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Is Norway immune to Dutch Disease?
CGE Estimates of Sustainable Wage Growth and De-industrialisation

Abstract:

Norway's petroleum wealth has become considerably more liquid and thereby visible to the public since the mid 1990s. In the policy debate transformation of wealth is often confused with ordinary income. Such a misconception may have contributed to de-industrialisation through real appreciation beyond what is sustainable in a long run perspective. Since re-industrialisation is typically considered difficult, it is important to estimate a norm for sustainable wage growth. In Norway the textbook model of the Small Open Economy (SOE) has often been used for this purpose. We argue that this model neglects important aspects of the Norwegian economy. Instead we use a large scale dynamic CGE-model to estimate sustainable paths for wage growth and the activity in the traded goods sector, especially manufacturing. Under plausible assumptions we find that about 0.5 percent annual reduction of manufacturing employment is sustainable. The real appreciation over the last 7 years has been substantially above a sustainable trend.

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1. Introduction

Norway is probably close to a prototype of a small open economy. Relatively large endowments of some few natural resources, including crude oil, natural gas, fish and hydropower energy, give rise to efficiency gains from specialisation of the traded goods sector according to resource based comparative advantage. Small domestic markets imply gains from trade through exploitation of economies of scale and a broader spectre of differentiated goods. After the findings of large profitable oil and gas fields in the early 1970s, Norway has also benefited from intertemporal specialisation. Access to international capital markets made it possible to finance large investments in the petroleum sector through relatively large current account deficits, without crowding out consumption. On the contrary consumption growth rates surged in the 1970s, which may be interpreted as a jump to higher living standards based on borrowing the expected petroleum resource rents. The fiscal policy rule adopted from 2002 explicitly exploits international capital markets; all Government petroleum revenues is to be invested in foreign assets, with only the real return on accumulated financial assets to be consumed each year.

However, both intra- and intertemporal specialisation involve risks. Small open economies are vulnerable to adverse external shocks that may have dramatic economic consequences. Finland's experience after the collapse of the Soviet Union is one example. In the Norwegian policy debate the unimpressive long run performance of countries rich in natural resources is often put forward to support warnings against making the well being of Norwegians too dependent on resource rents. The possibility that natural resources turn out to be a curse rather than a blessing is examined in e.g. Sachs and Warner (2001). The diagnosis *Dutch Disease* has often been used to describe some of the problematic or potentially problematic characteristics of resource rich countries. The typical pattern of the development of Dutch Disease is that the resource rents generates large proceeds for the state. This is indeed the case in Norway where the state collects most of the petroleum rents. Such a situation often implies a soft public budget constraint, and public services and social welfare programmes are expanded beyond sustainable ambitions. This process involves an *excessive* decline of the traditional traded goods industries, especially manufacturing, through real appreciation.

We stress *excessive*, because qualitatively a reallocation of resources from the traded goods sector into the non-traded goods sector is consistent with the equilibrium response to higher resource rents. As pointed out in e.g. Krugman (1996): Competitiveness may become an obsession, and participants in the public debate often demonstrate that they ignore or do not understand general equilibrium effects

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and the theory of comparative advantage. But, if the economy is ridden by real rigidities, the economy may end up in a disequilibrium in which producers do not find it sufficiently profitable to produce traded goods that should be produced according to comparative advantage.

More specifically, there are at least three reasons why the reallocation in practice may turn out problematic. First, the mobility of resources is limited so that labour and other input factors become unemployed rather than reallocated to the non-traded goods sector, see van Wijnbergen (1984). Second, de-industrialisation and expansion of welfare programmes are processes, which may be hard to reverse once they have gathered momentum. The reasons for such irreversibility are probably not yet fully understood, but myopic behaviour of both individuals and politicians as well as habit formation are likely to be parts of the story. Krugman (1991) and Venables (1996) give precise meaning to the concepts "manufacturing base" and "critical mass" suggesting that there may be activity levels below which further contraction of an industry is difficult to reverse. Third, de-industrialisation reduces dynamic learning by doing effects if these effects are stronger in manufacturing than in other industries, see e.g. Krugman (1987), Matsen and Torvik (2003) and Torvik (2001).

Any debate on the de-industrialisation will benefit from a well founded quantitative answer to the following questions: Do the trends of deterioration of international competitiveness and de-employment in manufacturing industries, reflect a sustainable reallocation of resources based on changes in comparative advantages? Or do they reflect an unsustainable development that should be quickly reversed if one wants to avoid Dutch Disease? Specifically, since the petroleum sector became important in the Norwegian economy during the 1970s, participants in the economic policy debate in Norway have questioned if the de-industrialisation process has gone too far, and if the Norwegian economy might be "infected" by the Dutch Disease that seems to have been the curse of most other resource rich countries. The purpose of this paper is twofold: We discuss and suggest how such questions can best be answered, and we contribute with model based quantitative information that is needed for answering these questions in the Norwegian setting.

In Norway the questions stated above have been motivated by the deterioration of international competitiveness that Norwegian industries have experienced after 1974. Specifically, the growth in wage costs has been higher in Norway than in its trading partners in most of this period. In 2003 the average wage cost of blue-collar employees was estimated to be 30 percent higher than the corresponding average in Norway's trading partners. Including white-collar employees reduces the

difference to about 20 percent.[1] International comparisons of estimated productivity growth do not indicate that the cost effect of the extra wage growth in Norway is offset by a corresponding difference in productivity growth, see e.g. OECD (2003).[2] The number of employees in manufacturing declined by 21 000 or 7.4 percent from 2002 till the end of 2004.

Assessments of norms for wage setting as part of the income policy in Norway, have to a large extent relied on the textbook model of a small open economy (SOE), or the Scandinavian Model of Inflation (SMI). However, we argue in this paper that the SOE and the SMI suffer from several shortcomings, which may produce misleading results. Especially, the static nature of the SOE model cannot take properly into account that the current large revenues from the petroleum sector are temporary. Moreover, by assuming constant returns to scale, the SOE model determines the wage growth independently of the activity level of the traded goods. Much of the export oriented manufacturing in Norway is based on natural resources. This suggests that these industries run into decreasing returns to scale. Econometric evidence supports this hypothesis.

Rather than relying on the simple SOE model, we use a large scale dynamic CGE-model, that does not suffer from the shortcomings that plagues the SOE and the SMI model, to estimate sustainable long run growth paths of the Norwegian economy. Sustainable growth is here defined as a scenario in which the national budget constraint is met, i.e. the national debt does not explode in either direction. We compare our estimates of sustainable growth paths with the observed trends over the last ten years. A significant deviation indicates that continuation of the observed trend is not sustainable. We also examine the consequences of not reversing an unsustainable development.

The paper is organised as follows. Section 2 discusses the SMI as a norm for wage-setting and identifies shortcomings that may make it misleading for such a purpose. In Section 3 we describe the CGE model. In Section 4 we use the model to estimate a sustainable development, focusing on wage growth and the activity ion manufacturing industries. We compare our estimate with the estimates derived from the SMI model used in the Norwegian policy debate. Section 5 checks the sensitivity of the sustainable paths with respect to some key exogenous variables. Section 6 examines the seriousness of the imbalances resulting from a continuation of the wage growth observed in the period 1998 - 2002. Section 7 concludes.

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[1] These estimates are taken from Ministry of Labour and Administration (2004) (NOU 2004:14, Section 5). The estimate including all employees is more uncertain than the estimate that applies to blue-collar employees only.

[2] Specifically the deterioration of cost competitiveness was dramatic in 2001 and 2002, mostly due to nominal appreciation of the NOK.

2. The standard Small Open Economy model as a norm for wage setting

The textbook equilibrium model of a Small Open Economy (SOE) is a natural starting point for an assessment of sustainable wage growth an economy like the Norwegian, which is in fact both small and open. As a matter of fact, the model has also been used for this purpose, recently in what we subsequently will refer to as the Holden-II (H-II) report[3] (Ministry of Finance, 2003) and Bank of Norway (2003) (BN-03). To make the subsequent discussion precise, we set up the SOE-model for an economy with labour as the only primary factor. All product prices and the interest rate are determined exogenously in the world markets. There are constant returns to scale in all production sectors. In a perfect competitive equilibrium the wage rate is determined by

$$(1) \qquad P_T = c\left(\frac{W}{A_L}, \frac{RP_K}{A_K}\right),$$

where P_T is the exogenous world price of Traded (T) goods measured in domestic currency; W is the competitive wage rate, which is equalised over all industries; R is the exogenous international interest rate. We ignore depreciation of capital. P_K is the exogenous price of imported capital goods. RP_K is the cost of capital; A_L and A_K denote, respectively, exogenous labour and capital augmenting technical change in the traded goods sector; $c()$ is the marginal cost function. Provided that (1) holds at any point in time, it implies that the equilibrium wage growth becomes

$$(2) \qquad p_T = \theta_L w + \theta_K (r + p_K) - (\theta_L a_L + \theta_K a_K) \Leftrightarrow w = \frac{p_T + (\theta_L a_L + \theta_K a_K) - \theta_K (r + p_K)}{\theta_L},$$

where lower capital letters denote relative change rates. θ_L and θ_K are the cost shares of labour and capital, respectively. The weighted average of the factor specific productivity change rates has a natural interpretation as total factor productivity (TFP) growth. Assuming that i) prices of capital goods and traded goods grow at the same rate, i.e. $p_T = p_K$; ii) there is no capital augmenting technical change, i.e. $a_K = 0$; iii) the interest rate is constant, i.e. $r = 0$, (2) degenerates to

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[3] The report is issued as NOU 2003: 13. It was written by an expert group was headed by Professor Steinar Holden at the Department of Economics at the University of Oslo. Especially ch. 7.5 uses the SOE-model to discuss and estimate a norm for wage growth.

(3) $w = p_T + a_L$.

(3) is the same solution for wage growth as the one derived in the Scandinavian Model of Inflation (SMI), see e.g. Aukrust (1977) and Rødseth (2000).[4] Aukrust (1977) interprets (3) as a positive model of how the wage growth trend was determined in Norway. According to such a positivistic interpretation the labour market institutions are "responsible" in the sense that they recognize that (1) must hold in order to maintain the external balance of the economy. If (1) holds, there are no profitability problems of scaling the T-sector up or down in order to find the output level consistent with external balance. This justifies the interpretation of (2) or (3) as a *norm* for wage setting in small open economies. More precisely, the wage concept here refers to labour cost per hour, which include the payroll tax.

Specifically, in the design of the income policy in Norway, (3) has been interpreted as the ceiling for the maximum sustainable long-run wage growth.[5] There is, however, a potential danger in using the SMI as a norm for wage setting, since the model neglects the following potential real world mechanisms:

1.   Even if (2) or (3) holds, they do not imply (1). For the rate of return to capital to be at a competitive level in the T-sector, it is not enough that the wage rate grows according to (2) or (3); the wage *level* must also be consistent with the condition for a sustainable equilibrium, see Rødseth (2000).

2.   Rødseth (2000) also notes that changes in the cost share of labour should be taken into account. Since this is a second order effect, it is more relevant the larger are the changes in relative factor prices.

3.   In principle, (1) should be interpreted as the equilibrium outcome of a selection process. In the textbook SOE-model, see e.g. Woodland (1985) the long run equilibrium is characterised by the same number of T-industries as the number of primary non-tradable factors. The active T-industries will be those who can pay the highest remuneration to the owners of the factors. But the outcome of this endogenous selection process may change over time making the long run equilibrium selection T-industries a "moving target". Consequently, it will be hard to identify *the* particular T-sector that should set the norm for wage setting.

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[4] Aukrust obtained (3) directly by assuming a constant cost share of wages in value added in the traded goods sector.

[5] This view is explicitly stated in the expert report on competitiveness, wage setting and the exchange rate published as NOU 2003: 13, especially ch. 7.5. The report is often and hereafter referred to as the Holden-II (H-II) report, since the expert group was headed by Professor Steinar Holden at the Department of Economics at the University of Oslo.

4. This problem is magnified when one takes into account that the observed industry structure in a given year typically represents a temporary equilibrium; some active industries are on an exit path, being unable to pay competitive remuneration of all input factors.

5. The simplicity of the SOE-model rests on the general assumption of constant returns to scale. The working horse models of small open economies introduced in the 1980's highlighted fixed costs and increasing returns to scale as important for the equilibrium industry structure. In Norway, the most export-oriented industries have typically been based on natural resources, such as waterfalls, forests, fish, crude oil and natural gas. Such production processes typically run into decreasing returns to scale.[6] Non-constant returns to scale implies endogenous productivity. For example, decreasing returns implies that a T-industry can stay in business by shutting down the least profitable production units. This makes it difficult to distinguish productivity changes caused by shifts in the production function from productivity changes caused by scale variations. It also adds to the difficulties of identifying which industries that should be included in the wage-setting T-sector.

6. In practice there is no one-to-one correspondence between traded goods and T-sectors. An operational industry classification implies that most industries produce both several traded and non-traded goods, and each traded good is also produced by several industries. A practical "solution" is to let the T-sector include industries primarily producing traded goods. An alternative, or at least complementary guideline, would be to pick traded goods industries according to the volatility of the observed rate of return to capital.[7]

7. The SOE-model usually neglects all inputs but labour. Accounting for inputs of capital goods and intermediaries makes the model much more complex and less transparent, but its solution represents no computational challenge today.

8. The SOE-model is static. With free access to international capital markets, external balance implies that trade is balanced in present value terms, not in each year. Intertemporal specialisation may justify that the actual wage setting in certain periods exceeds the long run growth defined by (2) or (3), as long as the opposite is true in other periods. Thus, definite

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[6] Klette (1999) finds that Norwegian manufacturing industries are characterised by decreasing returns to scale at the plant level. Using evidence from a panel data set for four high-tech, manufacturing industries, covering a 10-year period, Klette and Raknerud (2005) conclude (pp 24, Section 7.1): "Thus, we find clear evidence of diminishing returns to scale." However, Biørn *et al.* find evidence of increasing returns in Norwegian energy intensive manufacturing industries.

[7] Information about the volatility of the operating surplus was used in Aukrust (1977) when he decided which Norwegian industries that should be included in the T-sector. A highly volatile rate of return was takes as indicator of product prices being exogenously determined in the world market. On the other hand, a relatively constant rate of return indicates that the product price is determined by the marginal costs of the domestic industry, which is precisely what characterizes the industries producing non-traded goods in the SMI.

conclusions about the sustainability of the wage growth observed over some few years cannot be justified by comparisons with estimates based on the SOE-model.

9. In the case of Norway intertemporal specialisation is far more than a theoretical possibility. The large revenue from extraction of off-shore crude oil and natural gas is a temporary phenomenon. The static SOE-model is not appropriate for taking into account the windfall gains in terms of trade implied by the findings of such valuable natural resources.

For the reasons listed above, we claim that estimates of the scope for long run wage growth may be seriously misleading if based on the simple SOE-model or the even simpler SMI-model. Our alternative is to estimate the sustainable long run wage growth by employing a much richer CGE-model that does not suffer from the shortcomings listed above. We will support our claim by a comparison of estimates of sustainable wage growth in Section 4.

3. A dynamic disaggregated CGE-model of the Norwegian economy

General features

In MSG6[8], as in the SOE-model, world prices are exogenous, and the exchange rate is fixed since it is a purely nominal phenomenon in the model. All agents have unlimited access to international financial markets, where they face an exogenous nominal rate of interest. Goods and services, including those from labour and capital, are perfectly mobile across industries. Supply equals demand in all markets in all periods. Consequently, aggregate consumption will basically be determined from the supply side, i.e. by the growth in exogenous endowments, including the labour force and profitable reserves of oil and gas, and by industry specific growth rates of total factor productivity (TFP). In addition, aggregate consumption is constrained by an intertemporal budget constraint formulated as a non-Ponzi game condition on the accumulation of net foreign debt. When this constraint is met, we define the economic development as *sustainable* or *balanced*. This budget constraint is met by flexible adjustment of a sufficiently large production of traded goods - *over time*. Thus, we use MSG6 to determine a sustainable path of the wage rate level, cf. point 1 in the previous section. Contrary to the static SMI, the intertemporal constraint on foreign debt allows specialisation in time with respect to production of traded goods, cf. point 8 in the previous section. The macroeconomic structure of MSG6

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[8] MSG is an abbreviation for Multi Sectoral Growth. MSG6 is the sixth generation of this model. It differs substantially from its predecessors.

is described formally in Appendix 1. For a more complete overview of MSG6 and its empirical properties, see Heide, Holmøy, Lerskau and Solli (2004).

MSG-6 specifies 32 private business industries, 7 government sectors and 60 commodities. 9 commodities are supplied by imports, only. The classification is conducted to obtain homogeneity within aggregates with respect to the actual design of trade- and industry policies, as well as to production and demand functions. The Norwegian National Accounts (NA) is the main data source for the model. Even with such a rather disaggregated classification of industries and commodities most industries produce tradables, and most tradables are produced in several industries. The multi output production structure makes the "T-sector" concept superfluous, cf. point 6 in the previous section. An industry will be more vulnerable to a rise in costs the higher are the output shares of exported products, and the more exposed the outputs are to import competition.

The representative household decides on labour supply, aggregate private consumption and the composition of private consumption by maximizing utility as a price taker subject to its budget constraint. Government consumption and the real value of transfers, including pension benefits, are exogenous. Taxes and other Government revenues are described in relatively great detail. The fiscal policy is assumed to follow the policy guideline introduced in 2002. This guideline allows a deficit on the budget net of the petroleum revenue equal to the real return on the capital in the Government Petroleum Fund, in which the petroleum revenues is invested. The exogenous time paths of the petroleum revenues and the real rate of return on the Fund determine directly the time path of the public budget surplus. This public budget constraint is satisfied by endogenous pay-as-you-go adjustments of the payroll tax rate.

Imports

Imports of manufactures and services are considered as close but imperfect substitutes for the corresponding differentiated products produced domestically. It follows from this Armington hypothesis that the import shares of these tradables depend negatively on the ratio of the import price to the price index of domestic deliveries. The import price includes tariffs and the price effect of various non-tariff barriers. The elasticities of substitution have been set in accordance with the stationary time series estimates reported in Naug (1994). Commodities produced by mainly by primary industries (*Agriculture, Forestry* and *Fishery*, *Crude Oil, Natural Gas* and *Electricity*) are considered to be homogenous by both Norwegian and foreign consumers. The domestic prices of these commodities are equal to the corresponding world prices of imports. The model determines *net* imports of these tradables.

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Market Structure, Producer Behaviour and Exports[9]

The model of producer behaviour in MSG6 is much richer than in the SMI. All firms in the private business sector are run by managers with perfect foresight, who maximise present after tax value of the cash flow to owners. The private profitability is affected by the system of capital income taxation, the payroll tax, taxes on other input factors and various commercial policy instruments. MSG-6 distinguishes between the behaviour of the individual firms and the aggregate industry behaviour. Output and input in an industry can change both because of changes at the firm level and as a result of entry or exit of firms. Firms within the same industry differ with respect to productivity. Entry (exit) takes place in an industry if the variable after-tax profit increases (decreases) relatively to the net fixed cost associated with entry.

Producers of manufactures and tradable services allocate their output between the domestic and the foreign market, which are segregated. It is costly to change the output composition between these markets.[10] Domestic firms take prices as given in the export markets. On the other hand, they participate in Large Group Monopolistic Competition (LGMC) in the domestic markets of manufactures and services. Bowitz and Cappelen (1994) find empirical support for these (common) assumptions about the market structure facing Norwegian firms in the export and the domestic markets. The mark-up ratios between the output price and marginal costs are less than 5 percent, which is consistent with the estimates in Klette (1999).

Firms are price takers when they combine labour, 3 types of fixed capital and 8 composites of intermediate inputs. Most of the elasticities of substitution between input factors have been set in accordance with estimates presented in Alfsen, Bye and Holmøy (1996, Ch. 3). Contrary to the SOE, the production functions for the firms in all private industries exhibit decreasing returns to scale, cf. point 4 and 5 in the previous section. The scale elasticities range from 0.85 - 1.00. Evidence of decreasing returns to scale at the firm level is presented in Klette (1999)[11]. The endogenous selection of profitable firms also contributes to decreasing returns to scale at the industry level.

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[9] Holmøy and Hægeland (1997) provide a detailed analysis of the production model in MSG-6. Below we summarise the features most relevant for our projections.

[10] This aspect of the technology is captured by a Constant-Elasticity-of-Transformation function of deliveries to the export market and deliveries to the domestic market.

[11] Compared to the estimates in Klette (1999), the scale elasticities in MSG-6 are negatively biased. This bias was accepted in order to avoid unrealistic specialisation patterns within the export oriented industries.

Intertemporal closure rule

We have designed the simulation experiment in order to answer the following question: What is the rate of wage growth consistent with the national intertemporal budget constraint, given our assumptions? We answer this question by letting *the growth rate of the producer real wage rate facing exporting firms be constant but endogenous over the simulation period*, so that the present value of net imports equals the value of initial net foreign assets. This intertemporal closure rule reflects that the exogenous prices of exports grow at constant rates. It represents a dynamic analogy to the (sequential) solution for the wage rate in the static SMI.

4. A CGE estimate of sustainable wage growth

4.1. Key exogenous assumptions and macroeconomic growth patterns

The following exogenous assumptions are most significant with respect to the wage growth. (All growth rates are *per annum* if nothing else is stated.)

- Based on historical trends *Total Factor Productivity (TFP)* grows by 1.3 percent.[12]

- Except for crude oil and natural gas, international prices, measured in NOK, grow by 1.5 per cent.

- The nominal interest rate is 5.5 percent throughout the simulation period.[13]

- We adopt the projections of future petroleum revenues reported in Ministry of Finance (2001), according to which the net cash flow measured in current prices, declines from 170 billion NOK in 2002 to 110 billion NOK in 2050. Export of crude oil declines at an annual rate of 4.4 percent to 2010 in value terms. Thereafter the percentage annual decline will be approximately 5.4 per cent. Export of natural gas is projected to increase by an annual rate of 6.8 per cent to 2010 and thereafter to stabilise.

- The demographic development is based on the middle alternative in the population projections presented in Statistics Norway (1999). The labour force increases by 11 percent, from 2.7 millions in 1999 to about 3.0 millions in 2050. The old-age dependency ratio (those 67 and older relative to those of working age 20-66) is expected to increase from 22 percent to about

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[12] Taking decreasing returns to scale into account, the TFP residual grows by approximately 1 percent when computed by the standard formula, which assumes constant returns. In government sectors labour productivity grows by 0.5 per cent per year, which is the standard assumption in the Norwegian National Accounts.

[13] Combined with the 1.5 percent growth in international prices, this assumption implies a real interest rate of 4 percent in terms of international purchasing power. This is in line with what has been assumed in the current fiscal policy guidelines, and with American interest rates in the second half of the 1990's.

36 percent in 2050. The number of all kinds of pensioners increases by 57.8 percent from 2002 to 2050. The number of old-age pensioners grows by 78.7 percent over the same period.

- We have made the rather cautious assumption that no changes take place in standards and coverage ratios of Public services beyond already approved reforms. A plausible interpretation of our scenario is that the growth in private consumption per capita involves privatisation of services traditionally provided by the government sector in Norway. Ageing alone implies an annual growth in government employment of 0.6 percent from 2002 to 2020, 1.1 percent in 2021-2030 and 0.8 percent in 2031-2040. Thereafter government employment grows by 0.3 percent per year.

- The total number of pensioners increases by 57.8 percent from 2002 to 2050. *Ex ante* indexation, the average old-age public pension benefit is projected to increase by about 20 percent from 1999 to 2050. On top of this comes wage indexation of the benefits.[14]

Table 4.1 summarizes the growth picture in our baseline scenario. Growth in the labour force and TFP results in an average annual GDP growth of 1.7 percent over the period 2002-2050. The GDP effect of TFP growth is both direct and indirect through endogenous capital deepening. The sustainable growth in private consumption per capita averages 2.5 percent. The projected growth is moderate compared to historical trends for the following main reasons: 1) The strong contribution from the petroleum sector to the aggregate growth over the last three decades will not continue; 2) the increase in labour force is moderate; 3) an increasing share of the labour force becomes employed in the government sector, especially in health and social care, in which productivity growth is significantly lower than in the private business sectors. The growth rate of private consumption declines over time because ageing raises government consumption related to health and social care, see Figure 4.2.

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[14] The public pension expenditures have been projected by simulations on a detailed dynamic micro simulation model, documented in Fredriksen (1998).

Table 4.1. Macroeconomic development in the baseline scenario and 1990-2002. Average annual growth rates in percent

	1990-2002	2002 level (bill.)	2002-2020	2021-2050
Man hours	0.5	3116.5	0,3	0,0
Fixed capital	1.6	3553.4	1,8	1,6
GDP	3.4	1512.3	1,8	1,6
Off-shore industries	5.4	377.4	-3,0	-0,9
Mainland industries	2.9	984.5	2,4	1,7
Government sectors	2.2	219.3	0,9	1,1
Manufacturing	1.4	144.1	2,9	1,6
Other mainland industries	3.5	621.0	2,6	1,9
Net disposable real income	4.5	1241.6	2,0	1,8
Exports	4.7	709.9	0,6	0,9
Exports excl. petroleum	3.6	386.7	2,2	1,1
Imports	4.0	442.5	2,1	1,7
Private consumption	3.1	663.2	3,0	2,1
Government consumption	3.3	301.5	0,7	1,0
Gross fixed investment	2.4	252.6	1,5	1,3
Labour cost per hour/export price, manufacturing	4.2		2,7	2,7
Consumer real wage rate	2.1[1]		3,2	1,8

[1] Wage per standardized man year.

4.2. Wage growth and industry structure in a sustainable growth scenario[15]

Wage growth

We find that there is room for a sustainable constant growth rate of the nominal wage cost per hour equal to 4.2 percent. As world prices grow by 1.5 percent annually, the producer real wage cost in a completely export oriented firm grows at a rate of 2.7 percent. Over time the growth rate for this real wage concept deviates significantly from the growth rate for the consumer wage rate. The latter declines over time from 2.9 percent until 2020, to 1.8 - 1.9 percent in the subsequent three decades. The decline in the consumer real wage rate is foremost due to the gradual increase in the payroll tax, which is required to meet the public budget constraint on a pay-as-you-go basis as ageing makes

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[15] In an accompanying paper, Heide and Holmøy (2005), we provide a more detailed description of the sustainable reference scenario, as well as sustainable scenarios based on alternative exogenous assumptions about key variables and different intertemporal closure rules.

government expenditures grow faster than the tax bases after 2020. The growth in wage costs is basically determined by the international competitiveness consistent with the foreign debt constraint. A rise in the payroll tax is therefore almost completely paid by wage earners. In 2050 the payroll tax is about 25 percent, i.e. nearly twice as high as the present average rate of 13 percent. On the other hand, the payroll tax can be lower than the present level until about 2015. Another reason for the declining growth in the consumer real wage rate is the gradual increase in the budget share of labour intensive goods, especially services. The prices of labour intensive goods grow faster than other prices due the real wage growth.

The essential general equilibrium mechanisms in the determination of the stationary growth in the real wage cost and the long run level of private consumption can be explained by using Figure 3.1, which depicts a reduced form of MSG6. The LL- and the BB-locus describe combinations of the real wage cost growth rate and private consumption that are consistent with, respectively, labour market equilibrium and the budget constraint for the total economy implied by the external balance requirement. The point where the two loci intersect represents the stationary general equilibrium.

The LL-locus is upward sloping because a partial increase in the utility level causes households to decrease labour supply and increase consumption of goods, both contributing to excess demand for labour. Increasing the wage rate, by a more rapid wage growth, restores labour market equilibrium because: 1) Labour supply increases because the substitution effect dominates the income effect. 2) Firms substitute labour for other factors of production. 3) The aggregate production structure becomes less labour intensive due to a Rybczynski effect: The surge in the unit cost functions depends positively on the cost shares of labour. Higher costs deteriorate the international competitiveness of Norwegian producers. In particular export supplies are sensitive to higher costs. The result is a negative scale effect on labour demand. In addition, households will face an increase in the relative price of the most labour intensive products, and substitution effects contribute to a reallocation of resources from the most labour intensive to less labour intensive industries.

The BB-locus is downward sloping because a partial increase in the utility level implies that households increase their consumption, including imported goods, so that the current account surplus falls. A fall in the wage rate, resulting from a fall in the growth in the wage rate, restores the external balance through export expansion, substitution of domestic deliveries for imports, and substitution of leisure for consumption.

The movement from A to B in Figure 4.1 illustrates the equilibrium adjustment of private consumption and the real wage cost per hour to an exogenous increase in the labour force. First, recall that changes in supplies of primary factors have no effect on factor prices in the SOE-model, as long as the conditions for the Rybczynski theorem holds, since reallocation of resources in favour of the most labour intensive industries absorbes the increase in employment.[16] In MSG6 an increase in labour supply shifts the LL-locus from LL_0 to LL_1, since the wage rate must fall in order to raise labour demand for a given level private consumption. The BB-locus is unaffected by changes in labour supply. Thus, the new equilibrium (B) is characterised by higher private consumption and a lower wage cost per hour compared to the initial one (A). Rybczynski effects are at work in MSG6, but they are modified by the changes in large labour intensive non-traded goods sectors and by decreasing returns to scale. In result, the labour supply expansion is not completely absorbed through a reallocation of resources in favour of the most labour intensive industries. Decreasing returns to scale necessitates a reduction of the wage costs, which induces firms to choose more labour intensive input combinations.

Figure 4.1. Equilibrium adjustments of the consumption level and the growth in the real wage cost caused by an exogenous increase in the labour force and TFP in MSG6

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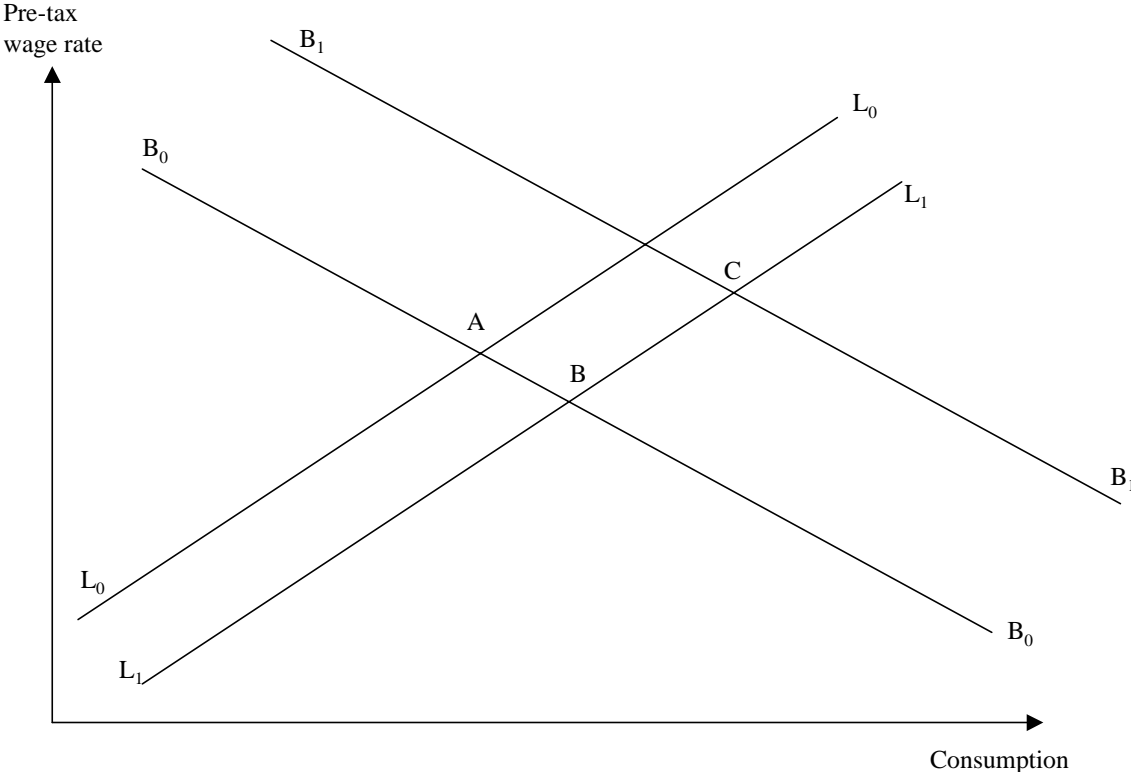
[16] The precise conditions that make factor prices independent of changes in factor endowments are rigorously explained in e.g. Woodland (1985).

Whereas the increase in the labour force highlights the qualitative difference between the SOE- model and MSG6 with respect to the determination of the wage rate, TFP growth is the dominant determinant of the real wage growth in our sustainable scenario. An increase in TFP implies a downward shift in the LL-locus, such as from L_0L_0 to L_1L_1, whereas the BB-locus shifts outwards from B_0B_0 to B_1B_1. In result the increase in TFP changes private consumption and the real wage cost per hour from A to C in Figure 4.1. The shift in the LL-locus can be explained as follows: At a given consumption level and wage cost higher TFP has a direct negative effect on labour demand. This effect is reinforced by the factor substitution within industries, since the prices of produced inputs decrease relative to the wage cost. In addition, Rybczynski effects further strengthen the increase in the aggregate capital-labour ratio. Labour supply increases as the decrease in costs is shifted to lower domestic prices, which increases the consumer real wage rate. In order to restore labour market equilibrium consumption must increase and/or the wage cost must fall. The shift in the BB-locus can be explained as follows: At a given consumption level and wage cost higher TFP implies a positive shift in the export supply functions. Moreover, the decrease in domestic prices reduces import shares in domestic demand. The external balance can be restored by an increase in the wage rate and/or an increase in consumption. The combined effect of the shifts in the loci has an unambiguous positive effect on consumption. The wage rate will also increase. The basic reason is that the wage effect on the external balance is much stronger than the wage effect on labour demand.

Note that although the real producer wage rate must fall, the consumer real wage may increase if direct taxes on labour income or indirect taxes on consumption are used to endogenously restore the government budget constraint. The reason is that the surge in employment, other inputs, sectoral outputs and demand expands most direct and indirect tax bases. The net budget effect of the reduction of the wage rate is less important since both tax bases and government consumption are negatively affected.

As in the SOE model the wage cost determined in MSG6 will reflect the producer value of the marginal productivity of labour. However, whereas the marginal productivity of labour equals the exogenous average labour productivity in the SOE model, labour productivity is endogenously determined by several complex mechanisms in MSG6. This is reflected by the disparity of the labour productivity growth rates between industries, and by the changes over time in these growth rates. For the aggregate Mainland Business sector the average annual growth rate of value added per man-hour declines steadily from 2.4 percent in the period 2002-2010 to 1.8 percent in the period 2040-2050, see Table 4.2. Endogenous capital deepening is the main reason why labour productivity growth exceeds

the 1.3 percent annual TFP-growth. Capital deepening results from optimal adjustment to the growth in wages relative to the prices of imported and produced inputs at the firm level. The increase in the aggregate capital-labour ratio also reflects a reallocation of resources in favour of the relatively most capital intensive industries.[17]

The slowdown of the aggregate labour productivity growth is foremost due to the reallocation of labour and other resources from primary and the manufacturing industries, especially the most export oriented ones, into private services. This reallocation reduces, *cet. par*, aggregate labour productivity for two reasons. First, export oriented manufacturing industries are more capital intensive, and the average labour productivity is therefore higher in absolute terms compared to other industries. Second, the labour shares constituting the weights in the average labour productivity growth rate shift in favour of the private services, in which labour productivity grows more slowly than in the primary and the manufacturing industries, see Table 4.2.

Table 4.2. Labour productivity growth in the sustainable scenario. Average growth rates in value added per man-year. Percent

	2002-2020	2021-2050
Private Mainland Business Sector	2,3	2,1
Primary industries	3,2	2,9
Manufacturing	2,9	2,7
Export oriented manufacturing	2,9	2.9
Import competing manufacturing	2,6	2,3
Private services	1,7	1,7

Even within the traded goods sector labour productivity growth differs between industries despite a uniform TFP-growth. Value added per man-hour is highest in the export oriented manufacturing (Metals, Machinery, Pulp and paper, Chemical raw materials). In these industries labour productivity growth is close to 3.0 percent in all years, which equals the BN-03 assumption of future labour productivity growth in the traded goods sector as a whole. In manufacturing industries that sell most of their output in the domestic market (import competing manufacturing), growth in labour productivity declines steadily from 2.9 percent prior to 2010 to 2.1 percent in 2050, which is slightly above the H-II estimate for the traded goods sector as a whole. The disproportionate labour productivity growth within manufacturing reflects a more rapid growth in the capital-labour ratio in the export oriented

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[17] Specifically, the above average growth in Dwellings contributes positively to the increase in the aggregate capital-labour ratio.

industries than in other manufacturing industries. Moreover, a given increase in the capital-labour ratio raises labour productivity more the higher is the cost share of capital. Recall that the capital intensity is higher in the export oriented industries than in other manufacturing industries.

Based on the 1.5 percent growth in world prices and the simulated 3.0 percent growth in labour productivity in the export-oriented industries, the SMI model predicts a sustainable growth in wage costs equal 4.5 percent (cf. equation (3) above). The corresponding MSG6 estimate is slightly lower, 4.2 percent. The deviation is due to revenues from sales in the domestic market, and other costs than wage costs. Specifically, our MSG6 calculation captures that the prices of capital goods and intermediates grow, which contributes to reduce to reduce the room for wage growth. However, in our simulation this cost effect is offset by growth in the output prices obtained in the domestic market.

However, the small difference between the two estimates should not be used to conclude that the simple wage growth formula from the SMI provides a good approximation of the much more complex solution computed in MSG6. The small difference between the estimates is a result of different mechanisms, and it is a coincidence rather than an autonomous rule that these effects offset each other. The crucial variable is the labour productivity growth. Though undeniably hard to predict, TFP-growth is a more fundamental productivity concept than labour productivity growth. By being a "measure of ignorance" it reflects by definition output growth that cannot be accounted for by growth in inputs. As explained above, our CGE model captures a large number of endogenous effects on labour productivity.

The Norwegian policy debate demonstrates both the importance of, as well as the uncertainty about, the labour productivity growth assessment. Within the SMI model the Holden-II report and Bank of Norway (2003) (BN-03) discussed the norm for sustainable wage growth. Based on historical trends, the Holden-II report uses 2 percent growth in labour productivity in the Norwegian traded goods sector as the most plausible point estimate. BN-03 uses 3 percent as the most plausible estimate, which equals our MSG6 estimate of labour productivity growth in the traded goods sector. However, the basis for the BN-03 estimate is qualitatively unrelated to the endogenous mechanisms working in MSG6. Rather than being built up from an assumption on TFP-growth, capital deepening etc., the BN-03 estimate rests on the assumption that future labour productivity growth in the traded goods sector in Norway will be equal to the corresponding growth trend in Norway's trading partners over the last 20 years.

Industry structure: Is further reductions in manufacturing employment sustainable?

The relatively strong projected productivity performance in manufacturing industries makes it possible to reduce employment in this sector without violating the sustainability constraint on foreign debt. On average the number of employees in manufacturing can be reduced by 0.5 percent every year, see Figure 4.2. This corresponds to a reduction in the number of employees from approximately 300 000 in 2002 to 230 000 in 2050. Due to decreasing returns to scale at both the firm level and the industry level in MSG6 the reduction in employment has contributed to the productivity growth in the manufacturing industries. Table 4.3 shows the historical and the projected sustainable development in employment in main industry categories. The strongest contraction will take place in the most export oriented and most labour intensive industries. The supply of exports is more elastic with respect to the producer wage rate than supplies to the home-market, since world prices are exogenously given, whereas the prices of domestic deliveries result from mark-up pricing.

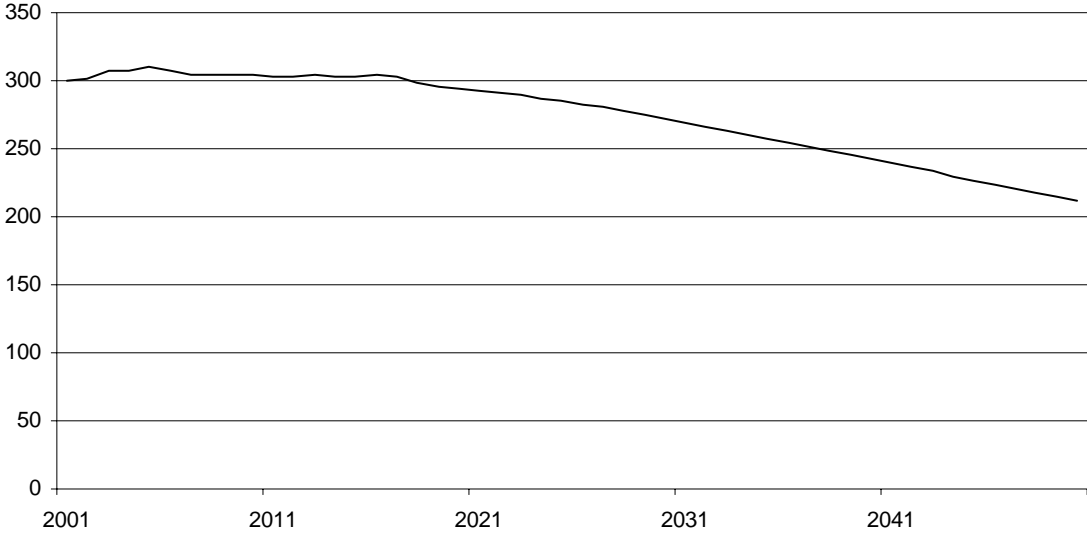**Figure 4.2. Employment in the manufacturing industry. Thousand persons**

Table 4.3. Employment by industry in the sustainable scenario. Average annual growth rates. Percent

	1990-2002	2002-level (1000s)	2002-2020	2021-2050
Total	1.0	2322	0,3	0,0
Government sector	2.0	731	0,4	0,6
Private business sector	0.6	1591	0,3	-0,3
Manufacturing	-0.1	297	0,0	-1,0
Primary industries	-3,1	86	-2,0	-2,0
Private services	1.7	848	0,3	-0,2

Intertemporal trade and accumulation of financial assets

The simulation results show that the intertemporal external balance constraint is met by an extensive use of international capital markets as the path of exports deviates quite markedly from the path of imports, see Figure 4.3. The volume of imports grows more slowly than private consumption, but the growth rate follows the same u-shaped development as private consumption and GDP; it is about 2,2 percent in the period 2000-2020, 1.6 percent 2021-2040 and 2.1 percent after 2040. On the other hand, the growth rate of the volume of non-petroleum exports is steadily declining, from about 1.9 percent until 2020 to 0.9 percent in the period 2041-2050. Thus, Norway follows a funding strategy in the sustainable scenario; over the first three decades Norway accumulates financial assets, see Figure 4.4. In the first 20 years, extraction and exports of oil contributes strongly to the current account surpluses. Over time an increasing share of imports is financed by interest on the net foreign wealth.

Figure 4.3. Private Consumption, 2002 =1, and Net Foreign Assets relative to GDP in the sustainable scenario

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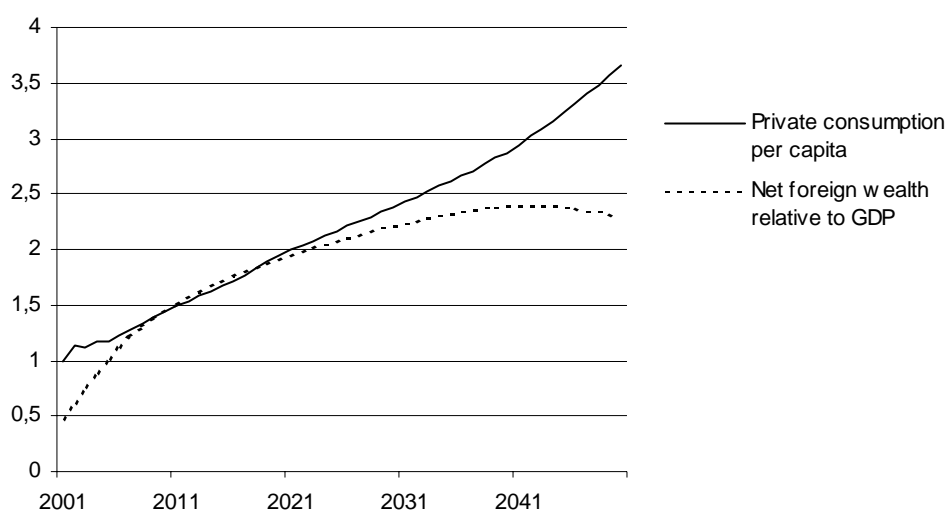
Three forces mitigate the growth in imports, and thereby also the necessary growth in manufacturing industries. First, a substantial part of the imports is intermediate inputs and capital goods used in domestic production sectors. Both demand components grow significantly slower than private consumption. Second, the composition of private consumption changes in favour of goods with import shares below the average. Relatively high income elasticities for services contribute to this effect. Third, the scenario is by construction sustainable, and this is ensured by the endogenous adjustment of the growth rate of wages. This means that endogenous import shares are lower compared to a scenario in which labour costs and domestic prices grow at a higher rate than in our sustainable scenario. Non-petroleum exports consist mainly of manufactures. Production in manufacturing grows at a higher rate than exports, which implies that manufacturing industries to an increasing extent compete against foreign firms in the home-market.

5. Sensitivity analysis[18]

We have examined how robust our estimates of the sustainable real wage growth and reduction in manufacturing employment are to i) an increase in the growth rate of TFP from 1.3 to 1.6 percent in private business industries; ii) an increase in the interest rate from 5.5 to 6.5 percent; iii) a 20 percent increase in the world prices of crude oil and natural gas. These are exogenous variables being both highly uncertain and presumably of great importance for our estimates. The shifts are permanent and implemented from 2007. In the following we will refer to the sustainable scenario described in the previous section as the reference scenario. Table 5.1 summarizes the results from the sensitivity analysis.

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[18] See Heide and Holmøy (2005) for further details on the scenarios presented in this section.

Table 5.1. Equilibrium adjustments to alternative assumptions on TFP growth, interest rate, petroleum prices and demographic development. Percentage deviations from the reference scenario

	TFP		Interest rate		Petroleum prices	
	2015	2050	2015	2050	2015	2050
Private consumption	0.1	19.2	1.2	5.4	-0.7	1.6
Exports	7.7	17.5	-1.7	-10.4	-1.1	-5.8
Imports	1.2	13.6	0.6	5.7	-1.6	-1.2
GDP	3.9	16.6	0.3	0.3	0.7	0.3
Manufacturing ind.	10.0	24.9	-1.3	9.1	0.0	-3.5
Total employment	0.0	0.0	0.0	0.0	0.0	0.0
Manufacturing ind.	5.1	1.4	-1.9	-11.6	0.1	-3.0
Fixed capital	4,5	7,2	0,8	-0,1	3,7	1,9
Wage cost/export price	3.5	20.5	1.2	6.6	0.2	0.9
Payroll tax, perc. points	0,8	-1,1	-3,5	-5,1	-0,6	-2,1
Consumer real wage rate	6.3	21.9	3.9	5.5	2.6	2.1

TFP-growth

Over time the cumulative effect of raising the annual TFP-growth rate in private business sectors from 1.3 to 1.6 percent is an accelerating expansion of production and consumption possibilities. In 2050 private consumption and GDP are, respectively 19.2 and 16.6 percent higher than in the reference scenario. The induced growth effects are both direct and indirect through capital deepening. The annual growth rate of the sustainable real wage cost can increase by 0.6 percentage points. In 2050 the ratio of wage cost to the export price and the consumer real wage rate can be, respectively, 20.5 and 21.9 percent higher than in the reference scenario. The main mechanisms of the determination of the equilibrium adjustments of the real wage rate and consumption were explained in connection with Figure 4.1 above. The higher real wage growth increases government expenditures on consumption and wage indexed pensions and other transfers. However, this effect on the fiscal surplus is roughly offset by the growth in tax bases. The necessary pay-as-you-go adjustments of the payroll tax are therefore small.

Growth in income raises demand for imports, and long run sustainability requires that exports also must also rise. Basically, the additional export is produced in manufacturing industries. In 2050 value added in manufacturing industries must be 24.9 percent higher than in the reference scenario. Due to stronger productivity growth, manufacturing employment increases by only 1.4 percent in 2050.

Interest rate

The international interest rate is important since Norway, mainly the central government, has accumulated, and will continue to accumulate foreign assets as the petroleum wealth is converted to financial assets through the fiscal policy rule. Increasing the interest on these assets from 5.5 to 6.5 percent raises national income, and the economy can afford some loss in the international competitiveness. The annual growth in the sustainable real wage cost can increase by 0.15 percentage points from the reference scenario. In 2050 the real wage cost is 6.6 percent above the corresponding reference level. The corresponding increase in private consumption is 5.4 percent. The percentage contraction of exports and output from the manufacturing industries is substantial. Factor substitution makes the reduction in employment somewhat stronger than the output reduction.

Petroleum prices

This experiment is partial in the sense that we do not take into account that a 20 percent rise in the prices of crude oil and natural gas is likely to affect the world economy and increase the prices of Norwegian exports and imports of other tradables. Moreover, we neglect that a permanent increase in petroleum prices is likely to have a positive effect on the number of profitable oil and gas fields and the activity in the petroleum sector. As Norway is a net exporter of petroleum products, the shift implies a terms-of-trade gain. However, the effects are not very strong, reflecting that the petroleum wealth, measured by the permanent income constitutes only about 6 percent of the national income. Moreover, the price shift takes place from 2007, and a large share of the profitable oil reserves has been depleted by then.

Qualitatively, the effects following from the income effect is in many respects similar to the ones that follow from an increase in the interest rate explained above. However, there are some differences. Although the terms-of-trade gain allows for a loss in international competitiveness, there is almost no room for increasing the sustainable growth rate of the real wage cost compared to the reference scenario. The reason is that the increase in the price of petroleum products raises costs depending on the cost share of these inputs. Since the government collects most of the revenue from the petroleum sector, there is, however, room for a reduction of the pay-roll tax rate. This reduction accounts for most of the increase in the consumer real wage rate.

6. Are the observed trends for wage growth and manufacturing employment sustainable?

The observed de-industrialization in Norway, as well as the public debate on this issue calls for an answer to the following questions: Are the observed trends for real wage growth and manufacturing employment symptoms of Dutch Disease? Or do they reflect a sustainable reallocation of resources that is an integral part of economic growth and adjustments to the terms-of-trade gain implied by the petroleum wealth?

The relevant aspects of the observed trends in international competitiveness and performance of the manufacturing industries are summarised in Appendix 2. A comparison with the reference path described in Section 4 reveals that over the period 1994 - 2003 the annual wage growth in Norwegian manufacturing averaged 5.0 percent. Until 1998, the 1990s was characterised by a macroeconomic policy agreement, in which moderate wage growth played an important role. This policy broke down in 1998. In the years 1998 - 2002 the annual wage growth varied close to 6.0 percent, exceeding our estimate of the sustainable wage growth rate by 1.8 percentage points.[19] In 2003 the wage growth dropped to 4.2 percent. Moreover, the decline in manufacturing employment has been much more rapid over the last years than the sustainable rate of reduction. Employment in manufacturing fell by, respectively, 2.4, 1.4 and 1.1 percent in the years 2000, 2001 and 2002. 2003 has witnessed an even sharper reduction in employment in export oriented manufacturing industries. Trends calculated as extrapolations from these observations are far from sustainable with respect to the long run external balance.[20]

How serious are the imbalances that result from a continuation of the observed wage growth? We shed quantitative light on this question by simulating a scenario in which the closure rule of the model is altered: labour cost is now exogenous and the intertemporal restriction on foreign debt is removed. The annual growth rate of the nominal labour cost per hour is set exogenously to 6.0 percent, i.e. 1.8 percentage points higher than the sustainable growth rate in the reference scenario. A 6.0 percent wage growth represents the wage growth observed in the period 1998 - 2002. The results are shown in the Figures 4.2 and 4.3 above, and in Table 6.1.

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[19] The appreciation of NOK in 2001 and 2002 reinforced the sharp deterioration of the international competitiveness. However, the exchange rate fluctuates under the present monetary policy regime, and depreciated to the 1996-level during 2003.

[20] Our simulations do not account for the sharp deterioration of international competitiveness in 2001 and 2002. This implies a positive bias in our estimate of the future sustainable growth in the real wage costs.

Table 6.1. Macroeconomic effects of a growth in the real wage cost exceeding the sustainable growth rate by 1.8 percentage points. Percentage deviations from the reference scenario

	2010	2030	2050
Private consumption	18,6	45,1	91,9
Exports	-21,3	-45,9	-51,2
Imports	16,6	61,5	141,3
GDP	3,5	4,1	-2,3
Manufacturing industries	-17,8	-44,9	-59,5
Manufacturing employment	-26,4	-54,1	-66,8
Labour cost per hour/export price	10,4	49,2	146,4
Consumer real wage rate	12,4	43,6	84,8
Net foreign debt	-59,6	-190,5	-331,0

The results show that some imbalances grow at an exploding pace after quite few years. In 2010 labour costs are more than 26 percent above our reference scenario. Net imports increases quickly, and private households accumulate an exploding debt. Norway's total financial claims on foreigners will be run down in about 15 years. In order to maintain full employment, the non-traded goods sector absorbs the workers that are fired in the traded goods sector. In particular, resources are moved from the export-oriented industries. Due the rise in debt financed net imports, private consumption grows much faster in this scenario than in the reference scenario.

This scenario is obviously not a realistic one. Sooner or later a broad consensus of crisis will trigger some kind of reversal of the unsustainable development. However, "turning Norway around" will probably be painful. Thus, continuation of recent loss of international competitiveness results in an unsustainable scenario that clearly qualifies for the Dutch Disease diagnosis. The main lesson to learn from this scenario is that even a quite moderate excessive growth in the real wage cost is enough to erode the very favourable financial situation of the Norwegian economy in surprisingly few years. The current revenues from the petroleum sector may give rise to overly optimistic opinions in the public of how large the petroleum wealth really is.

7. Conclusions

We have employed a large scale dynamic CGE-model to assess a norm for sustainable real wage growth in the small, open and petroleum rich Norwegian economy. Assessments of such a norm has been at the heart of the Norwegian economic policy discussions for decades. The findings of large

profitable oil and gas resources have stimulated these discussions, because of the danger that the natural resources may turn out to be a curse rather than a blessing. The rapid de-industrialisation of the Norwegian economy over the recent years has led many observers to question the long run sustainability of the current development. Is the loss of international competitiveness a symptom of Dutch Disease? Or is the loss of jobs in manufacturing industries an integral part of a sustainable growth path in which the observed reallocations are efficient responses to income growth, changes in relative prices, new comparative advantages, as well as a result of exploitation of open capital markets?

The simple SMI model has played an important role for setting the norm for the negotiations on wage setting in Norway. We have pointed out that the SMI model suffers from several weaknesses for this purpose. Among other things, our CGE approach takes into account that labour productivity is endogenous, and that the relevant external balance requirement should be formulated as an intertemporal national budget constraint. Recognising the intertemporal nature of the external balance constraint is particularly relevant for Norway because of the temporary nature of net exports of crude oil and natural gas.

Our simulations justify the following conclusions:
- Contingent on a 1.5 percent annual growth in international prices measured in NOK, 1.3 percent growth in TFP in private industries, and the same assessments of the petroleum revenues as in the Government's Long Term Programme 2002-2005, we find that there is room for a constant 4.2 percent annual growth in nominal labour costs.
- There is room for a moderate but steady reduction in the employment in manufacturing and other traded goods sectors in a long run perspective. Without violating the national budget constraint related to foreign debt, manufacturing employment could be reduced by about 0.5 percent per year.
- The sustainable scenario commands that not only the government but also private households, accumulate foreign assets. Over time an increasing share of imports is financed by interest on foreign assets rather than current exports.
- Our CGE estimate of the sustainable growth in the real wage cost is close to the estimate in BN-03 derived from the SOE model. However, this should be interpreted as a coincidence. It reflects that BN-03 exogenously assumes that labour productivity growth in the traded goods sector grows by 3 percent, which happens to be about the same as the corresponding growth derived in our sustainable reference scenario as a result of complex endogenous mechanisms.

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Other observers have considered 3 percent growth in labour productivity in the traded goods sector to be unrealistically high. For example, the H-II report finds 2 percent to be a more plausible estimate.

- The real appreciation and reduction of the manufacturing sector experienced in the period 1998 - 2003 deviates substantially from the development in the sustainable scenario. The observed growth in the producer real wage cost has exceeded the sustainable growth rate by 1.5 - 2.0 percentage points. According to our simulations, manufacturing employment will be about halved within 20 years if the observed growth in the producer real wage rate were continued.

- Our results concerning sustainable employment in the manufacturing sector is quite robust with respect to alternative exogenous assumptions on TFP growth and petroleum prices. On the other hand, raising the interest rate by 1 percentage point allows for a significant reduction in manufacturing employment.

An overall conclusion is that the petroleum wealth is far from large enough to make the Norwegian economy immune to Dutch Disease. There is a danger that the favourable current financial situation for the government and for the economy as a whole may confuse the public with respect to long run consumption possibilities. Basically, it reflects the pace of the temporary transformation of the petroleum reserves into liquid foreign assets. Systematic use of numerical simulation models is one of the few possibilities for obtaining more adequate information about the sustainable possibilities for growth in real wages, consumption and sectoral reallocations. Our results suggest that the SOE model provides an overly simplified description of the important determinants of the sustainable real wage growth. Consequently, these models may produce misleading norms for the wage negotiations. More qualified quantitative assessments based on more realistic and complex CGE models cannot be obtained without costs. There is a trade-off between accuracy and transparency. However, the dramatic increase in the possibilities to solve sophisticated CGE models, implies a decrease in the relative price of accuracy, which should be exploited.

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2.6. A stylised one-sector version of MSG6

Consumer behaviour

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

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

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

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

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

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

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

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

The consumer takes the wage rate and all consumer prices as given and maximizes the intertemporal utility function subject to the intertemporal budget constraint

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

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

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

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

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

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

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

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

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

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

Behaviour of firms and aggregate industries

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Equilibrium

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

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

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

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

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

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

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

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

Aggregate demand for capital and labour becomes

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

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

Labour market equilibrium implies

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

Net foreign wealth, B, develops according to

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

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

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

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

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

The exogenous variables are: r, P_I, P_W, O, T, A_0, t, F, t_I, P_I, K_0, B_0. 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.

Facts about the recent development of Norwegian manufacturing

1. Over the period 1996-98 gross production in Norwegian manufacturing, measured in fixed prices, increased by 19.6 percent. In 2003 the volume of gross production was 4.3 percent lower than in 1999.

2. The number of employees and self-employed in Norwegian manufacturing fell from 304 400 in 1996 to 274 200 in 2003. In 2003 the manufacturing industries employed 11.9 percent of total employment. Manufacturing employment peaked at 394 000 persons in 1974. Most of the employment reduction took place during the period 1982 - 1991.

3. When measured in common currencies the average annual growth in wage costs in Norwegian manufacturing exceeded the corresponding growth among the main trading partners by 1.4 percent over the period 1994-2003. Using this measure, the international competitiveness of Norwegian manufacturing deteriorated by 14.9 percent over this 10-year period. Over the period as a whole, approximately all of the deterioration is due to rising wage costs.

4. The deterioration of the international competitiveness of Norwegian manufacturing after 1997 more than outweighs the improvement during the first half of the 1990s. The deterioration was particularly strong in 2001 and 2002. However, this was mainly due to the appreciation of NOK. In 2003 a 3.0 percent depreciation of NOK contributed to improve the inernational competitiveness by 2.3 percent.

5. After 1996 wage costs in Norwegian manufacturing industries have risen consistently by more than the wage costs in Norway's main trading partners. Measured in national currencies the annual growth rate of wage costs in Norwegian manufacturing averaged 5.0 percent over the period 1994-2003, whereas the corresponding growth among the trading partners averaged 3.8 percent. The wage growth in Norwegian manufacturing was especially high in the years 1998 - 2002, varying close to 6.0 percent.

6. In 2003 the average *level* of wage costs for all employees in Norwegian manufacturing, Mining, Electricity production and Construction was estimated to be 20 percent higher than the corresponding average level in Norway's main trading partners. For blue-collar workers the corresponding difference was as high as 33 percent in 2003.

7. The annual average growth rate of labour productivity, measured by value added per man-hour, in Norwegian manufacturing equalled 1.3 percent over the period 1994-2003. The corresponding growth among the main trading partners is estimated to 3.5 percent. However, a part of this difference is likely to be attributable to problems of obtaining comparable

estimates of value added. When labour productivity is measured by gross production per man-hour, labour productivity growth in Norwegian manufacturing averaged 3.2 percent over the period 1994-2003, whereas the corresponding growth among Norway's main trading partners averaged 3.8 percent.

8. The export market share of Norwegian manufacturing declined by about 14 percent from 1990 to 2000. During the three years 2001-03 the export market has been relatively stable. The home market shares of manufactures have declined steadily over the last 20 years. Parts of this declining trend are due to increased international specialisation.

A more detailed description of historical trends and the reference scenario

Table A2.1. Macroeconomic development. Historical trends and projections in the reference scenario. Average annual growth rates in percent

	1970 - 1980	1980 – 1990	1990- 2002	2002 level (bill.)	2002- 2010	2010- 2020	2020- 2030	2030- 2040	2040- 2050
Man hours	0.2	0.0	0.5	3116.5	0,5	0,2	-0,1	0,0	0,1
Fixed capital	4.9	3.1	1.6	3553.4	1,8	1,8	1,5	1,5	1,7
GDP	5.4	2.7	3.4	1512.3	1,8	1,8	1,6	1,5	1,7
Off-shore industries	27.1	8.4	5.4	377.4	1.4	1.5	1.8	1.7	1.8
Mainland industries	2.8	1.9	2.9	984.5	2,6	2,3	1,8	1,7	1,8
Government sectors	4.5	2.9	2.2	219.3	1,1	0,8	1,3	1,2	0,8
Manufacturing	0.6	-0.1	1.4	144.1	3,2	2,7	2,1	1,6	1,2
Other mainland industries	3.1	1.8	3.5	621.0	2,8	2,5	1,8	1,8	2,0
Net disposable real income		1.5	4.5	1241.6	1,8	2,2	1,8	1,7	1,8
Exports	6.1	5.3	4.7	709.9	0,3	0,7	1,0	0,9	0,7
Exports excl. petroleum	2.9	3.5	3.6	386.7	1.9	1.8	1.6	1.3	0.9
Imports	2.0	2.9	4.0	442.5	2,2	2,1	1,5	1,6	2,1
Private consumption	3.6	1.8	3.1	663.2	3,0	3,0	2,0	1,9	2,4
Government consumption	5.0	2.6	3.3	301.5	1,0	0,5	1,3	1,1	0,5
Gross fixed investment	4.2	-0.2	2.4	252.6	2,2	1,0	1,0	1,4	1,6
Labour cost per hour/export price, manufacturing			4.2		2.7	2.7	2.7	2.7	2.7
Consumer real wage rate	2.4	0.6	2.1[1]		2.9	2.9	1.9	1.8	1.8

[1] Wage per standardized man year.

Table A2.2. Employment in main sectors. Historical trends and projections in the reference scenario. Average annual growth rates in percent

	1970 - 1980	1980 - 1990	1990- 2002	2002- level (1000s)	2002- 2010	2010- 2020	2020- 2030	2030- 2040	2040- 2050	2050- 2060
Total	1.8	0.6	1.0	2322	0.3	0.2	-0.1	-0.1	0.1	0.0
Government sector	5.1	2.3	2.0	731	0.4	0.2	0.8	0.6	0.2	0.0
Private business sector	0.9	-0.1	0.6	1591	0.4	0.1	-0.5	-0.5	0.0	0.1
Manufacturing	-0.1	-2.4	-0.1	297	0.1	-0.3	-0.8	-1.2	-1.4	-1.5
Primary industries	-2.6	-2.6	-3.1	86	-1.7	-1.5	-1.4	-1.4	-1.6	-1.6
Private services	2.9	1.5	1.7	848	0.7	0.6	-0.4	-0.3	0.5	0.5