increase permanently from \$30 to \$120 (2007 dollars) in 2010, the equilibrium real appreciation corresponds to a 26% increase in the labor cost per hour in 2050 relative to the non-petroleum world prices (Table 3.5). The increase in the wage rate raises government expenditures more than the tax bases, foremost because a wage independent out-take equal to 4% of the GPF is used to finance government expenditure. The budget-neutral reductions in the payroll tax rate are passed over to labor, raising

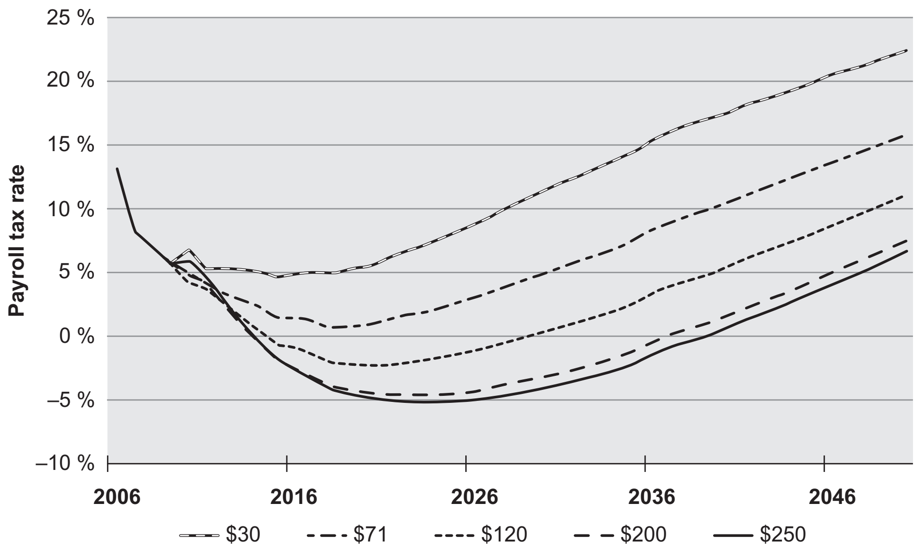

Figure 3.3 Payroll tax rate in different oil price scenarios (%).

Table 3.4 Government revenues and expenditures measured in current prices in 2050 for different oil prices (% unless otherwise indicated)

	$30	$71	$100	$120	$150	$250
Pay roll tax rate (%)	22.3	15.7	12.6	11.0	9.2	6.5
Total expenditures (1000 NOK *per capita*)[1]	910.8	989.2	985.6	1112.0	1204.6	1584.6
Financed by (percentage shares)						
4% out-take of the GPF capital	6.3	12.2	16.6	17.4	19.8	24.4
Non-petroleum revenues	93.7	87.8	83.4	82.6	80.2	75.6

Table 3.5 Macroeconomic development under different oil prices; fixed prices unless otherwise indicated (2050 levels relative to the $30 scenario)

	$71	$120	$200	$250
Private consumption	1.07	1.14	1.26	1.32
Employment (man-hours)	0.99	0.98	0.96	0.94
Payroll tax rate	0.70	0.49	0.33	0.29
Labor costs	1.10	1.26	1.61	1.87
Net imports	1.65	2.44	3.79	4.65

the consumer wage rate more than the labor cost. This reduces the scope for lowering the tax burden. When all equilibrium effects are taken into account, the payroll tax rate has fallen from 22.3 to 11.0% in 2050. The corresponding increase in the consumer wage rate equals 35.2%.

The results demonstrate that real appreciation represents an important channel through which increased higher government wealth is automatically rebated to households. This automatic rebatement significantly reduces the room for tax rate reductions. The potential importance of this redistribution mechanism is especially high in economies similar to the so-called "Scandinavian Model." Such economies are characterized by relatively strong egalitarian norms, which imply a relatively strong impact of wage rate adjustments on government expenditures for two reasons: (i) A relatively high degree of centralized wage formation ensures that wage changes rapidly spread to the government sectors, and (ii) the relatively generous public pension benefits and most other government transfers to households are indexed to the average wage level.

Reduced labor supply is another general equilibrium effect, which contributes to reduce the scope for cutting tax rates, since most tax bases are positively related to employment. However, this effect is relatively modest; employment falls by 1.3% in 2050. It reflects that on balance the income effects caused by the terms-of-trade gain weakly dominate the substitution effect of the strong increase in the real consumer wage rate. The income effect captures that both labor and non-labor income increase. On the other hand, the terms-of-trade gain allows for an expansion of private consumption, which reinforces the tax rate reduction as the average indirect consumption tax rate is close to 20% in Norway. In 2050, private consumption in fixed prices would be 10.2% above the baseline scenario.

The simulations also demonstrate that there are "diminishing fiscal returns" of increasing the oil price in terms of budget-neutral reductions of the tax burden (Figure 3.3 and Table 3.5). A higher oil price implies a higher capital in the GPF. Consequently, the out-take of 4% from the fund can finance a higher wage dependent non-petroleum deficit. Table 3.5 shows how the share of government expenditures that can be financed by the 4% out-take of the GPF capital increases with the oil price. As the wage-dependent deficit grows, the equilibrium increase in the wage rate brings about a successively greater automatic expansion of the non-petroleum deficit. This non-linearity explains why the long-run scope for tax cuts is diminishing in the petroleum wealth.

The strength of the fiscal effect of wage rate adjustments is likely to differ significantly between countries and over time, because it depends on both the magnitude of the change in the wage rate, and the initial wage dependent government net revenues. Norway is a special case, because the large government petroleum wealth finances a substantial deficit of wage-dependent government net revenues, and because government expenditures are highly wage dependent. In countries where both the government and the economy as a whole must serve substantial debt, wage-dependent government net revenues may be positive. In such economies, an exogenous increase in government non-tax revenue in the form of traded goods (e.g. a drop in the interest rate) will have the opposite effects of those examined above.

The equilibrium wage growth compatible with the external balance constraint will, in this case, magnify the direct fiscal improvement.

The magnitude of the changes in the wage rate depends crucially on the degree of decreasing returns to scale in the traded goods sector. This assumption may be disputed, but decreasing returns is a realistic implication of productivity heterogeneity within the specified industries and it rests on empirical evidence (Klette, 1999). This approach to modeling industry adjustments and international trade also seems to imply a good compromise between a realistic degree of specialization of industries producing traded goods and the widespread view that small economies cannot affect world prices in the long-run. The approach also meets the criticism raised in Kehoe (2003) against alternative applied modeling approaches of exports and imports.

3.4.3 Higher returns to foreign investments

As the petroleum wealth is gradually transferred from the North Sea to the GPF, the rate of return to foreign investments will overtake much of the same role for the Norwegian economy as the prices of oil and gas have played during the years with large petroleum production and exports. One effect of globalization is improved access to profitable international investment projects, raising the opportunity costs of domestic investments. Having net foreign financial wealth, an increase in the international rate of return implies the same kind of income effect for Norway as an increase in the oil price. Moreover, the central government collects most of the additional income. As with changes in petroleum prices, changes in the international rate of return will affect relative prices of goods and production factors, since it will strongly influence the capital costs facing both firms and consumers. With government net financial assets reaching nearly 3 times current GDP around 2035, one would expect significant fiscal effects of permanent changes in the world interest rate. For the government finances, the terms-of-trade gain and the direct government revenue effect are by far most important.

Heide *et al.,* (2006) examined the fiscal effects obtained by MSG6 of increasing the world interest rate permanently from 5.5 to 6.5%. However, in this study the income effects were relatively modest since the real oil price was assumed to prevail at $25 (2004 dollars), which generated a much smaller capital in the GPF than in the baseline presented in Section 3.3. In Holmøy and Kravik (2008), the real oil price was assumed to be $50 (2004 dollars). The payroll tax rate can then be 4.5 points lower than in a reference scenario in 2050. The key mechanisms were explained above. However, as for the effect of higher petroleum prices, the quantitative effects depend strongly on when the exogenous variables deviate. The fiscal effect of a higher oil price will be negative and relatively small if the shift takes place after the profitable oil resources have been depleted. Analogously, the fiscal effect of a higher world interest rate increases as long as the GPF grows relatively to government expenditures.

3.5 NORWEGIAN PUBLIC PENSION REFORM

Estimates of pension reform effects typically belong to one of three strands of literature: (i) Highly detailed dynamic microsimulation of purely mechanical effects on individual benefits and government pension expenditures; (ii) econometric studies of behavioral effects of particular elements of pension system, especially labor supply; and (iii) CGE estimates of the long-run effects of rather stylized reforms on employment, fiscal sustainability and the inter-generational welfare distribution. Recent examples of CGE estimates include *inter alia* Beetsma *et al.,* (2003); Bovenberg and Knaap (2005); Fehr and Habermann (2006); Fehr *et al.,* (2003); Fehr (2000); Kotlikoff *et al.,* (2001); Lindbeck and Persson (2003); McMorrow and Roeger (2002) and Miles (1999).

Holmøy and Stensnes (2008) integrate these three approaches when simulating the effects of the Norwegian pension reform of 2011 by combining the microsimulation model MOSART and MSG6. This section draws on this paper's assessments of how the reform can be expected to perform when evaluated against two inter-related goals shared by most other recent pension reforms: (i) Improving fiscal sustainability and (ii) stimulating employment.[8] MOSART includes a nearly accurate description of the details in the different pension systems, as well as a representative sample of the heterogeneous individual earning profiles and other aspects of individual life courses. On the other hand, the MSG6 model captures many relevant aspects of behavioral adjustments and general equilibrium repercussions. The models are run iteratively to ensure consistency. This strategy seeks to exploit the maximum of available information relevant for analyzing pension reform in Norway.

3.5.1 Main reform elements

The old public pension system was established in 1967 as a mandatory, defined benefit, pay-as-you-go pension system. The total benefit combined a flat-rate universal benefit, a means-tested supplement and an earnings-related income benefit. The income benefit was based on pension entitlements accrued through labor market earnings after 1967 and some other criteria. Both entitlements and benefits have, in principle, been wage indexed. In the stylized case where an individual earns the average wage for 40 years, the after-tax replacement ratio of the public old-age benefit would be about 65%.[9] Due to several complex non-actuarial elements, including a best-years rule, the old system implied a relatively weak income dependent on pension benefits. According to MOSART simulations, increasing earnings by 1 NOK raised the average present value of

[8] Since this paper was written, some elements of the pension reform have been modified. However, the reform proposal discussed in this section still captures the most important reform elements.

[9] Special tax rules for pension benefits makes the after-tax replacement ratio about 15 percent higher than the corresponding pretax ratio. Income from private pension schemes and special pension schemes for public employees come in addition to this figure.

future pension benefits by 0.10 NOK (Stensnes, 2007). The formal retirement age was 67 years. More than 40% of the population receives disability benefits at this age, and about 60% of the (still) employed are entitled to early retirement from the age of 62. Thus, the effective retirement age averages about 60 years in Norway. Note that early retirement through these arrangements did not reduce future pension benefits at any point in time. Both disability pensioners and early retirees obtain entitlements as if they remained working until the age of 67.

The new system continues to be financed on a pay-as-you-go basis. The pension benefit continues to include a minimum income guarantee at the same level as before, as well as an earnings-based benefit. Contrary to the basic benefit in the old system, however, it is means-tested against the income based pension benefit.

The expenditure risk associated with increases in longevity is shifted from taxpayers onto each cohort of pensioners through an actuarial mechanism. With some qualifications, the new system converts the implicit pension wealth of accumulated entitlements into an annuity over the average expected remaining lifetime. An increase in the expected number of retirement years reduces the annual benefit such that the present value of total pension benefits is nearly invariant to changes in current remaining life expectancy and retirement age. The statutory retirement age and current early retirement arrangements are phased out and replaced with a flexible retirement age from the age of 62 years, available to everyone. If life expectancy increases by one year, an additional eight months of labor market participation will be needed to maintain the annual benefit. The mechanism increases the individual cost of early retirement. Labor supply is also stimulated by a stronger dependency between earnings and pension benefits. The income based benefit is 1.35% of lifetime labor market earnings below an annual wage-indexed threshold. The reform strengthens the incentives to retire as a disability pensioner, but the present analysis takes as given both the disability scheme and observed rates of transition into disability.

The new system is not intended to be cost saving for the government at the time of implementation. Over time, it will be cost saving compared to the old system due to the actuarial life expectancy adjustment and the less generous indexation of benefits in payment. Income dependent entitlements will still be indexed by wage growth until retirement, but benefits will be indexed to an average of the growth in wages and consumer prices in payment.[10]

3.5.2 Fiscal effects

The model simulations suggest that the pension reform is likely to be highly successful in achieving a lower tax burden and stimulating employment. Compared to the no-reform

[10] In practice, the reform implements the less generous indexation in payment as a fixed annual deduction of 0.75 percent relative to wage indexation.

path, i.e. the baseline, the scope for cutting the payroll tax rate increases gradually after reform implementation, passing as much as 9.5 points in 2050 (Figure 3.4). Towards 2020, the reform boosts employment by 8% relative to the no-reform path, rising further to 11% in 2050. The following explanation of the results is intended to demonstrate that one would seriously underestimate the fiscal effects of the pension reform if behavioral effects and equilibrium repercussions were ignored.

Table 3.6 shows that the scope for tax rate reductions results from a rather complex mix of changes in government expenditure and revenue components. The reform is indeed cost saving: public old-age pension expenditures would be 12.2% below the no-reform scenario in 2050. On the other hand, it invokes two mechanisms which raise

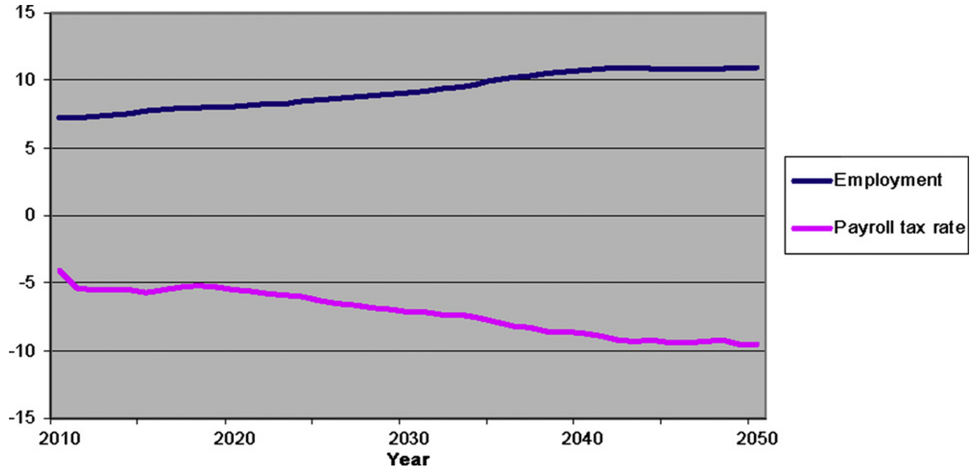

Figure 3.4 Deviation between reform and no-reform scenarios for the payroll tax rate (%) and employment (%).

Table 3.6 Reform effects on tax bases and government expenditures in 2050, measured in current prices (deviations from the baseline scenario)

	Billions NOK	Percent
1. Total revenues	−315	−5.1
a. Given baseline tax rates	262	4.2
b. Including the tax base effect of changed tax rates	399	6.4
c. Residual (=1 − 1b)	−714	−11.5
2. Total expenditures	−328	−5.9
a. Transfers to households	−113	−3.6
i. Public old-age pensions	−210	−12.2
ii. Other transfers	97	6.8
b. Government consumption	−224	−8.7
3. Net financial investment (=1 − 2)	13	1.9

other government cash transfers by 6.8% in 2050: the reform transfers some of the early retirees into disability and sickness schemes, rather than work. This reclassification of beneficiaries raises transfers by 4.7 points. The remaining effects are due to the increase in the pretax wage rate, which reflects that most transfers are indexed to wage growth. In absolute terms, lower labor costs in public service production account for the greatest contribution to lower expenditures. However, this is a bookkeeping effect, reflecting that the government pays less payroll tax to itself.

On the revenue side, the scope for cutting tax rates levied on labor income reflects the reduction in government expenditure, as well as the expansion of most tax bases. The tax base expansion can be decomposed into a pure reform effect and an indirect effect induced by lower tax rates on labor income. The pure reform effect on the tax base can be estimated to 4.2% in 2050 by simulating the reform scenario while keeping the payroll tax rate at the no-reform path and neglecting the government budget constraint (Table 3.6, row 1a). This tax base expansion is driven by the stronger labor supply incentives at the intensive and extensive margins. The CGE model captures that higher employment expands almost all tax bases. The indirect effect of realizing the scope for tax cuts by reducing the payroll tax rate magnifies the tax base expansion from 4.2 to 6.4% through a further expansion of labor supply. The residual in row 1c in Table 3.6 should be interpreted as the direct and indirect revenue effect of tax rate reduction.

The surge in the pretax wage rate contributes to raise both government expenditures and the tax bases. As explained in Sections 3.4.1 and 3.4.2, the net budget effect is negative, because the direct and indirect wage share in government expenditures exceeds the wage share in the tax bases.

Table 3.7 decomposes the total reform effects on the tax rate and employment measured in 2050 into partial contributions from key reform elements: delayed retirement, stronger income dependency of benefits and reduced average old-age benefits.

Table 3.7 Decomposition of the reform effects in 2050 (deviations from the baseline scenario in % unless otherwise indicated)

	Employment	Payroll tax rate (%)	Consumer real wage, including stronger income dependency
1. Increased retirement age	6.6	−6.9	3.8
Direct effect	4.5		
2. Stronger income dependency of benefits	3.8	−2.8	5.6
Direct wage effect	2.5		5.1
3. Reduced average benefits	0.4	−1.0	0.8
4. Interaction effects (=5 − 1 − 2 − 3)	0.2	1.2	−0.7
5. Total effect	11.0	−9.5	9.5

These contributions are identified by simulating the effects of each one separately. In 2050, delayed retirement corresponds to a 4.5% increase in employment. The equilibrium effects of such a shift, including the budget-neutral cut in the payroll tax rate, raises the employment effect to 6.6%, which accounts for 60% of the total surge in employment.

Stronger income dependency of benefits works as if a larger share of the tax rate on earnings is perceived as compulsory savings. This effect allows a 2.8 points cut in the payroll tax rate and employment goes up by 3.8%; 2.5 points of the employment effect is a direct response to the stronger link between earnings and benefits, the remaining 1.3 points are caused by the real wage effect following the cut in the payroll tax rate.

A striking example of the importance of behavioral and equilibrium effects is the finding that the reform leaves the average benefit unaffected. Table 3.8 reports the contributions from mechanical reform effects and equilibrium repercussions. *Cet. par.*, the new entitlement structure raises the compensation by 7%, for given earnings histories. Over time, however, increased life expectancy and less generous indexation reduce the average benefit for given earnings and retirement. In 2050, these effects would have reduced the average benefit to 0.889 of the no-reform benefit. However, labor supply responses, mainly through delayed retirement, counteract the mechanical effects, brings this ratio up to 0.976. This ratio is brought back to 1 when accounting for the partial effect of indexing entitlements to the endogenous wage growth. The labor supply responses shift most of the cost-saving effect of the reform from lower annual benefits to fewer old-age pensioners and expanded tax bases. In 2050 delayed retirement would reduce the number of old-age pensioners by 10.4% (from 1.249 to 1.119 million) compared to the no-reform scenario.

Table 3.8 Reform effects on public old-age pension expenditures, average old-age benefit and number of old-age recipients (cumulative contributions from different effects in 2050; indexes, 2050 levels in the no-reform scenario = 1)

	Number of old-age recipients	Old-age benefit	Public old-age pension expenditures
1. No-reform scenario	1	1	1
2. Mechanical reform effects			
a: 1 + New entitlement structure	1	1.070	1.070
b: 2a + Actuarial benefit adjustment	1	0.955	0.955
c: 2b + New indexation of benefits	1	0.889	0.889
3. Behavioral and equilibrium effects			
a: 2c + Delayed retirement	0.896	0.963	0.863
b: 3a + Increased labor supply at the intensive margin	0.896	0.976	0.874
c: 3b + indexation of entitlements to new wage rate = *Total effects*	0.896	1.000	0.896

Section 3.3 pointed out that the main long-run fiscal sustainability problem in Norway lies in a gap between the growth rates of government expenditures and the total tax base after 2020. The simulated growth rates reported in Table 3.9 suggest that the reform makes a surprisingly small contribution to resolve this problem. The reform shrinks this gap from 0.99 to 0.92 percent and the annual increase in the payroll tax after 2020 drops from 0.42 to 0.29%. This kind of dynamic fiscal improvement can be completely attributed to accelerated growth in the tax base, whereas the reform has practically no effect on the annual growth rate of total expenditures after 2020. Interestingly, and contrary to the explicit goal of the reform, this conclusion also applies to the growth rate of public old-age pension expenditures. Accordingly, the reform can indeed be expected to have strong cost-saving effect on future public pension expenditures, but this effect reflects a shift in the expenditure *level* — not a lower long-run *growth rate*. The small reform effects on the growth rates of the tax base and the government expenditure components, including the old-age pensions, are quite robust to alternative exogenous assumptions on demography and labor supply responses.

The general equilibrium repercussions need, however, some qualifications. First, most of the wage rate adjustments result from the choice of the payroll tax rate as the endogenous budget-neutral fiscal policy instrument. This mechanism reflects that the determination factor price in MSG6 is very close to the textbook SOE model of the SOE, and it was explained in Sections 3.4.1 and 3.4.2. The reform effects would have been different if the government budget constraint were met by other fiscal adjustments. There is also obvious scope for modeling improvements. Specifically, there is scope for

Table 3.9 Average growth rates in the period 2020—2050 of government budget components measured in current prices (%)

	Present system	New system
1. Total government expenditures	4.45	4.46
Government consumption	4.39	4.44
Transfers to households	4.77	4.84
Total public old-age pension expenditures	5.57	5.56
Number of old-age pensioners	1.47	1.25
Average annual benefit		
ex ante indexation	0.12	0.21
indexation with wage growth	3.94	4.06
Total tax base, no-reform tax rates	3.46	3.62
2. Total tax base, tax rates after reform	3.46	3.54
3. Gap between growth in expenditures and tax base (2−1)	0.99	0.92
Gap between growth in public old-age pension expenditures and tax bas	2.11	2.02
Employment	0.19	0.28
Payroll tax rate (%)	0.42	0.29

improving tradeoff between theoretical consistency and a detailed description of system details and population heterogeneity. Moreover, the importance of the employment effects suggest that labor supply behavior at both the intensive and the extensive margins should modeled in more detail.

3.6 DEMOGRAPHIC UNCERTAINTY[11]

3.6.1 Increased longevity

Demographic projections have regularly underestimated the reduction in mortality among the elderly. The baseline rests on the assumption that the average expected lifetime for newborn boys and girls increases by 0.14 years *per annum* for men and women. In an alternative "High population growth scenario" the average longevity increases by 0.19 years *per annum*, which translates to an increase in average expected lifetime for men and women of 2.2 years in 2050 compared to the baseline. The reductions in mortality rates will have potentially significant effects on fiscal sustainability in the long run, since they are experienced by the elderly. The resulting additional population growth will have small effects on the number of children and the labor force, but it will be almost equal to the growth in the population of old-age pensioners, who are also the heaviest users of tax-financed health services and long-term care.

Lower mortality among the elderly raises the question of the health conditions of the elderly. The baseline scenario assumes no changes in the age specific demand for health and social care services. This is a pessimistic assumption, but it serves the role of a transparent benchmark for sensitive analyses. It is maintained in this subsection. Section 3.6.2 examines the effects when increased longevity is accompanied by improved health among the elderly.

Figure 3.5 shows how employment in the public health and long-term sector will develop under different assumptions. In 2050, the baseline this employment would be 2.14 times the corresponding 2004 level. Recall that this growth reflects changes in the size and the age composition of the population only. Age-specific service standards and user ratios are constant. The increase in longevity described above contributes *cet. par.* to raise the required employment in this sector to 2.38, which is 11.0% higher than the baseline level in 2050. Inputs of other factors increase by the same proportion, and the mix between tax financing and user fees is not changed.

The MSG6 simulations account for the increase in government employment. They also account for direct changes in the number pensioners and the labor force caused by increased longevity. As pointed out in Section 3.5, the Norwegian pension reform is especially designed to make the public pension expenditures more invariant to changes

[11] This section draws on Holmøy and Nielsen (2008).

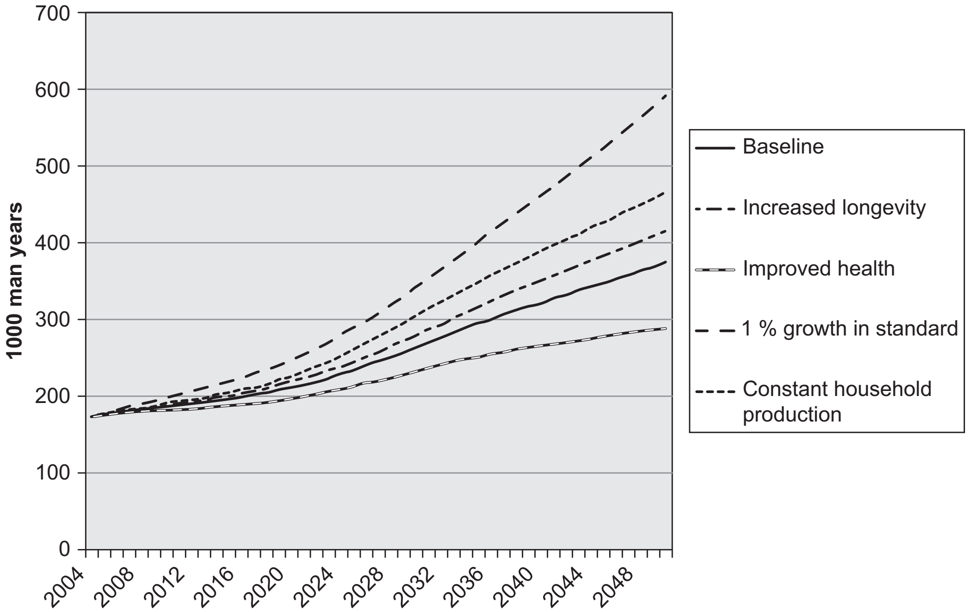

Figure 3.5 Projected employment in public health and long-term care under different assumptions: 1000 normal man-years.

in longevity. To what extent this will be the case is examined below by computing the effects of increased longevity for both the old and the new public pension system.

Given the old pension system, the MSG6 simulation shows that the payroll tax rate must increase gradually compared with the baseline path in order to meet the government budget constraint implied by the fiscal rule. The required increase becomes higher as the difference between the numbers of elderly in the two scenarios gradually grows (Figure 3.6). It passes 4.2 percent in 2050. The figures in Table 3.10 allow a more detailed examination of the mechanisms driving this result. The 11% increase in government health and long-term care employment entails an increase in real government consumption of 7.9%. The increase in cash transfers in current prices may seem surprisingly small (0.5%) since public old-age pension expenditures amount to more than one-third of total cash transfers. However, almost all of these transfers are wage indexed and the wage rate falls by 3.7%. Thus, old-age pensions deflated by the wage rate are about 12.6% higher than in the baseline in 2050.[12]

12 Let X be the percentage change in old-age pensions measured in fixed wages. The share of old-age pensions in total transfers is one-third, the remaining transfers are the same in both scenarios, the wage rate falls by 3.7%, and the increase in total transfers measured in current prices is 0.5%. It then follows that $(1/3) * (-3.7 + X) + (2/3) * (-3.7) = 0.5 \leftrightarrow X = 12.6$.

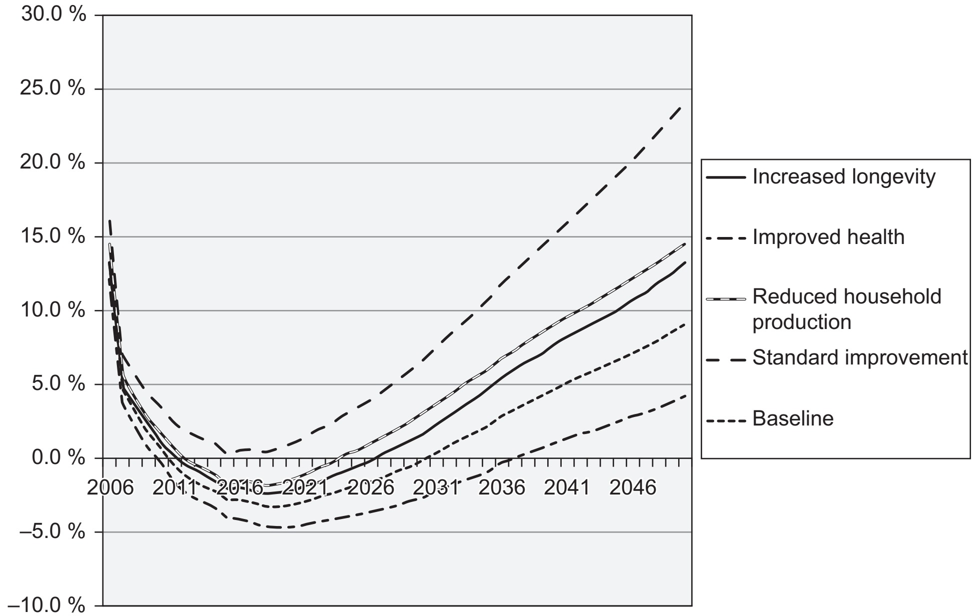

Figure 3.6 Payroll tax rate in different oil price scenarios (%).

The wage rate adjustment is a general equilibrium effects that modifies the need for raising the payroll tax rate. As explained in Sections 3.4.1 and 3.4.2 the reason is that the share of wages is greater in government expenditures than in government revenues. The fall in the wage rate reflects the changes in the payroll tax rate and the labor cost per hour. First, a given increase in the payroll tax rate implies higher labor cost per hour for a given consumer wage rate. *Cet. par.* this means a deterioration of the international competitiveness that is inconsistent with the external balance constraint. In the textbook SOE model, the labor cost must remain constant by a decline in the consumer wage rate. This mechanism is important in MSG6, but there is some scope for changes in the labor cost since there are increasing marginal costs in the production of traded goods. The increase in consumption of health and long-term care services crowds out consumption of other goods, which reduces the average import share in total demand. This effect does not depend on the degree of public provision of these services. Thus, in order to maintain external balance, the traded goods sector must be lower in the scenario with the largest number of elderly. This is realized by a real appreciation in the form of an increase in labor cost per hour equal to 1.7%.

Other equilibrium mechanisms have also affected the need for raising the tax burden. A given change in labor supply has a strong effect on total tax revenues, since most tax bases are positively related to employment. However, total employment is almost unaffected, since the negative substitution effect of the decline in the real consumer wage

Table 3.10 Effects of changes in demography and in determinants of the demand for health and long-term care services

	Increased longevity		**Improved health**		**1% growth in standard**		**Constant household production**	
	2020	**2050**	**2020**	**2050**	**2020**	**2050**	**2020**	**2050**
Total government expenditures (current prices)	1.4	3.5	−1.7	−3.6	4.6	10.0	1.9	4.0
Government consumption (fixed prices)	2.1	7.9	−3.1	−13.5	7.8	34.4	3.1	14.0
Government employment	1.0	4.0	−1.9	−8.3	4.8	21.0	1.9	8.8
Employment in public health and long-term care	3.4	11.0	−7.0	−22.9	17.3	58.0	7.0	24.3
Cash transfers to households (current prices)	0.4	0.5	0.6	4.0	−1.4	−10.2	−0.7	−3.9
Payroll tax rate (%)	1.0	4.2	−1.5	−4.9	4.1	15.0	1.7	5.5
Total employment	−0.1	0.2	0.4	−0.4	−1.3	1.0	−0.6	0.5
Consumer wage rate	−0.5	−3.7	0.6	4.2	−1.3	−10.8	−0.6	−4.1
Private consumption (fixed prices)	0.1	−2.0	0.5	3.5	−0.9	−9.0	−0.3	−3.5

rate is nearly neutralized by the income effect, which also include lower profits and wage indexed transfers.

However, the tax revenue also depends on the allocation of labor between the private and the government sector. Almost all the increase in government employment is taken from the private sector, since labor supply is almost equal in the two scenarios. In 2050, this reduces private consumption by 2.0% from the baseline level. This shrinks the indirect tax base, and the average indirect tax rate on private consumption is close to 20% in Norway. In addition, the effective base of the payroll tax rate is the wages in the private sector only, since the payroll taxes paid by government production represent an identical component of government labor costs. Thus, the crowding out of private consumption and employment contributes to increase the necessary tax hike.

3.6.2 Increased longevity under a more actuarial pension system

As explained in Section 3.5, one of the most important elements in the Norwegian pension reform of 2011 is the actuarial mechanism supposed to neutralize the effects of changes in longevity on public old-age pension expenditures. Holmøy and Stensnes (2008) analyze how well the reform lives up to this intention by comparing a no-reform and a reform scenario under the assumption that average longevity increases by 0.19 years rather than 0.14 *per annum*.

The simulations demonstrate that the reform indeed works as intended (Table 3.11). In 2050, the increase in longevity would magnify the reduction in public old-age pension expenditures from 12.2 to 17.1%. This reflects that prolongation of the existing non-actuarial system is more costly the longer people live as pensioners. The corresponding feasible cut in the payroll tax rate increases from 9.5 to 13.6%. Stronger labor supply incentives at both the extensive and intensive margin contribute to the magnified scope for tax cuts.

Table 3.11 Pension reform effects under alternative assumptions on demographics and labor supply (deviations from respective reference scenarios in 2050; % unless otherwise indicated)

	Main alternative	Longevity
Changes from main alternative		2.2 extra years
Total government expenditures (current prices)	−5.9	−8.1
Cash transfers to households (current prices)	−3.6	−5.9
Old-age pension expenditures (current prices)	−12.2	−17.1
Payroll tax rate (%)	−9.5	−13.6
Total employment	11.0	13.4
Consumer real wage rate (including stronger dependency between earnings and pensions)	9.4	11.5
Pretax wage rate	2.0	4.1
Total tax base (current prices)	6.4	8.8

As pointed out in Section 3.5, the simulated reform effects on the growth rate of key variables after 2020 are quite insensitive to changes in exogenous assumptions. The exception is variation in longevity. With the old pension system, the required payroll tax rate grows annually by 0.42% on average between 2020 and 2050. Under the same longevity assumptions, the corresponding growth in the pay roll tax rate is reduced by 0.13 points from the baseline. When the reform is combined with increased longevity the growth in the pay roll tax rate can be 0.21 points lower than in the baseline.

3.6.3 Immigration

The substantial increase in immigration to Norway over the last years has demonstrated that this variable is notoriously hard to predict. The following sensitivity analysis incorporates an increase in net immigration of 8000 persons per year, which is 50% above the net immigration in the main demographic alternative. The extra immigrants are assumed to behave as Norwegians with the lowest education. Accordingly, it reduces *cet. par.* the average labor market participation rate, earnings and pension entitlements. Immigrants are also assumed to have the same age- and gender-specific user ratios of public services as natives, and they get the same (constant) service standards. Government consumption of public goods increases proportionally to the changes in the total population.

On balance, additional immigration improves government finances (Table 3.12). However, this reflects that we do not compute effects after 2050. Few of the additional immigrants become elderly within 2050. Extending the simulation period would therefore show less positive fiscal effects. In 2050, the payroll tax rate can be 3.0% below the corresponding baseline level without violating the fiscal rule. The government revenues from increasingly higher tax bases dominate the increase in government consumption and cash transfers. Table 3.13 reports the changes in the main primary budget components measured in current prices.

Table 3.12 Effects on the size and the age composition of the population of increasing net immigration by 8000 (50%) per year (deviations from the baseline scenario; % unless otherwise indicated)

	2025	2050
Total population, absolute change (1000 persons)	163	467
Total population	3.1	8.0
0–19 years	4.3	9.8
20–66 years	3.4	9.2
67 years or older	0.4	2.9
Demographic dependency ratio (%)	−0.5	−1.7

Table 3.13 Effects on government finances of increasing net immigration by 8000 (50%) per year (current prices; deviations from the baseline scenario; % unless otherwise indicated)

	2025	2050
Total government expenditures	−1.1	2.5
Cash transfers	−0.8	2.7
Government consumption	−1.7	1.3
Total government primary revenues	−0.7	2.4
Taxes, Mainland sector	−1.1	2.7
Petroleum sector	0.7	1.5
Payroll tax rate (%)	−2.8	−3.0

The reason why higher immigration cause a fall in several budget components is the negative equilibrium effect on the wage rate, which has a strong impact on all budget components in Table 3.13 except the petroleum revenues. As explained above, the wage rate reduction contributes to reinforce the positive budget effect of higher immigration. The wage rate reduction is required because a larger population expands the demand for traded goods, which *cet. par.*, violates the external balance constraint.

In 2050, the additional immigration has contributed to raise government employment by 6.5% compared to the baseline (Table 3.14), whereas the corresponding increase in total employment equals 10.0%. It also raises the number of recipients of cash transfers from the government. The simulations have incorporated the empirical regularity that immigrants will to a greater extent than natives qualify for disability pension, since they are assumed to have the lowest degree of education.

The macroeconomic changes vary around the relative change in the size of the total population. The deviations are basically due to a higher average labor market participation rate among immigrants. However, this reflects that on average the extra immigrants are younger than natives. As noted above, this effect would be weakened if the simulation period had been extended. Controlling for age, the average immigrants work less than the average native. However, even before 2050 higher immigration causes a reduction in the

Table 3.14 Effects on age dependent determinants of government expenditures of increasing net immigration by 8000 (50%) per year (deviations from the baseline scenario %)

	2025	2050
Number of pensioners	1.3	4.7
Old-age	0.7	3.0
Disabled	1.0	7.8
Government employment	2.8	6.5
Education	4.2	9.8
Health and care	3.1	8.0

Table 3.15 Effects on macroeconomic aggregates *per capita* of increasing net immigration by 8000 (50%) per year (fixed prices; deviations from the baseline scenario; %)

	2025	2050
Employment	2.6	2.0
Per capita, age 20–66 years	2.3	0.8
GDP	0.0	−0.8
Real disposable income	0.9	−0.4
Private consumption	−1.9	−1.0

per capita levels of real disposable income and private consumption (Table 3.15). The reason is simply that more inhabitants will share the petroleum wealth, including both the capital in the GPF and the remaining undepleted resources, since this is owned by the government.

The effects can also be measured relatively to the change in the number of immigrants, as in Table 3.16. The ratios between the reported percentage deviations from the baseline and the percentage increase in the total population are significantly lower than unity. The most significant reason is that the variables are measured in current prices and the wage rate falls. However, the ratio associated with the number of pensioners is also as small as 0.1 in 2050. On the other hand, the corresponding ratio for government employment exceeds unity.

Table 3.16 Effects on government finances of increasing net immigration by 8000 (50%) per year: elasticities (measured by the percentage deviation from the baseline effects divided by the percentage increase in population caused by the increased immigration)

	2025	2050
Population growth (%)	3.1	8.0
Government expenditures (current prices)	−0.4	0.3
Cash transfers	−0.3	0.3
Number of pensioners	0.4	0.1
Old-age	0.2	0.1
Disabled	0.3	0.2
Government consumption	−0.5	0.2
Government employment	1.8	1.3
Education	1.4	1.2
Health and care	1.0	1.0
Government revenues (current prices)	−0.2	0.3
Taxes, Mainland sector	−0.4	0.3
Petroleum sector	0.2	0.2

3.6.4 Improved health among the elderly

The majority of international projections of government health expenditures assume that lower mortality among the elderly reflects improved health. More precisely, the simulation of this alternative assumes that the age-specific demand for health and social care services is reduced so that the individual use of these services on average remains constant over the individual lifetime. This implies, for example, that the 70-year-old average individual is almost 30% more healthy in 2050 than he would have been at the same age in 2006. This would significantly slow down the growth in the required employment in the government health and long-term care sectors. In 2050, this employment is 23% lower than in the baseline and 34% lower than in the case where longevity increases with no health improvements. The required payroll tax rate would be 4.9% below the baseline level in 2050. The equilibrium effects are qualitatively the same as those explained above, but they are weaker.

3.6.5 Increased household production

Based on time used surveys household production of care services is roughly estimated to about one-third of the employment in the government *Health and social care* sector in 2005. The baseline scenario assumes that household production of care services grows at the same rate as government production of these services. This assumption may be positively biased. The scope for further outsourcing of household production of these services is limited due to increased female market labor participation historically, and this is continued in the baseline scenario. Table 3.10 and Figures 3.5 and 3.6 show the effects of alternatively assuming no growth in household production from the present level. The fiscal effects are significant and nearly symmetrical to the effects of improved health among the elderly described above. Government employment would be 8.8% higher in 2050 than the baseline in order to provide the same service standards. The corresponding increase in the payroll tax rate would have to be 5.5%.

3.6.6 Improved service standards

The baseline assumption of constant service standards would break the trend observed over the last decades in Norway and all other OECD countries (Holmøy and Nielsen, 2008). There is a strong correlation between improved living standards and the standard of public health services measured by inputs per user. Hall and Jones (2007) argue that this reflects a causal relationship. The most common assumption in international projections is to let the standard of health services growth as least as rapid as GDP *per capita*. For long-term care, the assumptions are more varied. The "Improved standard" alternative reported in this section assumes that the standard of both health services and long-term care grows by 1% annually.

The long-running effects are strong. In 2020, employment in this sector would be 17% above the corresponding baseline level and this deviation passes 58% in 2050. The increasing slope of the payroll tax rate path after 2020 becomes steeper and has become 15% higher than the baseline rate in 2050. An interaction between the growth in standards and the number elderly users contributes to this, and it causes a stronger growth in the necessary payroll tax rate than in the baseline also after the standard improvements are halted. Thus, the highly plausible policy of further, but rather moderate, improvements in the standard of health services and long-term care will dramatically reinforce the long-run problems of financing the Norwegian welfare state. On the other hand, such improvements will be politically hard to resist as the share of elderly in the voters increases and private consumption *per capita* continues to grow at an even higher rate.

On balance, general equilibrium effects significantly modify the budget effect. The effect of wage rate reduction and a slight increase in labor supply dominate the negative tax base effects of the reallocation of labor and consumption from the private to the government sector. However, if government consumption of individual goods entered the individuals' utility functions, the income effects on labor supply would have been weaker.

3.7 INCREASING PREFUNDING THROUGH A STRICTER FISCAL POLICY RULE

The U-shaped curve of the tax burden in Figure 3.2 triggers questions about tax smoothing. This would require more prefunding compared to what follows from the present fiscal rule, which is equivalent to a slower phasing in of the petroleum wealth in the Norwegian economy. A stronger correlation between the out-take from the fund and the ratio between government expenditures and the tax bases of the Mainland economy would result in a smoother time path for the tax burden. However, although no other alternative policy has been tried out, it is a widespread opinion that the present fiscal rule has worked well. It has disciplined the politicians, and with one exception, all political parties accept the rule. Without such a rule more, rather than less, of the petroleum wealth would have been spent before population ageing hits the welfare state hard after 2020. Accordingly, if frequent changes in the fiscal rule are accepted, there is a risk that the respect for any rule will vanish. The public budget constraint may then in practice become very soft as long as the government is highly liquid. The result would be the opposite of more tax smoothing. This line of reasoning suggests that more tax smoothing should be obtained without fundamentally changing the fiscal rule.

One way of doing this is to reduce the parameter interpreted as the expected real rate of return to the GPF assets, from the present 4% which is best interpreted as an estimate of the rate of return in terms of imports. This underlies the baseline assumptions presented in Section 3.3: the exogenous nominal international (risk free) interest rate is set to 5.5% and all world prices grow by 1.5%. Consequently, setting the real rate of return to 4% is reasonable if the nominal capital returns are spent on imports. This is the relevant choice if one wants to calculate the aggregate gain from an increase in the petroleum wealth, because the only way that the economy as a whole can benefit from a higher petroleum wealth is to spend it on imports within the external balance constraint.

However, the petroleum wealth accrues to the government in the first hand. One rationale for linking the out-take from the GPF to the *real* rate of return is to prefund the part of expenditure growth attributable to growth in prices. The share of import prices in the relevant price index for government expenditures is very small. Rather, it is very close to the average wage rate. Almost all cash transfers are wage indexed and wages are by far the dominating cost component in the production of public services. In most of the scenarios described in the previous sections the wage growth is close to 4%. Replacing the growth in world prices by the wage growth implies that the growth in the GPF capital will be equal to the wage growth when the inflow of petroleum revenues stops. Thus, such a tightening of the fiscal rule represents a step towards elimination of the growth gap between government expenditures and the tax bases.

Figure 3.7 shows the results of using MSG6 to simulate how the payroll tax rate would have to adjust if the fiscal rule were tightened. In the "tighter rule" scenario, the

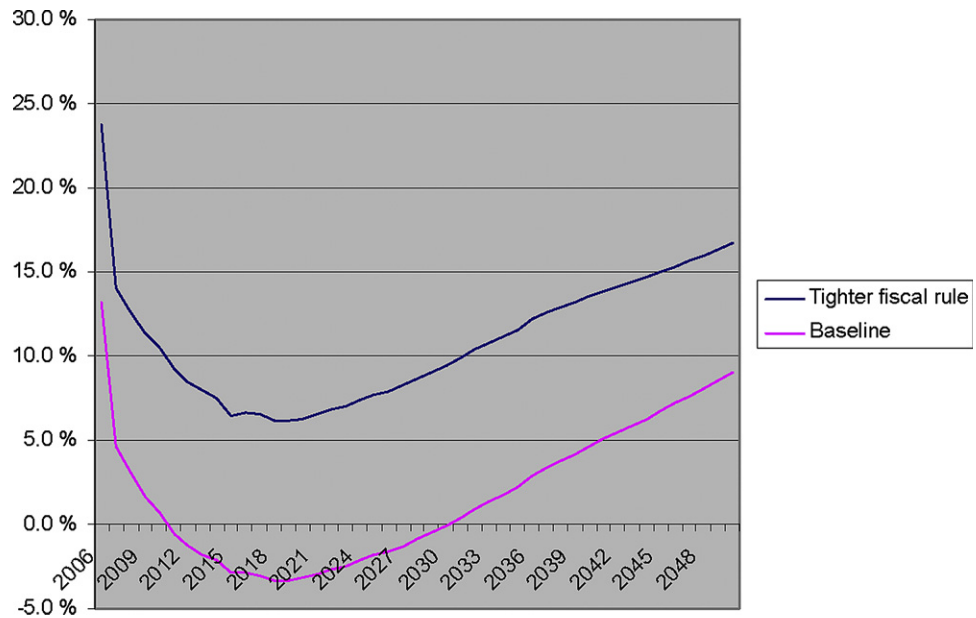

Figure 3.7 Payroll tax adjustments required to obey the present (baseline) and a tighter fiscal rule (%).

annual rate of out-take from the GPF is reduced from the present 4 to 1.5%, which is close to the difference between the world interest rate and the simulated wage growth. After 2020 the payroll tax rate must be 7–8% points higher than in the baseline. As explained in the previous sections, the simulation accounts for several potentially important equilibrium effects, including the positive budget effect of the reduced wage rate caused by the higher payroll tax rate, and a negative effect on labor supply induced by the reduced consumer real wage rate.

The effects shown in Figure 3.7 should of course not be taken too literally. Especially, it has never been the ambition when constructing different MSG models to provide realistic short run adjustments. Therefore, Figure 3.7 gives a highly stylized picture of the tax smoothing effect of delaying spending of the petroleum wealth. The need for compensating the reduced out-take from the GPF by a higher tax burden is quite strong. The benefits in terms of lower taxes in the future – when 1.5% of a greater GPF exceeds 4% of the baseline GPF belongs to a future which is beyond 2050. The payroll tax rate can grow more slowly after 2020 under the tighter rule than in the baseline, but the returns to higher prefunding in terms of lower future tax burden appears to be rather modest. The basic reason is that after 2020 the difference between the interest rate and the growth rate of the primary fiscal deficit is less than 1 percent. Such a low growth adjusted rate of return implies that the prefunding needed to bring about a given reduction in the future tax burden must be very high.

3.8 FINAL REMARKS

This paper has employed the CGE model, called MSG6, of the Norwegian economy to assess the problems of financing the Norwegian welfare state until 2050. MSG6 has been developed for different purposes. In the analyses of fiscal sustainability issues it has been combined iteratively with other models, especially a microsimulation model of labor market participation and public pension expenditures. In this way, the simulations capture both consistent equilibrium repercussions and individual effects that cannot be calculated without a detailed description of population heterogeneity, income histories and the pension system. Thus, the simulations have exploited most of the available detailed information required to project long-term growth in government expenditures and revenues in Norway.

The main substantive conclusion is that the fiscal prospects for Norway are gloomy if one takes a careful look beyond the first couple of decades. This is true despite the fiscal rule adopted in 2001, which is an ambitious plan for transforming large government petroleum revenues into higher consumption for both the present and all future generations. Ageing will be costly in the generous Norwegian welfare state and the permitted out-take from the GPF will decelerate as the petroleum resources are gradually depleted. The petroleum wealth is far from sufficient to finance the *increase* in government expenditures permanently when a rapidly growing number of elderly switch roles from contributors to clients of the welfare state after 2020.

The baseline assumptions imply that a relatively broad tax on wages such as the payroll tax rate must be continuously raised after 2020 in order to obey the fiscal rule. This is not a realistic projection. It is rather supposed to stimulate the debate on policy reforms by demonstrating quantitatively that prolongation of the current policy is indeed unrealistic; it is probably unfeasible. This big unpleasant difference between the fiscal presence and the distant fiscal future makes long-run fiscal sustainability assessments even more important in Norway than in other countries, where strained budgets already trigger unpopular cost-saving reforms.

The gloomy fiscal prospects are quite, but far from completely, robust to variations in exogenous key determinants of government revenues and expenditures. An important insight is that productivity growth in the private sector will reduce the primary budget surplus through wage growth. This result differs from corresponding assessments for other economies. In some cases, this difference reflects different modeling approaches, but they are also a consequence of economy specific characteristics. Compared to models designed to be solved analytically with the help of just pen and paper, the obvious advantage of computational models is the ability to account for much relevant information.

Fundamentally, the adverse fiscal effect in Norway of productivity growth reflects the strong position of egalitarian preferences in Norway. Specifically, centralized wage formation and wage indexation of the pension benefits and most other cash transfers ensure that productivity gains in private firms are distributed automatically to all inhabitants, including civil servants and pensioners.

Wage rate adjustment is an uncontroversial general equilibrium effect in long-run analyses of productivity changes. However, the MSG6 simulations discussed in the chapter demonstrate that wage rate adjustments also strongly influence the fiscal effects of other exogenous changes. This is perhaps most strikingly demonstrated in the analyses of an increase in oil prices. The scope for budget-neutral tax reductions were reduced by an order of magnitude when taking the wage rate adjustment and other general equilibrium effects into account. The wage effect is a good example of how CGE modeling can add relevant insight and information about the plausible empirical significance of the multitude of effects and arguments being mentioned in the fiscal sustainability debate.

The pension reform of 2011 is intended to be a major part of a solution of the fiscal sustainability problems facing Norway. The reform has incorporated actuarial mechanisms in order to neutralize much of the trend-driven expenditure growth, especially increased longevity. It also includes several incentives that stimulate labor supply. It would be peculiar if the intended large effects could be obtained without complex and significant equilibrium repercussions. The combined CGE and microsimulations confirm that the pension reform is likely to significantly improve government finances in the long-run. Moreover, they demonstrate that one would seriously underestimate the fiscal effects of the pension reform if behavioral effects and equilibrium repercussions were ignored. Interestingly, most of the fiscal improvement is achieved by an expansion of the tax bases due to increased labor supply. However, these are primarily level effects. The reform makes a surprisingly small contribution to reduce the gap between the long-run *growth rates* of government expenditures and the tax base, which appear to be the root of the Norwegian fiscal sustainability problem.

The big unresolved fiscal sustainability problem is the growth in government health and care expenditures. Health services and care for the elderly will probably be the fastest growing sector in the Norwegian economy after 2020, irrespective of the mix between public and private provision of these services. Given the present dominant role of the government sector in producing and financing these services, the growth in government health and care expenditures is the most important source to growing primary non-petroleum budget deficit after 2020. This is true even in the unrealistic case when today's service standards are not improved. A standard growth of 1% is moderate compared to both historical trends in Norway and to corresponding assumptions in projections for other countries. However, the simulations suggest that such a scenario this will necessitate a much stronger growth in the tax burden or cuts in other expenditures after 2020 than in the baseline scenario.

Despite the exceptional solid fiscal stance in Norway, the majority of politicians and the public have accepted both a cost-saving pension reform, as well as a fiscal rule that distributes the petroleum wealth to all future generations, not only to the one who found and produced it. Economists may argue that the implemented pension reform should have included even stronger labor supply incentives, and that the fiscal rule should have been tighter. However, these examples indicate that the fiscal policymaking in Norway does take long-term problems into account. In order to establish understanding of the importance of long-run issues, quantitative projections have played an important role. This is both a consequence of and a premise for the tradition for the continuous development of large scale computational models used for both research and policy making. Probably, numbers are the best adjectives to make the distant future count in decisions made today.

APPENDIX

A.1 More detailed picture of MSG6

Heide *et al.*, (2004) provide a more comprehensive description of MSG6 and detailed explanations of how the model works.

A.1.1 Aggregation

MSG6 specifies 60 commodity groups, including nine that are non-competing imports and 12 Government services. Different proportions of the remaining 39 goods are produced in the private business sector, which is split into 32 industries. The description of taxes and subsidies is detailed in order to make the model operational for policy analyses.

A.1.2 Household behavior

The model user may choose between different submodels of intertemporal consumer behavior. The standard version of MSG6 includes endogenous intertemporal consumer behavior. In this model the time profiles of labor supply and consumption of the specified goods are derived from the decisions of one representative price-taking household with perfect foresight. It maximizes an additively intertemporal utility function over an infinite horizon subject to an intertemporal budget constraint and a time constraint in each period. The intertemporal elasticity of substitution is constant and equal to 0.3, which is within the range spanned by the estimates used in the literature (see, e.g. Steigum, 1993). The rate of subjective time preference is exogenous as well as the after-tax interest rate. It is a well-known property of this kind of model that a steady state solution requires these exogenous rates must be equal. This restriction is not necessarily problematic in practice since it is only required in the last part of the simulation period, which may be very distant from the years of interest for the analysis.

As pointed out in Section 3.2, the intertemporal model based on a representative consumer with an infinite life expectancy is irrelevant in studies of fiscal sustainability, where, for example, ageing and pensions are key elements. In these studies the savings of the households adapts passively so that private consumption absorbs what is left of the production and net imports after the demands from firms and government sectors have been satisfied. However, the economy maintains an intertemporal budget constraint on net foreign debt.

The utility obtained in each period corresponds to the concept Full Consumption, which is a homothetic CES utility function in leisure and an aggregate of all types of consumer goods referred to as Material Consumption. The elasticity of substitution is set to 0.6. The initial budget share of leisure has been set to 0.5 based on studies of time spending by Norwegian households. Combined with the base year levels of non-labor income, these parameter values imply a direct Cournot wage elasticity of labor supply equal to 0.1. Such an order of magnitude is in line with the empirical properties of the microeconometric model estimated by Aaberge *et al.,* (1995).

Material Consumption is an aggregate of 19 types of consumer goods, each being a Leontief composite of the specified commodities in the model. Within this aggregate the substitution possibilities are specified by a nested separable structure of origo adjusted CES subutility functions. The origo adjustment of the CES functions allows non-homotheticity without violating the conditions for sequential budgeting associated with the specified nests. The estimation of the parameters has been based on panel data.

Aasness and Holtsmark (1995) provide further details on the nested CES structure and on the estimation results.

A.1.3 Market structure, producer behavior and exports

MSG6 distinguishes between the behavior of the individual firms and the aggregate industry behavior. Output and input in an industry can change because of adjustments at the firm level and as a result of entry or exit of firms. All private firms are run by managers with perfect foresight, who maximize the present value of the cash flow. The private profitability is affected by indirect taxation of inputs, capital income taxation and a rich menu of subsidies and government transfers.

Producers of manufactures and tradable services allocate their output between the domestic and the foreign market. The cost of changing the composition of these deliveries is captured by assuming that output is a CET function of deliveries to the export market and deliveries to the domestic market. Exports are sold at fixed world prices. On the other hand, domestic consumers regard products from different firms within the same industry, as close but imperfect substitutes. MSG6 employs the model of the LGMC to formalize the market structure for domestic deliveries. The elasticities of substitution between the varieties in different industries are calibrated to be consistent with the estimated markup ratios between the output price and marginal costs in Klette (1999). None of the markup ratios exceeds 1.05. Entry (exit) takes place in an industry if the variable after tax profit increases (decreases) relatively to the fixed entry cost. The model of monopolistic competition in MSG6 differs from the standard textbook model by allowing productivity differentials between firms within the same industry, which generates an *asymmetric* equilibrium (see Holmøy and Hægeland, 1997).

For inputs, the separability assumptions allows all inputs to be perfectly aggregated into one index of aggregate input through a system of nested constant returns to scale CES functions. Labor is homogeneous, whereas the capital goods and intermediaries are Leontief aggregates of the commodities specified in the model. The production function of the firm is assumed to exhibit decreasing returns to scale. The scale elasticities range from 0.85 to 1.00, which implies a small negative bias compared to those estimated in Klette (1999). This bias was introduced in order to avoid unrealistic specialization patterns of the industry structure.

A.1.4 Imports

The Armington assumption holds for manufactures and a few tradable services, i.e. imports are considered as a close but imperfect substitute for the corresponding differentiated product supplied by the domestic industry. The import shares depend negatively on the ratio between the price of imports and the price of corresponding domestic deliveries. The elasticities of substitution have been set in accordance with the stationary time series estimates reported in Naug (1994). Commodities produced by primary industries, including Agriculture, Forestry, Fishery, production of Electricity, Crude Oil and Natural Gas, are assumed to be regarded as homogenous by both Norwegian and foreign consumers. In the absence of any trade restriction, the prices of these commodities would be equal to the corresponding exogenous world prices, and the model would determine only net imports as the residual between domestic production and domestic demand. Import protection is captured by nominal tariffs and non-tariff barriers modeled either as additional costs for foreign producers when exporting to the Norwegian market, or quantitative restrictions, such as import quotas.

A.2 Stylized one-sector version of the standard version of MSG6

A.2.1 Consumer behavior

A representative price taking consumer with perfect foresight decides on consumption, savings and labor supply. Treating time as a continuous variable, the intertemporal utility function has the common additively separable CES form:

$$W_0 = \int_0^{\infty} e^{-\rho t} U(D, T - L)^{1-\frac{1}{\sigma}} dt. \tag{3.1}$$

The intratemporal utility function, U, is a homothetic CES function with σ as the elasticity of substitution, D is consumption, and T is the hours that can be allocated to leisure or labor, L, per year. $T - L$ is leisure. The ideal CES price index for U takes the general form:

$$P_U = P_U((1 - t_W)W, (1 + t_C)P), \tag{3.2}$$

where W is the pretax 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:

$$P = P(P_H, (1 + t_I)P_I), \tag{3.3}$$

where P_H is the price index for the domestic product, t_I is the tariff rate and P_I is the c.i.f. (cost, insurance and freight) 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:

$$P_H = \left[\int_0^n (P_{iH})^{1-\nu} di\right]^{\frac{1}{1-\nu}}. \tag{3.4}$$

The intertemporal budget consumer constraint is:

$$\int_0^n e^{-(1-t_\pi)r}[(1+t_\mathrm{C})PD + (1-t_\mathrm{W})W(T-L) + (1-t_\pi)\pi + Y]\mathrm{d}t = V_0, \quad (3.5)$$

where $D = D(D_\mathrm{H}, D_\mathrm{I})$ is the volume index (subutility) 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 exogenous interest rate, assumed constant here.

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

$$U = (\mu P_\mathrm{U})^{-\sigma_\mathrm{C}} \quad (3.6)$$

$$D = \left(\frac{(1+t_\mathrm{C})P}{P_\mathrm{U}}\right)^{-\sigma_\mathrm{F}} U \quad (3.7)$$

$$L = T - \left(\frac{(1-t_\mathrm{L})W}{P_\mathrm{U}}\right)^{-\sigma_\mathrm{F}} U \quad (3.8)$$

$$D_\mathrm{H} = \left(\frac{P_\mathrm{H}}{P}\right)^{-\sigma_\mathrm{I}} D \quad (3.9)$$

$$D_\mathrm{I} = \left(\frac{(1+t_\mathrm{I})P_\mathrm{I}}{P}\right)^{-\sigma_\mathrm{I}} D \quad (3.10)$$

$$D_{i\mathrm{H}} = \left(\frac{P_{i\mathrm{H}}}{P_\mathrm{H}}\right)^{-\nu} D_\mathrm{H}, \quad (3.11)$$

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 endogenous but constant. $D_{i\mathrm{H}}$ is the demand for the domestic variety i.

A.2.2 Behavior of firms and aggregate industries

A representative firm is a price taker in all factor markets and in the export market, whereas the domestic market is characterized by monopolistic competition. Each firm has perfect foresight and maximizes the present value of the after-tax cash flow. This exposition ignores intermediary inputs, capital depreciation and the capital income taxation. The value of the ith firm at time 0 is:

$$V_{i0} = \int_0^\infty e^{-(1-t_C)rt}(\pi_i - P\dot{K} - F)dt, \tag{3.12}$$

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

$$\pi_i = P_{iH}X_{iH} + P_W X_{iW} - (1 + t_L)wL_i, \tag{3.13}$$

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:

$$X_{iH} = E(P_{iH})^{-\nu}, \tag{3.14}$$

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

$$[(X_{iH})^\rho + (X_{iW})^\rho]^{\frac{1}{\rho}} = [A_i f(L_i, K_i)]^s, \tag{3.15}$$

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

$$C_i = c_i\left[\left(X_{iW}\right)^{\frac{1}{s}} + (X_{iH})^{\frac{1}{s}}\right]. \tag{3.16}$$

c_i is the dual price index of the composite CES input of labor and capital:

$$c_i = \frac{1}{A_i}\left[((1 + t_L)W)^{1-\sigma_K} + ((1 + t_K)(rP - \dot{P}))^{1-\sigma_K}\right]^{\frac{1}{1-\sigma_K}}. \tag{3.17}$$

Here, A_i is 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 formalized by:

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

After integrating (3.12) (by parts) 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:

$$X_{iW} = \left(\frac{sP_W}{c_i}\right)^{\frac{s}{1-s}}, \tag{3.18}$$

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

$$X_{i\mathrm{W}} = X_{0\mathrm{W}} \mathrm{e}^{\frac{-sti}{1-s}}. \tag{3.19}$$

Optimal price setting for domestic deliveries implies the markup rule:

$$P_{i\mathrm{H}} = \frac{mc_i}{s}(X_{i\mathrm{H}})^{\frac{1}{s}-1}, \tag{3.20}$$

where $m = \nu/(\nu - 1)$ is the markup factor. Consistency between perceived demand and supply for product i implies:

$$P_{i\mathrm{H}} = \frac{mE^{\frac{1}{s}-1}c}{s}\mathrm{e}^{ti}(P_{i\mathrm{H}})^{-\nu\left(\frac{1}{s}-1\right)}. \tag{3.21}$$

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

$$X_{i\mathrm{H}} = X_{0\mathrm{H}} \mathrm{e}^{\frac{-mti}{m/s-1}}, \tag{3.22}$$

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

For a given number, n, of firms and products the industry output variables are easily calculated. Defining $h_\mathrm{H} = \dfrac{m/s-1}{t}$ and $h_\mathrm{W} = \dfrac{1/s-1}{t}$ yields:

$$X_\mathrm{H} = \int_0^n X_{i\mathrm{H}} \, \mathrm{d}i = X_{0\mathrm{H}} \frac{h_\mathrm{H}}{m}\left(1 - \mathrm{e}^{\frac{-mn}{h_\mathrm{H}}}\right) \approx X_{0\mathrm{H}} \frac{h_\mathrm{H}}{m} \tag{3.23}$$

$$X_\mathrm{W} = \int_0^n X_{i\mathrm{W}} \mathrm{d}i = X_{0\mathrm{W}} h_\mathrm{W}\left(1 - \mathrm{e}^{\frac{-n}{h_\mathrm{W}}}\right) \approx X_{0\mathrm{W}} h_\mathrm{W}. \tag{3.24}$$

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 this 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 (Holmøy and Hægeland, 1997) for a detailed discussion of this approximation.

A.2.3 Equilibrium

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

$$\left(\frac{m}{s} - 1\right)c_n(X_{n\mathrm{H}})^{\frac{1}{s}} + \left(\frac{1}{s} - 1\right)c_n(X_{n\mathrm{W}})^{\frac{1}{s}} = F. \tag{3.25}$$

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

$$P_{\mathrm{H}} \approx bP_{0\mathrm{H}}, \tag{3.26}$$

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 $P_{0\mathrm{H}}$ in the ideal index. Moreover, the perceived domestic demand function can now be written:

$$X_{0\mathrm{H}} = b^{\nu} E(P_{\mathrm{H}})^{-\nu}. \tag{3.27}$$

Equilibrium in the domestic product market requires $X_{i\mathrm{H}} = D_{i\mathrm{H}} + J_{i\mathrm{H}}$, where:

$$J_{i\mathrm{H}} = \left(\frac{P_{i\mathrm{H}}}{P_{\mathrm{H}}}\right)^{-\nu} \left(\frac{P_{\mathrm{H}}}{P}\right)^{-\sigma_{\mathrm{I}}} \dot{K},$$

is the investment of the ith domestic variety. This equilibrium condition can be written:

$$X_{0\mathrm{H}} = b^{\nu} \left(\frac{P_{\mathrm{H}}}{P}\right)^{-\sigma_{\mathrm{I}}} \left(D + \dot{K}\right). \tag{3.28}$$

Aggregate demand for capital and labor becomes:

$$K = \left(\frac{(1+\tau_{\mathrm{K}})(rP - \dot{P})}{c}\right)^{-\sigma_{\mathrm{K}}} \left[h_{\mathrm{H}}(X_{0\mathrm{H}})^{\frac{1}{s}} + h_{\mathrm{W}}(X_{0\mathrm{W}})^{\frac{1}{s}}\right] \tag{3.29a}$$

$$L = \left(\frac{(1+\tau_{\mathrm{L}})W}{c}\right)^{-\sigma_{\mathrm{K}}} \left[h_{\mathrm{H}}(X_{0\mathrm{H}})^{\frac{1}{s}} + h_{\mathrm{W}}(X_{0\mathrm{W}})^{\frac{1}{s}}\right]. \tag{3.29b}$$

Labor market equilibrium implies:

$$T - \left(\frac{(1-t_{\mathrm{L}})W}{P_{\mathrm{U}}}\right)^{-\sigma_{\mathrm{F}}} U = \left(\frac{(1+\tau_{\mathrm{L}})W}{c}\right)^{-\sigma_{\mathrm{K}}} \left[h_{\mathrm{H}}(X_{0\mathrm{H}})^{\frac{1}{s}} + h_{\mathrm{W}}(X_{0\mathrm{W}})^{\frac{1}{s}}\right]. \tag{3.30}$$

Net foreign wealth, B, develops according to:

$$\dot{B} = rB + P_{\mathrm{W}}X_{\mathrm{W}} + O - P_{\mathrm{I}}(D_{\mathrm{I}} + J_{\mathrm{I}}), \tag{3.31}$$

where O is the value of oil and gas exports and J_I is the investment of imported goods, which is given by:

$$J_I = \left(\frac{(1 + t_I)P_I}{P} \right)^{-\sigma_I} \dot{K}.$$

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

$$\lim_{t \to \infty} B e^{-rt} = 0. \tag{3.32}$$

The exogenous variables are: r, P_I, P_W, O and 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.

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