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Standardtegn i tabeller	Symbols in tables	Symbol
Tall kan ikke forekomme	Category not applicable	.
Oppgave mangler	Data not available	..
Oppgave mangler foreløpig	Data not yet available	...
Tall kan ikke offentliggjøres	Not for publication	:
Null	Nil	-
Mindre enn 0,5 av den brukte enheten	Less than 0.5 of unit employed	0
Mindre enn 0,05 av den brukte enheten	Less than 0.05 of unit employed	0,0
Foreløpig tall	Provisional or preliminary figure	*
Brudd i den loddrette serien	Break in the homogeneity of a vertical series	—
Brudd i den vannrette serien	Break in the homogeneity of a horizontal series	I
Desimalskilletegn	Decimal punctuation mark	,(.)

Abstract

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Macroeconomic Properties of the Norwegian Applied General Equilibrium Model MSG6

MSG6 is an Applied General Equilibrium (AGE) model of the Norwegian economy developed at Statistics Norway. As its five predecessors the sixth generation of the MSG model is designed in order to calculate consistent long run projections of the Norwegian economy, as well as effects of changes in economic policy instruments and other exogenous variables. In particular, MSG6 has been designed in order to address issues such as the efficiency effects of changes in taxation, trade policy, various types of industry subsidies, environmental and energy policies. MSG6 has become considerably larger and, in several respects, much more complex than MSG5. Moreover, MSG6 should be regarded as a family of several different model versions rather than as one model. This paper is confined to the so-called "dynamic" version, which is characterised by perfect foresight of consumers and producers, as well as an intertemporal restriction on net foreign debt. Its purpose is to give an overview of the model structure, as well as to illustrate and explain the properties of MSG6 by interpreting the simulated effects of shifts in a relatively comprehensive set of exogenous variables. In the shift analyses, we focus on the macroeconomic properties of the model.

Contents

1. Introduction

MSG6 is an Applied General Equilibrium (AGE) model of the Norwegian economy developed at Statistics Norway. As its five predecessors the sixth generation of the MSG model is designed in order to calculate consistent long run projections of the Norwegian economy, as well as effects of changes in economic policy instruments and other exogenous variables. The sixth version is in several respects very different from its predecessors. Most of the recent changes have been motivated by a need for improving the relevance of the model as an analytical and empirical tool in policy analyses focusing on effects on welfare and resource allocation. In particular, the model has been designed in order to address issues such as taxation, trade policy, various types of industry subsidies, environmental and energy policies. MSG6 has become considerably larger and, in several respects, much more complex than MSG5. A complete documentation of MSG6 does not exist. General overviews of the model are provided in papers based on application of MSG6, see e.g. Bye (2002), Bye and Åvitsland (2003) and Fæhn and Holmøy (2000, 2003).

The purpose of the present paper is the same as that of Holmøy, Strøm and Åvitsland (1999), hereafter HSÅ99, i.e. to illustrate and explain the structure and properties of MSG6 by interpreting the simulated effects of shifts in a relatively comprehensive set of exogenous variables. If the results from such large and complex models as MSG6 cannot be given convincing explanations to economists, the credibility of both the results and the whole model will be low. Our ambition is to shed some light on the mechanisms captured by MSG6, in order to reduce the stigma "black box" often raised against large scale models.

MSG6 should not be regarded as *one* model. Rather it is a family of several different models (or model versions) having most equations in common, but differing in important respects depending on the issues being analysed. Specifically, one has traditionally distinguished a "static" version from a "dynamic" version by changing the closure rule of MSG6. The present version reports the properties of the dynamic version, which is characterised by perfect foresight, i.e.

model consistent expectations of consumers and producers, as well as an intertemporal restriction on net foreign debt, which ensures that the present value of imports equals the present value of exports plus the initial net financial claims on foreigners. The static version differs from the dynamic one by replacing i) forward looking expectations in the consumer and producer behaviour by exogenous (static) expectations; ii) the intertemporal constraint on foreign debt accumulation by a fixed exogenous ratio between the current account surplus and nominal GDP in each year. *A priori*, even the long run results may be sensitive to changing the model from the dynamic to the static version. The Norwegian Ministry of Finance typically uses the static version of MSG6.

Switching the model from the static to the dynamic version opens up for analyses of a richer menu of shifts in a given exogenous variable. With forward looking behaviour it is important to distinguish the period in which new *information* about exogenous changes is announced from the period when the exogenous changes are actually *implemented*. Accordingly, we may simulate the effects of a given change in a variable X in year t under two different assumptions: 1) We assume that the future shift in period t is announced and completely understood by the agents in the first simulation period. The shift is then fully *anticipated*. 2) The shift in period t may be *unanticipated* in the years until it actually shocks the economy. In forward-looking models it is also important to distinguish exogenous shifts along the dimension A) permanent, i.e. lasting from the period of implementation to eternity, or B) transitory, i.e. lasting for a specified number of years. For several shifts, this paper shows how and explains why the simulated shift effects depend on whether it belongs to type 1A, 1B, 2A or 2B in this classification scheme.

This paper is mainly concerned with the aggregate behaviour of the model based on adding up sectoral or commodity results from the disaggregate structure (bottom-up). When the aggregate behaviour is well understood it is usually not difficult to explain changes in industry structure, relative commodity prices and

other market specific results. However, we often comment on reallocations between the traded goods and the non-traded goods sector because these are typically closely related to macroeconomic adjustments, especially the intertemporal ones. Furthermore, the disaggregated structure of the model is in several cases important for understanding the aggregate results. For example, changes in the industrial composition of the production sector affect the aggregate demand for labour and capital since the industries differ with respect to factor intensities. Such a Rybczynski effect reduces the need for adjustments in the relative factor prices in order to restore factor market equilibrium after shifts in exogenous variables.

In an accompanying annex to the present paper - Heide, Holmøy, Lerskau and Solli (2004) - the simulation results at both the aggregate and the disaggregate level are reported in greater detail.

There are several reasons why the effects reported in the present paper differ from the corresponding ones in HSÅ99:

1. HSÅ99 simulated the "static" version of the model, whereas we simulate the dynamic version.
2. HSÅ99 assumed that labour supply was exogenous, whereas the effects simulated in the present paper take endogenous labour supply into account.
3. HSÅ99 assumed that the public budget constraint was met on an annual basis through endogenous adjustments of government consumption. In the present simulations government employment as well as purchases of goods and services are exogenous, while endogenous lump sum transfers adjust to realize an exogenous reference path of government financial investment.
4. The reference scenario in HSÅ99 was a so-called "flat" path in which the base year (1991) values of most exogenous variables were prolonged. In contrast, the reference scenario used in the present simulations is a growth scenario reflecting most of the assumptions underlying the scenarios discussed in the Government's Long Term Programme 2002-2005.

The paper is organised as follows: Section 2 first provides a non-technical overview of the model. Section 2.6 supplements the non-technical description by describing the macroeconomics of the model by the equation structure of a stylised one-sector version of MSG6. Finally, Section 2.7 describes the main characteristics of the growth path that serves as the reference scenario in the shift analyses. Section 3 starts by explaining in more detail the nature of the exogenous changes and how the shift effects are measured. The remaining sections explain the results of several partial exogenous shocks simulated on MSG6. The exposition of each of the various shift analyses is intended to be understandable without reading the other sections. Accordingly, explanations of some mechanisms in the model are more or less strictly repeated in several sections.

2. An overview of the dynamic version of MSG6

MSG6 represents the sixth and latest modelling step in a continuous research program where changes in policy or other exogenous conditions for Norway are analysed by AGE-models. Among several other aspects, the design of MSG6 gave particular priority to analyses of welfare effects of a wide range of tax, trade- and industry policies within a consistent intertemporal framework. The Norwegian National Accounts (NA) constitutes the main empirical data source for both calibration and estimation of behavioural and technology parameters.

2.1. Aggregation

MSG6 provides a relatively disaggregated description of the Norwegian economy. The model specifies 60 commodity groups, including 9 that are non-competing import goods and 12 Government services. Different proportions of the remaining 39 goods are produced in the 32 private business industries. Moreover, the specification of taxes and subsidies is detailed in order to make the model operational for policy analyses. The model is a general equilibrium model in the sense that the behavioural relations are the result of optimising behaviour by individual rational agents, and all markets clear by flexible adjustment of relative prices. Commodities, primary factors, including labour and capital, are perfectly mobile across different sectors and kinds of absorption. Capital goods are also malleable.
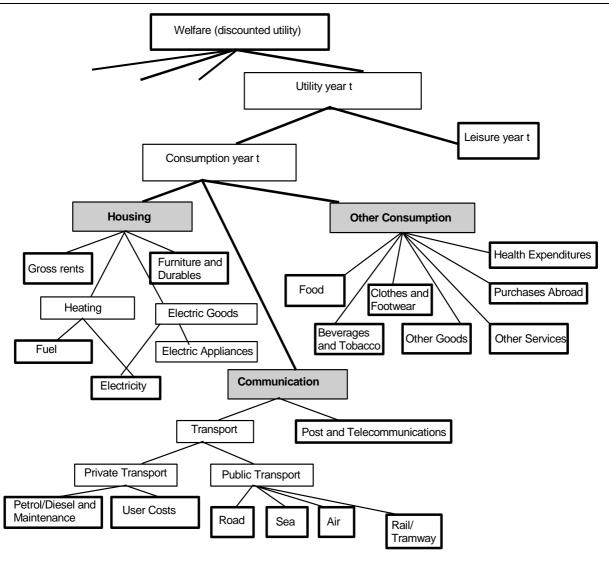
2.2. Household behaviour

The time profiles of labour supply and consumption of the specified goods are derived from the decisions of one representative price-taking household with perfect foresight. It maximises an intertemporally additive utility function over an infinite horizon subject to two effective constraints: a) an intertemporal budget constraint; b) a time constraint in each period. The intertemporal budget constraint is derived from a non-Ponzi game condition, which prevents the total Norwegian net debt to foreigners from exploding. When Government net debt follows an exogenously specified time path, which does not explode, it follows from Walras' law that the transversality condition for the net foreign debt for the economy as a whole implies an intertemporal budget constraint for the consolidated private sector, which includes the household sector and the corporate business sector.

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. So is 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 to 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.

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, see Statistics Norway (1992). Combined with the base year levels of non-labour income, these parameter values imply a direct Cournot wage elasticity of labour supply equal to 0.1. Such an order of magnitude is in line with the empirical properties of the microeconometric model estimated by Aaberge, Dagsvik and Strøm (1995). We refer to Bye and Holmøy (1997) for a detailed description of the intertemporal behaviour and the labour supply decision in MSG6.

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. Figure 2.1 shows the separable preference structure in MSG6.

Figure 2.1.   The preference structure of households in MSG6

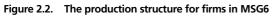## 2.3. Market structure, producer behaviour and exports

MSG6 distinguishes between the behaviour of the individual firms and the aggregate industry behaviour. 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. Entry (exit) takes place in an industry if the variable after tax profit increases (decreases) relatively to the net fixed cost associated with entry. We refer to Holmøy and Hægeland (1997) for a detailed analysis of the production model in MSG6.

All firms in the private business sector are run by managers seeking to maximise the firm value, which is assumed to equal the present value of the cash-flow. As for the household, expectations are model consistent. The private profitability is affected by indirect taxation of inputs and the system of capital income taxation. In addition various kinds commercial policy instruments are specified, including a detailed description of transfers and government subsidies. In order to capture

the impact of these measures on the entry/exit incentives, the model distinguish output dependent transfers and subsidies from neutral ones, the magnitude of which is independent of firm size. Trade policies affect producer prices on both outputs and inputs and thereby maximum profits. These impulses generate both substitution and scale effects. The scale effects take place both at the level of the individual firms as well as on the aggregate industry level due to endogenous entry and exit.

The model of the entry/exit mechanism in MSG6 differs from the standard textbook model of mono-polistic competition. While the standard model assumes that all firms have the same technology, which generates a symmetric equilibrium, MSG6 generates an *asymmetric* equilibrium because the model allows for productivity differentials between firms within the same industry. There has long been strong empirical evidence that such differences are both substantial and persistent, see for example Sutton (1997). Klette and

Mathiassen (1995, 1996) confirm that this conclusion indeed also applies to Norwegian manufacturing industries. For computational reasons the modelling of productivity heterogeneity relies on restrictive simplifying assumptions. In particular, the relative productivity differentials between any two adjacent firms are assumed to be constant. The reward for imposing this restriction is that the equilibrium differentials between firm variables can be represented by exponential difference equations which makes it straightforward to carry out the relevant integrals defining the corresponding aggregate industry variables. Incorporating this kind of productivity heterogeneity implies that variation of the activity of an industry through changes in the number of firms exhibits decreasing returns to scale. However, this effect will be modest as long as the changes in the number of active firms are not very large, see Holmøy and Hægeland (1997).

Producers of manufactures and tradable services allocate their output between the domestic and the foreign market. These markets are assumed to be segregated. It is assumed to be costly to change the composition of these deliveries. This aspect of the technology is captured by assuming that output is a Constant Elasticity of Transformation (CET) function of deliveries to the export market and deliveries to the domestic market. Aukrust (1970) and Bowitz and Cappelen (1994) find empirical evidence supporting the view that Norwegian firms behave more like price takers on the export market than they do in the domestic markets. Thus, the model assumes that exports from Norwegian firms are sold at fixed world prices. The underlying reason for this may be that foreign consumers consider imported products from other countries to be perfect substitutes for Norwegian ones, and that Norwegian firms in general are too small to exercise any market power abroad. Contrary to models adopting the Armington assumption to justify a declining world demand function for domestic products, there is no possibility to obtain endogenous terms-of-trade gains in any of the specified commodity markets.

Figure 2.2. The production structure for firms in MSG6

On the other hand, domestic consumers are assumed to 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 formalise the market structure for domestic deliveries. The demand function facing each firm in a differentiated industry is derived through decisions at several stages for firms and households. For all agents on the demand side, separability assumptions imply that an industry composite can be defined as a symmetric CES-function of the quantities of the different product varieties produced by the industry. The elasticities of substitution between the varieties in different industries are calibrated to be consistent with the estimated mark-up ratios between the output price and marginal costs in Klette (1999). None of the mark-up ratios exceed 1.05, which implies that the scope for love-of-variety effects on aggregate welfare is relatively small.

For inputs, the separability assumptions allow all inputs to be perfectly aggregated into one index of aggregate input through a system of nested constant-returns-to-scale CES-functions. Labour is homogeneous, whereas the capital goods and intermediaries are Leontief aggregates of the commodities specified in the model. Figure 2.2 shows the nested structure of the production structure. Firms are assumed to be price takers in all factor markets. The production function for the firm is assumed to exhibit decreasing returns to scale. The scale elasticities range from 0.85 - 1.00, which implies a small negative bias compared to those estimated in Klette (1999). This bias was introduced in order to avoid unrealistic specialisation patterns of the industry structure. Moreover, the firm technology is assumed to be separable in such a way that the determination of the optimal supply of exports and deliveries to the domestic market can be separated. This separability is obtained through a restrictive assumption relating the scale elasticity to the elasticity of transformation between exports and domestic deliveries. In result the variable cost function is additively separable in a cost function for exports and a cost function of the same form for domestic deliveries.

2.4. Imports
The Armington assumption is supposed to hold for imports of manufactured goods 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. Commodity specific Armington composites of imports and domestic deliveries are defined by linearly homogeneous CES-functions. From these functions standard unit demand functions are derived through cost minimisation. The import shares depend negatively on the ratio between the price of imports and the price of corresponding domestic deliveries. All import prices are exogenous. Note that for each

commodity (group) specified in the model, the exogenous world price of imports may differ from the corresponding exogenous world price of exports. The main rationale for this is that the composition of actual commodities in the imports of each commodity aggregate in the model in general differs from the corresponding composition in exports of the same model commodity. For example: The products covered by the label *Textiles* are very different when one compares Norwegian exports with imports. The share parameters in the Armington composites are calibrated to the NA in the base year. They will in general vary between both commodities and the source of absorption. 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, Electricity, Crude Oil and Natural Gas are assumed to be homogenous. In the absence of any trade restrictions 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.

MSG6 distinguishes three main categories of protective trade policies:
1. Nominal tariffs. Computed on ad valorem bases, these tariff rates are typically small.
2. Non-Tariff-Barriers (NTBs), which generate additional costs for foreign producers when exporting to the Norwegian market. One category of such NTBs is specific technical standard requirements and home preferences in government procurement. The costs associated with such NTBs will have an impact on the domestic producer price equivalent to that of a nominal tariff. They have been estimated on ad valorem bases, see Fæhn (1997) and Fæhn and Hægeland (1996).
3. NTBs that imply quantitative restrictions on trade flows such as import quotas and voluntary export restraints. Prices of commodities subject to such NTBs are determined independently of world prices. The relative difference between the domestic producer price and the c.i.f. price of potential imports is defined as an equivalent tariff rate or a quota rent associated with the import quota.

2.5. The government sector
MSG6 provides a relatively detailed description of the government expenditure related to consumption and pensions and other transfers. With the exception of one small sector (water supply) employment, intermediate inputs and investment are exogenous variables. So is the real value of all transfers. Specifically pension outlays are measured in so-called Basic Points Unit (BPU), which is the measurement unit used in the Norwegian National Insurance Scheme. The indexation

of BPU is a policy question. Traditionally, the BPU has been indexed to wages, but the model user may also choose alternative indexation rules.

In long run projections the exogenous assessments related to government consumption and transfers are typically based on other models developed in Statistics Norway. First, government consumption within the sectors health care and education has often utilised the MAKKO-model, a model that decomposes changes in the input of labour and intermediate inputs into a) changes in the size of different age groups; b) changes in the service and standards; c) changes in coverage ratios. Thus, the projections capture the fact that ageing, *cet. par.*, increases the public health care expenses. Second, government pension expenditure has been projected by simulations on the micro simulation model MOSART. MOSART simulates entry into public pension schemes based on old age, disability, widow(er)hood and early retirement (AFP). Fredriksen (1998) gives a detailed description of MOSART and the way it may be used. Fredriksen, Heide, Holmøy and Stølen (2003) provide an example of the combined use of MOSART and MSG6.

MSG6 gives a rather detailed description of taxes and other Government revenues. In particular, the detailed classification of industries, commodities and various types of indirect taxes improves the accuracy of the computations of revenues from indirect taxation. In simulations it is necessary to specify how the public budget constraint is to be met; an exogenous restriction on this budget surplus implies that one tax rate or one expenditure item must adjust endogenously. Alternatively, a certain mix of tax rates and/or expenditures may be changed.

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:

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

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

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

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

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

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

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

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

$$(5)$$

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

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

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

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

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

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

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

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

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

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

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

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

(13) $\pi_i = P_{iH}X_{iH} + P_W X_{iW} - \left(1+t_L\right)wL_i$,

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

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

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

where E is a demand parameter regarded by the firm as given.

The transformation function between outputs and inputs has the separable structure

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

where the mark-up formula has been used.

$X_{0H} = \left(\dfrac{mc}{s}\right)^{-\left(\frac{m}{m/s-1}\right)} E^{\frac{m-1}{m/s-1}}$.

For a given number, n, of firms and products the industry output variables are easily calculated.

Defining $h_H = \dfrac{m/s-1}{t}$ and $h_W = \dfrac{1/s-1}{t}$, we get

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

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

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

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

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

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

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

where $0 < b = \left(\dfrac{t}{m/s-1}\right)^{m-1} < 1$ 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) $X_{0H} = b^\nu E(P_H)^{-\nu}$.

Equilibrium in the domestic product market requires

$X_{iH} = D_{iH} + J_{iH}$, where $J_{iH} = \left(\dfrac{P_{iH}}{P_H}\right)^{-\nu}\left(\dfrac{P_H}{P}\right)^{-\sigma_I}\dot{K}$ is the

investment of the i'th domestic variety. This equilibrium condition can be written:

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

Aggregate demand for capital and labour becomes

(28)

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

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

Labour market equilibrium implies

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

Net foreign wealth, B, develops according to

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

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

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

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

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

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

2.7. The reference scenario

Our reference projection of the Norwegian economy covers the period 2002 - 2050. This projection is based on the same assumptions as used in Fredriksen *et al.* (2003), which in turn relies heavily on the Norwegian Ministry of Finance (2001). The subsequent overview of exogenous assumptions is confined to the most important determinants of macroeconomic growth.

Key exogenous assumptions

*   *Productivity:* Total Factor Productivity (TFP) grows by 1.3 percent per year in private business sectors. In government sectors labour productivity grows by 0.5 percent, in accordance with the Norwegian national accounting practice.
*   *Labour force*: We rely on the projections in the middle alternative of the population projections in Statistics Norway (1999). The labour force is assumed to increase by 0.5 percent per year until 2010. Thereafter the labour force stays roughly constant throughout the scenario. Due to demographic changes, the number of man man-hours increases by 12.8 percent from 1995 to 2050.
*   *The number of pensioners*: The old-age dependency ratio, defined as those 67 and older relative to those of working age 20-66, rises from 22 percent in 2002 to 40 percent in 2050. Over the same period the ratio of people 80 years or older to those of working age will rise from 7.2 percent to 13.8 percent, and the number of old-age pensioners grows by 78.7 percent.
*   *Petroleum wealth*: In 2002 the exports of *petroleum* products amounted to 42 percent of total exports, and taxes and petroleum revenues amounted to approximately 27 percent of total Central Government income. Estimates of the future petroleum revenues are of course very uncertain. In our scenarios the net cash flow measured in current prices, declines from 170 billion NOK in 2002 to 128 billion NOK in 2010 and to 110 billion NOK in 2050.
*   *World interest rate:* As Norway, especially the government, accumulates financial assets, the international interest rate is important for the national and government income. The nominal interest rate is 5.5 percent throughout the scenario.
*   *World prices:* All world prices, except petroleum prices, measured in NOK grow annually by 1.5 percent.
*   *Government revenues and expenditures:* In the simulation in this paper, employment, investment, and material inputs are exogenous variables. The same is true for all tax- and subsidy rates, as well as government transfers in terms of the BPU. BPU is indexed by the growth in the average wage rate. The central government use lump sum transfers/ taxes to ensure that the local government budgets are balanced on an annual basis. The time path of the budget surplus of the central government is exogenously determined in accordance with the fiscal policy rule adopted in Norway from 2002. This rule allows a deficit on the structural central government budget, net of the cash flow from the petroleum sector, equal to the real rate of return on the financial assets held by the Central government's petroleum fund. This budget constraint is met by endogenous lump sum taxes in the simulations in this paper. The main government expenditures have been set under the following assumptions:
*   The growth in government real consumption reflects the changes in the age structure of the population specified in the MAKKO model. No changes take place in standards and coverage ratios beyond already approved reforms. 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.
*   Government expenditures related to public pension benefits have been projected by simulations on the MOSART model.

Macroeconomic growth

Table 2.1 shows how the macro economic key variables grow from 1995 to 2050. The combined effect of exogenous growth in employment and TFP, as well as endogenous capital deepening, expands GDP by 1.7 percent per year as an annual average over the period 1995-2050. On average private consumption per capita can grow by an annual rate equal to about 2.5 percent without breaking the intertemporal constraint on net foreign debt. This implies a doubling of private consumption per capita in about 28 years. The deviation between the growth rates of private consumption and GDP is partly due to the moderate growth in government consumption, which may be interpreted as a higher degree of privatisation of services traditionally provided by the government sector. Also it reflects that a part of the present value of the private consumption is financed by the initial petroleum wealth.

Table 2.1. Long run macroeconomic development with fixed individual labour supply and endogenous payroll tax rate

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

3. Explanation of the simulated elasticities

3.1. Exogenous shifts and computation of the shift effects

We have simulated the effects of shifts in the following exogenous variables (the figures indicate the sub-section in Section 3 in which the shift is analysed):

2. The world interest rate falls from 5.5 to 4.5 percent, and the households' rate of time preference falls by the same proportion.
3. Rise in world prices
    3.1. All export prices rise by 10 percent
    3.2. All import prices rise by 10 percent
    3.3. All export- and import prices rise by 10 percent
    3.4. The prices of crude oil and natural gas rise by 10 percent
4. Factor productivities increase by 10 percent
    4.1. Total factor productivity in production
    4.2. Labour productivity
    4.3. Total factor productivity in production and productivity of leisure
    4.4. Labour productivity and productivity of leisure
5. The labour force increases by 10 percent
6. All user costs of capital rise by 10 percent
7. The fixed costs in all firms rise by 10 percent

For the shifts in the interest rate, all world prices and the prices of crude oil and natural gas we distinguish between *anticipated* versus *unanticipated* shifts and between *permanent* versus *transitory* shifts. Table 3.1 shows the four types of shifts (A - D) that have been simulated for each of these variables.

When the shift comes unanticipated in period 10, the shift scenario is identical to the reference scenario in the years [0,9], since both the information about the future and all exogenous variables are identical in the two paths in these years. When the shift is anticipated in advance, the results depend on when the agents in the economy are informed about the shift. In our simulation (D) the correct information is available in period 0, so there is no period in which agents make decisions and take actions based on false information. An unanticipated transitory shift, such as (B) involves two shifts: First, there is an unanticipated shift in exogenous variables in period 1, as well as a change in the information set about the future. Second, there is a permanent reversal of the exogenous change in period 2, which is anticipated due to the updating of the information set in period 1.

We first simulate the reference scenario. Then we calculate a shift scenario in which some specified variables are changed relative to their time paths in the reference scenario, while the remaining exogenous variables keep their time paths from the reference scenario. In a particular year we compare the simulated solution for a given variable in the shift scenario with the corresponding solution in the reference scenario. Occasionally, we refer to the ratio between the percentage deviation between the two solutions and the percentage exogenous shift as the (general equilibrium) multiplier or elasticity.

3.2. Effects of reducing the world interest rate and the time preference rate by 1 percentage point (5.5 to 4.5 percent)

In MSG6 the time preference rate of households has to be equal to the after-tax interest rate, at least in the last years of the simulation period. Thus, the time preference rate is reduced simultaneously with the reduction in the interest rate. In result, the simulations do not capture the direct intertemporal substitution effect on consumption from a *partial* change in the interest rate.

The effects of the exogenous shift are measured as percentage deviations from the reference scenario. Even if the absolute change is moderate, the percentage deviation will be very large if the reference value is small. Moreover, a positive absolute change will result in a negative percentage deviation if the reference value is negative. Such results are often found for gross fixed investment in specific industries and for the trade surplus.

3.2.A. Permanent unanticipated shift from period 0
A complete analysis of a shift in foreign monetary policy should account for induced effects on international prices and demand relevant for the Norwegian economy. In the present simulations, however, such effects are ignored since our focus is on the marginal properties of the model.

Table 3.1. Types of exogenous shifts

	Permanent	Transitory
Unanticipated	From period 0 (A) From period 10 (C)	In period 1 only (B)
Anticipated	From period 10 (D)	

A reduction of the world interest rate is carried forward to a reduction of all interest rates on debt and deposits in the model. These changes affect the economy through two channels. First, reduced interest income from the net financial wealth accumulated in the reference scenario influences the economy through the intertemporal budget constraint on net foreign debt. Since the Norwegian economy has positive net financial wealth on the reference scenario, this corresponds to a negative *wealth/income effect* on the aggregate consumption possibilities, which is analogous to a terms-of-trade (TOT) effect. Secondly, there is a negative effect on production *costs*, since the interest rate is the main determinant of the user cost of capital, i.e. the opportunity cost associated with real investment. The direct intertemporal substitution effect on consumption vanishes since the rate of time preference is equal to the after tax interest rate both ex ante and ex post the shift.

The direct impact - i.e. the impact prior to endogenous general equilibrium adjustments - of the reductions in total wealth and the user cost of capital is to violate the intertemporal budget constraint. It is obvious that lost interest income from foreigners has this impact. The impact on the current account of lower capital costs is theoretically ambiguous. On the one hand, lower capital costs improve the international competitiveness; the marginal cost curves associated with export supplies shift downward and firms find it profitable to raise exports. In addition, the capital cost reductions are shifted forward to the prices of domestic products, which leads domestic consumers to reduce the price dependent import shares, i.e. chose more Norwegian products. On the other hand, taking the initial wage rate as given, the decrease in capital costs induces firms to choose a more capital-intensive factor composition. Moreover, the aggregate capital intensity grows because labour is reallocated into industries that are relatively capital-intensive.[1] Taking the initial employment as given, the increase in the average capital-labour ratio implies an increase in investment, which is partially directed to imported goods. But labour supply is directly positively affected: At a given wage rate, the loss of interest income has a positive income effect on labour supply, which is reinforced by the increase in the consumer real wage rate caused by the transmission of lower capital costs to lower prices

of consumer goods. Provided that the additional labour supply is employed, the demand for imports of capital goods and goods used as intermediate input increases. due to a scale effect

Empirically, the net direct impact on the current account of the permanent fall in the interest rate is negative. Thus, in order to restore the intertemporal budget constraint the present value of net exports must increase compared to the reference scenario. The intertemporal budget constraint can in principle be restored by a) a reduction of domestic absorption, which reduces the demand for imports at given relative prices; b) a fall in the wage rate, which raises export supplies and reduces price dependent import shares. In equilibrium the economy chooses a combination of the mechanisms a) and b). The reason is that the fall in the wage rate, *cet. par.*, creates excess labour demand: Labour supply declines as the substitution effect dominates the income effect, and labour demand increases due to factor substitution and reallocation of resources into the most labour intensive goods/ industries. Therefore, a contraction of consumption is necessary in order to restore labour market equilibrium. Lower consumption implies, *cet. par*, less imports and modifies the necessary reduction of the wage rate.

The transmission to prices of lower capital and wage costs makes the effect on the consumer real wage rate ambiguous. In the long run the consumer real wage rate is almost unaffected compared to the reference scenario, see Table 3.2. In the short run the consumer real wage rate falls.

As noted above the labour supply response captures the effect of changes in the consumer real wage rate as well as the income effect of non-labour income.[2] Employment increases in all years. In the long run the 1.4 percent increase is a pure effect of reduced non-labour income. The income effects also dominate in the first years when the consumer real wage rate falls. The increase in employment is strongest in manufacturing, reflecting the need for raising exports.

The negative equilibrium adjustment of the wage rate reverses the initial decrease in capital costs relative to the wage rate. The new equilibrium path is characterised by a ratio of wage costs to prices of capital being about 1.8 percentage points lower than along the reference scenario. Still the user costs of capital drop more than 7 percent from the reference path in the long run, and the total fixed capital stock increases relative to the reference scenario; in the long

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[1] This Rybczynski effect takes place because the negative shift in the marginal cost functions is greater the more capital intensive are the industries. In particular the increase in the consumption of housing services contributes to raise the average capital-labour ratio. See Section 3.5 for an explanation of what is meant by a Rybczynski effect in the context of MSG6.

[2] The government owns most of the net financial wealth in the reference scenario. Therefore, households do not directly experience most of the fall in interest income. However, as the government budget constraint is met by endogenous lump sum transfers in our experiments, the loss of government interest income is in fact carried by the households.

run the capital stock is 4.8 percent higher. This is in part a scale effect due to higher employment. However, after about 10 years there is also a significant increase in the aggregate capital-labour ratio (3.4 percent in the long run) despite substitution of labour for capital at the firm level triggered by the changes in relative factor prices. The reason is a reallocation of labour and capital into the relatively most capital intensive industries. The expanding manufacturing industries are on average more capital intensive than the other private business industries. More significantly, households increase their consumption of housing services. The price of Housing services is almost purely determined by the user cost of buildings. This user cost falls both because of the drop in the interest rate, and because the price of buildings is heavily dependant on the wage rate when the input-output structure of the economy is taken into account through the cost-price linkages. Accordingly the price of Housing services falls relative to the price of other consumer goods.

The increase in Housing services is also the main explanation of the deviation between the long run changes in gross investments (4.3 percent) and the fixed capital stock (4.8 percent). The point is that buildings applied for Housing has much lower depreciation rates than other capital items. Thus, a change in the composition of the aggregate capital stock in favour of houses reduces the replacement investments.

GDP increases by one percent initially, growing to a 2.4 percent increase in the long run. This reflects the increase in the capital stock, higher labour supply, as well as changes in the composition of aggregate GDP.

The dynamics of the changes are basically related to the accumulation of fixed capital during the first 10 years. There are two main reasons why investments are spread over several years. First, decreasing returns to scale implies adjustment costs since large investments imply higher marginal costs in the sectors producing mostly capital goods (*Building and Construction* and *Machinery and Metal Products*). Secondly, the transitory investment creates a transitory excess demand for labour. This explains why the wage rate reduction is smaller in periods characterised by the largest investments. The wage dynamics is transmitted to parallel price dynamics, which makes it profitable to postpone investment.

The wage and price dynamics also affects the time paths of consumption and leisure. The reduction in the price index of full consumption, which comprises the prices of consumer goods and the price of leisure (which equals the wage rate), is stronger over time. Intertemporal substitution therefore leads the households to postpone consumption and leisure at a given real wage rate. The intertemporal elasticity of substitution in consumption is only 0.3, so the time profile of the percentage change in utility from consumption and leisure shows a weak

Table 3.2. Macroeconomic effects of a lower world interest rate. Permanent unanticipated reduction by 1 percentage point from period 0. Percentage deviation from reference scenario

Years after exogenous change	0	1	10	20	48
Constant prices:					
Private consumption	-2.9	-2.3	-1.6	-1.3	-1.2
General government consumption	-0.4	-0.4	-0.3	-0.3	-0.1
Gross fixed investment	13.2	9.5	6.2	5.6	4.3
Manufacturing	-400.2	25.1	14.9	14.9	-15.7
Dwellings	-8.2	12.6	9.0	7.5	4.3
Other mainland industries	32.1	10.5	4.2	3.4	4.7
Exports	2.1	2.8	6.0	7.6	10.3
Imports	2.8	1.5	0.9	0.3	-2.4
GDP	1.0	1.2	1.8	2.1	2.4
GDP, mainland	1.1	1.4	2.0	2.3	2.5
Fixed capital stock	0.8	1.3	4.0	5.0	4.8
Total employment, man-hours	2.4	2.4	2.2	2.1	1.4
Government sector	0.0	0.0	0.0	0.0	0.0
Private business sector	3.4	3.3	3.1	3.0	2.2
Manufacturing	5.5	6.0	8.2	9.5	12.4
Price indices:					
Hourly wages	-2.1	-2.4	-3.3	-3.7	-5.2
Consumer price index	-1.4	-1.9	-3.7	-4.3	-5.2
Price of capital goods	0.3	0.0	-1.2	-1.7	-3.4
Percent of GDP:					
Trade surplus	-0.2	4.3	34.4	-808.0	-25.0
Current account	-3.9	-1.5	-0.7	-2.3	12.0
Net foreign wealth, Norway	-1.1	-1.0	-0.2	-0.3	-1.4

upward trend (not shown in Table 3.2). The change rates for private consumption and leisure are also influenced by the intratemporal substitution caused by the dynamics of the change in the consumer real wage rate. This initial decline in this real wage rate diminishes over time. *Cet. par* this contributes to raise the consumption-leisure ratio over time. The figures in Table 3.2 indicate that the intertemporal substitution effect dominates the dynamics of the percentage changes in consumption and labour supply. The decrease in private consumption is 2.9 percent in the first year but 1.2 percent in the long run, whereas the increase in labour supply is dampened from 2.4 percent in the short run to 1.4 percent in the long run.

In result the dynamics implies that investment is financed by an increase in domestic savings, reduced leisure, as well as a reduction of the national financial wealth. The latter effect is reflected by the dynamics of the change rates of exports and imports. The export expansion becomes significantly stronger and the increase in imports becomes smaller as the change rate of investments converges to its long run level.

3.2.B. Transitory unanticipated shift in period 1 only
The wealth effects pointed out in the previous section will be of negligible importance when the reduction of the world interest rate lasts only for the first period, and relative prices return to their reference paths.

Table 3.3. **Macroeconomic effects of a lower world interest rate. Transitory unanticipated reduction by 1 percentage point in period 1 only. Percentage deviation from reference scenario**

Years after exogenous change	1	2	10	48
Constant prices:				
Private consumption	0.2	-0.2	0.0	0.0
General government consumption	0.0	0.0	0.0	0.0
Gross fixed investment	3.8	-1.8	0.0	0.0
Manufacturing	9.4	-0.1	0.0	-0.1
Dwellings	0.1	2.4	-0.1	0.0
Other mainland industries	11.5	-7.4	0.0	0.0
Exports	-0.3	0.4	0.1	0.1
Imports	1.6	-0.8	0.0	0.0
GDP	0.3	-0.1	0.0	0.0
GDP, mainland	0.3	-0.1	0.0	0.0
Fixed capital stock	0.2	0.1	0.0	0.0
Total employment, man-hours	0.2	0.0	0.0	0.0
Government sector	0.0	0.0	0.0	0.0
Private business sector	0.3	0.0	0.0	0.0
Manufacturing	-0.2	0.3	0.1	0.1
Price indices:				
Hourly wages	0.4	-0.2	-0.1	-0.1
Consumer price index	0.2	-0.2	0.0	0.0
Price of capital goods	0.4	-0.1	0.0	0.0
Percent of GDP:				
Trade surplus	-4.3	3.0	0.7	-0.2
Current account	-9.7	2.2	-0.1	-0.1
Net foreign wealth, Norway	-2.3	-0.9	-0.5	-0.2

Table 3.4. **Macroeconomic effects of a lower world interest rate. Permanent unanticipated reduction by 1 percentage point from period 10. Percentage deviation from reference scenario**

Years after exogenous change	10	11	20	30	48
Constant prices:					
Private consumption	-3.0	-2.3	-1.6	-1.4	-1.3
General government consumption	-0.5	-0.5	-0.4	-0.3	-0.1
Gross fixed investment	15.2	10.6	6.7	5.5	4.3
Manufacturing	78.7	28.2	16.2	16.3	-16.7
Dwellings	-3.6	13.2	9.3	7.0	4.4
Other mainland industries	26.4	9.0	3.9	2.8	4.7
Exports	3.1	4.2	7.3	8.6	10.6
Imports	3.0	1.6	0.4	-0.2	-2.5
GDP	1.1	1.4	2.0	2.3	2.4
GDP, mainland	1.3	1.6	2.2	2.4	2.5
Fixed capital stock	0.9	1.5	4.2	5.2	4.7
Total employment, man-hours	2.5	2.5	2.2	2.0	1.5
Government sector	0.0	0.0	0.0	0.0	0.0
Private business sector	3.6	3.5	3.1	3.0	2.2
Manufacturing	6.3	6.8	9.3	10.7	12.9
Price indices:					
Hourly wages	-2.2	-2.5	-3.6	-4.1	-5.4
Consumer price index	-1.7	-2.2	-4.0	-4.7	-5.3
Price of capital goods	0.3	0.0	-1.5	-2.1	-3.5
Percent of GDP:					
Trade surplus	1.7	20.0	-765.2	-97.4	-26.1
Current account	-13.9	-8.9	-4.8	-5.8	10.7
Net foreign wealth, Norway	-0.7	-1.1	-1.8	-2.5	-2.5

Consequently, most long run macroeconomic effects are too small to be visible in Table 3.3.

There are transitory effects however. The user cost of capital is reduced in period 1, and according to MSG6 firms find it optimal to raise the capital stock temporarily since there are no costs associated with reversing investments. Higher investment demand implies *cet. par* excess demand in the labour market. In result, the wage rate increases by 0.4 percent in this period. The consumer real wage rate increases by 0.2 percent. In the subsequent periods there is a slight reduction in the real wage rate compared to the reference scenario. Intertemporal substitution contributes to postpone consumption and leisure to periods after period 1. This effect is however dominated by the intratemporal substitution effect on consumption and leisure caused by the increase in the consumer real wage rate. Both private consumption and labour supply actually increase in period 1 (0.2 percent). After period 2, private consumption returns to the reference path. The temporary capital accumulation is therefore financed by reduced financial saving abroad and reduced leisure. Net export is crowded out through the temporary increase in the wage rate. Over the subsequent years the present value of net exports must increase in order to meet the intertemporal budget constraint. Consequently, the wage rate is slightly reduced in all periods following period 1.

3.2.C. Permanent unanticipated shift from period 10
Until period 10 all variables follow the same path as in the reference scenario since the shift is unanticipated. The effects are qualitatively the same as in experiment A. However, since the reduction in the interest rate is postponed by 10 years, the present value of lost interest income is lower than in experiment A. Compared to a situation in which agents are informed in period 0 about the future exogenous shift, see Section D below, consumption and leisure is too high in the first 10 years. Consumers must pay for their overly optimistic expectations about the future interest rate in the years after the shift. The long run decline in consumption is 1.3 percent, see Table 3.4, which is only slightly less than the decline in experiment A (1.2 percent). The long run increase in employment is 1.5 percent, while the corresponding effect in experiment A was 1.4 percent.

3.2.D. Permanent anticipated shift from period 10
Producers and consumers have model consistent expectations and they are now also assumed to foresee correctly the exogenous permanent decrease in the interest rate from period 10. Specifically, the consumer realizes in period 0 that he will become less wealthy due to the loss of interest income from period 10 and all years henceforth. Thus, in contrast to the case where the same shift is unanticipated, agents reduce consumption and leisure over the entire path. In period

0 consumption is 2.7 percent lower and labour supply 1.3 percent higher than the reference scenario, see Table 3.5. However, ignoring second order effects, the present value of the lost interest income is the same as when the increase in import prices is unanticipated. Therefore, the *annual* reduction in consumption and leisure is now smaller after period 10 compared to shift C, since the loss of consumption possibilities is spread over 10 extra years. When the loss of interest income is unanticipated the long run reduction of private consumption equals 1.3 percent compared to the reference scenario, whereas the corresponding reduction is 0.9 percent when the same loss is anticipated from period 0. Analogously, the long run increase in labour supply in the unanticipated and the anticipated case is 1.5 and 1.3 percent respectively.

The reduction in leisure and consumption in the first 10 years implies an increase in private saving. Basically the additional saving takes the form of accumulation of foreign financial assets until period 9, whereas the capital stock is almost unaffected in these first 8 year. However, in period 9 investors face relatively large capital gains because they correctly anticipate that the next year's permanent fall in the interest rate will boost investment and increase the price of capital goods in period 10 *compared to period 9*. The same line of reasoning can be repeated for period 8, 7, …,0., but the empirical importance of the capital gains rapidly diminishes the more distant is the fall in the interest rate. Instead two other effects are important for investments in the first years, but they almost cancel out: First, higher employment raises the demand for fixed capital at given factor prices. Second, as will be explained below, the wage rate falls in all periods relatively to the price of capital goods. As long as there are small changes in expected capital gains, firms reduce their capital intensity.

The increase in the net foreign wealth during the first 10 years of the new scenario requires an increase in net exports, which is also necessary in order to maintain full employment. The mechanism is a fall in the wage rate by about 3.3 percent over the first years. This boosts exports and reduces price dependent import shares. Exports increase by 3 - 4 percent in these years.

The reduction in private consumption diminishes over time. In the short run private consumption falls by 2.7 percent, whereas the long reduction is 0.9 percent. The reduction of leisure is relatively constant. The basic reason for the time profile of private consumption is intertemporal substitution induced by a gradually stronger reduction of the price of leisure and the consumer price index over time. The consumer real wage rate falls in the short run but is slightly increased in the long run. Thus the intratemporal substitution effect counteracts the intertemporal substitution effect on labour supply.

Table 3.5. Macroeconomic effects of a lower world interest rate. Permanent anticipated reduction by 1 percentage point from period 10. Percentage deviation from reference scenario

Years after exogenous change	0	1	9	10	11	48
Constant prices:						
Private consumption	-2.7	-2.2	-1.9	-1.5	-1.6	-0.9
General government consumption	0.0	0.0	-0.4	-0.4	-0.4	-0.1
Gross fixed investment	0.8	0.9	7.8	11.0	8.7	4.2
Manufacturing	-340.5	5.7	11.3	20.6	21.9	-14.0
Dwellings	-29.8	-0.6	11.4	14.0	13.4	4.4
Other mainland industries	5.9	2.5	6.8	11.1	5.0	4.6
Exports	3.4	3.4	3.5	3.4	4.1	9.2
Imports	-0.4	-0.4	0.9	2.3	1.4	-2.1
GDP	0.1	0.4	1.2	1.6	1.6	2.3
GDP, mainland	0.1	0.5	1.3	1.8	1.7	2.4
Fixed capital stock	0.0	0.1	1.7	2.3	2.7	4.9
Total employment, man-hours	1.3	1.4	2.0	2.2	2.1	1.3
Government sector	0.0	0.0	0.0	0.0	0.0	0.0
Private business sector	1.8	1.9	2.8	3.1	3.0	1.9
Manufacturing	5.9	5.9	5.9	5.8	6.3	11.0
Price indices:						
Hourly wages	-3.4	-3.3	-2.3	-2.0	-2.2	-4.6
Consumer price index	-1.8	-1.8	-2.2	-2.2	-2.5	-4.8
Price of capital goods	-1.7	-1.6	-0.3	0.1	-0.2	-3.0
Percent of GDP:						
Trade surplus	9.0	10.7	16.2	8.2	21.5	-22.2
Current account	9.3	11.0	13.7	-6.1	-2.8	12.7
Net foreign wealth, Norway	3.8	4.9	9.1	7.5	7.2	1.3

From period 9 and henceforth the anticipated and actual fall in the interest rate leads to an increase in the average capital intensity of the production sector. Together with the scale effect caused by 1.3 percent higher employment, the long run increase in the capital stock is 4.9 percent. GDP is 2.3 percent higher than in the reference scenario in the long run. The long run changes in the fixed capital stock and investment is almost identical to the long run effects in experiment A. With respect to investments, the major difference between these shifts is that the main share of the investments is postponed until period 9 when the interest rate falls in period 10 instead of period 0. A significant contribution to the rise in the average capital-labour ratio comes from the increase in the extremely capital intensive Housing services. The price of Housing services falls relatively to other prices of consumer goods because it highly depends on the interest rate and because the direct and indirect share of wage costs is relatively high in the price of buildings used in this sector.

Capital goods and the endogenous part of total exports are largely produced in manufacturing industries. This explains why the strongest increase in employment is seen here (about 6 percent over the first years, about 11 percent in the long run).

3.3. Effects of a general rise in world prices by 10 percent

Note that MSG6 distinguishes the world price of exports of a commodity from the import price of the same commodity. The main reason is that the model commodities are aggregates of a large set of actual commodities. The underlying composition of an exported commodity is typically very different from the composition of the imports of the same model commodity. Therefore, a shift in the world price of an exported commodity does not imply that the corresponding import price also shifts. In this respect MSG6 differs from other disaggregated models of the Norwegian economy, such as KVARTS and MODAG, both developed by Statistics Norway.

3.3.1. Effects of a general rise in world prices of exports by 10 percent

The effects of the exogenous shift are measured as percentage deviations from the reference scenario. Even if the absolute change is moderate, the percentage deviation will be very large if the reference value is small. Moreover, a positive absolute change will result in a negative percentage deviation if the reference value is negative. Such results are often found for gross fixed investment in specific industries and for the trade surplus.

3.3.1.A. Permanent unanticipated shift from period 0
This shift exemplifies a pure gain in terms-of-trade (TOT) from period 0 to "eternity", which allows an increase in consumption possibilities through higher net imports. As shown in Table 3.6 the economy (consumer) benefits from improved TOT by increasing consumption as well as leisure. The subsequent interpretation of the results concentrates on how the agents and main markets in the economy adjust to realize the welfare gain from the TOT improvement. We focus on the following points:
1. The increase in net imports takes place by making the economy more open in the sense that both imports and exports increase.
2. The activity level measured by GDP is almost unaffected, reflecting a small decrease in employment combined with higher labour productivity due to an increase in the input of fixed capital per worker.
3. The relative increase in the wage rate exceeds the 10 percent rise in the export prices by about 4 percentage points. The price indices of consumer- and capital goods increases 1-2 percentage points less than 10 percent.
4. The percentage changes in most macroeconomic variables are close to stationary from the first year of higher export prices.

The economy, i.e. the households, can only benefit from the TOT improvement by raising the (volume of) imports relative to the (volume of) exports. Otherwise,

the rate of accumulation of foreign financial assets would soon exceed the interest rate and violate the intertemporal budget constraint. Despite the decline in *net* exports, *gross* exports increase. Given the initial wage rate and prices of domestic products, the surge in the export prices raises import possibilities in every year directly and indirectly as the supply of exports is relatively price elastic. (Note that the price elasticity of export supply is finite due to decreasing returns to scale. However, this price elasticity is quite high. For example, in manufacturing industries the elasticity equals *s/(1-s)*, where *s* is the scale elasticity, which is close to 0.9. This implies that the price elasticity of exports is 9.)

The external balance can in principle be restored by a) an increase in domestic absorption, which raises the demand for imports at given relative prices; b) an upward adjustment of the wage rate, which shrinks export supply and leads to substitution of imports for home goods. In equilibrium the economy chooses a combination of these mechanisms. The reason is that the increase in the wage rate, *cet. par.*, creates excess labour supply. Labour demand falls due to factor substitution, reallocation of resources out of the most labour intensive industries, especially the traded goods industries. Moreover, labour supply is increasing in the wage rate as the substitution effect dominates the income effect. Therefore, an expansion of consumption is necessary in order to restore labour market equilibrium. However, a higher consumption level also implies more imports, and this income effect modifies the necessary increase in the wage rate. The equilibrium wage adjustment is not strong enough to reverse the exogenous positive price effect on exports.

The equilibrium adjustment of the wage rate exceeds the percentage increase in the export prices. The reason is that competition instantaneously drives net rate of return to fixed capital down to the exogenous interest rate corrected for non-neutrality in the capital income taxation. Accordingly, all additional revenue per produced unit to the firms is received by labour in the new equilibrium. Due to the input of fixed capital and intermediaries the cost share of labour averages somewhat above 50 percent. This magnifies the increase in the wage rate compared to the increase in the export prices. Although the simulated figures are influenced by other effects, including changes in the industry composition and endogenous labour productivity caused by decreasing returns to scale and capital deepening, this is still the empirically most important reason why the wage rate increases by 4.1 percentage points more than the general increase in export prices.

Decreasing returns to scale implies a modification of the increase in the wage rate, since export expansion brings about an increase in the marginal cost of exports at given factor prices. The necessary wage adjustment is also slightly modified by factor substitution. Since

Table 3.6. Macroeconomic effects of a 10 percent rise in world prices of exports. Permanent unanticipated shift from period 0. Percentage deviation from reference scenario

Years after exogenous change	0	1	10	20	48
Constant prices:					
Private consumption	5.0	4.1	4.1	4.1	3.8
General government consumption	-0.2	-0.3	-0.3	-0.2	-0.2
Gross fixed investment	11.8	6.4	4.0	3.4	1.6
Manufacturing	62.3	23.3	6.8	5.8	15.3
Dwellings	40.6	7.9	5.1	3.8	2.3
Other mainland industries	15.8	5.6	4.3	3.9	2.0
Exports	0.8	1.8	3.9	4.0	3.4
Imports	15.4	12.7	13.2	13.0	13.2
GDP	0.9	0.5	0.7	0.7	0.0
GDP, mainland	1.1	0.6	0.8	0.7	0.0
Fixed capital stock	0.7	1.0	2.5	2.9	2.4
Total employment, man-hours	0.1	0.0	-0.2	-0.3	-0.8
Government sector	0.0	0.0	0.0	0.0	0.0
Private business sector	0.2	-0.1	-0.3	-0.5	-1.2
Manufacturing	-3.4	-2.9	-2.4	-3.0	-5.1
Price indices:					
Hourly wages	16.2	15.7	15.1	14.7	14.1
Consumer price index	9.4	9.0	8.3	8.4	8.8
Price of capital goods	9.0	9.0	8.9	9.2	9.8
Percent of GDP:					
Trade surplus	-9.4	-3.6	4.1	-125.6	-1.0
Current account	-10.0	-4.5	-1.4	-0.1	13.8
Net foreign wealth, Norway	-11.7	-9.9	-5.2	-3.2	-0.9

import prices are fixed, the surge in the wage rate brings about changes in relative prices depending on their direct and indirect cost share of labour. Substitution of capital and intermediaries for labour raises the labour productivity. However, the incidence from export expansion to wage rate reduction depends on the *cost share* of labour, which increases if the substitution possibilities are less flexible than in the Cobb-Douglas case in which all elasticities of substitution are equal to unity. This is the typical situation in MSG6. Anyway, this modification of the wage rate adjustment due to factor substitution is a second order effect, playing a minor empirical role in the reported simulations.

The capital deepening induced by the increase in the producer wage rate relative to the prices of other inputs, is the basic reason why the capital stock has increased by 2.4 percent in the long run. On the other hand employment is slightly reduced, by 0.8 percent. The effects on GDP of these opposing changes almost cancel out. The labour supply response captures both the substitution and income effects of the increase in the marginal real consumer wage rate, as well as the income effect of higher non-labour income, i.e. capital income and cash transfers, which are indexed to the wage rate. The elasticity of substitution between consumption and leisure is 0.6. Taking non-homothetic

preferences into account, this figure is consistent with the change in the consumption-leisure of 4.6 percent and the increase in the consumer real wage rate of 5.3 percent. The reduction of employment is strongest in industries facing strong competition from imports, most notably *Machinery and Metal Products, Chemical and Mineral Products* and *Shipbuilding*.

The dynamics is not very exciting when the rise in export prices is permanent from the first period and unanticipated. For two reasons it takes some years to build up the optimal capital stock: First, decreasing returns to scale in effect implies adjustment costs since large investments leads to expansion in the sectors producing mostly capital goods (*Building and Construction* and *Machinery and Metal Products*) along increasing marginal cost curves. Second, the additional investment demand implies a tighter labour market, pressing the wage rate up compared to subsequent periods. Both effects generate higher prices in the first years of the simulation period than in the long run. However, the intertemporal elasticity of substitution in consumption is only 0.25, so the time profile of the utility of private consumption and leisure shows a very weak upward trend towards the stationary relative deviation from the reference path. This is reflected in the decreasing development of the change rate for employment. On the other hand, the increase in private consumption falls from 5.0 percent in the first year to 3.8 percent in the long run. Recall that the time paths of the change rates for private consumption and leisure (employment) are the results of both intertemporal substitution and intratemporal substitution caused by the dynamics of the change in the consumer real wage rate. As noted above, the consumer real wage increases more during the phase of investment in the first years than in the long run. The dynamic price effects cause investment to be largely financed by a smaller increase in the net exports compared to the accumulation of financial assets in the years until about 2030. In addition, investment also crowds out leisure.

3.3.1.B. Transitory unanticipated shift in period 1 only
The main difference between this shift and the one discussed in the previous section is of course that the wealth effect of the TOT gain is much smaller because it accrues in only one year. Consequently, all long run effects are much smaller than in the case where the shift is permanent. However, there are long run effects of the transitory shift due to the intertemporal perfect foresight structure of the model. Specifically, a TOT gain in any period is treated as an increase in wealth, and the income effects on consumer decisions are based on changes in wealth. The economy can now afford only a slight increase in private consumption and leisure; relative to the reference scenario the stationary increase in private consumption is only 0.2 percent and the corresponding decrease in labour supply is 0.1 percent, see Table 3.7.

Table 3.7. Macroeconomic effects of a 10 percent rise in world prices of exports. Transitory unanticipated shift in period 1 only. Percentage deviation from reference scenario

Years after exogenous change	1	2	10	48
Constant prices:				
Private consumption	-1.6	0.7	0.2	0.2
General government consumption	0.4	-0.1	0.0	0.0
Gross fixed investment	-7.8	0.1	0.3	0.0
Manufacturing	113.6	-122.4	-0.3	0.5
Dwellings	-35.2	22.6	0.7	0.0
Other mainland industries	-21.4	12.3	0.2	-0.1
Exports	11.7	-0.6	-0.5	-0.6
Imports	8.6	-0.2	0.1	0.2
GDP	-0.4	0.2	-0.1	-0.1
GDP, mainland	-0.4	0.3	-0.1	-0.1
Fixed capital stock	-0.5	-0.5	-0.1	0.1
Total employment, man-hours	1.5	0.0	-0.1	-0.1
Government sector	0.0	0.0	0.0	0.0
Private business sector	2.1	-0.1	-0.1	-0.1
Manufacturing	12.6	-1.2	-0.7	-0.7
Price indices:				
Hourly wages	4.7	0.6	0.4	0.4
Consumer price index	4.0	0.6	0.3	0.3
Price of capital goods	1.4	0.6	0.3	0.3
Percent of GDP:				
Trade surplus	35.0	-1.9	-4.3	1.5
Current account	33.3	0.5	0.7	0.6
Net foreign wealth, Norway	1.2	6.1	3.1	1.2

Table 3.8. Macroeconomic effects of a 10 percent rise in world prices of exports. Permanent unanticipated shift from period 10. Percentage deviation from reference scenario

Years after exogenous change	10	11	20	30	48
Constant prices:					
Private consumption	4.1	3.4	3.4	3.4	3.4
General government consumption	-0.2	-0.3	-0.3	-0.2	-0.2
Gross fixed investment	12.5	7.0	3.9	3.1	1.8
Manufacturing	20.5	29.4	8.0	7.0	13.5
Dwellings	3.4	7.7	4.3	2.8	2.3
Other mainland industries	26.4	4.0	4.1	3.7	2.3
Exports	2.3	3.7	5.1	5.1	5.0
Imports	16.7	13.8	12.8	12.7	12.5
GDP	0.8	0.6	0.7	0.6	0.2
GDP, mainland	0.9	0.6	0.7	0.6	0.2
Fixed capital stock	0.7	1.1	2.4	2.6	2.2
Total employment, man-hours	0.4	0.2	0.0	-0.2	-0.5
Government sector	0.0	0.0	0.0	0.0	0.0
Private business sector	0.5	0.3	-0.1	-0.3	-0.8
Manufacturing	-2.8	-2.0	-1.6	-2.1	-3.2
Price indices:					
Hourly wages	15.4	14.8	13.9	13.6	12.9
Consumer price index	9.4	8.8	8.1	8.1	8.1
Price of capital goods	9.2	9.1	8.8	9.1	9.0
Percent of GDP:					
Trade surplus	-24.5	-0.2	-253.5	-28.2	-5.2
Current account	-18.7	-9.0	-3.8	-2.1	11.9
Net foreign wealth, Norway	-12.9	-12.0	-8.9	-6.6	-4.2

This simulation can be understood as a combination of two shifts: a) an unanticipated increase in export prices in period 1; b) an anticipated and permanent reversal of export prices back to the reference levels from period 2. The broad picture of the dynamics is that the economy unexpectedly faces a sharp increase in the return to export oriented production. Indeed, the *endogenous* part of total exports expands by 26.7 percent in the period in which the export prices are 10 percent above the reference level. This is the reason why *total* exports increase by 11.7 percent in this period. At the outset the wealth effect gives the consumer an incentive to raise private consumption and reduce labour supply. Therefore, at the initial relative prices and investment level the export expansion leads to excess demand for labour in period 1. The labour market is balanced through an increase in the wage rate in this period. The equilibrium adjustment is 4.7 percent. This modifies the export expansion and stimulates labour supply, which increases by 1.5 percent in period 1.

However, the wage adjustment is transitory because the sudden increase in the return to export production is transitory. And, importantly, consumers and investors are now aware of this from period 1. Specifically, consumers know that the prices of leisure and consumer goods will be particularly high in period 1, and they

postpone consumption and leisure to later periods. Also investors/producers know that the prices of capital goods will be exceptionally high in period 1, which means that they clairvoyantly foresee the negative capital gain of buying capital goods in period 1. Rather, they reduce investment below the replacement level in period 1. Investors prefer to change their composition of assets from fixed capital goods to financial assets, i.e. financial claims on foreigners. The increase in net exports, together with the transitory rise in the export prices, is exactly the way in which these financial claims on foreigners are acquired without unemployment. In the subsequent periods the fixed capital stock is built up to the long run level, which is almost the same as in the reference scenario. Simultaneously, the value of net exports is reduced below the reference level. This is feasible without violating the long run budget constraint on foreign debt, since the increase in the value of net imports is financed by interest on the financial assets acquired in period 2.

3.3.1.C. Permanent unanticipated shift from period 10
Compared to the corresponding permanent shift from period 0, the TOT gain is reduced when the shift is postponed by 10 years. Compared to experiment A, the present simulation experiment may also be considered as a drop in national income due to 10 years with lower export prices. The equilibrium adjustments take of

course into account that this TOT loss during the first 10 years is subject to relatively low discounting. Moreover, the very profitable production of crude oil is largest in these years, which means that the petroleum wealth is more reduced than if the oil production were constant along the reference path.

However, the long run changes in the main macro-economic aggregates are quite similar to the results obtained when export prices increased from period 0, see table 3.8. Now private consumption ends up 3.4 percent above the reference path, compared to 3.8 percent when the shift was implemented in period 0. In addition the consumer cannot afford the same increase in leisure, since employment now is reduced by 0.5 percent rather than by 0.8 percent in experiment A. Not surprisingly, the difference between the two simulation experiments is largest for exports and imports. Net exports cannot be reduced as much as in the case of greater TOT improvement. However, the economy becomes even more open in the sense that the long run increase in exports is stronger in the present shift than in experiment A. The reason is that export is the most price sensitive component in the current account. Since the shift is unanticipated, the dynamics is of the same type as described in the case with full TOT gain, from the period in which the shift sets in.

3.3.1.D. Permanent anticipated shift from period 10
Producers and consumers have model consistent expectations and foresee the rise in all export prices 10 years ahead at the start of the simulation period. Specifically, the consumer realizes in period 0 that he will become more wealthy due to the TOT gain 10 years ahead and in every years onwards. Thus, in contrast to the case where the same shift is unantici-pated, he/she starts to enjoy the improved consump-tion possibilities at once by raising private consump-tion by 4.4 percent and reduce labour supply by 1.5 percent, see Table 3.9. However, ignoring second order effects, the present value of the additional resources transferred from foreigners to the Norwegian consumer through the TOT gain is the same as when the increase in export prices is unanticipated. Therefore, the *annual* increase in consumption and leisure is smaller when the extra consumption possibilities are spread over 10 more years. Also recall that the increase in consump-tion and loss in labour income is least discounted in the first 10 years. These points are reflected by the long run effects: When the TOT gain is unanticipated the stationary increase in private consumption equals 3.4 percent compared to the reference scenario, whereas the corresponding increase is 2.6 percent when agents get information in period 0 about the TOT gain in period 10. The long run effects for labour supply in the unanticipated and the anticipated case are, respectively, -0.5 and -0.2 percent.

Table 3.9. Macroeconomic effects of a 10 percent rise in world prices of exports. Permanent anticipated shift from period 10. Percentage deviation from reference scenario

Years after exogenous change	0	1	9	10	11	48
Constant prices:						
Private consumption	4.4	3.6	4.6	2.3	3.0	2.6
General government consumption	-0.2	-0.2	-0.4	-0.1	-0.1	-0.2
Gross fixed investment	4.0	3.9	14.7	4.6	2.2	1.9
Manufacturing	591.0	-5.0	22.6	181.4	16.5	10.3
Dwellings	61.6	10.6	9.6	-39.1	-4.1	2.2
Other mainland industries	1.7	1.8	25.2	5.8	6.3	2.7
Exports	-6.3	-6.2	-7.9	7.8	8.2	7.8
Imports	2.1	2.0	6.3	14.3	12.8	11.4
GDP	0.1	-0.3	1.1	0.7	1.1	0.5
GDP, mainland	0.1	-0.3	1.2	0.7	1.3	0.5
Fixed capital stock	0.3	0.5	3.5	3.6	3.5	1.9
Total employment, man-hours	-1.5	-1.6	-0.6	0.5	0.5	-0.2
Government sector	0.0	0.0	0.0	0.0	0.0	0.0
Private business sector	-2.2	-2.2	-0.9	0.8	0.7	-0.2
Manufacturing	-9.9	-9.8	-10.0	3.2	2.9	0.3
Price indices:						
Hourly wages	7.2	7.1	8.6	12.1	12.0	11.0
Consumer price index	3.7	3.6	3.4	6.2	6.2	6.9
Price of capital goods	4.5	4.4	5.7	6.3	6.5	7.7
Percent of GDP:						
Trade surplus	-18.4	-22.0	-79.3	25.1	41.1	-12.5
Current account	-19.1	-22.8	-53.5	-10.9	-7.2	9.9
Net foreign wealth, Norway	-8.1	-10.6	-26.1	-27.9	-26.9	-10.1

Another striking difference brought about by the shift in information about the increase in export prices from period 10, is that firms start to accumulate fixed capital once they get the information. They foresee that the real wage rate will rise in order to bring about the real-locations necessary to benefit from the TOT improve-ment, and that it will be profitable to equip each worker with more capital than in the reference scenario. The user cost of capital will now include a significant expected capital gain element, reflecting that the prices of capital goods will increase over time in this scenario. The magnitude of this expected increase in the capital goods prices increase over time as the economy approaches the year when export prices actually shift upward. Thereafter, expected capital gains diminish rapidly. Higher expected capital gains reduce the user cost of capital compared to the reference scenario and explains why investment increase in the first years. Relative to the reference scenario, the increase is close to 4 percent in the first couple of years rising to nearly 15 percent in the last years prior to the actual rise in export prices. This means that a large share of the optimal investments is carried out prior to period 10, and that investments after period 10 are smaller than in the scenario in which investors do not anticipate the shift in export prices.

Investments differ significantly across industries. Invest-ments fall below the replacement level in manufacturing

industries[3], whereas capacity is accumulated in the service industries. In general resources are reallocated from manufacturing industries to the private service sector during the first 10 years. The changes in employment by industry reflect this pattern; prior to the export price shift manufacturing employment falls by about 10 percent, whereas employment is approximately unaffected in private service industries. These reallocations are reversed in the years after the shift in export prices. They are necessary supply side adjustments to the dynamic changes in investment and consumption demand.

The rise in private consumption and investments implies excess demand for labour, especially in the first years when labour supply drops, and the installation of new optimal capital stock has not yet been completed. It is natural to interpret the increase in the wage rate by 7-8 percent in the years 1-10 as the mechanism that balances the labour market. As a result net exports is crowded out. Especially, this takes place through reduced gross exports, which falls by 6-8 percent in the years prior to the rise in export prices. The endogenous part of total exports is largely produced in manufacturing industries. This explains why resources are removed from manufacturing industries during the first part of the scenario.

After the increase of 10 percent in export prices in period 10, there is room for a stronger increase in the wage rate. It exceeds the time path in the reference scenario by 11-12 percent after period 10. But the increase in the wage rate is modified by the need for expansion of net exports in the remaining part of the scenario. The long run increase in exports is almost 8 percent in this simulation, whereas the corresponding increase varied around 5 percent in the simulation where the shift was unanticipated. The additional increase in net exports, which largely takes place by expanding gross exports, is required to restore the long run external balance; compared to the case where the shift was unanticipated, the extra net imports over the first 10 years plus interest must be repaid by extra net exports in the rest of the scenario.

Since most commodity prices are positively related to the wage rate, depending on the direct and indirect cost share of wages, prices are in general higher after the rise in export prices than ex ante. In particular, both the rise in the price of leisure (i.e. the wage rate) and the price index of private consumption contribute to make the full consumption, i.e. the aggregate of leisure and private consumption, more expensive after

period 10 than in the first 10 years of the scenario. The intertemporal substitution induced by this price dynamics explains why private consumption increases and labour supply falls more during the first 10 years than after the export price shift.

The fact that the user cost of capital is reduced by the expected capital gains in the first 10 years of the scenario, contributes to this broad pattern of private consumption dynamics. However, the dynamics of the capital costs also explains the more detailed intertemporal changes in private consumption over the first 10 years. As noted above the expected capital gains are strongest in the first year and in the last years prior to the increase in export prices (which generates the general rise in all prices and the wage rates through correctly foreseen equilibrium effects). It follows that the user cost of capital is lower in these periods compared with other periods, and these cost variations are transmitted to the prices of home goods. Of particular importance in this respect is the strong influence of capital costs in the price of Dwellings.

3.3.2. Effects of a general rise in world prices of imports by 10 percent

The effects of the exogenous shift are measured as percentage deviations from the reference scenario. Even if the absolute change is moderate, the percentage deviation will be very large if the reference value is small. Moreover, a positive absolute change will result in a negative percentage deviation if the reference value is negative. Such results are often found for gross fixed investment in specific industries and for the trade surplus.

3.3.2.A. Permanent unanticipated shift from period 0
This shift exemplifies a loss in terms-of-trade (TOT) from period 0 to "eternity". In addition, the rise in import prices affects the relative price structure, resulting in a new composition of factors of production and of private consumption of goods and leisure. As shown in Table 3.10 the TOT loss results in lower consumption and leisure. The long run effect on consumption possibilities is of the same magnitude with opposite sign as an equivalent shock to the export price. This reflects that foreign trade is balanced in present value terms in all scenarios, and the initial financial wealth is small compared to the present value of exports/imports. The subsequent interpretation of the results concentrates on how agents and the main markets in the economy adjust to the negative wealth effect caused by the TOT deterioration. We focus on the following points:
1. The activity level measured by GDP is almost unaffected.
2. The economy becomes less open in the sense that both imports and exports fall.
3. The real wage rate declines.

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[3] Note that the increase from the reference path in manufacturing gross investment of 591.1 percent in 2003 reflects that the simulated gross investment level is negative in the reference scenario. In absolute terms manufacturing gross investment falls by 20.5 billions. Such a dramatic change is obviously unrealistic and illustrates that MSG6 abstracts from irreversibility problems and costs of reallocating resources between industries.

Table 3.10. Macroeconomic effects of a 10 percent rise in world prices of imports. Permanent unanticipated shift from period 0. Percentage deviation from reference scenario

Years after exogenous change	0	1	10	20	48
Constant prices:					
Private consumption	-5.0	-4.1	-4.1	-4.0	-3.8
General government consumption	0.2	0.3	0.3	0.2	0.2
Gross fixed investment	-11.5	-6.0	-3.8	-3.2	-1.5
Manufacturing	28.4	-19.9	-6.3	-5.1	-13.9
Dwellings	-35.2	-6.0	-4.6	-3.3	-1.9
Other mainland industries	-13.3	-8.1	-4.4	-4.1	-2.0
Exports	-0.9	-1.8	-3.5	-3.5	-2.5
Imports	-13.9	-11.4	-11.6	-11.3	-11.4
GDP	-1.3	-0.8	-1.0	-1.0	-0.3
GDP, mainland	-1.5	-0.9	-1.1	-1.0	-0.3
Fixed capital stock	-0.7	-1.0	-2.4	-2.7	-2.2
Total employment, man-hours	-0.1	0.0	0.2	0.4	0.7
Government sector	0.0	0.0	0.0	0.0	0.0
Private business sector	-0.2	0.1	0.3	0.5	1.1
Manufacturing	2.8	2.6	2.5	3.3	5.8
Price indices:					
Hourly wages	-5.8	-5.3	-4.8	-4.6	-4.2
Consumer price index	0.4	0.8	1.4	1.3	0.7
Price of capital goods	0.8	1.2	1.1	0.7	0.1
Percent of GDP:					
Trade surplus	10.6	3.9	-2.8	114.2	0.8
Current account	11.1	4.6	1.3	-0.5	-16.0
Net foreign wealth, Norway	5.8	5.0	3.4	2.0	0.2

This intertemporal budget constraint on net foreign debt - the external balance - is violated by the general increase in import prices for three main reasons. First, a higher price must be paid for the initial imported quantities. Secondly, households and firms substitute home goods for imports. Thirdly, the cost effect of higher import prices reduces export supplies, because imported products are used both directly and indirectly as factors of production. The indirect use follows from the input-output structure of the economy, combined with endogenous mark-up pricing of domestic deliveries of most products. To maintain the external balance the economy must adjust to the TOT loss by raising the (volume of) exports relative to the (volume of) imports.

The external balance can in principle be restored by a) a decrease in domestic absorption, which reduces the demand for imports at given relative prices; b) a fall in the wage rate, which raises export supplies and leads to substitution of home goods for imports. In equilibrium the economy chooses a combination of these two mechanisms. The reason is that the fall in the wage rate, *cet. par.*, creates excess labour demand. Labour demand increases due to factor substitution, reallocation of resources in favour of the most labour intensive goods/industries, especially the traded goods industries. Moreover, the wage reduction causes households to reduce labour supply as the substitution

effect dominates the income effect. Therefore, a fall in both consumption and the wage rate is necessary in order to restore *both* labour market equilibrium and the external balance when import prices increase. In the long run private consumption is 3.8 percent lower than in the reference scenario. The long run reduction of the wage rate is 4.2 percent.

The wage rate reduction is not sufficient to prevent (gross) exports from falling. This is an equilibrium adjustment. It reflects that the total import in volume terms falls by more than 10 percent, so that the aggregate import expenditure is reduced by higher import prices. However, this result reflects empirical characteristics of MSG6 (or in more offensive terms: empirical characteristics of the Norwegian economy captured by MSG6), it is not a general property of open economy models with the same structure as MSG6. On one hand, the wage rate reduction must neutralise the negative import price effects on the external balance. On the other hand, at given prices the required wage reduction is modified by the equilibrium reduction in domestic absorption, including investment and intermediate inputs in addition to consumption. It turns out that the latter effect is strong enough to generate a new equilibrium in which the aggregate import value in current prices is lower than in the reference path. Combining this result with the external balance constraint explains the decline in total exports.

Both higher import prices and the decrease in the wage rate reduce the real consumer wage rate, which in turn contributes to reduce labour supply. On the other hand the TOT loss also reduces non-labour income (capital income and cash transfers), which *cet. par* stimulates labour supply. The small increase in employment shows that the total income effect of reduced labour- and non-labour income weakly dominates the substitution effect. Employment increases by 0.7 percent in the long run.

Firms find it profitable to reduce the capital-labour ratio as a response to the fall in the ratio of wages to the cost of capital. This substitution effect dominates the scale effect on the capital stock caused by the slight increase in employment. The long run reduction in the real capital stock is 2.2 percent. The reduction in the capital stock implies lower replacement investment. In the long run investment is reduced by 1.5 percent. The difference between the change rates for capital and investment reflects an increase in the average depreciation rate. The main reason is the reduction in the share of the relatively long-lived housing capital caused by the fall in private consumption. The slight increase in employment and the decrease in real capital leave GDP almost unaffected; in the long run GDP has become 0.3 percent lower than in the reference scenario.

Table 3.11. Macroeconomic effects of a 10 percent rise in world prices of imports. Transitory unanticipated shift in period 1 only. Percentage deviation from reference scenario

Years after exogenous change	1	2	10	48
Constant prices:				
Private consumption	-4.2	1.6	-0.1	-0.1
General government consumption	0.2	0.3	0.0	0.0
Gross fixed investment	-26.0	14.0	0.2	0.0
Manufacturing	-129.7	63.9	0.4	-0.2
Dwellings	21.2	-38.2	0.3	0.0
Other mainland industries	-87.2	59.4	0.1	0.0
Exports	-4.5	-2.4	0.1	0.2
Imports	-20.8	7.4	0.0	-0.1
GDP	-3.1	0.6	0.0	0.0
GDP, mainland	-3.7	0.7	0.0	0.0
Fixed capital stock	-1.5	-0.5	-0.1	0.0
Total employment, man-hours	-2.7	0.4	0.0	0.0
Government sector	0.0	0.0	0.0	0.0
Private business sector	-3.8	0.6	0.1	0.0
Manufacturing	-4.5	-1.3	0.1	0.3
Price indices:				
Hourly wages	-3.8	1.2	-0.1	-0.1
Consumer price index	1.5	1.2	0.0	-0.1
Price of capital goods	1.9	0.6	0.0	-0.1
Percent of GDP:				
Trade surplus	19.5	-23.4	0.3	-0.5
Current account	19.4	-20.5	-0.6	-0.3
Net foreign wealth, Norway	7.3	-2.5	-1.0	-0.4

Table 3.12. Macroeconomic effects of a 10 percent rise in world prices of imports. Permanent unanticipated shift from period 10. Percentage deviation from reference scenario

Years after exogenous change	10	11	20	30	48
Constant prices:					
Private consumption	-4.7	-3.8	-3.8	-3.8	-3.6
General government consumption	0.2	0.3	0.3	0.2	0.2
Gross fixed investment	-11.1	-6.8	-3.8	-2.9	-1.5
Manufacturing	-3.8	-25.2	-5.9	-4.5	-13.5
Dwellings	-11.4	-7.1	-4.2	-2.7	-2.0
Other mainland industries	-18.1	-5.0	-4.4	-4.0	-2.1
Exports	-0.9	-2.2	-3.6	-3.4	-2.9
Imports	-14.2	-12.0	-11.3	-11.2	-11.2
GDP	-1.2	-0.8	-0.9	-0.8	-0.3
GDP, mainland	-1.3	-0.9	-1.0	-0.8	-0.4
Fixed capital stock	-0.7	-1.0	-2.3	-2.5	-2.2
Total employment, man-hours	-0.1	0.0	0.3	0.4	0.7
Government sector	0.0	0.0	0.0	0.0	0.0
Private business sector	-0.1	0.1	0.4	0.6	1.0
Manufacturing	3.9	3.3	3.1	3.8	5.3
Price indices:					
Hourly wages	-5.6	-5.1	-4.5	-4.3	-3.9
Consumer price index	-0.1	0.5	1.2	1.1	0.9
Price of capital goods	0.1	0.5	0.7	0.4	0.3
Percent of GDP:					
Trade surplus	33.4	10.3	116.9	13.7	1.9
Current account	17.1	7.2	1.2	-0.1	-15.1
Net foreign wealth, Norway	5.4	4.6	3.5	2.4	1.1

3.3.2.B. Transitory unanticipated shift in period 1 only
The negative wealth effect on private consumption and leisure is obviously much smaller in this experiment than in experiment A, since the TOT loss accrues in the first year only. For the same reason, the necessary adjustments in order to restore general equilibrium, in particular the external trade balance and the labour market equilibrium, are much smaller and hardly visible in Table 3.11. Private consumption is reduced by 0.06 percent in the long run. The corresponding increase in labour supply equals 0.03 percent.

Households and firms are surprised by the rise in import prices, but they foresee that these prices return to their reference paths after the first year. Households adjust their time profile of full consumption, i.e. the utility index of private consumption and leisure, to the dynamics of the new equilibrium price index of this aggregate. Intertemporal substitution results in a much stronger decline in private consumption (4.2 percent) in the year in which import prices are particularly high, than in the subsequent years. This intertemporal substitution effect applies also to labour supply. However, it is dominated by the intratemporal effect caused by the particularly strong reduction of the consumer real wage rate in the first year.
The temporary rise in the import prices also causes a temporary change in the composition of the aggregate wealth of the economy. In period 1, real capital is

particularly expensive because a) the prices of capital goods unexpectedly rise depending on their direct and indirect import shares; b) the expected reversal of import prices implies negative capital gains for the owners of real assets. Both effects contribute to generate a 26 percent drop in investment in the year the shift is instigated. This is matched by an increase in the net financial wealth through a 19.5 percent increase in the current account surplus. In the subsequent period, the prices of capital goods are closer to the corresponding levels in the reference path. However, the investment response is not symmetric to the one in period 1, because the expected capital gains are now a result of general equilibrium effects and much smaller. Firms gradually reinstall the capital stock sold and depreciated in period 1.

3.3.2.C. Permanent unanticipated shift from period 10
Until period 10 all variables follow the same path as in the reference scenario. The effects are qualitatively the same as in experiment A. However, since the shift is instigated after ten years the TOT loss is lower than in experiment A, because fewer periods are affected by the increased price of imports. Compared to a situation in which agents are informed in period 0 about the future exogenous shift, see Section D below, consumption and leisure is higher in the first 10 years. Consumers must pay for their overly optimistic expectations about the TOT in the years after the shift. The

long run decline in consumption is 3.6 percent, see Table 3.12, which is only slightly less than the decline in experiment A, despite the fact that the present value of the TOT loss is much greater when it also accrues in the first 10 years. The long run increase in labour supply is also approximately the same as in shift A.

3.3.2.D. Permanent anticipated shift from period 10
Producers and consumers have model consistent expectations and they are now also assumed to foresee correctly the exogenous permanent rise in all import prices from period ten. Specifically, the consumer realizes in period 0 that he will become less wealthy due to the TOT loss from period ten and all years henceforth. Thus, in contrast to the case where the same shift is unanticipated, agents reduce consumption and leisure over the entire path. In period 0 consumption is 2.3 percent lower and labour supply 1 percent higher than the reference scenario, see Table 3.13. However, ignoring second order effects, i.e. endogenous changes in the export and import volumes, the present value of the TOT loss is the same as when the increase in import prices is unanticipated. Therefore, the *annual* reduction in consumption and leisure is now smaller after period 10 compared to shift C, since the loss of consumption possibilities is spread over 10 extra years. When the TOT loss is unanticipated the stationary reduction in private consumption equals 3.6 percent compared to the reference scenario, whereas the corresponding reduction is 3.2 percent when the TOT gain is anticipated from period 0. Analogously, the long run increase in labour supply in the unanticipated and the anticipated case is 0.7 and 0.5 percent, respectively.

The reduction in leisure and consumption in the first 10 years implies an increase in private saving. Basically the additional saving takes the form of accumulation of foreign financial assets until period 9, whereas the capital stock is almost unaffected in the first 8 year. However, in period 9, i.e. the year prior to the rise in import prices, investment increases sharply by 14.1 percent because investors then face relatively large capital gains due to their anticipation of the rise in import prices in next year. In the first eight years two effects on the capital stock approximately cancel out: First, higher employment raises the demand for fixed capital at given factor prices. Second, as will be explained below, the wage rate falls in all periods relatively to product prices, including the price of capital goods. As long as there are small changes in expected capital gains, firms reduce their capital intensity.

After period 10 the economy starts to consume the accumulated assets and additional interest. This decumulation of assets takes place even though the percentage decrease in private consumption is stronger after period 10 than prior to the import price shift. What happens is that the increase in labour supply is

Table 3.13. Macroeconomic effects of a 10 percent rise in world prices of imports. Permanent anticipated shift from period 10. Percentage deviation from reference scenario

Years after exogenous change	0	1	9	10	11	48
Constant prices:						
Private consumption	-2.3	-1.9	1.1	-5.6	-3.5	-3.2
General government consumption	0.0	0.0	0.0	-0.1	0.2	0.2
Gross fixed investment	-0.3	-0.2	14.1	-19.2	-8.0	-1.6
Manufacturing	-299.2	4.2	67.9	-78.5	-55.3	-12.3
Dwellings	-28.5	-2.3	-21.2	30.0	-3.7	-2.0
Other mainland industries	3.4	1.0	45.1	-65.9	-4.1	-2.3
Exports	3.1	3.1	3.9	0.9	-2.1	-4.4
Imports	-0.5	-0.5	8.3	-18.4	-12.2	-10.7
GDP	0.0	0.3	2.3	-1.6	-0.8	-0.5
GDP, mainland	0.0	0.3	2.6	-1.7	-0.8	-0.5
Fixed capital stock	0.0	0.0	1.1	-0.1	-0.6	-2.0
Total employment, man-hours	1.0	1.1	2.3	-0.5	-0.2	0.5
Government sector	0.0	0.0	0.0	0.0	0.0	0.0
Private business sector	1.4	1.5	3.2	-0.8	-0.3	0.7
Manufacturing	5.2	5.2	6.1	3.3	2.1	3.2
Price indices:						
Hourly wages	-3.1	-3.0	-1.0	-5.3	-4.2	-2.8
Consumer price index	-1.6	-1.6	-1.0	-0.5	0.7	1.6
Price of capital goods	-1.7	-1.6	-1.0	0.1	1.1	1.0
Percent of GDP:						
Trade surplus	8.4	10.1	-22.0	75.1	12.1	6.0
Current account	8.7	10.4	-5.5	40.5	14.1	-12.9
Net foreign wealth, Norway	3.6	4.7	5.5	14.2	12.2	4.4

significantly lower. The explanation is that the rise in import prices reduces the real wage rate, so that after period 10 the total income effects and the substitution effect approximately cancel out. The reduction of labour supply reduces the demand for capital, as well as output. Moreover, higher import prices strengthen the incentive to reduce the capital intensity of the factor input. In the long run the real capital stock is reduced by about 2 percent from the reference scenario.

The increase in the net foreign wealth during the first 10 years of the new scenario requires an increase in net exports. This is brought about by the reduction of consumption, which, *cet. par*, reduces imports, and an improvement of the international competitiveness through a fall in the wage rate by 1.0 - 3.0 percent over the first 10 years. This boosts exports and reduces price dependent import shares. The rise in exports is 3 - 4 percent in these years. In the years after period 10 exports fall by about 4.4 compared to the reference scenario. The reason why firms decide to reduce exports from period 10 and henceforth is the cost effect of higher import prices. The decrease in imports is moderate during the first years, as long as import prices follow their reference paths. In period 9 the investment boom triggers a sharp increase in imports. After period 10 import is reduced by almost 11 percent due to a) lower consumption, investment and

Table 3.14. Macroeconomic effects of a 10 percent rise in world prices of exports and imports. Permanent unanticipated shift from period 0. Percentage deviation from reference scenario

Years after exogenous change	0	1	10	20	48
Constant prices:					
Private consumption	0.1	-0.4	-0.2	-0.2	-0.1
General government consumption	0.1	0.0	0.0	0.0	0.0
Gross fixed investment	-1.5	0.1	0.0	0.1	0.1
Manufacturing	206.2	19.1	-0.3	-0.1	-0.7
Dwellings	54.0	-23.8	0.3	0.4	0.1
Other mainland industries	-33.8	28.7	-0.2	-0.2	0.1
Exports	-0.4	0.0	0.2	0.2	0.4
Imports	-0.4	0.1	0.0	0.0	0.0
GDP	-0.3	-0.2	0.0	0.0	0.0
GDP, mainland	-0.3	-0.3	0.0	0.0	0.0
Fixed capital stock	-0.1	-0.1	0.0	0.1	0.1
Total employment, man-hours	-0.3	0.0	0.1	0.1	0.0
Government sector	0.0	0.0	0.0	0.0	0.0
Private business sector	-0.4	0.0	0.1	0.1	0.1
Manufacturing	-1.0	0.0	0.1	0.2	0.3
Price indices:					
Hourly wages	8.8	9.5	9.5	9.5	9.5
Consumer price index	9.5	9.8	9.7	9.7	9.6
Price of capital goods	10.3	9.9	9.9	9.9	9.8
Percent of GDP:					
Trade surplus	0.4	0.2	1.2	-17.7	-0.5
Current account	0.2	-0.1	-0.3	-0.7	-0.2
Net foreign wealth, Norway	-6.2	-5.2	-2.0	-1.4	-0.8

intermediate inputs; b) lower import shares due to the rise in import prices and the decrease in the wage rate.

The endogenous part of total exports is largely produced in manufacturing industries, which explains why the strongest increase in employment is seen here (above five percent in all periods before period 10). Note that the effect of higher labour intensity in the input composition dominates the negative scale effect on manufacturing employment caused by the decrease in exports after period 10.

3.3.3. Effects of a general rise in world prices of exports and imports by 10 percent

The effects of the exogenous shift are measured as percentage deviations from the reference scenario. Even if the absolute change is moderate, the percentage deviation will be very large if the reference value is small. Moreover, a positive absolute change will result in a negative percentage deviation if the reference value is negative. Such results are often found for gross fixed investment in specific industries and for the trade surplus.

3.3.3.A. Permanent unanticipated shift from period 0
In a hypothetical situation without any financial claims on foreigners, a proportional shift in all world prices of exported and imported products in all periods is equivalent to a permanent change in the nominal

exchange rate. This would be a purely monetary phenomenon without real effects in a general equilibrium model such as MSG6. The only result would have been a proportional increase in all other prices, including the wage rate. However, along the reference scenario, which satisfies the intertemporal budget constraint for the economy, the value of imports exceeds the value of exports in present value terms due to the presence of initial wealth. Thus a proportional shift in world prices is not equivalent to a similar change in the nominal exchange rate, but implies a terms-of trade (TOT) loss. Since the initial wealth is small relative to the present value of imports, the exogenous TOT loss is small; the numerical results are quite close to zero, at least for the macroeconomic key variables. In the long run private consumption is reduced by 0.14 percent, labour supply is increased by 0.04 percent and GDP is reduced by 0.02 percent, see Table 3.14.

The intertemporal budget constraint can in principle be restored by a) a reduction of domestic absorption, which reduces the demand for imports at given relative prices; b) a fall in the wage rate, which raises export supplies and reduces price dependent import shares. In equilibrium the economy chooses a combination of the mechanisms a) and b). The reason is that the fall in the wage rate, *cet. par.*, creates excess labour demand. Labour supply is increasing in the wage rate as the substitution effect dominates the income effect, and firms are motivated to increase the labour intensity of their aggregate input. Therefore, a contraction of consumption is necessary in order to restore labour market equilibrium. Lower consumption implies, *cet. par*, less imports. These adjustments also reflect that the TOT loss reduces non-labour income. This income effect explains why the necessary increase in the wage rate is slightly less than 10 percent (9.5 percent). The under proportional increase in the wage rate generates the real exchange rate depreciation necessary to restore the intertemporal budget constraint without unemployment. Since the combined cost effect of higher import prices and wages is slightly smaller than the 10 percent increase in export prices, firms find it profitable to redirect output from consumption to exports.

The negative labour supply effect that can be attributed to the small decrease in the consumer real wage rate is slightly dominated by the income effects from the TOT loss. This loss affects the consumer through a reduction in the real value of non-labour income, including capital income and various cash transfers. The capital stock is slightly increased in the long run, reflecting basically a reallocation of labour into relatively more capital intensive sectors. It is somewhat surprising that investments in Dwellings sector increases in the long run, since private consumption falls. The reason is a substitution effect. Wages represent a relatively large fraction of the costs in this extremely capital intensive sector when the input-output structure is accounted for. Since wages

increase less than import prices, the relative price of Housing services falls relatively to the prices of other consumer goods.

3.3.3.B. Transitory unanticipated shift in period 1 only
In period 1 there was a trade surplus in the Norwegian economy. Consequently, a proportional shift in all world prices of exports and imports in this particular year only implies *improved* terms-of-trade (TOT), whereas a permanent shift in the same prices implied a TOT loss. The long run effects of such a temporary TOT gain are due to the effect on consumers' wealth. The wealth effect implied by a 10 percent increase in all export and import prices in 2002 is very small. The long run increase in private consumption is 0.1 percent compared to the reference scenario. The long run effects on employment, the stock of fixed capital and GDP are too small to be visible in Table 3.15. Free access to capital markets and preferences for consumption smoothing dampen the effects on private consumption and labour supply in other years too. In the following we therefore focus on the dynamics caused by the shift.

The temporary shift causes strong but mainly transitory effects on the composition of the national savings and wealth. Relative to the reference scenario, gross investment drops by 37.2 percent in period 1, only to increase to 16 percent above the reference scenario the following year. This is matched by an increase in the current account surplus of 53.2 percent in period 1 followed by a reversal to 19.9 percent below the reference scenario in period 2. The investment dynamics can be explained as follows: In period 1, real capital is particularly expensive because a) the prices of capital goods unexpectedly rise depending on their direct and indirect import shares; b) the expected reversal of import prices implies negative capital gains for the owners of real assets. In the subsequent period, the prices of capital goods are closer to (but not exactly equal to) the corresponding levels in the reference path as world prices return to their reference paths. However, the investment response is not symmetric to the one in period 1 because the expected capital gains are now a result of general equilibrium effects and much smaller. Firms gradually reinstall the capital stock sold and depreciated in period 1.

Note that the increase in investment in period 2 to 9 takes place in spite of a simultaneous reduction of the capital stock. The reason is that the composition of the aggregate capital stock changes in favour of capital items with relatively high depreciation rates. Especially investment in long-lived Dwellings decreases in period 2. The investment dynamics for Dwellings reflect the dynamic changes in the price of Housing services relative to other prices of consumer goods. The price of Housing services is relatively more dependent on the wage rate than other consumer goods when the input-output structure of the production sector is taken into account.

Table 3.15. Macroeconomic effects of a 10 percent rise in world prices of exports and imports. Transitory unanticipated shift in period 1 only. Percentage deviation from reference scenario

Years after exogenous change	1	2	10	48
Constant prices:				
Private consumption	-5.3	1.6	0.0	0.1
General government consumption	0.8	0.1	0.0	0.0
Gross fixed investment	-37.2	16.1	0.5	0.0
Manufacturing	-61.6	10.7	0.1	0.3
Dwellings	16.1	-88.5	1.1	0.0
Other mainland industries	-150.1	127.5	0.3	0.0
Exports	6.0	-2.6	-0.5	-0.3
Imports	-14.2	7.7	0.1	0.1
GDP	-3.7	0.8	-0.1	0.0
GDP, mainland	-4.4	1.0	-0.1	0.0
Fixed capital stock	-2.2	-1.1	-0.3	0.0
Total employment, man-hours	-1.9	0.7	0.0	0.0
Government sector	0.0	0.0	0.0	0.0
Private business sector	-2.7	1.0	-0.1	-0.1
Manufacturing	5.9	-1.2	-0.6	-0.4
Price indices:				
Hourly wages	-0.7	2.5	0.3	0.2
Consumer price index	5.1	2.1	0.3	0.2
Price of capital goods	3.5	0.8	0.3	0.2
Percent of GDP:				
Trade surplus	55.0	-25.2	-3.9	0.9
Current account	53.2	-19.9	0.0	0.3
Net foreign wealth, Norway	9.1	3.2	2.0	0.7

The dynamics of the trade- and current account surplus reflects the investment dynamics and the consumption smoothing that follows from preferences and free access to international capital markets.

Households, like firms, are surprised by the rise in import prices, but they foresee that these prices return to their reference paths after the first year. Households adjust their time profile of full consumption, i.e. the utility index of private consumption and leisure, to the dynamics of the new equilibrium price index of this aggregate. Intertemporal substitution results in a decline in private consumption (5.3 percent) in period 1, i.e. the year with particularly high import prices. In the subsequent years the combined effect of the TOT gain and savings in period 1 allows households to raise their consumption in the subsequent years. This intertemporal substitution effect applies also to labour supply. However, it is dominated by the intratemporal effect caused by the reduction of the consumer real wage rate in the first year. In the subsequent years the intratemporal substitution effect exactly outweighs the wealth effect and the intertemporal substitution effect on labour supply.

Table 3.16. Macroeconomic effects of a 10 percent rise in world prices of exports and imports. Permanent unanticipated shift from period 10. Percentage deviation from reference scenario

Years after exogenous change	10	11	20	30	48
Constant prices:					
Private consumption	-0.2	-1.0	-0.5	-0.5	-0.5
General government consumption	0.1	0.0	0.0	0.0	0.0
Gross fixed investment	-2.3	0.3	-0.1	0.0	0.1
Manufacturing	-42.2	42.6	1.0	1.4	-1.7
Dwellings	48.7	-49.9	-0.2	-0.1	0.0
Other mainland industries	-48.2	42.8	-0.4	-0.3	0.2
Exports	-0.1	1.0	1.2	1.3	1.5
Imports	-0.7	0.1	-0.2	-0.2	-0.5
GDP	-0.4	-0.3	0.0	0.0	0.1
GDP, mainland	-0.4	-0.3	0.0	0.0	0.1
Fixed capital stock	-0.1	-0.1	-0.1	-0.1	-0.1
Total employment, man-hours	-0.3	0.2	0.2	0.2	0.2
Government sector	0.0	0.0	0.0	0.0	0.0
Private business sector	-0.4	0.3	0.4	0.4	0.3
Manufacturing	-0.6	1.5	1.4	1.6	1.8
Price indices:					
Hourly wages	7.7	8.7	8.8	8.7	8.6
Consumer price index	9.0	9.3	9.3	9.3	9.1
Price of capital goods	10.1	9.3	9.4	9.3	9.2
Percent of GDP:					
Trade surplus	4.6	7.4	-148.8	-16.1	-3.6
Current account	-3.4	-2.9	-2.7	-2.1	-1.7
Net foreign wealth, Norway	-7.7	-7.6	-5.7	-4.5	-3.3

The reduction of both consumption and investment would result in unemployment in period 1 if resources were not reallocated into net exports. In order to make it profitable for the manufacturing industries and other industries exposed to foreign competition to absorb labour and other input factors, the international competitiveness must be improved. This takes place through a reduction in the wage rate by 0.7 percent in period 1. Exports increase by 6.0 percent, whereas imports decrease by 14.2 percent due to both lower domestic demand and reduced import shares. Unemployment in period 1 is also avoided by the reduction of labour supply caused by the drop in the consumer real wage rate. In subsequent periods the increase in domestic absorption must crowd out net exports. In period 2 also leisure is crowded out.

3.3.3.C. Permanent unanticipated shift from period 10
Since the shift now is unanticipated all variables follow their reference paths until period 10. The net financial wealth held by the domestic economy at the beginning of period 10 is much greater than in period 0. Therefore the present value of the trade deficits computed in period 10 in the reference path is greater than the corresponding present value computed in period 0. The 10 percent permanent rise in all import and export prices therefore yields a TOT loss. Moreover, this loss is greater when it accrues from period 10 than the

economy experiences when the same permanent shift is instigated in period 0.

The long run changes in private consumption and leisure reflect that the TOT loss is greater than in experiment A. Now the long run decline in private consumption is 0.5 percent whereas labour supply increases by 0.2 percent, see Table 3.16. In experiment A the corresponding figures are -0.1 and 0.0 percent. Note that labour supply increases in spite of a reduction in the consumer real wage rate (which is also stronger than in shift A). The reason lies in the reductions of capital income and cash transfers to households, which stimulates labour supply.

The capital stock is slightly reduced in the long run (-0.1 percent) compared to the reference scenario. This reflects a decline in the average capital-labour ratio, which dominates the scale effect from increased employment. The average capital-labour ratio falls for two reasons. First, the price of capital goods increases relatively to the wage rate, which makes it profitable to decrease the capital intensity at the micro level. Secondly, labour and other resources are reallocated into relatively less capital intensive industries. Specifically, resources are removed from the extremely capital intensive Dwellings sector.

3.3.3.D. Permanent anticipated shift from period 10
Ignoring second order effects, i.e. endogenous changes in exports and imports, the TOT loss is the same in this experiment as in experiment C. The difference is that agents are fully informed about the shift in period 0.

Full information about the future change in world prices, as well as model consistent expectations on how the economy responds to these changes, triggers immediate actions by households and firms. The reduction in wealth implied by the present value of the TOT loss motivates *cet. par* households to reduce consumption and leisure in all periods. On the other hand households foresee that, compared to the reference scenario, prices will be significantly higher from period 10 and henceforth than they are prior to period 10. Intertemporal substitution leads *cet. par* to a reallocation of consumption and leisure from years after period 9 to the first nine years. Table 3.17 shows that the intertemporal substitution effect plays a significant role in the determination of the dynamics of the changes in private consumption and labour supply. Private consumption increases prior to period 10. Thereafter private consumption falls. The long run reduction is 0.8 percent from the reference scenario, which is stronger than in experiment C where the same shift in world prices was unanticipated. The reason is of course that households now have reduced their savings in the first nine years, which is the flip side of the intertemporal substitution effect.

Intertemporal substitution also affects labour supply; it increases in the long run and falls in the short run compared to the reference scenario. However, the changes in labour supply are modest. Other mechanisms must have counteracted the intertemporal substitution effect and the wealth effect. The most important one is the intratemporal substitution effect caused by the changes in the real consumer wage rate over time. Table 3.17 shows a significant increase from the reference path in the real wage rate in the first nine years. From period 10 and henceforth, real wages fall compared to the reference scenario. Labour supply is an increasing function of the consumer real wage rate. Therefore, the real wage adjustments stimulate labour supply prior to period 10, whereas the opposite is true from period 10 and all subsequent years. Hence, this effect counteracts the intertemporal substitution effect and the wealth effect, and explains why the net impact on employment is quite small in all years.

Qualitatively the changes in investment follow the same pattern as the changes in private consumption: Firms and households accumulate fixed capital in the years prior to the expected increase in world prices, because capital goods are relatively cheap in these years. Specifically, the prices of capital goods increase less than the wage rate in the first nine years. In addition, the expected capital gains increase and the user cost of capital decreases as the economy approaches period 10. This explains why the increase in investment is especially high in period 9 (31.2 percent) compared to the reference scenario. The changes in the relative factor prices induce firms to raise the capital intensity in their factor input. Moreover, the changes in the industry structure reinforce the increase in the average capital-labour ratio during the first nine years. From period 10 and henceforth these mechanisms work in the opposite direction. In the long run the fixed capital stock is reduced by 0.2 percent compared to the reference scenario.

What explains the changes in the wage rate? In the first nine-year period the rise in both consumption and investment contributes to increase labour demand. In addition, at the initial wage rate, the intertemporal substitution effect dominates the wealth effect of the TOT loss and contributes to reduce labour supply. A rise in the wage rate is necessary in order to eliminate the resulting excess demand for labour. In the first years the wage rate increases by about 3.5 percent. In period nine, the pressure in the labour market is exceptionally strong due to the sharp increase in investment triggered by the relatively high expected capital gains facing investors in this particular period. From period 10 and onwards import- and export prices are 10 percent higher than in the reference scenario. At the initial wages, this raises the labour demand from export oriented industries and industries facing competition from imports. On the other hand, as explained above, intertemporal substitution induces consumers to reduce private consumption and

Table 3.17. Macroeconomic effects of a 10 percent rise in world prices of exports and imports. Permanent anticipated shift from period 10. Percentage deviation from reference scenario

Years after exogenous change	0	1	9	10	11	48
Constant prices:						
Private consumption	2.0	1.6	5.8	-2.9	-1.1	-0.8
General government consumption	-0.2	-0.2	-0.4	0.0	0.2	0.0
Gross fixed investment	3.6	3.8	31.2	-21.5	-7.4	0.1
Manufacturing	282.0	-1.0	96.9	28.4	-13.0	-2.8
Dwellings	34.4	8.4	-13.7	60.0	-57.9	-0.1
Other mainland industries	3.6	3.1	77.5	-134.9	44.5	0.3
Exports	-3.2	-3.2	-4.2	7.2	5.0	2.7
Imports	1.2	1.2	15.5	-9.0	-2.1	-0.9
GDP	0.2	0.0	3.6	-1.1	0.1	0.2
GDP, mainland	0.2	0.1	4.0	-1.2	0.2	0.2
Fixed capital stock	0.2	0.5	4.9	3.3	2.6	-0.2
Total employment, man-hours	-0.6	-0.5	1.7	-0.7	0.2	0.4
Government sector	0.0	0.0	0.0	0.0	0.0	0.0
Private business sector	-0.8	-0.8	2.4	-0.9	0.2	0.6
Manufacturing	-4.8	-4.7	-4.0	5.1	4.9	3.4
Price indices:						
Hourly wages	3.5	3.4	7.3	4.3	6.5	7.7
Consumer price index	1.7	1.6	2.2	5.0	6.7	8.6
Price of capital goods	2.4	2.4	4.2	7.2	7.2	8.6
Percent of GDP:						
Trade surplus	-9.8	-11.8	-104.7	110.0	56.5	-6.9
Current account	-10.1	-12.2	-60.5	32.7	7.7	-2.4
Net foreign wealth, Norway	-4.2	-5.7	-20.5	-14.7	-15.2	-5.9

firms reduce their investment. The net effect is a stronger increase in the nominal wage rate. In the long run it exceeds the reference level by 7.7 percent. However, as the world prices rise, the real wage rates facing both consumers and producers are lower than in the reference scenario.

The dynamics of the saving responses can be summarised as follows: The economy reduces aggregate saving prior to the rise in world prices due to intertemporal substitution. The long run reduction in private consumption is therefore stronger when this future price shift is anticipated than in the case where the same shift is unanticipated. The reduction in aggregate savings takes the form of decumulation of foreign wealth. The reductions in the current account surpluses finance accumulation of fixed capital as well as increased consumption prior to the rise in world prices. The changes in the industry structure reflect the changes in the main demand components. Thus, labour and other resources are reemployed into the exposed industries after period nine.

3.3.4. Effects of higher world prices of crude oil and natural gas

The effects of the exogenous shift are measured as percentage deviations from the reference scenario. Even if the absolute change is moderate, the percentage deviation will be very large if the reference value

is small. Moreover, a positive absolute change will result in a negative percentage deviation if the reference value is negative. Such results are often found for gross fixed investment in specific industries and for the trade surplus.

3.3.4.A. Permanent unanticipated shift from period 0
In the model the production and export of crude oil and natural gas are exogenous. The most important effect of this shift is a terms-of-trade (TOT) gain, as Norway is a net exporter of crude oil and natural gas in the reference scenario. The TOT gain from period 0 to "eternity" allows an increase in consumption possibilities through higher net imports. As shown in Table 3.18, the economy (consumer) benefits from improved TOT by increasing consumption as well as leisure. In addition, the price shift has a direct effect on the relative price structure since petroleum products are used as production factors. Numerically, this effect is, however, rather insignificant. The subsequent interpretation of the results concentrates on how the agents and main markets in the economy adjust to realize the welfare gain from the TOT improvement. Specifically, we focus on the following points:

1. The activity level measured by GDP and total employment is slightly reduced.
2. The economy becomes less open in the sense that the volume of both imports and exports decreases.
3. The real exchange rate appreciates, measured by the increase in the wage rate relatively to the relevant indices of the world prices
4. The relative reduction of employment is strongest in the manufacturing industries.
5. The percentage changes in most macroeconomic variables are close to stationary from the first year of higher export prices.

The economy, i.e. the households, can only benefit from the TOT gain by raising the (volume of) imports relative to the (volume of) exports. Otherwise, the rate of accumulation of foreign financial assets would soon exceed the interest rate and violate the intertemporal budget constraint. This effect is qualitatively equivalent to the TOT gain implied by a general rise in all export prices, which was discussed in Section 3.3.1. The numerical effect is lower, reflecting the share of present value of oil and gas exports in the present value of total exports. The intertemporal budget constraint can in principle be restored by a) an increase in domestic absorption, which increases the demand for imports at given relative prices; b) an increase in the wage rate, which reduces export supplies and leads to substitution of imports for domestically produced goods. Note that the finite response to a partial increase in the wage rate reflects decreasing returns to scale in the production structure. This property illustrates that the MSG6 model deviates from the Small Open Economy (SOE) model.

In equilibrium the economy chooses a combination of the mechanisms a) and b). The reason is that the increase in the wage rate, *cet. par.*, creates excess labour supply. Labour supply is increasing in the wage rate as the substitution effect dominates the income effect, and firms are motivated to reduce the labour intensity of their aggregate input. Therefore, an expansion of consumption is necessary in order to restore labour market equilibrium. The higher consumption level implies, *cet. par*, more imports, and this income effect modifies the necessary increase in the wage rate. In addition, the increase in the wage rate, combined with the cost effect of higher prices of inputs of petroleum products, raises the import shares in the domestic demand components.

Aggregate import still falls. There are two main reasons for this. First, the impact on gross trade flows would have been more positive if export supplies of oil and gas were not exogenous but positively related to the corresponding product prices as the model assumes for most other commodities. Secondly, there is a reduction in imported intermediates and capital goods induced by the lower general activity level, which is in turn caused by the reduction of employment.

Aggregate employment falls by about 0.5 percent over the whole simulation period. The labour supply response captures both the substitution and income effects of the increase in the real consumer wage rate, as well as the income effect of higher non-labour income, i.e. capital income and cash transfers, which are indexed to the wage rate. The sum of income effects dominates the substitution effect of the slight increase in the real consumer wage rate.

The simulated increase in the different measures of the real wage rate, e.g. the consumer real wage rate and the industry specific producer real wage rates, takes into account that the increase in both the wage rate and the prices of petroleum products are carried over to all endogenous prices through the input-output structure. Moreover, the endogenous price changes capture cost effects generated by endogenous productivity changes caused by input variations under decreasing returns to scale. However, as import prices are exogenous and constant, the rise in the prices of consumer- and capital goods is under proportional. Consequently, the real wage growth provides an incentive to raise the capital-labour ratio in the production sectors. The aggregate capital-labour ratio is also affected by reallocations between sectors with different capital intensities. Since exports is most sensitive to changes in costs, the relatively strongest contraction will take place in export oriented industries which are relatively most intensive in their use of labour and petroleum products. The relatively strong reduction of employment in manufacturing reflects that several manufacturing industries are export oriented. In addition the expansion of private consump-

Table 3.18. Macroeconomic effects of a 10 percent rise in world prices of crude oil and natural gas. Permanent unanticipated shift from period 0. Percentage deviation from reference scenario

Years after exogenous change	0	1	10	20	48
Constant prices:					
Private consumption	0.7	0.7	0.7	0.6	0.6
General government consumption	0.0	0.0	0.0	0.0	0.0
Gross fixed investment	0.0	-0.2	-0.4	-0.3	-0.6
Manufacturing	175.3	-7.7	-4.7	-5.4	-2.9
Dwellings	16.6	3.8	0.7	0.8	-0.6
Other mainland industries	-2.5	-3.5	-0.5	-0.5	-0.9
Exports	-1.4	-1.5	-2.6	-3.2	-4.5
Imports	-0.1	-0.2	-0.8	-0.8	-0.3
GDP	-0.1	-0.2	-0.2	-0.3	-0.5
GDP, mainland	-0.1	-0.2	-0.3	-0.3	-0.5
Fixed capital stock	0.0	0.0	-0.1	-0.1	-0.1
Total employment, man-hours	-0.5	-0.5	-0.5	-0.5	-0.4
Government sector	0.0	0.0	0.0	0.0	0.0
Private business sector	-0.7	-0.7	-0.8	-0.7	-0.6
Manufacturing	-2.1	-2.2	-2.5	-2.8	-3.5
Price indices:					
Hourly wages	1.1	1.1	1.0	1.0	1.3
Consumer price index	0.8	0.8	0.8	0.9	1.1
Price of capital goods	0.7	0.7	0.6	0.7	0.9
Percent of GDP:					
Trade surplus	7.1	7.2	6.6	60.3	6.5
Current account	7.2	7.4	7.2	6.2	-0.1
Net foreign wealth, Norway	0.1	1.8	5.7	6.4	5.1

Table 3.19. Macroeconomic effects of a 10 percent rise in world prices of crude oil and natural gas. Transitory unanticipated shift in period 1 only. Percentage deviation from reference scenario

Years after exogenous change	1	2	10	48
Constant prices:				
Private consumption	-0.1	0.2	0.1	0.1
General government consumption	0.0	0.0	0.0	0.0
Gross fixed investment	0.0	-0.1	0.0	0.0
Manufacturing	-13.1	7.8	-0.2	0.2
Dwellings	3.7	-1.0	0.1	0.0
Other mainland industries	-0.7	-1.3	0.0	0.0
Exports	-0.4	-0.2	-0.1	-0.2
Imports	-0.4	0.1	0.0	0.1
GDP	-0.1	0.0	0.0	0.0
GDP, mainland	-0.1	0.0	0.0	0.0
Fixed capital stock	0.0	0.0	0.0	0.0
Total employment, man-hours	-0.1	0.0	0.0	0.0
Government sector	0.0	0.0	0.0	0.0
Private business sector	-0.2	-0.1	0.0	0.0
Manufacturing	-0.3	-0.3	-0.2	-0.2
Price indices:				
Hourly wages	0.0	0.1	0.1	0.1
Consumer price index	0.2	0.1	0.1	0.1
Price of capital goods	0.1	0.1	0.1	0.1
Percent of GDP:				
Trade surplus	11.0	-0.8	-1.1	0.5
Current account	10.4	0.0	0.4	0.2
Net foreign wealth, Norway	0.6	1.9	1.0	0.4

tion raises the demand for housing capital. The net effect on the capital stock from period 10 and onwards is, however, a 0.1 percent reduction from the reference path. The reason is that the rise in the aggregate capital-labour ratio is slightly dominated by the negative scale effect caused by the contraction of labour supply.

Aggregate gross investment falls relatively more than the capital stock. In the long run gross investments fall by 0.6 percent. This reflects that the composition of the total capital stock changes in favour of capital items with low depreciation rates, especially housing capital. The same effect also explains why the relative reduction of GDP is somewhat stronger compared to the relevant weighted average of the relative reductions of the aggregate employment and capital stock.

The dynamics at the macroeconomic level is not very exciting when the rise in oil and gas prices is permanent from the first period and unanticipated. Moreover the stock-flow dynamics related to investments is weak since the aggregate capital stock is almost unaffected.

3.3.4.B. Transitory unanticipated shift in period 1 only
The main difference between this shift and the permanent one discussed above, is of course that the wealth effect of the TOT gain is much smaller because it accrues in one year only. Consequently, all long run

effects are so small that they are hardly visible in Table 3.19.

At the outset the wealth effect of one year with higher petroleum revenues than in the reference scenario, motivates the consumer to slightly raise private consumption and reduce labour supply in every year. The resulting increase in domestic demand and reduction in supply requires an increase in net imports. This is brought about through an increase in the wage rate, which contributes to the necessary deterioration of international competitiveness together with the direct and indirect cost effect of higher prices of petroleum products. The export oriented manufacturing sector responds to the changes in costs and domestic demand by reducing employment by 0.3 - 0.2 percent compared to the reference scenario. Recall that the production and export of oil and gas is exogenous in volume terms. Thus, the temporary nature of the price shift has no dynamic effects through adjustments of output and exports of oil and gas.

Whereas the wealth effect of higher petroleum revenue is permanent due to preferences for consumption smoothing and unlimited access to international capital markets, the price effect of the rise in petroleum prices is temporary. Moreover, whereas the increase in petroleum prices is unanticipated, consumers and investors have full information about the reversal of

Table 3.20. Macroeconomic effects of a 10 percent rise in world prices of crude oil and natural gas. Permanent unanticipated shift from period 10. Percentage deviation from reference scenario

Years after exogenous change	10	11	20	30	48
Constant prices:					
Private consumption	0.3	0.3	0.3	0.2	0.2
General government consumption	0	0	0	0	0
Gross fixed investment	-1.1	-0.8	-0.5	-0.4	-0.5
Manufacturing	-29.4	-10.2	-4.2	-4.9	-3.5
Dwellings	8	4.1	0.3	0.4	-0.6
Other mainland industries	-3.9	-4.1	-0.6	-0.5	-0.7
Exports	-1.3	-1.6	-2.2	-2.7	-3.4
Imports	-1.2	-1.1	-1	-1.1	-0.8
GDP	-0.1	-0.2	-0.2	-0.3	-0.3
GDP, mainland	-0.1	-0.2	-0.3	-0.3	-0.4
Fixed capital stock	-0.1	-0.1	-0.2	-0.2	-0.2
Total employment, man-hours	-0.3	-0.3	-0.3	-0.3	-0.3
Government sector	0	0	0	0	0
Private business sector	-0.4	-0.5	-0.5	-0.4	-0.4
Manufacturing	-1.1	-1.3	-1.5	-1.7	-2
Price indices:					
Hourly wages	0.3	0.2	0.3	0.3	0.5
Consumer price index	0.3	0.4	0.5	0.5	0.5
Price of capital goods	0.2	0.2	0.2	0.3	0.4
Percent of GDP:					
Trade surplus	17.3	16.3	-70.4	3.2	3.4
Current account	6.6	5.7	4.2	3.1	-1.5
Net foreign wealth, Norway	-0.5	0	2.1	2.7	2.6

Table 3.21. Macroeconomic effects of a 10 percent rise in world prices of crude oil and natural gas. Permanent anticipated shift from period 10. Percentage deviation from reference scenario

Years after exogenous change	0	1	9	10	11	48
Constant prices:						
Private consumption	0.3	0.2	0.2	0.1	0.2	0.1
General government consumption	0.0	0.0	0.0	0.0	0.0	0.0
Gross fixed investment	0.0	0.0	-0.6	-0.8	-0.8	-0.5
Manufacturing	39.4	-0.5	-2.3	-21.5	-9.3	-3.7
Dwellings	3.6	0.3	-0.1	5.8	3.7	-0.6
Other mainland industries	-0.4	-0.2	-1.1	-2.8	-3.6	-0.7
Exports	-0.4	-0.4	-0.5	-1.2	-1.5	-3.2
Imports	0.1	0.1	-0.1	-1.1	-1.1	-0.9
GDP	0.0	0.0	-0.1	-0.1	-0.2	-0.3
GDP, mainland	0.0	0.0	-0.1	-0.2	-0.2	-0.3
Fixed capital stock	0.0	0.0	-0.1	-0.1	-0.2	-0.2
Total employment, man-hours	-0.1	-0.1	-0.2	-0.3	-0.3	-0.2
Government sector	0.0	0.0	0.0	0.0	0.0	0.0
Private business sector	-0.2	-0.2	-0.3	-0.4	-0.4	-0.3
Manufacturing	-0.7	-0.7	-0.7	-1.0	-1.1	-1.7
Price indices:						
Hourly wages	0.4	0.4	0.3	0.2	0.1	0.3
Consumer price index	0.2	0.2	0.2	0.3	0.3	0.4
Price of capital goods	0.2	0.2	0.1	0.1	0.1	0.3
Percent of GDP:						
Trade surplus	-1.1	-1.3	-2.0	17.2	17.0	2.8
Current account	-1.1	-1.4	-1.8	5.8	5.2	-1.7
Net foreign wealth, Norway	-0.5	-0.6	-1.2	-1.5	-1.0	2.2

these prices in period 2. Therefore, they know that the prices of consumer and capital goods will be particularly high in period 2, which motivates them to postpone consumption and investment to the subsequent years. Private consumption falls by 0.1 percent in period 1 and increases by about 0.1 percent afterwards. In order to balance the labour market in period 1, the general increase in the wage rate has to be modified in this particular period. *Cet. par.* a temporary lower wage rate reduces labour supply and induces a positive intertemporal substitution effect on consumption in period 1 through the cost-price linkages. This explains why the increase in the wage rate is 0.0 in period 1, and 0.1 afterwards.

3.3.4.C. Permanent unanticipated shift from period 10
Until period 10 all variables follow the same path as in the reference scenario. The effects are qualitatively the same as in experiment A. However, compared to the same price shift instigated from period 0, the wealth effect is now lower as there are no TOT gains in first 10 years, see table 3.20. In addition the wealth effect of the TOT improvement is directly related to the exogenous time profile for extraction. After period 10 the annual production of crude oil is significantly lower than in the first 10 years. The feasible long run improvement in consumption is 0.2 percent, less than half the improvement analysed in experiment A.

3.3.4.D. Permanent anticipated shift from period 10
In this simulation experiment the exogenous world price for crude oil and natural gas is permanently increased by 10 percent from period 10, anticipated from period 0. Since the shift is only instigated after ten years the TOT gain is lower than in shift A because less periods are affected by the increased price of net export. Compared to shift A, the present value of the TOT improvement is also reduced by the fact that the quantity of oil left to extract has declined significantly by period 10.

Unlike experiment C, the increase in total consumption/leisure possibilities in the path is also enjoyed in the first ten years by exploiting the free access to international capital markets. The consequence of this is that the long run positive effect on consumption and leisure is lower than in experiment C. The long run increase in private consumption is only 0.1 percent, see table 3.21, whereas labour supply is 0.2 percent lower than in the reference scenario in the long run. On the other hand private consumption can be raised by 0.2 - 0.3 percent in the first 10 periods. The increase in leisure is, however, stronger in the long run than in the first periods.

The uneven allocation of the increase in consumption is due to the price dynamics. The consumer knows that the exogenous 10 percent increase in the petroleum

prices will raise consumer prices directly and indirectly from period 10. Intertemporal substitution leads households to raise their consumption relatively more prior to the exogenous price shift than after period 10. This is the main point in the explanation of the dynamics of the consumption adjustment.

This point is, however, modified by some other mechanisms. In particular, the percentage increase in the wage rate is stronger in the first 10 years than afterwards. This is a general equilibrium effect caused by the combination of the following assumptions: 1) Agents are forward looking and have full information about the exogenous shift from period 0; 2) The prices of oil and gas do not increase until period 10; 3) Agents have unlimited access to international capital markets. In order to benefit from the future TOT gain in all periods, the consumer finances the increase in consumption and leisure by borrowing in the first 10 years. At the aggregate level such borrowing implies a reduction of the national net financial wealth. This reduction can only take place through a reduction of net exports. Although the increase in consumption contributes to raise the demand for imports, a deterioration of the international competitiveness is necessary to bring about the reallocation of resources. From period 10 the cost effect of the rise in petroleum prices contributes to such a deterioration, but even then an increase in the wage rate by 0.2 - 0.3 percent is required. Prior to period 10, the necessary increase in domestic costs must take place through wage growth only. In these years the wage rate increases by 0.4 percent.

Thus, the dynamics of the increase in the price index of full consumption, which comprises both the prices of consumer goods and the price of leisure, is a result of two opposing forces. The exogenous price shift in period 10 contributes to higher prices in the long run than in the first 10 years. The equilibrium adjustments of the wage rate work in the opposite direction. The *intertemporal* substitution effect of the dynamics of the increase in the wage rate contributes, *cet par.*, to postpone consumption and leisure. However, the *intratemporal* substitution effect dominates the effect on labour supply. This effect is stronger in the first 10 years than afterwards because the increase in the consumer real wage rate is 0.2 percent in the first 10 years, whereas it falls by 0.1 - 0.2 percent in the subsequent years. This explains why the reduction of employment is stronger after period 10 than prior to the exogenous price shift.
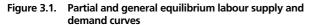
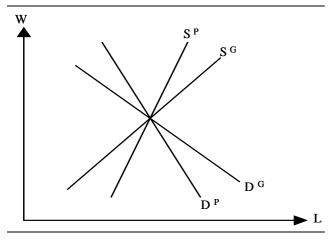## 3.4. Effects of increased productivity
This section examines the effects of increasing the productivity of different input factors. We also explain the effects of increasing the productivity of leisure, i.e. the utility effect of a given number of leisure hours. The specified productivity parameters are increased

permanently by 10 percent from period 0. Thus, the shift is unanticipated. The shift in factor productivities is, however, implemented in the private mainland industries only. In the reference scenario, only 67 percent of the total employment works in these sectors in 2002, dropping to 62 percent in the long run. The remaining labour is employed in the public sector, in the petroleum industry and in the Electricity sector, and in these sectors the development of the factor productivities are the same as in the reference scenario. Therefore, the 10 percent increase in for example the specified labour productivity parameters results in an increase in the labour productivity of the economy as a whole that is significantly lower than 10 percent.

First, in Section 3.4.1, the Total Factor Productivity (TFP) is increased. In Section 3.4.2, only labour productivity is increased. There are many similarities between the effects of increased labour productivity and increased TFP, and the *interpretations* of the effects in the two sections will be fairly similar. In Sections 3.4.3 and 3.4.4, the same two shifts are implemented, with the addition of increased "leisure productivity" in both shifts. Since the interpretations of the effects of increased TFP and labour productivity is still valid in these shifts respectively, we confine the exposition to the additional effects.

Increased productivity of leisure implies that a given utility of leisure can be reached with less leisure measured in hours. Such a shift can be interpreted in at least two ways. First, it may be considered as a change in the preference structure in a less "materialistic" direction. Secondly, it may represent an improvement in the availability and/or the quality of goods that are complements to leisure, but not included in the specified structure of the model. Examples include more and/or better supply of public goods such as cultural services (theatres, concerts, entertainment), and development of recreation areas such as beaches and parks.

There is a particular theoretical motivation for studying the effects of increased leisure productivity. It is well known that in the text-book Solow general equilibrium model, productivity growth has to be labour augmenting (Harrod-neutral) in order to ensure convergence towards a steady state solution. The Solow model assumes e.g. the economy to be closed and labour supply exogenous. When this model is extended to include endogenous labour supply, convergence towards a steady state solution requires that labour augmenting productivity growth is combined with the same relative growth in leisure productivity. Such a combined productivity shift can be translated into growth in the exogenous time endowment, which is allocated to leisure and labour supply.

Figure 3.1. Partial and general equilibrium labour supply and demand curves

Technically, the share parameter associated with leisure in the CES utility function in private consumption and leisure is raised. This changes the marginal rate of substitution between leisure and consumption at any given ratio between these variables, i.e. the indifference curve is tilted. However, the elasticity of substitution between the two goods is constant, i.e. the degree of relative convexity of the indifference curves is unchanged.

The long run (or stationary) general equilibrium effects on employment and wages of all the productivity shifts can be summed up in wage-labour-diagrams, and this pedagogical device has been used in the following sections. It is important, however, to realize that the demand and supply curves capture the *general equilibrium effects*, including much more complex relationships than those accounted for in the corresponding supply and demand curves illustrated in standard *partial equilibrium analyses* of the labour market. The general equilibrium curves represent reduced forms of the whole model. In particular, both curves take implicitly into account the intertemporal national budget constraint on net foreign debt. This makes both functions (much) more elastic than in the analogous partial equilibrium diagram. In short, the reason is that a given increase in the wage rate deteriorates the international competitiveness, reducing exports and increasing imports shares. In order to restore the intertemporal budget constraint, the discounted welfare must be reduced through a proportional reduction in consumption and leisure, and thereby in imports.[4] The welfare reduction required to restore the national budget balance must be rather large because

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[4] The numerical solution algorithm reduces the utility level in each period through an increase in the single endogenous shadow price associated with the budget constraint. The time profile and the order of magnitude of this reduction depend on the dynamic profile of the wage shift. For the sake of the argument, we consider a constant permanent shift.

Table 3.22. Macroeconomic effects of a permanent unanticipated 10 percent increase in Total Factor Productivity (TFP) from period 0. Percentage deviation from reference scenario

Years after exogenous change	0	1	10	20	48
Constant prices:					
Private consumption	16.1	14.4	14.4	14.0	12.5
General government consumption	-0.8	-1.0	-0.9	-0.9	-0.9
Gross fixed investment	21.0	13.9	7.5	5.7	1.2
Manufacturing	-496.1	57.1	16.7	11.8	36.9
Dwellings	0.9	14.1	9.1	6.0	-2.0
Other mainland industries	38.9	13.8	6.9	6.0	6.8
Exports	5.6	7.5	11.2	10.5	4.8
Imports	10.5	6.4	6.9	7.0	9.1
GDP	11.5	11.1	11.6	11.3	9.1
GDP, mainland	13.8	13.2	12.9	12.0	9.4
Fixed capital stock	1.3	2.0	5.0	5.5	3.8
Total employment, man-hours:	-1.1	-1.3	-1.7	-2.1	-2.5
Government sector	0.1	0.1	0.1	0.1	0.1
Private business sector	-1.5	-1.8	-2.5	-3.0	-3.8
Manufacturing	-1.4	-0.1	0.0	-2.0	-8.0
Price indices:					
Hourly wages	22.3	21.3	19.7	19.1	19.1
Consumer price index	2.3	1.4	0.1	0.5	2.8
Price of capital goods	0.4	-0.1	-0.6	0.0	2.2
Percent of GDP:					
Trade surplus	-16.7	-6.6	15.5	-310.0	3.5
Current account	-17.6	-8.0	3.1	7.5	31.8
Net foreign wealth, Norway	-13.8	-12.3	-5.1	-0.6	3.4

the net export value is relatively elastic with respect to the increase in the wage rate. The fall in consumption implied by the national budget constraint is a general equilibrium effect, which is not captured in a partial equilibrium framework. It magnifies the reduction in labour demand, making the general equilibrium labour demand function more elastic wrt. the wage rate than its partial counterpart. Analogously, the reduction in leisure demand caused by the welfare reduction implies a positive general equilibrium effect on labour supply, making the general equilibrium labour supply function more elastic wrt. the wage rate than the partial counterpart. In the limit case formalised in the Small open economy model assuming infinitely price elastic exports and imports, the labour demand function becomes horizontal; the equilibrium wage rate is determined purely by the world prices and the technology in the traded goods sector. Figure 3.1 illustrates the difference between the partial and the general equilibrium labour supply and demand functions. S^P and S^G denotes Partial and General equilibrium labour supply curves, respectively. D^P and D^G denotes the corresponding labour demand curves. W is the wage rate and L is labour.

3.4.1. Effects of a permanent unanticipated 10 percent increase in Total Factor Productivity (TFP)

The effects of the exogenous shift are measured as percentage deviations from the reference scenario. Even if the absolute change is moderate, the percentage deviation will be very large if the reference value is small. Moreover, a positive absolute change will result in a negative percentage deviation if the reference value is negative. Such results are often found for gross fixed investment in specific industries and for the trade surplus.

In this experiment Total Factor Productivity (TFP), i.e. the productivity of all production factors in private industries, is permanently increased by 10 percent from period 0. The shift is implemented in private mainland industries only. Table 3.22 summarizes the most important effects, measured as percentage deviations from the corresponding paths in the reference scenario.

We focus on the following effects:
1. The consumers becomes more wealthy as the economy receives additional resources through a productivity gain, often referred to as "manna from heaven";
2. Measured in percent, wages increase by more than twice the exogenous productivity increase;
3. Despite higher wages, employment is reduced;
4. The economy becomes more open;
5. Capital deepening.

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

The nominal wage rate increases by 19 percent in the long run. The *main* mechanisms can be explained by reference to the text-book model of a Small Open Economy (SOE) or the Scandinavian Model of Inflation: Since export prices are given, producer real wages are determined by the productivity in the export sector. When technologies exhibit constant returns to scale, an increase in labour productivity will be carried over to wages in its full magnitude. Furthermore, the additional revenue per produced unit due to higher productivity of *all* factors is carried over to wages. The reason is that competition drives net rate of return to fixed capital down to the exogenous interest rate corrected for non-neutrality in the capital income taxation. Technical complementarity between labour and other inputs implies that the marginal labour productivity increases both with increased productivity and with more input of capital and intermediates.

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

The rise in the consumer real wage rate of immediately 20 percent has a positive effect on labour supply, since the positive substitution effect dominates the negative income effect in MSG6.[5] However, *ex ante* equilibrium adjustments in the wage rate, consumers want to reduce their labour supply because of the income effects caused by the increase in profits distributed to the consumers.

The combination of various income effects dominates the substitution effect of the increase in the real wage rate, and employment is reduced by 2.5 percent in the long run.

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

The rise in wages makes labour relatively more expensive than other production factors, since the increase in the wage rate is only partly carried over to the prices of capital goods and material inputs as they include imported products. This change in relative factor prices induces substitution in favour of capital and material inputs, and increases the capital-labour ratio at the firm level. Substitution in consumption raises the aggregate capital intensity even more by a reallocation of resources in favour of the more capital intensive sectors. In the long run, the capital stock has increased by 3.8 percent compared to the reference scenario.

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

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

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

raises the electricity demand. The electricity market is balanced by raising the price along the steep supply curve. The pressure in the electricity market grows over time as the growth in the reference path implies that a gradually increasing resource base is subject to the TFP-shift. This explains why the change rate of the electricity price increases over time.

The broad picture of the new investment path is a substantial increase from the reference path in the first years after the shift is instigated. An important dynamic feature is that although the capital stock technically could be adjusted to the optimal level immediately after the shift, investments are smoothed out over some years for two reasons: First, decreasing returns to scale is a feature of the technology also in the industries producing capital goods (most notably *Buildings and Construction, Machinery and Metal Products*). This has the same modifying effect on investments as convex adjustment costs in standard macroeconomic models: The increased demand for investment goods has to be supplied by a relatively small fraction of the economy. As resources are reallocated into production of investment goods, marginal costs in these industries increase substantially and are by far not outweighed by the reduced marginal costs in the remaining large part of the economy where resources are drawn from.[6] Second, the temporary high investment demand tightens the labour market. The wage rate increases to restore labour market equilibrium, and brings about a relatively stronger increase in prices in the investment period than in subsequent periods. Thus the combination of high capital goods prices and negative expected capital gains leads firms to postpone investments.

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

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[6] The price effects on products from the manufacturing industries producing machinery etc illustrate the point: Due to expanded production, the drop in the prices of these products is smaller than the drop in most other prices. Without the smoothing of investments over the first couple of years, the difference in price reductions would be even bigger.
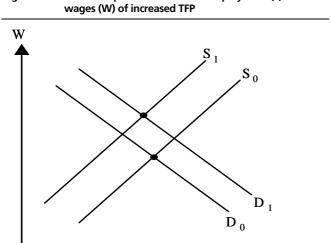
**Figure 3.2.   General equilibrium effect on employment (L) and
                wages (W) of increased TFP**

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

Consumption is continuously falling from 16 percent
above the reference scenario in the short run down to
12.5 percent in the long run, whereas labour supply is
falling from 1 percent below the reference scenario in
the short run to 2.5 percent in the long run. The
dynamics of consumption and labour supply result
from the intra- and intertemporal substitution effects,
reflecting the time profiles of the consumer price index
and the wage rate. The relative change rate of the
consumer price index follows a U-shaped curve,
whereas the increases in the wage rate equals 22.3
percent initially, falling gradually to 19.1 percent in
the long run. The consumer real wage rate is initially
20 percent above the reference scenario, but drops
gradually down to 16.3 percent. This real wage
dynamics induce substitution over time in favour of
leisure and less consumption. In addition the
intertemporal effect induces consumers to postpone
consumption and leisure from the first periods.
However, this effect is small, due to a low
intertemporal rate of substitution, i.e. strong
preferences for consumption smoothing.

The long run general equilibrium effects on employ-
ment and wages of the increase in TFP can be illustra-
ted in the wage-labour-diagram explained in the intro-
duction to Section 3.4. Recall that the demand and

supply curves in Figure 3.2 capture general equilibrium
adjustments and are not the standard curves found in
partial equilibrium analyses of the labour market. In
particular, both curves take implicitly into account the
intertemporal national budget constraint on foreign
debt, which makes both functions (much) more elastic
than their partial equilibrium counterparts.

The increase in TFP shifts the equilibrium demand
curve for labour upwards, since producers are willing
to pay more for a given number of man-hours. The
shift represents the net effect after substitution away
from labour. The general growth and increased profits
distributed to the consumers have an income effect on
labour supply, which shifts the general equilibrium
supply curve inwards and reduces labour supply for
given wages. In the new equilibrium the wage rate is
higher. The effect on employment depends on the
empirical strength of various counteracting effects, but
in this experiment employment is reduced compared to
the reference scenario.

3.4.2. Effects of a permanent unanticipated
            10 percent increase in labour
            productivity

The effects of the exogenous shift are measured as
percentage deviations from the reference scenario.
Even if the absolute change is moderate, the percen-
tage deviation will be very large if the reference value
is small. Moreover, a positive absolute change will
result in a negative percentage deviation if the
reference value is negative. Such results are often
found for gross fixed investment in specific industries
and for the trade surplus.

In this experiment labour productivity is permanently
increased by 10 percent from period 0. Table 3.23
summarizes the most important effects, measured as
percentage deviations from the corresponding paths in
the reference scenario.

To a great extent, the interpretations of the effects in
the experiment with a shift in total factor productivity
(Section 3.4.1) are still valid, and only repeated here,
because there are many similarities between the
qualitative effects of increased labour productivity and
increased TFP.

We focus on following effects:
1.   The consumers becomes more wealthy as the
     economy receives extra resources through the
     productivity gain
2.   The relative increase in the wage rate is smaller
     than the productivity shift
3.   Despite higher wages, employment is reduced
4.   The economy becomes more open
5.   Capital deepening

Table 3.23. Macroeconomic effects of a permanent unanticipated 10 percent increase in labour productivity from period 0. Percentage deviation from reference scenario

Years after exogenous change	0	1	10	20	48
Constant prices:					
Private consumption	4.7	4.3	4.6	4.7	4.8
General government consumption	-0.8	-0.8	-0.8	-0.9	-0.9
Gross fixed investment	12.0	7.9	5.0	4.6	5.3
Manufacturing	-44.3	20.9	8.3	8.1	-3.9
Dwellings	8.8	10.5	6.7	5.5	6.1
Other mainland industries	31.3	8.6	4.9	4.5	5.6
Exports	1.5	2.2	4.7	5.6	6.0
Imports	7.1	5.2	4.9	4.5	3.3
GDP	3.2	3.0	3.7	4.2	4.9
GDP, mainland	3.8	3.6	4.1	4.5	5.0
Fixed capital stock	0.7	1.2	3.2	4.0	4.6
Total employment, man-hours:	-0.9	-1.0	-1.0	-1.0	-0.9
Government sector	0.0	0.0	0.0	0.0	0.1
Private business sector	-1.3	-1.4	-1.4	-1.4	-1.3
Manufacturing	-2.2	-1.5	0.2	0.9	2.1
Price indices:					
Hourly wages	5.5	5.1	4.5	4.4	4.3
Consumer price index	1.0	0.5	-0.8	-1.2	-1.6
Price of capital goods	0.0	-0.3	-1.3	-1.7	-2.2
Percent of GDP:					
Trade surplus	-11.3	-7.8	-2.3	-83.3	-4.3
Current account	-11.7	-8.5	-5.3	-4.3	-9.3
Net foreign wealth, Norway	-6.1	-6.2	-6.0	-5.5	-3.9

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

The nominal wage rate increases by 4.3 percent in the long run compared to the reference scenario. The *main* mechanisms can be explained by reference to the textbook model of a small open economy (SOE) or the Scandinavian Model of Inflation: Since export prices

are given, changes in producer real wages are determined by productivity changes in the export sector. When technologies exhibit constant returns to scale, an increase in labour productivity will be carried over to wages in its full magnitude. In MSG6, this line of reasoning serves only as an approximation of the full picture, since decreasing rather than constant returns to scale makes the wage determination more complex. Increased total demand raises imports according to the import shares. In present value terms the rise in imports has to be financed by a corresponding growth in exports, in order to meet the intertemporal budget constraint on foreign debt. The expanded export production reduces the marginal productivity of all inputs, which in turn modifies the equilibrium effect on the wage rate compared to the exogenous productivity increase.

The rise in the consumer real wage rate of immediately 4.5 percent has a positive effect on labour supply, since the positive substitution effect dominates the negative income effect in MSG6.[7] However, prior to equilibrium adjustments in the wage rate, consumers want to reduce their labour supply because of the income effects caused by the increase in profits distributed to the consumers.

The combination of various income effects dominates the substitution effect of the increase in the real wage rate, and employment is reduced by 1 percent.

The rise in wages makes labour relatively more expensive than other production factors, since the increase in the wage rate is only partly carried over to the prices of capital goods and material inputs as they are partly imported. This change in relative factor prices induces substitution in favour of capital and material inputs, and increases the capital-labour ratio within firms. The increase in the relative price of labour is transmitted to changes in the relative product prices. Substitution in consumption raises the aggregate capital intensity even more by a reallocation of resources out of the most labour intensive sectors. In the long run the total capital stock has increased by 4.6 percent from the reference scenario.

In the long run, GDP has increased as a result of the exogenous increase in labour productivity and endogenous capital deepening. The long run expansion of GDP is not greater than nearly 5 percent. It is significantly lower than the 10 percent increase in labour productivity because of decreasing returns to scale, and a slight reduction in labour supply. Furthermore, it is important to keep in mind the design
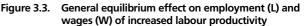
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[7] It should be recalled that an endogenous lump sum transfer is adjusted to meet the given development of the public budget surplus. If the public budget constraint is met by adjustments in a distortionary tax rate, e.g. the payroll tax rate, there may be significant feed back effects on relative prices and resource allocation, see e.g. Fredriksen *et al.* (2003).
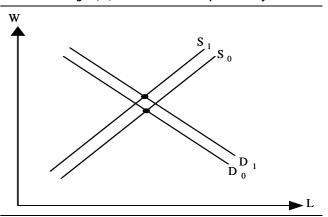
of the shift: It is implemented in private mainland industries only, which employs less than two thirds of the total employment. The average increase in labour productivity is therefore significantly lower than 10 percent.

Dynamics: In this dynamic version of MSG, producers and consumers are forward looking and equipped with model consistent expectations. In accordance with the intertemporal substitution possibilities consumers postpone consumption till periods when the cost of living index is relatively low. *Cet. par.* firms increase their investment if they foresee that the prices of capital goods will be higher in future periods. In the simulations the increased labour productivity results in initially higher prices than in the reference scenario, but the rise in the prices diminishes during the entire simulation period.

The broad picture of the investment path is a substantial increase in the first years after the shift is instigated, in order to accumulate the new higher optimal capital stock. An important dynamic feature is that although the capital stock technically could be adjusted to the optimal level immediately after the shift, investments are smoothed out over some years for two reasons: First, there are decreasing returns to scale also in the industries producing capital goods (most notably *Buildings and Construction*, *Machinery and Metal Products*). This has the same modifying effect on investments as convex adjustment costs in standard macroeconomic models: The increased demand for investment goods has to be met by supplies from a relatively small fraction of the economy. As resources are reallocated into production of investment goods, the marginal costs in these industries increase substantially and are by far not outweighed by the reduced marginal costs in the remaining large part of the economy where resources are drawn from.[8] Second, the temporary high investment demand tightens the labour market. The wage rate increases to restore labour market equilibrium, and brings about a relatively stronger increase in prices (or a smaller drop in prices) in the investment period than in subsequent periods. Thus, the combination of high capital goods prices and negative expected capital gains leads firms to postpone investments.

Changing the wage rate to adjust international competitiveness is an important dynamic mechanism in MSG6. Since producers of export deliveries face given prices, changes in nominal wages equal changes in

Figure 3.3.   General equilibrium effect on employment (L) and wages (W) of increased labour productivity

producer real wages for completely export oriented firms. The rise in the nominal wage rate is initially higher than in subsequent years. This is required to meet the temporary increase in investment demand: To accumulate capital up to desired capital intensity, investments crowd out exports in the periods following the shift by reallocating resources into production of investment goods. In addition, the higher demand for investment goods is partly met by higher imports, adding to the negative impact on net exports. As the capital stock is expanding, demand for (domestic and imported) investment goods declines, nominal wages fall and producers find it profitable to expand exports.

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

The dynamic effects on consumption and labour supply are driven by both intertemporal and intratemporal substitution effects. The growth rate in both the wage rate and the consumer price index is lower after the productivity shift than in the reference path. Moreover, the growth rate of the consumer real wage rate has increased. Thus, intertemporal substitution contributes to a higher growth rate in both consumption and leisure.[9] The intratemporal substitution effect reinforces the consumption growth, but counter-balances the intertemporal substitution effect on

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

[9] The immediate increase in private consumption (4.7 percent) reflects that this is the consumption concept used in the national accounts. By definition this concept includes the investment expenditure rather than the capital cost of cars. Obviously the purchases of more cars as consumption jumps to its new level makes the investment expenditure much higher than the corresponding capital cost.

labour supply. However, also the change rates in consumption are close to stationary due to moderate price and wage effects and a low intertemporal rate of substitution, which implies strong preferences for consumption smoothing.
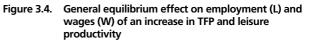
The shift in labour productivity can be graphically illustrated in general equilibrium wage-labour diagram: The higher labour productivity shifts the equilibrium demand curve for labour upwards, see Figure 3.3, since producers are willing to pay more for a given number of man-hours. The shift represents the net effect after substitution away from labour, due to changes in relative factor prices. The general growth following the productivity increase has an income effect on labour supply, which shifts the general equilibrium supply curve inwards and reduces labour supply for given wages. In the new equilibrium wages are higher. The effect on employment depends on the empirical strength of various counteracting effects, but in this experiment employment falls compared to the reference scenario.
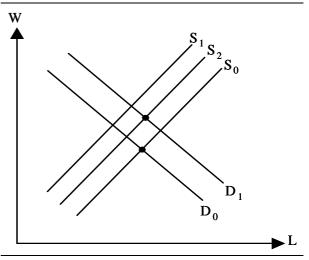
3.4.3. Effects of a permanent unanticipated 10 percent increase in Total Factor Productivity (TFP) and leisure productivity

The effects of the exogenous shift are measured as percentage deviations from the reference scenario. Even if the absolute change is moderate, the percentage deviation will be very large if the reference value is small. Moreover, a positive absolute change will result in a negative percentage deviation if the reference value is negative. Such results are often found for gross fixed investment in specific industries and for the trade surplus.

In this experiment the productivity of leisure is increased proportionally to the increase in Total Factor Productivity (TFP). Increased productivity of leisure implies that a given utility of leisure can be reached with less leisure measured in hours. Such a shift can be interpreted in at least two ways. First, it may be considered as a change in the preference structure in a less "materialistic" direction. Secondly, it may represent an improvement in the availability and/or the quality of goods that are complements to leisure, but not included in the specified structure of the model. Examples include more and/or better supply of public goods such as cultural services (theatres, concerts, entertainment), and development of recreation areas as beaches and parks.

Basically, the interpretation of the experiment with a shift in total factor productivity *without* a shift in leisure productivity, see Section 3.4.1, is still valid. The current shift has only modifying effects through changes in the labour supply. Below we confine the explanations to the additional effects.

Figure 3.4. General equilibrium effect on employment (L) and wages (W) of an increase in TFP and leisure productivity

An increase in leisure productivity affects labour supply through two channels: 1) A positive income effect as a given utility level can be maintained with less leisure measured in hours; 2) a negative substitution effect as the relative (effective) price of consumption in terms of leisure has increased. In MSG6 the income effect dominates the substitution effect, resulting in higher labour supply in this experiment than in Section 3.4.1.

Illustrated in a wage-labour diagram of the general equilibrium adjustments, see Figure 3.4, we will first briefly sum up the effects from Section 3.4.1 following the TFP-shift: The increase in TFP shifts the equilibrium demand curve for labour upwards, since producers are willing to pay more for a given number of man-hours. The general growth following the productivity increase has an income effect on labour supply, which shifts the general equilibrium supply curve inwards and reduces labour supply for given wages. In the new equilibrium the wage rate is higher. The effect on employment depends on the empirical strength of various counteracting effects, but in the experiment with increased TFP only, employment is reduced compared to the reference scenario.

The increase in leisure productivity shifts the supply curve for labour outwards since workers are willing to supply more labour for given wages. Compared to the effects from Section 3.4.1, the new equilibrium employment is increased by 2 percentage points, and the wage rise modified by 2 percentage points, see Table 3.24. Compared to the reference scenario, the wage rate is higher, and the effect on employment theoretically ambiguous. In this experiment, employment drops down from 0.8 percent above to 0.7 percent below the reference scenario over the simulation period.

Table 3.24. Macroeconomic effects of a permanent unanticipated 10 percent increase in Total Factor Productivity and leisure productivity from period 0. Percentage deviation from reference scenario

Years after exogenous change	0	1	10	20	48
Constant prices:					
Private consumption	18.0	16.2	16.3	15.9	14.5
General government consumption	-1.1	-1.3	-1.2	-1.2	-1.3
Gross fixed investment	25.2	16.7	9.1	7.2	3.1
Manufacturing	-526.9	64.8	20.1	15.1	39.9
Dwellings	-1.3	17.8	10.8	7.2	0.0
Other mainland industries	53.2	16.8	8.9	7.9	9.3
Exports	6.3	8.5	13.1	12.7	6.9
Imports	13.0	8.3	8.7	8.8	10.6
GDP	12.8	12.3	13.1	13.0	11.0
GDP, mainland	15.3	14.7	14.6	13.8	11.4
Fixed capital stock	1.5	2.4	6.1	6.7	5.3
Total employment, man-hours:	0.8	0.6	0.1	-0.2	-0.7
Government sector	0.1	0.1	0.1	0.1	0.1
Private business sector	1.1	0.8	0.1	-0.4	-1.1
Manufacturing	1.3	2.9	3.5	1.7	-4.3
Price indices:					
Hourly wages	20.7	19.6	17.9	17.3	17.3
Consumer price index	2.5	1.6	-0.2	0.2	2.3
Price of capital goods	0.3	-0.4	-1.1	-0.6	1.4
Percent of GDP:					
Trade surplus	-19.7	-8.4	15.7	-339.2	3.5
Current account	-20.7	-10.0	2.3	7.1	28.3
Net foreign wealth, Norway	-15.3	-13.7	-6.4	-1.5	3.2

The effects on the remaining variables as compared to the effects from Section 3.4.1, include moderately higher consumption, investments and GDP due to the higher employment level in this shift. Since the development in the relative prices of consumption and leisure is roughly similar in the two experiments, there are no additional effects due to intertemporal and intratemporal substitution.

3.4.4. Effects of a permanent unanticipated 10 percent increase in labour and leisure productivity

The effects of the exogenous shift are measured as percentage deviations from the reference scenario. Even if the absolute change is moderate, the percentage deviation will be very large if the reference value is small. Moreover, a positive absolute change will result in a negative percentage deviation if the reference value is negative. Such results are often found for gross fixed investment in specific industries and for the trade surplus.

In this experiment the productivity of leisure is increased proportional to the increase in labour productivity. Increased productivity of leisure implies that a given utility of leisure can be reached with less leisure measured in hours. Such a shift can be interpreted in at least two ways. First, it may be considered as a change in the preference structure in a less

"materialistic" direction. Secondly, it may represent an improvement in the availability and/or the quality of goods that are complements to leisure, but not included in the specified structure of the model. Examples include more and/or better supply of public goods such as cultural services (theatres, concerts, entertainment), and development of recreation areas as beaches and parks.

Basically, the interpretation of the experiment with a shift in labour productivity only, see Section 3.4.2, is still valid. The current shift has only modifying effects through changes in the labour supply. Below we confine the explanations to the additional effects.

An increase in leisure productivity affects labour supply through two channels: 1) A positive income effect as a given utility level can be maintained with less leisure measured in hours; 2) a negative substitution effect as the relative (effective) price of consumption in terms of leisure has increased. In MSG6 the income effect dominates the substitution effect, resulting in higher labour supply in this experiment than in Section 3.4.2.
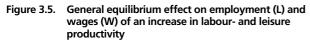
Illustrated in a wage-labour diagram, see Figure 3.5, we will first briefly sum up the effects from Section 3.4.2 following the increase in labour productivity: The increase in labour productivity shifts the equilibrium demand curve for labour upwards, since producers are willing to pay more for a given number of man-hours. The general growth following the productivity increase has an income effect on labour supply, which shifts the general equilibrium supply curve inwards and reduces labour supply for given wages. In the new equilibrium the wage rate is higher. The effect on employment depends on the empirical strength of various counteracting effects, but in this experiment with increased labour productivity only, employment is reduced compared to the reference scenario.
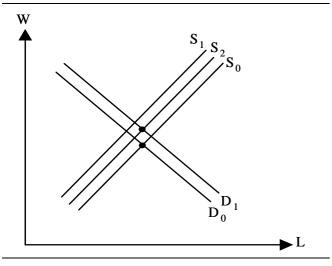
The increase in leisure productivity shifts the supply curve for labour outwards, since workers are willing to supply more labour for given wages. Compared to the effects from Section 3.4.2, the new equilibrium employment is increased by nearly 2 percentage points, and the wage rise modified by nearly 2 percentage points, see table 3.25. Compared to the reference scenario, the wage rate is higher and the effect on employment theoretically ambiguous. In this experiment, employment remains stable at nearly 1 percent above the reference scenario over the simulation period.

The effects on the remaining variables as compared to the effects from Section 3.4.2, include moderately higher consumption, investments and GDP due to the higher employment level in this shift. Since the development in the relative prices of consumption and leisure is roughly similar in the two experiments, there are no additional effects due to intertemporal and intratemporal substitution.

Table 3.25. Macroeconomic effects of a permanent unanticipated 10 percent increase in labour and leisure productivity from period 0. Percentage deviation from reference scenario

Years after exogenous change	0	1	10	20	48
Constant prices:					
Private consumption	6.4	5.8	6.3	6.5	6.6
General government consumption	-1.1	-1.1	-1.1	-1.2	-1.2
Gross fixed investment	16.0	10.5	6.5	6.0	7.2
Manufacturing	-75.4	28.2	11.4	11.2	-2.6
Dwellings	5.4	13.5	8.3	6.7	8.2
Other mainland industries	45.3	11.7	6.8	6.3	8.0
Exports	2.1	3.2	6.4	7.7	8.2
Imports	9.6	7.0	6.7	6.1	4.7
GDP	4.4	4.1	5.0	5.7	6.6
GDP, mainland	5.2	4.9	5.6	6.0	6.9
Fixed capital stock	1.0	1.6	4.2	5.1	6.0
Total employment, man-hours:	1.0	0.9	0.9	0.9	1.0
Government sector	0.0	0.0	0.1	0.1	0.1
Private business sector	1.3	1.2	1.2	1.3	1.4
Manufacturing	0.5	1.5	3.6	4.6	6.2
Price indices:					
Hourly wages	4.0	3.5	2.8	2.7	2.7
Consumer price index	1.2	0.6	-1.1	-1.5	-2.1
Price of capital goods	-0.1	-0.5	-1.8	-2.3	-2.9
Percent of GDP:					
Trade surplus	-14.4	-9.7	-2.4	-109.8	-4.6
Current account	-15.0	-10.6	-6.4	-5.0	-14.0
Net foreign wealth, Norway	-7.6	-7.7	-7.4	-6.6	-4.3

Table 3.26. Macroeconomic effects of a permanent unanticipated 10 percent increase in the labour force from period 0. Percentage deviation from reference scenario

Years after exogenous change	0	1	10	20	48
Constant prices:					
Private consumption	7.8	7.2	7.7	7.8	8.0
General government consumption	-1.3	-1.3	-1.4	-1.4	-1.7
Gross fixed investment	17.8	11.6	7.0	6.2	8.6
Manufacturing	-107.4	32.4	13.4	13.5	3.2
Dwellings	-11.9	14.0	7.3	5.2	9.7
Other mainland industries	62.0	13.8	8.6	8.1	9.8
Exports	2.5	3.7	7.6	9.0	10.4
Imports	11.2	8.2	8.0	7.4	6.0
GDP	5.1	4.9	5.9	6.6	8.1
GDP, mainland	6.1	5.8	6.5	7.0	8.3
Fixed capital stock	1.1	1.7	4.5	5.3	6.3
Total employment, man-hours:	9.1	9.0	9.0	9.1	9.1
Government sector	0.0	0.0	0.1	0.1	0.1
Private business sector	12.7	12.6	12.6	12.8	13.7
Manufacturing	12.5	13.8	16.4	17.7	21.1
Price indices:					
Hourly wages	-6.0	-6.4	-7.0	-7.1	-7.4
Consumer price index	1.4	0.7	-1.1	-1.6	-2.5
Price of capital goods	-0.5	-0.9	-2.2	-2.8	-3.6
Percent of GDP:					
Trade surplus	-15.6	-10.1	-2.6	-99.4	-3.6
Current account	-16.2	-11.0	-6.5	-5.3	-17.3
Net foreign wealth, Norway	-7.6	-7.7	-7.4	-6.6	-3.6

Figure 3.5. General equilibrium effect on employment (L) and wages (W) of an increase in labour- and leisure productivity

3.5. Effects of a permanent unanticipated 10 percent increase in the labour force

The effects of the exogenous shift are measured as percentage deviations from the reference scenario. Even if the absolute change is moderate, the percentage deviation will be very large if the reference value is small. Moreover, a positive absolute change will result in a negative percentage deviation if the reference value is negative. Such results are often found for gross fixed investment in specific industries and for the trade surplus.

In this experiment the labour force is permanently increased by 10 percent relative to the reference scenario from period 0. Note that the labour force is exogenous in MSG6, whereas the individual labour supply is endogenous. Table 3.26 summarizes the macroeconomic effects.
We focus on the following three effects:
1. The increase in employment is less than the exogenous increase in the labour force;
2. The real wage rate declines, as opposed to the standard textbook theory for a small open economy;
3. Growth in GDP is less than the exogenous increase in the labour force, even if all input factors can be adjusted immediately.
Finally, we explain the dynamic transition of the effects.

1) General equilibrium feed-back on employment:
The 10 percent increase in the labour force results in a 9 percent increase in employment. This is due to a drop in real wages, which makes it relatively less attractive to work and increases the demand for leisure. The mechanisms behind the drop in wages cannot be explained without recognizing the strong

impact of the wage rate on the accumulation of foreign assets. At the initial relative prices, the output produced by the extra man-hours has to be absorbed by consumption and investments, which raises imports according to the import shares. The resulting increase in net imports in every year violates the intertemporal budget constraint on net foreign debt. To restore the long run external balance, the present value of net exports must rise. However, producers do not find it profitable to raise exports at the initial relative prices due to decreasing returns to scale. A drop in the wage rate is required. The marginal cost curves then shift downward, depending on the direct and indirect cost shares of labour, and results in expanded production of export deliveries at given world prices. Lower wages also reduce the prices of Norwegian products relative to the given prices of close but imperfect imported substitutes, and both firms and consumers substitute domestic products for imports. Moreover, the fall in the wage rate induces factor substitution away from capital and other material inputs, which are partly imported. Both substitution effects have a negative impact on imports.

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

It should be recalled that an endogenous lump sum transfer is adjusted to meet the given development of the public budget surplus. If the public budget constraint were met by adjustments in a distortionary tax rate, e.g. the payroll tax rate, there may be significant feed back effects on relative prices and resource allocation, see e.g. Fredriksen *et al.* (2003). Alternatively, the government consumption, e.g. employment, is adjusted to meet the public budget constraint. This procedure is often followed in policy analyses by the Norwegian Ministry of Finance. Implications of this closure rule are discussed in HSÅ99.

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

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

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

4) Dynamics:
Producers and consumers are forward looking and equipped with model consistent expectations. According to the intertemporal substitution possibilities, consumers postpone consumption till periods when the cost of living index is relatively low. *Cet. par.* firms increase their investment if they foresee that the prices of capital goods will be higher in future periods. In the simulations the increase in the labour force causes the prices of consumption and capital goods to decline continuously over the entire time path. The broad picture of the investment path is a substantial increase the first years after the shift is instigated, in order to equip the additional labour with the optimal capital-labour ratios. After a drop in the midst of the period, investments again increase, reflecting that a higher capital stock requires more replacement investments. An important dynamic feature is that although the capital stock technically could be adjusted to the optimal level immediately after the shift, investments are to some extent smoothed out over some years out of two reasons: First, decreasing returns to scale is a feature of the technology also in the industries producing capital goods (most notably *Buildings and Construction, Machinery and Metal Products*). This has the same modifying effect on investments as convex adjustment costs in standard macroeconomic models: The increased demand for investment goods has to be met by supplies from a relatively small fraction of the economy. As resources are canalised into the industries producing capital goods, marginal costs increase substantially in these industries. Mark-up pricing of domestic deliveries shifts transmits higher costs into higher prices. This price effect is by far not outweighed by the reduced marginal costs in the remaining large part of the economy where resources are drawn from.[11] Secondly, the temporary high investment demand tightens the labour market. The wage rate increases to restore labour market equilibrium, and brings about a relatively stronger increase in prices in the investment period than in subsequent periods. Thus the combination of high capital goods prices and negative expected capital gains leads firms to postpone investments.

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

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

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

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

3.6. Effects of a permanent unanticipated 10 percent rise in the user costs of capital
The effects of the exogenous shift are measured as percentage deviations from the reference scenario. Even if the absolute change is moderate, the percentage deviation will be very large if the reference value is small. Moreover, a positive absolute change will result in a negative percentage deviation if the reference value is negative. Such results are often found for gross fixed investment in specific industries and for the trade surplus.

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

In this simulation experiment the user cost of capital is permanently increased by 10 percent from period 0. The shift is designed as an increase in the shadow price of all capital goods, whereas the interest rate is unchanged. It should be interpreted as an increase in the rate of return to investments in Norway required by investors. Whether or not this is justified by increased risk or other costs, such costs are not captured by the model. Thus, in the model the increment in the user cost works as a new wedge between the returns to domestic investments in fixed capital and financial investments abroad.

For a given level of private consumption and a given wage rate, the increase in capital costs has a negative substitution effect on labour supply because higher capital costs are transmitted to higher prices of consumer goods depending on their direct and indirect cost shares of capital. Labour demand is affected through the following mechanisms: i) Firms undertake a substitution from capital to labour. ii) At the macro level factor substitution is reinforced by substitution on the demand side, which tends to reallocate resources from the most to the least capital-intensive industries. iii) Higher domestic prices lead to substitution from domestically produced goods to imports, and thereby to lower demand for labour. iv) Increased costs imply lower export production and lower demand for labour. In the model the net impact on labour demand of these effects is negative. But since labour supply is also reduced, the net impact on *excess* demand for labour is ambiguous.

The export reduction and increased import shares also imply less net financial savings abroad. Consequently, in order to restore labour market equilibrium and the intertemporal national debt constraint a new equilibrium is in *most* years characterised by a lower wage rate and less total domestic demand. More specifically, the numerical results show that the long run reduction in GDP is 2.1 percent, see Table 3.27. The long run reduction in private consumption is 1.1 percent. The wage rate falls in the first three decades, but is nearly unaffected in the long run. Note that the change rates for consumption/GDP and the wage rate are inversely related: The stronger is the decrease in aggregate demand, the weaker is the decrease in the wage rate.

The reduction of employment can be explained from the supply side as a consequence of the decrease in the consumer real wage rate. This effect dominates the positive effect on labour supply from the decrease in non-labour income. Thus the households adjust to the shift by reducing consumption, while they enjoy more time for leisure.

Both lower employment and the reduction of the aggregate capital-labour ratio reduce the stock of fixed capital. In the long run the capital stock is 5.0 percent lower than in the reference scenario. About 4/5 of this reduction is carried out within the first 10 years.

The downsizing of the capital stock is the driving force behind the dynamics of the equilibrium adjustments. It is profitable to spread the reduction of the capital stock over several periods for two reasons, which are both related to the endogenous capital gains. First, decreasing returns to scale implies adjustment costs since large investments imply a costly expansion in the sectors producing mostly capital goods (*Building and Construction* and *Machinery and Metal Products*). Thus, a sharp reduction in the investment demand in a given period generates particularly low prices of capital goods in this period. This implies an increase in the expected capital gains accruing from this period to the next one. Higher capital gains reduce the cost of capital and contribute to postpone the reduction of the capital stock. Secondly, the transitory decrease in investment creates a transitory excess supply of labour. This explains why the wage rate reduction is strongest in periods characterised by the largest investment reductions. The wage dynamics is transmitted to parallel price dynamics, which makes it profitable to postpone investment.

The wage and price dynamics also affects the time paths of consumption and leisure. The reduction in the price index of full consumption, which comprises the prices of consumer goods and the price of leisure (i.e. the wage rate), becomes stronger over time. Intertemporal substitution therefore leads the households to postpone consumption and leisure at a given real wage rate. The intertemporal elasticity of substitution in consumption is only 0.25, so the time profile of the percentage change in utility from consumption and leisure shows a weak upward trend (not shown in Table 3.27). However, the change rates of, respectively, private consumption and leisure are also influenced by the intratemporal substitution caused by the dynamics of the change in the consumer real wage rate. The initial decline in this real wage rate is reinforced over time, which *cet. par* contributes to raise the consumption-leisure ratio over time. The figures in Table 3.27 indicate that the intertemporal substitution effect dominates the dynamics of the change rates of consumption and employment. The decrease in private consumption is about twice as high in the long run as in the short run, whereas the decrease in labour supply is dampened from 1.2 percent in the short run to 0.6 percent in the long run.

In the first couple of years the reduction of labour supply is smaller than the reduction in labour demand attributable to the decrease in investments and consumption. Unemployment is avoided by the increase in net exports. This is brought about by improved international competitiveness induced by the

Table 3.27. Macroeconomic effects of a permanent unanticipated 10 percent increase in the user costs of capital from period 0. Percentage deviation from reference scenario

Years after exogenous change	0	1	10	20	48
Constant prices:					
Private consumption	-0.7	-0.4	-0.9	-1.0	-1.1
General government consumption	0.4	0.4	0.3	0.3	0.3
Gross fixed investment	-16.2	-10.6	-6.4	-5.7	-6.9
Manufacturing	149.0	-32.8	-11.6	-10.7	19.1
Dwellings	5.7	-12.0	-7.6	-6.0	-7.3
Other mainland industries	-54.9	-12.9	-7.1	-6.6	-7.6
Exports	1.6	0.4	-2.1	-2.8	-3.6
Imports	-5.6	-3.0	-2.3	-2.0	-0.9
GDP	-1.3	-1.2	-1.7	-1.9	-2.1
GDP, mainland	-1.6	-1.5	-1.9	-2.0	-2.2
Fixed capital stock	-1.0	-1.5	-4.0	-4.7	-5.0
Total employment, man-hours	-1.2	-1.1	-1.0	-0.9	-0.6
Government sector	0.0	0.0	0.0	0.0	0.0
Private business sector	-1.7	-1.6	-1.3	-1.2	-0.9
Manufacturing	0.6	-0.3	-2.0	-2.4	-3.0
Price indices:					
Hourly wages	-2.4	-1.9	-1.0	-0.7	0.0
Consumer price index	-0.9	-0.3	1.4	1.8	2.1
Price of capital goods	-2.1	-1.6	-0.7	-0.4	-0.1
Percent of GDP:					
Trade surplus	14.0	8.7	1.9	68.4	4.0
Current account	14.5	9.4	4.8	3.8	8.7
Net foreign wealth, Norway	5.8	6.0	5.5	4.7	3.5

decrease in the wage rate, which boosts exports and reduces the price dependent import shares. As the reduction of the wage rate is dampened the cost curves eventually shift upwards as the increase in the user cost of capital dominates the decrease in the wage costs. This explains why the short run increase in exports is turned into a decrease in less than 10 periods.

However, the value of net exports is significantly increased through the contraction of aggregate demand. Note that the reduction of the use intermediate inputs (not reported in Table 3.27) contributes significantly to the reduction of (gross) imports. Consequently, the composition of the national wealth changes as the reduction of fixed capital is met by an increase in net foreign wealth, i.e. financial claims on foreigners.

The prices of domestically produced goods have increased for some sectors and decreased for others. The dispersion in the price changes mainly reflects the direct and indirect cost shares of wages and capital costs in the products. In particular, the prices of consumer goods tend to increase relative to the prices of capital goods. (Note that the increase in the exogenous shadow price of capital does not directly affect the prices of capital goods.) In addition to

differences in the direct and indirect cost shares of labour and capital, the price index of capital goods decreases as a result of decreasing returns to scale: the lower is the production of capital goods the higher is the productivity in this production process.

3.7. Effects of a permanent unanticipated 10 percent rise in the firms' fixed costs

The effects of the exogenous shift are measured as percentage deviations from the reference scenario. Even if the absolute change is moderate, the percentage deviation will be very large if the reference value is small. Moreover, a positive absolute change will result in a negative percentage deviation if the reference value is negative. Such results are often found for gross fixed investment in specific industries and for the trade surplus.

The firm specific fixed costs, in constant prices, are permanently increased by 10 percent from period 0, so the shift is unanticipated. Directly, this shift affects only industries characterised by monopolistic competition, i.e. most industries in manufacturing and private services. In these industries equilibrium requires that fixed costs equals variable profit in what we refer to as the marginal firm, i.e. that firm among the active ones in the industry earning the lowest variable profit. A rise in the fixed cost requires that the profit earned by the marginal firm must increase by the same amount. This can only be obtained through exit of firms. Note, however, that firms are heterogeneous with respect to total factor productivity in the differentiated industries in MSG6. Accordingly, the firms that exit will be the least efficient ones because variable profit earned by an individual firm is, *cet. par.*, an increasing function of its total factor productivity level. This implies that the output of those varieties that vanish is relatively small compared to the case where firms have the same productivity.

Fewer firms imply that there will be fewer varieties since each firm produces a specific variety. Both consumers and producers value variety in its own right. This means that for a given level of spending on the composite good and given prices of the available individual varieties, welfare is increasing in the number of varieties. Analogously, productivity, and thereby output, increases as the number of (input) varieties becomes larger. Fewer varieties will therefore reduce utility for consumers and reduce productivity for producers. However, the fact that firms differ with respect to productivity in MSG6 implies that this "Love of Variety" effect is modified, because it is the varieties produced by the least efficient firms that vanish from the markets.

Before explaining the effects further, it should, however, be emphasised that the effects of this shift are relatively small. The absolute value of the multipliers is

Table 3.28. Macroeconomic effects of a permanent unanticipated 10 percent rise in the firms' fixed costs from period 0. Percentage deviation from reference scenario

Years after exogenous change	0	1	10	20	48
Constant prices:					
Private consumption	-0.3	-0.3	-0.3	-0.3	-0.2
General government consumption	0.1	0.1	0.1	0.0	0.0
Gross fixed investment	-2.0	-1.4	-0.5	-0.4	-0.6
Manufacturing	33.7	-3.9	-0.9	-0.6	2.1
Dwellings	1.0	-1.4	-0.6	-0.4	-0.5
Other mainland industries	-5.9	-2.0	-0.6	-0.4	-0.7
Exports	0.0	-0.1	-0.3	-0.2	0.0
Imports	-0.6	-0.3	-0.2	-0.1	-0.1
GDP	-0.4	-0.4	-0.3	-0.3	-0.2
GDP, mainland	-0.5	-0.5	-0.4	-0.3	-0.2
Fixed capital stock	-0.1	-0.2	-0.4	-0.4	-0.3
Total employment, man-hours:	-0.3	-0.3	-0.2	-0.1	-0.1
Government sector	0.0	0.0	0.0	0.0	0.0
Private business sector	-0.4	-0.4	-0.3	-0.2	-0.1
Manufacturing	-0.5	-0.6	-0.5	-0.3	-0.1
Price indices:					
Hourly wages	-0.8	-0.8	-0.6	-0.5	-0.5
Consumer price index	0.0	0.1	0.2	0.1	0.0
Price of capital goods	0.1	0.2	0.2	0.2	0.1
Percent of GDP:					
Trade surplus	1.4	0.7	-0.6	9.3	0.0
Current account	1.4	0.8	0.0	-0.1	1.8
Net foreign wealth, Norway	0.7	0.7	0.3	0.1	0.1

well below 0.5 percent for most of the endogenous variables, see Table 3.28.

At given factor prices, the productivity fall of the composites used as capital goods and intermediates distorts both the constraint on foreign debt and the labour market equilibrium. The productivity fall raises costs in all industries. Thus, as a first round effect, exports are scaled downed and import shares rise. Both effects contribute to reduce net financial savings abroad. The foreign debt constraint can be restored by improving the international competitiveness through a fall in the wage rate and/or a fall in imports through a fall in the consumption level. In the labour market the reduction of exports and increase in import shares contributes to reduce labour demand. On the other hand, firms substitute labour for capital and intermediates. In the model the net impact of these demand effects is negative. However, for a given nominal wage rate and consumption level the increase in the effective price of consumer goods implies a fall in the consumer real wage rate, which causes a negative substitution effect on labour supply as well.

The new general equilibrium is obtained through a reduction in both the wage rate and in total domestic demand. More specifically, the long run reduction in the wage rate and private consumption is 0.5 and 0.2 percent, respectively. The drop in consumption and

leisure is partly due to reduced non-labour income, which counteracts the negative substitution effect on labour supply. In the new equilibrium labour supply is almost unaffected in the long run; the reduction is 0.1 percent. Factor substitution brings about a stronger reduction in the capital stock, which falls by 0.3 percent in the long run. The GDP reduction of 0.2 percent is the result of several effects, including the reduction in inputs, lower productivity of less differentiated composite goods, productivity effects due to decreasing returns to scale as well as effects from changes in the industry structure.

Both the general reduction in the activity level, the rise in the labour intensity of production and the productivity drop contribute to reduce imports. The fall in the wage rate is not strong enough to change this result. Accordingly, the wage rate reduction is neither strong enough to prevent exports from decreasing.

As usual the reduction of the optimal fixed capital stock is brought about by relatively strong reductions in investments in the first years after the shift in the fixed costs. This temporary decrease in aggregate demand requires a greater reduction in the wage rate in these years than in the subsequent years in order to equilibrate the labour market. Consequently the labour supply reduction is strongest and the export reduction is smallest in the first years of the scenario. This reflects a change in the composition of national savings from fixed to financial assets.

Compared to the effects of the similar shift reported in HSÅ99, the contraction of the macroeconomic activity level found in the present simulations are smaller. For example GDP fell by 0.5 percent in HSÅ99, despite the fact that employment was exogenous and constant in this simulation. The basic reason for the deviations between the two sets of simulations is the closure of the public budget constraint. In the present simulations lump sum transfers keep the annual public budget surplus at the reference path. In HSÅ99 the balancing policy was proportional changes in the government employment and material input. As a matter of fact, government employment and material inputs were allowed to increase because the expenditure effect of the wage rate reduction dominated the effect of reduced tax bases. Thus, the increase in government consumption crowds out private consumption. Since the model adopts national accounting definitions, the reallocation of resources from private industries to the government sector shows up as a decline in GDP. In the present simulations, however, such reallocation of resources from the private to the government sector does not take place.

References

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

Aasness, J. and B. Holtsmark (1995): Effects on consumer demand patterns of falling prices in telecommunication, Working Paper 1995:8, Center for International Climate and Environmental Research - Oslo (CICERO).

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

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

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

Bye, B. and E. Holmøy (1997): Household behaviour in the MSG6 model, *Documents* 97/13, Oslo: Statistics Norway.

Bye, B. and T. Åvitsland (2003): The welfare effects of housing taxation in a distorted economy: A general equilibrium analysis, *Economic Modelling* 20 (5), 895-921.

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

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

Fæhn, T. (1997): Non-Tariff Barriers - the Achilles Heel of Trade Policy Analyses, Discussion paper 195, Oslo: Statistics Norway.

Fæhn, T. and T. Hægeland (1996): Effektive satser for næringsstøtte 1994, Reports 96/18, Oslo: Statistics Norway.

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

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

Heide, K. M., E. Holmøy, L. Lerskau and I. F. Solli (2004): Virkningsberegninger på modellen MSG6. Forthcoming as Notater, Oslo: Statistics Norway.

Holmøy, E., B. Strøm and T. Åvitsland (1999): Empirical characteristics of a static version of the MSG6 model, *Documents* 99/1, Oslo: Statistics Norway. (Referred to as HSÅ99 in the text)

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

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

Klette, T. J. and A. Mathiassen (1995): Job Creation, Job Destruction and Plant Turnover in Norwegian Manufacturing, *Annales d'Economie et de Statistique* 41/42, 97-125.

Klette, T. J. and A. Mathiassen (1996): Growth and Turnover among Norwegian Manufacturing Plants. *Social and Economic Studies* 95, Oslo: Statistics Norway.

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

Norwegian Ministry of Finance (2001): Langtidsprogrammet 2002-2005, Oslo: Akademika.

Statistics Norway (1992): "Tidsnyttingsundersøkelsen", Official Statistics of Norway C 10, Oslo.

Statistics Norway (1999): "Population Projections 1999-2050", Official Statistics of Norway C 693, Oslo.

Steigum, E. (1993): "Accounting for Long Run Effects of Fiscal Policy by Means of Computable Overlapping Generations Models", in S. Honkapohja and M. Ingeberg (eds), *Macroeconomic Modelling and Policy Implications*, Amsterdam: Elsevier Science Publishers B.V.

Sutton, J. (1997): Gibrat's Legacy, *Journal of Economic Literature* XXXV, 40-59.

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