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MODAG
A Medium Term Macroeconometric Model of the Norwegian Economy

by
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Abstract

This paper describes the main structure of the MODAG model, an annual macroeconometric model of the Norwegian economy. A short description of the main features of the model including forcasting performance is followed by a more detailed look at the various parts of the model.

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Contents

1 Introduction

The first MODAG-model was operative in 1980 cf. Cappelen et al (1981), and was an aggregated version of MODIS IV, cf. Bjerkholt and Longva (1980) which for nearly twenty years had been the main model used in Norwegian economic planning. In 1983 the first econometric version of MODAG was operative and this version called MODAG A is presented in Cappelen and Longva (1987).

By international comparison it is worth noting that the trend in Norwegian large scale econometric modelbuilding has been a move towards more aggregated models. While MODIS IV had more than 200 commodities, the MODAG-models specify around 40 commodities. Still, by international standards MODAG is a very disaggregated model. Large scale models in most countries have moved in the opposite direction, from being fairly aggregated to becoming more disaggregated.

Although supply-side factors have become more important as new model blocks have been added to the model, the main use of MODAG is still in preparing short and medium term policy documents and white papers to the Norwegian parliament. In this setting, demand management and income policy still play an important role. Questions regarding "structural reforms", however, have become more important during the latter part of the 1980s. The present version of MODAG is not well suited for many studies of such reforms, even if certain long run equilibrium factors are present. The research which is presently going on in the Central Bureau of Statistics (CBS) aims at improving the model in this respect.

The main structure of MODAG is presented in section 2 of this paper, while section 3 contains a more detailed look at the various model blocks. Some empirical characteristics of the present MODAG (1988-version) are presented in section 2.5 and in section 3. Empirical features of the model (1988-version) are also presented in the comparative study of the Nordic models, see Whitley (1992) in this volume.

2 Main features of MODAG

2.1 The main structure of the model

MODAG is an input-output based model used in short- and medium-term macroeconomic planning and policy analysis in Norway. MODAG is influenced by the Scandinavian model of inflation, with its distinction between exposed and sheltered commodity markets, Keynesian macro theory and input-output modelling. The Norwegian national accounting system forms the conceptual framework and the empirical basis of the model. Nearly all parameters of the various submodels are estimated econometrically from national accounts time series, whereas the coefficients of the input-output structure are estimated from national accounts for the base year of the model. The model is rebased every year, with the base year normally lagging two years behind the current year. The description of the commodity flows is one of the main elements of MODAG. Just as in the national accounts, commodity transactions are represented by means of two commodity by sector-matrices; one for the flow of commodities *to* each sector and one for the flow of commodities *from* each sector. MODAG has 40 commodities, 28 production sectors and 14 categories of private consumption. Real capital and investments are grouped into 4 categories for each of the production sectors. For Crude oil and natural gas exploration investment goods are disaggregated further.

Households

The submodel for household behaviour involves the demand for goods (private consumption and housing capital) and labour supply. As opposed to earlier versions of MODAG, the present model has no macro consumption function. Instead there are separate equations determining purchases of durable consumer goods and investment in housing. Consumption of housing services is proportional to the housing stock following the accounting rules in the Norwegian national accounts. Consumption of non-durables except housing services is determined by a semi-macro consumption function depending on real disposable income and the rate of interest. Different categories of non-durables are further disaggregated using a two-stage dynamic version of the linear expenditure system.

Labour supply is disaggregated by sex, marital status, and age, and depends in general on after (marginal) tax real wages, labour market conditions (a discouraged worker-effect) and other factors such as education etc. Labour supply is fairly inelastic with respect to after tax real wages.

Firms

It is useful to distinguish between two main groups of firms in the private sector; those belonging to resource-based sectors, and other firms. By resource-based industries we mean Agriculture, Forestry, Fishing, Crude oil and natural gas exploration and Hydro-electric power generation. For these sectors both production and prices are generally exogenous in MODAG. Most other industries are modelled as if the market for each good is characterized by monopolistic competition. Table 1 below shows the relative importance of the resource-based industries in the total economy. The shares of these sectors for value-added and exports depend critically on the crude oil price.

Table 1: Relative importance of main groups of industries in the Norwegian economy. 1989. Per cent

Sector	Value-added	Exports	Investment	Employment
Resource-based	19	32	32	11
General government	16	0	13	24
Other sectors	65	68	55	65

In modelling the commodity markets we assume that commodities are imperfect substitutes. More precisely, the model has been constructed on the assumption that it is possible to identify separate demand curves for competing Norwegian products both on foreign and domestic markets. Thus, for each commodity there are three market prices, an export price, an import price and a price on goods delivered to the domestic market by Norwegian producers.

Export prices and domestic prices are given as mark-up equations where we use variable unit costs in addition to a capacity utilization index as instruments for marginal costs while the ratio between the import price and the relevant Norwegian price may change the price elasticities of demand and thereby the mark-up. The export-volume of each commodity is determined by a demand equation depending on the relative commodity price (as an indicator of competitiveness) and an index of imports by the main trading partners (as an indicator of market size). Import-volumes are either determined directly by the commodity balance equation (for non-competitive goods and most resource-based goods) or by import shares where the import shares vary not only between goods but also between different users of each good. Most import shares are endogenous depending on the relative price of imports and the domestic price. Thus, with no changes in relative prices, exports are determined by foreign demand while imports and production are determined by domestic demand.

In the production sectors, material inputs are determined by the input-output structure. However, energy inputs (electricity and fuels) are given special treatment. These energy goods are assumed to be substitutes and the input share depends on relative prices. Total energy input by sector is determined by a CES aggregate which is proportional to gross output. Labour demand (hours) is modelled as a function of gross output, relative factor prices, lagged capital stock and a time trend. In sectors where labour demand depends on relative factor prices, material inputs also depend on factor prices and the capital stock. This means that when the wage rate increases, material input is substituted for labour. For other sectors material inputs except energy are proportional to gross output. Gross investment by sector and type of capital good is determined by gross output and profitability.

Government

The size of the public sector in Norway is by OECD standard of average size in terms of public consumption, employment and investment. However, total tax revenue is much higher than the OECD average. Roughly half of total tax incomes are given back to firms, households and as development aid (the latter constituting more than one percent of GDP). These transfers are to a large extent public pensions and subsidies to certain production sectors such as Agriculture, Domestic transport and consumers. Given the size of tax revenues and transfers, the modelling of these flows are important for the model properties as a whole. Due to the fairly detailed input-output structure, indirect taxes and subsidies are modelled in great detail. The model distinguishes between tax rates ad valorem and on quantities as well as commodity-related and sector related taxes. The latter are lump-sum transfers to production sectors and their real value by sector is exogenous. Direct taxes are also treated in detail and a separate micro data-based model is used in order to estimate average and marginal tax rates for three socio-economic groups in MODAG. Government transfers to households are endogenous depending mainly on demographic variables. However, some transfers such as unemployment benefits and transfers to disabled persons depend on variables describing labour market conditions. Thus, the transfer system partly operates as a built-in stabilizer. However, as most transfers are also linked to either wages or prices, this indexation is potentially destabilizing when the economy is hit by a nominal shock.

Financial variables

In the present model version, financial variables and interest rates in particular, mainly affect households due to the income effects and through substitution effects such as in the housing investment equation. These interest rates are modelled as mark-up or mark-down equations of the money market interest rate which again depends on interest rates abroad, the difference in domestic and international inflation rates as well as changes in the current account. The exchange rate is exogenous reflecting the link between the Norwegian krone and ECU. Changes in net asset by institutional sectors are determined by identities based on the income-expenditure definitions.

2.2 The working of the model

In MODAG most industrial sectors and domestic transport have production functions that exhibit increasing returns to scale. Combined with markup pricing rules and a non-competitive labour market where wage rates are determined by Phillips-curve equations, the flavour of the model is definitely Keynesian both in the short and medium term. In the long run, the NAIRU-feature inherent in the wage equations is the main equilibrating mechanism of MODAG. As the model contains sectorial wage-equations there is no single NAIRU in the model.

In MODAG, the non-linearity of the wage-equations with respect to unemployment makes the impact multipliers heavily dependent upon the reference path and the level of unemployment in particular. With low levels of unemployment wage growth is quite sensitive to changes in demand, while this is not the case when unemployment is high. Some of these features are illustrated by figures 1 and 2 which show the effects of a demand shock. Government employment is reduced by one percent of base year GDP. Figure 1 shows the effects on GDP, employment and unemployment. There are large effects on the labour market in the short and medium term, while the effects after 10-15 years are moderate. Note that unemployment is permanently reduced in the long run. This is a consequence of the disaggregated modelling of wages in MODAG. Thus, according to the model, NAIRU is reduced by lowering the relative size of the public sector. In the short run GDP is reduced due to traditional multiplier effects. After 5 years the effect on private sector GDP becomes positive and in the long run the effect is quite large even through employment has hardly changed. The main reasons for this productivity increase are the relatively low wages paid to public employees in Norway and increasing returns to scale in the production structure of many private industries. This also explains why consumer prices are reduced, cf. figure 2.

Factor demand equations now (1988-version) allow for substitution between labour and material input. In most sectors, the number of hours depend on output, the capital stock, a trend and the rate between wage costs per hour and the price index of materials. Consequently, material input by sector is made a function of the same variables. A distinction between hours worked and employed persons, has also been introduced recently based on new data from the national accounts. These recent developments on the factor demand equations, together with larger (absolute) values of the price elasticities in foreign trade, have significantly increased elasticities of employment (hours) with regard to the real wage, as shown by figure 3. These changes in the model structure are also partly responsible for the changes in GDP-multipliers, cf. figure 4. However, they are also due to changes in interest rates which were exogenous in earlier versions of the model. The short and medium term multipliers are roughly similar in spite of these changes.

2.3 Estimation and updating of the model

Compared to earlier versions of MODAG more emphasis has been put on dynamic specification and testing. This is of course in line with the development of econometric modelling during the 1980s. In particular, tests for cointegrating relations between variables describing the theory-based long-run structure are used quite frequently. The dynamic specification is usually some variant of an error-correction-model. Other distributed lag specifications such as Almon-lags or simple partial adjustment are still used in some cases but much less then in the early versions of the model. It is therefore interesting to observe that the short-run multipliers have changes relatively little in spite of more emphasis put on dynamic specification. Our experience is that long-run features of the model are more sensitive to the choice of dynamic specification than short-run features.

Ordinary least squares (OLS) is still the dominating estimation method, but the use of an instrument variables approach and FIML have become more frequent.

The estimation period varies somewhat but is restricted by our data base which goes back to 1962. However, due to the lack of detail in the national accounts figures for the early 1960s, before the present SNA system was taken into use (in 1973), the data series sometimes start in 1970.

Due to the annual revisions of the national accounts figures and the fact that the Norwegian national accounts change base year every year, we reestimate all the parameters of MODAG each year, adding one more observation to the estimation period. The structure of the equations are normally not changed, only the estimated parameters. This reassessment of model blocks serves as a test of autonomy of the specified equations. If the adding of one more observation leads to significant changes in parameters, that sometimes initiate a new specification search. The frequent change of base year as well as reestimation is not a very costly affair in spite of the size of the model as efficient routines for this work are developed. The Ministry of Finance, which is the main user of MODAG, regards this up-dating procedure as a "must" if MODAG is to be used in the preparation of various economic policy documents.

2.4 The use of MODAG

The Ministry of Finance is the main *outside* user of MODAG. Presently, MODAG is by far the most important model used by the Ministry in preparing both short-term forecasts for the annual National Budget and medium term forecasts and policy analysis for the Long Term Programme. In addition, MODAG is sometimes used quite intensively in connection which specific case studies. In order to adapt MODAG to specific needs when preparing the National Budget, two separate versions of the model have been designed. The first is a version where a number of econometric equations have been omitted. These equations determine variables which the Ministry feels it has more short-run information than what is included in the model. The other model version is what we call the error-term-version where the econometric error-terms and error-terms in the input-output equations are endogenous while the *corresponding* endogenous variable in each equation is exogenous. This model version serves two purposes. In the National Budget process it is used when the Ministry feels it has worked out the main features of the baseline forecast and thus *knows* how the forecast should be. The error-term-version is then used to produce a book of detailed and consistent tables of the forecast. The same model version is used by the Research Departement to calibrate the model through national account figures for the year after the base year. When preparing the National Budget for year $t + 1$ (the model exercise takes place in August and September in year t, MODAG is based on $t - 2$ prices. The national accounts figures for year $t - 1$ (preliminary estimates) available in May year t, in $(t - 2)$ prices are then used to calibrate the model through year $t - 1$, using the error-term-version, preserving all estimated parameters. Thus the Ministry uses a model that contains *all* the information that is available from the annual national accounts.

Our own use of the model is mainly related to projects financed by research councils and other ministries. The model is also available to the public who can by model runs from the Research Department at low costs.

2.5 The partial nature of the model

In MODAG there are a number of important economic variables which are exogenous in the model structure but endogenous in the economic system which the model tries to replicate in a simplified manner. Compared to large scale econometric models in many other countries the modelling of financial markets are very crude, cf. section 3.6. The determination of key interest rates in the economy is included in the present model version. To develop a more detailed model of the financial flows of the economy poses serious data difficulties in Norway both with regard to the availability of consistent time series of financial balances for each institutional sector and the lack of consistency between the national accounts and financial balances. In spite of these problems, we believe that MODAG should be expanded somewhat in this direction.

Another aspect of the model which is not satisfactory is the modelling of factor demand, cf. section 3.2. In the medium and long term, changes in relative factor prices probably play a more prominent role than what is presently the case in MODAG. In particular, the lack of a user cost of capital term in the investment equation is unfortunate. A simultaneous modelling of factor demand by industry is thus an on-going research project.

Third, supply side modelling of resource-based industries would be an important improvement of the model. It should be noted, however, that Crude oil and natural gas exploration is very difficult to model by traditional econometric methods, due to government regulation and the specific character of that industry. With large single projects with very high sunk costs implying virtually no response to price changes, this sector is probably better handled using micro information outside the model. Finally, there is no forward-looking behaviour in the model. While it is not obvious that such behaviour is important for our results, it has so far not been tested for.

2.6 Forecasting performance

Assessing the forecasting performance of MODAG is important given the role of the model as a tool in short and medium term planning, cf. the previous section. As model builders we are primarily concerned with the models ability to reproduce the historical development of the Norwegian economy rather than assessing the reliability of ex ante forecast, where the ability of the model user is usually as important. There are two ways of testing the historical tracking performance of a model. The most common is "in-sample" test where the model is simulated on the same historical data as those used for estimating the parameters of the model. The use of such simulations as a model validation criteria has recently been critizised by several authors, see

Pagan (1989). The other test of tracking performance is "post-sample" simulations where a subset of the data - usually the most recent historical period - are reserved for testing the post-sample forecasting ability of the model. Post-sample simulation (and tests) can be carried out on single equations, or on the model as a whole. In the following, we present some results from a post-sample test where MODAG has been simulated on preliminary national accounts data for 1988-1990. In evaluating the results, one should note the following points

i) The model has been estimated using final and not preliminary national accounts data. Any verdict on the forecasting properties of the model should be based on final data which are not yet available.

ii) The simulation results for 1988, is not really a full post-sample test because parts of the model have been estimated on data including 1988.

iii) In 1988 and partly in 1989, wage growth was regulated by law and the wage equations in the model will surely overpredict wage growth in both years. This has not been corrected for in the simulations.

iv) Finally, the general economic conditions in Norway changed quite markedly from 1987 to 1990. The level of mainland-GDP fell in two subsequent years, the unemployment rate increased from 2 to 5 percent, there was a turnaround on the current account from a deficit or nearly 5 percent of total GDP in 1987 to a surplus of nearly 4 percent in 1990. Accordingly, the test for the ability of MODAG to forecast the economic conditions is carried out for a period which differs a lot from those of the estimation period.

The results are shown in figures 5-16 for a number of macroeconomic variables. As in apparent from the figures, the tracking performance is quite good. Minor systematic errors may be observed for some variables. The systematic overprediction of wages and prices are mainly due to the wage regulations of 1988 and 1989. The model does not fully reproduce the dramatic decline in gross investment. That comes as no surprise and fits well with the observation that the model tends to cut through the cyclical movements of investment also in in-sample simulations. But all in all we regard the macroeconomic results as very good. When looking at more detailed results, the forecasting errors are sometimes very large and suggest that a respecification of some part of the model is necessary.

3 A closer look at the submodels

3.1 The input-output structure

MODAG is an input-output based model. Commodity transactions are represented by means of two commodity by sector matrices, one for the flow of commodities to each sector and one for the flow from each sector. The commodity balance equation for each commodity is (somewhat simplified) given by

$$\begin{aligned} I_j + \Sigma_i \Lambda_{xji} X_i &= \Sigma_i(\Lambda_{Mji} M_i + \Lambda_{Eji} E_i + \Lambda_{Fji} F_i) \\ &\quad + \Sigma_l \Lambda_{Cjl} C_l + \Sigma_k \Lambda_{Jjk} J_k + A_j + DS_j \end{aligned} \tag{1}$$

where the Λ's are commodity by sector/activity coefficients giving commodity flows in basic values relative to corresponding activity levels in market values. Imports of commodity $j(I_j)$ plus gross output of commodity j from domestic sectors/activities (X_i), represents total supply of each commodity. Note that more than one domestic sector will normally produce each commodity according to the national accounts. The E's, F's and M's represent input-activities by industries for electricity, fuels and other material inputs. C_l and J_k represent private consumption and investment. Note that commodities used for public consumption are taken care of by the input activities M, E and F. Investment in new capital goods (as distinguished from gross investment which also takes account of sales and purchases of second hand capital goods) is specified as investment by type of capital goods. Similarly, the summation of C's is across private consumption categories. A_j represent exports of commodity j and DS_j denotes change in inventories. The latter variables are mainly exogenous.

Imports of commodity j is usually determined as a share of domestic demand for each commodity

$$\begin{aligned} I_j &= DI_j \Sigma_i(\Lambda_{MIji}\Lambda_{Mji} M_i + \Lambda_{EIji}\Lambda_{Eji} E_i + \Lambda_{FIji}\Lambda_{Fji} F_i) \\ &\quad + \Sigma_l \Lambda_{CIjl}\Lambda_{Cjl} C_l + \Sigma_k \Lambda_{JIjk}\Lambda_{Jjk} J_k) + DSI_j \end{aligned} \tag{2}$$

where DI_j is the (average) import share relative to the base year, cf. section 3.5, DSI_j is change of inventories of imports of commodity j. The Λ_{MI}-coefficient show the import share in the base year for each use of commodity j for different purposes. Thus, while $\Lambda_{Mji}M_i$ measures total demand for commodity j by sector i as material input, a certain share (in the base year of the model) given by an element in Λ_{MIji}, is imported. When the import share changes in the simulations due to changes in relative prices, all users of commodity j are assumed to change their import share proportionally relatively to the base-year share. Given demand, represented by the right hand side of equation (1) and (2), these two equations determine imports and output of each commodity. The change in import share, ie. DI_j, is determined by relative prices cf. section 3.5. For natural resource-based commodities the output levels are exogenous. In these cases either exports or the import share index are endogenized using equation (2). Accordingly, no import share equation is specified.

The dual of the commodity balance equation in (1) is a set of price indices of each demand category. As an example, the input price index for other materials is given by

$$\begin{aligned} PM_i &= \Sigma_j(1+TM_j)((1+TVV_j+TPV_j)\Lambda_{Mji}((1-\Lambda_{MIji}DI_j)BH_j \\ &\quad +\Lambda_{MIji}DI_jBI_j)+TVX_j+TPX_j) \qquad (3) \end{aligned}$$

where Λ_{Mji} is the transpose of Λ_{Mij} in eq. (1). In eq. (3) TM_j is the VAT rate, and the TPV_j are other ad valorem tax rates paid by producers. TVV_j denotes other ad valorem tax rates paid by the distribution sector, TPX_j and TVX_j are similarly defined quantity tax rates. Thus, eq. (3) states that the price index for other materials is a weighted share of the domestic price (BH) and import price (BI) of different commodities used as inputs in sector j. Since BH and BI are price indices related to basic value, taxes are included in order to arrive at market values. The structure of the price index for PE_j, PI_j, PC_j and PJ_j are similar to that of eq. (3). For a discussion of indirect taxes and subsidies see section 3.7.

3.2 Factor demand

Energy and other material inputs

Material inputs are divided into three groups in MODAG; electricity, fuels and other material inputs. We assume that total energy input by industry is a CES-aggregate of the volume in fixed prices of electricity (E) and fuels (F)

$$U = [\delta_E(E/\delta_E)^{-\varrho} + \delta_F(F/\delta_F)^{-\varrho}]^{-1/\rho} \qquad \delta_F = 1 - \delta_E \tag{4}$$

where δ_E, δ_F and ϱ are parameters. The energy aggregate U is proportional to gross output X by industry

$$U = Z_U \cdot X \tag{5}$$

U is not observable but is calculated by (4) when the parameters are estimated. If we assume that producers minimize total energy costs ($PE \cdot E + PF \cdot F$) we have

$$E/F = (\delta_E/\delta_F)(PE/PF)^{-\sigma} \tag{6}$$

where $\sigma = 1(1+\varrho)$ is the elasticity of substitution between E and F and PE and PF are price indices. Eq. (4)-(6) then determine U, E and F as functions of PE, PF and X. The parameters in (4) are estimated by specifying an error-correction-model on eq. (6). We have tested for factor-specific technical change in (4) allowing the δ's to change according to an exponential trend. This hypothesis, which is not rejected for most sectors, is very important for the estimates of the elasticities of substitution. In the present model version, this substitution parameter is assessed to about 0.2 in most industries, compared to 1.0 in earlier versions of MODAG where no trend in the δ's was allowed for.

The input of other materials (M) by industry is proportional to gross output

$$M = Z_M X \tag{7}$$

In sectors where labour demand depends on relative factor prices (W/PM), Z_M in (7) is endogenized so that M and labour demand are modelled simultaneously, cf. eq. (16) below.

Capital, investment and depreciation

The capital stock in the model is disaggregated by type of capital good and by sector. Desired capital stock is assumed to be a function of the production level, the rate of return on the capital stock and a time trend. For each type of capital i in sector j, K_{ij}, we assume

$$K_{ij} = f((\Pi^*_{ij}/K_{ij})/r_a, X_j, t) \tag{8}$$

where X_j is the level of output in sector j, Π^*_{ij} is sector $j's$ net operating surplus deflated by the price index of investment in capital good i, and r_a is the rate of return on alternative investment (fx on foreign bonds).

Eq. (8) may be regarded as a combination of the acceleration theory and a portfolio theory of investment. This may be seen as a result of the aggregation of firms with different investment behaviour within each sector.

Since we have more than one type of capital good in most sectors, it would be natural to try to estimate the distribution of the different capital goods through a simultaneous system depending on user cost of capital for different capital goods. Earlier empirical work in Norway has shown that the elasticities of substitution between different capital goods are very small for most sectors.

If the rate of return on alternative investment and the ratio between the rate of return and the depreciation rate are more or less constant we may approximate equation (8) by

$$K_{ij} = g(X_j, \Pi_{ij}, t) \tag{9}$$

where $\Pi_{ij} = GOS_j/PJ_i, GOS_j$ is gross operating surplus in sector j, and PJ_{it} is the price index of investment in capital good i.

To simplify, we linearize (9), and after excluding cross-effect terms we get

$$K_{ij} = \alpha_0 + \alpha_1 X_j + \alpha_2 \Pi_{ij} + \alpha_3 t \tag{10}$$

By definition

$$K_{ij} - K_{ij-1} = J_{ij} - D_{ij} \tag{11}$$

where J_{ij} is gross investment and D_{ijt} is depreciation. In MODAG depreciation is modelled exactly as in the national accounts for all capital goods with a life-time of 25 years or less. Thus, depreciation by sector and capital good is given by

$$D_{ijt} = \Sigma_{l=0}^{T} \frac{1}{T_{ij}} J_{ijt-l} \tag{12}$$

where T_{ij} is life time for capital good i in sector j. For capital goods with a life-time of more than 25 years, a term $\epsilon_{ij} K_{ijt-26}$ is added and the parameters ϵ_{ij} are calibrated using base-year data only so that there is no error-term in (12). For the purpose of deriving the investment equations we simplify and assume

$$D_{ij} = \delta_{ij} K_{ij-1} \tag{13}$$

Substituting (13) and (10) into (11) we obtain gross investment as

$$J_{ij} = \alpha_0 + \alpha_1 X_j + \alpha_2 \Pi_{ij} + \alpha_3 t - (1 - \delta_{ij}) K_{ij-1} \tag{14}$$

Eq. (14) may be regarded as the long run investment equation. The estimated investment equations for each sector and capital good are specified as an error correction model. Investment equations have been implemented for 15 sectors and 3 different capital goods leaving out most of the resource-based industries and ocean transport.

Demand for labour

In MODAG we distinguish between wage earners and self-employed persons. The number of persons in the latter group is exogenously given. Apart from local and central government, Crude oil and natural gas extraction and Agriculture the employment of wage earners is determined endogenously. Man hours, L, is split into number of employees, N, and number of hours worked per employee, H.

Demand for man hours in each industry is modelled by assuming that for given production (X) and capital stock (K), industries minimize their short-run variable costs for labour and materials. Short run demand for man hours is assumed to be given by

$$L = c_0 (W/P_M)^{c_1} X^{c_2} K^{c_3} e^{c_4 t} \tag{15}$$

where W is the wage rate and P_M is the price index for material inputs. c_2 represents the inverse of the short run returns to scale regarding the variable inputs labour and materials. c_1 and c_3 may catch up both scale and substitution effects while c_4 reflects Hicks neutral technical progress.

In the analysis of short term demand for labour one often assumes that the number of hours worked per worker is a more flexible factor in the short run than the number of persons employed. Firms are assumed to balance the costs of extra overtime against the costs of a rapid change in the number of persons employed. As a result of this an adjustment equation between the number of persons employed (N), man hours and normal working hours, (H^N), is specified as

$$N = (L/H^N)^\lambda \cdot N_{-1}^{1-\lambda} \tag{16}$$

Compared to the earlier version of MODAG documented in Cappelen and Longva (1987) where the impact fram normal hours was incorporated directly in the demand for man years, new employment data from the national accounts, which include both man hours and number of persons employed. The adjustment parameter λ is now much higher than in the earlier versions of the model and is not significantly less than one in any sector. This reflects that the amount of overtime in the new annual employment series in the national accounts is only weakly influenced both by fluctuations in the demand for man hours and by a change in normal working hours.

The earlier estimation resulted in increasing returns to scale in most sectors, both in the short and in the long run when capital also is a variable factor. Without any restrictions on the parameters c_2 and c_3 in (16), there is generally a tendency for arriving at unrealistically high levels of returns to scale. We have therefore restricted c_2 to be one when estimating the other parameters and the short-run effects again specifying an error-correction-model. Most manufacturing sectors, Domestic transport, Construction and some other minor sectors show increasing returns to scale, while for most service sectors there are constant returns to scale and K is excluded because c_3 was estimated to be positive. Because of the lagged response of employment to a change in production there is still increasing returns to scale in the short run for almost all industries. Thus the pro-cyclical character of productivity is still an important short-run aspect of the model.

The new estimation results indicate some possibilities for substitution between labour and material inputs in nearly every industry and the elasticities seem particularly large in Building of ships and oil platforms, Construction, Ocean transport, Bank and insurance and Other private services.

The estimation results indicate a significant term for technical progress in Ocean transport, Paper and pulp and to some degree in Machinery and Metal products.

3.3 Households

Supply of labour

The participation rates, and thereby the number of persons in the labour force, are determined for eight groups differentiated by sex, age, educational and marital status, cf. Lindquist et al (1990). The model is a logit-analogy which secures that the participation rates yp_j are restricted to be in the interval between 0 and 1. The equations are of the following form:

$$yp_j = \frac{e^{X_j'\beta_j}}{1 + e^{X_j'\beta_j}} \tag{17}$$

The relevant explanatory factors (X_j) differ between different groups. From economic theory a person's supply of labour depends on real wages (after taxes) and non-labour real incomes. Except for people under education in the group 16-19 years and pensioners the wage elasticities turned out to be very small, giving a rather steep aggregate labour supply curve in the model. For married women their own real wage elasticity and the cross elasticity with respect to their husbands' income seem to outweigh each other, and the aggregate participation rate for men in the group 25-54 years has been almost constant the last 20 years.

The situation in the labour market seems to be the most important explanatory factor for labour participation in almost all groups. For youths and married women a variable representing growth in demand for labour in private and public services seems to be the main factor indicating that these groups partly are rationed in the labour market. A significant effect of the rate of unemployment on the participation rates for middle aged men and pensioners indicate that a discouraged worker effect is of importance for these groups. As an average for all groups a negative shift in demand for labour moves the supply curve to the left, increasing the number of unemployed about one half of the reduction in employment.

In addition to the growth in service sectors a decreasing number of children has been the main factor behind the growth in the participation rate for married women with an elasticity of about -0.2. An expansion in the school system has lowered the participation rate for youths, while a shortening of the pension age and a more liberal practice in achieving disability pensions have lowered the participation rates for the oldest groups.

Private consumption

The consumption block in MODAG can be divided into four parts, cf. Magnussen and Skjerpen (1990):

i) equations which determine consumption-motivating income

ii) equations which determine consumption of housing services and purchase of personal transport equipment and other durable goods

iii) a consumption function for non-durables

iv) a two-stage dynamic expenditure system which allocate consumption of non-durables to ten consumption groups

This implies that the present MODAG-version does not contain a macro consumption function, but separate consumption functions for non-durables and two groups of durable goods in addition to consumption of housing services. The main reason for this specification is that it is easier to apply relevant investment theory to durable goods outside the demand system.

Consumption motivating nominal income (YC) in the household sector is defined as

$$YC = YW + YE + YU + YR + YA + YV - YT \tag{18}$$

where YW is wages and salaries, YE is households share of net operating surplus, YU is net transfers exclusive health benefits, YR is net interest income, YA is dividends, YV is other consumption-motivating income and YT is direct taxes.

Consumption of housing services is modelled in accordance with the way it is measured in the national accounts, building on the user cost of capital principle. The capital stock of houses in current and previous period is therefore the only explanatory variable in the equation which is estimated over the period 1970-89. The equation is specified as

$$\log(C50) = \alpha_0 + \alpha_1[\log(HC50) + \log(HC50_{-1})] \tag{19}$$

where $C50$ is consumption of housing services and $HC50$ the capital stock of houses.

The model for investment in housing is based on a theoretical model similar to that of investment in real capital by firms. Housing investments are regarded as the way the households generate their desired level of housing consumption which again depends on the capital stock of houses, cf. eq.(19) above.

We take desired capital stock of houses as a starting point:

$$K83/BEF = f((YC/PJ83)/BEF, PC/PJ83, RUC) \tag{20}$$

where $K83$ is desired housing capital, BEF total population, YC is disposable consumption-motivating income, $PJ83$ the investment deflator, PC the consumption deflator and RUC the real user cost defined as

$$RUC = (i(1-m) - \Delta PJ83/PJ83 + 0.015) \tag{21}$$

where i the nominal interest rate, m the average marginal tax on net income and 0.015 an approximation to the depreciation rate. Gross investment is by definition

$$J83 = K83 - K83_{-1} + D83 \tag{22}$$

where $J83$ is the gross investment in housing and $D83$ denotes depreciation.

Assuming $D83 = \delta K83_{-1}$ and using (20) gives a gross investment equation for housing. To simplify we linearize this expression and get

$$\begin{aligned} J83/BEF &= \alpha_0 + \alpha_1(YC/PJ83)/BEF + \alpha_2 PC/PJ83 + \alpha_3 RUC \\ &\quad + (1-\delta)K83_{-1}/BEF \end{aligned} \tag{23}$$

To get the actual investments we formulate an error correction model, which is estimated on the basis of data from the period 1963 to 1989. In this model changes in the unemployment rate is added as a short run variable in addition to short run changes in variables entering the error-correction term. To take account of the formation of expectations we let the user cost be represented by a weighted 3 years average. The implicit long-run elasticities for housing consumption are calculated on the basis of a simulation from 1990 to 2020. The income elasticity was almost 1.1, the pure relative price elasticity just below -0.2 and the real user cost elasticity almost -0.1.

The capital stocks of personal transport equipment and other durable goods are determined in two error-correction equations applying the two-step procedure described in Engle and Granger (1987). First, a linear long-run relation between each capital stock and real disposable income is established. These equations can be written

$$HC_i = \beta_0 + \beta_1(YC/PC_i) \qquad i = 30, 40 \tag{24}$$

where HC_i is the capital stock of good i and PC_i the price index for good i. No significant effects of relative prices were found in these equations.

Since the estimated value of the constant term is negative for both goods, the income elasticities will decline towards 1. During the estimation period, 1964 to 1988, the elasticity for personal transport equipment declines from around 2 to around 1.4, while the elasticity for other durable goods declines from around 1.7 to 1.2.

In the second step, lagged residuals from equations (24), RES_{i-1}, are combined with relevant short-run variables. The error-correction equations which follows can then be written

$$\begin{aligned} \Delta HC_i &= b_0 + b_1\Delta(YC/PC_i) + +b_2\Delta HC_{i-1} \\ &\quad +b_3 RES_{i-1} + b_4 DVAT \end{aligned} \tag{25}$$

where $DVAT$ is a dummy for introduction of VAT in 1970.

Purchases of the two goods of durables are determined in dynamic definitional equations between purchase, capital stock and depreciation where depreciation of each good, given as a distributed lag of earlier purchases.

The consumption function for non-durables is an error-correction equation where real consumption-motivating income is the main explanatory variable. In addition, nominal interest rates affects consumption of non-durables in the short run. The dummy variable for introduction of VAT in 1970 is also present in this equation. The equation is log-linear and the income elasticity is estimated to be slightly less than one.

The estimated equation is

$$\begin{aligned}\Delta\log(CIVP) &= a_0 + a_1\Delta\log(YC/PCIVP) \\ &\quad + a_2\Delta\log(RENBG300) + a_3\log(CIVP_{-1}) \\ &\quad + a_4\log(YC_{-1}/PCIVP_{-1}) + a_5 DVAT\end{aligned} \tag{26}$$

where $CIVP$ is consumption of non-durables by resident households, $PCIVP$ is the price index for $CIVP$ and $RENBG300$ is the average nominal interest rate paid by households.

A two stage dynamic expenditure system allocates total consumption of non-durables to ten different consumption categories. Starting at the second stage we operate with two subsystems. In the first subsystem total expenditure on energy consumption is allocated to electricity, $C12P$ and oil, $C13P$ using a CES utility function approach. The following equation has been estimated by OLS

$$\begin{aligned}\log(C12P/C13P) &= f_0 + f_1\cdot\log(HC40_{-1}) + f_2\cdot\log(PC12/PC13) \\ &\quad + f_3\cdot\log(C12P_{-1}/C13P_{-1})\end{aligned} \tag{27}$$

In this equation $PC12$ and $PC13$ are the consumer price indices for electricity and oil respectively. Further $HC40$ is the capital stock of other durable goods. The reason for including this variable is that in some consumer activities the consumption of electricity depends heavily on installed capital stocks and in these areas consumption of oil is no alternative.

In the other subsystem we allocate total expenditure on non-durable transport activities by resident households to Operation of personal transport equipment ($C14P$) and consumption of Public transport services and communication ($C61P$) using a linear expenditure system formulated on per capita basis and extended with effects from the capital stock of cars, $HC30$. The variable $HC30$ is the stock of cars held by the household sector. The reason for including this variable is the belief that an increase in the stock of cars reflects a preference change in favour of private transport.

The subsystem can be written as

$$\frac{CiP}{BEF} = \gamma_i + \frac{\beta_i}{PCi}\left[\frac{VCTR}{BEF} - \sum_k PCi\gamma_i\right] \tag{28}$$

where $i, k \in I = \{14, 61\}$ and

$$\gamma_{14} = \gamma_{14} + \zeta_{14} \cdot \frac{HC30_{-1}}{BEF_{-1}} \tag{29}$$

while γ_{61} is constant. BEF is the population size.

The choice of a CES utility function for the energy aggregate and a Stone-Geary utility function for the transport aggregate, is based on empirical criterias such as goodness of fit and plausible price elasticities. At the upper decision level, we use aggregated energy and transport as the choice variables.

At the upper stage we operate with a dynamic version of the per capita linear expenditure system. The system at the upper stage is written as

$$\frac{C_jP}{BEF} = \gamma_j + \left(\frac{b_j}{PC_j}\right)\left[\frac{VCIVP}{BEF} - \sum_k \gamma_k PC_k\right] \tag{30}$$

$$\gamma_j = \gamma_{j0} + \gamma_{j1}\frac{C_jP_{-1}}{BEF_{-1}} \tag{31}$$

$$VCIVP = \sum_j PCj \cdot CjP \quad j, k = \{00, 11, U, TR, 20, 21, 60, 66\} \tag{32}$$

In the above equations CjP denotes consumption of category j by resident households in year t whereas PCi denotes the accompaning price indices. Total expenditure on non-durables $VCIVP$ may be decomposed as

$$VCIVP = PCIVP \cdot CIVP, \tag{33}$$

To ensure adding up both in value and volume the variable $PCIVP$, which is the price index for total non-durable consumption, has to be determinded simultaneously with the other variables in the expenditure system. Total consumption by foreigners in Norway $C70$ is modelled by an export equation. $C70$ is allocated to the different consumption categories according to fixed volume shares.

3.4 Prices and Wages

Price equations

In recent years there have been a number of studies trying to provide a microeconomic foundation for Keynesian macroeconomics. Theoretical macro models based on micro models of imperfect competition have become one major line of research, often combining imperfect competition with an assumption of increasing returns to scale either due to fixed set up costs or for some other reasons.

There exists two main models of imperfect competition when analyzing equilibrium in an individual market. The quantity-setting model with homogenous products and the price-setting model where products are differentiated. In both cases it is common to use the Cournot-Nash assumption that firms take other firms' strategic variables as given.

Monopolistic competition seems as a more accurate description of many markets than perfect competition. If we assume a constant elasticity of substitution both in consumption and in production cf. Blanchard and Kiyotaki (1987), it can be shown that in a symmetric equilibrium there exists an "aggregate price rule"

$$P = (\Theta/(\Theta - 1))kWY^{\alpha-1} \tag{34}$$

where Θ is the constant elasticity of substitution between all goods (restricted to be greater than unity), k is a positive constant, W is the wage rate, Y is output and α is the inverse of the degree of returns to scale. In (34) the pricing rule (independent of the number of firms as Θ is assumed to be constant) states that price is a (constant) mark-up on marginal costs which is equal to $WY^{\alpha-1}$. In what follows we describe how we have specified marginal costs and the mark-up in MODAG.

Marginal costs are given by

$$dC/dX = WdL/dX + PMdM/dX + PUdU/dX \tag{35}$$

Remember that we assume U is proportional to X according to eq. (5). An assumption of constant returns to scale in M and L is consistent with the factor demand equations in MODAG, see section 3.2 above.

In this case the factor demand equations can be written as

$$M/X = g_M(W/PM, K_{-1}, t) \quad (36)$$
$$L/X = g_L(W/PM, K_{-1}, t) \quad (37)$$

where K is the capital stock and t is a time trend relating to technological progress.

Variable unit cost is now equal to marginal cost as given by (35) defined as

$$PV = WL/X + PMM/X + PUU/X \quad (38)$$

We have tested whether a capacity utilization index defined as a modified Wharton index, see Cappelen and v.d. Fehr (1986), has any effect on prices. Should this index be significant in the price equations, the model of producer behaviour becomes inconsistent. A preferred procedure in this case would be to estimate the price equation together with factor demand equations as a simultaneous system. In general only weak and mostly insignificant effects on prices have been found.

The mark-up is related to properties of the demand function for the product which again depends on parameters of utility and production functions. In MODAG demand for a product is assumed to be a CES-aggregate of Norwegian and foreign goods classified as similar goods in the national accounts at our level of aggregation. In MODAG, Norwegian and foreign goods are treated as heterogenous. Assuming that the buyers minimize the costs of buying Norwegian and foreign goods and that the CES-aggregate is homothetic (this is similar to assumptions in Blanchard and Kiyotaki (1987)) the mark-up will generally depend on relative prices between Norwegian and foreign goods.

If marginal cost is equal to variable unit cost, the price equations may therefore be expressed as

$$BN = f(PV, BI) \quad (39)$$

BN are price indices of Norwegian goods. On the domestic market $BN = BH$ (the *domestic* price index). On the export markets $BN = PA$ (the export price index). BI is the import price.

When estimating the model, we have chosen a log linear specification of equation (39). In addition we have tested whether a capacity utilization

Table 2: Increase in aggregate (endogenous) price indices of 1 pct increase in unit variable costs, import prices and capacity utilization. [1] Pct.

Increase in	Domestic price		Export price	
	1. year	long run	1. Year	long run
Unit costs	0.82	0.95	0.63	0.61
Import price	0.01	0.05	0.31	0.39
Capacity util.	0.10	0.10	0.40	0.40

1) By 1 pct-point.

index should be included or not. Both domestic prices and export prices are modelled in this way, letting Norwegian import prices of the different commodities represent foreign prices. About 90 pct. of domestic prices (share in value-added) are endogenous, the exceptions being prices of agricultural products and electricity. In MODAG export functions are covering about half of total exports and for these goods export prices are endogenous. Export prices from resource based industries are usually exogenous.

We have in general used an error correction formulation to capture the short-run dynamics. Long run homogeneity of degree one in PV and BF is imposed, although data reject this restriction in a few cases.

A main result is that domestic costs play an important role in determining Norwegian prices, especially in the domestic market, cf. table 2. Foreign prices play a minor role but influence domestic prices indirectly via the input-output structure and unit costs. For export prices the direct price impulses from foreign prices are much larger, although domestic costs is the most important factor in determining export prices as well. Thus, our results differ quite markedly from the pure version of the Scandinavian model of inflation where export prices are assumed to be equal to world market prices.

The effect of capacity utilization is significant only in some of the price equations. The effect of changes in the degree of capacity utilization is generally larger in the export price equations than for domestic prices.

We have in general allowed for overshooting in the short-run price dynamics of changes in prices and costs. This occurs in a number of export price equations, so that the aggregate short run effect of increased costs are sometimes larger than the long run effects.

In addition to equations for determining domestic and export prices we have also estimated import price equations for crude oil and refined petroleum products. Import prices of refined petroleum products and crude oil and the export price of natural gas are all functions of the export price of crude oil.

Wage formation

The wage formation in MODAG combines the Scandinavian theory of inflation with a simple Phillips curve. From theories of union behaviour wage demand may be considered as a compromise between wage growth necessary to retain the members real disposable income and wage growth in accordance with the firms competitiveness to maintain employment. It is reasonable to believe that more weight is put on firms competitiveness in the competing sectors where the consequences for employment of too large wage increases will be most severe. Firms in the sheltered sectors have better possibilities to pass on higher wages to higher prices. Concern about the members relative wage position also imply that unions in the different sectors put weight on wage formation in other sectors.

In MODAG wage equations are estimated separately for different industries (both inside and outside manufacturing). The wage equation for manufacturing industries may be written as

$$\begin{aligned}\frac{\Delta W}{W_{-1}} &= c_0 + \frac{c_1}{U_{-1}^2} + c_2\frac{\Delta BI}{BI_{-1}} + c_3\frac{\Delta P_c}{P_{c,-1}} + c_4\frac{\Delta Y}{Y_{-1}} \\ &\quad + c_5\frac{\Delta(1-\bar{t})}{1-\bar{t}_{-1}} + c_6\frac{\Delta(1+a)}{1+a_{-1}} + c_7\frac{\Delta H^N}{H_{-1}} \qquad (40)\end{aligned}$$

where

W = hourly wage rate

U = rate of unemployment

$$
\begin{aligned}
BI &= \text{import price index for competing manufacturing} \\
& \text{products} \\
P_c &= \text{price index for private consumption} \\
\bar{t} &= \text{average income tax} \\
Y &= \text{output per man hour} \\
a &= \text{employers contribution to the social security system} \\
H^N &= \text{standard hours of work}
\end{aligned}
$$

The Scandinavian theory of inflation implies that $c_2 = c_5 = -c_6 = 1$ and $c_3 = c_4 = 0$ for exposed industries. If these restrictions are valid and there is no change in standard hours of work, the unemployment rate $u_0 = \sqrt{(c_1/-c_0)}$ is in accordance with a wage growth within the "wage corridor" and may be considered as an equilibrium rate of unemployment, or NAIRU. For the aggregate manufacturing industry in MODAG (and also as an average of all industries) the NAIRU is estimated to about 2.8 per cent. However, since MODAG is a multisectoral model, there is no unique value of NAIRU in the model.

Effects of consumer prices and income taxes are only of minor importance for wage growth in the aggregate manufacturing sector according to our estimates. In the implemented equation in MODAG however, some weight is put on factors determining real disposable income as these factors also seem to be of some importance for the various manufacturing industries. As a result of a rather parallel development in consumer and import prices in the long run, import prices and productivity are the main factors behind wage growth in manufacturing industries. In the Construction sector and private and public services consumer prices and income taxes have been of greater importance, but the coefficients for income taxes in most sectors are clearly less than one.

3.5 Foreign trade

Exports

In MODAG, export demand equations have been introduced for about one third of the commodities, covering fifty per cent of total exports. Exports of resource-based products such as Crude oil and Natural gas, Fish and Agricultural products, etc., covering about twenty-five per cent of total exports, are assumed to be capacity-constrained or supply-determined. Capacity changes in production of these commodities are strongly influenced by economic policy and exports are therefore exogenous, given the medium-term character of the model. Exports of Ocean transport services, exports of some minor services and second-hand real capital, are also exogenously determined, as it has proved difficult to establish stable and meaningful export equations for these commodities.

The implemented export equations cover manufactures and also some services. For these commodities it is assumed that Norwegian producers face specific demand curves on the world market, represented by equations such as

$$A = f(PA/BI, V) \tag{41}$$

(41) expresses the assumption that the volume of Norwegian exports A, is a function of the ratio between the Norwegian export price PA and the import price BI, and a variable V which denotes the size of the world market. The usual argument for adopting a specification like (43), is that domestically and foreign produced commodities are imperfect substitutes.

For relatively homogenous goods, such as raw materials or intermediate goods, the assumption that there exist separate demand curves for Norwegian commodities may seem reasonable only if they constitute a considerable share of world trade in the commodity in question. However, for small countries this will rarely be the case, and it is customary to assume that exports may be better modelled by constructing a socalled small-open-economy model. This implies that exports are assumed to consist of homogenous commodities which are sold at fixed prices on the world market. Exports are thereby determined by supply conditions. For three staple commodities in MODAG (Paper and paper products, Industrial chemicals and Metals) attempts have been made to estimate a more supply-oriented model for exports, with exports depending on the export price, capacity and factor prices. However, this work has not lead to changes in our general specification.

In MODAG, we have chosen a log-linear error-correction form of (43) for most commodities. Price homogeneity in the long run has been imposed as an a priori restriction. Restrictions on the long run market demand elasticity or price homogeneity of the short run price elasticities have only been imposed when supported by the data.

The empirical results may be summarized as follows cf. Lindquist (1992),

i) The estimated equations indicate sluggishness in the adjustment of export. As a consequence, the long run elasticities of changes in both relative prices and market demand are larger (in absolute values) than the corresponding immediate effects for most commodities. The only exception is the market demand elasticity for Metals.

ii) In general, the results imply reasonable and fairly high (absolute value) price elasticities compared to many studies based on the Armington approach. Only for two of the service commodities are the estimated long run price elasticities less than 1 in absolute value. If we weight the elasticities together by using the export values for 1988 as weights, we get an average long run price elasticity (for the commodities for which export equations have been estimated) of approximately -1.7.

iii) Most of the estimated long run market demand elasticities are greater than 1, and the average weighted market demand elasticity is just below 1.5. This seems somewhat on the high side given that imports and not GDP is used as indicators of market size.

Imports

The commodity imports in MODAG are, with two exceptions (Ships and oil platforms, and Electricity), determined endogenously. The determination of imports, however, is different for different groups of commodities, cf. Svendsen (1990). For so called non-competitive commodities which by definition are not produced in Norway, imports are determined directly from the commodity balance equations. This is also the case for imports of resource based commodities (primary industry products, Crude oil, and Natural gas) where production is exogenous and imports are determined residually. For the remaining commodities, imports are determined by import shares (imports of the commodity relative to domestic use). For manufacturing goods covering more than half of total imports, these import shares are endogenous and specified and estimated as functions of the ratio between the domestic and the corresponding import price. For the imports of services (except Tourism

Table 3: Determination of imports

Group of commodities	Share of import, 1988	Price elasticities [1]
Estimated import share equations	57 %	-1,44
Residual import	33 %	-
Exogenous import shares	3 %	0,0
Exogenous import levels	7 %	0,0

1) The elasticity of a change in the ratio between domestic price and import price on the demand for Norwegian goods.

and Domestic transport), the import shares are exogenous. Table 3 shows the part of total import covered by each of the commodity groups.

The specified import share equations in MODAG are derived as demand functions. Consumers and producers are assumed to minimize their total expenditures for the purchase of each commodity, whether imported or produced domestically. Total demand for the commodity concerned is defined as a CES-aggregate homogeneous of degree 1 in the input of the domestically produced commodity and the imported commodity. The specification is based on the assumption of weak separability in demand between the input of this composite commodity and other commodities. The ratio between imports and Norwegian production of corresponding commodities may thereby be expressed as a function of the price ratio beteen these two commodities alone. More precisely, in MODAG the following set of import share equations are specified

$$DI_t = \frac{1}{MB_0[1 + e^{a_0} \cdot \Pi_{m=1}^{M}(BI/BH)_{t-m+1}^{a_m} \cdot \Pi_{n=1}^{N}(DI_{t-n} * MB_0 - 1)^{b_n}]} \tag{42}$$

The long-run elasticity of substitution between imported and Norwegian goods σ, is defined by

$$\sigma = \frac{\sum_{m=1}^{M} a_m}{1 - \sum_{n=1}^{N} b_n} \tag{43}$$

Equation (42) defines the import share index of a commodity, DI (the import share relative to the import share in the base year (MB_0), as a function of the ratio between import price (BI) and domestic price (BH) and lagged values of the ratio between Norwegian goods and imports (lagged endogenous). The a's and b's are estimated parametres. M and N are the number of lags on the price ratio and the ratio between imports and Norwegian goods, respectively. The b's are equal to zero for some of the commodities. For some of the commodities a trend term has been included.

Equation (42) is estimated for all manufactured goods in the model. The results can be summarized in the following way

i) The direct price elasticities (long run) for Norwegian products - defined by the elasticity of substitution multiplied by the cost shares - vary for most of the commodities between 0,2 and 1,0 in absolute values. One exception is Machinery with a direct price elasticity of -2,8. The average price elasticity - using the import values for 1988 as weights - is -1,4. Machinery alone covers about 38 per cent of the import in this group, and consequently has a great influence on the average price elasticity.

ii) Textiles and wearing apparels, Paper and pulp, Industrial chemicals and transport more than 50 per cent of the effect of a relative price change on the import share is realized within the first year. For Food products, Beverages and tobacco, Miscellaneous industrial products, Metals and Machinery it takes two years before 50 per cent of the effect is realized. The first year effect has been estimated to be zero for Beverages and tobacco and Metals.

iii) For Textiles and wearing apparels, Paper and pulp and Domestic transport equation (44) also includes a trend. This is due to autocorrelation in the error term and for Textiles and wearing apparels and Domestic transport, insignificant effects of the price ratio. After introducing the trend the effects of the price ratio are still insignificant. This result throws some doubt upon the validity of the chosen specification. The trends indicates an autonomous increase in the import shares by 4-8 percent per annum.

iv) The equations have all been tested for misspesification and structural changes during the period of estimation. The hypothesis of any autocorrelation and heteroscedasticity are rejected in all implemented equations. There are tendencies of unstable parameters towards the end of the estimation period for Textiles and wearing apparels, Miscellaneous industrial products and Metals.

3.6 Financial variables

Norwegian financial markets have been subject to comprehensive regulations until the mid 1980s, with interest rate control and credit rationing. Consequently, the model contains only a rudimentary description of the financial sector of the economy, linking the accumulation of financial wealth, the flow of interest payment and interest rates for the household-, government- and foreign sectors. In the present version of MODAG interest flows and interest rates constitute the only link between the financial and real parts of the economy. As shown by the previous discussion of investment and consumption behaviour, all effects come as a result of household behaviour including housing investment.

The main interest rate indicator is the 3 month NOK interbank rate. The indicator is modelled on the assumption that the openess of the Norwegian economy leaves no long run discretionary power to the monetary authorities. The interest rates that enter into the various accounting and behavioural equations are modelled as simple bridge equations.

For each of the three sectors households and local- and central government, MODAG tracks the development of gross financial claims and liabilities. The development of gross claims are either exogeneously given (all government) or follows the growth of nominal income (households). The change in gross liabilities then follows from an accounting identity linking claims, liabilities, savings, investments and revaluations of assets. For the foreign sector, the changes in total net assets follow from an accounting identity while gross assets are exogenous.

For domestic sectors, gross interest receipts and payments are modelled separately. For the household sector gross payments are defined as the sum of payments to state banks and private financial institutions.

The (implicit) interest rates on household financial claims and liabilities are tied to the NOK rate through linear equations capturing the behaviour of financial intermediaries. The estimated equations are quite stable in spite of the heavy changes in the financial regulatory framework during the mid 1980s. The implied long run margin between household borrowing and lending rates range from 3.5 to 5.5 per cent for in-sample variations of the NOK rate.

The long run equilibrium value of the NOK rate are modelled as a linear combination of weighted averages of foreign rates of interest and inflation and the domestic rate of inflation. Short run behaviour is also influenced by the change in the same variables, by the change in the current account and by the lagged change in the exchange rate. In the long run, a one percentage point increase in the foreign interest rate indicator or the domestic rate of inflation results in an increase in the domestic interest rate of .35. A one percentage point decrease in the foreign rate of inflation has the same effect. The relationship is remarkably stable throughout the period 1984 to 1990. The above result suggests a moderat link between Norwegian and foreign interest rates. However, a more recent experiment on monthly observations indicate that domestic monetary policy changes may only have a transitory effect on the domestic rate of interest, cf. Jore and Moum (1991).

Interest payments between Norway and other countries are treated on a net base, as the product of an implicit rate and the average net claims. The implicit rate is estimated as a linear combination of short and long run US rates. An increase in the long run rate results in an increase in net interest payments from Norway while an increase in the short run rate results in a decrease. This reflect the maturity structure of Norwegian assets and liabilities.

3.7 The Government sector

The government sector is modelled in great detail in MODAG. One reason for this is obviously the fact that the main user of the model is the Ministry of Finance. However, given that the government sector constitutes a large share of the economy, cf. table 1 above, this fact alone warrant a fairly detailed analysis. The government sector is disaggregated into central and local government and each of these two sectors are further disaggregated into three sectors, Education, Health and Other sectors. In addition, in the central government sector Defense is specified as a separate sector. Public consumption and investment are specified independently for each of these seven public sectors. Direct and indirect taxes and transfers are also disaggregated between central and local government.

Indirect taxes and subsidies

Indirect taxes and subsidies are specified in great detail in the model. Each commodity tax and subsidy is specified according to information on the tax base, tax rate and tax payer. The tax base is either the volume or the value of one or several commodities. Thus the tax rates are specified as rates on volumes or values. In addition the tax payer is either the importing or producing sector for each commodity and is then called a production tax, or the tax is paid by the trading sector and is then called a trade tax. The tax rates also varies between different buyers of each commodity. For example commodities for exports are generally not taxed. The tax rates are specified in greater detail than the commodities in the model. Thus several taxes are levied on each model commodity and the model thus containes aggregation equations showing the link between the actual policy variables (tax rates) and model tax rates. In eq. (3) in section 3.1 we specified a number of tax variables. Each of these are in general defined by equations such as

$$TVV_i = \Sigma_j \alpha_{vvij} TART_j \tag{44}$$

where $TART_j$ is a specific indirect tax on beer say, while we in the model specify tobacco and beverages as one commodity so that the relevant TVV for consumption of this commodity includes a whole range of taxes on alcohol, soft drinks and tobacco. Equations similar to (44) are specified for each of the four tax rates specified in eq. (3) in section 3.1. The α_{vvij}s show the importance of each tax on model tax rate TVV_i.

Not all indirect taxes or subsidies are commodity related. Some taxes are sector related. These do not enter the input price equations but are instead included in the equations defining operating surplus by industry. Consequently they are pure transfers from (central) government to the private sector and affect the solution of the model only in as far as operating surplus affects household income or investment decisions by firms.

Direct taxes

Direct taxes are paid according to different socioeconomic groups (salary earner, self-employed, pensioners). Taxes are determined by a two-step procedure. In a separate micro-based tax model average and marginal macro tax rates (t_g and t_m respectively) are calculated for each socioeconomic group and for each type of tax. The model specifies a number of different direct taxes; central and local government taxes on income, contribution to social security and pensions, taxes on wealth etc. For each type of tax and socioeconomic group we specify

$$T = t_m(RMOD - RREF) + t_g RREF \tag{45}$$

where $RMOD$ is income per person (tax-payer) generated by the model in each year while $RREF$ is the base year income multiplied with an assumed real income growth (usually taken from previous runs with the model) and adjusted for inflation in the previous year. The reason for this procedure is as follows. It is reasonable to assume that tax rates are adjusted when nominal incomes grow as the tax rates themselves are nominal. If the assumed nominal income growth in the micro-tax model is equal to that of a representative person in MODAG, taxes are paid according to the average tax rate t_g. If nominal incomes are different, that difference should be taxed according to marginal rates. Each autumn the tax system for direct taxes for the following year, is passed by the parliament and these rates are nominal in nature. If nominal incomes are different from what was expected, marginal taxes become effective. However, tax rates the year after are related to the actual nominal income growth and not the assumed growth the previous year. That is why it is the lagged nominal growth in incomes that affects $RREF$.

Government consumption and investment

Government consumption in current prices by each government sector j is defined as

$$VCO_j = w_j L_j + \Sigma_i PJ_{ij} \cdot D_{ij} + PM_j \cdot M_j + PE_j E_j + PF_j F_j - BH_j X_j \tag{46}$$

where $w_j L_j$ are wage cost in government sector j and $BH_j X_j$ is the value of marketed government services. D_{ij} is depreciation of the capital stock of type i in government sector j, cf. section 3.2. A similar expression in fixed prices is found by excluding all price terms and fixing the wage cost per hour w_j at its base year value and multiply it with an index for labour productivity growth. The X_j's are determined by the input-output structure of the model, cf. eq. (1) in section 3.1 and the BH_j's are determined in a simple mark-up price equation similar to those presented in section 3.4. The price deflator for government consumption PCO_j is defined implicitly using eq.(46) above and a similar expression in fixed prices. Government investments by sector and capital good are exogenous variables and affects output via demand given by eq. (1) in section 3.1. However, due to the way depreciation is modelled, investment affects value added in the public sector by the same amount as it affects government consumption as defined by eq.(46) above. The number of hours worked in each government sector L_j, as well as the volume of other material input M_j are exogenous. Energy input is determined by the same set of equations as those shown in section 3.2.

Transfers

Transfers from the public sector constitute a large fraction of households' income. In 1989 aggregate transfers from state and municipalities (incl. the national social security system) amounted to 118 bill. kroner, which is about 1/4 of household income before taxes, or about 1/5 of GDP.

In MODAG transfers are specified in rather great detail, and all transfers to households are endogenized. This is done to take account of the more or less automatic payments from the national social security administration e.g. to the elderly, the unemployed and the disabled. But other transfers given by the state and the municipalities also have a great deal of endogeneity, e.g. family allowances, childbirth allowances and social care allowances.

Some other components contributing to a smaller fraction of aggregate transfers are endogenized simply by linking them to the size of the population and the average wage rate. Table 4 gives an overview of the relative importance of the different transfer categories.

Below follows a short description of the equations determining transfer cate8gories not only linked to population and wages, cf. Bowitz (1991).

Old age pensions are determined by a separate micro-model for the national social security old age pensions. This model calculates the real value of old age pensions accounting for the demographic development and the

Table 4: Transfer categories in MODAG

	Bill.kr.1989	Share of GDP in %
Old age pensions	35.0	5.6
Disability pensions	16.3	2.6
Illness and childbirth allowances	12.9	2.1
Family allowances	7.0	1.1
Unemployment benefits	6.5	1.0
Rehabilitation allowances	5.0	0.8
Miscellaneous municipal allowances	7.2	1.2
Other transfers 1)	28.1	4.5
Total	118.0	18.9

1) 6 small categories mainly assumed to be proportional to population and the average wage rate.

fact that average pensions increase as the social security system matures. In MODAG old age pensions are indexed by consumer prices.

For disability pensions we have constructed a rather disaggregate model accounting for the inflow and outflow of persons. We divide the population into the age groups 16-39, 40-49, 50-59, 60-64 and 65-66 for men and women, respectively. We have specified entry to disability pension, ageing of the pensioners, and exit (death or entry to old age pension) in some detail. A great number of people are being classified as disabled because of slack or mismatch in the labour market, and there has been a market rise in the number of disabled in the 1980's, as this have been a period of very high unemployment in Norway by historical standards. We have estimated a significant effect of unemployment on disability pension entry. For women there also have been an upward trend independent of the labour market situation, which we have attributed to the increased participation rates for women. In addition to unemployment, a variable procying layoffs is also included, implying that there is a separate effect on disability pension entry from layoffs. This is modelled by a variable that includes the sum of the employment changes in sectors where employment is falling, sectors having increased employment give zero contribution to this variable.

The equation in the model for disability pensions are specified as (for the different age groups and sexes):

$$\begin{aligned} \log(ER/ER(-1)) &= A0 + A1^{*}\log(UR(-1)) + A2^{*}\log(ER(-1)) \\ &\quad + A4^{*}LO(-1) + A3^{*}\log(PR(-1)) \qquad (47) \end{aligned}$$

ER = Entry rate

UR = Unemployment rate

PR = Participation rate (only for women)

LO = Sum of changes in employment in sectors having reduction of employment, divided by aggregate labour supply

The elasticities wrt. unemployment are estimated to around 0.5 for most categories, both for men and women. In addition the long run estimated elasticity of entry rates for women wrt. the participation rate is around 1.2. The aggregate effects on receivers of disability pensions of an increase in unemployment e.g. from 4 to 5 pct is approximately zero the first year increasing to 12 000 persons after 5 years and 20 000 after 10 years. This amounts to 0.5 pct and 0.8 pct, respectively, of the labour force. Consequently, the expenditure effects also appear rather slowly. The disability pension model has hysteresis properties, as increased unemployment pushes people into disability pension, but these persons do not enter the labour force later as unemployment declines again.

Allowances for childbirths are linked to the number of births, the wage rate and the participation rate for women, as in practice only women in paid work receive this allowance.

Illness allowances are determined in two steps. The starting point is an indicator of *paid illness days*, taking account of changes in the composition of the employed wrt. age and sex. This indicator is constructed by deflating the value of the allowances by the aggregate wage rate, and using base year values for *paid illness days* by sex and age. The illness indicator is determined by unemployment, increasing by increased unemployment. As the model does not distinguish between employed men and women, we determine the number of male and female employed persons by using the ratio of female labour supply to total labour supply.

Unemployment benefits, rehabilitation allowances and miscellaneous municipal allowances are all functions of the number of unemployed persons and the aggregate wage rate. The reason why unemployment benefits depend on these variables is obvious. Rehabilitation allowances have historically to a great extent moved in line with unemployment, the number of receivers increasing in period of high unemployment. Miscellaneous municipal allowances also have a large cyclical component, mainly because they include social care expenditures.

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FIGURE 1. DECREASE IN GOVERNMENT EMPLOYMENT OF 1% OF BASEYEAR GDP. Difference from base solution in %

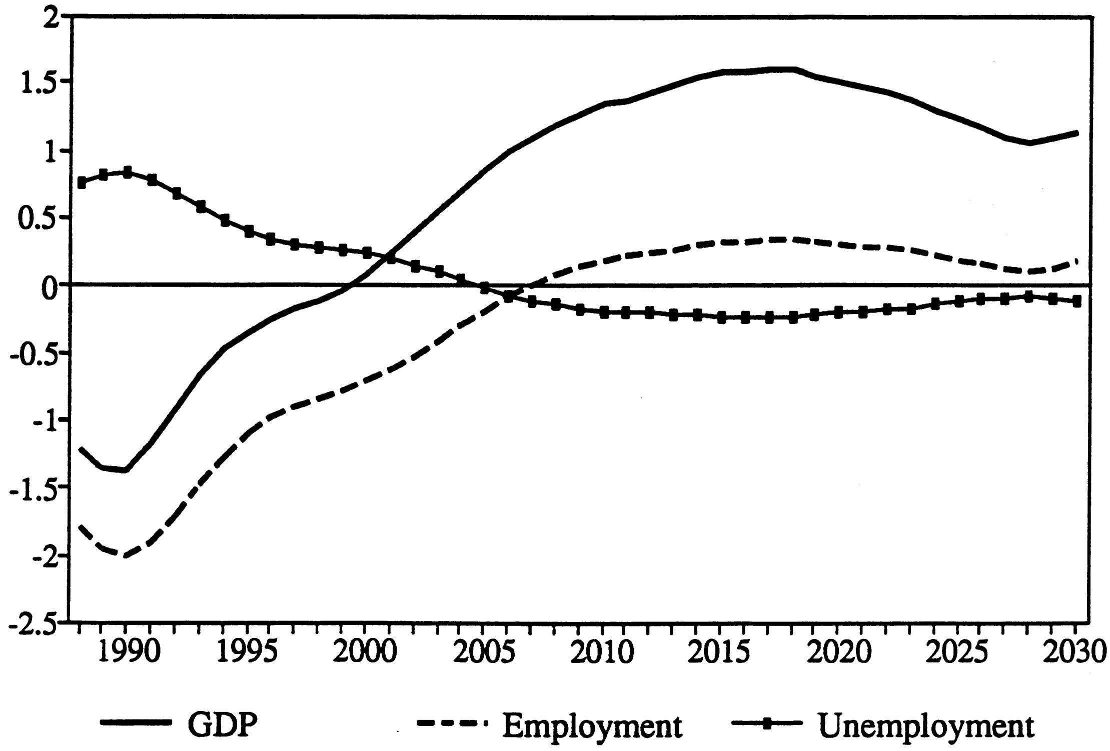

FIGURE 2. DECREASE IN GOVERNMENT EMPLOYMENT OF 1% OF BASEYEAR GDP. Difference from base solution in %

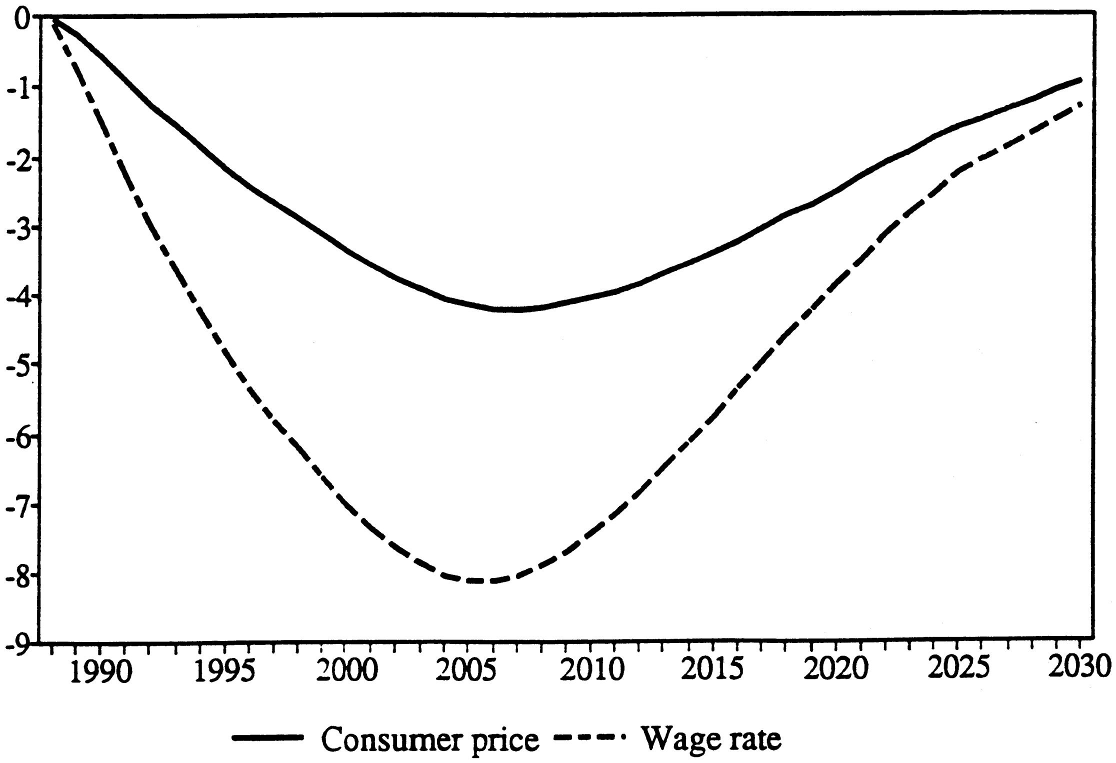

FIGURE 3. THE ELASTICITIES OF EMPLOYMENT WRT. THE REAL WAGE

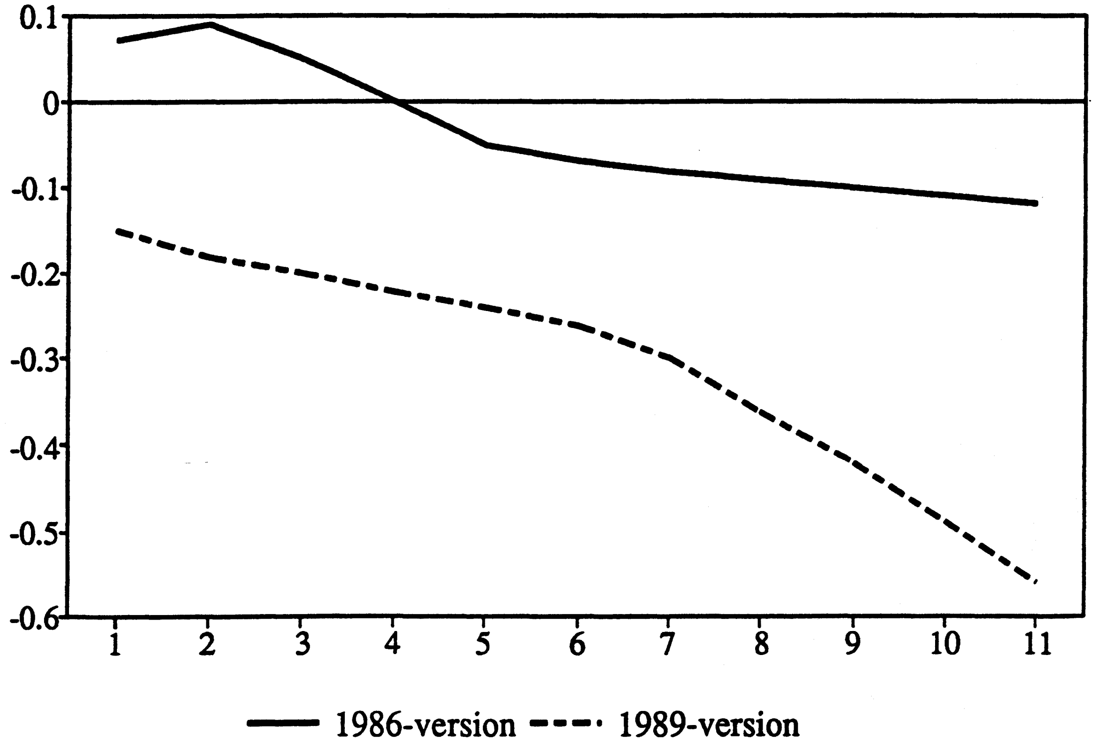

FIGURE 4. GDP-MULTIPLIERS OF AN INCREASE IN GOVERNMENT EMPLOYMENT

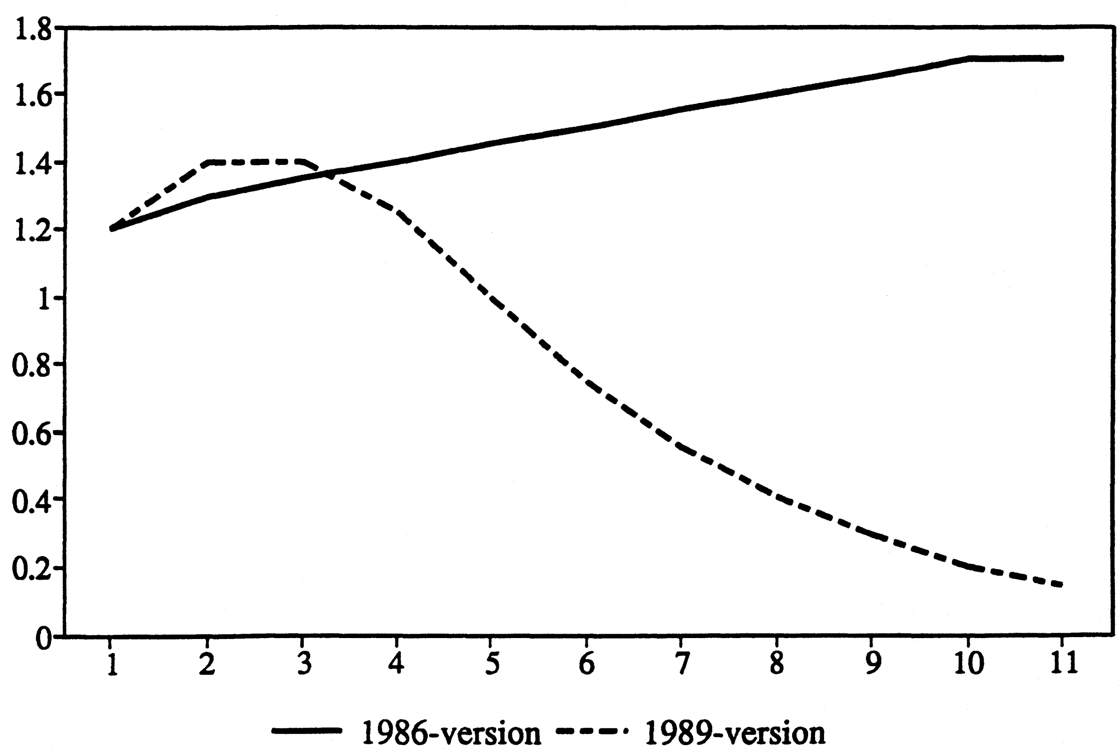

FIGURE 5. GDP, mainland economy excl. government
(Bill. NOK 1988-prices)

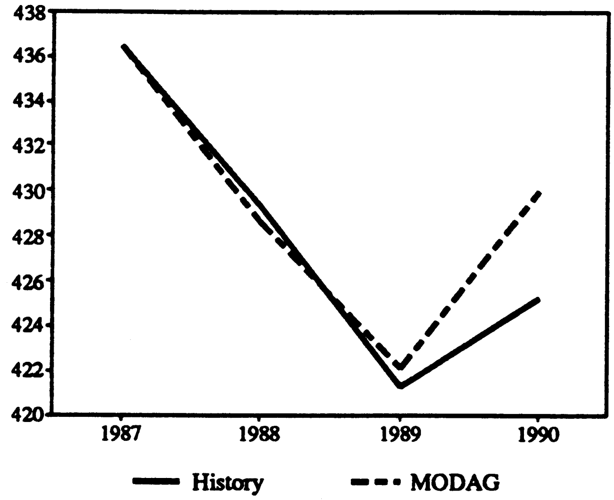

FIGURE 6. PRIVATE CONSUMPTION
(Bill. NOK 1988-prices)

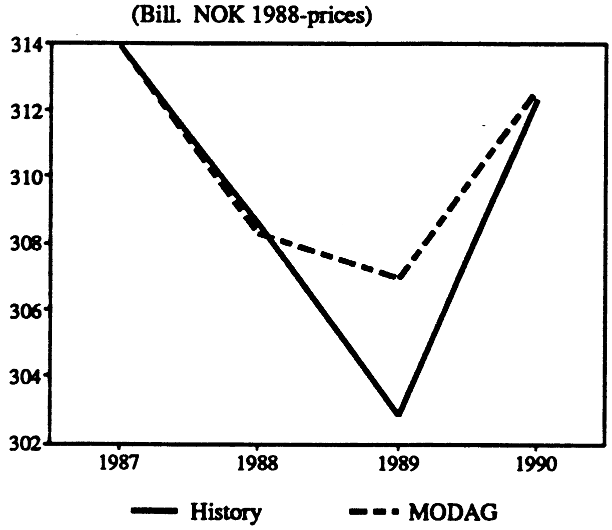

FIGURE 7. GROSS INVESTMENT, MAINLAND
ECONOMY, EXCL. GOVERNMENT
(Bill. NOK 1988-prices)

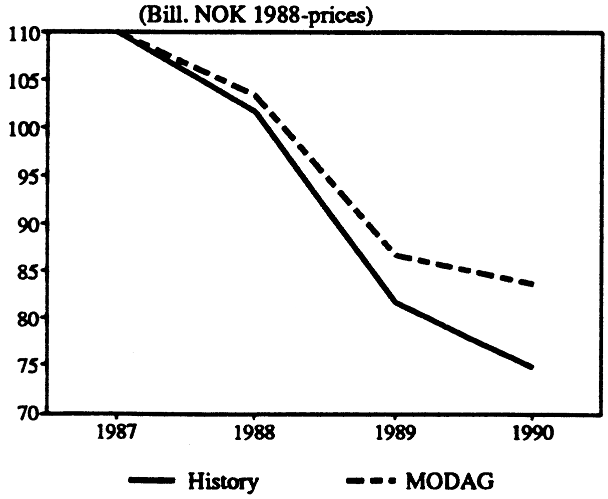

FIGURE 8. EXPORT, EXCL. OIL, GAS AND SHIPPING
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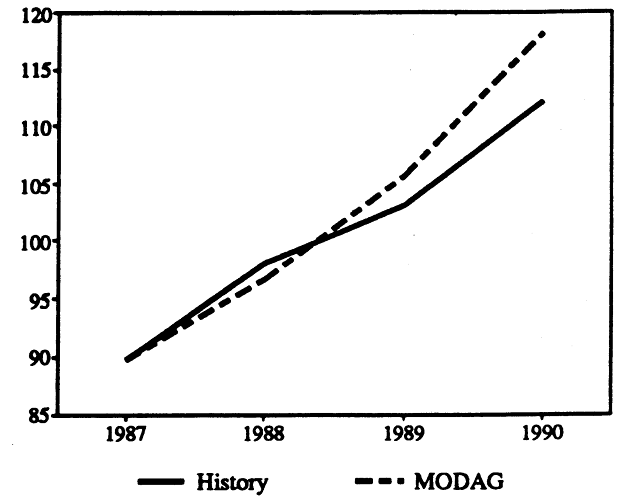

FIGURE 9. IMPORTS. EXCL. OIL, GAS AND SHIPPING
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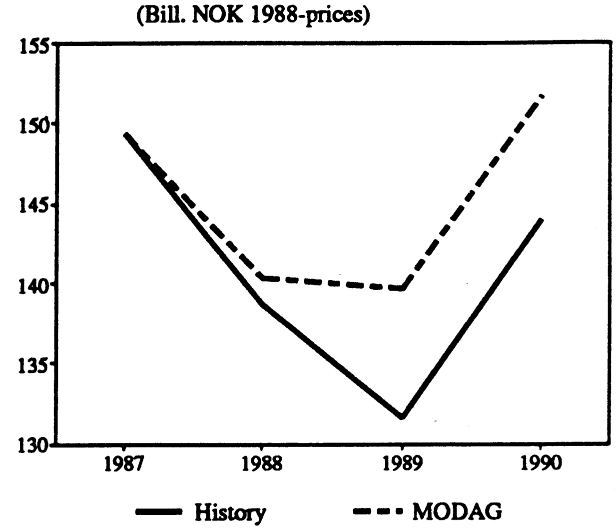


FIGURE 10. CURRENT ACCOUNT (Bill. NOK)

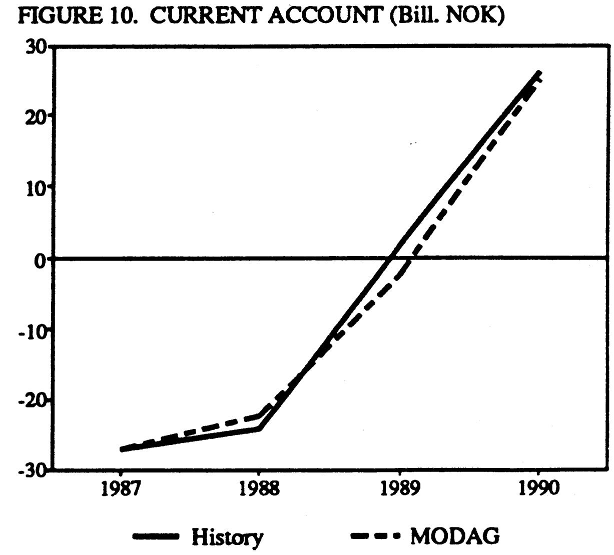


FIGURE 11. UNEMPLOYMENT RATE

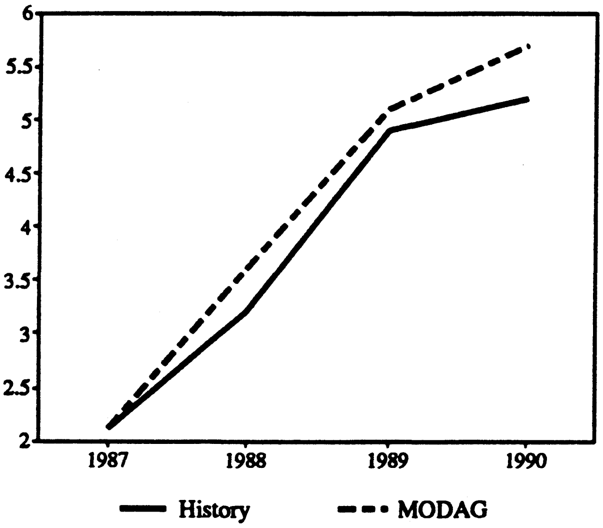


FIGURE 12. EMPLOYMENT, TOTAL, PRIVATE SECTOR (1000 persons)

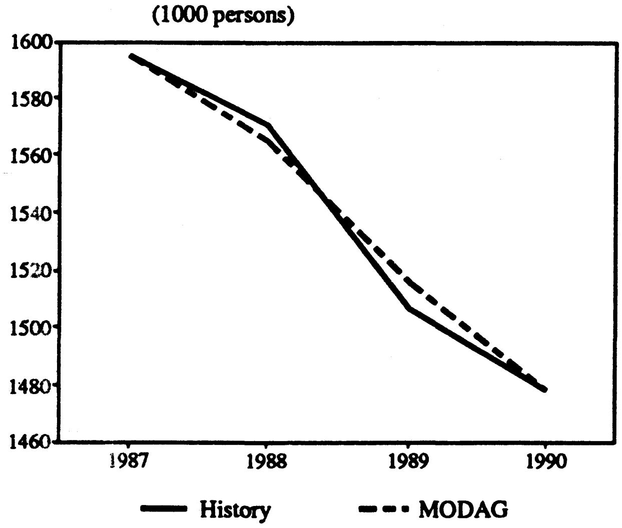


FIGURE 13. CONSUMER PRICE INDEX (1988=100)

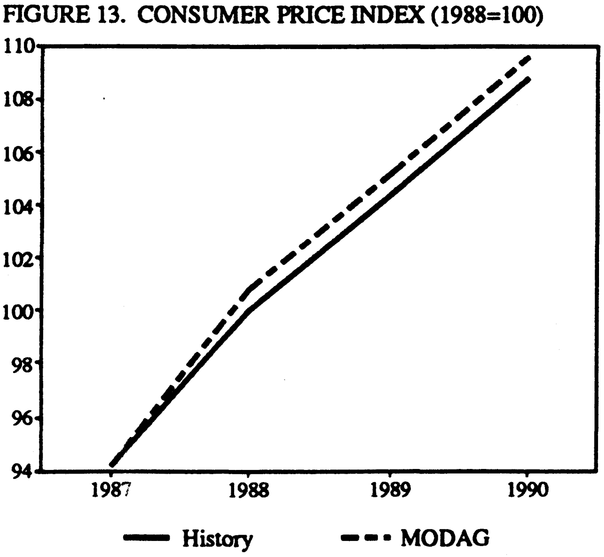


FIGURE 14. WAGE RATE PER HOUR (NOK per hour)

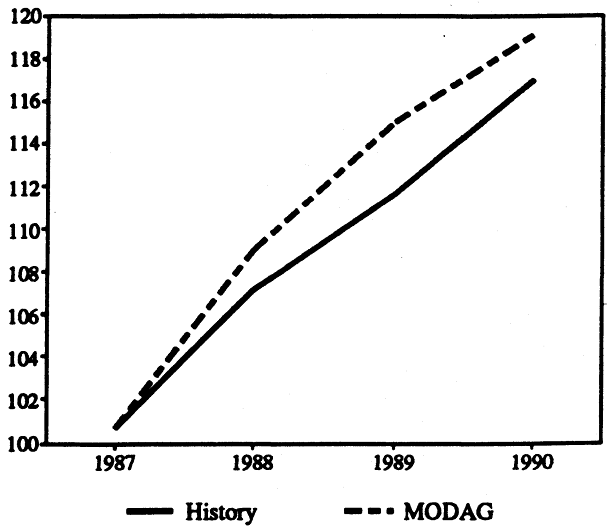


FIGURE 15. GENERAL GOVERNMENT FINANCIAL BALANCE (Bill. NOK)

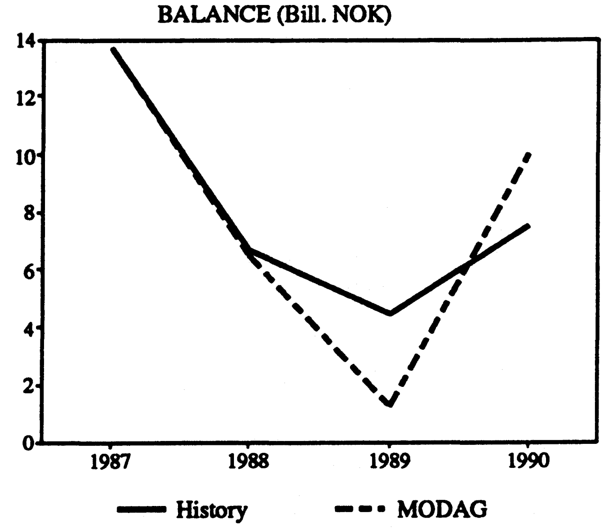
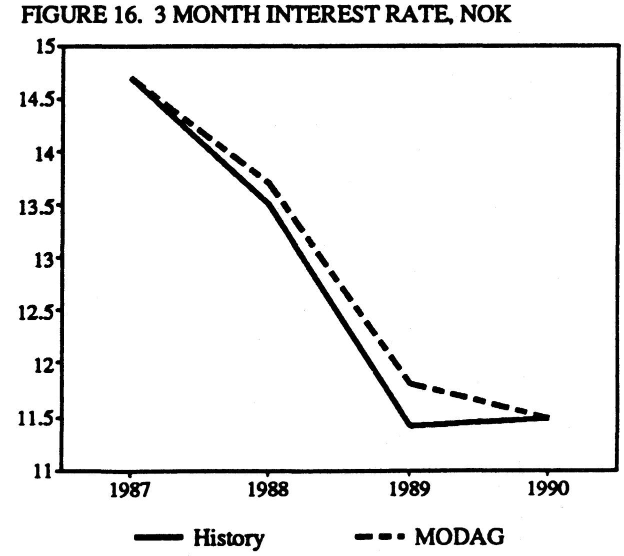


FIGURE 16. 3 MONTH INTEREST RATE, NOK



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