Danmarks Nationalbank

MONA

- a quarterly model of the Danish economy

MONA – A QUARTERLY MODEL OF THE DANISH ECONOMY

November 2003

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Preface

The economic model, Mona, was developed at the end of the 1980s. Over the years the equations in Mona have been reestimated on an ongoing basis and the design has been changed, so that the original description is no longer adequate. A new and complete account of Mona is presented in this publication. Alongside Danmarks Nationalbank's working papers this publication describes the model development as a contribution to the professional debate regarding modelling of the Danish economy.

Right from the start of the modelling work in the 1980s until now, Dan Knudsen has been the driving force behind the development of the model. Without his efforts Mona would never have become the valuable tool for economic analyses that it is today. He is also responsible for the work on this publication, which includes a number of contributions from former and present staff in Economics. Thank you all.

Anders Møller Christensen

I: Introduction

The quarterly economic model, Mona, is developed by Economics at Danmarks Nationalbank. The name Mona is a contraction of the words "model" and "Nationalbank". The model is applied to forecasting of the Danish economy and other macroeconomic calculations. The forecasts are always internal and are not published. However, the model itself and its relations are, in principle, accessible to the public. Some elements of the model work have been described in articles, and the model has been used for teaching purposes in economics. The model may be seen as a tool with no official status. The first version of Mona is described in Christensen and Knudsen (1992).

Mona is a model of the business cycle describing demand components, production and employment as well as wages and prices. In its present form the model consists of 336 equations, of which 42 are estimated behavioural relations. The 294 non-estimated equations comprise identities, so-called technical relations, e.g. for the determination of tax yields, as well as non-estimated behavioural relations, e.g. for the determination of agricultural exports and exports of services.

Like many other models of the business cycle, Mona may be viewed as a synthesis between the pure short-term model where prices are never changed and the pure long-term model where volumes always balance because prices clear the market. In the first quarters after a demand shock Mona reacts as a typical short-term model, as it takes some quarters before wages start to respond. On the other hand, in the long term there is no particular limit to wage adjustment, whereby demand shocks tend to influence prices rather than production in the long term.

Mona is to describe the conditions for the Danish economy. This implies e.g. that interest rates and exchange rates as well as foreign demand and foreign prices are given externally as exogenous variables. Thus, the model really describes the same type of fixed-exchange-rate regime as that which applies to euro area member states.

Public consumption as well as the tax and transfer rates of the model are also exogenous, but these variables may be used as fiscal instruments. Thus, Mona does not provide for an independent Danish monetary policy, but fiscal policy may be implemented and analysed within the model's framework.

In the rest of the introduction Mona as a model type is described and the choice of model type is discussed.

MODEL TYPE 1

In principle, the estimated relations of a model should be theoretically sound and at the same time describe data exhaustively. However, in practice it is not so easy to encompass both data and theory conformity. Consequently, Mona does not conform to both aspects, but represents a compromise between the two.

The trade-off between theoretical and empirical orientation is a well-known problem and is used e.g. by Pagan (2003) to characterise the macroeconomic models applied by central banks. Pagan's paper gives a thorough discussion of forecasts and models at the Bank of England.

At the most empirical end of a scale of model types are the pure time-series models such as the so-called VAR models or e.g. diffusion indices, cf. Stock and Watson (1998). At the theoretical end are the dynamic stochastic equilibrium models as applied in academic research.

Hybrids are found in between. Pagan, for instance, refers to a hybrid type where the model's equilibrium is the result of estimated equations. An estimated relation on error-correction form will always have potential long-term equilibrium. Mona's relations are typically on error-correction form, and the multiplier experiments in Chapter IV indicate that Mona produces a steady-state solution in the long term.

Mona thus produces a long-term course reflecting the long-term equilibrium relations. It is normally easier to understand the outcome when a model stabilises in a steady state than when it does not. This stability, for instance, makes it easier to compare the estimated model with more theoretical models and forms the basis for forward-looking expectations. This is probably part of the reason why Pagan makes the requirement of long-term equilibrium a benchmark for empirical/theoretical hybrids.

Models based solely on simple estimated error-correction relations are, however, not recommended by Pagan. He emphasises that, in principle, the model is improved and clarified if the adjustment to equilibrium is based on forward-looking expectations. In this connection it is also recommended to add the restriction of long-term fiscal sustainability. If these recommendations are followed the result will be an empirical/theoretical hybrid in which the short-term dynamics are also based on theory and not just on simple error correction.

Pagan probably emphasises forward-looking expectations because he focuses on economies with floating exchange rates and individual interest-rate formation. The formation of forward-looking expectations often focuses on the foreign-exchange and financial markets.

This does not mean that issues such as expected inflation and expected income should not be treated, but they are difficult to estimate and we have no good estimation results concerning forward-looking expectations in any relation. In Mona, the inflation terms in the user-cost term may be used for inclusion of forward-looking expectations. Specifically, the model-based estimate of price increases in the coming years may be included in the user cost.

As regards fiscal sustainability, this version of Mona comprises a simple calibrated equation adjusting the rate of excise duty on private consumption to stabilise the government-budget balance as a ratio of GDP. This naturally affects the adjustment of the economy. However, it is important to remember that the endogenisation of the excise duty is only a calculation example and that the adjustment of the economy changes if the sustainability is ensured by another instrument. Ensuring fiscal sustainability concerns the long term, and the equation is not part of short-term forecasts.

On the whole, the long-term properties relate to the steady state and are of less importance when the model is used for short-term calculations. In the short term simple properties dominate, e.g. the fact that the consumption and investment ratios often increase if they are low at the starting point, and that fluctuations may be self-increasing as demand generates more activity and thus increased demand. Furthermore, in a short-term calculation it is important how the constant term is adjusted in relations that seem to systematically over- or undershoot. In general, short-term forecasts are normally based on more information that is inherent in the estimated relations of the model, so it must be easy to adjust the model by means of adjustment terms.

As regards the more fundamental adjustment of the model, Mona has been reestimated many times since the first version and has changed in some respects. Now, Mona includes e.g. a direct effect on imports from capacity utilisation, i.e. from the production side of the model. In addition, price formation has been constructed around the marginal wage cost calculated on the basis of the model's production function. These are examples of incorporation of capacity effects that influence the model in so far as a significant coefficient is estimated. The most important change in principle since the first version is the removal of endogenous determination of the long-term interest rate. However, for years the long-term interest rate has always been exogenised in Mona, so the actual change is nothing new. In total the changes have clarified Mona's properties, but Mona is essentially the same type of simple estimated cyclical model as it was in the first version.

CHOICE OF MODEL 2

The construction of forecasts and related calculations concerning cyclical phenomena and cyclical policy is a standard task for many institutions in many countries. For many years, several institutions have made use of economic models for this purpose, thus accumulating considerable experience.

General experience with forecasts and models shows that many estimated relations tend to break down from time to time. If all that is required is a number cruncher, a model with structured economic relations is too complicated. A better solution would be non-theoretical time-series models e.g. based on diffusion indices developed for forecasting purposes. These time-series models can more easily be reestimated following a break, as an economic explanation is not required.

In most cases, however, it is required that a forecast can be substantiated, so a pure time-series model is not appropriate. In practice time-series models are too partial to provide the user with an overview. For instance, a time-series model typically offers an estimate of private consumption without corresponding estimates of tax burden, disposable income and wealth. Furthermore, it is doubtful whether a time-series model can provide useful information on the consequences of e.g. a change in indirect taxes.

On balance, time-series models can hardly be seen as an alternative but rather as a supplement to a more structural model, such as Mona. The time-series supplement may relate to the forecast, and the construction of relations may be inspired by the VAR methodology. For instance, this inspiration has contributed to Mona's factor demand where the initial estimates were based on the so-called Johansen method and consequently on the VAR approach.

If a model with structural relations is required, the task is to make do with the recurring breaks in the relations. Since Mona is supposed to consist of estimated relations that can be interpreted it is naturally most rewarding if a break can be explained and the coefficients of the relation can be stabilised. However, such rescue operations are not automatically successful in practice. The problem may be that it is necessary to wait several years to gain sufficient observations if estimates are made only for the period for which final national-accounts data are available.

In reality the model relations always comprise weaknesses and unless something is done, the accuracy of Mona forecasts will clearly be poorer than that of forecasts based on a simple time-series model.

If a better relation cannot be generated, the weak relation must be adjusted. Consequently, Mona is used for forecasts not only as it is estimated. All relations in Mona comprise an additive adjustment term. Systematic movement of the adjustment term is an indication that the relation is no longer appropriate. For instance, the adjustment term may move from an interval around zero in most of the estimation period to a systematically positive position after the estimation period.

In Mona forecasts the adjustment terms are usually extended at their most recent level – or relatively close to this level. This corresponds to applying a possible break to the constant term but otherwise continuing with the estimated coefficients, whereby the marginal properties of the model remain unaffected. This procedure is not unique to Mona forecasts. It is the usual practice for this model type, cf. Hendry and Clements (2003). This systematic application of adjustment terms should improve the accuracy of a model like Mona, possibly to make it resemble a re-estimated time-series model.

We have now described Mona and its use in relation to time-series models and now need to delineate Mona in relation to the more calibrated cyclical models that attempt to explain cyclical adjustment and cyclical movements as a result of the behaviour of utility- and profit-maximising agents.

A precise theoretical foundation can be advocated by taking the previously mentioned problem of breaks in estimated relations as the point of departure. The central point of the traditional Lucas critique, Lucas (1976), of economic models is that simple and possibly superficial economic relations (as in Mona) easily collapse. The use of theoretically-based models may be seen as an attempt to accommodate the Lucas critique. It is, however, a theoretical rather than an empirical reaction to the problem of breaks as theoretically-based models may also be in dire need of adjustment of the relations.

A slightly different reason for having a precise theoretical foundation is that the responsible institution – often a central bank – wishes to apply a formal model summarising the institution's opinion on the functioning of the economy, partly to incorporate it in the institution's forecasts and analyses, partly to develop and hone the institution's opinion on economic relations and economic policy.

In practical terms the adjustments in a theoretically-based model may be of such magnitude that the generated forecast is far from being a result of the theoretically elegant equations of the model.

Thus, it may be easier to base forecasts on models like Mona, which also facilitates interpretation. However, once a basic forecast is made there may be a need for calculating alternatives, e.g. to evaluate political measures. To that end theoretically-based models are more easily justified.

If, for instance, the forecast is used as the basis for changing income tax, Mona may also indicate the effects on the business cycle. Mona will then show no effect on the labour supply as no relation between tax and labour supply has been estimated.

If this lack of effect seems unlikely and the response of the labour supply constitutes a significant problem, it is necessary to apply calibrated relations that take such corrections into account, so that the effect of tax on the labour supply can be analysed. Even if the effect is not estimated, an impression of magnitude and transmission channel may be achieved. Besides, Mona is not calibration free but does include some simple calibrated relations. Non-estimated price elasticity has, for instance, been included for agricultural exports. Even if it has not been possible to make convincing estimates, it seems wrong to assume that the price elasticity on agricultural products is zero. Another example of simple calibration in Mona is that coefficients in the price relations are based on calculations in an input/output table.

Consequently, calibrated relations should not be rejected, but as they often diverge from data, they do not automatically improve the model. They provide a different weighting of theory and data.

Normally it is easier to use one model only. This calls for the inclusion of e.g. a calibrated supply effect of tax changes in Mona, which could be done merely by adjusting the participation rate. On the other hand, if possible, it might be better to use another, more theoretical model here than to enter a grey zone where a mainly estimated model like Mona is supplemented with more and more calibrated effects. The strength of a simple estimated model is its reflection of reality, whereas the strength of a calibrated model is its theoretical consistency. By mixing the two, both arguments may be lost.

In terms of model type Mona resembles both Adam from Statistics Denmark, cf. Dam (1996), and Smec from the Danish Economic Council, cf. Bocian, Nielsen and Smidt (1999). Unlike these annual models Mona is based on quarterly data and thus focuses on the short term. Furthermore, especially Adam is a more detailed and disaggregated model with nearly 2,000 equations.

In connection with the choice of model type it should be noted that the two principal users of Smec and Adam, the Danish Economic Council and the Danish Ministry of Finance, respectively, use these models for short-term analyses and usually also for medium-term projections, whereas they often use calibrated equilibrium models such as Gesmec and Dream for structural analyses.

It should be emphasised that Gesmec and Dream are equilibrium models that describe the economy in the long term. They provide little detail about cyclical movements, so they are not calibrated dynamic-equilibrium models.

Examples of application of or experiments with calibrated dynamic-equilibrium models are becoming increasingly common in the numerous central banks that now devote considerable effort to this model type. Another more recent trend in the modelling work of central banks is to develop more than one model. The central banks go beyond a compromise between different model types; they have a suite of models ranging from primarily empirical to more theoretical and calibrated models.

When the first version of Mona was constructed at the end of the 1980s Mona reflected more or less the type of cyclical model that was typical at the time, according to Pagan. Although several applied models still resemble Mona, today Mona no longer represents a new state-of-the-art economic model.

The trend has been towards the theoretical and calibrated models where attempts are made to model both a microfoundation for cyclical movements and elegant long-term properties. Another aspect of the work is to pull the calibration of the relatively theoretical models towards estimation, e.g. Smets and Wouters (2002). However, this is complicated and may not be the place to start if e.g. a central bank wants to construct a theoretically-based model for policy analysis or for forecasts. At the same time, some research is using VAR models and other time-series models. These are constructed partly to be included in a suite of different types of models and partly to examine the information content of data. It is safe to say that models with a clear theoretical or clear empirical orientation have been brought more into focus than simple hybrids like Mona.

International modelling trends naturally inspire further work on Mona. Danmarks Nationalbank would like to contribute to the analysis of the Danish economy, but the bank does not have the same need for models as a central bank applying inflation targeting. Specifically with regard to forecasts, the need is mainly confined to informing the bank management of the conditions and prospects for the Danish economy, and furthermore to inform the group of EU central banks.

For Mona to be used as a tool, the model must be kept operable. The easiest approach seems to be to remedy the specific problems in Mona's behavioural relations, cf. the description in Chapter II. This may turn out to be complicated when the properties and transparency of the entire model have to be taken into account. The result will hardly be a new type of model, but an interesting estimation result may emerge, and Mona can be applied for another number of years.

Concerning a possible construction of VAR models and calibrated cyclical models Mona does not necessarily have to be replaced as work-horse model in order to produce faster and better forecasts. Instead the starting point should be a specific issue such as the transmission from interest rate and exchange rate to the domestic economy. Mona offers a description of this transmission, but it may be useful to apply other approaches that allow you to focus on the issue without the requirement of a forecast for all key economic figures. Applying alternative modelling may also help analyse problems in Mona. However, there are limits to what can be achieved.

PLAN FOR THE REMAINING PUBLICATION 3

Chapter II describes the most important behavioural relations in Mona. Mona is an empirically oriented model, and in Chapter II it is emphasised that Mona's relations represent empirical regularities, stylised facts, in data. Importance is also attached to illustrating the degree of stability in the relations, e.g. by estimation for rolling estimation periods. Estimation residuals are shown in an Appendix.

The relatively short Chapter III summarises the technical and definitional relationships that are needed to supplement the estimated behavioural relations to arrive at a complete model.

Chapter IV reviews a number of experiments on Mona to describe the properties of the model. These multiplier experiments illustrate the model's response to a change in one or a few exogenous variables. A considerable part of the chapter concerns the effect of a major public purchase of goods where several facets of Mona are sought illustrated. This includes clarifying the importance of forward-looking expectations, requirements for long-term fiscal sustainability as well as changes in key coefficients. The issue of compilation at constant prices, cf. the chain indices currently used in e.g. the USA, is briefly touched upon. Chapter IV furthermore comprises a calculation of a change in interest rates in the euro area and a simple example of stochastic shocks.

Chapter V gives an assessment of the full model and its use for forecasting purposes. In connection with a simulation for a historical period the correlation pattern in Mona's result is compared to the correlation pattern in data. The application of adjustment terms in forecasts is also illustrated.

II: Behavioural Relations

This Chapter discusses the most important of the model's 42 estimated relations. We have excluded a few very simple relations, e.g. those making reinvestments proportional to the capital stock, as well as a number of financial relations which no longer play any important role in the model, in that the bond yield is exogenous.

The presentation does not emphasise the theoretical content of the generally simple behavioural relations. Instead, focus is on illustrating how some of the relations reflect "stylised facts" in data.

The core of the data base is the official quarterly, seasonally-adjusted national accounts, supplemented with own calculations and financial statistics. Statistics Denmark's quarterly national accounts starting in 1988 have been extended back to 1971 using a previous official data set in 1980-prices, as well as own indicators. For the public sector in particular the official quarterly figures are not available before 1999 (1991 in some cases), so these data are mainly based on our own quarterly interpolation of the official annual series. In all interpolations the annual averages of quarterly data make up the annual data. This method is equivalent to the one applied by Statistics Denmark, but it is based on a more limited selection of indicator series, cf. Christensen (1989).

Mona's behavioural relations are estimated as single equations, using either OLS or IV estimation. The construction of some of the behavioural relations is inspired by results of multivariate estimation, more specifically Johansen's cointegration method, but the normal estimation and reestimation of the relations are based on single-equation methods. These methods are potentially less efficient, but easier to repeat on reestimation when e.g. national accounts are updated.

The presentation of the key relations is divided into a number of sections. The first one is exports, representing foreign demand. This is followed by the main items in domestic demand, as well as imports, and finally wage and price formation. A list of all variables in the model can be found at the end of this publication.

The estimated part of the model is based on estimation samples, ending in 1997 and beginning in the 1970s. When the first calculations for the publication were finalised, 1997 was the latest year for which final national accounts were available. With the applied data set 1999 is the latest final year. Out-of-sample properties are illustrated via rolling regressions up to 2001, for which year the data are still preliminary.

The response of exports to changes in competitiveness is a key balancing mechanism in the economy. Overheating and pressure on the labour market entail higher wage increases than abroad. The resulting increase in relative wages restores equilibrium by reducing exports so that the pressure from total demand subsides. The wage elasticity and responsiveness of exports are key to this crowding-out process.

The wage elasticity of industrial exports is estimated at 1.2 as a long-term effect. If wage elasticity is 0.6 for the price of industrial exports, this corresponds to long-term price elasticity of 2 (1.2/0.6) for exports. This is at the high end when compared with typical international surveys for OECD countries including Denmark, cf. e.g. Murata et al. (2000). On the other hand, long-term elasticity of 2 is not unrealistic, and Danish export-price elasticity of 3 is found in Bocian et al. (1999) and in Nielsen (2001). The latter uses variables from Mona's data bank.

Industrial exports, volume

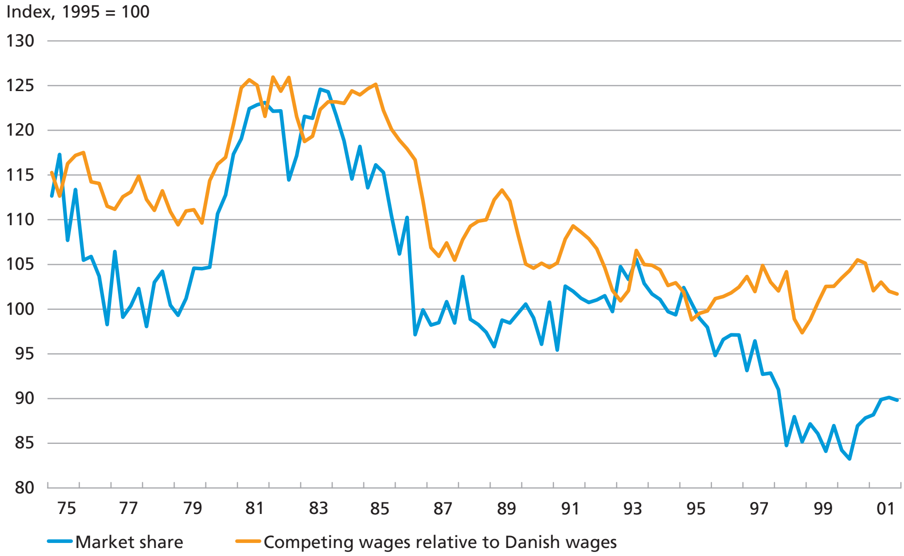
A simple comparison of the market share of industrial exports and their relative price confirms that the market share is high when Danish labour is relatively cheap, cf. Chart II.1.1. On the other hand there are no clear indications that the market share continues to grow as long as Danish labour is cheap. Overall the data seem to be consistent with a traditional framework with final price elasticity in foreign trade, cf. Armington (1969).

Furthermore, the correlation between relative wages and market share seems to have weakened after the mid-1980s. The market share thus appears to respond to other factors than relative wages, for in the early 1990s the market share increases, and in the late 1990s it decreases, even though this is not related to relative wages. In the 1990s strong growth in the market share in Germany is observed following Germany's reunification. German imports, especially from Denmark, generally rose significantly in those years. This may be attributable to a combination of Denmark's proximity to Eastern Germany, i.e. the source of the new demand for imports, and a weak domestic Danish market in those years. A "reunification dummy" is applied to explain the particularly favourable export reaction in the 1990s.

With the dummy a simple long-term relation for the market share can be written as follows:

$$\log\left(\frac{\text{exports}}{\text{export market}}\right) = a\cdot\log\left(\frac{\text{foreign wages}}{\text{Danish wages}}\right) + b\cdot d90q3 + \text{trend} \qquad \text{(II.1)}$$

DANISH MARKET SHARES AND COMPETITIVENESS Chart II.1.1



Note: Industrial exports are defined as SITC groups 5-9 and comprise approximately half the total Danish exports. Market shares are calculated as the ratio of Danish export volumes over export-market volumes defined as a weighted average of imports in 21 OECD countries. The weights represent the country distribution of Denmark's industrial exports in 1998. Together the 21 markets receive approximately 85 per cent of total Danish industrial exports. Price competitiveness in the short-term dynamics is calculated as the deflator in Danish kroner in the just defined export market relative to the Danish export price.

where a is the wage elasticity of exports, and b is expected to be positive. The trend captures structural aspects not explained by the expression for relative wages. For instance, the composition of Danish industrial exports differs from that of other countries' imports of industrial goods. In addition, Denmark's market share and that of other long-industrialised countries tend to fall when emerging economies enter the trading pattern.

The information on trading partners' imports is based on OECD statistics for the industry segment SITC 5-9, and Danish industrial exports are defined correspondingly in the estimation. This deviates slightly from the model's industrial exports, which follow a Danish classification. Nevertheless, the estimated equation is used in the model.

The export relation is estimated in two steps: first the long-term relation, and then the full relation including the short-term dynamics.

The estimated long-term relation focuses on the significance of relative wages in a common currency, and the wage elasticity is estimated at 1.2. A test indicates that the residuals of the long-term relation are almost stationary, so the included variables are closely linked. This is reflected in the ADF (Augmented Dickey Fuller) value of the residuals being close to a 95-per-cent limit of 3.9 taken from MacKinnon (1991). The

EXPORT VOLUME, LONG-TERM RELATION			Table II.1.1
Variable	Name	Coefficient	t value
Market share	log(*feind*/*feu*)		
Foreign wages/Danish wages	log(*lonudl*/(*lnio*·*efkrks*))	1.1902	11.9
Dummy, German reunification	dum903	0.0589	3.2
Trend	0.001·trend	-1.1822	1.0
Constant		11.9461	5.1
T = 1975:1 – 1997:4 R^2 = 0.7218	DW = 0.958	ADF = 3.824	Se = 0.0436

Note: The relation is estimated by OLS. *Dum903* is a dummy given the value 0 from 1975 to 1990Q2 and then 1. Augmented Dickey Fuller test (ADF) is shown for long-term relations. See the note in Table II.1.2 for comment on other test statistics.

trend has a low t-value and can easily be left out. On the other hand, it has no detrimental effect and is maintained to make the relation more robust to reestimation. The long-term relation is shown in Table II.1.1.

In step two the residual from the long-term relation is used in an export relation with short-term dynamics. The supplementary variables in this relation are mainly expressed as quarterly changes, but a measure of capacity utilisation is also included, based on Mona's production function for the private non-farm sector. This give a direct volume-to-volume capacity effect in addition to the effect seen via relative wages in the error-correction term. The relative price term also has a rapid effect on

EXPORT VOLUME			Table II.1.2
Variable	Name	Coefficient	t value
Change in exports	Δlog(*feind*)		
Change in exports	$\Delta\log(feind_{-1})$	-0.2580	2.8
Change in exports	$\Delta\log(feind_{-4})$	-0.1346	1.7
Change in market	Δlog(*feu*)	0.9032	6.0
Change in relative price	Δlog(*pxudl*/*pxden*)	0.4431	2.5
Error-correction term	$\log(feind_{-1}) - \log(feind^*_{-1})$	-0.2077	2.4
Capacity utilisation	tuc_{-1}	-0.1298	2.3
Constant		2.4607	2.4
T = 1976:2 – 1997:4 R^2 = 0.4856	DW = 2.201 JB = 2.457	AR(1) = 3.235 AR(4) = 6.032	Se = 0.0280

Note: The relation is estimated by OLS. Wanted industrial exports, log(*feind**) is according to Table II.1.1: log(*feu*) + 1.1902·log(*lonudl*/(*lnio*/*efkrks*)) + 0.0589·*dum903* - 1.1822·0.001·trend. Capacity utilisation, *tuc*, measures gross value added (GVA) in the private non-farm sector in relation to GVA for optimum utilisation of the capital stock, cf. the section on business investments.
The Tables on estimated relations in Chapter II show standard concepts as dispersion also known as standard error (SE) as well as R^2, t values and Durbin-Watson (DW). The autocorrelation of the residuals is also described in terms of LagrangeMultiplier tests for 1 and up to 4 quarters, AR(1) and AR(4), which are χ^2 distributed with 1 and 4 degree(s) of freedom, respectively. The normality of the residuals is also tested using the Jarque-Bera test (JB), which is χ^2 distributed with 2 degrees of freedom. JB becomes significant with outliers or skewness in the residuals.

RECURSIVE ESTIMATION, EXPORT VOLUMES — Chart II.1.2

Note: The upper and lower limits are determined as the point estimate plus/minus twice the standard deviation.

exports, if e.g. Danish exporters raise their prices relative to the competitors. The export relation is shown in Table II.1.2.

The residuals have a certain negative autocorrelation that may reflect measurement errors in the distribution of exports by quarters. The LM tests are, however, below the significance threshold for the associated χ^2 distributions, so the autocorrelation is not significant, and the Jarque-Bera test cannot rule out normality.

The parameter stability in the export relation in Table II.1.2 is tested using rolling regressions with an initial sample from 1976 to 1980, which is extended up to 2001. Final national accounts are not available up to 2001, but we get an impression of how the relation fits beyond the estimation period in the Table. The result of the recursive estimation is shown in Chart II.1.2. All parameters are relatively stable from 1990 onwards.

Industrial exports, price

The export price is determined on the basis of costs and the import price. Loglinearly the long-term price relation is written as

$$\log\left(\frac{\text{export price}}{\text{market price}}\right) = b \cdot \log\left(\frac{\text{costs}}{\text{market price}}\right) + \text{trend} \qquad \text{(II.2)}$$

The market price is the price on the export market. The relation states that the more domestic costs deviate from the market price, the more Denmark's export price deviates from the market price. In relation (II.2) the export price is a geometric average of domestic costs and the market price with b and 1-b, respectively, as weights, and in this context the market price may also be seen as the import price of industrial goods. The trend may for instance capture that the rate of growth in productivity and costs in the manufacture of industrial goods differs from that in the total private non-farm sector.

Domestic costs are represented by marginal labour costs. Applying a marginal cost measure gives rise to a capacity effect whereby the export price increases if employment rises relative to the capital stock. This capacity effect on the price is, however, relatively small.

The market price is linked to the market concept applied in the volume relation, i.e. the imports of our trading partners. The market price is an international price of industrial goods based on an average of importing OECD countries' unit values. The market price is measured in an average currency corresponding to the effective krone rate and converted into kroner at this rate.

The dynamic relation for the export price is estimated directly. Thus the long-term relation is determined simultaneously with the short-term dynamics, which comprise changes in costs and in the market price. The estimated export-price relation is shown in Table II.1.3.

There is no major autocorrelation, cf. the LM statistics, and the Jarque-Bera test indicates normality.

As regards the coefficients it should be noted e.g. that the immediate price impact of the exchange rate is small and insignificant in comparison with the impact of the market price and costs.

The long-term impact of costs on the export price is just over 0.6 (0.1866/0.3073), and with marginal labour costs as the cost concept it

EXPORT PRICE			Table II.1.3
Variable	Name	Coefficient	t value
Change in export price	$\Delta\log(pxden/efkrks)$		
Change in market price	$\Delta\log(pxudl/efkrks)$	0.3074	3.1
Change in effective krone rate	$\Delta\log(efkrks)$	0.1429	1.2
Change in cost	$\Delta\log(mulc)$	0.3677	3.4
Export price	$\log(pxden_{-1} /efkrks_{-1})$	-0.3073	4.3
Market price	$\log(pxudl_{-1}/efkrks_{-1})$	0.1207	5.1
Cost	$\log(mulc_{-1})$	0.1866	3.7
Trend	0.001·trend	-3.1369	3.5
Constant		5.4876	3.5

T = 1975:2 – 1997:4	DW = 2.028	AR(1) = 0.512	Se = 0.0082
R^2 = 0.6511	JB = 2.839	AR(4) = 1.280	

Note: The relation is estimated by OLS. The applied homogeneity restriction is easily accepted with a test statistic of 4.2, which is F(1.83) distributed.

also represents the long-term pass-through of wages. Combining this pass-through with the wage elasticity of exports of 1.1902, cf. Table II.1.1, implies that the price elasticity of industrial exports is close to 2. Price elasticity of 2 may seem too low, since this comes close to saying that the export price is too low. If numeric price elasticity is below one, revenue from exports can be increased by raising prices. At an import share of 40 per cent in exports, net income from exports increases if the numeric price elasticity is lower than the fraction 1/(1-0.4) = 1.67. At an average of 2 for all industrial goods we are actually above 1.67, but the margin is small. Assuming a certain spread between highest and lowest elasticity would imply that some exporters are not exploiting their market power. For such exporters it just takes a higher price to increase long-term profits, which seems an unrealistic picture. This problem is not specific to the Mona model or Danish data. Moderate price elasticity is often estimated for exports.

The parameter stability is illustrated via recursive estimation, cf. Chart II.1.3. The coefficients become more stable when the sample end reaches the late 1980s.

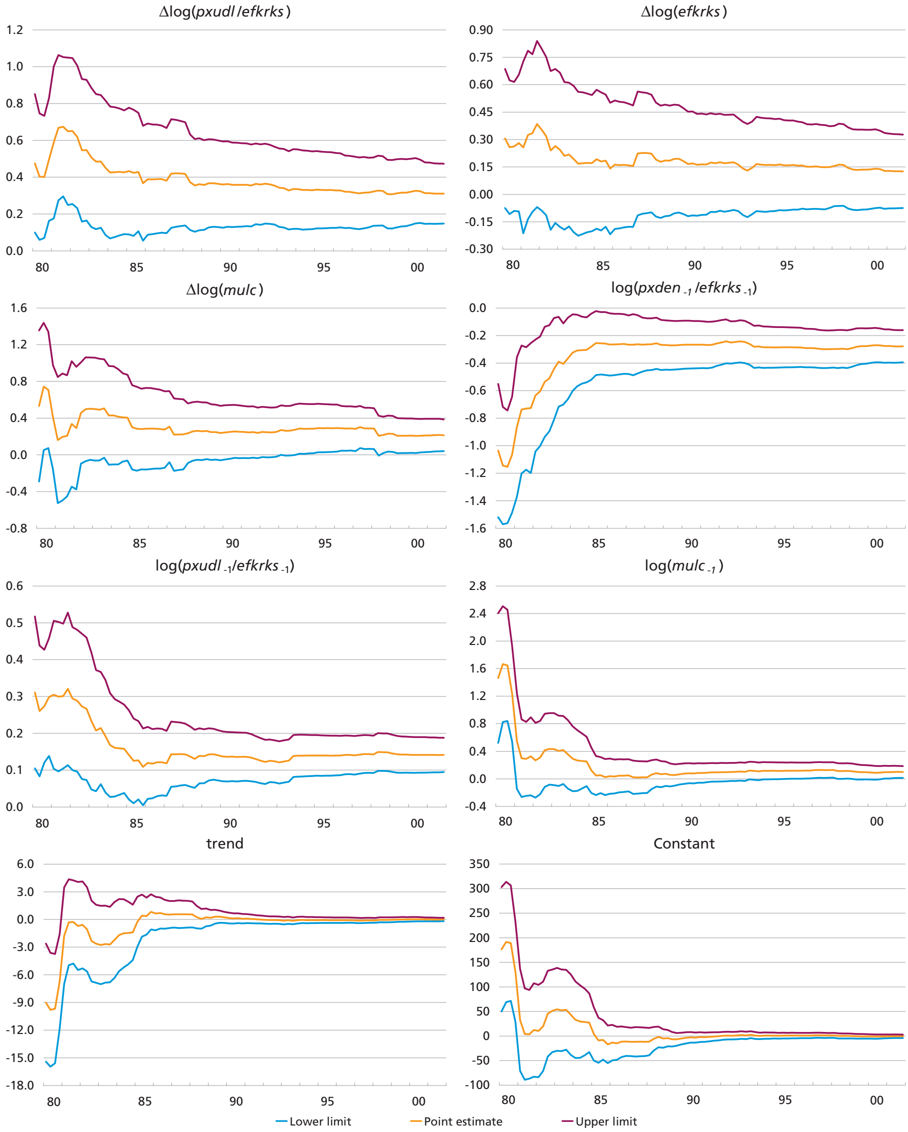
Export price, energy and services

On the export side relations have furthermore been estimated for the price of energy exports and services excluding travel receipts.

The price of energy exports basically follows the oil price, but there is also a small impact from wage costs. The result is shown in Table II.1.4.

The simple relation for the price of energy exports has a few outliers in the residuals, where e.g. the price of energy exports has not reflected

RECURSIVE ESTIMATION, EXPORT PRICE Chart II.1.3



a major movement in the price of crude oil. This contributes to rejecting a normal distribution of the residuals, cf. the large Jarque-Bera statistic. If we remove the three largest outliers by a dummy for the 1st and 2nd quarters of 1979 and the 1st quarter of 1982, we get a JB statistic below the 5-per-cent threshold. Introducing these three dummies only has a minor impact on the other coefficients.

In addition to oil products, energy exports include power. This is one of the reasons why the relation not only reflects the simple correlation between the price of Denmark's oil sales and the quoted spot price of

PRICE OF ENERGY EXPORTS Table II.1.4

Variable	Name	Coefficient	t value
Change in export price	$\Delta\log(pebra)$		
Change in export price	$\Delta\log(pebra_{-1})$	0.1698	3.4
Change in oil price	$\Delta\log(praoli \cdot eusd)$	0.5492	15.1
Export price	$\log(pebra_{-1})$	-0.4447	6.5
Oil price	$\log(praoli_{-1} \cdot eusd_{-1})$	0.4105	6.5
Wage cost	$\log(lonudl_{-1}/efkrks_{-1})$	0.0342	3.3
Constant		-1.7414	6.4

T = 1974:2 – 1997:4	DW = 1.928	AR(1) = 1.863	Se = 0.0434
R^2 = 0.7806	JB = 49.319	AR(4) = 7.051	

Note: The applied homogeneity restriction is easily accepted with a test statistic of 0.13, which is F(1.89) distributed.

crude oil from the North Sea, *praoli*. The relation for the price of fuel exports greatly resembles the relation for the price of energy imports, cf. below under imports.

A major item under exports of services is freight receipts, and an index for freight rates (in dollars), as well as foreign wages, are explanatory variables in an estimated relation for the price of exports of services excluding travel receipts. The dollar rate is included separately in the dynamics, and a relatively fast reaction to the dollar's fluctuations is seen. There is presumably a certain – albeit limited – pass-through from Danish costs, e.g. on the price of engineering services. However, no effect of Danish costs is estimated. Thus the price of exports of services excluding travel receipts is fully given from abroad.

Although there is a clear immediate covariation between the dollar-rate and the price of exports of services, the long-term impact of the dollar should not be overestimated. International prices such as oil prices and freight rates in dollars depend on the position of the dollar vis-à-vis a major currency like the euro, to which the krone is linked. A significant change in the dollar/euro rate can be expected to pass through to e.g. oil prices and freight rates in dollars. This example illustrates that exogenous variables in Mona cannot always be seen as independent variables. They may interact outside the model as in this case via the world market. The relation for the price of exports of services excluding travel receipts is shown in Table II.1.5.

There tend to be outliers in the relation's residuals since a number of large price fluctuations in exports of services cannot be explained. This is reflected in the large Jarque-Bera statistic. Deflators for exports and imports of services are potentially volatile and difficult to explain. It should also be noted that the freight-rate variable is estimated to have a

PRICE OF EXPORTS OF SERVICES — Table II.1.5

Variable	Name	Coefficient	t value
Change in export price	$\Delta\log(pes)$		
Change in sea freight rate	$\Delta\log(pship\cdot eusd)$	0.2233	3.0
Change in foreign wage rate	$\Delta\log(lonudl/efkrks)$	0.5364	2.7
Change in dollar exchange rate	$\log(eusd/eusd_{-4})$	0.1026	3.8
Export price	$\log(pes_{-1})$	-0.1881	3.6
Sea freight rate	$\log(pship_{-1}\cdot eusd_{-1})$	0.0378	1.4
Wage cost	$\log(lonudl_{-1}/efkrks_{-1})$	0.1502	3.5
Trend	$0.001\cdot trend$	-4.5049	3.3
Constant		9.5148	3.3

T = 1974:2 – 1997:4	DW = 2.146	AR(1) = 1.255	Se = 0.0274
R^2 = 0.4470	JB = 21.472	AR(4) = 2.861	

Note: The applied homogeneity restriction has a test statistic of 2.2, which is F(1.87) distributed.

significantly lower impact than foreign wages, even though sea freight plays an important role in exports of services. The JB statistic can be brought below the 5-per-cent threshold by using a dummy to remove the largest outlier, which is found in the 4th quarter of 1979, when we also find the strongest quarterly fluctuation in the price of exports of services. Application of this dummy only has a minor impact on the other coefficients, and e.g. the freight rate does not become more significant.

Overall export reaction to wages and exchange rates

For several of the export components with no estimated price elasticity results for industrial exports are applied – either from the relation in Mona or from Nielsen (2001). However, for some components fairly low elasticity – in some cases zero – is applied. Where the price is fully given from the world market one cannot expect demand elasticity with respect to the Danish export price. In that case supply elasticity with respect to the Danish cost level is a more likely factor.

Specifically, price elasticity is set at zero for exports of energy products and for fish, furs and skins and agricultural products of vegetable origin. These exports variables are exogenous in the model. The speed of extraction of North Sea oil may be affected by oil prices, so supply elasticity could have been included in energy exports, but has been omitted. Energy extraction is also exogenous in the model, but in connection with projections one would tend to establish a link between the two by letting energy exports reflect North Sea production.

As regards the agricultural products listed as exogenous, the supply may be affected e.g. via investments in spite of dependence on regula-

PRICE ELASTICITIES IN EXPORTS		Table II.1.6
Variable	Elasticity	Relative price
Feind Industrial exports	-1.19	(*lnio·efkrks*)/ *lonudl* Danish wages over foreign wages in common currency
Feani Agricultural exports of animal origin	-3.14	*peani·efkrks/pxudl* Own price over foreign price in common currency
Fekqd Exports of milk and meat	-3.14	*pekqd·efkrks/pxudl* Own price over foreign price in common currency
Fey Exports of ships and aeroplanes	-2.00	*pey*/(*pxudl·efkrks*) Own price over foreign price in common currency
Fet Travel receipts	-1.50	*pet*/(*pxudl·efkrks*) Own price over foreign price in common currency
Fes Exports of services excl. travel receipts	0.30[1]	*pes/mulc* Own price over Danish costs

[1] Elasticity of supply.

tions and weather conditions, so that price elasticity of zero underestimates the sensitivity of exports to Danish costs.

Supply elasticity is applied to exports of services excluding travel receipts. This elasticity is relatively small since much of the revenue from services is based on input of labour and capital abroad and thus independent of the Danish level of costs.

Table II.1.6 summarises the relative prices of the individual export components. The euro area accounts for more than half of the effective krone rate, so the fixed-exchange-rate policy entails that the krone changes by just over 2 per cent vis-à-vis other currencies when the effective krone rate changes by 1 per cent. The export-volume reaction to a 1-per-cent change in the relative price is also shown. The resulting price elasticity for total exports is approximately -2.5, so the price elasticity of exports is slightly higher than in e.g. Adam.

PRIVATE CONSUMPTION 2

Private consumption is the largest demand component, and it is important to activity and employment. Economic cycles often reflect fluctuations in the consumption ratio. Consumption is also interesting because private – and public – consumption are final goals of economic activity. Exports and investments have no direct beneficial value. They have an indirect value in that they help to provide the economy with consumption options.

In the model total private consumption is determined in a single behavioural relation with the income and wealth of the private sector as the two major explanatory variables. This is in line with standard theory, cf. Modigliani and Brumberg (1979) and the overview in Muelbauer and Lattimore (1996). It is also a standard approach in many models. Determination of consumption on the basis of wealth and income could, with some approximation, be interpreted as an intertemporal budget restriction with consumption on the left-hand side. With this starting point, the wealth effect on consumption should be straightforward, cf. Poterba (2000); but even though the fundamental relation seems to be fairly simple, it is not immediately clear how income and wealth should be measured.

Especially wealth can be compiled in several ways. In connection with more theoretical concepts, wealth in principle represents the value of all expected future income. In Mona wealth is primarily limited to valuation of the capital stock and securities. An imputed value of expected old-age pensions is the exception from basing the wealth variable on real capital and financial net assets. The capital stock comprises the value of the households' stock of houses, so the development in the model's housing market affects consumption. The impact of house prices contributes to making consumption cyclically sensitive, and house prices create a channel for an interest-rate impact on consumption.

In addition to income and wealth, the relation includes a negative reaction to increased unemployment, which increases the risk of declining income. This correlation makes consumption more cyclically sensitive. Finally, there is an inflation term, which means that changes in the price level affect consumption faster than changes in the nominal income of households.

While the consumption relation determines consumption, it also determines savings and thus growth in the consumers' financial wealth. Wealth is therefore not a genuine exogenous variable in terms of the consumption relation. In the long term, income is the basic exogenous determinant in relation to which consumption and wealth adapt and grow proportionally.

Total private consumption

Consumption and the wealth concept chosen have more or less the same trend, and their fluctuations around the trend correlate positively. Measured relative to income, consumption and wealth show more or less the same pattern. The two ratios are shown on separate scales in

CONSUMPTION AND WEALTH RATIOS Chart II.2.1

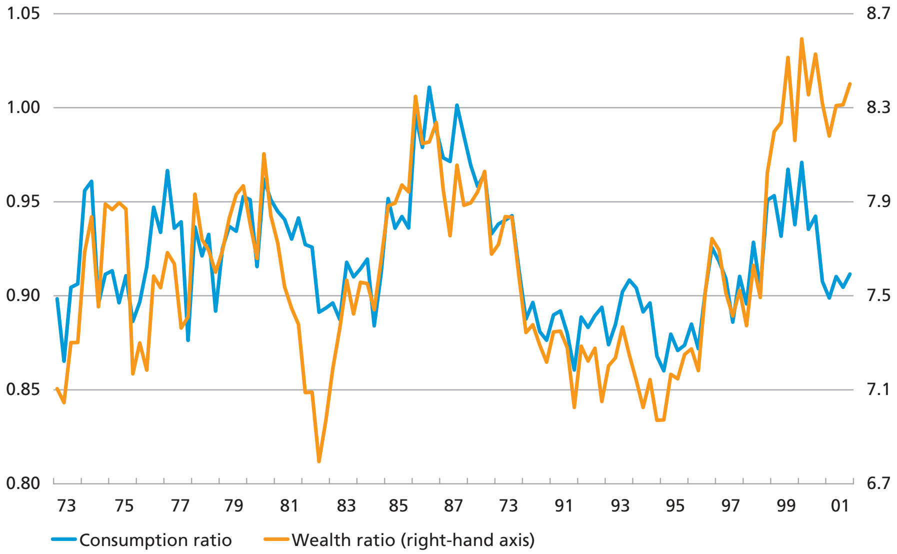


Chart II.2.1. The correlation between the two may reflect that the consumption ratio follows the wealth ratio with positive elasticity of less than 1.

This simple assumption entails that consumption follows a loglinear relation in income and wealth

$$\log(\text{consumption}) = a \cdot \log(\text{wealth}) + (1-a) \cdot \log(\text{income}) + \text{constant} \qquad \text{(II.3)}$$

It is arguable whether the relation should be expressed in logarithms. If it is seen as a budget restriction, there is no reason to use logarithms. In any case it is not essential to the statistical properties of the relation whether logarithms are used.

As *disposable income* in Mona we apply the entire private sector's disposable income, i.e. not only that of the households, less income in the energy sector. An argument in favour of a broad income concept is that many companies are ultimately owned by Danish households. Another reason why a broad income concept has been chosen is that we apply replacement costs of the companies' real capital, cf. the section on wealth below, and thus do not include a market value of the corporate sector. In the short-term dynamics household savings in pension funds and life-assurance companies are subtracted from income, and in the long-term relation (II.3) income net of depreciation is applied.

In the long term wealth formation is decisive. If. e.g. an income segment is excluded from the relation's income concept, but remains included in the formation of wealth, it will be accumulated under wealth and thus ultimately affect consumption. Regardless of the income concept used in the long-term relation (II.3), consumption reflects the definition of wealth.

The definition and compilation of wealth appear to be larger problems than the definition of income. In theory wealth often comprises the rediscounted value of future income equivalent to a consumer having his or her entire expected lifetime income at his or her disposal and distributing the spending of this income over the life cycle. In Mona, however, a narrower wealth concept is applied.

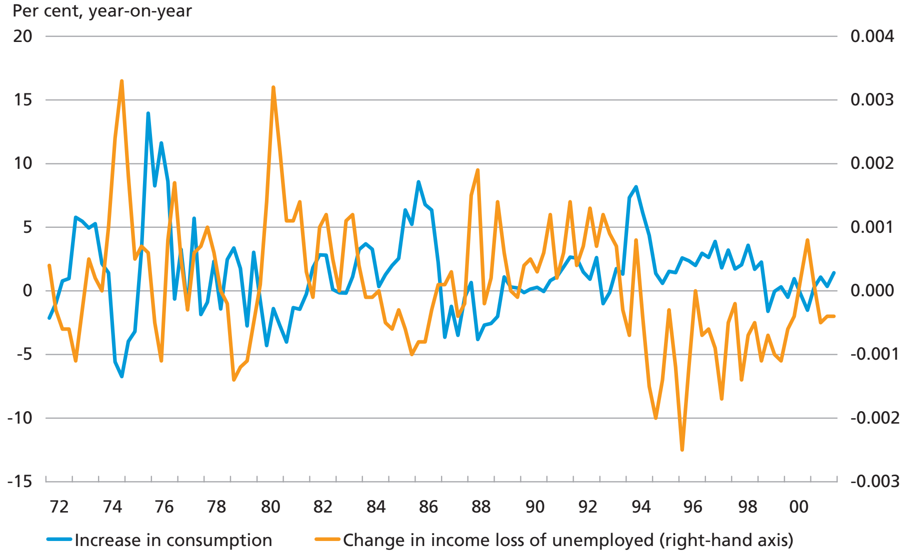
Wealth in the consumption relation is the sum of the following elements:

- the cash value of the stock of housing;
- the private sector's financial net claims at market value. There is no Ricardian equivalence. Government bonds are included alongside mortgage-credit bonds and foreign bonds. Claims accumulated via pension funds and life-assurance companies are given a lower weight since they are typically taxed upon disbursement and seem further away than untied funds;
- business real capital at replacement cost. Business capital includes machinery and transport equipment, as well as plant and buildings;
- an imputed value of future old-age pensions for 30-65-year-olds. For 30-year-olds the value of old-age pension is zero, but it grows linearly up to the age of 65. A 65-year-old is attributed wealth corresponding to a remaining life expectancy of 16 years, multiplied by the current annual pension.

Including housing wealth in the wealth concept applied makes consumption sensitive to interest rates and also contributes to the consumption reaction to cyclical fluctuations.

Housing wealth does not represent a claim on other sectors, and the potential effect of increases in the value of real property has always been subject to discussion. A higher value of owner-occupied homes reflects a higher expected value of the rediscounted housing service. After an increase in rent, the tenant pays more to the owner, whose income thus rises. Anyone owning his or her own home "pays" the higher rent to himself or herself when the value of the home increases. The owner of a home may thus not become more wealthy when house prices go up, but he or she saves the extra cost imposed on tenants. Buying your home insulates you against such market-determined changes in rent, and owing to the significant fluctuations in house prices over time it is important when you purchase.

UNEMPLOYMENT AND CONSUMPTION Chart II.2.2



Note: Loss of income is defined as $\frac{(\text{average wage} - \text{average benefit}) \cdot \text{unemployment rate}}{\text{average wage}}$

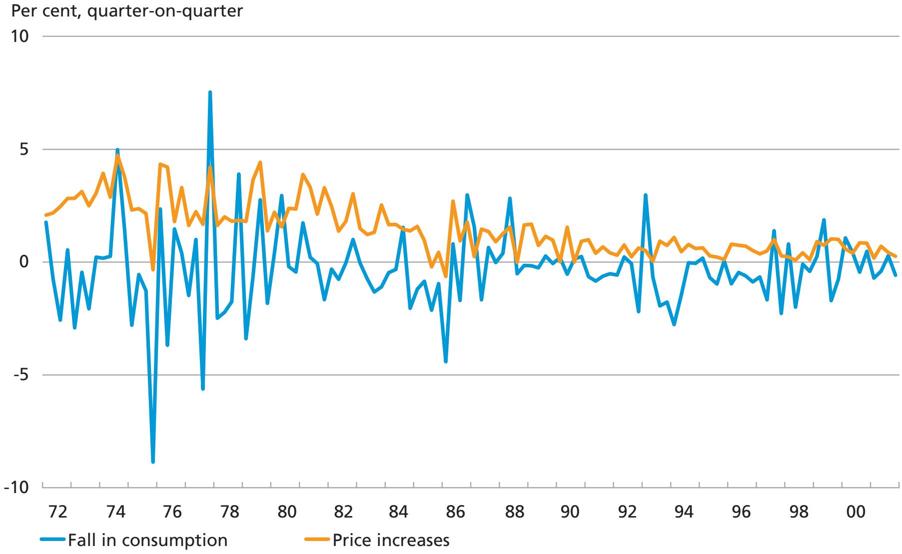
A possible reason why housing wealth affects private consumption is that a house may serve as collateral. Homeowners subject to credit rationing thus get an option to increase consumption when the value of the home rises. In the estimation period there is positive correlation between the development in the housing market and the propensity to consume, and this is captured by the estimated consumption relation. It is, however, uncertain whether private consumption simply reacts to housing wealth or whether both private consumption and the housing market reflect the same underlying factors.

Housing wealth is also interesting in that the price of housing is the only forward-looking endogenous market price included under wealth in Mona. As mentioned, business capital is measured by the replacement costs of real capital, not by a market value reflecting share prices. A particularly high coefficient for housing wealth might therefore be justifiable, but this would not improve the consumption relation, particularly as regards the recent years, cf. also the recursive estimation, Chart II.2.4.

Including imputed pension wealth entails that a reduction in the real size of old-age pensions increases savings in funded assets. The pension wealth variable also implies an age effect whereby a higher average age lowers the propensity to save.

Income and wealth are key to the consumption relation, particularly in the long term, but the dynamics are also affected by other factors. For instance, the change in the unemployment rate multiplied by the aver-

PRICE INCREASES AND FALL IN CONSUMPTION Chart II.2.3



age loss in income on moving from wage income to unemployment benefit is included. The variable expresses (the change in) the average expected loss of income on unemployment. A higher risk of loss reduces consumption. The unemployment variable is shown together with the consumption ratio in Chart II.2.2.

The relation also reflects that strong price development often results in weak development in consumption. The quarterly changes in consumption and prices are volatile, so the correlation can only just be perceived in Chart II.2.3, showing quarterly increases in prices and decreases in consumption.

A negative impact from price changes on consumption is not a new phenomenon, cf. e.g. Deaton (1977), and the effect in Mona's consumption relation is discussed in Høyer (1998). The effect may reflect a sluggish reaction in household consumption budgets in kroner. This means that consumption at constant prices reacts rapidly and relatively significantly to price changes.

Chart II.2.3 shows clear zigzag fluctuations in consumption in connection with an announced temporary reduction of VAT back in the 4th quarter of 1975 and the 1st quarter of 1976. This rapid reaction is even clearer as regards an announced indirect-tax package in the autumn of 1977. The expectation-related effects are described via dummies in the consumption relation. The dummies have zeros in most quarters and the sequence 1,-1, when they have an effect.

PRIVATE CONSUMPTION			Table II.2.1
Variable	Name	Coefficient	t value
Change in consumption	$\Delta\log(fcp)$		
Change in income	$\Delta\log(ydpk/pcp)$	0.0972	1.3
Income over consumption	$\log(ydpl_{-1}/pcp_{-1}) - \log(fcp_{-1})$	0.1125	2.7
Wealth over consumption	$\log(realfor_{-1}) - \log(fcp_{-1})$	0.1631	2.6
Unemployment term	*arblos2*	-3.4255	2.5
Inflation term	*dlogpcpt*	-0.6035	3.0
Dummy	*d7734*	0.0528	5.3
Dummy	*dmims*	0.0321	3.0
Constant		-0.3529	2.6

T = 1973:3 – 1997:4	DW = 1.992	AR(1) = 0.036	Se = 0.0135
R^2 = 0.5854	JB = 9.454	AR(4) = 3.330	

Note: *ydpl = ydp - ipv - pyfe·fyfe* and *ydpk = ydp - dalo - pyfe·fyfe.* The formulation implies that long-term consumption is homothetic in income and wealth. 5 per cent is accepted with a test statistic of 3.2, F(1.89) distributed.

We have now introduced and illustrated the elements in the consumption relation. In summary the consumption relation says that changes in consumption are determined by deviations from the long-term relation (II.3) and by changes in income, inflation term, unemployment term and by two dummies. The result of the estimation is shown in Table II.2.1.

As the LM statistics show, there is no major autocorrelation in the residuals, but the residuals do not have a normal distribution due to an outlier in the 4th quarter of 1978. This outlier coincides with an increase in VAT. Removing this quarter using a dummy, which is 1 in the quarter and otherwise zero, would reduce the JB statistic to an insignificant value of 2 without changing the other coefficients to any considerable degree.

The estimated consumption relation has moderate, short-term income elasticity of 0.1 for the same quarter. Income elasticity for the first year amounts to 0.2, equivalent to an average consumption reaction of 0.2 per cent for the same quarter and the first three quarters after a sustained increase in income by 1 per cent. This is comparable to the first-year elasticity for a consumption relation on annual data. It is normal to suspect that estimated consumption relations have a simultaneity bias, so that the immediate income elasticity is overestimated. However, the moderate short-term income elasticity indicates that the bias problem is small with our rather volatile quarterly data.

In the long-term consumption relation, income elasticity is 0.41 (0.1124/(0.1124+0.1631)), and wealth elasticity is 0.59. Converted into ratios, these elasticities imply that an increase in income by kr. 1 augments consumption by kr. 0.35-0.40 – provided that wealth remains constant – and an increase in wealth by kr. 1 augments consumption by around kr. 0.08.

The size of the wealth elasticity should be seen in relation to the delineation of wealth; the more sluggish the wealth variable, the higher the wealth elasticity. On average Mona's wealth variable is more sluggish than compilations without business capital at replacement cost. In e.g. the Smec model consumption elasticity with respect to wealth is less than half of this elasticity in Mona, but there is only a minor difference in consumption out of an increase in wealth by kr. 1, so basically the wealth effects of the two models are similar, cf. Bocian et al. (1999).

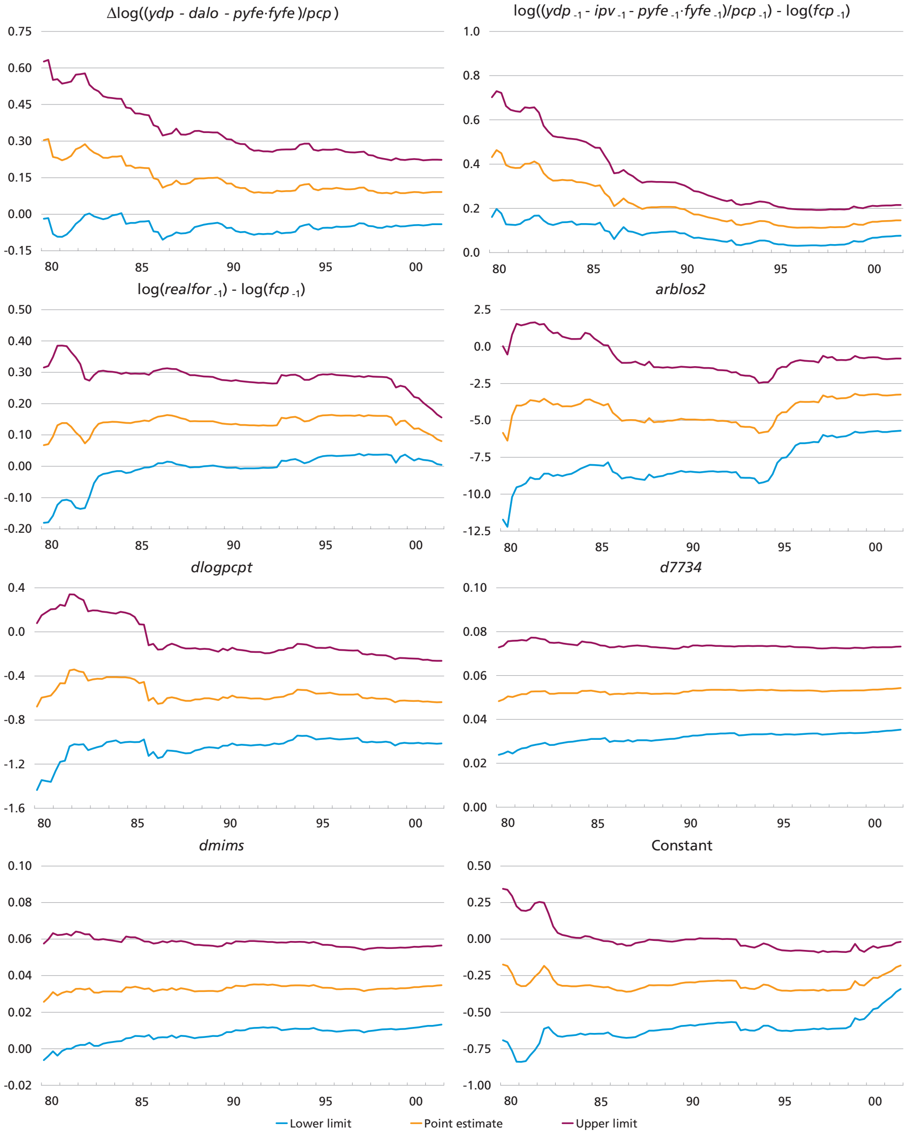
The above-mentioned reactions to kr. 1 in income and kr. 1 in wealth, respectively, are calculated *ceteris paribus*. Changes in wealth, e.g. via house prices, may well be the most interesting consumption determinant during an economic cycle , but in the long run the development in income is decisive. Income is a flow, while wealth is a stock. When increased wealth augments consumption, savings and consequently wealth are reduced. In the long term the increase in wealth is consumed, and its impact on consumption recedes.

While the long-term effect of wealth on consumption is more limited than the estimated wealth coefficient would seem to suggest, the long-term effect of income on consumption is stronger. The moderate income elasticity of 0.41 implies that an increase in income expands wealth, and subsequently the growing wealth boosts consumption until consumption evens out the increase in income. In the long term income elasticity is therefore not 0.41 but 1, reflecting that wealth is an endogenous variable. In the long term it also applies that 1 per cent more on income not only boosts consumption, but also wealth by 1 per cent.

The variable with the effect of changes in unemployment helps to describe the consumption reaction to cyclical changes. Only consumption dynamics are affected since the variable reflects the change in unemployment, not its level. A sustained increase in unemployment by 1 percentage point reduces consumption by just over 0.5 per cent per quarter for two quarters, i.e. by just over 1 per cent in total, after which the impact returns to zero over two quarters.

Price increases are included as an explanatory factor involving an auxiliary relation which defines an inflation term without any linear trend. In the 1990s price increases were significantly lower than in the 1970s, and specifically the inflation trend seen up to the early 1990s is removed. For the subsequent years the quarterly price increase is applied as it is. If the price increase in the estimation period was not detrended, the inflation term would partly replace income and wealth as explana-

RECURSIVE ESTIMATION, CONSUMPTION RELATION Chart II.2.4



tory factors, which is not a helpful result. The inflation term should only capture short-term monetary illusion among consumers.

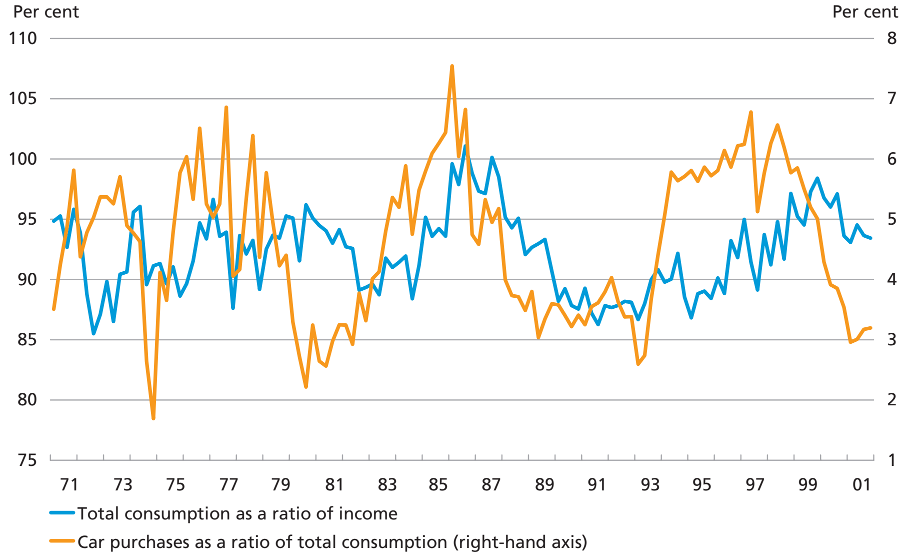
The parameter stability has been examined using recursive estimation, cf. Chart II.2.4. In general the coefficients are stable over the last 10-15 years seen in relation to their standard errors. However, there is a drift in e.g. the coefficient for the income term. The coefficient would have been higher if the estimation period had ended in the 1980s. The trend towards lower short-term impact of income may reflect the liberalisation of the financial markets. However, there is not a clear trend towards higher influence from any of the major wealth variables. On the basis of the modest development in consumption since 1998, the impact of total wealth rather seems to have weakened – particularly the impact of housing wealth. There may be a need for a broader wealth concept, so that e.g. reduced expectations of early retirement benefits appear as a savings-enhancing loss of wealth.

A few consumption components

The central element of the model's determination of consumption is the overall consumption function described above. Less emphasis has been placed on the composition of consumption, but some components are determined in the model. Housing consumption follows the stock of houses, which is determined by residential investments, cf. the section on the model's housing block. Moreover, travel expenditures and travel receipts are determined explicitly in order to be included in foreign trade and the balance of payments. Total private consumption comprises consumption in Denmark plus Danish tourists' purchases abroad less foreign tourists' purchases in Denmark.

The only consumption component with an estimated behavioural relation is car consumption, i.e. car purchases. Like other purchases of durable consumer goods, they are comparable to investments. Car purchases are especially cyclical and often linked to borrowing. The content

CAR PURCHASES AND TOTAL CONSUMPTION Chart II.2.5



CAR PURCHASE			Table II.2.2
Variable	Name	Coefficient	t value
Change in car purchase	$\Delta\log(fcb)$		
Change in income	$\Delta\log((ydp - ipv)/pcp)$	1.1579	1.7
Error-correction term	$\log(fcb_{-1}) - \log(fcb^*_{-1})$	-0.2999	4.0
Constant		0.0047	0.3

T = 1971:2 – 1997:4	DW = 2.246	AR(1) = 3.544	Se = 0.1865
R^2 = 0.1567	JB = 17.407	AR(4) = 9.959	

Note: The relation is estimated by OLS. Wanted car purchase $\log(fcb^*) = 1.7795 \cdot \log(fcp_{-1}) - 5.4717 \cdot \text{interest} - 7.5340$, which is estimated with an ADF-statistic of -2.994 that is too low in numerical terms to indicate cointegration.

of private Danish income in car purchases is rather low, although the import element is not particularly high. Danish car prices have a high element of taxation, so the separate determination of car purchases is interesting in relation to public finances, which become slightly more cyclically sensitive when car purchases are allowed to fluctuate.

Car purchases as a ratio of private consumption have fluctuated between 2 and 8 per cent since the 1970s, i.e. by a factor of four. The ratio correlates with the total consumption ratio, but the significant cyclical reaction in car purchases is typically seen at an early stage in an economic cycle. Car purchases relative to total consumption are shown in Chart II.2.5 together with the consumption ratio.

The relation for car purchases should merely capture the particular cyclical sensitivity. The model has no long-term relation for the stock of cars. Instead a long-term relation is estimated for car purchases, which follows total consumption with elasticity significantly above one. Furthermore, this relation depends on interest rates after tax. The residual from the long-term relation is included in a relation for the change in car purchases, cf. Table II.2.2.

The relation's residuals are not white noise, cf. the LM test for autocorrelation. In addition, the residuals are large. The standard error is equivalent to 20 per cent. Car purchases often react strongly to expectations of price changes, etc., and the large Jarque-Bera statistic indicates outliers. The relation makes car purchases cyclically sensitive, but apart from that there is not much in the simple relation.

THE HOUSING MARKET 3

The housing market is described in a model block with two key behavioural relations – one for house prices, and one for residential investments.

House prices are determined by interest rates, income and the stock of houses. Residential investments and thus also the stock of houses are in the long term determined by house prices relative to construction costs. On a fall in interest rates both house prices and housing construction go up, and the expanded supply of housing gradually forces house prices back towards equilibrium where they correspond to construction costs.

Basically we use a traditional approach to the investment side implying that the house prices/construction costs ratio governs residential investments. This is an application of Tobin's q also found in other housing models, cf. Andersen (1992). However, as can be seen, our investment relation deviates from a standard Tobin's q formulation. In the relation the house prices/building costs ratio has only a minor impact on investments, which are driven directly by income and capital costs.

Such direct application of the variables underlying the demand for housing is not contrary to Tobin's q, but our relation for residential investments can be said to resemble the other investment relations.

House prices not only influence housing construction, they are also included in the consumption relation's housing wealth and affect private consumption. This means that interest rates primarily impact on private consumption via the housing market, which is a further reason to examine the housing market.

The house-price relation

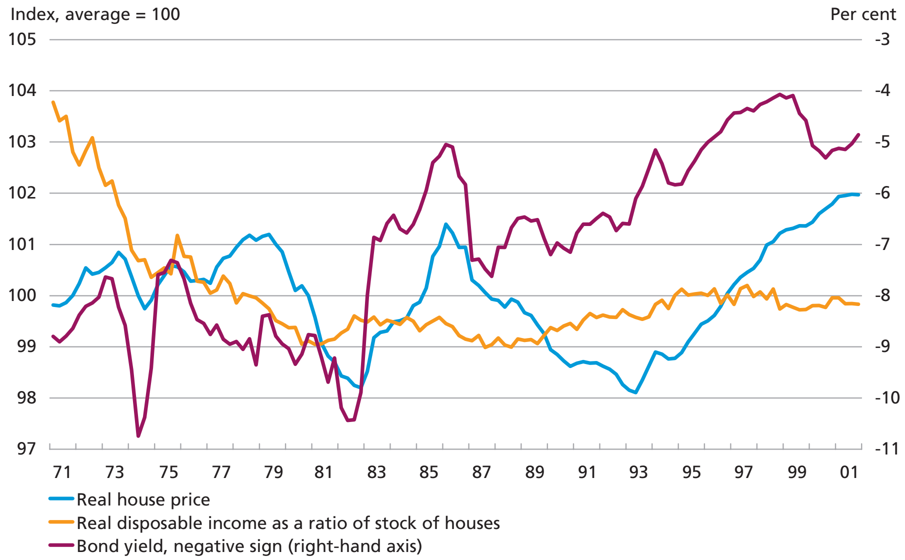
First we consider the determination of house prices in relation to the demand side. After a shock to the demand for housing, it will take a while before a significant pass-through effect is seen in the stock of houses. Residential investments are small relative to the stock. Instead, house prices may react rapidly to stronger or weaker demand.

The correlation between real house prices and the bond yield after tax is clearly negative, cf. Chart II.3.1. The ratio of income to stock of houses decreased in the 1970s, but since then it has moved around a horizontal trend. Relatively high income tends to be followed by relatively high house prices, cf. also Chart II.3.1.

This picture of variables expressed as levels and ratios can be supplemented with an illustration of the immediate positive correlation between falling interest rates and rising house prices, as well as the positive correlation between income over stock of houses and increases in house prices, cf. Chart II.3.2.

Factors such as interest rates and the ratio of income to stock of houses seem to drive house prices. To structure the corresponding relation we perceive house prices as being determined by a demand relation for housing.

HOUSE PRICES, INCOME AND INTEREST — Chart II.3.1



Note: The series for real house price and real disposable income as a ratio of stock of houses have been scaled to have the same mean value and variance in the period 1971-2000. A rate for the tax value of imputed rent has been added to the bond yield after tax.

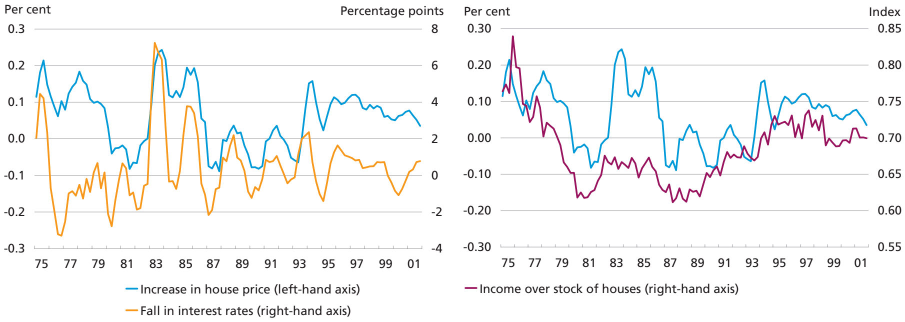
In a long-term demand relation the demand for housing depends positively on income and negatively on the user cost of dwellings relative to the price of substitutes, e.g. relative to the total consumer price.

$$\log(\text{stock of houses}) = \log(\text{income}) - a \cdot \log\left(\frac{\text{user cost}}{\text{consumer price}}\right) \quad \text{(II.4)}$$

The residual in this long-term relation may affect the change in house prices in the subsequent period, equivalent to an error-correction form.

In the long-term relation outlined (II.4) income elasticity is 1, and the own-price elasticity is negative. User cost for dwellings can in principle be

CHANGES IN HOUSE PRICE AND INTEREST RATE, PLUS INCOME/STOCK OF HOUSES — Chart II.3.2



HOUSE PRICE — Table II.3.1

Variable	Name	Coefficient	t value
House price	$\Delta\log(kp)$		
Consumption deflator	$\Delta\log(pcp)$	0.3074	1.4
User-cost change	$\Delta(rente + ssats)$	-3.7811	8.7
Lagged user-cost change	$\Delta(rente_{-1} + ssats_{-1})$	-0.7791	1.7
User cost	$rente_{-1} + ssats_{-1} + 0{,}01$	-0.7927	2.5
Expected change in consumption deflator	$dpcpe_{-1}$	0.7709	2.2
Expected change in house price	$dkpe_{-1}$	0.1949	2.9
Real house price	$\log(kp_{-1}/pcp_{-1})$	-0.1026	3.8
Real income/stock of houses	$\log((ydp_{-1} - ipv_{-1})/pcp_{-1}) - \log(fwh_{-1})$	0.0554	2.0
Constant		0.0663	3.5

T = 1974:2 – 1997:4	DW = 1.691	AR(1) = 2.499	Se = 0.0169
R^2 = 0.6920	JB = 0.803	AR(4) = 6.388	

Note: The relation is estimated by restricted OLS. The restriction equals the sum of price increase coefficients to the interest-rate coefficient. It is accepted with a test statistic of 0.0, F(1.87). Furthermore, income elasticity in housing demand is restricted to 1. It is accepted with a test statistic of 0.4, F(1.86).

written as real interest rate plus a tax element plus depreciation multiplied by the house price. There are some measurement problems related to these variables, particularly the real interest rate, and above all expected inflation. We will therefore take a less restricted approach whereby the relative price term in (II.4) is divided into 1) the house price/consumer price ratio, 2) nominal interest rates plus tax element, and 3) expected rate of inflation, with several contributions to the latter. With this less restricted formulation we can estimate how much the individual components in the price term' contribute to explaining house prices.

To help formulate the expected rate of inflation, which goes into the real interest rate, we will now introduce a price-increase term based on the consumption deflator smoothed by an HP filter and with a coefficient of ½ for the increase. This is to model the sluggishness of inflation expectations, cf. Knudsen (2002). It could be argued that the rate of inflation should reflect the price increase in the capital goods, and the increase in house prices is also included in the house-price relation, where it contributes to the expected rate of inflation.

The estimated house-price relation is shown in Table II.3.1. There is a minor tendency towards positive autocorrelation in the residuals, but it is not significant, cf. the LM statistics, and there is no major problem with outliers, cf. the Jarque-Bera statistic.

You may note that an assumed depreciation rate of 0.01 is included explicitly in the user-cost term. This has no bearing given the additive form, but is a reminiscence from a logarithmic form of the user-cost term.

The estimated coefficients show that an increase in real income by 1 per cent for a given stock of houses augments house prices by 0.5 per cent (0.0554/0.1026) in the long term, while a fall in long-term interest rates after tax by 1 percentage point in the long term increases house prices by almost 8 per cent (0.7927/0.1026). The corresponding first-year effects can be calculated at almost 0.1 per cent and 5 per cent, respectively, measured as the average of the first four quarters. In other words house prices adapt relatively quickly to changes in interest rates. The explanation is that long-term interest rates automatically represent future financing costs. A shock to income, on the other hand, must be felt for a while before it is perceived as permanent and housing decisions are made on the basis thereof.

On estimation of the house-price relation a restriction has been applied to the coefficients for the price-change variables in Table II.3.1, to ensure a formal real-interest-rate correlation. Specifically, the coefficients for all terms with price changes are restricted, so a lift of the price increase by 1 percentage point per annum in the long term will raise house prices by the same factor as a fall by 1 percentage point in interest rates after tax, 0.3074/4 + 0.7709 + 0.1949 – 0.25 = 0.7927. The rate of interest is per annum, so the weighting of quarterly price increases is one fourth. Minus 0.25 is the contribution from the price increase on the left-hand side of the relation. No distinction is made between increases in house prices and consumer prices. In a steady-state scenario with the relation the two prices increase at the same rate.

We identify the expected inflation in the relation by placing price increases and the nominal interest in the same parenthesis. If the dates of the variables are ignored, the implied inflation expectation may be expressed as a weighted average of the price changes

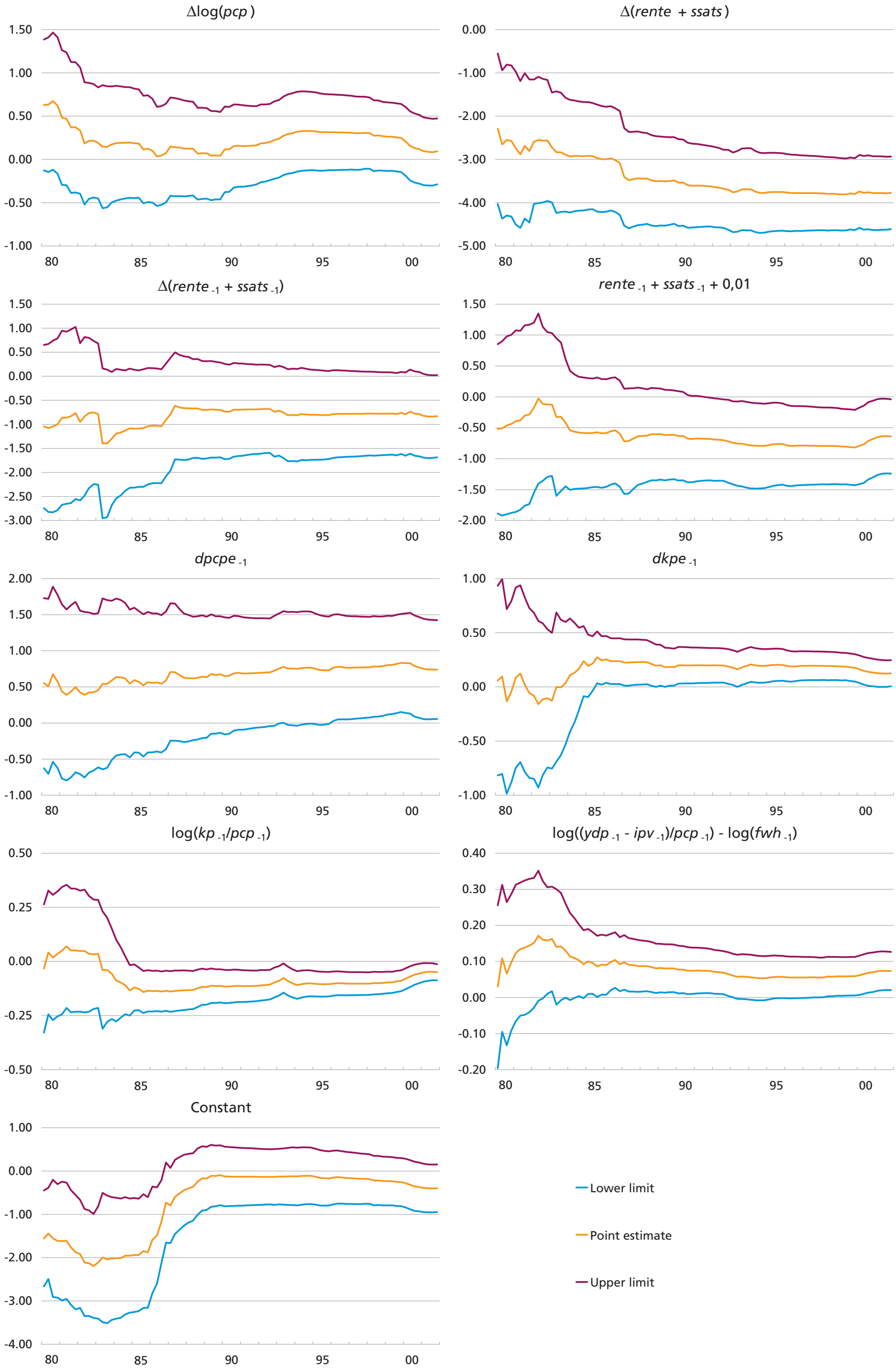
$$0{,}10 \cdot \Delta \log (pcp) + 0{,}97 \cdot dpcpe + 0{,}25 \cdot dkpe - 0{,}32 \cdot \Delta \log (kp) \qquad \text{(II.5)}$$

where 0.10 = (0.3074/4)/0.7927, 0.97 = 0.7709/0.7924, etc.

With this expression representing the inflation term in the real interest rate, the formation of the real rate is not consistent with simple theory. Behind the expected consumer-price increase, *dpcpe*, there is, as mentioned, an expression with only half weight attributed to the price increase. In addition, there is a considerable lag, since the price series is filtered before the price increase is calculated.

As stated below in the Chapter on multiplier experiments, the model can also be solved with forward-looking expectations of price increases, implying a more model- and theory-consistent formation of real interest rates.

RECURSIVE ESTIMATION, HOUSE PRICE Chart II.3.3



Recursive estimation of the house-price relation shows no clear breaks within the last 10 years, but there is a little drift in the coefficients over the most recent years when the increase in house prices has proved to be surprisingly robust after a reduction of the tax deductibility of interest payments in 1998. In the future the relation should presumably be estimated on the basis of a lower average interest rate considering the new short-term mortgage loans. The result of the recursive estimation is shown in Chart II.3.3.

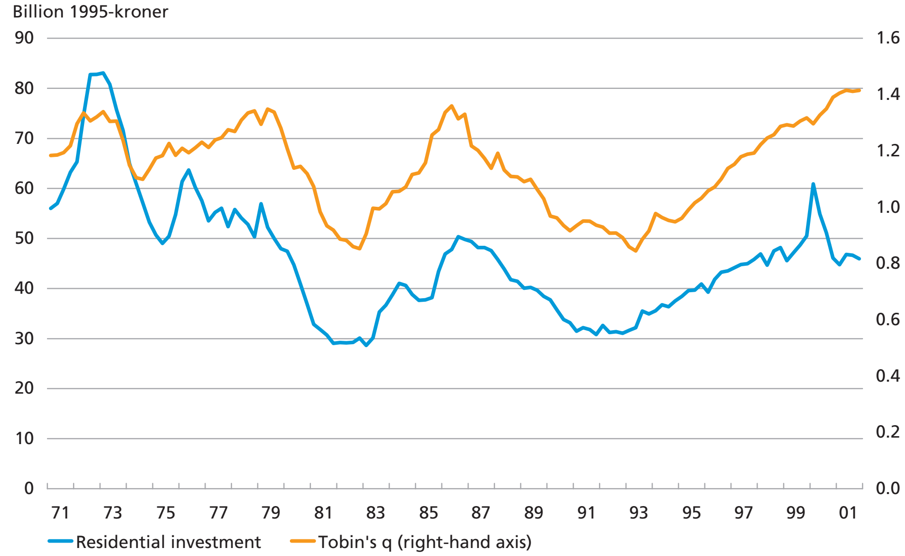
The residential-investment relation

Residential investments can be determined on the basis of the ratio of the prices for existing housing to construction costs. When house prices are high in relation to construction costs, new building is favourable, and residential investments increase. We will here disregard the fact that land or rather development sites with a certain location are non-reproducible factors.

Relating production costs to prices for finished products corresponds to the essence of the Tobin's q model, cf. Tobin (1969). The correlation in data between Tobin's q, i.e. house prices/construction costs, and residential investments is illustrated in Chart II.3.4.

In the investment relation Tobin's q is supplemented with the ratio of actual to wanted stock of houses, where the latter is defined as the demand level at which house prices equal construction costs. Adding this term opens up for short-term dynamics where residential investments are affected by other factors than house prices. At the same time the

RESIDENTIAL INVESTMENTS AND TOBIN'S Q — Chart II.3.4



TOBIN'S Q AND WANTED STOCK OF HOUSES Box II.3.1

Disequilibrium in relation to Tobin's q indicates that the house price is either higher or lower than construction costs, which represent the replacement price. This disequilibrium in relative prices is also reflected in volumes. If the house price is higher than the construction costs, the actual stock of houses is lower than the wanted stock. The latter is called fwhoe and defined as demand for stock of houses for house price = building cost.

The long-term relation for demand for stock of houses can be derived from the estimated house-price relation in Table II.3.1. We ignore leads and lags and changes in interest rates, merge the user cost and price-increase variables into a real user cost, and write the house-price relation with the stock of houses on the left-hand side, and income and real user cost on the right-hand side.

$$\log(fwh) = \log\left(\frac{ydp - ipv}{pcp}\right) - 1.85 \cdot \log\left(\frac{kp}{pcp}\right) - 14.31 \cdot \text{"real user cost"} \qquad (1)$$

1.85 = 0.1026/0.0554, 14.31 = 0.7927/0.0554. The constant is ignored.

The Tobin's q mechanism implies that the steady-state house-price index follows the residential-investment deflator, which reflects the construction costs. This gives the simple long-term relation log(*kp*) = log(*pih*), expressing a long-term horizontal supply relation. If this is inserted in (1) we get the expression of wanted stock of houses, *fwhoe*

$$\log(fwhoe) = \log\left(\frac{ydp - ipv}{pcp}\right) - 1.85 \cdot \log\left(\frac{pih}{pcp}\right) - 14.31 \cdot \text{"real user cost"} \qquad (2)$$

By introducing the ratio of actual to wanted stock of houses in addition to the ratio of market price to replacement price, we permit a more flexible adaptation of the stock of houses.

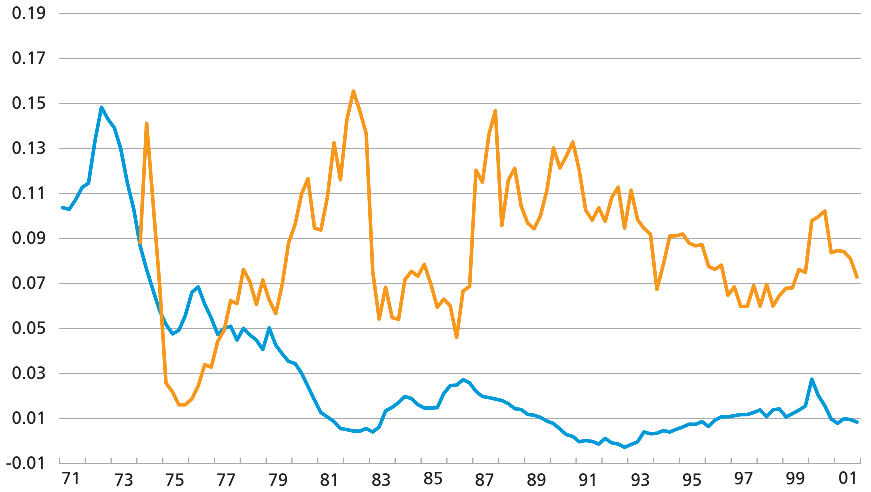
Applying a wanted stock of houses, defined as in (2), to model residential investments is analogous to modelling business investments in the traditional manner on the basis of activity and relative factor price, where the capital cost is based on the investment deflator, cf. the section on business investments.

basic long-term relation of the Tobin's q mechanism remain unchanged. The formulation is discussed in Box II.3.1.

The correlation between residential investments on the one hand and the ratio of house price to investment price on the other hand is clearly positive. The negative correlation between residential investments and the ratio of actual to wanted stock of houses is also seen, cf. Chart II.3.5. Among other things, including the ratio of actual to wanted stock may help to explain the fall in residential construction activities in the latter half of the 1970s.

The estimated relation for residential investments includes two dummies which capture outliers in the 1st quarter of 1976 and the 1st quarter of 1979. The outlier in 1976 is presumably related to the temporary VAT reduction. The estimation result for the residential-investment relation is shown in Table II.3.2.

RESIDENTIAL INVESTMENTS AND STOCK OF HOUSES | Chart II.3.5



The Jarque-Bera test rules out normality due to a few outliers of little significance to the parameter estimates. There is some tendency towards negative autocorrelation over four quarters, i.e. the associated LM statistic is close to the 5-per-cent threshold for the corresponding χ^2 distribution. This may reflect a measurement error in the breakdown of residential investments by quarters.

The estimated dynamics are relatively slow, in that the coefficient for the lagged net investments is relatively close to 1 (1-0.1424). It is also seen that the Tobin's q price ratio for houses is insignificant. Instead the

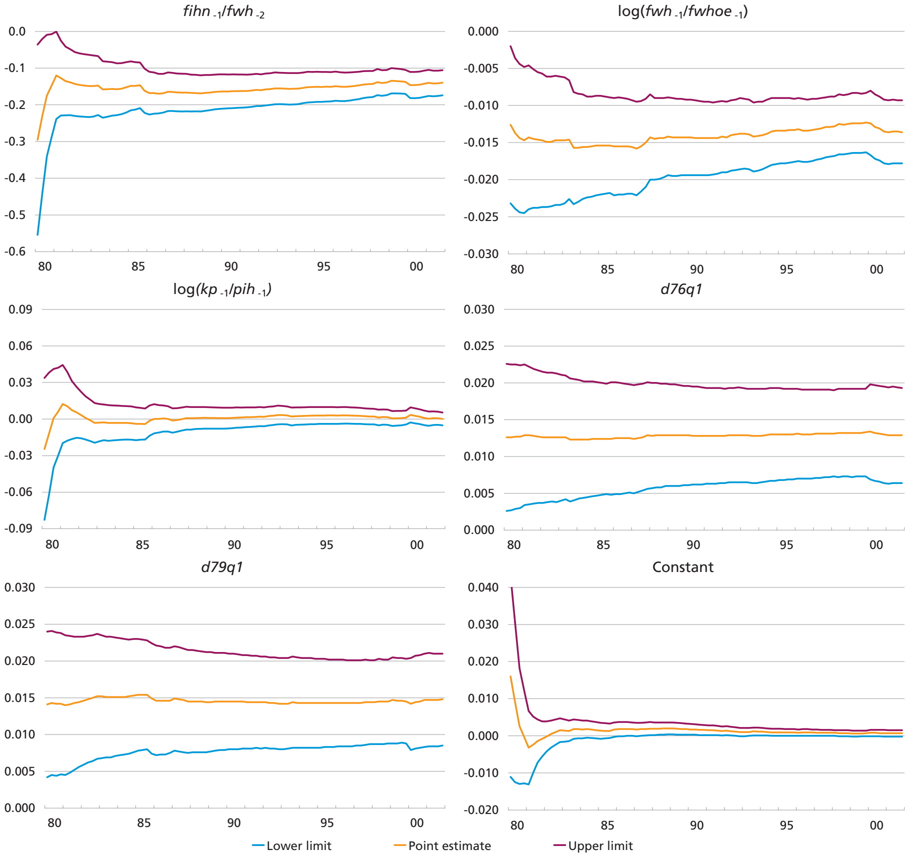
RESIDENTIAL-INVESTMENT RELATION | Table II.3.2

Variable	Name	Coefficient	t value
Net investment/stock	$\Delta(fihn/fwh_{-1})$		
Net investment/stock	$fihn_{-1}/fwh_{-2}$	-0.1424	7.5
Actual/wanted stock of houses	$\log(fwh_{-1}/fwhoe_{-1})$	-0.0131	6.1
House price/investment price	$\log(kp_{-1}/pih_{-1})$	0.0019	0.7
Dummy	*d76q1*	0.0112	4.4
Dummy	*d79q1*	0.0124	5.0
Constant		-0.0011	3.0

T = 1974:3 – 1997:4	DW = 1.690	AR(1) = 2.426	Se = 0.0024
R^2 = 0.5804	JB = 10.181	AR(4) = 8.919	

Note: The relation is estimated by OLS. In the expression for the wanted stock of houses $\Delta\log(kp)$ and $\Delta\log(pcp)$ are replaced by *dkpe* and *dpcpe*, respectively. $\log(fwhoe) = \log((ydp\text{-}ipv)/pcp) - 1.8521\cdot\log(pih/pcp) - 14.3142\cdot(rente + ssats + 0.01) + 15.3084\cdot dpcpe - 0.9942\cdot dkpe + 1.1977$.

RECURSIVE ESTIMATION OF RESIDENTIAL-INVESTMENT RELATION Chart II.3.6



ratio of actual to wanted stock of houses contributes significantly to explaining residential investments. Despite its insignificance, the Tobin's q term is maintained in the relation with a view to future reestimation.

The recursive estimation of the residential-investment relation shows fairly good parameter stability with minor fluctuations in a few coefficients in the last few years, cf. Chart II.3.6. Particularly in 2000 residential investments soared due to extensive repair activities after a hurricane in December 1999. This is not captured by the explanatory variables and would justify a dummy when the residential-investment relation is estimated up to the year 2000.

The overall housing model

The relations for house prices and residential investments can be seen as one housing block when supplemented with a definitional relation to generate the stock of houses on the basis of the investments. In the

ISOLATED EFFECTS ON HOUSING MODEL Table II.3.3

	Deviation from initial course			
	1st year	5th year	10th year	Long term
	Permanent fall in interest rate by 1 percentage point			
House price, per cent	5.0	6.6	4.5	0.0
Stock of houses, per cent..............	0.1	3.5	8.5	15.4
Residential investments, per cent .	3.4	17.8	20.5	15.4
	Permanent income increase by 1 per cent			
House price, per cent	0.1	0.4	0.3	0.0
Stock of houses, per cent..............	0.0	0.2	0.6	1.0
Residential investments, per cent .	0.2	1.1	1.3	1.0
	Permanent investment-price increase by 1 per cent			
House price, per cent	0.0	0.1	0.5	1.0
Stock of houses, per cent..............	0.0	-0.5	-1.1	-1.8
Residential investments, per cent .	-0.5	-2.4	-2.5	-1.8

Note: The base solution resembles that of the multiplier experiments.

housing block, house prices and residential investments are endogenous, whereas interest rates, income and investment prices are exogenous.

The reaction to changes in interest rates, income and investment prices is shown in Table II.3.3. Shocks to interest rates and income only affect house prices in the short term. In the longer term the stock of houses adapts when income or interest rates change. The only factor which affects house prices in the long term is shocks to investment prices – i.e. to construction costs. This reflects that changes in investment prices move the horizontal supply curve.

The reaction in e.g. the stock of houses is generally slow and is not completed within 10 years. This is particularly true when interest rates fall, in which case the adaptation of the stock of houses is only just over halfway after 10 years. The high degree of sluggishness in the estimation results can be questioned. It is natural that adaptation is sluggish in a market for durable capital goods where investments and thus the change in the capital stock are minor in relation to the level of the capital stock. At the same time we have not necessarily found a relevant adaptation rate and profile.

A general concern is that if we have problems regarding the formulation of the relation or the data used the coefficient for lagged investments will be overestimated, whereby the adaptation becomes too slow.

In the adaptation phase residential investments change relatively more than the stock of houses, while the percentage changes in flow and stock are equal in the long term. The Table shows the impact on gross investments. Reinvestments follow the stock of houses, which means that the percentage change in net investments is even greater.

CAPITAL STOCK AND EMPLOYMENT 4

The demand for capital and labour is to a large extent determined by output. Particularly in the long run technological advances and changes also play an important role. In addition, there is an impact from the costs of the two factors of production. The more expensive labour is relative to capital, the greater the incentive to make the production capital-intensive.

The capital stock is applied over several periods, so interest rates are part of the cost of capital. Financial variables thus impact on the real economy not only via the housing market, as described in the previous section, but also via capital formation in the business sector. Labour and the business-sector capital stock are necessary inputs for production, so in this section we will analyse the demand for business investments and for labour.

The approach to modelling investments is a simple application of the "benchmark" model in the overview article Chirinko (1993), and in the construction of the model block for capital and labour both factors are included in the production function. There is a wide range of literature on estimation of production functions. In this case, with only two input variables, the problem is not too complex, so we will take a relatively empirical approach to formulating the relations and will neither insist on a strict functional form nor on always being on the isoquant.

Specifically, the wanted capital and thus the need for investment are determined by output and relative factor prices, assuming that the entrepreneurs are minimising costs. In this connection substitution elasticity between capital and labour is estimated at 2/3, i.e. slightly less than 1. Nonetheless, the wanted input of labour is expressed by entering output and capital to a Cobb-Douglas production function.

Adaptation to the wanted factor inputs takes time, and output can be above and below the isoquant. Adaptation is most sluggish for capital, but sluggishness is also observed for employment. This implies that in the short term labour productivity correlates with output, equivalent to a labour-hoarding effect.

Not all real business capital is included in the production function, only the stock of machinery. Machinery investments include machinery, transport equipment and software. This means that there is no feedback on labour demand from the business building stock.

In principle it is wrong that the output elasticity of the business building stock is zero. Production usually requires a building, and a well-equipped building increases efficiency. On the other hand, machinery investments have a more direct impact on labour productivity than building investments.

The following focuses on determination of two production factors, labour and machinery. We will illustrate and discuss the two factors, emphasising their interaction. This is followed by a description of the business building stock, which is unrelated to the demand for labour. Finally we will consider stockbuilding, which is not an integral part of the production side either, but which nonetheless plays a special role in the model's short-term output reaction, particularly since Mona is a quarterly model.

About factor demand overall

The demand for the production factors labour and capital is determined by output and factor prices. Output means gross value added (GVA) in the private non-farm sector, more specifically gross value added excluding product-related net indirect taxes. Output and capital are stated at constant prices, while labour is measured in hours, i.e. employment multiplied by the agreed annual working hours per person. Specifically, working hours per person are raised to the power of 0.7, which implies that reductions in working hours increase productivity by an elasticity value of 0.3.

A key economic property of factor demand is that capital and labour may be substituted for each other. The core of the factor substitution is that capital intensity affects labour productivity; the more capital per output unit, the higher output per labour unit.

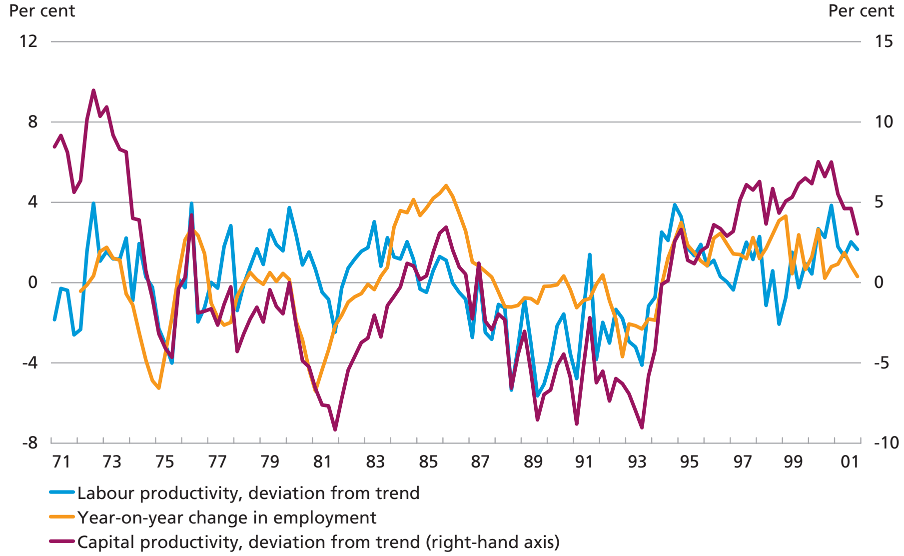
The substitution mechanism implies a negative correlation between the two simple factor productivity measures, output per labour unit and output per capital unit. However, this negative correlation cannot be seen in Chart II.4.1 showing labour and capital productivity. On the contrary, the productivity of the two factors seems to have a positive correlation.

This is not entirely surprising. Both productivity measures have output in their numerators so any sluggishness in the adaptation of the factor inputs implies immediate positive correlation between factor productivities during a business cycle. The negative correlation implied by the factor substitution may take too long to materialise to be directly observable in the data on productivity levels.

However, it can be observed that high labour productivity and high capital productivity normally stimulate employment, cf. Chart II.4.1. The

DETRENDED LABOUR AND CAPITAL PRODUCTIVITY PLUS CHANGE IN EMPLOYMENT

Chart II.4.1



factor productivity values shown are detrended as regards linear trends, and the visible correlation with change in employment can, with a lag of one quarter, be expressed as

$$\Delta\log(\text{labour}) = a\cdot\log\left(\frac{\text{output}_{-1}}{\text{labour}_{-1}}\right) + b\cdot\log\left(\frac{\text{output}_{-1}}{\text{capital}_{-1}}\right) + \text{trend} \qquad \text{(II.6)}$$

The relation (II.6) describes that employment is attracted by a long-term production relation between the levels of output, labour and capital. Normalised on labour, this long-term relation can be written as

$$\log(\text{labour}) = \frac{a+b}{a}\cdot\log(\text{output}) - \frac{b}{a}\cdot\log(\text{capital}) + \text{trend} \qquad \text{(II.7)}$$

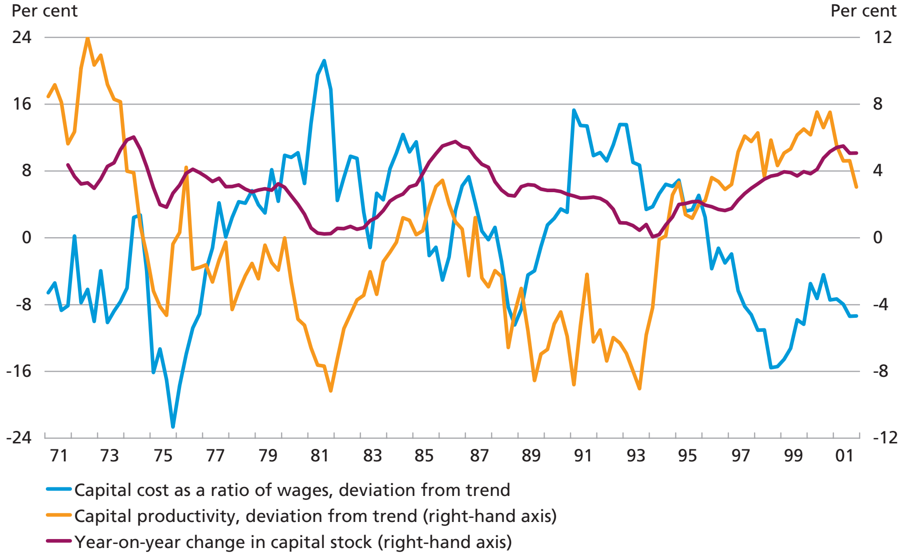
The loglinear relation (II.7) is a simple Cobb-Douglas production function. The trend in (II.7) is a linear function of the trend in (II.6), and e.g. labour output elasticity a/(a+b) is expressed by the parameters from (II.6). Relation (II.7) is one of the two long-term relations in Mona's determination of factor demand for given output and given factor prices.

There are two production factors so one more relation is required, which must necessarily include relative factor prices since they are not included in the production function.

Again our starting point is the substitution mechanism, which implies that relative factor prices affect capital productivity. Just as the substitu-

DETRENDED RELATIVE FACTOR PRICE AND CAPITAL PRODUCTIVITY PLUS CHANGE IN CAPITAL STOCK

Chart II.4.2



tion between factor productivity levels was not obvious, no immediate positive correlation can be seen between output over capital on the one hand and capital cost over hourly wage cost on the other hand, cf. Chart II.4.2.

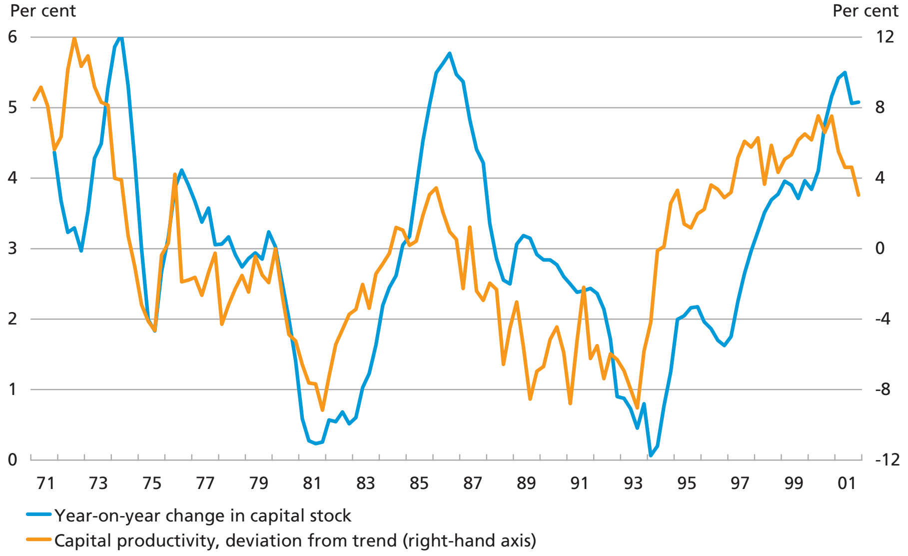
A negative correlation is observed in Chart II.4.2, presumably reflecting that high interest rates weaken the business cycle and thus reduce output relative to the more sluggish capital. This cyclical effect on capital productivity overshadows the underlying tendency for a higher capital cost to reduce the input of capital.

It is necessary to relate to the movement in the capital stock to see a substitution-driven correlation with relative factor prices. The capital stock tends to fall when capital cost over wages is high, cf. Chart II.4.2. It is also possible to illustrate the simple quantitative mechanism that the capital stock usually increases when output over capital is high, cf. Chart II.4.3. Taken as a whole, the two illustrations relating to the movement of the capital stock can be described by a relation for the change in the capital stock where a lag is inserted as in relation (II.6).

$$\Delta \log(\text{capital}) = \quad c \cdot \log\left(\frac{\text{output}_{-1}}{\text{capital}_{-1}}\right) - d \cdot \log\left(\frac{\text{capital cost}_{-1}}{\text{wages}_{-1}}\right) \qquad \text{(II.8)}$$

In principle there could also be a trend as in (II.6), but a trend variable is less crucial to the demand for capital than to the demand for labour. Relation (II.8) describes what can be observed in Charts II.4.2 and II.4.3,

DETRENDED CAPITAL PRODUCTIVITY AND CHANGE IN CAPITAL STOCK Chart II.4.3



and the relation implies that the capital stock adapts to the long-term relation

$$\log(\text{capital}) = \log(\text{output}) - \frac{d}{c} \cdot \log\left(\frac{\text{capital cost}}{\text{wages}}\right) \tag{II.9}$$

Relation (II.9) reflects homogeneity with respect to output, as well as cost minimisation conditioned on the factor-price ratio. In principle elasticity, d/c, for a Cobb-Douglas function corresponds to labour output elasticity, a/(a+b). However, data indicate lower elasticity as regards the factor-price ratio in (II.9), and we have chosen not to restrict the coefficient in (II.9). Instead we get two loglinear relations which together imitate a production function with slightly less substitution than Cobb-Douglas without the specific introduction of e.g. a CES function. This entails a modest element of approximation.

We apply (II.7) and (II.9) as the two long-term relations of factor demand. It may be useful to apply a multivariate estimation method when seeking two relations on a data set with a manageable number of variables. In Kristensen and Knudsen (1999) cointegration analysis has been applied to estimate the two simple long-term relations. The data set comprises (the logarithm of) capital stock, labour, output and relative factor prices, as well as a linear trend, and two relations are found, which can be interpreted as (II.7) and (II.9).

We make no attempt to repeat the multivariate analysis here, but estimate the employment and investment relations individually. This is more practicable, particularly with a view to recurring reestimation, and in addition the single-equation estimation does not change the result significantly.

The, perhaps, most important result in Kristensen and Knudsen does not directly concern the content of the relations for investments and employment, but their interaction with other variables. Not only investments and employment, but also output, turn out to be endogenous in a multivariate analysis. For instance, output reacts to capacity utilisation expressed as deviations from the production relation. This correlation in the data set has led to the inclusion of the residual from the production function in the import relation. A similar correlation from change in employment to output has led to the inclusion of the change in employment in the stock relation, cf. later on the stock relation and on imports. Thus the overall model reflects a direct quantity-to-quantity capacity effect from the factor side to output.

As mentioned, we now determine the model's demand for labour and capital using single-equation estimation. We will first consider the estimated employment relation.

Employment

We set output elasticity and factor share of labour at 2/3 and capital at 1/3, i.e. a/(a+b) from (II.7) equals 2/3. This resembles the shares of wages and profits, respectively, in the private non-farm sector. The trend of the production function is estimated without restrictions in the employment relation. It is a simple employment relation. In addition to trend and lagged residual from the production function only the output change in the same quarter is included as an explanatory variable. This implies an immediate impact of output on employment. The result of the estimation is shown in Table II.4.1.

There are no problems concerning autocorrelation or outliers in relation to the LM tests and the Jarque-Bera test. It should be noted that instrument estimation is applied because we want to estimate a coefficient for the unlagged output change. In this case the problem is not simultaneity, but measurement errors. The quarterly change in output is considerably more volatile than the associated change in employment. Output naturally fluctuates most, but it seems evident that the considerably stronger volatility of the change in output also reflects measurement problems as regards private non-farm GVA at constant prices.

In the estimation the lagged changes in employment, output and capital are used as instruments for the unlagged change in output. Lags of 1 and 2 quarters are applied, so there are 6 instrumental variables. This is not optimal in that a Sargan test for instrumentation rules out the pos-

EMPLOYMENT			Table II.4.1
Variable	Name	Coefficient	t value
Change in employment	$\Delta\log(qbyx)$		
Change in output	$\Delta\log(fyfbx)$	0.4248	3.8
Residual from production function	a)	0.2149	4.9
Trend	$0.001\cdot$trend	-2.0182	4.3
Constant		-3.9504	4.3

T = 1971:4 – 1997:4	DW = 2.056	AR(1) = 0.908	Se = 0.0084
R^2 = 0.0645	JB = 0.382	AR(4) = 4.781	

Note: IV estimation with $\Delta\log(qbyx)$ and $\Delta\log(fyfbx)$ as endogenous variables. Lags of 1 and 2 quarters are applied to the instruments: $\Delta\log(qbyx)$, $\Delta\log(fyfbx)$ and $\Delta\log(km)$. Test of identifying restrictions: 11.54 ; $\chi^2(5)$, Sargan's test .
a) $\log(fyfbx_{-1}) - 0.67\cdot\log(qbyx_{-1}) - 0.33\cdot\log(km_{-1})$.

sibility that the estimated equation can be seen as a linear combination of reduced equations for employment and output. The choice of instruments is inspired by the multivariate analysis of the slightly older data set in Kristensen and Knudsen.

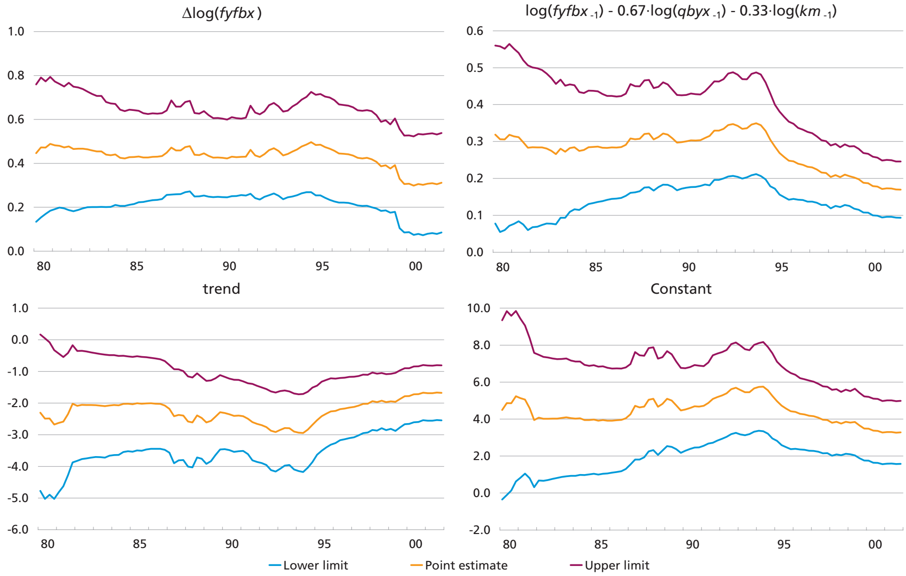
The coefficient for the change in output is just over 0.4, cf. Table II.4.1. In an OLS regression the coefficient for the change in output is only half of this value. In the IV estimation applied the actual change in output is replaced by the change in output regressed on the instrumental variables. This estimate of the change in output is more stable than the actual change and, as mentioned, it has a higher coefficient in the relation.

The coefficient of just over 0.4 is, however, still significantly lower than 1, implying that labour productivity rises when output increases. This procyclical effect on productivity is a frequently observed and expected result. Adaptation of labour entails costs, and therefore labour reacts sluggishly. We have not formulated the adaptation costs, etc., so there is no explicit structure behind the estimated dynamics.

The use of output elasticity of around 2/3 and 1/3 for labour and capital, respectively, was tested and accepted in Kristensen and Knudsen (1999). With the more recent data set the restriction cannot immediately be accepted in the employment relation. For instance, it is rejected by an F-test on the reduced equation for the change in employment. However, it is difficult to construct a simple model without a simple long-term relation between output and the two inputs, for which reason the restriction has been maintained for the time being.

The recursive estimation indicates some instability and drift in the parameters in recent years, cf. Chart II.4.4. For instance, the coefficient for the relation's error-correction term gradually declines, whereby ad-

RECURSIVE ESTIMATION, EMPLOYMENT Chart II.4.4



aptation slows down when data for recent years enter the estimation period. This may reflect that the Danish labour market becomes tighter towards the end of the sample.

Capital

Just as the employment relation is kept simple, only few variables appear in the relation for capital formation, i.e. the investment relation. The three variables in the long-term relation (II.9) are included with a lag. The relation also includes the unlagged quarterly change in output and the change in capital stock lagged by one and two quarters. The capital stock reacts far more sluggishly than employment, and the lagged changes in capital stock contribute to modelling the sluggish dynamics. The result of the estimation is shown in Table II.4.2.

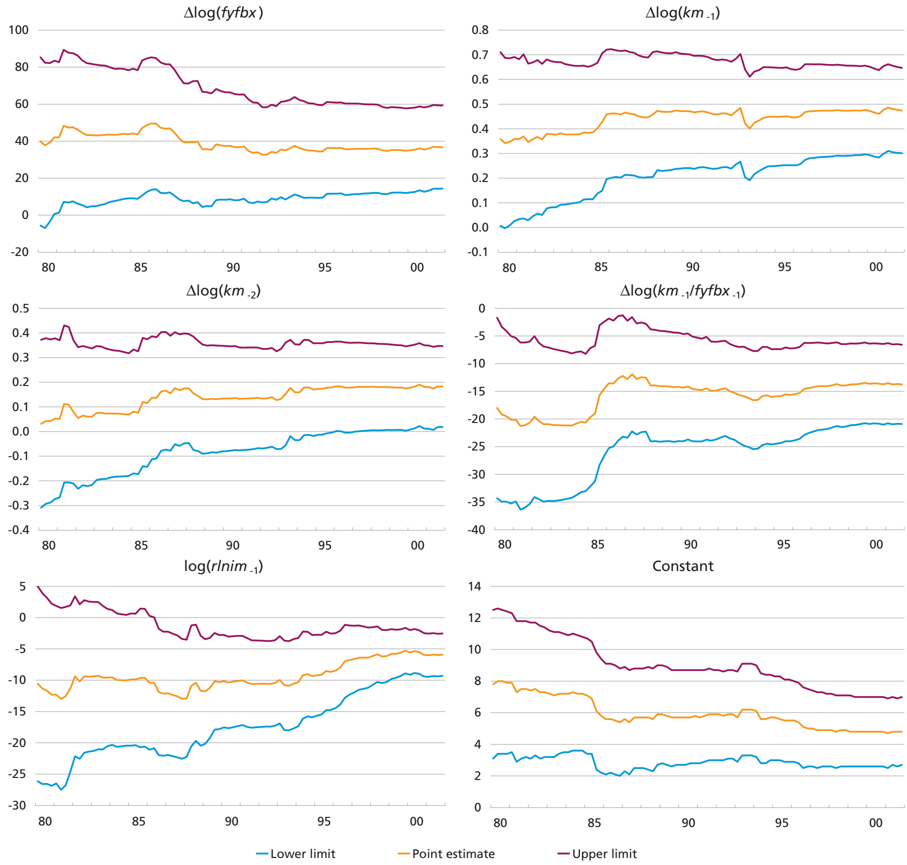
There are no problems with the residuals, cf. the statistics for autocorrelation and normality. Outliers might have been expected, e.g. in connection with announced changes in depreciation rules, just as dummies are used in the consumption relation in connection with changes in indirect taxes. However, it may be difficult to distinguish between the effect of political measures and ordinary volatility, and the residuals in the relations seem to have a normal distribution with a large dispersion relative to the level of investments rather than being characterised by a few outliers.

MACHINERY INVESTMENTS			Table II.4.2
Variable	Name	Coefficient	t value
Change in capital stock	$\Delta\log(km)$		
Change in output	$0.001\cdot\Delta\log(fyfbx)$	35.9805	3.0
Change in capital stock	$\Delta\log(km_{-1})$	0.4736	5.1
Change in capital stock	$\Delta\log(km_{-2})$	0.1816	2.0
Capital/output ratio	$0.001\cdot\log(km_{-1}/fyfbx_{-1})$	-13.9047	3.6
Factor price ratio	$0.001\cdot\log(rlnim_{-1})$	-6.1497	2.6
Constant	0.001	4.8604	3.2

T = 1971:3 – 1997:4	DW = 1.973	AR(1) = 0.128	Se = 0.0024
R^2 = 0.6676	JB = 0.795	AR(4) = 3.615	

Note: Estimated by OLS. The restriction of long-term output elasticity to 1 is accepted with an F value of 0.13, F(1.99).

RECURSIVE ESTIMATION, MACHINERY INVESTMENTS Chart II.4.5



The standard error of 0.0024 indicates that the relative error on the capital stock is ¼ per cent. When related to the volume of investments, particularly net investments, the error in per cent is considerably larger.

The sluggishness of capital formation reflects the estimated dynamics with a numerically small coefficient of -0.0139047 for the lagged capital stock and thus for deviations from the long-term relation. It is also seen that the change in output in the same quarter plays a far smaller role in this investment relation than in the employment relation. It makes no great difference if we estimate with instruments in order to take account of measurement errors in output, so we have chosen OLS, cf. Table II.4.2.

In the long-term relation for the capital stock the relative factor prices have the coefficient -0.44 (6.1497/13.9047). It should have been -0.67 to reflect a pure Cobb-Douglas function with substitution elasticity of 1. Now the coefficients indicate that substitution elasticity is around 2/3 (0.44/0.67). The deviation is not significant. The Cobb-Douglas restriction has an F statistic of 2.24, which is not significant for F(1,100). However, we have chosen to omit the restriction with a view to future reestimation and possible respecification of the capital costs, which can be expressed in several ways and may affect the estimate of substitution elasticity.

A recursive estimation points to stable coefficients over the last 10-15 years assessed in relation to their dispersion, cf. Chart II.4.5.

More about capital costs in particular

As in the other relations, the input variables are typically based on figures from Statistics Denmark. For instance, the capital stock is measured as the official figures for the gross capital stock in the private business sector, excluding rental housing and excluding ships. The official capital figures are only available at year-end, but here they have been interpolated to end of quarters based on quarterly investments and the associated depreciation rates.

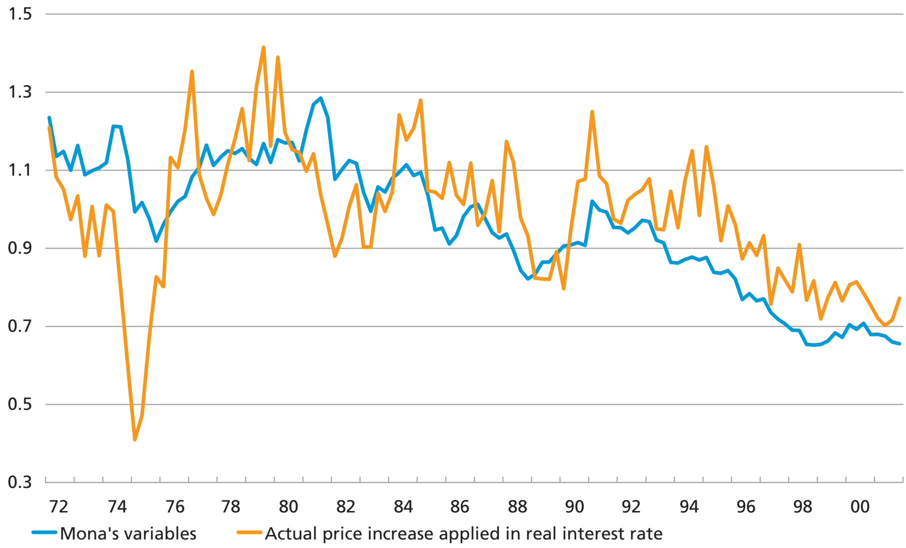
However, one of the variables applied is not immediately found in or derived from public statistics – capital costs. Here a simple Jorgenson user-cost expression is applied. It is called *cum* for machinery.

$$cum = \frac{1 - tax \cdot zmmask}{1 - tax} pipm \cdot ((1 - tax) \cdot ibz - dpyfbxe + 0.16) \tag{II.10}$$

tax is the tax rate, *pipm* the investment deflator, *ibz* the bond yield, *dpyfbxe* expected inflation, and *zmmask* the present value of tax depreciation.

The present value of tax depreciation is based on the declining-balance rule for equipment. With adaptations, this rule as been in force

CAPITAL COST RELATIVE TO WAGE COST Chart II.4.6



throughout the estimation period since the early 1970s. It is outside the scope of this publication to discuss the calculation of *zmmask,* but reference is made to Sørensen (1984).

One of the vague questions in relation to capital costs is how expected inflation is to be represented. Here expected inflation in the user-cost expression is half the year-on-year increase in a moving average of the deflator, *pyfbx*, for private non-farm gross value added. The inflation rate applied is thus both smoothed and down-weighted. This is in line with the construction of expected consumer-price inflation for the house-price relation, cf. the discussion in the section on housing.

The investment relation applies user cost over hourly wage cost, *cum/lnio*, corrected for linear trend in the estimation period. The detrended expression of relative factor cost is called *rlnim*, cf. Table II.4.2 with the regression result. The formulation of the inflation term is particularly important to the result of the estimation. In Chart II.4.6 the applied measure of relative factor prices is compared with an alternative measure where the real interest rate in user cost is based on the simple year-on-year increase in the gross value added deflator (GVA deflator) without smoothing.

It appears that the latter user cost is more volatile, particularly in the first half of the 1970s. The oil-price hikes at that time amplified the price increase of the value added, presumably without giving rise to expectations of an equivalent reduction in real interest rates in the following years, and at the same time the negative supply shock from oil prices

MARGINAL COST IN MONA Box II.4.1

With substitution elasticity of 0.67 we have the simple relation between relative factor input and relative factor price

$$\log\left(\frac{\text{labour}}{\text{capital}}\right) = 0.67 \cdot \log\left(\frac{\text{capital cost}}{\text{wages}}\right) \tag{1}$$

where we ignore the constant and trend. Relation (1) can be said to represent the optimum relative factor input. However, we can also rearrange (1) to express capital cost as a function of actual input of factors of production and actual wages. The result is the shadow price of capital. If the price of the capital input were its shadow price, the input of factors would be optimal and we would have an equilibrium.

We will now exploit the fact that when factor application is in equilibrium the average and the marginal costs are identical. This means that the marginal cost can be calculated by inserting the shadow price of capital in an expression of total unit price, cf. Thomsen (1995). Specifically, we substitute the shadow price derived from (1) for the capital cost in the Cobb-Douglas unit-cost formula

$$\log\ (\text{unit cost}) = 0.67 \cdot \log(\text{wages}) + 0.33 \cdot \log(\text{capital cost}) \tag{2}$$

and get

$$\text{marginal cost} = \frac{\text{wages}}{\left(\left(\frac{\text{capital}}{\text{labour}}\right)^{\frac{1}{0.67}}\right)^{0.33}} \tag{3}$$

The intuitive interpretation of (3) is that the marginal cost increases with labour input increases relative to the capital stock. As regards Mona's relations the use of a pure Cobb-Douglas relation is a misrepresentation. With substitution elasticity of 0.67 it is more correct to take the marginal-cost definition as the starting point

$$\text{marginal cost} = \frac{\text{wages}}{\text{marginal labour product}} \tag{4}$$

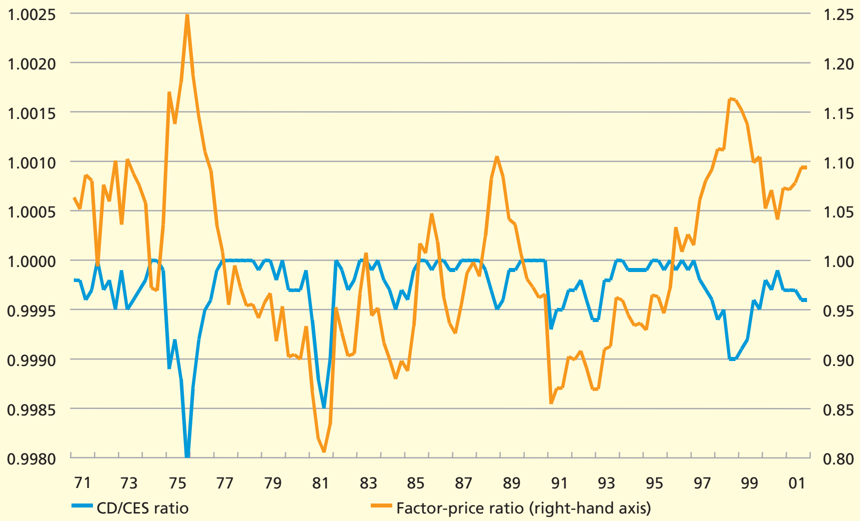
where the marginal labour product can be calculated for a CES function with substitution elasticity of 0.67. However, there is no significant difference between applying (3) and (4). The close approximation may be illustrated by assuming that for actual output and factor prices 1971-2001 capital and labour are determined by a CES function with 0.67 as substitution elasticity, so that (4) yields the correct result per assumption. The development in the ratio of the marginal cost, cf. (3) and (4), the CD/CES ratio is shown in the Chart along with the relative factor-price ratio wages/capital cost. The factor-price ratio is detrended by removing anysimple exponential trend, equivalent to the model variable *rlnim* being similarly detrended.

It is seen that the CD marginal cost always declines in relation to the CES marginal cost, irrespective of whether labour becomes relatively more expensive or cheaper. This reflects that higher substitution elasticity means more efficient adaptation. The point of the Chart is that the deviation in results between the applied (3)

CONTINUED Box II.4.1

and formally correct (4) is negligible. The greatest deviation is 0.02 per cent in 1975, when the factor-price ratio deviates most from the average. This is overshadowed by the general uncertainty as to choice of functional forms and compilation of variables. In general, we may use the approximation suggested, also if substitution elasticity was even lower than 0.67, e.g. 0.33

MARGINAL COSTS, APPROXIMATION ERRORS



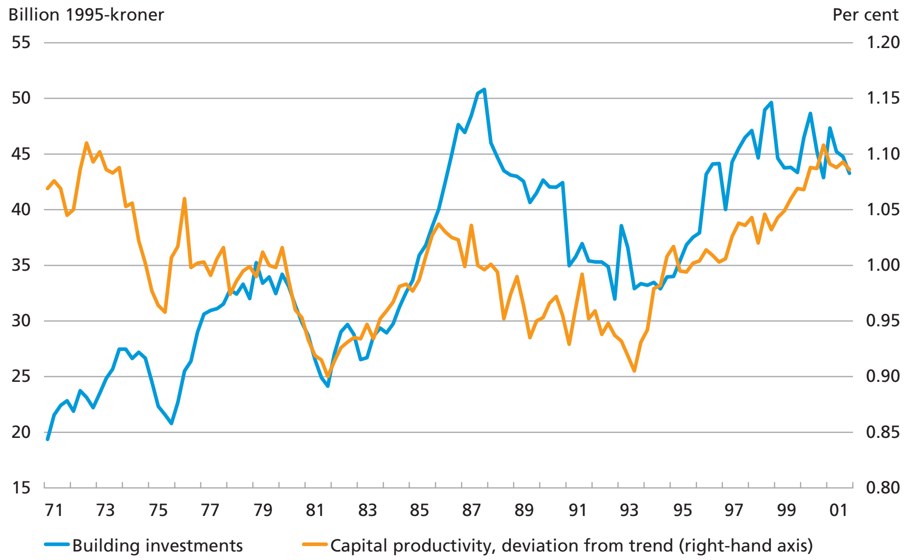
Note: The factor-price ratio is scaled so that the average for the period 1971-2001 is one.

dampened investments. If the real interest rate in user cost is based on the simple year-on-year increase in the GVA deflator, the relative factor price variable becomes insignificant in the investment relation, even if the first half of the 1970s is excluded from the estimation period.

Derived production cost

In addition to describing employment and investment the estimated relations are the basis for formulating costs and capacity measures. In particular it should be noted that the marginal unit cost is applied in the price formation, cf. below on price relations. Within the framework of the two-factor model constructed, the marginal cost is hourly wages divided by the marginal labour product. As mentioned, we apply a simple loglinear formulation of the factor model, and Box II.4.1 shows how the marginal cost is derived on that basis.

BUILDING INVESTMENTS AND DETRENDED CAPITAL PRODUCTIVITY Chart II.4.7



Building investments

Building investments typically involve a considerable planning period and therefore react even more slowly to cyclical impacts than machinery investments. This does not necessarily mean that building investments fluctuate less than machinery investments. The building stock is large in comparison with building investments, and consequently investments react relatively strongly to e.g. a wanted 1-per-cent increase in the capital stock.

The investment relation for buildings is very similar to that for machinery. The wanted building stock is to a large extent determined by output and also affected by relative factor prices. The correlation with output entails a positive correlation between the output/building stock ratio on the one hand and building investments on the other hand, cf. Chart II.4.7.

In addition, an increase in capital costs over wages reduces the building stock relative to output, just as higher capital costs reduce the use of machinery. The difference is that the building stock is not included in the employment relation, so this part of the capital stock does not affect labour productivity.

There is no significant autocorrelation in the relation's residuals, cf. Table II.4.3. Unlike machinery investments, building investments include one outlier observation in the 1st quarter of 1991. This is no major problem. If a dummy is inserted to remove this observation, the Jarque-Bera statistic drops below 1 without any major changes in the coefficients.

BUILDING INVESTMENTS			Table II.4.3
Variable	Name	Coefficient	t value
Change in capital stock	$\Delta\log(kb)$		
Change in capital stock	$\Delta\log(kb_{-1})$	0.8037	21.3
Capital/output ratio	$\log(kb_{-1}/fyfbx_{-1})$	-0.0041	4.0
Factor price ratio	$\log(rlnib_{-2})$	-0.0007	3.4
Constant		0.0043	4.5

T = 1971:3 – 1997:4	DW = 3.003	AR(1) = 0.000	Se = 0.0004
R^2 = 0.9273	JB = 5.534	AR(4) = 0.788	

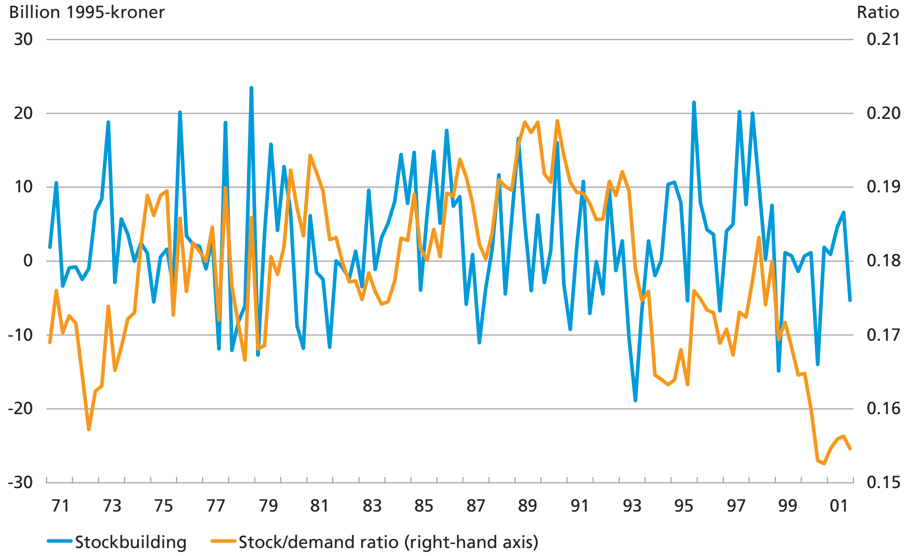
Note: Estimated by OLS. The restriction of long-term output elasticity to 1 is accepted with an F value of 1.0, F(1.101).

Stockbuilding

Stockbuilding reacts to the ratio of inventories to demand. If this ratio is low, stockbuilding is stimulated; if the ratio is high, stockbuilding diminishes. This resembles the activity impact on the stock of machinery or buildings. The correlation is illustrated in Chart II.4.8. It is noted that the stock/demand ratio has been declining in recent years. An equivalent tendency in other countries is sometimes related to technological advances in respect of stock registration and management.

No official stock figures are available. The series applied is created as cumulated stockbuilding plus a constant that removes the trend in the stock/demand ratio over the entire estimation period. The stock relation concerns private non-farm stocks excluding energy stocks.

STOCKBUILDING AND STOCK/DEMAND RATIO — Chart II.4.8



STOCKBUILDING			Table II.4.4
Variable	Name	Coefficient	t value
Stockbuilding/demand	$filbx/demand_{-1}$		
Change in demand	$\Delta(demand)/demand_{-1}$	-0.2864	5.7
Change in employment	$\Delta\log(qbyx_{-1})$	0.6400	4.6
Stock/demand	$0{,}01\cdot\log(stock_{-1}/demand_{-1})$	-5.3823	2.5
Constant	0,001	-85.9256	2.3

T = 1971:3 – 1997:4	DW = 1.743	AR(1) = 2.149	Se = 0.0111
R^2 = 0.4033	JB = 1.866	AR(4) = 6.009	

Note: The relation is estimated by OLS. The long-term restriction of the demand elasticity to 1 is easily accepted with an F value of 0.0. The construction of the stock series envisages elasticity of 1.

The demand expression applied corresponds to private non-farm output plus imports less stockbuilding. In other words, increased demand can be satisfied in three ways: a rise in output, an expansion of imports or depletion of stocks.

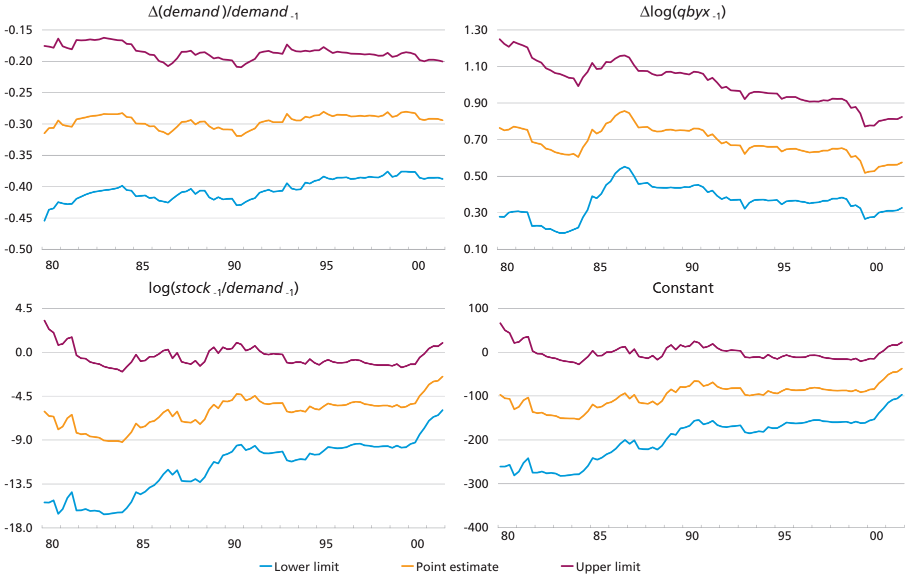
The latter reaction, i.e. depletion of stocks, is restricted to demand for goods. Services are not stocked. Moreover, it is a clear short-term effect, which will relatively soon be supplemented and replaced by import and output reactions. Normally only a small part of the short-term stock reaction can be observed in annual data.

The quarterly changes in output do not correlate perfectly with changes in the demand expression, and on the existing data we estimate a relation for stockbuilding where increased demand reduces stocks in the quarter when the increase occurs.

This effect, whereby stocks are used as a buffer, tends to smooth output relative to demand. It should, however, be added that the fact that changes in output correlate only partially with changes in demand does not necessarily mean that output varies less than demand. The quarterly national-accounts stock movements are only based on actual primary statistics from 1987, and in the period from 1987 until now the dispersion of changes in output and demand is more or less the same. In some quarters the fluctuation in output even seems to be boosted by stockbuilding, so the output-smoothing role of stockbuilding is dubious. This is neither a new nor a specifically Danish observation. According to the overview in Maccini (1992) it is well-known that this role is not always dominant.

The last explanatory variable is the development in employment. A part-result of analysing factor demand in Kristensen and Knudsen (1999) was that increased employment boosts output in the subsequent quarter. This effect is captured in the model in that changes in employment

RECURSIVE ESTIMATION, STOCKBUILDING Chart II.4.9



affect stockbuilding. A simple interpretation is that increased employment augments the volume of goods in processing, and goods in processing are included in the stock variable.

It can also be envisaged that the desired stock/demand ratio may be affected by interest rates, which affect the stock-related costs, but this interest-rate sensitivity is neither seen in data nor included in the relation. The result of the estimation for stockbuilding is shown in Table II.4.4.

There are no major problems in terms of autocorrelation or outliers, cf. the associated test statistics. The coefficient for the change in demand entails that just under 29 per cent of an increase in the demand expression *demand* is taken from stocks in the same quarter.

Recursive estimation indicates that the rate of adaptation to the wanted stock level is changing, cf. Chart II.4.9, which might be related to the change in the stock/demand ratio over recent years.

IMPORTS 5

Imports largely follow demand, particularly when the demand categories are weighted by import content, with a large weight attributed to e.g. machinery investments and a smaller weight attributed to private and public consumption with its content of services. In addition to demand, imports depend on the ratio of domestic prices to import prices.

This is analogous to e.g. the sensitivity of industrial exports to relative wages. However, the content of commodities and other goods without obvious Danish substitutes, e.g. cars, in imports reduces the price sensitivity of imports, and imports are clearly less important than exports for the model's reaction to competitiveness.

While price sensitivity is lower for imports than for exports, the direct capacity effect on imports is relatively strong. This effect is generated in that the short-term demand elasticity of the import relation is greater than one, and a capacity-utilisation expression is included.

While import volumes are primarily determined by domestic demand, import prices are to a greater extent determined externally. In the model they are, however, not entirely exogenous, but affected a little by the domestic price level, cf. the well-established pricing-to-the-market effect described in Krugman (1987).

Imports of goods are broken down into three components 1) ships and aeroplanes, 2) energy, and 3) other imports. Relations have been estimated for 2) and 3). We will concentrate on 3), which comprises 90 per cent of imports of goods. Volume and price relations have been estimated separately.

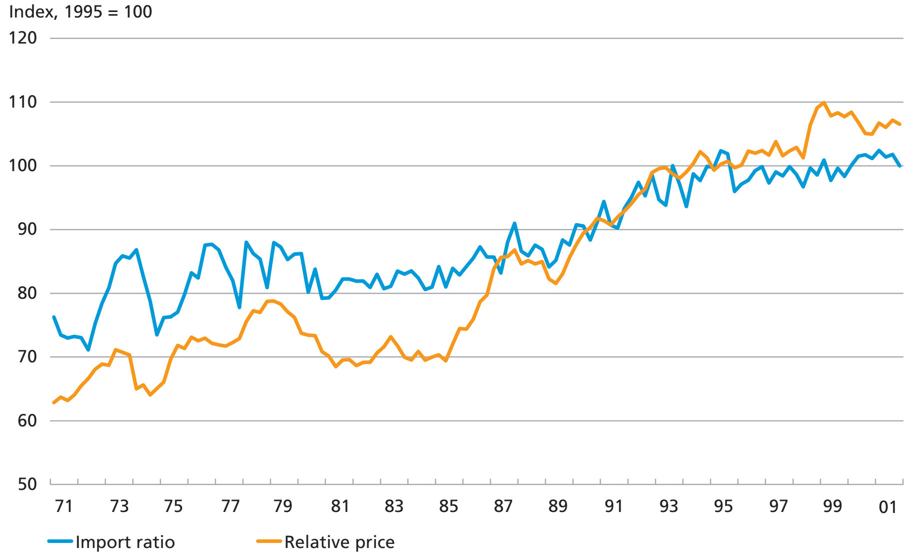
Imports of goods, volume

Demand is the key import determinant. In the model the demand for imports is calculated as the demand components weighted together with their average import content in 1995 taken from the input-output table, i.e. the applied demand variable is standardised. The ratio of imports to the demand variable is the standardised import share. The import share is normally increasing, which could reflect a general trend towards increased division of labour. The import share is shown in Chart II.5.1.

The immediate reaction of imports to demand can be illustrated by comparing the year-on-year increases in imports and demand. There is clear positive correlation and also a tendency for imports to react more strongly than demand, in percentage terms. This illustrates that short-term demand elasticity is greater than one. In other words, the marginal import share is higher than the average share, and together with the short-term stock reaction described in the preceding section this dampens the immediate output reaction to changes in demand. The increases in demand and exports are shown in Chart II.5.2.

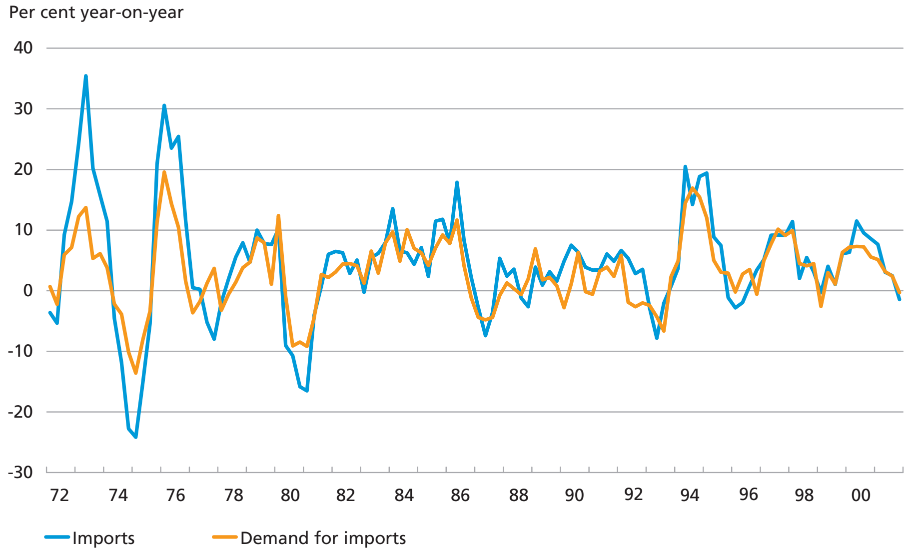
Imported goods compete with similar goods manufactured in Denmark. Competition is fiercest for uniform products, but even commodities not found in Denmark can in principle compete with input of Danish factors of production, e.g. labour, if there is a substitution possibility

STANDARDISED IMPORT SHARE AND RELATIVE PRICE Chart II.5.1



in the production process. Basically the distribution of consumption of Danish goods and consumption of imported goods depends on the price of imports relative to the price of Danish value added. The price of domestic value added may be represented by e.g. marginal wage costs.

CHANGE IN IMPORTS AND DEMAND FOR IMPORTS OVER THE PRECEDING YEAR Chart II.5.2



There is some positive correlation between the standardised import share and a relative price measured as marginal wage cost relative to import price, cf. Chart II.5.1. In this Chart we must disregard the part of the correlation which just reflects growing trends in both series. The import relation is estimated with an unrestricted trend to capture the effect of increased division of labour, and it is impossible to identify any effect of different trends in the import price and domestic price.

As we did on the export side, we can summarise the illustrated correlations in a simple long-term relation with demand and relative price

$$\log\left(\frac{\text{imports}}{\text{weighted demand}}\right) = -b \cdot \log\left(\frac{\text{import price}}{\text{Danish cost}}\right) + c \cdot \text{trend} \qquad \textbf{(II.11)}$$

where the parameter -b is price elasticity. Use of the import share in the long-term relation implies that in the long-term price elasticity from demand to imports is tied to one, so the long-term increase in the import share is carried by the exogenous trend. Thus the trend includes a standard effect of increasing division of labour. As indicated above, the trend also captures other factors than division of labour, e.g. a special trend in wage costs for the product segments which compete most with imports. This cannot be isolated and identified, but that is not a problem here.

In addition to the long-term import relation there is a special short-term impact of capacity utilisation on imports. As mentioned in the section on investments and employment, it seems that not only employment reacts and increases when output is high in relation to factor input. Output reacts by declining. This capacity-related output reaction may in principle be attributable to several factors. One mechanism is that imports go up if output has become too large in relation to factor input. We therefore apply the residual from the production function as the capacity measure in the import relation. The production relation thus also contributes to explaining imports.

The estimated import relation is shown in Table II.5.1.

There are no problems with outliers, but there seems to be some autocorrelation in the relation's residuals. From quarter to quarter the autocorrelation is negative, which may reflect a measurement problem in that e.g. machinery imports and associated machinery investments are not always registered in the same quarter.

In spite of the autocorrelation we have chosen not to introduce more complex dynamics in the relation. Complex dynamics are difficult to interpret when the model is applied.

The estimation method chosen is complicated in so far as both instrumental variables estimation and non-linear estimation are applied. Non-

IMPORT VOLUME			Table II.5.1
Variable	Name	Coefficient	t value
Change in imports of goods	$\Delta\log(fmvx)$		
Demand change	$\Delta\log(xfmvx - 0.2443 \cdot filbx)$	1.9780	5.4
Change in relative price	$\Delta\log((pmvx + tmvx)/mulc)$	-0.3227	1.8
Import share	$\log(fmvx_{-1}/xfmvx_{-1})$	-0.5319	5.3
Import price/cost	$\log((pmvx_{-1} + tmvx_{-1})/mulc_{-1})$	-0.2678	3.9
Capacity measure	a)	0.5512	3.0
Trend	0.001·trend	-6.0905	2.8
Constant		12.0692	2.8

T = 1974:1 – 1997:4	DW = 2.244	AR(1) = 5.304	Se = 0.0302
R^2 = 0.4613	JB = 0.259	AR(4) = 9.417	

Note: a) $\log(fyfbx_{-1}) - 0.33 \cdot \log(km_{-1}) - 0.67 \cdot \log(qbyx_{-1})$.
The estimation is done by iterating between IV estimation using $\Delta\log(xfmvx - 0.2443 \cdot filbx)$ as the endogenous right-hand variable and non-linear estimation of the coefficient for *filbx* in $\Delta\log(xfmvx - 0.2443 \cdot filbx)$. The instruments are three lagged changes $\Delta\log(xfmvxk_{-1})$, $\Delta\log(fmvx_{-1})$ and $\Delta\log(xfmvx_{-1})$. The identifying restrictions are accepted with a test statistic of 3.57 which is $\chi^2(2)$ distributed.
The non-linear parameter in the demand change is estimated at 0.2443 with a t value of 10.1.

linear estimation concerns the coefficient for stockbuilding in the change in demand, cf. the expression for this term in Table II.5.1. The estimated coefficient implies that the marginal import content in stockbuilding is 0.24 against an average of 0.48.

Imported goods are often stocked, so the import content of stockbuilding is normally relatively large, cf. the average ratio of 0.48. A relatively high coefficient of 0.48 suggests that diminishing stocks will immediately lower imports. Diminishing stocks may, however, reflect that unexpected growth in demand has been met by stock depletion. In that case imports are not likely to fall, but rather to expand in the same quarter in response to the increased demand. Short-term dynamics thus entail that imports and stockbuilding may fluctuate in opposite directions, and the marginal import reaction to stockbuilding must be relatively low to permit this adaptation pattern.

The use of IV estimation is motivated by measurement problems with the demand variable. The role of stockbuilding does not constitute a special problem. It is rather a case of general measurement problems as in the employment relation, cf. the section on this relation. In the employment relation instruments were applied to avoid underestimating short-term elasticity between output and labour. For the import relation we want to avoid underestimating short-term elasticity between demand and imports.

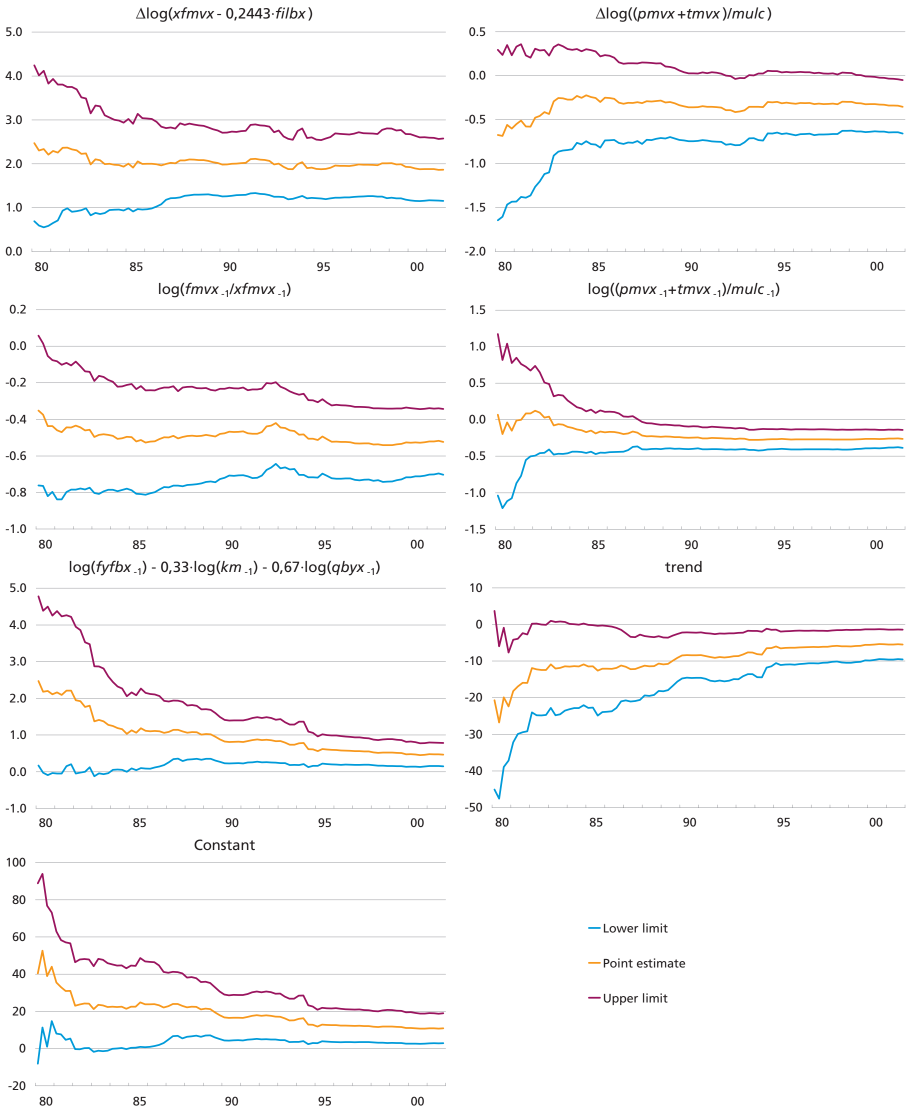
The instruments applied are the lagged changes in imports and the demand for imports, and the instruments are accepted according to the so-called Sargan test, cf. the note in Table II.5.1. The Sargan test cannot rule out that the estimated relation is a linear combination of reduced equations for changes in imports and demand, respectively.

Since the coefficient for stockbuilding in the change in demand should be estimated simultaneously with the rest of the relation, we iterate between non-linear estimation and IV estimation, until the estimates converge.

In the estimated equation short-term elasticity with respect to demand is 1.98 so the marginal import share is higher than the average share. This gives imports the expected buffer function. Without IV estimation

RECURSIVE ESTIMATION OF IMPORT VOLUME

Chart II.5.3



short-term elasticity to demand would be relatively close to 1. Long-term price elasticity is approximately -0.5 (-0.2678/0.5319), and the associated adaptation seems to be fairly rapid since 53 per cent of the deviation from wanted imports is removed every quarter.

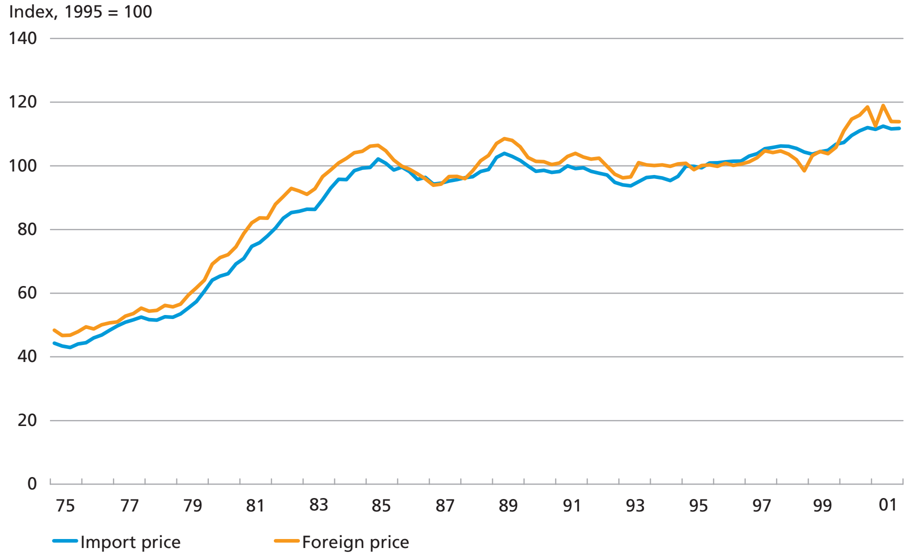
The coefficient for the linear trend is negative in the equation. The import share shows an increasing trend, but the estimated trend is not only capturing the trend of the import share, but also adjusting the impact of the explanatory variables, including offsetting the trends in the marginal unit costs and the production function. The parameter estimates are relatively stable, cf. Chart II.5.3.

Imports of goods, price

Import prices are foreign exporters' prices in Denmark, and the predominant explanatory factor for a Danish import price is the foreign price in Danish kroner. The foreign price index applied is calculated as a weighted average of the export prices of 17 countries, weighted according to their proportion of Danish imports. Chart II.5.4 shows import price and foreign price. There is a general trend for prices of internationally traded goods to flatten from the mid-1980s.

Another factor – in addition to the impact of the price level abroad – is that foreign exporters take Danish circumstances into consideration when pricing in Denmark. The effect of domestic prices on import prices is presumably greater for larger economies, but the effect also contributes to the formation of Danish import prices, cf. Kongsted (2003). A

IMPORT PRICE AND FOREIGN PRICE — Chart II.5.4



IMPORT PRICE, LONG-TERM RELATION			Table II.5.2
Variable	Name	Coefficient	t value
Import price	log*(pmvx)*		
Foreign price	log*(pmudl/efkrks*)	0.8639	31.2
Marginal unit labour costs	log*(mulc)*	0.1361	4.9
Trend	0.001·trend	-0.1626	0.2
Constant		4.4166	3.4

T = 1975:1 – 1997:4 DW = 0.445 ADF = 3.372 Se = 0.0187
R^2 = 0.9958

Note: Estimated by OLS.

simple example is that the high car taxes in Denmark have moderated the import price of cars.

The long-term relation for the import price is

$$\log(\text{import price}) = a \cdot \log(\text{foreign price}) + (1-a) \cdot \log(\text{Danish price}) + \text{trend} \tag{II.12}$$

The relation is homogeneous so that a proportional increase in foreign and domestic prices leads to an equivalent increase in the import price. Tables II.5.2 and II.5.3 show the result of the estimation for the dynamic equation for import prices.

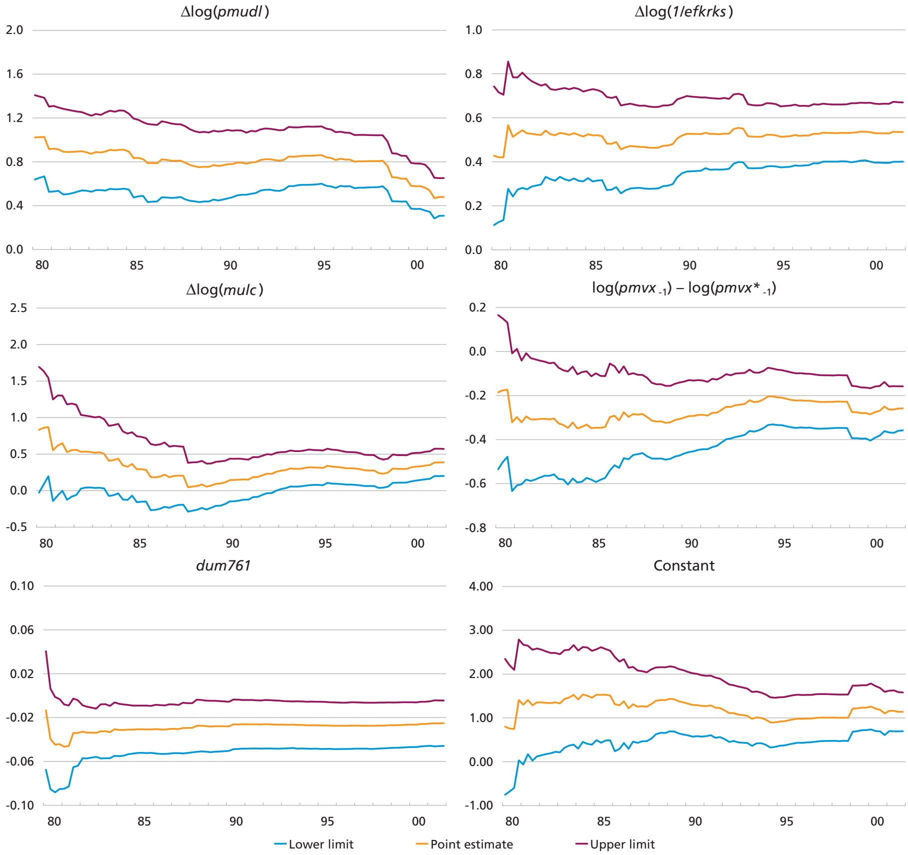
Changes in the foreign price are reflected slightly faster than changes in exchange rates, and the short-term impact of Danish costs is higher than the long-term impact, cf. the short-term coefficient of 0.2760 and the long-term coefficient of 0.1361. The tests indicate that the distribution of the residuals is not completely random. For instance, there is a

IMPORT PRICE			Table II.5.3
Variable	Name	Coefficient	t value
Change in import price	Δlog(*pmvx*)		
Change in foreign price	Δlog(*pmudl*)	0.8057	11.6
Change in foreign currency	Δlog(1/*efkrks*)	0.5311	8.0
Change in marginal cost	Δlog(*mulc*)	0.2760	2.5
Error-correction term	$\log(pmvx_{-1}) - \log(pmvx^*_{-1})$	-0.2286	3.7
Dummy	*dum761*	-0.0265	2.5
Constant		1.0087	3.7

T = 1975:2 – 1997:4 DW = 2.223 AR(1) = 1.801 Se = 0.0101
R^2 = 0.7164 JB = 4.436 AR(4) = 5.328

Note: Estimated by OLS. In the error-correction term $\log(pmvx^*_{-1}) = 0.8639 \cdot \log(pmud_{-1}l/efkrks_{-1}) + 0,1361 \cdot \log(mulc_{-1}) - 0.1626 \cdot 0.001$ trend, cf. Table II.5.2.

RECURSIVE ESTIMATION OF IMPORT PRICE Chart II.5.5



tendency towards skewness, but the deviation from the normal distribution is not significant. Recursive estimation shows that the coefficient for the foreign price change becomes lower when the latest observations are included, cf. Chart II.5.5.

Imports of energy products

Imports of energy products are treated *per se* and also endogenised in terms of price and volume. The volume relation models energy imports plus Danish energy extraction as a function of a demand expression and a relative price term: the price of energy imports relative to wage costs.

In the demand expression applied the demand components have weights reflecting the direct and indirect content of both imported energy products and Danish oil and gas from the North Sea. When imports and energy extraction are substitutes, imports decline if North Sea output increases for a given demand level. In principle output from en-

ENERGY IMPORTS			Table II.5.4
Variable	Name	Coefficient	t value
Change in import ratio	$\Delta\log(fmbrak/xfmbra)$		
Change in import ratio	$\Delta\log(fmbrak_{-1}/xfmbra_{-1})$	-0.2710	2.8
Import ratio for fuel	$\log(fmbrak_{-1}/xfmbra_{-1})$	-0.4938	4.4
Import price/wage cost	$\log(ter_{-1}\cdot(pmbra_{-1} + tmbra_{-1})/lnio_{-1})$	-0.0454	1.5
Trend	$0.001\cdot$trend	-12.9899	4.3
Constant		25.9127	4.3

T = 1971:3 – 1997:4	DW = 2.098	AR(1) = 2.344	Se = 0.0576
R^2 = 0.3899	JB = 1.006	AR(4) = 5.167	

Note: Estimated by OLS.

ergy extraction thus functions as a commodity which can be sold in random volumes at a given price.

Specifically, the relative price expression applies the import price plus an expression of Danish taxes on energy, which have affected energy consumption. The price elasticity may be difficult to measure. Substitution is possible, but the substitution process is slower as for many manufactured goods. The result of the estimation for imports of energy products is shown in Table II.5.4.

The relation's residuals seem to be random according to the tests for autocorrelation and outliers/skewness. Long-term price elasticity is modest, -0.1 (-0.0454/0.4938) and scarcely significant. The negative trend captures e.g. a number of energy-saving measures over the sample, which starts in the early 1970s.

The import price is determined as a function of the price of crude oil and foreign wages, both in Danish kroner. The result of the estimation is shown in Table II.5.5.

PRICE OF ENERGY IMPORTS			Table II.5.5
Variable	Name	Coefficient	t value
Change in import price	$\Delta\log(pmbra)$		
Change in import price	$\Delta\log(pmbra_{-1})$	0.1654	3.7
Change in crude-oil price	$\Delta\log(praoli\cdot eusd)$	0.5388	16.0
Import price for fuel	$\log(pmbra_{-1})$	-0.4363	6.6
Crude-oil price in Danish kroner	$\log(praoli_{-1}\cdot eusd_{-1})$	0.3904	6.6
Foreign wages in kroner	$\log(lonudl_{-1}/efkrks_{-1})$	0.0460	4.2
Constant		-1.6217	6.5

T = 1974:2 – 1997:4	DW = 1.892	AR(1) = 0.700	Se = 0.0403
R^2 = 0.7909	JB = 4.517	AR(4) = 4.583	

Note: Estimated by restricted OLS. The homogeneity restriction on price levels is accepted with a test value of 1.87, which is F(1.89).

There is no significant autocorrelation, but the JB statistic indicates a tendency towards outliers, although it does not become significant at the 5-per-cent level. The coefficients show that the price of Denmark's energy imports mainly reflects the price of crude oil and to a lesser degree foreign wages. Naturally the price of crude oil does not account for 100 per cent, since Denmark also imports e.g. coal and electricity. No special index of the market prices of these products has been included.

The volume and price relations for imports of energy products are simple macro relations, and a considerable dispersion is seen in the residuals of both relations.

LABOUR MARKET 6

Wage formation is an important element of the equilibrium mechanism in a small, open economy. At a high level of activity unemployment falls, wages accelerate, and competitiveness declines. This means loss of market shares, and unemployment goes up again.

Since Denmark pursues a fixed-exchange-rate policy, wage development cannot deviate permanently from that of the euro area, and thus not from a level of wage increase which ensures that consumer-price inflation does not exceed 2 per cent. Specifically, the impact of competition means that in a steady state the model generates Danish wage increases in line with foreign wage increases.

In relation to a steady-state solution the wage relation determines the level of unemployment required to stabilise wage increases at the foreign level. In economic theory it is often argued that the Phillips curve is vertical in the long run. In that case the rate of steady-state wage increase is irrelevant. With a vertical Phillips curve the rate of unemployment would be precisely that which, for a given replacement rate of unemployment benefits, implies an unchanged rate of wage increase, i.e. ensures stable wage development without acceleration or deceleration.

However, we have not estimated a vertical Phillips curve, which is characterised by a one-to-one impact from price increases to wage increases. The estimated pass-through from price increases is less than one-to-one, so Mona's Phillips curve is not vertical, but downward sloping. With a sloping Phillips curve a lower rate of unemployment can formally be achieved by accepting a higher rate of inflation.

However, if the rate of inflation in Denmark is to deviate permanently from that of the euro area, the fixed-exchange-rate policy must be abandoned. That regime change would make it dubious whether lower unemployment could be achieved. Presumably the wage relation would change if we tried to utilise it. If expected inflation today is fairly constant at e.g. 2 per cent irrespective of actual increases in Danish prices, this may merely reflect the inflation target of the euro area. If the official exchange-rate policy entailed depreciation by 2 per cent per annum vis-à-vis the euro, expected inflation could easily rise from 2 to 4 per cent.

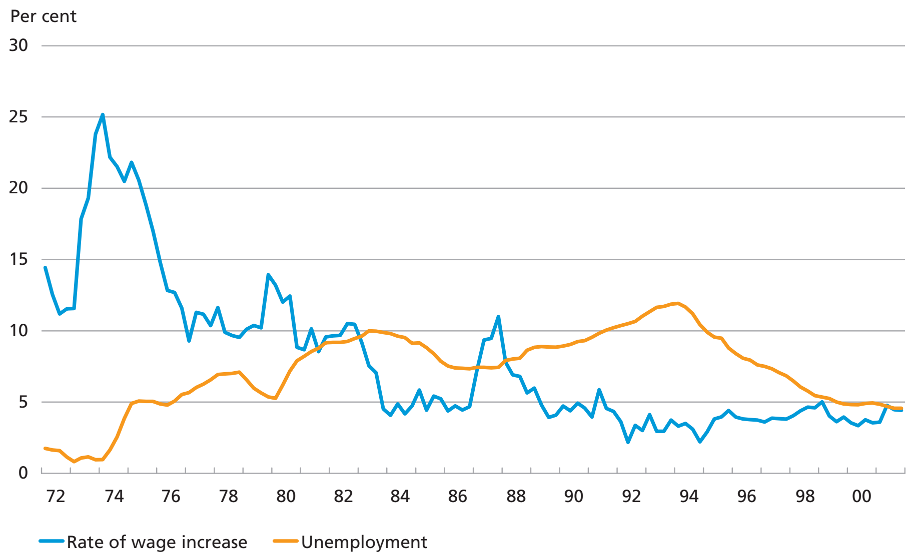
The business cycle does not only affect wages, but also the participation rate. A boom thereby stimulates both the price and supply of labour. Specifically, in the short run the labour force partly reflects changes in employment. As a result, unemployment changes less than employment, which has a delaying effect on wage formation.

We will look at the wage relation and then the relation for the participation rate.

The wage relation

The index of hourly earnings of industrial employees is endogenised in an augmented Phillips-curve relation, which *inter alia* captures the inverse correlation between unemployment and the rate of wage increase, cf. Chart II.6.1. The negative correlation can be seen in the Chart, but it is not a strong correlation. Unemployment was low until well into 1974, and large wage increases were seen after the first oil-price hike in 1973, partly as a result of a general cost-of-living clause in the wage agreements. The extreme observations on wage increases and unemployment at the start of the sample still affect the result of the estima-

ANNUAL RATE OF WAGE INCREASE AND UNEMPLOYMENT Chart II.6.1



tion, but the correlation has undoubtedly changed since the 1970s. In any case it seems unlikely that we should experience wage increases in the range of 25 per cent again. Since 1994 Danish unemployment has been falling significantly without any surge in wages.

Part of the explanation of the low rate of wage increase in the 1990s could be that labour-market policy has changed the composition of registered unemployment. Retirement schemes have removed groups with modest influence on wage formation. In principle the unemployment composition could be maintained by including those receiving e.g. early retirement benefits in the unemployment variable. However, there is no easy way to avoid breaks in the wage relation, and we must accept breaks or drift in the parameters. Specifically, when making projections we must extend the negative residuals in the wage relation in recent years into the projection period. This corresponds to inserting a break in the constant term, adjusting for e.g. poor representation of inflation expectations.

In the original Phillips curve, Phillips (1958), the rate of wage increase was explained by the rate of unemployment only. The simple interpretation is that the difference between supplied and employed labour drives the price of labour. In subsequent studies of wage formation the Phillips curve was soon augmented with other explanatory variables, e.g. the rate of inflation. A higher rate of price increase naturally leads to a demand for higher nominal increases in hourly wages, possibly with some delay.

In addition to the unemployment rate and rate of price increase, the development in the index of hourly wages is affected by changes in the working year. Normally a collective agreement on a reduction in working hours includes a compensational increase in hourly wages, whereby shorter working hours initially increase hourly wages. In the long term the degree of pass-through from working hours is more uncertain.

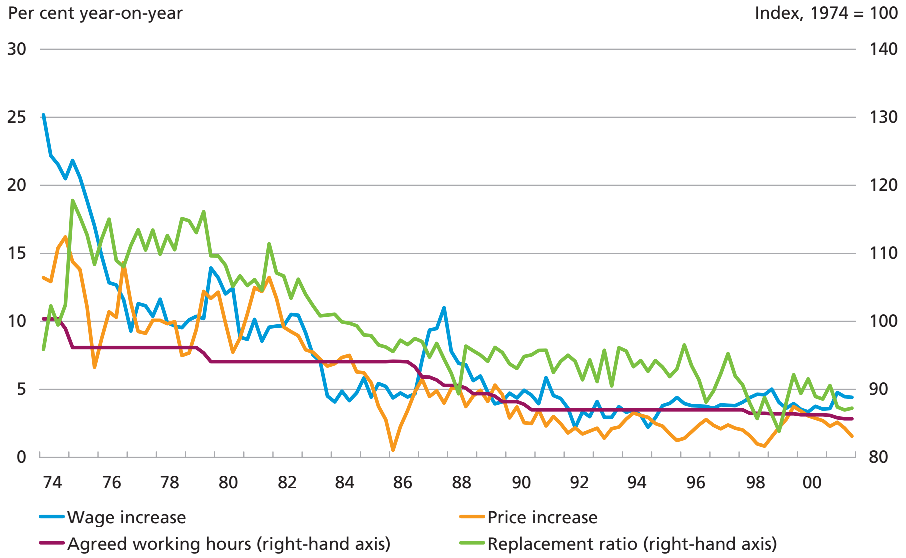
In addition the degree of compensation impacts on unemployment, so we also include the replacement ratio of unemployment benefits. The falling trend in this ratio and in the price-increase rate helps to explain the declining trend in the rate of wage increase from the first half of the 1970s until now. The impact of the replacement ratio can be seen as the effect from the reservation wage. The higher the benefit, the higher the required wages.

In Chart II.6.2 the rate of wage increase is shown together with consumer prices, as well as the index of working hours and the replacement ratio.

Finally the wage relation includes the difference between the rate of increase in respectively producer and consumer prices. This reflects that

ANNUAL RATE OF WAGE INCREASE, INFLATION, WORKING HOURS AND REPLACEMENT RATIO

Chart II.6.2



good sales prices may lead to employees being offered higher wages. There is no general theoretical framework for wage formation in the model. We determine wages in the following relation where lags are not specified

$$\begin{aligned}\Delta\log(\text{hourly wages}) = \;& a_1 \cdot \Delta\log(\text{consumer price}) + a_2 \cdot \Delta\log\left(\frac{\text{producer price}}{\text{consumer price}}\right) \\ & - a_3 \cdot \Delta\log(\text{working hours}) - a_4 \frac{\text{unemployment}}{\text{labour force}} \\ & + a_5 \frac{\text{unemployment benefit}}{\text{wages}} + \text{constant}\end{aligned} \tag{II.13}$$

All a's are positive, and if a_1 is 1, the Phillips curve is vertical. The choice of an augmented Phillips-curve relation of this kind is partially confirmed by multivariate analysis in Hansen (1998).

There is no clear consensus as to what should be included in a wage relation, but at least the elements in (II.13) appear in other wage relations as well. A discussion of wage development in Denmark in recent years and a wage relation on Danish annual data are found in Chapter III of DØR (2002), which e.g. applies filtered unemployment to represent structural unemployment.

Note that the wage level is not included on the right-hand side in (II.13), so the wage level cannot be determined on the basis of the wage relation alone. Indirectly the wage level is represented in the relation when the relation is inserted in the model, since employment, and thus

WAGE RELATION			Table II.6.1
Variable	Name	Coefficient	t value
Change in hourly wages	$\Delta\log(lna)$		
Change in consumer price	$\Delta\log(pcp_{-2}) + \Delta\log(pcp_{-3})$	0.1701	3.2
Change in relative price	$\Delta\log(pyfbx_{-3}/pcp_{-3})$	0.0849	2.0
Unemployment ratio	ul_{-1}/u_{-1}	-0.2374	6.4
Change in working hours	$\Delta\log(maxtid2)$	-0.6805	4.2
Replacement ratio	$\log(komp_{1})$	0.0217	1.6
Constant		0.0435	4.7

T = 1974:1 – 1997:4	DW = 2.216	AR(1) = 1.293	Se = 0.0064
R^2 = 0.7319	JB = 1.300	AR(4) = 3.094	

Note: The relation is estimated by OLS. Relative price is producer price/consumer price.

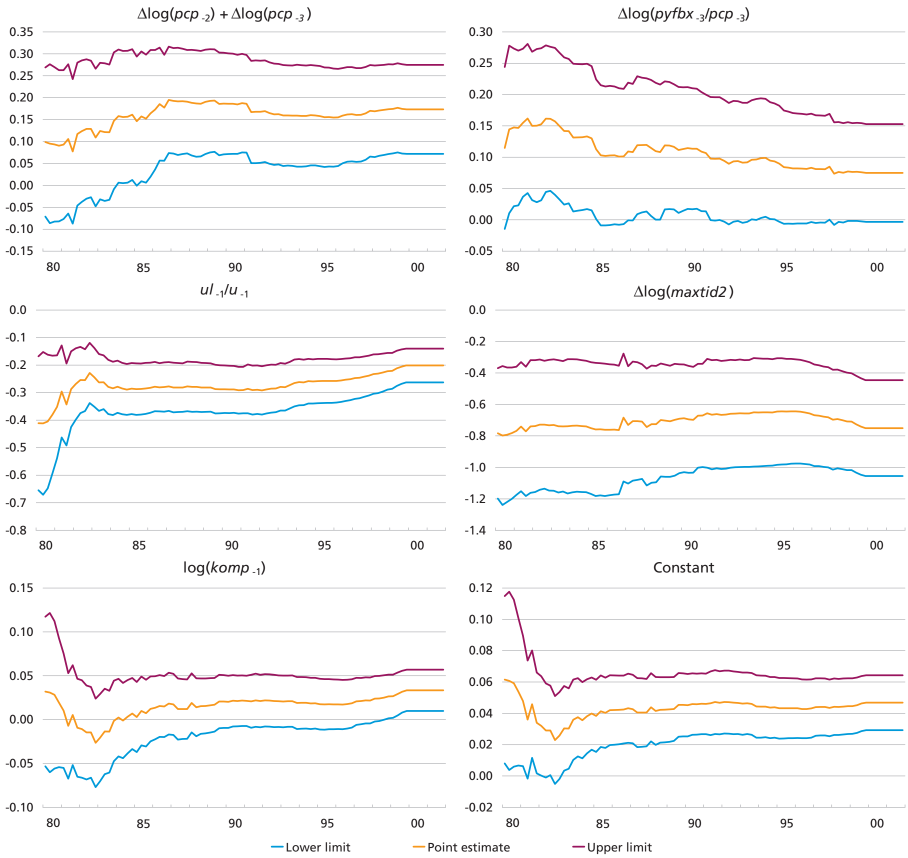
also unemployment, are affected by the ratio of Danish wages relative to those of other countries. This correlation with competitiveness means that the wage level can be determined within the entire model, cf. the section in Chapter IV on calculations on the entire model, where the wage reaction plays a central role. The estimated wage relation is illustrated in Table II.6.1.

The tests indicate no problems with autocorrelation or outliers.

We note that the coefficient for the rate of increase in the consumer price is 0.34 (2 times 0.1701). This is clearly below 1, so the Phillips curve is not vertical. In other words, the wage relation is not dynamically homogeneous. This apparently weak pass-through from prices to wages may, as stated in the introduction, reflect sluggishness in the formation of expectations. In a fixed-exchange-rate regime one would expect that a high rate of price increase in Denmark is followed by a low rate due to competition from the currency anchor. One would also expect that economic policy is aimed at preventing inflationary pressure with a view to such competition. Expected inflation is thus considerably more stable than actual inflation, and against this background it is natural to estimate a coefficient below 1 for the actual rate of price increase. For instance, a higher coefficient will be estimated for the rate of price increase if the price series is smoothed, cf. the discussion of expected inflation on Danish data in Knudsen (2002).

Another key correlation is the cyclical sensitivity of wage formation, whereby a 1-percentage-point rise in unemployment reduces the annual rate of wage increase by just under 1 per cent. A rise in the replacement ratio by 1 per cent augments the annual rate of wage increase by 0.09 per cent, and a 1-per-cent reduction in working hours increases the hourly wage by just over 2/3 per cent.

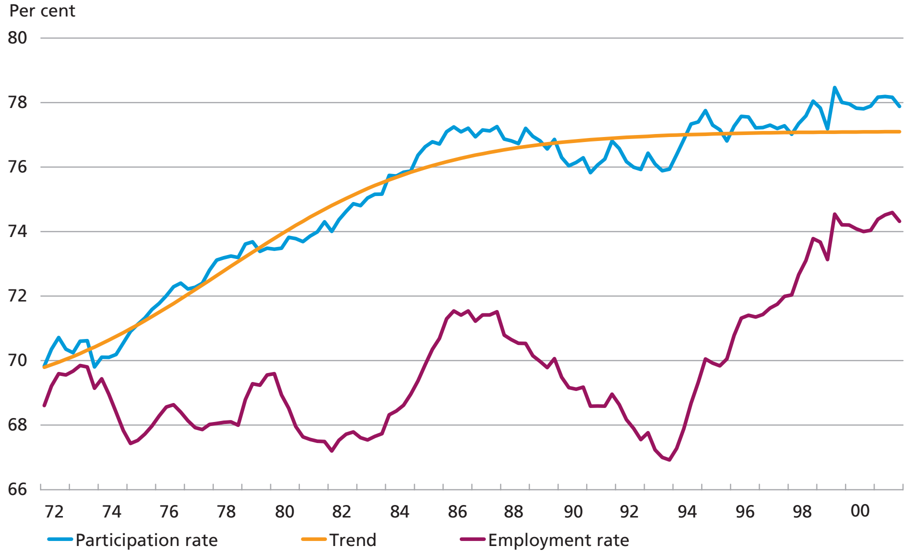
RECURSIVE ESTIMATION OF THE WAGE RELATION Chart II.6.3



As stated, the estimated wage relation affects the hourly wages of industrial employees. This wage index is used as the wage rate for all private-sector employees, equivalent to an unchanged private wage structure. In short-term forecasts the wages of public-sector employees and various transfer rates are usually exogenous. In more long-term projections and multiplier calculations public wages as well as unemployment benefits and transfer-income rates follow the wages of private-sector employees with a time lag.

Judging from recursive estimation of the wage relation there is no break in the relation immediately after 1994 when unemployment begins to decline without any strong reaction in wage increases. However, it is evident that e.g. the absolute value of the coefficient for the rate of unemployment declines when the end of the sample is rolled forward to 2001. At the same time the significance of e.g. the degree of compensation increases marginally, cf. Chart II.6.3.

PARTICIPATION AND EMPLOYMENT RATES Chart II.6.4



Participation rate

The participation rate increases over the estimation sample, which starts in the early 1970s. This increase reflects a higher participation rate among women, a development which began before the 1970s, so the average participation rate has increased even more relative to previous periods.

The participation rate has not followed a straight line over the sample, but rather a declining trend. This reflects that the participation rate of women in the labour market has now reached a point where it is similar to that of men. To describe this development we apply a logistic trend which will result in an s-curve bending towards a saturation point. Since the early 1970s the participation rate has followed this kind of curve.

The participation rate is the labour force as a ratio of the population of working age. The labour force is usually defined as those in employment plus the unemployed, but here we have applied a gross concept for the labour force, including early retirees, leave-takers and those comprised by training-oriented labour-market-policy schemes. There is nothing wrong with the usual definition of the labour force, but a gross labour force, compiled as described, is more stable in connection with the introduction of the schemes mentioned and thus easier to use in the estimation.

The logistic trend applied to explain the participation rate is estimated to flatten out during the 1990s, cf. Chart II.6.4, showing the estimated logistic trend along with the participation and employment rates. The

CORRELATION BETWEEN EMPLOYMENT AND LABOUR FORCE Chart II.6.5

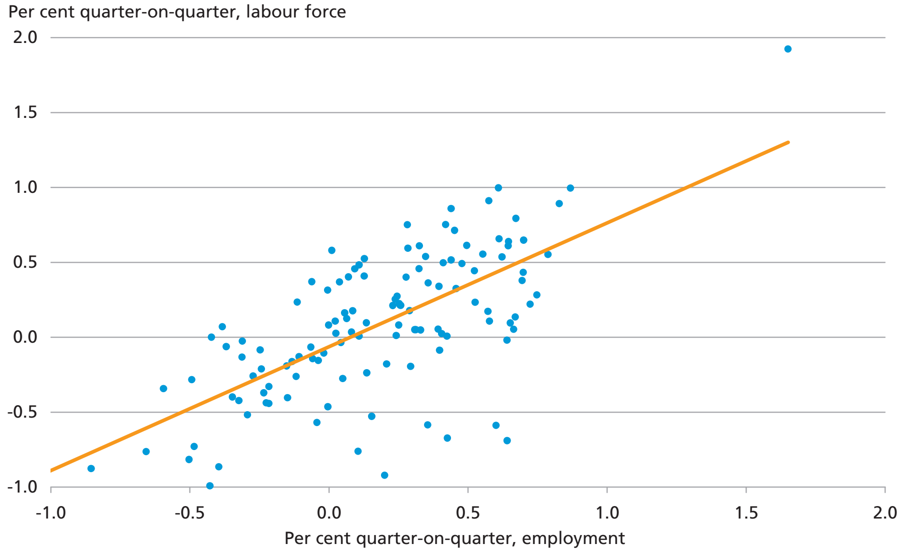


Chart shows that the participation rate fluctuates around its trend in some business cycles and thus partially follows the employment rate. One interpretation is that the long-term relation explains the participation rate as an average of the logistic trend and the employment rate.

The development indicates that the participation rate is procyclical. The reason may be that better employment options make more people enter the labour market. A particular element of the cyclical sensitivity of the labour force is the interaction with other labour markets, mainly in the other Nordic countries. The short-term correlation between employment and labour force is shown in Chart II.6.5, which compares the quarterly changes in employment and labour force, respectively.

Note that the short-term correlation between the series for labour force and employment also represents a measurement phenomenon. The employment figures include some statistical noise, which means that fluctuations in the employment series do not necessarily affect unemployment. When unemployment is unaffected, the measured change in employment is fully absorbed in the labour-force series, which is compiled as measured employment plus the unemployed (and in our case also persons comprised by various labour-market-policy schemes).

This common measurement error in employment and the labour force increases their correlation. However, the coefficients in the model's relation for the participation rate should not reflect this measurement-related phenomenon, because the model-generated changes in employment do not reflect measurement noise. Model-generated changes

PARTICIPATION RATE			Table II.6.2
Variable	Name	Coefficient	t value
Change in participation rate	Δlog(*erhfrk*)		
Change in employment ratio	Δlog(*employment ratio*)	0.3108	2.4
Differential to logistic trend	log($erhfrk_{-1}$) - log($lntren_{-1}$)	-0.1892	4.2
Differential to employment ratio	log($erhfrk_{-1}$) - log(*employment ratio* $_{-1}$)	-0.0246	2.2
Constant		0.0028	3.1

T = 1973:1 – 1997:4 DW = 1.688 AR(1) = 19.236 Se = 0.0026
R^2 = 0.4931 JB = 15.758 AR(4) = 23.002

Note: The relation is estimated using the once lagged change in the employment ratio as instrument for the unlagged change. *Employment ratio = (qp + qo + qs + uel + orlov + udda)/b1574*.

in employment only reflect output changes and other real economic conditions. Thus we have a problem with measurement bias (again), and we have chosen to estimate the participation rate with the lagged employment rate as an instrumental variable for the unlagged rate. The estimation of the participation rate is shown in Table II.6.2.

The residuals are affected by outliers as well as clear positive autocorrelation. There is no doubt that the simple relation for the participation rate lacks explanatory factors, but in the first instance no other factors have been found.

It is seen that a change in the employment rate affects the participation rate in the same quarter by the elasticity 0.31. This means that unemployment fluctuates less than employment in model calculations. Without the instrumental variables estimation the coefficient for the change in the employment coefficient would have been more than 0.5. In the long term the participation rate follows the logistic trend and employment rate with weights of 0.88 (0.1892/(0.1892+0.0246)) and 0.12, respectively.

DOMESTIC PRICE FORMATION 7

Prices or deflators for the demand components can be split into product taxes (product-related indirect taxes, net) and basic price. A basic price can be modelled by letting the import content follow the import price, the energy content follow the energy price and the value added excluding the energy sector follow the marginal cost. Omitting the non-product-related indirect taxes (e.g. real-estate tax) from the format implies that they are not added to the market price, but rather subtracted from net profits. The marginal cost is equivalent to the hourly wage cost divided by the marginal labour product, and its derivation was described in the section on capital and employment.

Applying the marginal cost means that increasing capacity utilisation augments prices. In the estimated price relations the pass-through from the marginal cost is, however, typically sluggish, and domestic prices in particular are not cyclically sensitive in the short run. This has an impact on the pass-through of the business cycle to e.g. the respective shares of wages and profits in value added.

In the long term capital and labour adapt optimally, which means that the marginal cost also represents the long-term unit cost. In other words, the long-term price of value added in the model is governed by the long-term unit cost. The estimated substitution elasticity between labour and capital is less than 1, and for this reason alone the wage share in the private non-farm sector can also vary in the long term. In addition there are a number of potential composition effects in the model which inevitably affect the GVA deflator and functional distribution of income in the private non-farm sector. For example, the impact of foreign prices on that sector is slightly stronger than the import share would imply, since prices for exports of services are to a large extent externally determined.

All long-term price relations are restricted to be homogenous, equivalent to the coefficients for price-driving components in the long-term relation adding up to one. As a main rule, such static homogeneity cannot be ruled out statistically when the price relations are allowed to show different trends.

None of the price relations are restricted to being dynamically homogenous, and in all relations the estimated coefficients for changes in cost and price variables add up to less than one. The absence of dynamic homogeneity means that shifts in the rate of inflation affect the equilibrium relation and thus the ratio of explained price to explanatory cost and price variables. Such a monetary illusion is *a priori* undesirable, cf. also the discussion of the wage relation in the previous section. When dynamic homogeneity is apparently not estimated, the reason – as in the wage relation – may be that it is difficult to represent expected inflation.

A monetary illusion of this nature has no major impact on short-term forecasts where it can be an advantage to apply empirically based relations, regardless of their inherent theoretical weaknesses. On the other hand, the illusion effect should be qualified if the calculation involves a regime shift, cf. again the discussion of the wage relation.

The price development in private consumption is particularly interesting, and Mona not only describes the national-accounts deflator for private consumption, but also the index of net retail prices.

On the face of it, the model's determination of prices is easier to grasp than the determination of constant-price quantities since the price relations are to a large extent tailored to the same pattern. On the other hand, the definitional identities in the national accounts create a special interdependency between the price relations which makes the model's price formation slightly more complex than one might immediately expect.

The basic problem is that a number of national-accounts identities must hold at both constant and current prices, and this consistency requirement is an implied restraint on the deflators that represent the link between components at constant and current prices.

There are price relations in the model to cover all main national-account components. Uses can be divided into exports and domestic demand. We have already discussed the price relations for exports in the section on exports, and import prices in the section on imports. This leaves the price relations for the components of domestic demand.

To provide a better overview, the basic principles of price formation are outlined first, after which the price relations for the main components of domestic demand are described, and finally price formation as a whole is assessed, including the inherent consistency problems.

The principles of Mona's price formation

The Mona version under review applies 1995-prices. The official input-output table for 1995 is an important starting point for splitting the individual market prices into 1) value added excluding energy from Mona's relatively few business sectors, 2) imports excluding energy, 3) energy (domestic value added as well as imports) and 4) product-related taxes. This is illustrated in Table II.7.1, where the coefficients cover direct

DIRECT AND INDIRECT CONTENTS OF PRIMARY INPUT — Table II.7.1

	Energy	Imports	Gross value added	Total basic price	Product-related taxes, net
			Per cent		
Private consumption	1.59	19.51	78.90	100.00	20.49
Cars, *qcb*	0.27	58.15	41.57	100.00	46.11
Food, *pfodev*	0.84	27.20	71.96	100.00	19.89
Public services, *poffyd*	1.37	10.37	88.26	100.00	-12.45
Public purchase of goods, *qcov*	1.96	37.28	60.75	100.00	22.01
Investments					
Machinery, *qim*	0.37	47.00	52.63	100.00	8.93
Buildings, *qib*	0.93	16.89	82.18	100.00	14.33

Note: Energy comprises both imports and domestic supply. In some variables the energy content is so small that the energy content in the price relations is set at zero.

Source: Statistics Denmark, Input-output table 1995.

and indirect deliveries of these inputs. The coefficients or weights are calculated on the basis of the input-output matrix for 1995, i.e. on the basis of an assumption of linear correlations. The Table shows the weighs of value added, imports and energy as well as indirect taxes in 1995, and these weights can be used to determine the coefficients in the long-term relations for prices before product-related taxes – the so-called basic prices.

The price index applied for value added is the marginal cost of labour in the private non-farm sector. This is equivalent to applying the well-known marginal condition for full competition.

$$\text{price} = \text{marginal cost} = \frac{\text{hourly wages}}{\text{marginal labour product}} \tag{II.13}$$

This relation need not be met in every quarter, but should be seen as a long-term relation. In the long term, when both labour and capital have adapted, the marginal cost will be equal to the average unit cost. This gives

$$\text{price} = \text{marginal cost} = \text{long - term unit cost} \tag{II.14}$$

Mona does not include any explicit price relation for value added in the private non-farm sector, which is the large endogenous sector in the model. The explicit behavioural relations only concern prices or deflators for demand components. Specifically, basic prices are modelled, i.e. prices before product-related taxes. In these price relations the marginal cost is inserted with a coefficient which in 1995 corresponds to the value-added share or weight, cf. Table II.7.1. Likewise, the import price is weighted with the import share and the energy price with the energy share in 1995. The basic outline of a price relation is given by

$$\begin{aligned} \text{basic price} = \; & \text{factor} \cdot (\text{GVA - share} \cdot \text{marginal cost} \\ & + \text{import share} \cdot \text{import price} + \text{energi share} \cdot \text{energy price}) \end{aligned} \tag{II.15}$$

The first term is a proportionality factor which varies over the different prices and often contains a trend. For example, the price of building investments tends to increase at a higher rate than the price of machinery investments, and the difference in the rate of increase is greater than can be explained by different import weights and import prices. In other words the price development is not the same for domestic gross value added in the two investment components, even though added value in both cases stems from the private non-farm sector. The model only includes one marginal cost for the private non-farm sector, and this marginal cost is applied in all price relations, so it is necessary to provide for flexibility in the form of different proportionality factors in different price relations.

As mentioned, the demand-component deflators are modelled directly, while the deflator for value added is calculated residually. Since value added plus imports equal demand, there is a definitional link entailing that one price in the model must necessarily be residually determined, and in Mona the residual price is the deflator for private non-farm value added. Another possible approach to modelling price formation would have been to start with a behavioural relation for the deflator for private non-farm value added and then to apply the value-added deflator when modelling the deflators for the demand components except one – for instance the deflator for stockbuilding, which follows residually. This kind of approach is applied in e.g. the ECB's Area Wide Model described in Fagan et al. (2001). Ideally, the two approaches are equivalent.

One approach cannot be said to be more correct than the other. A practical advantage of Mona's approach, i.e. starting with the price behaviour of the demand components rather than private non-farm value added, is that the deflators for consumption, investments, etc. are closer to the simple price indices which can be followed on a monthly basis. Prices of value added, on the other hand, are not really available until the national accounts have been published. Sometimes prices of demand components are also easier to interpret than the price of value added and consequently also easier to forecast.

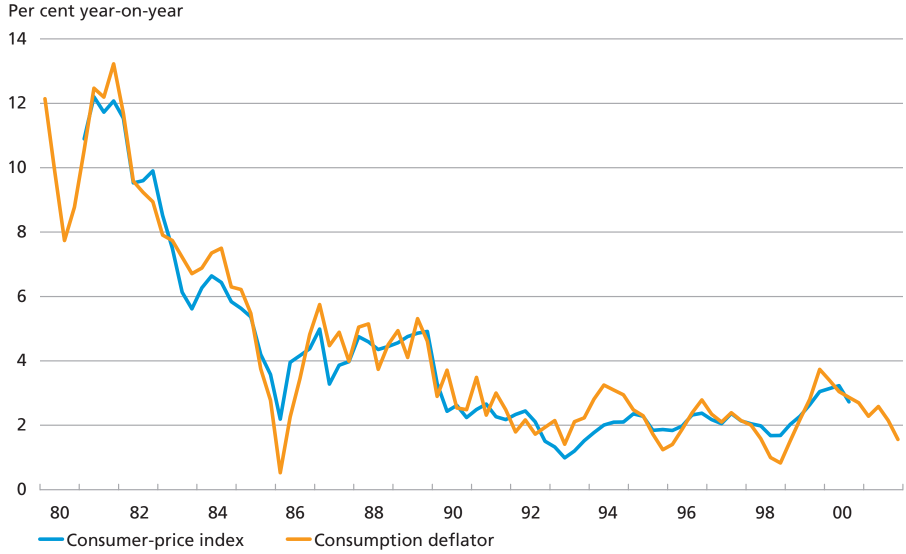
The price of private consumption

Mona is based on the national accounts, but a discussion of consumer-price inflation seldom centres on the consumption deflator in the national accounts. In recent years focus has rather been on the Harmonised Index of Consumer Prices, HICP, and also on the closely related national consumer price index, CPI, with the associated index of net retail prices, excluding indirect taxes and subsidies.

The national-accounts deflator is a Paasche index with current weights and thus in principle different from the typical price indices, which are Laspeyres indices with fixed weights. CPI and the consumption deflator do not display the same rate of increase, but the overall impression of the price development seems to be the same, cf. Chart II.7.1. In other words the difference between modelling one and the other should not be exaggerated.

The focus on the usual price indices rather than the quarterly consumption deflator has meant that Mona is set up to not only determine

INCREASES IN CONSUMER PRICES Chart II.7.1



the consumption deflator in the national accounts, but also the index of net retail prices. By determining the index of net retail prices Mona also provides a significant part of the basis for both CPI and HICP. We will first examine the determination of the index of net retail prices and then the determination of the consumption deflator.

About the index of net retail prices

The determination of the index of net retail prices in Mona is based on a determination of the subindices included in the decomposition of the index of net retail prices, which is regularly presented in Danmarks Nationalbank's Monetary Review. The decomposition consists in dividing the index of net retail prices into a group of subindices which are assumed mainly to reflect externally determined or administered prices, as well as a subindex reflecting domestic market-related price formation. Specifically, the net retail price, *ncp,* is split into six subcomponents: rent, *phusl*, food, *pfodev*, public services, *poffyd*, imports, *pimpor*, which are taken from wholesale prices, energy, *pener,* and as the sixth component a so-called IMI index, *restx*, the increase in which indicates the domestic market-determined inflation. This decomposition of price developments is described in more detail in Christensen (1994).

The index of net retail prices is compiled by weighting the six subindices together with weights that correspond to the index formula for net retail prices. For the energy price a partially input-output-based weight has been applied, which takes into account the indirect signifi-

NET PRICE OF ENERGY			Table II.7.2
Variable	Name	Coefficient	t value
Change in net price of energy	$\Delta\log(pener)$		
Change in import price	$\Delta\log(pmbra + tmbra)$	0.3900	13.2
Net price of energy	$\log(pener_{-1})$	-0.1051	2.1
Marginal cost	$\log(mulc_{-1})$	0.0476	1.9
Import price	$\log(pmbra_{-1} + tmbra_{-1})$	0.0575	1.9
Trend	0.001·trend	-0.1366	0.2
Constant		0.3182	0.2

T = 1974:2 – 1997:4	DW = 1.987	AR(1) = 0.000	Se = 0.0241
R^2 = 0.6907	JB = 2.069	AR(4) = 9.114	

Note: Estimated by OLS. Homogeneity in the long-term relation is accepted with a test value of 0.04, F(1.89).

cance of the energy price, and for the import price a pure input-output-based weight has been applied, reflecting the direct and indirect import content of private consumption. No import price is included among the official subindices of the index of net retail prices, and the import price is represented by a subindex from the wholesale-price index (now the price index for domestic supply). The weight of the purely domestic IMI index as well as the IMI index itself are residually determined.

In the model four of the six components of the index of net retail prices have simply been made proportional to a weighted average of other prices and costs in the model. Input-output-based weights are applied. There are no short-term dynamics in the determination of the four price components, but for some a linear trend is included.

The rent item, *phusl*, is proportional to the housing deflator, which follows the marginal unit labour cost, *mulc,* with a long distributed lag. The price of food consumption, *pfodev,* follows an average of the IMI index, *restx*, and the import price excluding energy, *pmvx*. The price of public services, *poffyd,* follows the public wage rate, the IMI index, and the import price excluding energy, while the import price, *pimpor,* is proportional to the import price excluding energy.

For the last two components of the index of net retail prices, the net energy price and the IMI index, behavioural relations with short-term dynamics have been estimated.

First we will examine the result of the estimation for the net energy price. It is shown in Table II.7.2.

The relation's residuals seem to be fairly random from quarter to quarter, but there is some autocorrelation over 4 quarters. This may seem surprising, since the price series are seasonally adjusted, and for the sake of simplicity this phenomenon is not countered by adding dynamics.

In the long term the net energy price is determined by the price of imports of energy products, *pmbra,* and by the marginal unit labour cost, *mulc*. The weights are estimated at 55 per cent (0.0576/(0.0576+0.0479)) and 45 per cent, respectively, and the homogeneity restriction applied is easily accepted. The relation entails that the energy price for consumers not merely mirrors the price of imports of energy products. Danish wage costs also play a role, and the estimated relation implies delayed price adaptation. This delay may be attributed to e.g. the partly administrative price formation for district heating.

The estimated short-term dynamics are most rapid in relation to import prices, cf. the short-term elasticity of just under 0.4 for the import price and zero for the wage cost.

We have also estimated a relation for the IMI index, which reflects domestic wages and profits per unit produced. The more exogenous price components are eliminated from the IMI index, so the rate of increase in the index can be seen as an expression of the underlying Danish inflation. Since import prices are excluded the IMI index can be seen as a price index for domestic market-determined value added.

In the model the long-term IMI index is determined by the marginal cost plus/minus a trend. The marginal cost variable also determines the private non-farm value-added deflator, but it is quite possible for the IMI index and the deflator for private non-farm value added to show different trends. Specifically, the sector producing IMI-related goods is a segment in the private non-farm sector which also produces export and investment goods. In addition, the compilation of the IMI index reflects net retail and wholesale price indices which are never revised, whereas Statistics Denmark regularly revises the national-accounts deflators, including the value-added deflators.

Owing to the compilation method behind the IMI index it is also obvious to include in the relation the import-price index eliminated from the index of net retail prices. The estimated relation is shown in Table II.7.3.

As for the relation for energy price, there are indications of autocorrelation over four quarters, but otherwise the relation's residuals seem to be random. A few dummies have been added which do not have any clear *a-priori* interpretation, but which neutralise some potential outliers back in the 1970s and early 1980s.

The unlagged change in import prices is included with a negative sign, the lagged changes in import prices with a positive sign. This part of the short-term dynamics mimics the normal sluggishness in the pass-through from import prices to the index of net retail prices. The sluggishness means that the residually calculated IMI index initially falls when import

DOMESTIC MARKET-DETERMINED PRICE INDEX (IMI INDEX)			Table II.7.3
Variable	Name	Coefficient	t value
Change in IMI index	$\Delta\log(restx)$		
Change in wage cost	$\Delta\log(lnio_{-1})$	0.1283	2.1
Change in import price	$\Delta\log(pimpor)$	-0.3777	6.2
Change in import price	$\Delta\log(pimpor_{-1})$	0.2125	3.0
Change in import price	$\Delta\log(pimpor_{-2})$	0.0843	1.3
Long-term relation	$\log(restx_{-1}) - \log(mulc_{-1})$	-0.0367	3.1
Dummy	*d7734*	0.0273	8.3
Dummy	*d8081*	0.0190	6.5
Trend	$0.001 \cdot trend$	-0.8618	7.3
Constant		1.7689	7.4
T = 1975:2 – 1997:4	DW = 2.108	AR(1) = 0.363	Se = 0.0046
R^2 = 0.7670	JB = 3.019	AR(4) = 9.223	

Note: Estimated by OLS. The homogeneity restriction is accepted with a test statistic of 0.73, F(1.81).

prices accelerate. This is equivalent to value added immediately falling when the value of imports increases. As the change in import prices passes through to consumer prices, the immediate negative effect on the IMI index is redressed.

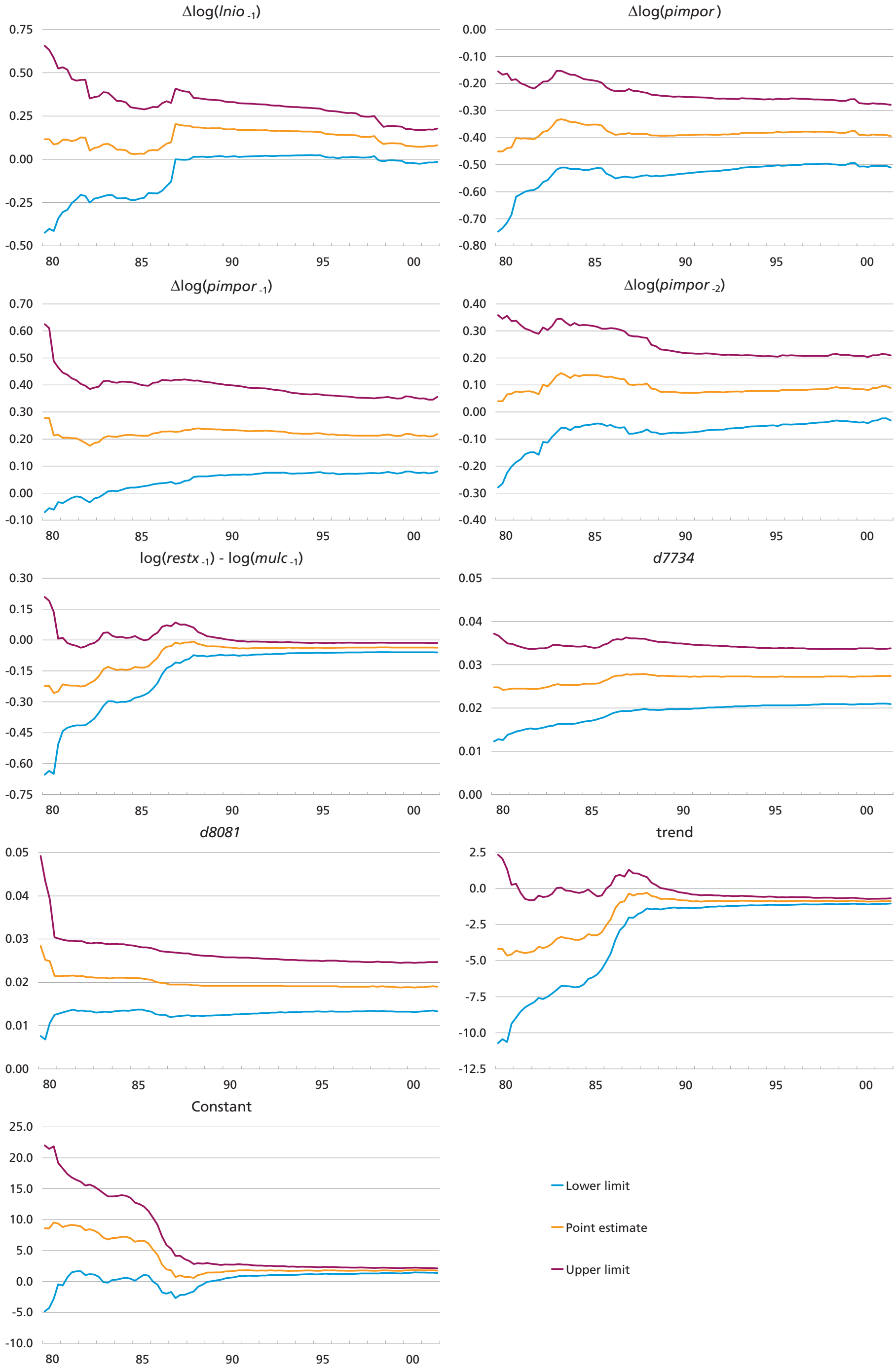
The simple long-term relation is that the IMI index follows the marginal cost and a trend. It is not a strong relation. Adaptation is thus rather slow, cf. the associated coefficient of only 0.037. It thus takes several years before just half the adaptation to the marginal cost is complete. The long-term relation is not cointegrating, judging from a relatively low ADF statistic (not shown). Furthermore, the relation's estimated trend is influenced by the fact that the relation's price changes also show a trend over the sample, where price changes are large at the beginning and small at the end.

The result of recursive estimation is shown in Chart II.7.2, and no clear breaks are seen over the past 15 years. Nonetheless, the weak adaptation to the long-term relation suggests that the simple relation lacks at least one explanatory variable. However, it is not obvious that such a variable can be found within the framework of the model.

We have now discussed the determination of six price components in the index of net retail prices. As mentioned, the overall index of net retail prices is compiled by weighting together the six price components

$$\begin{aligned} ncp = {} & 0.1494 \cdot pipmpor + 0.3512 \cdot restx + 0.0876 \cdot ener \\ & + 0.1397 \cdot pfodev + 0.0367 \cdot poffyd + 0.2354 \cdot phusl \end{aligned} \tag{II.16}$$

RECURSIVE ESTIMATION, IMI INDEX (DOMESTIC MARKET-DETERMINED PRICE) Chart II.7.2



About the consumption deflator

In the model private consumption has five subcomponents with independent deflators: car-purchase deflator, *pcb*, housing, *pch*, travel expenditures, *pmt*, travel receipts, *pet,* and finally rest of consumption or other consumption, *pcq*, which is by far the greatest item.

By definition the deflator for total private consumption is achieved by weighting the components' deflators together with the components at constant prices

$$pcp = \frac{pcq \cdot fcq + pcb \cdot fcb + pch \cdot fch + pmt \cdot fmt - pet \cdot fet}{fcp} \tag{II.17}$$

The five components in the consumption deflator have been created in a similar way to those of the index of net retail prices taking into account the difference in definitions. One of the differences is that the national-accounts deflators have current weights, and when constructing the basic price for other consumption, *qcq*, adjustment is made for the development in the import share. This should promote consistency in the model's price formation. Specifically, the relation is as follows using logarithms

$$\begin{aligned}\log(\mathrm{qcq}) = {} & \log\left(0.199 \cdot \frac{\mathrm{mkv}}{0.832} \cdot \mathrm{pimpor} + \left(1 - 0.199 \cdot \frac{\mathrm{mkv}}{0.832}\right)\right. \\ & \cdot \left(0.3512 \cdot \mathrm{restx} + 0.0876 \cdot \mathrm{pener} + 0.1397 \cdot \mathrm{pfodev}\right. \\ & \left.\left. + 0.0367 \cdot \mathrm{poffyd} - \left(1 - \frac{\mathrm{mkv}}{0.832} \cdot 0.584\right) \cdot 0.03097 \cdot \frac{\mathrm{qcb}}{0.224}\right)\right)\end{aligned} \tag{II.18}$$

We have ignored any trend and constant. The latter represents the proportionality factor between the basic price on the left-hand side and the weighted average of explanatory variables.

mkv is the import share. Specifically, we apply a four-quarter average of the standardised import share (*fmvx/xfmvx*), indexed so that 1995 = 1.

$$mkv = \frac{1}{1.007832} \cdot \frac{1}{4} \cdot \sum_{i=0}^{3} \frac{fmvx_{-i}}{xfmvx_{-i}} \tag{II.19}$$

It should also be noted that the basic price of other consumption is determined by relevant components from the index of net retail prices and that a negative term implies the exclusion of the basic price of car purchases, *qcb*.

It is seen from the price relation (II.18) that a higher import share increases the weight of the import price and reduces the other weights so that the weights or ratios still add up to 1.

As mentioned, the price relation indicates proportionality between the basic price and the weighted expression on the right-hand side. Note that relation (II.18) is applied as is. It is not an equilibrium relation in regard to which short-term dynamics are added. The reason is, cf. the description, that dynamic adaptation is modelled for the IMI index and energy price. For instance, it follows from the relation for the IMI index that the index is dampened by import-price acceleration, and this reaction creates a delayed pass-through from the import price to the basic price for other consumption.

It should be mentioned that there are no series for basic prices in the official quarterly national accounts. It is therefore necessary to construct the basic prices, e.g. *qcq*. Data construction takes the market price, *pcq*, from national accounts and subtracts product-related taxes net, *inter alia* determined using data for the Adam model on the distribution of product-related taxes.

When the basic price has been determined in a relation, product-related taxes net must be added. In Mona these are expressed as rates by value or volume, and the rates are exogenous variables. For e.g. the rest of consumption specific taxes and VAT are added

$$pcq = (1 + btgq \cdot tg) \cdot (qcq + tpkq) \tag{II.20}$$

where *tpkq* is the rate for specific taxes, *tg* is the VAT rate, and *btgq* is a VAT loading factor. The principle of including taxes in (II.20) is also applied in Adam and Smec.

The basic price of car consumption or car purchase, *qcb,* follows an equivalent ratio-adjusted weighting of import price and marginal cost, and the market price, *pcb,* is achieved by adding VAT and registration fees.

The housing deflator, *pch*, is proportional to the rent component in the index of net retail prices. There are no product-related taxes on this item. The travel-expenditure deflator, *pmt,* follows foreign wages stated in Danish currency, and the travel-receipt deflator, *pet,* follows domestic consumer prices represented by *pcq*. The five subdeflators of consumption have thus been determined, and the overall consumption deflator follows from (II.17).

Prices of machinery and building investments

In the long term, the net prices of investments in machinery and buildings, respectively, are determined by the import price and the marginal cost in the private non-farm sector. The respective import contents have been taken from the input-output table for 1995, cf. Table II.7.1.

In the relation for the basic price of machinery investments, *qim,* the import price is represented by the national-accounts deflator for imports in trade classification group SITC 7, *pm7*. The import price applied thus shows the same weak trend as the import deflator in the national accounts, where the price of computer equipment is adjusted for quality.

The weights in the long-term relation are adjusted for the development in the import share according to the principles illustrated for other consumption. If the constant and the linear trend are ignored, the long-term relation for the basic price of machinery investments is written as

$$\log\left(qim\right) - \log\left(0.473 \cdot mkv \cdot pm7 + \left(1 - 0.473 \cdot mkv\right) \cdot \frac{mulc}{0.6189}\right) \tag{II.21}$$

The modest energy content has been disregarded. The relation (II.21) is supplemented with a linear trend and short-term dynamics, after which the final behavioural relation for the basic price is estimated. The result is shown in Table II.7.4.

A negative autocorrelation is seen from quarter to quarter, which may reflect measurement problems in relation to the volatile basic price.

Since the import content of machinery investments is high, the import price naturally plays a special role, and short-term elasticity is just under 0.40. The short-term elasticity means that the pass-through of the import price is faster than that of domestic wage costs. The wage costs applied are not linked particularly to manufacture of machinery as the import price applied is.

Recursive estimation reveals a clear break in the mid-1980s, but relative stability in the coefficients since the first half of the 1990s, cf. Chart II.7.3.

For the basic price of building investments the same type of long-term relation is set up as for the basic price of machinery in relation (II.21).

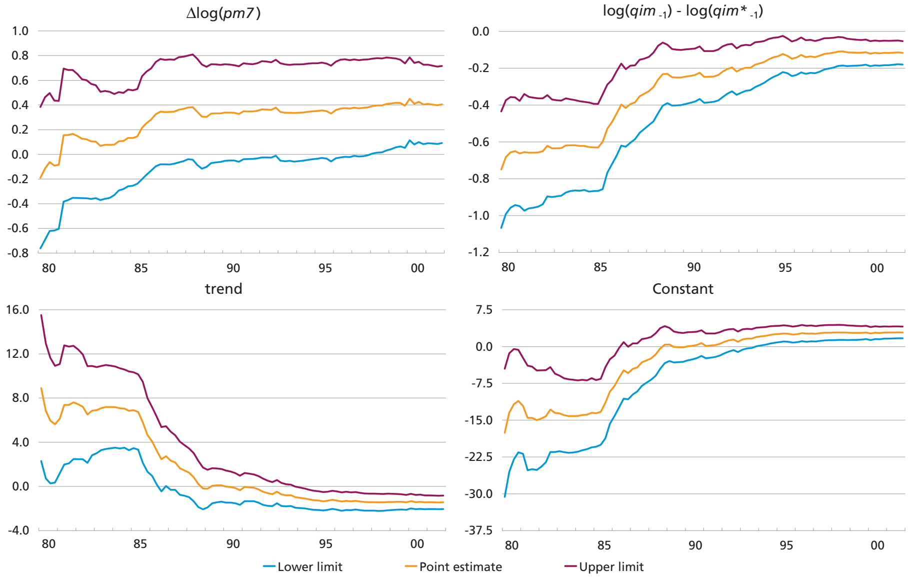
BASIC PRICE OF MACHINERY INVESTMENTS — Table II.7.4

Variable	Name	Coefficient	t value
Change in basic price	$\Delta\log(qim)$		
Change in import price	$\Delta\log(pm7)$	0.3812	1.9
Error-correction term	$\log(qim_{-1}) - \log(qim^*_{-1})$	-0.1193	2.8
Trend	$0.001 \cdot trend$	-1.4202	3.6
Constant		2.8368	3.6

T = 1974:2 – 1997:4	DW = 2.406	AR(1) = 4.933	Se = 0.0189
R^2 = 0.3611	JB = 0.216	AR(4) = 6.251	

Note: Estimated by OLS. In the error-correction term $\log(qim^*) = \log(0.473 \cdot mkv \cdot pm7 + (1 - 0.473 \cdot mkv) \cdot mulc/0.6189)$, where 0.473 is the direct and indirect import content in 1995.

RECURSIVE ESTIMATION, BASIC PRICE OF MACHINERY INVESTMENTS Chart II.7.3



The only difference is that the import share in 1995 is only 0.177 against 0.473 for machinery. This is supplemented with a linear trend and short-term dynamics for the estimation of the final behavioural relation. The result of the estimation is shown in Table II.7.5.

There are a number of large residuals back in the 1970s. This means that the Jarque-Bera test rules out normality and the outliers are by chance sequenced so it contributes to an impression of the residual term correlating with itself over four quarters. If the start of the sample is set

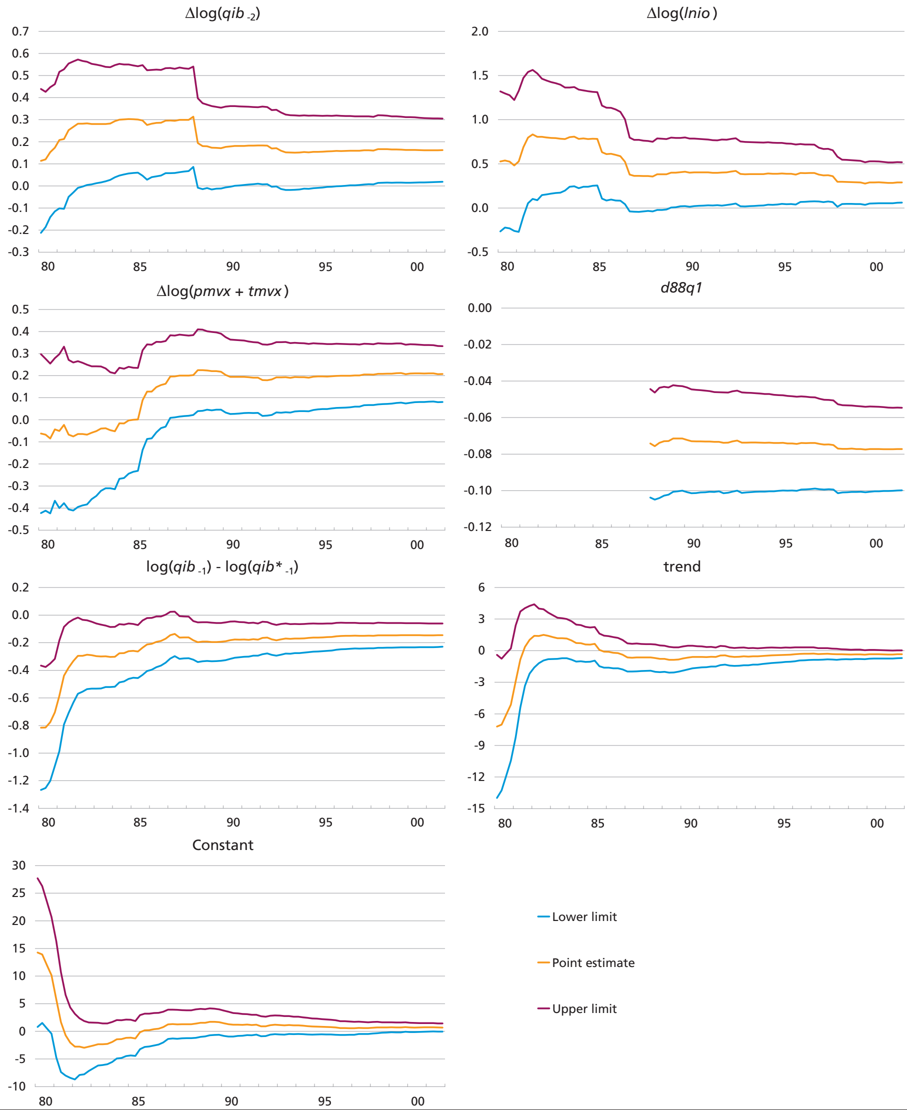
BASIC PRICE OF BUILDING INVESTMENTS Table II.7.5

Variable	Name	Coefficient	t value
Change in basic price	$\Delta\log(qib)$		
Change in basic price	$\Delta\log(qib_{-2})$	0.1614	2.1
Change in hourly wage cost	$\Delta\log(lnio)$	0.3712	2.4
Change in import price	$\Delta\log(pmvx + tmvx)$	0.2054	2.9
Dummy	*d88q1*	-0.0747	6.0
Error-correction term	$\log(qib_{-1}) - \log(qib^*_{-1})$	-0.1488	3.2
Trend	0.001·trend	-0.2915	1.1
Constant		0.5821	1.1

T = 1974:2 – 1997:4	DW = 2.182	AR(1) = 1.109	Se = 0.0113
R^2 = 0.5506	JB = 9.293	AR(4) = 12.831	

Note: Estimated by OLS. $\log(qib^*) = \log(0.177 \cdot mkv \cdot (pmvx + tmvx)/1.008 + (1 - 0.177 \cdot mkv) \cdot mulc/0.6189)$, where 0.177 is the direct and indirect import content in 1995.

RECURSIVE ESTIMATION, BASIC PRICE OF BUILDING INVESTMENTS Chart II.7.4



at e.g. the 1st quarter of 1980, the JB statistic falls to less than 1 and the LM test statistic for 4th order's autocorrelation to less than 5. At the same time, the endogenous variable lagged two periods becomes insignificant, whereas the rest of the relation's coefficients, i.e. the economically interesting ones, remain more or less as in Table II.7.5.

Unlike for machinery investments, wage costs have an immediate effect on the basic price of building investments. It would also seem natural that building investments to a larger extent reflect domestic wage costs. Compared with machinery investments, the adaptation in the price equation is also speeded up by a slightly higher coefficient for the *a-priori* determined long-term relation and by the endogenous variable lagged two periods.

The included dummy is 1 in 1988q1, but otherwise zero. The dummy removes an outlier reflecting that the national-accounts deflator for building investments falls by more than 6 per cent in the 1st quarter of 1988. This deflator volatility may reflect problems as regards the statistical treatment of the major rearrangement of labour-market contributions at that point.

Recursive estimation shows that there are no significant breaks since the 1980s, cf. Chart II.7.4.

The price of public consumption and stocks

Most of the public consumption is produced by public-sector employees, and the model's deflator for this part of public consumption reflects the public-sector wage rate. A relatively small part of public consumption consists of depreciation of public capital. This is an imputed item, the price component of which is defined so that it follows the investment price.

The third and final component in public consumption is external public purchases, e.g. from the private sector and imports. The relation for the associated basic price looks like the relation for the price of other private consumption. Since the energy content covers both domestic deliveries and imports, the energy price applied is a weighted average of the price of value added from energy extraction, *pyfe,* and the price of imports of energy products, *pmbra*. Specifically, the price of public purchase of goods, *qcov,* is determined as

$$\begin{aligned}\log(qcov) = \; & \log\Big(mkv \cdot 0.3728 \cdot pmvx + (1 - mkv \cdot 0{,}3728) \cdot \frac{0.0196}{0.0196 + 0.6076} \\ & \cdot (0.5 \cdot pmbra + 0.5 \cdot pyfe) \\ & + (1 - mkv \cdot 0.3728) \cdot \frac{0.6076}{0.0196 + 0.6076} \cdot \frac{restx}{2.1249} \Big)\end{aligned} \tag{II.22}$$

Finally we have to determine a deflator for stockbuilding. There is no need for thorough modelling of the price of stockbuilding. It is quite normal for the stock of some goods to increase while the stock of others decreases. If the associated deflators differ, the sum of such opposite changes in stock may be completely different at constant and current prices. For instance, total stockbuilding may be positive at current prices and negative at constant prices, in which case the deflator for change in stocks is negative. In the model the deflator for stockbuilding in the private non-farm sector is set equal to an average of the import price and the deflator for private non-farm value added.

Properties of the overall price system

The properties of the overall price system can be illustrated via a partial multiplier experiment on the change in wage costs.[1] The term partial implies that a number of non-price equations have been deleted in order to focus on the model's price formation, i.e. wages and output have been exogenised. In the calculation we permanently raise the level of private and public wages, *lnio* and *lo*, by 1 per cent and examine the reaction in the price and factor block.

Since output is unchanged, the adaptation of labour and capital inputs solely reflects substitution. In addition, the price determination reflects the price relations rather than effects from shifts in the composition of demand, since exogenisation of output is implemented by exogenising the demand components. The calculation implies that the capital stock of machinery and other equipment is endogenous, and thus the associated machinery investments are also endogenous, but the demand effect of this is blocked, so that the change in investments does not affect GVA at constant or current prices.

An example of a composition effect is that the overall price level and the GVA deflator are raised if the demand components with the largest deflator increase. Such composition effects are illustrated in connection with the review in Chapter IV of multiplier calculations on the model; but in the present section we will focus on the properties of price relations without composition effects.

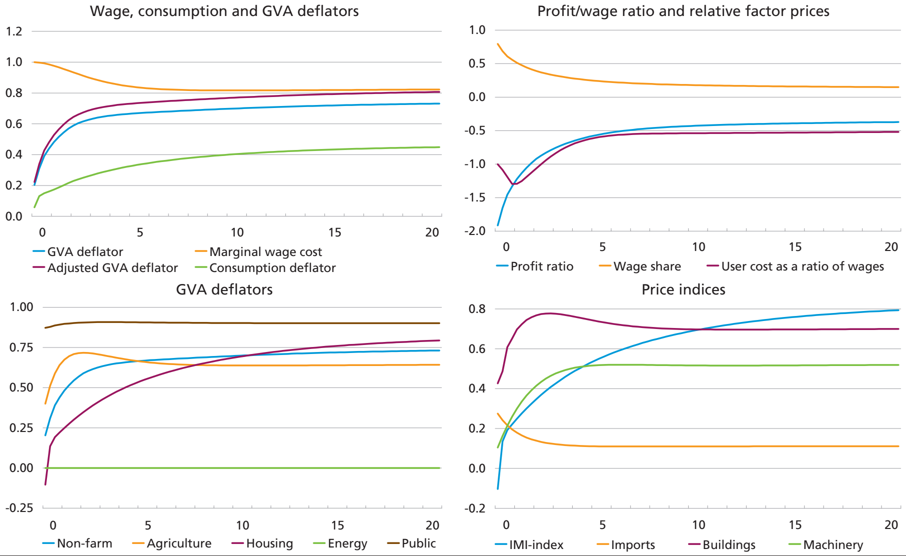
The key wage-cost variable in the price relations is the marginal cost in the private non-farm sector. This variable immediately increases by 1 per cent when hourly wages increase by 1 per cent. In the slightly longer term, firms start substituting capital for labour. This enhances productivity, and in the long term the marginal cost only increases by 0.82 per cent. The effect on the marginal cost in the short term and for up to 20 years is illustrated in Chart II.7.5.

The long-term change of 0.82 per cent in the marginal cost is, as it should be, close to the long-term change in the unit cost. The latter can be calculated as the change in input prices weighted with factor shares which are 1/3 capital and 2/3 labour. Specifically, the unit cost increases by 0.83 per cent (0.33·0.5+0.67·1).

The 0.5-per-cent change in the capital cost reflects an increase in the machinery deflator by 0.5 per cent. As regards pass-through to the prices of other demand components, the effects on the building-investment deflator and on the IMI index are shown, and it can also be seen that

[1] See Chapter IV for the construction of multiplier experiments.

EFFECT ON PRICES | Chart II.7.5



Note: The unit on the vertical axis in all charts is the deviation from the base line in per cent. Horizontal axes indicate time in years from introduction of the 1-per-cent wage shock.

the import price increases slightly as a pricing-to-the-market effect, cf. Chart II.7.5.

The IMI component and imports together with four other components are included in the index of net retail prices, where the long-term price effect in the experiment is 0.6 per cent. The long-term effect on the consumption deflator, which includes a deadweight effect from unit taxes, is only 0.5 per cent. Since the marginal cost changes by 0.82 per cent, the pass-through from marginal cost to consumption deflator is just over 60 per cent (0.5/0.82). This is also close to the input-output-based content of value added in consumer prices. The effect on the consumption deflator and the effect on the marginal cost are shown in Chart II.7.5.

In the model's price relations, the marginal cost in the private non-farm sector functions as the general price index for value added, and if the coefficients of the price relations are correct, the deflator for private non-farm value added calculated by the model should follow the marginal cost in the private non-farm sector.

The long-term increase in the private non-farm GVA deflator is marginally lower than the 0.82-per-cent increase in the marginal cost, cf. Chart II.7.5. This differential is mainly attributable to a deadweight effect of an exogenous price component in exports.

As stated in the review of exports, the export price of services excluding travel receipts is exogenous. The reason is that this export segment is dominated by revenue from sea freight, where the price is externally determined. Since sea freight has not been stated as a separate output sector, as e.g. energy extraction has, sea freight has a deadweight effect on the GVA deflator of the private non-farm sector. Excluding this effect, the long-term change in the private non-farm deflator is fairly close to the change in the marginal cost, cf. the adjusted GVA deflator in Chart II.7.5. This indicates that the price relations are working as they should in our price experiment.

The overall result of the model's price relations can also be seen in the effect on the private non-farm wage share. In the experiment the wage share increases both in the short and the long term, cf. Chart II.7.5. In the short term the increase is fairly large and close to one per cent in relative terms. This reflects sluggish prices and employment, so that the higher wages immediately press the wage ratio up and the profit ratio down. In the long term the application of factors adapts to the changed factor-price ratio, i.e. employment declines and the long-term increase in the wage ratio is lower than the short-term increase. The fact that the wage ratio increases in the long term partly reflects that substitution elasticity is less than 1, partly that export prices for sea freight do not reflect marginal costs in the supplying sector.

The GVA deflator in the private non-farm sector adapts far more rapidly than the consumption deflator. The different adaptation rates for consumer prices and the GVA deflator reflect, *inter alia*, the more rapid adaptation in investment prices and the effect via foreign-trade prices.

We will consider the GVA prices in more detail. The price of public value added primarily keeps pace with public wages. In Mona the public-sector value added constitutes a part of public consumption, so the public-sector GVA price may be changed without any direct spill-over on the private-sector GVA price. The price of extraction of raw materials follows the price of energy imports and thus the oil price, which is exogenous in this experiment, so the price of extraction of raw materials does not change. If the weight of energy prices in the prices of the demand components reflects the size of the energy-sector GVA, the development in exogenous energy prices will not have any direct impact on the rest of the private sector either.

The price of value added in the agricultural sector follows the price of agricultural exports less the import content. This means that changes in the sales prices of agricultural products affect the price of value added. In short-term forecasts agricultural export prices are exogenous, so there is no connection to private non-farm prices. In multiplier experiments agricultural export prices follow the prices of industrial exports. Since

PRICE OF VALUE ADDED	Table II.7.6
Mona's sectors:	Price determined in Mona as:
Public sector, *pyfo*	Price of certain part of public consumption I.e. (*pcow·fcow* + *piov·fiov*)/(*fcow* + *fiov*)
Energy extraction, *pyfe*	Price of energy exports I.e. *pebra*
Agriculture, *pyfla*	Price of turnover less input 1.30·*peani* + 0.07·*peveg* – 0.37·*pmvx*, which follows *mulc* in the long term
Housing sector, *pyfh*	Distributed lag in *mulc* i.e. *mulc* in the long term
Non-farm sector, *pyfbx*	Definition equation I.e. (*yfbx*)/(*fy* - *fsi* - *fyfo* - *fyfe* - *fyfla* -*fyfh*), which follows *mulc* in the long term

their content of Danish value added is governed by the private non-farm marginal cost in the long term, the price of agricultural value added is also governed by this in the long term.

The price of value added in the housing sector is a distributed lag in the private non-farm marginal cost. In the long term this price therefore also follows the private non-farm marginal cost.

Mona has only one production function and therefore only one marginal cost related to the private non-farm sector, on which price formation is primarily based. As stated above, the two major exceptions are the public sector and the energy sector, and these are indeed the two sectors where the GVA deflator deviates most from the deflator for the private non-farm sector, cf. Chart II.7.5. An overview of Mona's business sectors and the determination of the prices of their value added is shown in Table II.7.6.

With the review of prices in this Chapter II we have discussed the most significant behavioural relations in Mona. In Chapter III we will outline how these can be linked to form a model.

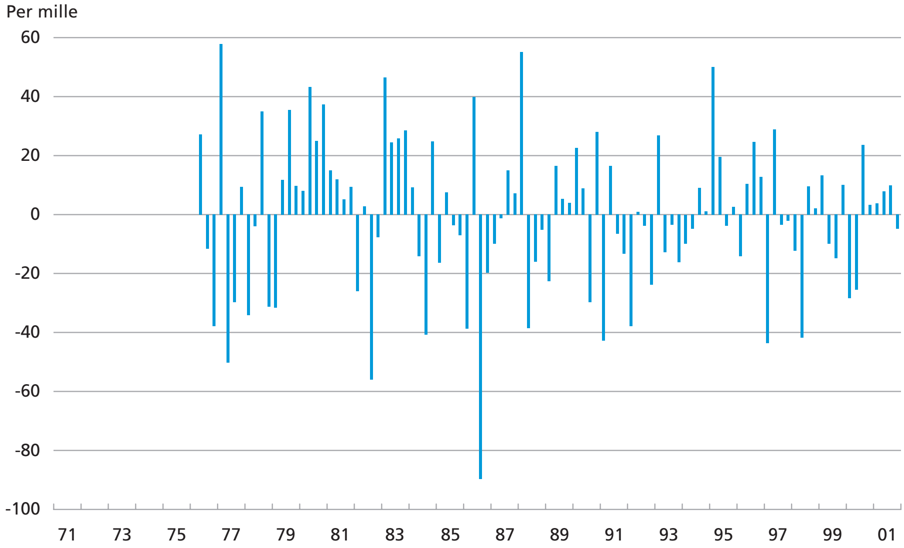
II Appendix: Charts of Residuals

The following Charts show the residuals of the estimated relations discussed in Chapter II. The Charts appear in the same order as the Tables for the estimation results. The latest final year in the national accounts was 1997 when the described model version was estimated, and the relations are estimated up to and including 1997, cf. the respective Tables. The Charts show the residuals up to and including 2001. For the last four years the residuals are thus out of sample. The applied national accounts are not final for 2000 and 2001, so the residuals for these years may easily change.

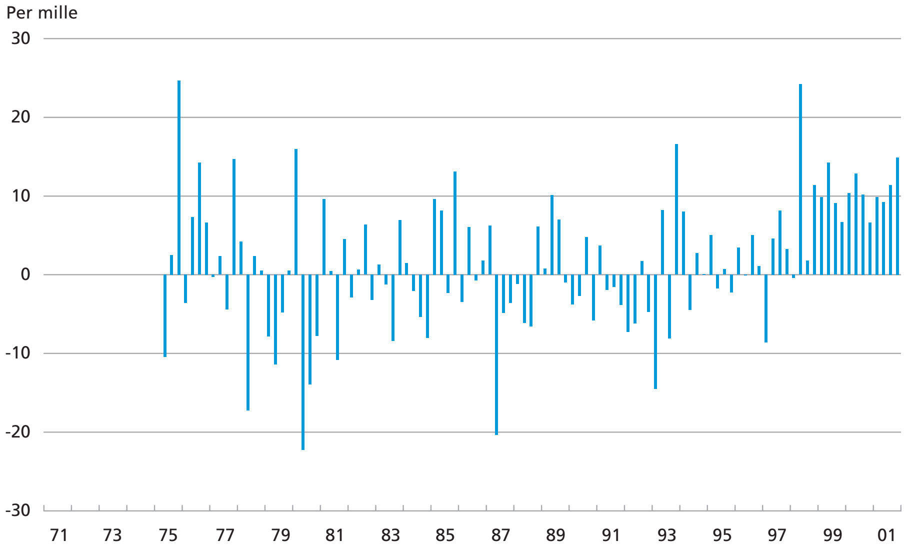
Apart from the uncertainty related to the latest observations, the Charts illustrate that the residuals are distributed more or less randomly around zero in the estimation period up to and including 1997, cf. the test statistics indicated in the relevant Tables. Also, several relations, e.g. private consumption and the house price, reveal an unpleasant systematic trend in the residuals in recent years. Adjustment terms are needed in forecasts.

Some of the post-sample residuals automatically become less systematic when the end of the estimation sample is moved from 1997 to 1999, but recent years' residuals also present a challenge in connection with model maintenance and development of explanatory variables.

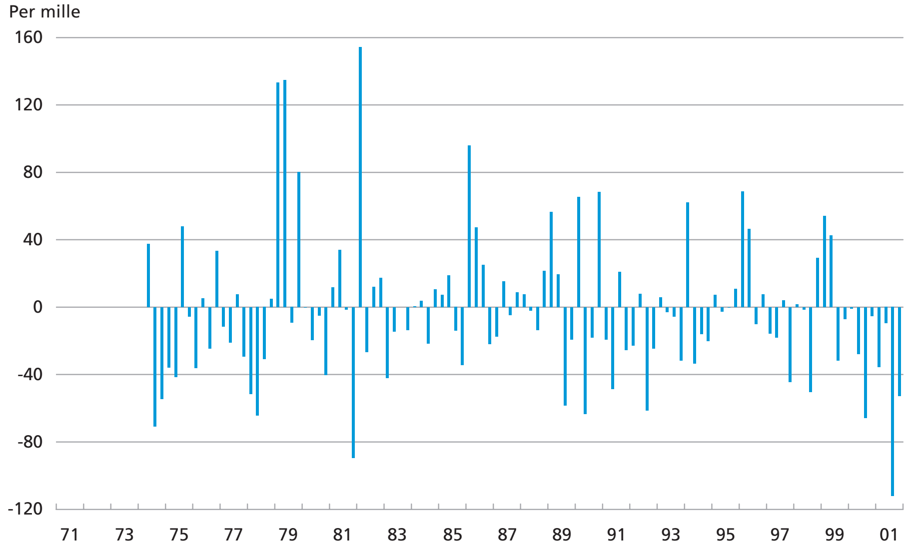
RESIDUALS, EXPORT VOLUME (Table II.1.2) Chart A.1



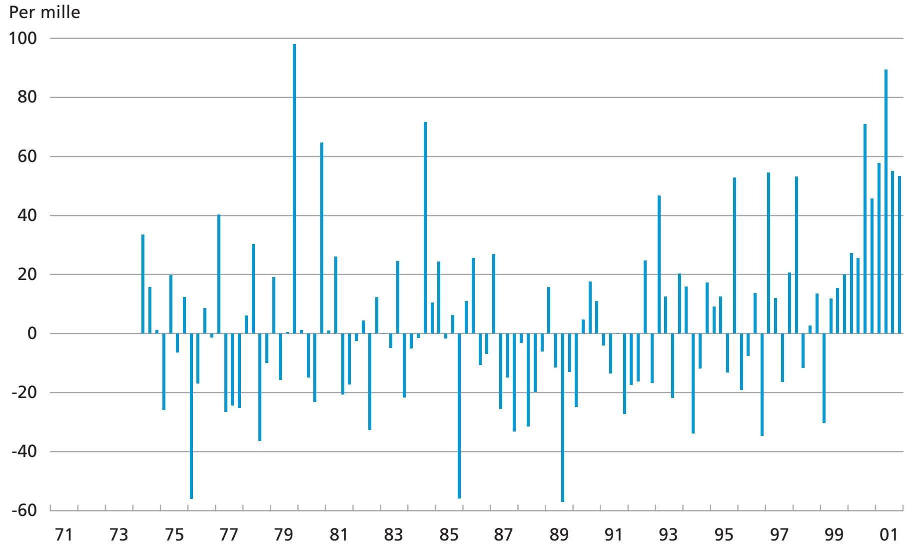
RESIDUALS, EXPORT PRICE (Table II.1.3) Chart A.2



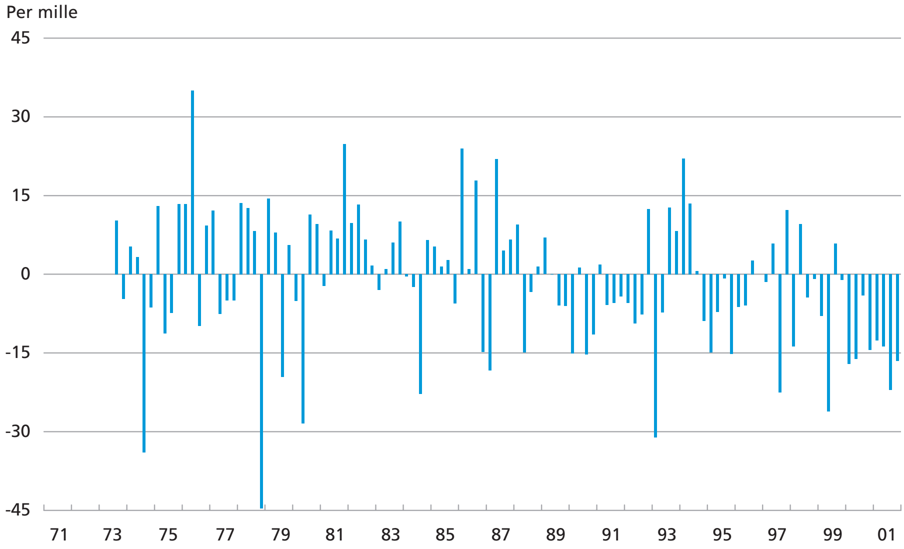
RESIDUALS, PRICE OF ENERGY EXPORTS (Table II.1.4) Chart A.3



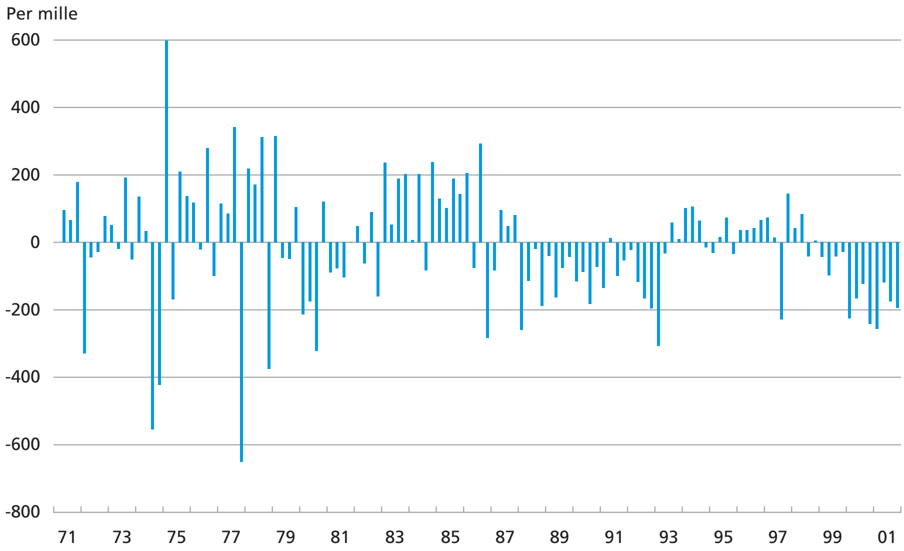
RESIDUALS, PRICE OF EXPORTS OF SERVICES (Table II.1.5) Chart A.4



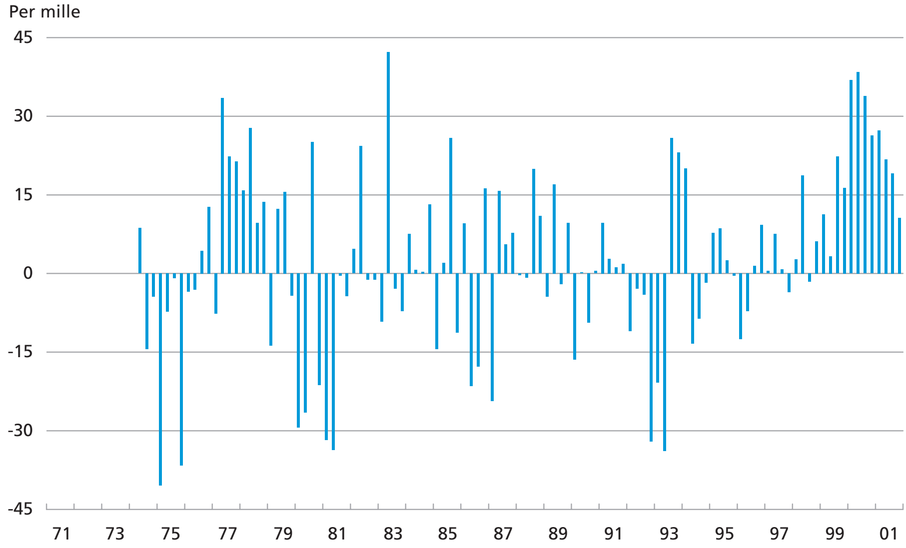
RESIDUALS, PRIVATE CONSUMPTION (Table II.2.1) Chart A.5



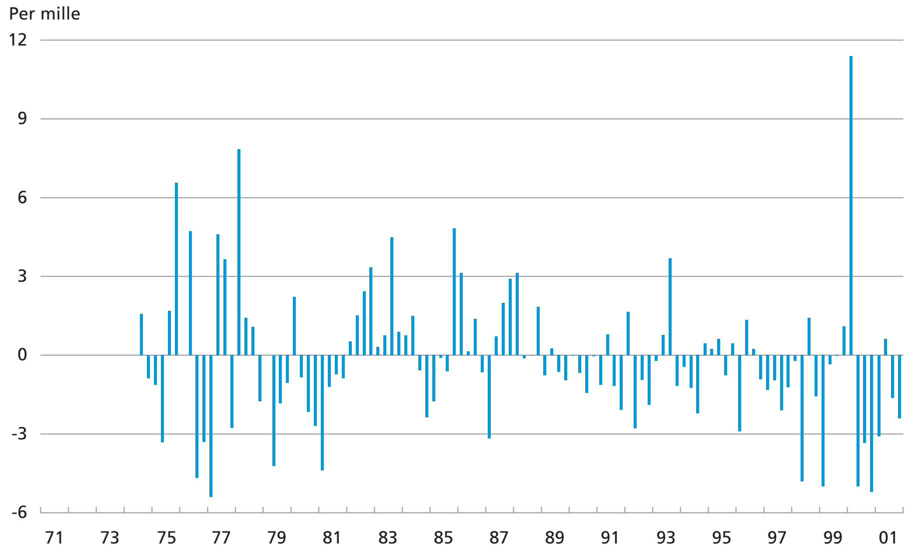
RESIDUALS, CAR PURCHASE (Table II.2.2) Chart A.6



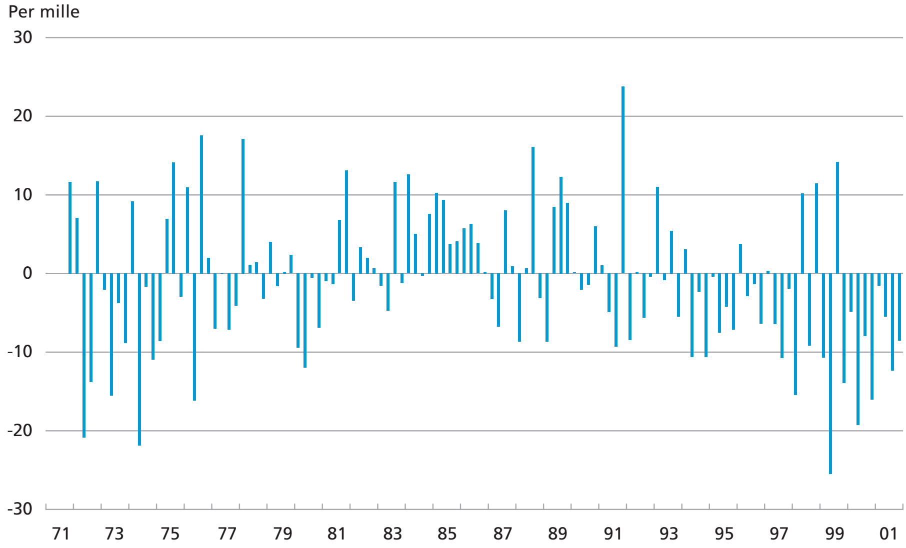
RESIDUALS, HOUSE PRICE (Table II.3.1) Chart A.7



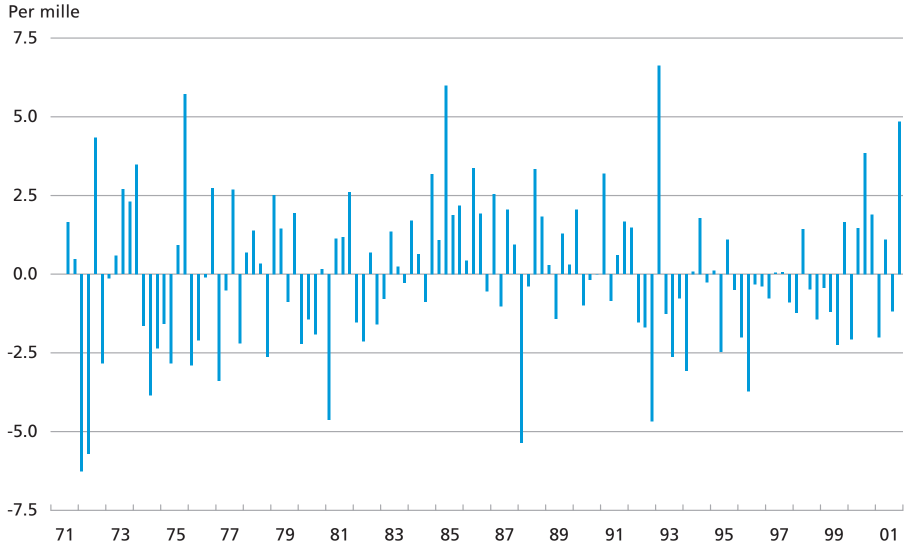
RESIDUALS, RESIDENTIAL INVESTMENTS (Table II.3.2) Chart A.8



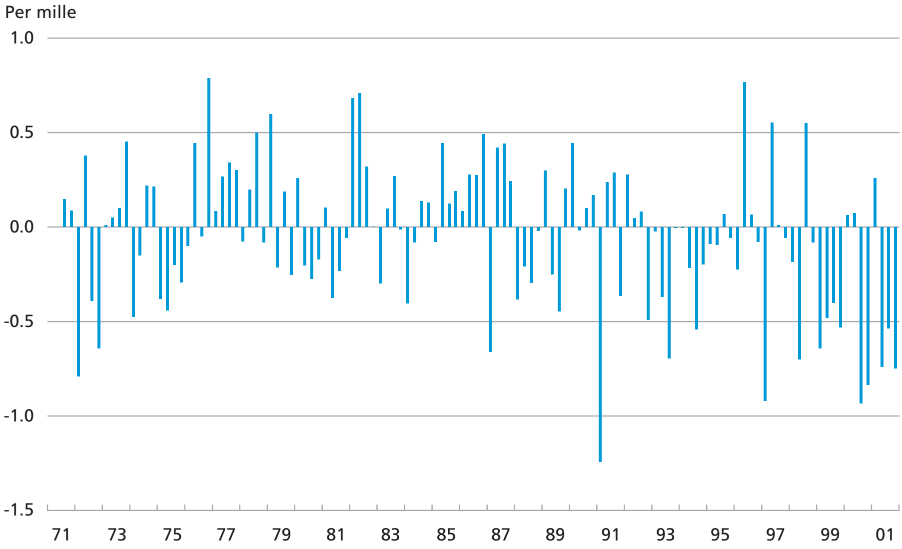
RESIDUALS, EMPLOYMENT (Table II.4.1) Chart A.9



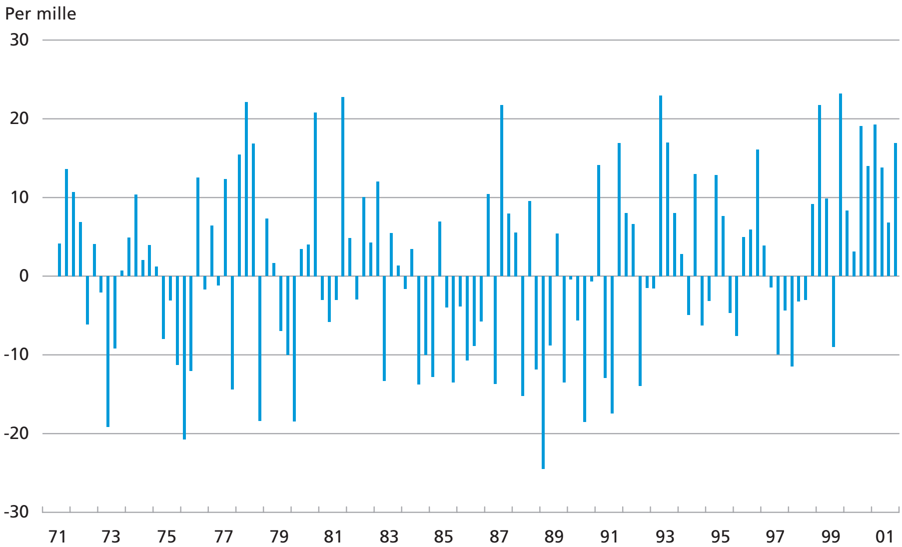
RESIDUALS, MACHINERY INVESTMENTS (Table II.4.2) Chart A.10



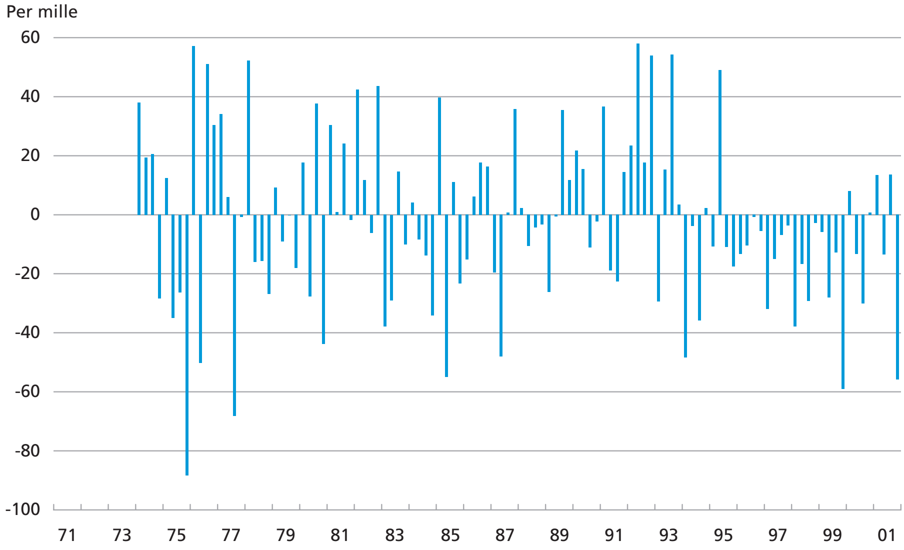
RESIDUALS, BUILDING INVESTMENTS (Table II.4.3) Chart A.11



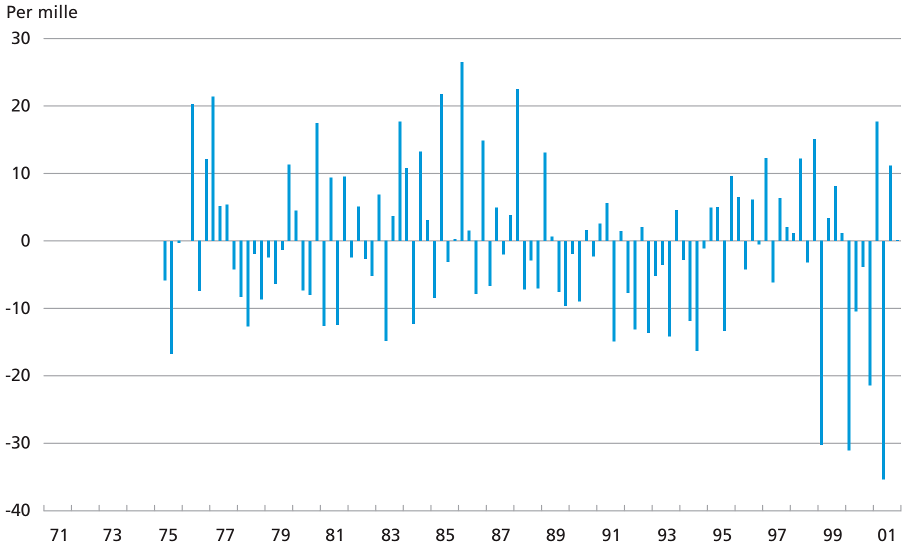
RESIDUALS, STOCKBUILDING (Table II.4.4) Chart A.12



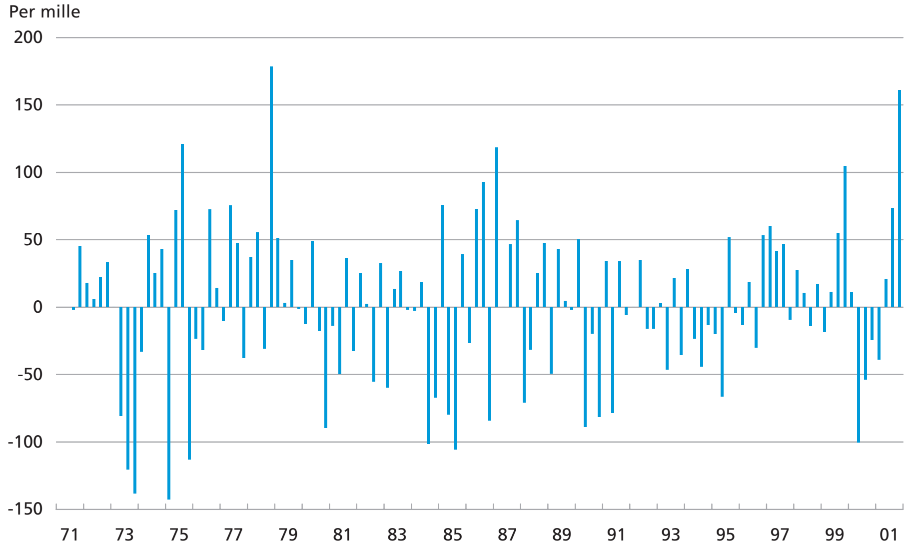
RESIDUALS, IMPORT VOLUME (Table II.5.1) Chart A.13



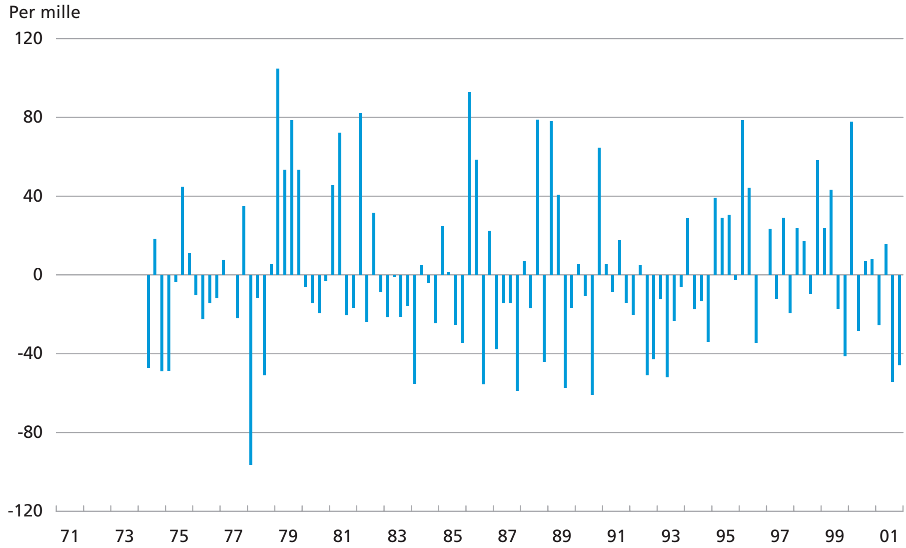
RESIDUALS, IMPORT PRICE (Table II.5.3) Chart A.14



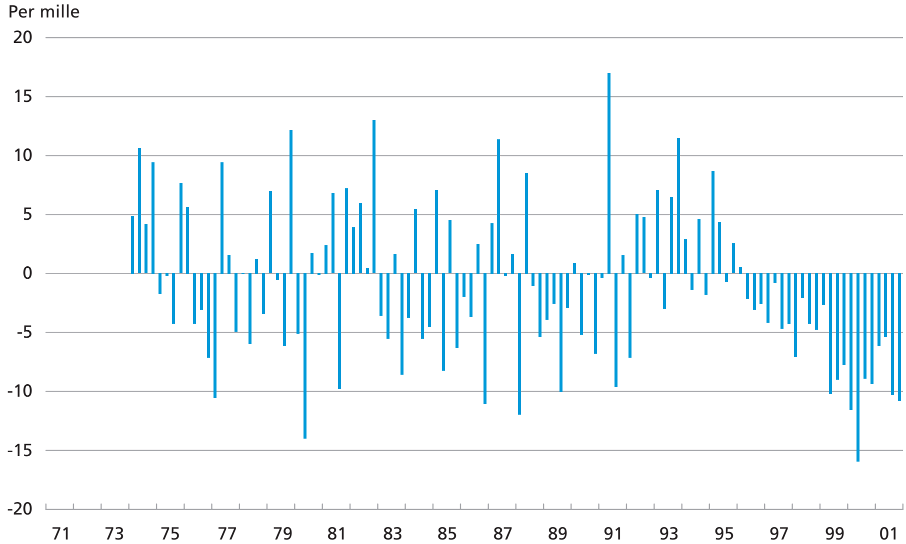
RESIDUALS, ENERGY IMPORTS (Table II.5.4) Chart A.15



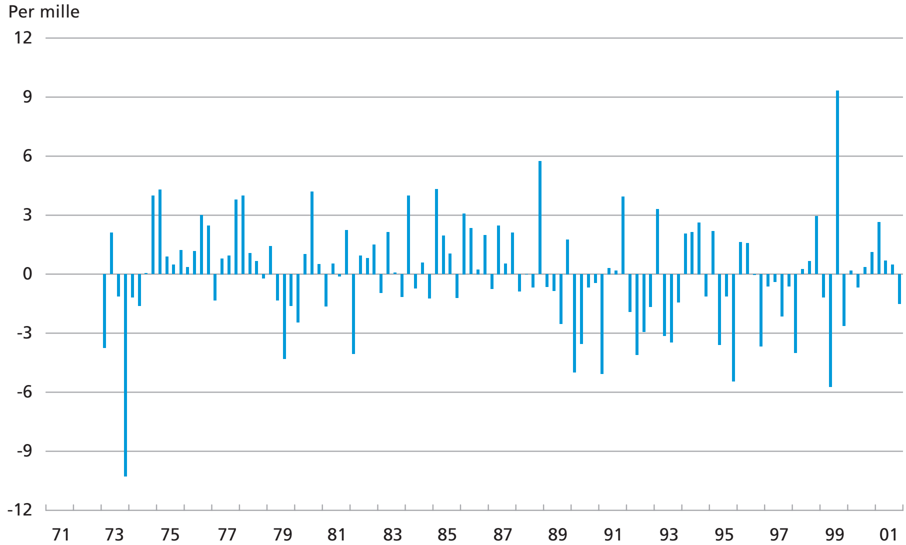
RESIDUALS, PRICE OF ENERGY IMPORTS (Table II.5.5) Chart A.16



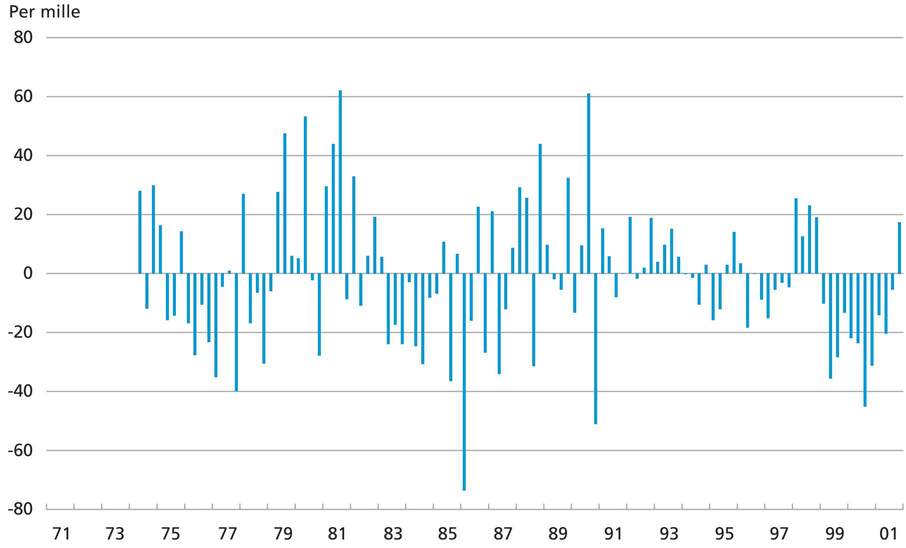
RESIDUALS, WAGE RATE (Table II.6.1) Chart A.17



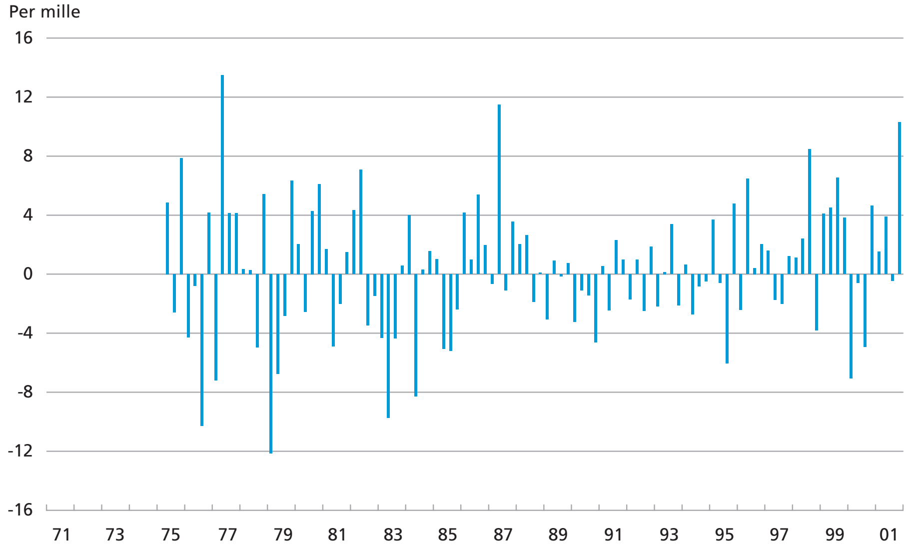
RESIDUALS, PARTICIPATION RATE (Table II.6.2) Chart A.18



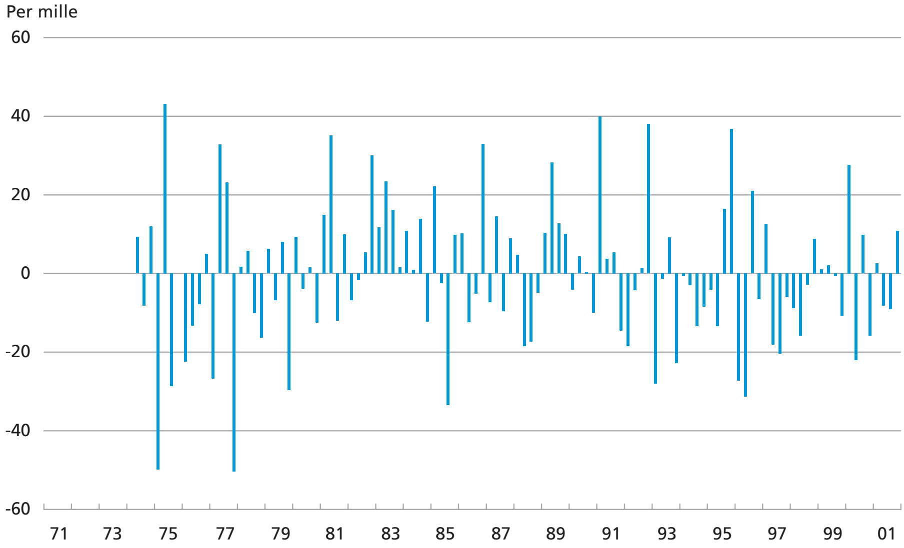
RESIDUALS, NET ENERGY PRICE (Table II.7.2) Chart A.19



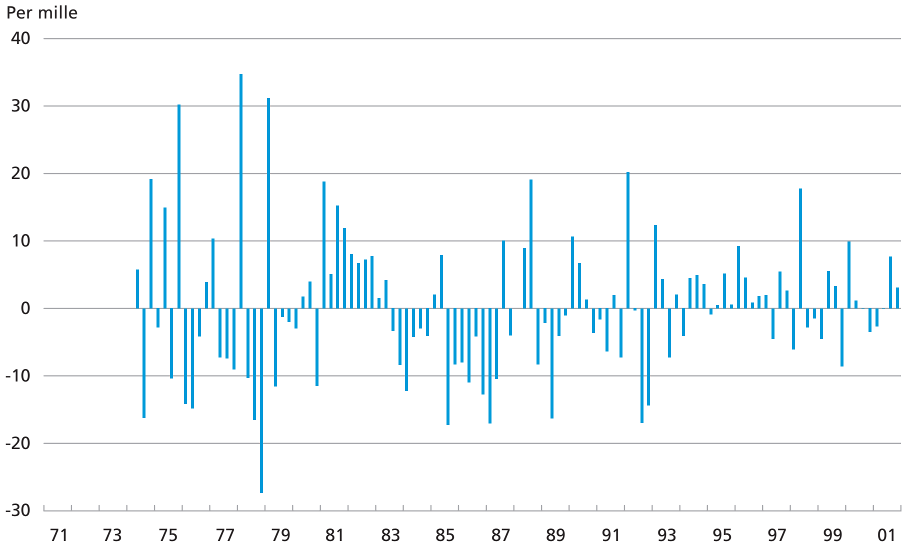
RESIDUALS, DOMESTIC MARKET-DETERMINED PRICE INDEX, (IMI INDEX) (Table II.7.3) Chart A.20



RESIDUALS, BASIC PRICE OF MACHINERY INVESTMENTS (Table II.7.4) Chart A.21



RESIDUALS, BASIC PRICE OF BUILDING INVESTMENTS ETC. (Table II.7.5) Chart A.22



III: Setting Up the Full Model

The estimated behavioural relations described in Chapter II are often the most complex building blocks in an economic model. At the same time, the estimated behavioural relations typically take centre stage when a model is assessed. However, merely lining up the 42 estimated relations does not make a model. The model must be closed to achieve a circular flow and consistent interaction between the estimated relations. Addition of a large number of non-estimated relations serves this purpose.

A range of identities are needed to reflect the relations in the national accounts, as regards uses and resources, constant and current prices as well as income formation. Apart from these bookkeeping identities Mona comprises identities that transform variables from logarithmic to ordinary form and vice versa. Such identities are primarily determined by how the model can best be written with the chosen software.

However, it is not enough to supplement the estimated relations with identities. Technical or calibrated relations are needed to bridge the gap where a relation has not been estimated, but where the variable should not be exogenous either, e.g. exports excluding industrial exports.

To sum up, Mona's relations can be divided into identities and non-identities, and non-identities can be divided into estimated and non-estimated relations. A division of non-identities into behavioural and technical relations is another possibility. The latter division does not necessarily correspond to the division of non-identities into estimated/non-estimated relations, and it should be noted that a division into behavioural and technical relations has to be a little fuzzy. For instance, an aggregated tax function captures both technicalities and behaviour in tax deductions.

The following presents an overview of Mona's main accounts followed by examples of technical relations in Mona regarding e.g. tax and indexation of public services. Finally the number of model variables is commented upon, and a diagram shows the general model flow.

Mona's national accounts-related flow variables fit into an account system with inflows and outflows for three sectors, private, public and foreign, as illustrated in Table III.1.1.

The difference between total receipts and total expenses in a sector describes the net lending of the sector in the quarter in question. This is also referred to as the savings balance since it corresponds to the sector's savings less investments. The private sector can be used as an example of this relation.

The private sector's disposable income, *ydp*, is the factor income of the sector, *y - iov*, plus current net transfer income. Using the variable names from Table III.1.1 this implies

$$\begin{aligned} ydp = \; & y - iov + (sisub + tyd + tye + tyo + typ + typi + jten + tien) \\ & - (siaf + sie + sbid + (sd - sak) + toi + tiov + tion) \end{aligned} \tag{III.1}$$

The model does not comprise a specific variable for private savings. If private savings are called *sp* and private investments including net capital costs are called *ip* the following applies

$$\mathrm{sp} = \; ydp - pcp \cdot fcp \tag{III.2}$$

and

$$\begin{aligned} \mathrm{ip} = \; & pipb \cdot fipb + pipm \cdot fipm + pih \cdot fih + pit \cdot fit + pile \cdot file \\ & + pila \cdot fila + pilbx \cdot filbx - tkon - tken + sak \end{aligned} \tag{III.3}$$

All items in the private account in Table III.1.1 are included in *sp* or *ip* except net lending, *tfpn*, which functions as the balancing item. According to the account format net lending equals savings less investments.

$$tfpn = \; \mathrm{sp} - \mathrm{ip} \tag{III.4}$$

An inherent feature of the double entry system of the account format is that for every expense there is a receipt so that net lending by the three sectors by definition sums to zero. This would also be the case if they were uniformly defined, but the foreign sector's savings balance is normally seen from a Danish point of view. What we call foreign net lending is thus the total domestic sector's net lending abroad. Consequently the bookkeeping identity is that private and public net lending add up to foreign net lending.

$$tfpn + tfon = tfen \tag{III.5}$$

BALANCE FORMAT FOR FLOW VARIABLES Table III.1.1

	Private		Public		Foreign	
	Debit	Credit	Debit	Credit	Debit	Credit
Inflows (credit) and outflows (debit)						
GDP – public reinvestment		*y-iov*				
Reinvestment				*iov*		
Imports						*pm·fm*
Consumption	*pcp·fcp*		*pco·fco*			
Exports					*pe·fe*	
Building investments	*pipb·fipb*		*piob·fiob*			
Machinery investments	*pipm·fipm*		*piom·fiom*			
Residential investments	*pih·fih*					
Change in breeding stock	*pit·fit*					
Stockbuilding, energy	*pile·file*					
Stockbuilding, agriculture	*pila·fila*					
Non-farm stockbuilding	*pilbx·filbx*					
Transfer flows						
Indirect taxes	*siaf*			*siaf*		
Subsidies		*sisub*	*sisub*			
Net indirect taxes, EU	*sie*					*sie*
Social contributions	*sbid*			*sbid*		
Direct taxes	*sd-sak*			*sd-sak*		
Other public receipts	*toi*			*toi*		
Unemployment benefits		*tyd*	*tyd*			
Early retirement benefits		*tye*	*tye*			
Leave benefits		*tyo*	*tyo*			
Pensions, etc.		*typ*	*typ*			
Transfers to private institutions		*typi*	*typi*			
Transfers to abroad			*tenou*			*tenou*
Transfers from abroad		*jten*		*tenoi*	*jten+tenoi*	
Surplus to public sector	*tiov*			*tiov*		
Net interest receipts	*tion*	*tien*		*tion*	*tien*	
Capital transfers	*sak*	*tkon+tken*	*tkon*	*sak*	*tken*	
Savings balances						
Net lending	*tfpn*		*tfon*			*tfen*
Memo:						
Excl. capital transfers	*tfpn-tkon-tken+ sak*		*tfon+tkon-sak*			*enl*

The foreign savings balance excluding capital transfers, *enl*, is also known as the balance of payments. The model's variables do not separate the household sector from the private sector. There is e.g. no corresponding disaggregation of private property income, whereby the model does not determine household income. However, based on Mona's variables it is possible to approximate quarterly household income, cf. Andersen et al. (1999).

On the output side the private sector is disaggregated to some extent, since gross value added (GVA) is available for the residential, energy and agricultural sectors as well as for the rest, i.e. the private non-farm sector. However, Mona should be seen as an aggregated model without particular focus on individual subsectors within the private sector.

Apart from national accounts-related flows Mona comprises series for financial holdings. These series represent a continuation of the data from Pedersen (1989).

In the present version of Mona, where the interest rate is given entirely from the euro area, the division into financial holdings plays an insignificant role, as the wealth effect on consumption goes via total private wealth included in the consumption function. Since it has little relevance to the model, no further comments are given regarding the breakdown by financial asset type. The original portfolio model and the remaining financial relations including the associated interest-rate formation were discussed in Christensen and Knudsen (1992).

NON-ESTIMATED RELATIONS 2

In chapter II we did not carefully examine each and every estimated relation and here we will only mention examples of non-estimated relations to illustrate the principles.

In continuation of the above outline of the model's account system we will begin with a few important identities concerning the transition between uses and resources for both constant prices and values and thus also for the relation between them, i.e. for prices.

In Mona GDP at constant prices, *fy*, is determined using the identity

$$\begin{aligned} fy = \; & (fcp + fco) + \\ & (fih + fio + fipm + fipb + fit + file + fila + filbx) + fe - fm \end{aligned} \tag{III.6}$$

in which the first parenthesis is total consumption and the second parenthesis is total investment. This corresponds to the inflow/outflow part of Table III.1.1 also applying at constant prices in the ordinary national accounts.

It should be noted that the normalisation on GDP does not imply that Mona determines GDP from the demand side. In the short term Mona is a demand-driven model, but in the longer term the model generates crowding-out effects whereby GDP becomes primarily a function of the labour force while exports are set in such a way that the GDP identity holds. In other words, it is necessary to view the entire model to understand how GDP is determined. The GDP identity is an inherent part of all models respecting the normal national accounts.

The model does not comprise a production relation for total GDP. The model's central endogenous production sector is the private non-farm sector and GVA of the private non-farm sector, *fyfbx*, is linked to GDP through the identity

$$fyfbx = fy - fsi - (fyfo + fyfla + fyfe + fyfh) \tag{III.7}$$

where on the right-hand side both net indirect taxes at constant prices, *fsi*, and a parenthesis with GVA in other production sectors, i.e. public, *fyfo*, agricultural, *fyfla*, energy, *fyfe* and housing, *fyfh*, are deducted from GDP.

This transition to the private non-farm sector's GVA also applies at current prices,

$$\begin{aligned} yfbx = \; & y - (siaf + sie - sisub - (siqej + siqv + siqam + siquab + siqr - sigs)) \\ & - (yfo + fyfla \cdot pyfla + fyfe \cdot pyfe + yfh) \end{aligned} \tag{III.8}$$

where the GVA variables are without the prefix, *f*, or multiplied by a price and the first parenthesis is total net indirect taxes. With GVA at constant prices and at value the private non-farm sector's GVA deflator, *pyfbx*, is by definition

$$pyfbx = \frac{yfbx}{fyfbx} \tag{III.9}$$

This residual determination implies that the deflator for the private non-farm sector reflects a number of variables in the model. The price relations for the individual demand components must be constructed to ensure the highest feasible consistency between the private non-farm sector GVA deflator and the supply block. This price consistency is difficult to ensure and has not been fully achieved in Mona, cf. the discussion in the section about domestic price relations in Chapter II and the Box about the composition effect in Chapter IV.

After the examples of identities for inflow/outflow and constant/current prices we will take a look at the technical relations for tax and transfers that are part of the model's income formation.

The indirect taxes that contribute to price formation are described as rates added to the basic price to arrive at the market price. Since the rates reflect the proceeds on indirect taxes allocated to demand components, it is possible to determine the proceeds on indirect taxes in the model by multiplying the rates on the demand components and adding up. Total VAT, *sig*, comprises e.g. a contribution from VAT on car purchases

$$\text{VAT on passenger cars} = \frac{tg \cdot btgb \cdot pcb \cdot fcb}{(1 + tg \cdot btgb) \cdot (1 + trb)} \qquad \text{(III.10)}$$

where *tg* is the official VAT rate, *btgb* is a loading factor relatively close to 1, which ensures that the calculated VAT proceeds on car purchases fit, and *trb* is the registration duty rate. Car purchases at market prices are *pcb·fcb* and the registration duty is added after VAT so car purchases excluding VAT and registration duty constitute the tax base for the adjusted VAT rate *btgb·tg*.

Consumers' car purchases correspondingly make (the largest) contribution to the registration duty proceeds, *sir*

$$\text{registration duty} = \frac{trb \cdot pcb \cdot fcb}{1 + trb} \qquad \text{(III.11)}$$

The registration duty rate is calculated implicitly so there is no need for a loading factor. The two relations (III.10) and (III.11) illustrate the principles, and the other endogenous tax proceeds are determined in identical relations with appropriate tax bases. Taxes on real property, which in national accounts are non-product related indirect taxes, are, for instance, related to the taxable value of the property, applying the model's house price.

The construction of the direct tax relations is equally simple. Thus the PAYE tax proceeds, *askat*, are determined by multiplying a tax rate by wage and transfer income minus allowances. Without specifying the relevant model variables the relation is as follows

$$\begin{aligned} askat = \; & bsda \cdot (\text{compensat ion} + \text{transfer} \\ & - \text{pension contributi on} - \frac{b1574}{1000} \cdot pfrd) \end{aligned} \qquad \text{(III.12)}$$

where the last deducted term in the parenthesis, *b1574·pfrd*, is population multiplied by personal tax allowance. The PAYE rate, *bsda*, is calculated implicitly, whereby the relation matches the official PAYE tax proceeds. The expression in the parenthesis does not necessarily match the official tax base. The aggregated approach means that the effect of a given change in the local or central government tax rate on the tax rate in the relation must be partly assessed outside the model. For example, the relative change in the relation's tax rate can be calculated by expressing the immediate proceeds effect of a tax change as a ratio of total PAYE tax proceeds. The Danish Ministry of Finance often states this immediate proceeds effect.

From among the transfers e.g. total unemployment benefits, *tyd*, are determined on the basis of the unemployment benefit rate and the number of unemployed.

$$tyd = \quad faktor \cdot dagst \cdot ul \tag{III.13}$$

The unemployment benefit rate, *dagst*, is the official maximum rate and *ul* is the number of registered unemployed people. The development of the pre-multiplied proportionality factor in the historical period ensures the validity of the relation. This factor e.g. captures changes in the benefit claimants/registered unemployed ratio and in the average/maximum unemployment benefit ratio. The factor is an exogenous variable in the model, whereby complete proportionality is implied in model calculations. In the historical period the factor is defined by the relation. In the projection period the factor is usually set at its latest historical value.

In the model the relation shown for unemployment benefits is arranged logarithmically in order that the factor can function as an additive adjustment term.

$$\log(tyd) = \quad \log(dagst \cdot ul) + \log(faktor) \tag{III.14}$$

The applied software makes it easier to formulate additive adjustment terms so that the same logarithmic arrangement can be applied to a number of other relations describing proportionality. For instance, the unemployment benefit rate, *dagst*, is not exogenous, but with a time lag it is made proportional to private wages, and this relation is also put into logarithms.

The application of private wages to index the unemployment benefit rate reflects the usual rule regarding rate adjustment, which is also applied to other similar relations in Mona. For instance the personal tax allowance from the PAYE equation is index-linked on the basis of wages.

Similarly, the wage rate for public employees is indexed with a lag to private wages. For years the collective wage agreements for the public sector have comprised an 80-per-cent adjustment clause. Besides, private wage formation via the market mechanism also influences public wage formation. Consequently, in the relation for public wages there is full indexation to private wages with a lag of one year.

Note that model calculations may not always activate all technical relations. In connection with short-term forecasts and other short-term considerations more information is often available about public wages and rates than what is implied by the simple technical relations, so it is easier if these variables are exogenous. On the other hand, e.g. in connection with multiplier calculations covering longer periods, it may be important that major parts of public finances accommodate the development in private wages through indexation. As mentioned, this wage indexation is inherent in the Danish adjustment mechanisms, but also as a general principle wage indexation of public finances can be a neutral starting point with a view to the distributional impact.

The technical relations regarding income formation are typically applied to ensure proportionality between a variable and an expression in other variables. Such proportionality-inducing relations are also found in connection with price formation.

Most demand components in the model have their own deflators, although price relations have not been estimated for all deflators in the model. For instance, a relation has been estimated for the basic price for total building investments whereas the deflators for residential investments, business building investments and public building investments are based on this basic price for total building investments, *qib*. The residential investment deflator, *pih*, has the following technical relation

$$pih = \text{faktor} \cdot (1 + btgih \cdot tg) \cdot qib \qquad \text{(III.15)}$$

where *tg* is the VAT rate and *btgih* is a loading factor, cf. the reference to *btgb* in the technical relation for VAT on car purchases. The proportionality factor *faktor* varies in the historical period so that the relation fits. In the projection *faktor* is constant. As indicated, the model comprises a number of these technical price relations. A number of relative prices are thus locked when shocks are applied to the model. This means that some prices move concurrently, so there are fewer autonomous price movements in the model than there are prices. This also fits with the fact that the price relations generally apply the non-farm marginal cost whereby the Danish production cost is measured on the basis of the production function for one sector, i.e. the private non-farm sector.

After the description of important non-estimated relations for real-economic variables it is appropriate to mention some financial relations where e.g. foreign debt, *fqqf*, based on flow-of-funds is defined on the basis of the balance of payments, *enl*.

$$fqqf = fqqf_{-1} - 0{,}25 \cdot enl \qquad \text{(III.16)}$$

Like the other flow variables the balance of payments is calculated on an annual basis and hence divided by four. To calculate the market price of the foreign debt a distribution by asset type is required, e.g. how many krone-denominated bonds are held abroad. This part of the model is closed by means of simple assumptions. In multiplier experiments the total effect on the balance of payments is normally assumed to be financed by movements in the foreign holdings of krone-denominated bonds.

The public and private sectors' net assets based on flow-of-funds are, in principle, calculated in the same way as the foreign debt by cumulating the sector's net lending. The so-called government-debt norm has been incorporated for the public sector as regards distribution by asset type. In connection with model calculations it is normally assumed that the effect on public net lending relates to central-government finances, and the effect is financed by issuing government bonds.

After the description of identities and simple technical relations we will look at the fiscal reaction function that determines the duty rate, *tpkq*, on consumption so that government net lending, *tfon*, is stabilised as a ratio of GDP, *y*. The actual relation is as follows

$$tpkq = \quad tpkq_{-1} \cdot \left(1 - \frac{0.5 \cdot tfon_{-1}}{y_{-1}} - 0.5 \cdot \Delta\left(\frac{tfon_{-1}}{y_{-1}}\right) + 0.5 \cdot \Delta\left(\Delta\left(\frac{tfon_{-1}}{y_{-1}}\right)\right)\right) + \text{adterm} \qquad \text{(III.17)}$$

The relation implies that the budget balance as a ratio of GDP must settle down before the duty rate can settle down. A simple relation which has proven stable has been selected, cf. the example of multiplier properties in Chapter IV. It is an auxiliary relation where the implied long-term restriction on public finances is the crucial point. However, the actual choice of instrument and the development over time of the fiscal reaction are difficult to determine *a priori*. Several other formulations will give the same end result. Gradual adaptation of the duty rate is decisive, otherwise fiscal policy will be too procyclical, resulting in an unstable or at least protracted adaptation period. The problem is that e.g. a boom improves the budget balance, so if the duty rate is reduced rapidly and substantially, the cyclical fluctuation is amplified.

The relation (III.17) is not applied in short-term forecasts but budget balancing is, in principle, an important property as regards more long-term projections and multiplier experiments.

We have now seen examples of the most important non-estimated relations in Mona.

MODEL SIZE AND DIAGRAM 3

Mona consists of 294 non-estimated relations and 42 estimated relations, totalling 336 relations which determine 336 endogenous variables. In addition, there are 401 exogenous variables, of which 227 are adjustment terms in Mona's relations. The remaining 174 are conventional exogenous variables such as public consumption, exchange rate, interest rate and the price of crude oil where the definition is not linked to Mona's relations in the same way as for the adjustment terms. Exogenous variables will often be taken to mean only the 174 conventional variables, but exogenous shocks to the model may also be introduced through the model's adjustment terms.

All model relations except the identities comprise adjustment terms. In an estimated relation the adjustment term reflects the estimation residual, and in a non-estimated relation it may reflect e.g. the proportionality factor of the relation. A case in point is the technical relation linking the unemployment benefit rate to wages. If the planned change of the rate exceeds what is inherent in the technical relation the rate change may be introduced via the adjustment term of the technical relation. Adjustment terms are often applied in connection with forecasts, cf. Chapter V.

Furthermore, it should be noted that the breakdown by endogenous and exogenous variables might vary. As mentioned, some of the non-estimated relations are less relevant when Mona is applied to short-term forecasts, which therefore exclude these relations. The corresponding variable on the left-hand side is exogenous instead. Mona may be perceived as a gross model where the purpose determines whether all relations are activated when the model is applied.

The size of the model cannot be described merely by its number of relations, i.e. 336. The number of relations or equations does not give any indication of the span or complexity of a model. Not all equations are equally important and their number may be changed by trivial restructuring. Inserting equations into other equations will reduce their number. Conversely, the number of equations may be increased by introduction of auxiliary variables, i.e. introduction of new variables defined as expressions in the existing variables.

It is immaterial whether one model has more equations than another because it defines more auxiliary variables. To take a closer look at the scope of a model it is necessary to make a qualitative assessment of the endogenous variables and to consider the level of detail.

Adam, for instance, comprises 1800 equations, i.e. many more than Mona. However, the two models resemble each other in terms of which and how large parts of the economy they describe in their equations. The difference in size relates to the level of detail where Mona is clearly more aggregated than Adam. The latter comprises a more detailed breakdown of the production side, including an input-output system. The level of detail in Adam is also higher regarding the public sector – where duty rates, etc. are distributed on more sectors and prices.

Mona, in turn, is more detailed than the ECB's Area Wide Model (AWM) for the euro area, cf. Fagan et al. (2001). The described version of the AWM has less than 100 equations. The AWM describes an economy with inherent interest-rate and exchange-rate formation including a Taylor rule for the short-term interest rate. In this respect the span of the AWM model – despite its fewer equations – is thus wider than that of both Mona and Adam.

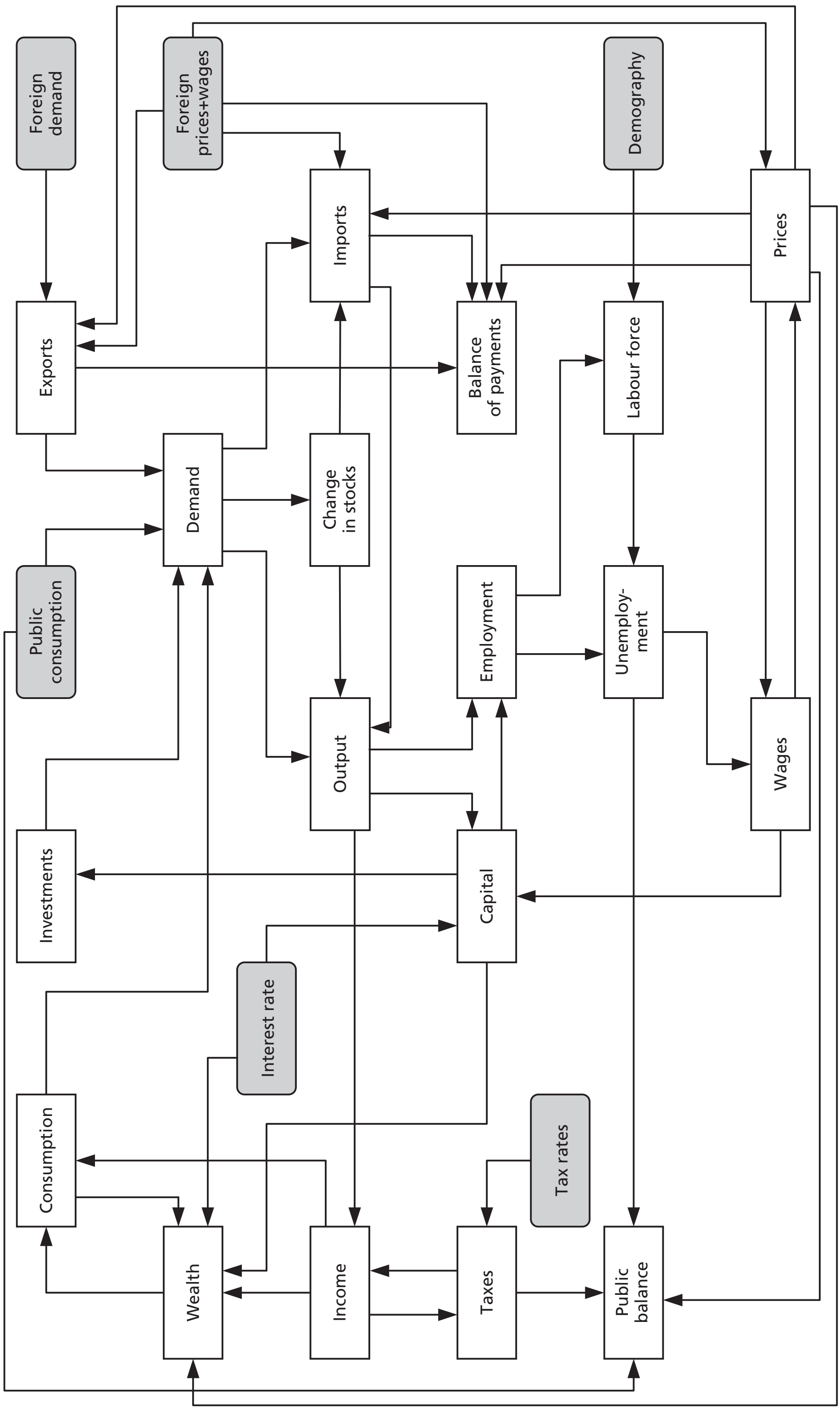
Diagram III.2.1 illustrates the most important relations in the model. Not surprisingly, the diagram resembles diagrams for Adam and especially diagrams for the Smec model, which is roughly the same size as Mona. A fundamental difference compared to the Smec diagram in Bocian et al. (1999) is that the diagram describing Mona does not contain an input/output-system for distribution of demand on output and imports. Instead it is indicated that stockbuilding in a quarterly model plays an integrated role in the short-term adaptation of supply to demand.

Otherwise the diagram illustrates how a change in an exogenous variable, e.g. public consumption, influences both demand and income as well as wage and price formation. There is a tendency for demand shocks to be amplified through the Keynesian multiplier accelerator, and an offsetting tendency for shocks to be crowded out via the reaction in wage and price formation as well as the price sensitivity of foreign trade.

The mechanisms are well known, but it is often more difficult to embrace Mona than textbook models. Mona comprises many more variables, and most of Mona's endogenous variables are determined in a big simultaneous block with complex interactions. An applied model does not focus on just one element but contains both short-term and long-term mechanisms.

In practice, Mona cannot be solved analytically so one cannot derive and study the reduced form of the model. The model is always solved numerically using an algorithm. To illustrate the properties of the Mona model, it can be solved for alternative values of the exogenous variables. This may be used to illustrate how the most important endogenous variables react to stylised exogenous changes. Chapter IV describes these multiplier experiments.

FLOW CHART FOR MONA | Diagram III.3.1



IV: Multiplier Experiments

This Chapter presents the effect on the model's endogenous variables of changes to selected exogenous variables. Such simulations can illustrate the effect of political measures or external shocks to the economy. At the same time, the simulations highlight the properties of the model, which is the purpose of this presentation.

Economic theory is often about relations describing equilibrium. In relation to a set of equilibrium relations a multiplier experiment often consists in comparing two equilibria without specifying the related adjustment over time. With an estimated economic model such as Mona, however, an experiment consists in comparing two trajectories over time. In other words dynamics are a key issue, and a quarterly model often focuses on the reaction in the first years and quarters rather than the long-term reaction. We will, however, also take long-term reactions into account in this Chapter.

Four experiments will be outlined, in which central exogenous variables are changed. First the effect of a permanent increase in the public purchase of goods is considered. This experiment is often used for model assessment, and the review is relatively detailed, to illustrate the model's most important relations, short-term dynamics and crowding-out mechanism.

Subsequently the impacts of an exogenous monetary shock are analysed. The shock includes a change in interest rates and its real effect in the euro area, which is Denmark's currency anchor. The third experiment concerns the supply side in terms of a permanent increase in the labour force. The fourth experiment is actually two experiments: two simple stochastic simulations in which random figures are used to shock the consumption function and wage relation, respectively.

SHOCK TO THE PUBLIC PURCHASE OF GOODS 1

The experiment comprises a permanent increase in the public purchase of goods corresponding to 1 per cent of GDP over the base line. The term purchase of goods covers public consumption not produced in the public sector, but purchased from the private sector. The component comprises purchase of goods and services from the private sector. The share of services is relatively high, so the term purchase of goods is a shortened form. Such purchases boost employment and value added in the private sector, as well as imports, while value added in the public sector is not affected. Public-sector employment thus remains unchanged.

The reason for applying a shock to the public purchase-of-goods segment when assessing economic macromodels is that it is an easily understandable policy variable where the related impacts on employment and output reflect behaviour in the endogenous private sector.

A review of a multiplier experiment could in theory be split into two: a short-term review where the wage and price reactions are insignificant, and a long-term review where the wage and price reactions are pivotal to adaptation. However, if this is the only approach to the model's results, the review will be rather simplistic. The model's wages, prices and other variables do not adapt by jumping, and in the simulation results the long-term effect gradually emerges from the short-term effect.

Instead the review of the purchase-of-goods experiment is based on one or two variables at a time, e.g. consumption and residential investments, with a view to identifying short-term and long-term reactions. Initially, we will, however, consider the calculation method and give an overview of the main elements of the result, including the reaction in the very first quarters of the experiment.

On the calculations behind the experiment

When a theoretical model is assessed, it is often solved so that the endogenous variables are expressed by exogenous or predetermined variables solely. Differentiation of this reduced form makes it possible to express how changes in the exogenous variables affect the endogenous ones via the model's interactions.

This is, however, a too complex and messy approach for an estimated macromodel such as Mona. Instead the effect of the exogenous variables on the endogenous ones is calculated numerically as the difference between two trajectories calculated by the model. More specifically, the model is first solved for a base-line solution. Then one variable, viz. the public purchase of goods, is increased, and the model is solved again. The difference between the two lines describes the effect of increasing the purchase of goods.

The base line can be set up in several ways. For instance, a historical period may be selected. In this case we have opted for a synthetic trajectory, starting in 2000 with sustained growth percentages for the exogenous variables, e.g. foreign demand, and with zero adjustment terms in the behavioural relations. The base line is described in more detail in Box IV.1.1.

CONSTRUCTION AND SIGNIFICANCE OF BASE LINE Box IV.1.1

As previously stated, multipliers are calculated as the difference between two model solutions: a base line and a trajectory with the desired exogenous change. The stylised base line is a steady-state growth scenario where

- growth rates in all price variables are constant and identical so that relative prices remain unchanged over time
- growth rates in all quantity variables are constant and identical, so that various ratios and rates are constant
- debt and wealth ratios for the private and public sectors are constant.

Specifically, the exogenous variables are set to target a real growth rate of 2 per cent per annum and a rate of inflation of 1.8 per cent with 2000 as the starting point. The adjustment terms are set at zero in the estimated relations. The nominal rate of interest is set at the sum of the targeted rates of real growth and inflation, so that the real rate of interest is equal to the real growth rate in steady state.

Many of Mona's relations are linear in logarithms, so the base line is not always paramount to the percentage effect. A different composition of the base line may, however, affect the result, since the demand components have different behavioural relations. Also another growth rate or rate of inflation in the base line may in principle also affect sensitivity.

The profile of the exogenous shock is just as decisive as the base line. For instance, the change in the public purchase of goods is expressed as 1 per cent of GDP in the base line. This means that the change at constant prices grows by a few per cent annually. This gives another, more expansive profile in the result than if the intervention had been fixed in billions of 1995-kroner.

The effect on an endogenous variable of a certain change in an exogenous one is known as a multiplier. In our calculation a multiplier for public purchase of goods is generated for each endogenous variable and for each quarter in the trajectory period. In other words there are numerous multipliers describing the effect on the endogenous variables. Normally one would focus on some of the effects, e.g. the activity effect in the first four quarters of the experiment, the long-term effect, the strongest effect on e.g. GDP, or how soon the employment effect returns to zero, etc. Here we will consider a number of effects.

Highlights of the calculation result

Some significant effects of increasing the public purchase of goods are shown in Table IV.1.1. The effect on output and demand is stated as the percentage deviation from the base line. This is in step with the shock being expressed as a percentage of GDP. The first line shows that private consumption increases by 0.04 per cent in the 1st quarter of the experiment, while e.g. unemployment falls by 0.04 per cent of the labour force. The impacts on the three savings balances (private, public and

EFFECT OF AN INCREASE IN PUBLIC CONSUMPTION BY 1 PER CENT OF GDP Table IV.1.1

	1st year				2nd year				5th year	10th year	20th year
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4			
	Percentage deviation from base line										
Private consumption	0.04	0.16	0.28	0.33	0.36	0.38	0.40	0.41	0.59	1.05	0.69
Public consumption	4.24	4.25	4.25	4.25	4.26	4.26	4.26	4.27	4.31	4.38	4.44
Residential investm.	0.00	0.05	0.14	0.24	0.32	0.38	0.42	0.43	-0.24	-0.51	0.21
Business investments	0.16	0.50	0.66	0.79	0.93	1.05	1.15	1.23	1.35	0.64	0.34
Stockbuilding[1]	-0.22	0.09	0.18	0.13	0.09	0.08	0.07	0.06	-0.01	-0.01	0.00
Exports	-0.01	-0.04	-0.10	-0.17	-0.23	-0.29	-0.35	-0.41	-1.12	-1.88	-1.31
Imports	1.09	1.40	1.56	1.53	1.48	1.46	1.45	1.42	1.11	1.14	1.10
GDP	0.38	0.69	0.78	0.78	0.78	0.80	0.81	0.81	0.63	0.36	0.46
Employment	0.06	0.23	0.33	0.40	0.45	0.51	0.55	0.58	0.50	-0.12	0.02
Unemployment[2]	-0.04	-0.13	-0.20	-0.24	-0.28	-0.32	-0.35	-0.38	-0.37	0.07	-0.01
	Deviation from base line in per cent of GDP										
Private savings bal.	0.35	0.12	-0.02	-0.06	-0.08	-0.11	-0.13	-0.15	-0.04	0.06	0.08
Public savings bal.	-0.74	-0.62	-0.56	-0.52	-0.50	-0.48	-0.47	-0.46	-0.67	-1.15	-1.36
Balance of payments	-0.39	-0.50	-0.58	-0.58	-0.59	-0.59	-0.60	-0.61	-0.71	-1.09	-1.28
	Percentage deviation from base line										
Consump. deflator	0.01	0.03	0.05	0.08	0.09	0.10	0.11	0.13	0.37	0.80	0.73
Wage costs	0.00	0.01	0.04	0.10	0.15	0.22	0.29	0.37	1.38	2.18	1.40
Productivity	0.14	0.39	0.37	0.26	0.17	0.11	0.05	-0.01	-0.23	0.20	0.18
Terms of trade	-0.02	-0.02	-0.01	0.01	0.03	0.06	0.08	0.11	0.40	0.61	0.41
	Deviation from base line in percentage points										
Consumption ratio	-0.14	-0.23	-0.18	-0.12	-0.09	-0.08	-0.07	-0.07	-0.12	0.02	-0.01
Wage share	-0.15	-0.27	-0.26	-0.20	-0.16	-0.12	-0.08	-0.05	0.25	0.22	0.01

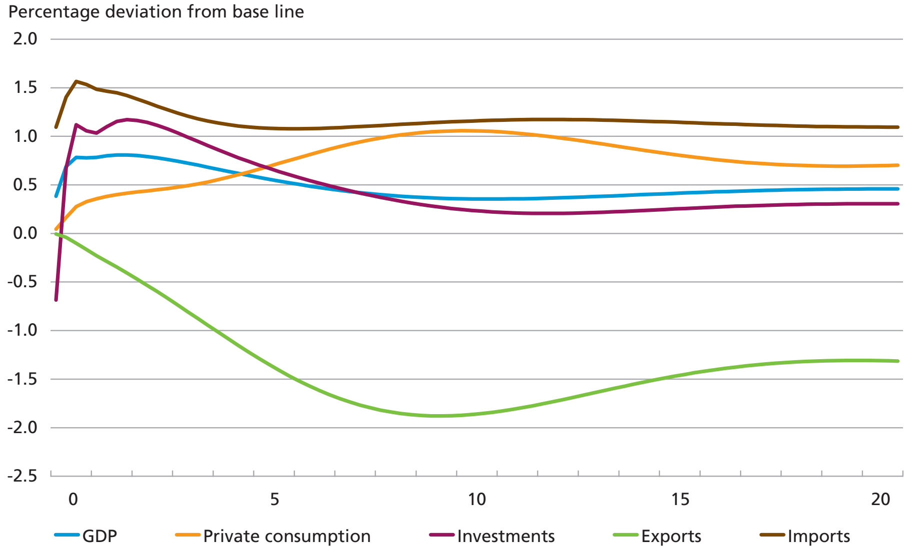
1 Per cent of GDP.
2 Percentage points.

foreign) are shown as percentages of GDP. The increase in the public purchase of goods by 1 per cent of GDP implies that total public consumption has increased by just over 4 per cent.

In the first years, Mona behaves like a short-term model where stronger demand boosts output. The increase in output triggers higher income, private consumption and investments, so the process is self-enhancing in that demand generates income, and income generates demand. This is the well-known Keynesian multiplier and accelerator process. The maximum effect on GDP is reached during the 2nd year, when output has increased by approximately 0.8 per cent compared with the base line. The effect on the main components of the supply balance is illustrated in Chart IV.1.1. The time unit on the x axis of the Charts in this Chapter is years, unless otherwise indicated.

In the following years the crowding-out mechanisms gradually take over. The increased activity exerts an upward pressure on wages and

EFFECT ON OUTPUT AND DEMAND Chart IV.1.1



Note: In all Charts in this Chapter, the unit of the horizontal axis is years, unless otherwise stated.

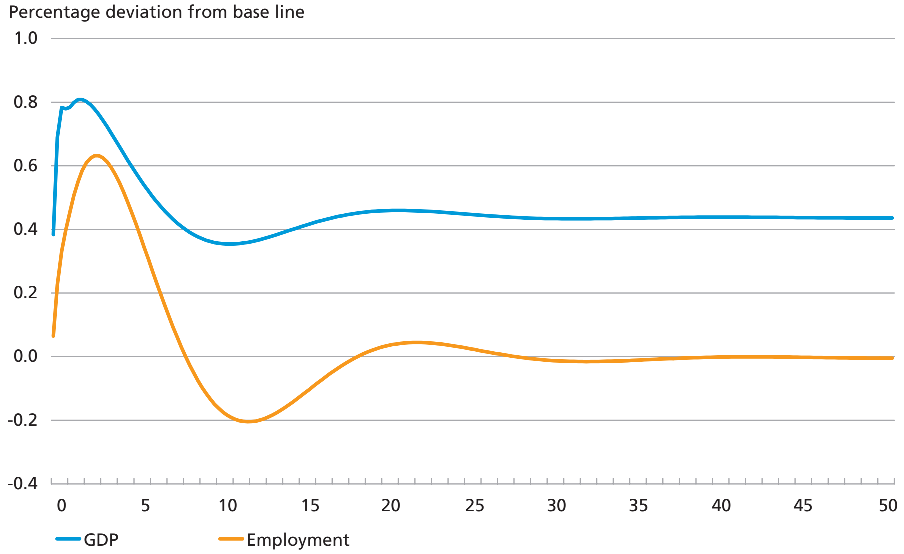
prices relative to the base line and thus also vis-à-vis foreign wages. This reduces exports, and the effect on employment and unemployment returns to zero after 7 years. However, although the long-term properties of the model are starting to dominate, the activity effect is not stabilised at zero after 7 years. It takes somewhat longer before the important quantity and price variables are in a steady state again. The model's output and demand variables do not in effect reach equilibrium until after approximately 30 years, cf. Chart IV.1.2 showing the effect on GDP and employment over 50 years.

Equilibrium should be taken to mean that the distance to the base line remains constant or only fluctuates insignificantly. The constant distance after 30 years does not apply to all variables, however, cf. the sections on the public and foreign debt ratios below.

The reason why the model in the long term crowds out the initial employment effect so that we return to the same level of unemployment, is not that unemployment must be at a certain NAIRU level in order to avoid permanently accelerating or decelerating wages. This is not an element of the model's wage relation, cf. the corresponding section in Chapter II. The reason for the crowding out is that we have to match the currency anchor's level of inflation.

Mona has an exogenous exchange rate reflecting the Danish fixed-exchange-rate regime. This means that the development of Danish wages and prices must be in sync with the euro area, subject to caveats concerning differences in productivity, if we are to maintain equilibrium

EFFECT ON GDP AND EMPLOYMENT Chart IV.1.2



with unchanged competitiveness. Unless the relative level of unemployment benefits is changed or parameters in the wage relation are moved, this parallelism to the euro area implies a certain level of unemployment.

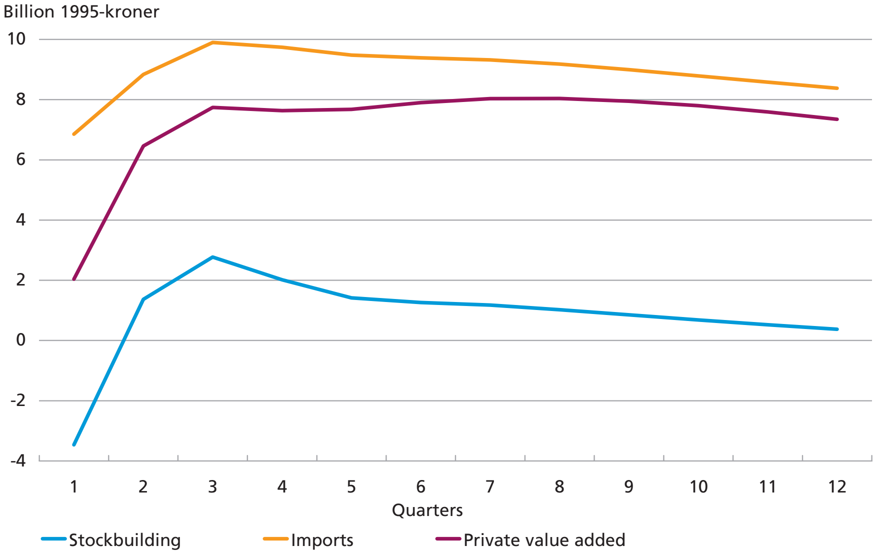
Incorporating the fixed-exchange-rate policy not only entails that wages and prices must follow those abroad in the long term. The fixed euro/krone rate also means that the nominal interest rate is determined externally, cf. the exogenous nominal interest rate in Mona. The real interest rate, too, is determined externally in the long run, in that inflation is determined externally.

More on the immediate response of activity

The increase in the public purchase of goods immediately expands final domestic demand, i.e. domestic demand excluding changes in stocks. Stronger final domestic demand must be satisfied via higher net imports from abroad, higher domestic output or higher consumption of stocks. There are no other options. In textbooks the latter effect on stocks is often referred to as "unintentional". It is often a quick reaction which disappears equally fast, so that it is not visible in annual data, but the reaction can be incorporated in a quarterly model.

The negative effect on stockbuilding in the first quarter moderates the increase in total domestic demand. The increase in total domestic demand is offset by domestic output or imports. In the first quarters especially, imports play a relatively large role in meeting domestic demand.

SHORT-TERM EFFECT ON STOCKS, IMPORTS AND VALUE ADDED Chart IV.1.3



The strong import reaction reflects the high short-term demand elasticity of the central import relation, cf. Chapter II. The stock, import and output reactions in the first 12 quarters are shown in Chart IV.1.3.

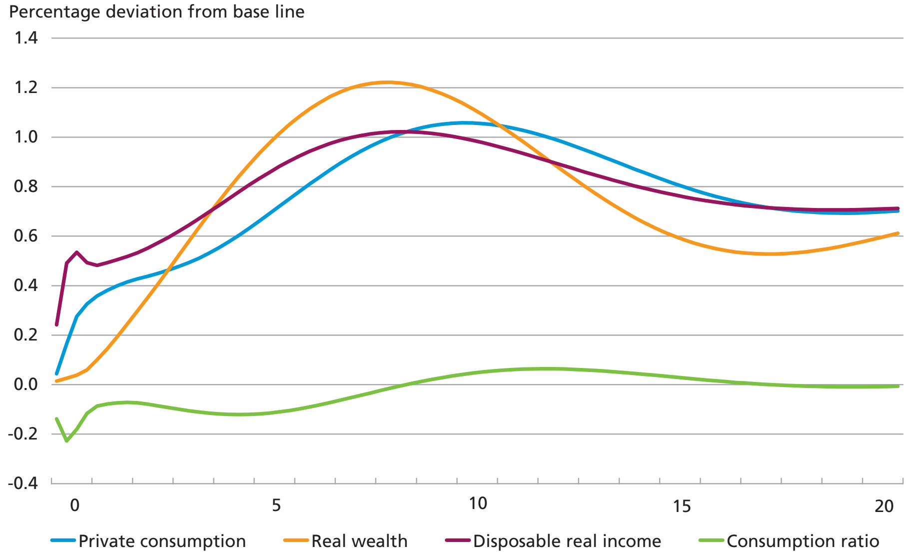
Private consumption and the housing market

According to the model's consumption relation, the marginal consumption ratio is somewhat below the average ratio. This leads to an immediate decrease in the average consumption ratio, and the effect on private consumption is modest at first. Later on the consumption effect grows stronger, cf. Chart IV.1.4. In addition to the self-enhancing multiplier process, which makes incomes rise, the increase in consumption may be attributable to an increase in wealth.

Firstly, the increase in real wealth reflects an accumulation of higher savings. In addition, house prices rise more than the consumption deflator, which includes sluggish and exogenous elements such as rent, imports, energy and specific taxes (cf. the house price/consumer price ratio shown in Chart IV.1.5). The increase in real house prices is a cyclical effect that expands real housing wealth. The increase in wealth stimulates consumption and thus redresses the fall in the consumption ratio. In the long run the consumption ratio is close to the base line.

The expansive reaction in consumption takes place over a number of years. When the consumption effect has peaked, consumption does not return to the base line, but remains higher. In the experiment Danish wages have increased permanently in comparison with wages abroad.

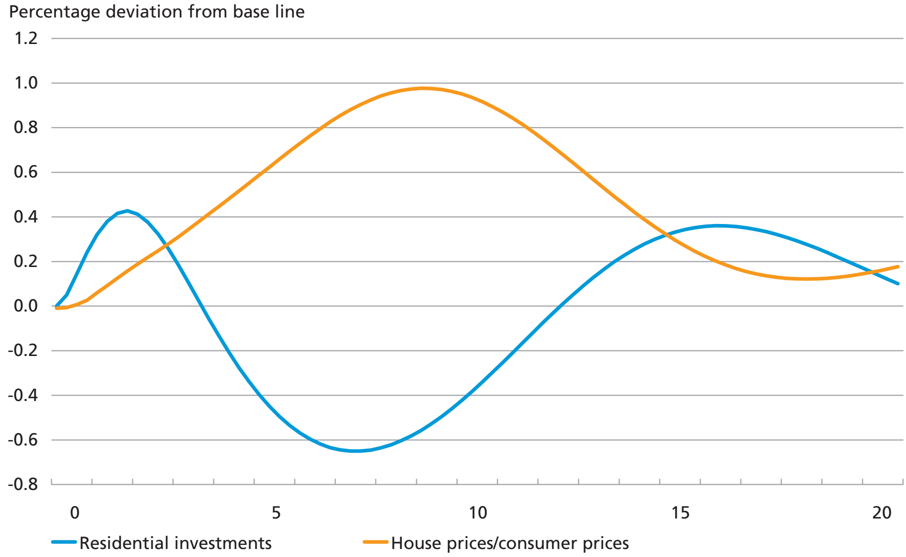
EFFECT ON PRIVATE CONSUMPTION Chart IV.1.4



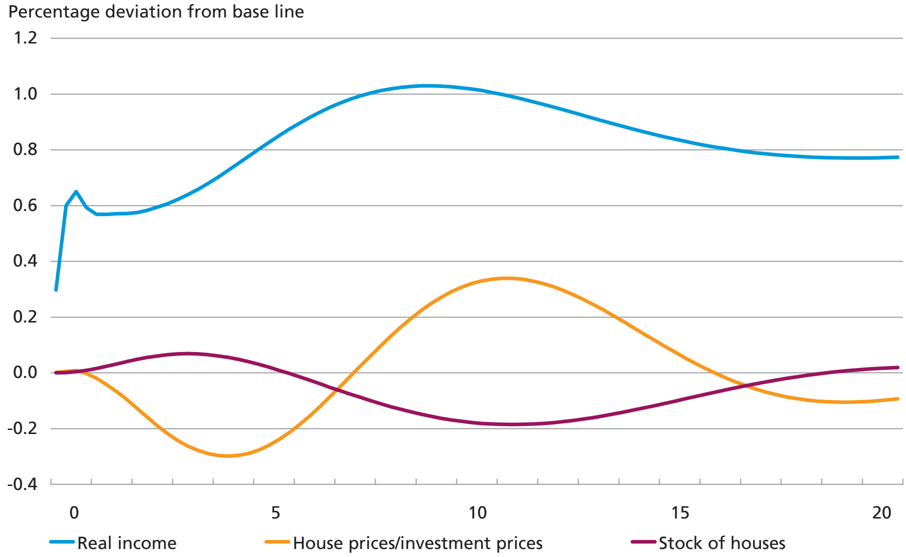
This gives the terms of trade a permanent lift, which is reflected in purchasing power and consumption.

The households do not only react in terms of increased consumption. Higher real income also stimulates housing demand. This means that the wanted stock of houses increases at an early stage of the experiment,

EFFECT ON HOUSE PRICES AND RESIDENTIAL INVESTMENTS Chart IV.1.5



EFFECT ON HOUSE PRICES AND STOCK OF HOUSES Chart IV.1.6



and since the actual stock cannot adapt at once, house prices go up and exert an upward pressure on residential investments, cf. Chart IV.1.5.

After a couple of years the initial increase in residential investments is reversed because construction costs exceed house prices. Construction costs are represented by the residential investments deflator, which has a relatively large wage component and reacts to wages relatively quickly. After a few more years the effect on wages and thus also on the residential investments deflator diminishes. House prices again increase slightly compared to construction costs, and the effect on residential investments once again rises to a positive level. The effect on house prices/construction costs is shown in Chart IV.1.6.

In the long run there is no significant effect on the stock of houses and thus on housing consumption. As mentioned, there is a positive long-term effect on real income, which stimulates housing demand. However, as house prices gradually reflect construction costs, relative prices shift towards a higher house price/consumption deflator, and the final result is a marginal reduction of the stock of houses.

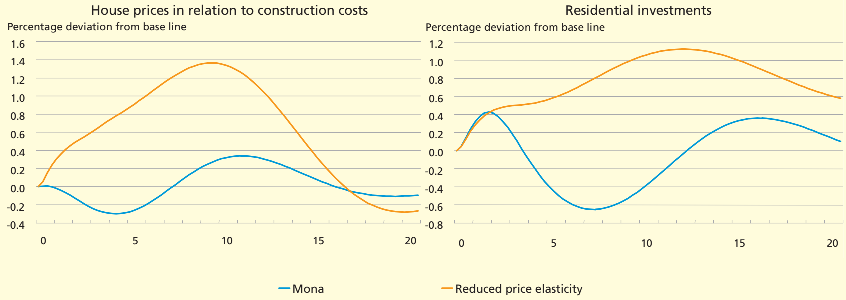
While the reaction of the deflators for residential investments and consumption represents a compilation of the reaction of a number of cost elements, the reaction of house prices reflects the shift in demand over supply in the housing market. In the long term the curve for supply of houses is horizontal, and ultimately house prices follow the deflator for residential investments. In the long term it is thus the supply of houses which adapts. In the short term, however, the reaction of the

SIGNIFICANCE OF PRICE ELASTICITY IN HOUSING DEMAND Box IV.1.2

In Mona's housing demand income elasticity is 1 and elasticity as regards relative prices is just over 2½ numerically. Income elasticity of 1 is rather conventional, while the price elasticity is at the high end when compared with other models. If price elasticity had only been e.g. ½, house prices would have increased considerably more in order to offset the increase in income in the experiment, whereby house prices would also have risen more than construction costs. Simultaneously with the larger house-price effect a stronger reaction would be seen in residential investments and consumption. If price elasticity falls to even less than ½, the result may be an explosive development. However, price elasticity of ½ does not make the model unstable, and the effect on residential investments is easier and more conventional with only one peak, cf. the Charts.

It might be added that price elasticity in housing demand decreases when the last quarter of the regression sample is moved from the 4th quarter of 1997 as in the model presented to the 4th quarter of 1999, which is currently the last year with final national accounts. In other words, simple reestimation seems to improve the housing model, in one respect at any rate.

EFFECT ON HOUSE PRICES AND RESIDENTIAL INVESTMENTS AT DIFFERENT LEVELS OF PRICE ELASTICITY IN HOUSING DEMAND

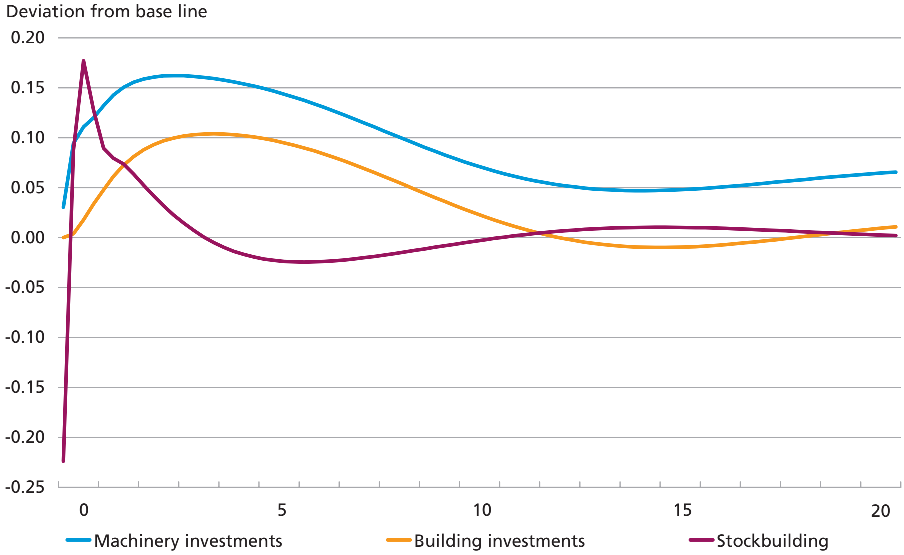


supply of houses is of minor importance to the pass-through to house prices. The key element here is the income and price elasticity of housing demand. The higher the price elasticity in relation to the income elasticity, the smaller the increase in house prices for a given rise in income. In the model the price elasticity is relatively high, and the significance of this is illustrated in Box IV.1.2.

Business investments

Business investments rise in the experiment because the wanted capital stock increases. This is primarily attributable to increased activity. There are three types of business capital in the model: stocks, machinery, and building. The timing of the response of the three types of business capital varies, but for all three types investments increase at some point owing to the gap between actual and wanted capital stocks, and when the

EFFECT ON BUSINESS INVESTMENTS, PERCENTAGE OF GDP Chart IV.1.7



gap gradually closes, the positive effect on investments is redressed. The reaction is shown in Chart IV.1.7 with the responses of the three types of business investments as percentages of GDP.

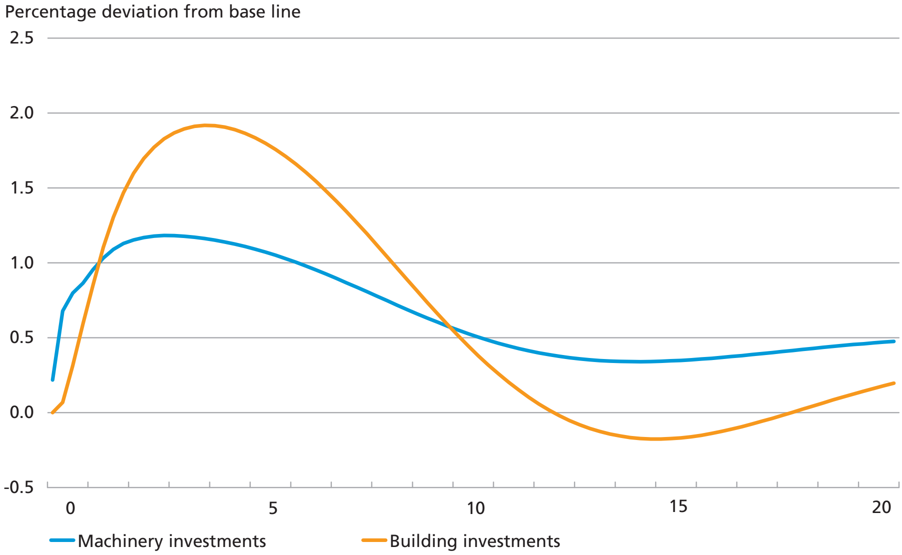
Stockbuilding shows the sharpest reaction. In the first quarter of the experiment stockbuilding drops due to its buffer function. It peaks fairly soon afterwards, reflecting rapid stockbuilding to the desired level, and after some years stockbuilding more or less settles at zero.

In the quarter when the effect on stockbuilding peaks, these investments boost demand more than the other two investment categories, i.e. the effect of stockbuilding is strongest as a percentage of GDP. The relatively strong effect of stockbuilding does not reflect that stocks of goods are the largest capital holding, but stocks reach the desired level much faster than the other types of capital, so the increase is concentrated within a short period of time.

Machinery comprises machinery, transport equipment, software, etc. Undoubtedly it requires more preparation to invest in additional machinery than to build stocks, and it takes some time before machinery investments peak and stabilise at a steady state where the capital stock has been increased as wanted relative to the base line. The permanent increase in investments reflects the need for reinvestments in order to maintain a permanently higher capital stock.

Building investments show the most sluggish response. It should also be noted that the effect in per cent on building investments peaks at a higher level than for machinery investments, cf. Chart IV.1.8.

EFFECT ON BUSINESS INVESTMENTS Chart IV.1.8



The reason is that the stock of durable capital goods is particularly large relative to the investment. So even though adaptation takes several years, a given percentage increase in building capital impacts relatively strongly on building investments.

To illustrate the adaptation pattern in investments it should be noted that the sluggish adaptation of building investments adds inertia to their fluctuations, so that they may reach both high and low levels relative to the long-term response. More specifically, it is the high coefficient for lagged investments which creates the inertia in building investments.

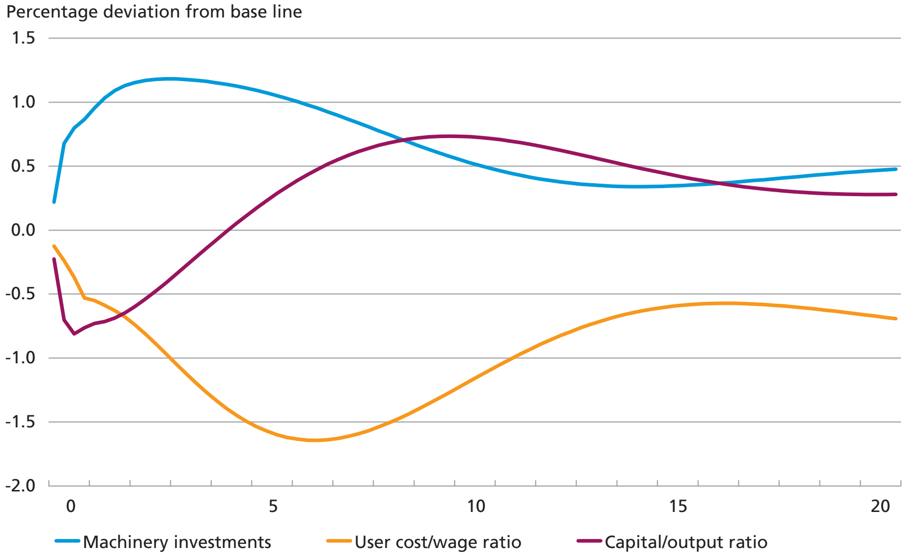
As mentioned, the increase in the wanted capital stocks primarily reflects stronger activity, but for machinery as well as building capital it also reflects that labour becomes relatively more expensive than capital since the price of imported capital does not mirror the domestic price level, cf. Chart IV.1.9 on machinery investments.

Changes in relative factor prices also stimulate the demand for buildings, but in the model only the stock of machinery affects productivity. The reason is that machinery and labour are included in the production function, so when machinery/output increases, labour productivity increases.

Employment

The positive effect on output in the experiment not only increases the wanted capital, but also the wanted labour. Labour reacts faster than the capital stock, but more slowly than output. The short-term elasticity of

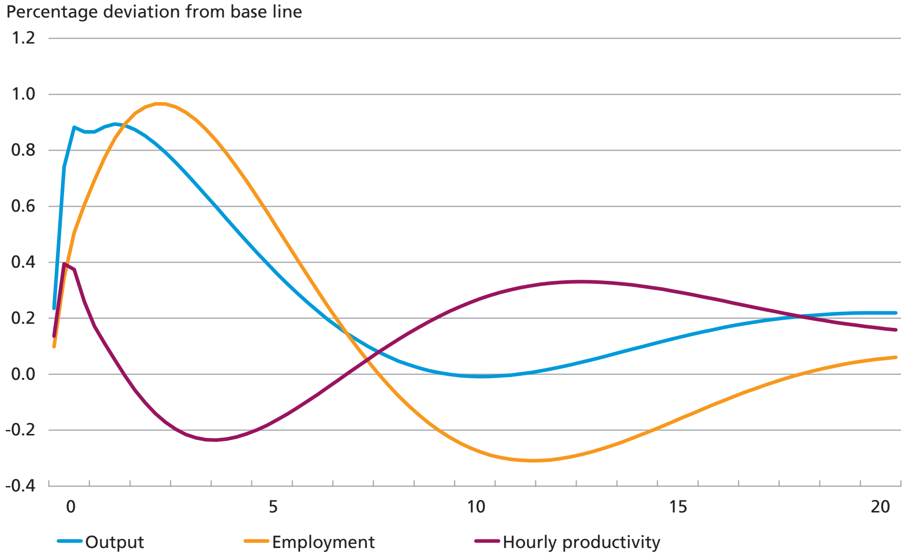
EFFECT ON MACHINERY INVESTMENTS Chart IV.1.9



employment with respect to labour is below 1. This sluggishness in the employment relation entails a positive initial effect on labour productivity, which thus becomes procyclical, cf. Chart IV.1.10. This sluggishness also entails e.g. a fall in the wage ratio during the first couple of years.

The outlined positive cyclical effect on productivity is not permanent. On the contrary, after a couple of years, the sluggishness in employ-

EFFECT ON EMPLOYMENT AND PRODUCTIVITY Chart IV.1.10



ment contributes to a decrease in productivity when the effect on output lessens. This negative effect on productivity, which is seen after a couple of years, also reflects that when the percentage increase is smaller for the capital stock than for output, employment must grow more in per cent than output in order to comply with the production function. The mechanism is that a shortage of capital reduces labour productivity.

The effect on employment affects unemployment, which declines when employment increases at the start of the experiment. The impact on unemployment is not quite one to one, since the participation rate is cyclically sensitive whereby it increases slightly when employment rises.

In the long term the employment response is zero. This does not follow from the employment relation, but from the wage relation and the exogenous exchange rate. In the long term a certain level of unemployment is thus reached, irrespective of the size of public demand.

Wages and prices

At the start of the experiment a relatively rapid increase is seen in output and capacity utilisation. Employment and unemployment react somewhat more sluggishly, and wages, which react to unemployment, are even slower to adapt. This is particularly striking considering the size and importance of the adaptation which ultimately takes place in wages.

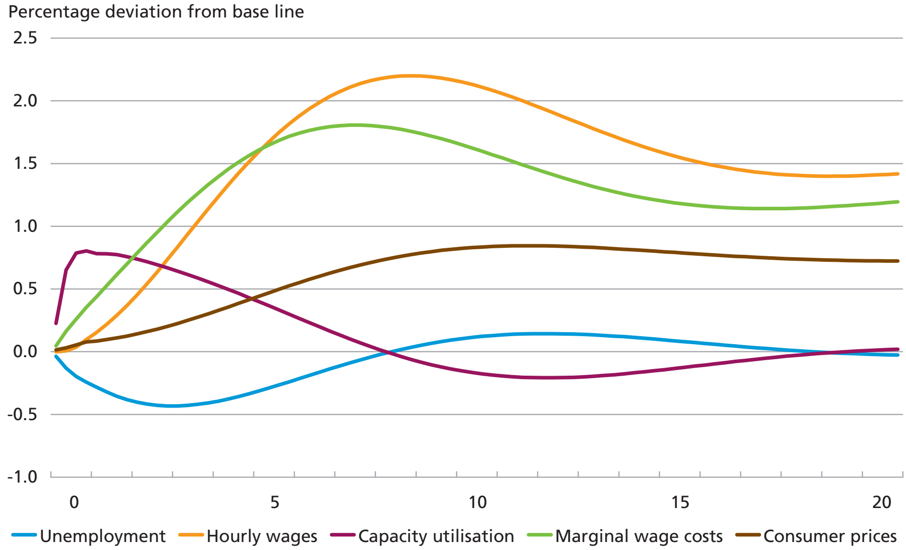
In principle a faster reaction in prices than in wages is possible if increased demand and capacity utilisation push prices upwards. More specifically, the content of domestic value added in the prices in the model depends on marginal wage costs, expressed as hourly wages over marginal productivity. In the experiment, marginal productivity decreases immediately when employment rises in relation to the capital stock, so marginal wage costs increase faster than hourly wages.

No rapid capacity effects of significance have, however, been estimated. The estimated price relations typically display sluggishness in the transmission from wage costs to prices.

Even though there are no rapid capacity effects on prices, the use of marginal wage costs in the price relations instead of average unit labour costs implies that the model's prices are stimulated already in the first quarters of the experiment, where average unit labour costs decrease slightly when average productivity immediately increases more than hourly wages. The effect on capacity utilisation and on wages and prices is illustrated in Chart IV.1.11.

The reaction in the prices of demand components depends on e.g. import content and specific taxes. The key price is the consumption deflator, which determines the purchasing power of income and wealth.

EFFECT ON CAPACITY, WAGE COSTS AND CONSUMPTION DEFLATOR Chart IV.1.11



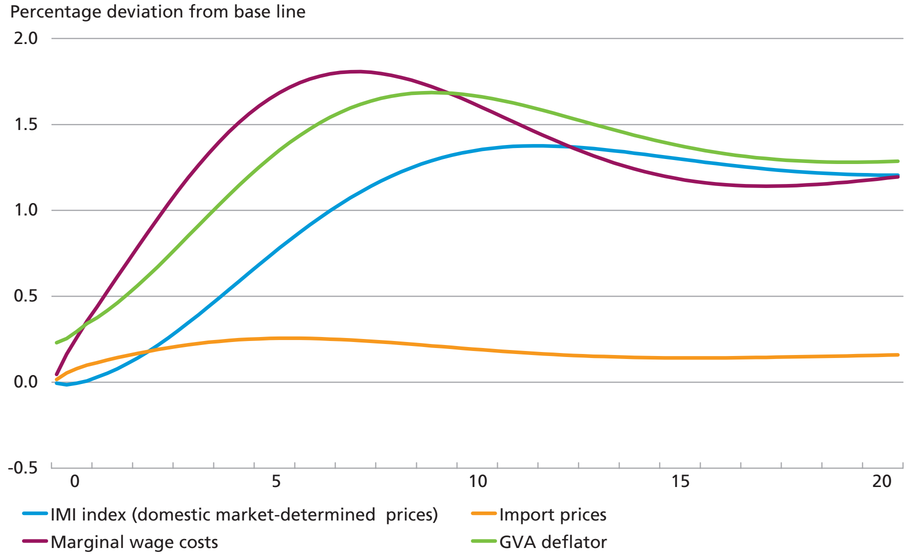
There are several sluggish components among the consumer prices, e.g. the rent item, and the consumption deflator adapts significantly more slowly than wages. The dead weight of the only moderately increased import prices and the unchanged specific taxes means that real wages rise in the experiment – also in the long term.

The consumption deflator is based on components in the net retail price index, including an index of domestic market-determined consumer prices, the IMI index. The marginal decrease in the IMI index in the first quarters reflects that the moderate increase in import prices is not immediately passed through to consumer prices. The sluggish price effect from import prices is modelled as a negative effect from the acceleration in import prices to the change in the IMI index, cf. below on the relation for the IMI index. In the long term the IMI index follows the development in marginal wage costs. Chart IV.1.12 shows the development in the IMI index, import prices and marginal wage costs.

As regards the price of firms' value added, the principle is that the marginal wage costs drive the price of the private non-farm sector's gross value added, the GVA deflator, since the marginal wage costs govern the value-added content of the deflators for the model's demand components.

Disregarding the first year of the experiment, the GVA deflator adapts more slowly than marginal wage costs, cf. Chart IV.1.12. One reason is that prices are not pulled by demand, but pushed by wage costs subject

EFFECT ON IMI INDEX AND UNIT LABOUR COSTS Chart IV.1.12



to a time lag. In the long term the effect on the GVA deflator is constant and close to the effect on marginal wage costs.

The impact on the GVA deflator from marginal wage costs is intentional and fairly uncomplicated, but it could be added that the model's GVA deflator also reacts to changes in the composition of demand, cf. Box IV.1.3. The Box illustrates that the composition problem can be reduced via a chain index in the output calculation. Some countries have begun to use chain indices to reduce the significance of relative price shifts to items at constant prices, so this is a relevant topic, but apart from the Box it will not be discussed further here.

The foreign price level is unchanged in Danish kroner, and even though import prices are affected by domestic prices, the model's import deflators increase significantly less than the domestic price level. At the same time, on the export side many deflators will eventually reflect domestic wage costs. This also applies to the price for industrial exports, so in the longer term profits on industrial exports reflects the general profitability in the private non-farm sector.

This equivalence is in line with the absence of a special industrial exports sector in the model. On the other hand, the price of exports of energy products is given from abroad, and the model's energy output is also exogenous.

The export and import price reaction entails a permanent terms-of-trade gain, cf. Chart IV.1.13. The terms-of-trade gain increases real income and boosts private consumption.

COMPOSITION EFFECT ON THE GVA DEFLATOR Box IV.1.3

In the experiment the composition of demand shifts from exports towards public purchase of goods. Since the latter in 1995-prices has a slightly higher deflator than exports, this entails a small positive composition effect on the deflator for total demand as well as the deflator for gross value added. However, the effect is small.

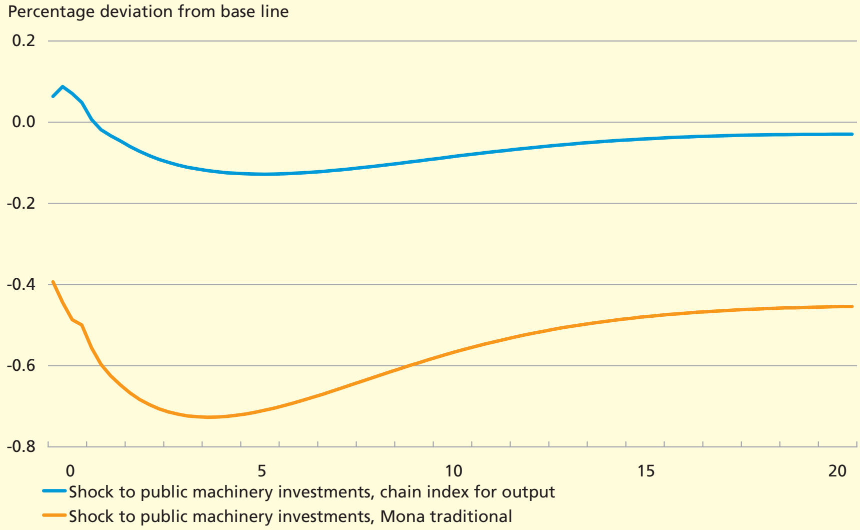
If one applies the shock of 1 per cent of GDP to public machinery investments instead of applying it to public purchase of goods, a relatively clear negative composition effect on the GVA deflator is seen, since the deflator on public machinery investments is one of the smallest deflators.

The composition effect is a well-known principle weakness of models such as Mona based on traditional national accounts with the Laspeyres fixed-weight index for compilation at constant prices, cf. e.g. Vastrup (1975). There is only one output function for the private non-farm sector in Mona, and in principle a simple assumption of full competition in the model is destroyed when the private non-farm sector supplies products with different value-added deflators. Since the input of production factors is the same per 1995-krone, the highest profitability is achieved for manufacture of the product with the highest deflator.

In principle the problem can be alleviated by introducing more output sectors. Another option is to measure the model's output on the basis of chain indices where products are weighted in relation to their current value and not their weight in 1995-kroner. This reduces the basic discrepancy that creates the composition problem.

More specifically, a chain index has been set up for GDP on the basis of Mona's demand components so that their real rates of increase are weighted together with the respective shares of nominal GDP. Several countries, e.g. the USA, have introduced such indices for constant-price calculations. Our example, however, only includes an approximation on the basis of constant-price quantities and deflators already in the model. It should be added that the approximation is not suitable for stockbuilding, which is included as a growth contribution at current prices instead. Private non-farm

EFFECT ON THE GVA DEFLATOR/MARGINAL WAGE COST RATIO



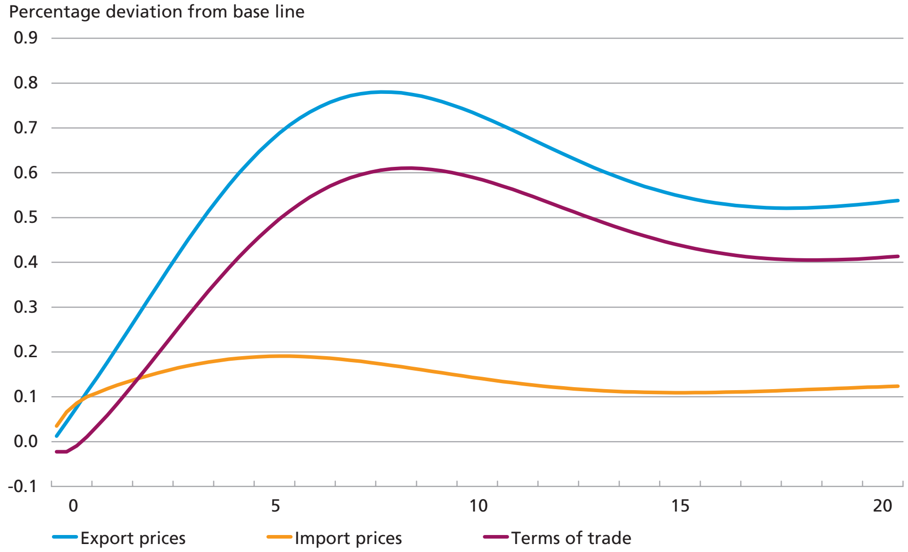
CONTINUED Box IV.1.3

GVA at constant prices is derived by using GDP shares at current prices to deduct the impact of the other sectors and indirect taxes from the GDP chain index.

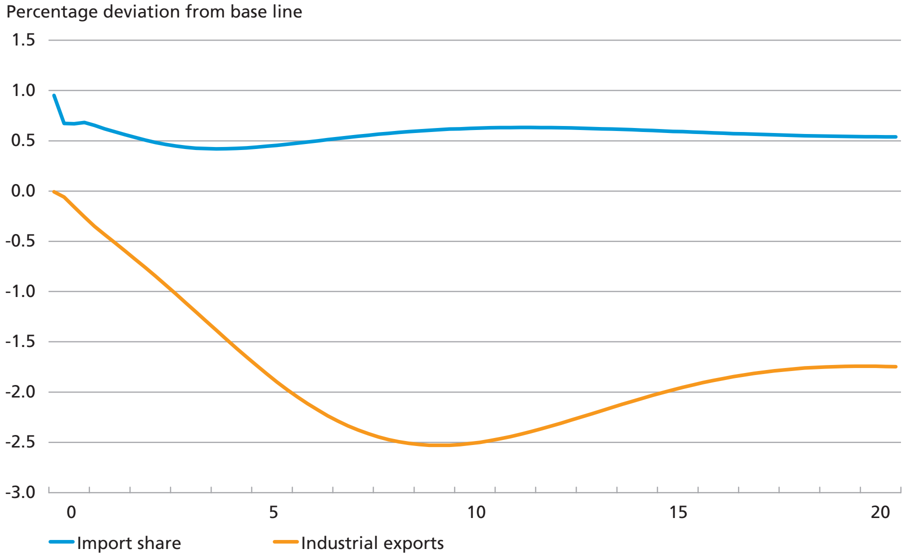
The principle in Mona's price formation is that marginal wage costs, calculated on the basis of the production function, drive the price element in private non-farm GVA. In the short term price formation is sluggish, but the price relations have been constructed so that marginal wage costs carries the GVA deflator in the longer term. However, on an increase in public machinery investments the private non-farm deflator increases less than marginal wage costs when private non-farm GVA is a normal Laspeyres fixed-weight index. This reflects a composition effect. The deflator and wage costs increase by more or less the same when the GVA in fixed prices is expressed in a chain index, cf. the Chart.

In this section the reaction in wages and prices is seen as a reflection of changed pressure on the labour market. In the longer term unemployment returns to the base line, so there is no permanent pressure from low unemployment. When wages and prices are permanently higher than on the base line, a new steady state is reached, which primarily reflects the price sensitivity of imports and exports. If this price sensitivity was e.g. indefinite, wages and prices would not permanently deviate from the base line.

EFFECT ON TERMS OF TRADE Chart IV.1.13



EFFECT ON IMPORT SHARE AND EXPORTS Chart IV.1.14



Imports and exports

We have mentioned the particularly rapid reaction in imports in the first quarters of the experiment. In the longer term import elasticity with respect to demand is 1, corresponding to simple proportionality and an unchanged import share. In the longer term, however, there is also an impact from imports becoming relatively cheaper when the domestic price level is pushed upwards, cf. Chart IV.1.14. The import share increases, which contributes to pushing back domestic output.

Unlike imports, exports are not affected much in the first year of the experiment. This reflects sluggishness in the wage reaction to lower unemployment and in the export reaction to wages. However, exports – and thus the export market share – eventually decrease more than imports increase, cf. Chart IV.1.14. The sensitivity of exports to wages and prices relative to abroad is clearly higher than that of imports, and the export reaction is crucial to the effect of competitiveness and to the crowding-out mechanism.

The fixed-exchange-rate policy implies that to reach a steady state we must achieve the same rate of wage increase as abroad, or competitiveness and the export market share will continue to shift. Wages may increase by more than abroad if productivity increases more, but in the relations and in the experiment we disregard such permanent differences in productivity growth vis-à-vis Denmark's trading partners. It is thus a question of the wage increase returning to the base line where the Danish rate of wage increase corresponds to the foreign one.

With a simple Phillips curve where unemployment explains the wage increase, adaptation to the foreign wage-increase rate entails a specific level of unemployment. There are other explanatory variables than unemployment in the model's wage relation, e.g. the replacement ratio implied by unemployment benefits, but none of these extra variables change relative to the base line, so unemployment must return to the base line for the wage-increase to return to the base line.

The need for a constant differential to wages abroad and thus to baseline Danish wages does not in itself depend on the wage sensitivity of exports. However, the latter decides the size of the constant differential. Altogether the crowding-out mechanism reflects interaction between the wage and export reactions. This is illustrated further by an examination of the effect of change in a couple of key parameters, cf. Box IV.1.4.

ASPECTS OF THE CROWDING-OUT MECHANISM — Box IV.1.4

To illustrate the model's crowding-out mechanism we will perform the purchase-of-goods experiment with other coefficients for a number of equations which are key in this connection. More specifically, three alternative calculations are performed.

The first alternative to the basic model is to double the long-term wage elasticity of industrial exports from 1.2 to 2.4 and to examine how this affects the purchase-of-goods experiment.

When the wage sensitivity of exports increases, the export effect is stronger at first. At the same time it requires lower wage changes to crowd out the activity effect, so the derived expansive effects on real income and consumption are reduced, and exports decline less than in the normal model. It may seem to be a paradox that exports ultimately adjust less when their elasticity has increased, but the explanation is that less room is required for consumption expansion.

The second alternative to the basic model is to quadruple the coefficient for unemployment in the wage relation. The significantly faster wage reaction speeds up the crowding-out process. At the same time a higher degree of overreaction is seen in wages, which soar higher and plunge deeper in a more cyclical trajectory, still ending in equilibrium, however. The forced wage cycle affects the other variables, for example GDP passes the zero line 4-5 years sooner, but the cycles are larger. The larger cycles indicate that it has become more difficult for the model to reach equilibrium. The dynamic problem is intensified by greater wage elasticity in exports since this increases the tendency to overshoot.

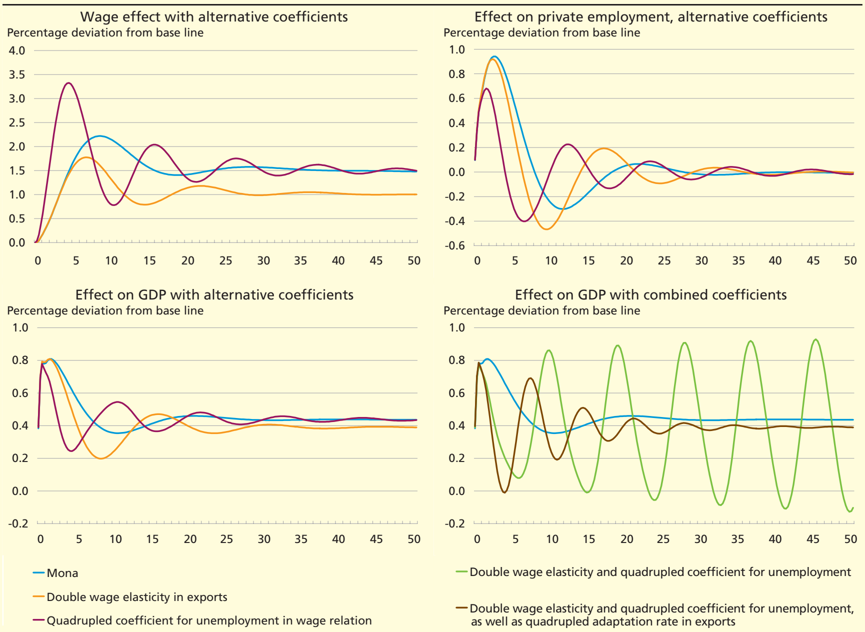
The third alternative to the basic model is to double the wage elasticity of exports and at the same time quadruple the response of the wage relation to unemployment. With this combination wages can no longer find a steady state, but cycle violently up and down, driving the other variables.

This example illustrates that increased wage flexibility does not necessarily in itself entail faster adjustment and smaller cyclical fluctuations in the economy. Fast adjustment requires that exports react sufficiently quickly to competitiveness, cf. Hansen (1998). A similar view is often stated by referring to the negative impact of inflation

CONTINUED Box IV.1.4

on real interest rates, cf. DeLong and Summers (1986). In our example, however, the interaction between the export reaction, the wage reaction and the terms-of-trade effect is the driving force.

PURCHASE-OF-GOODS EXPERIMENT WITH CHANGED ELASTICITY

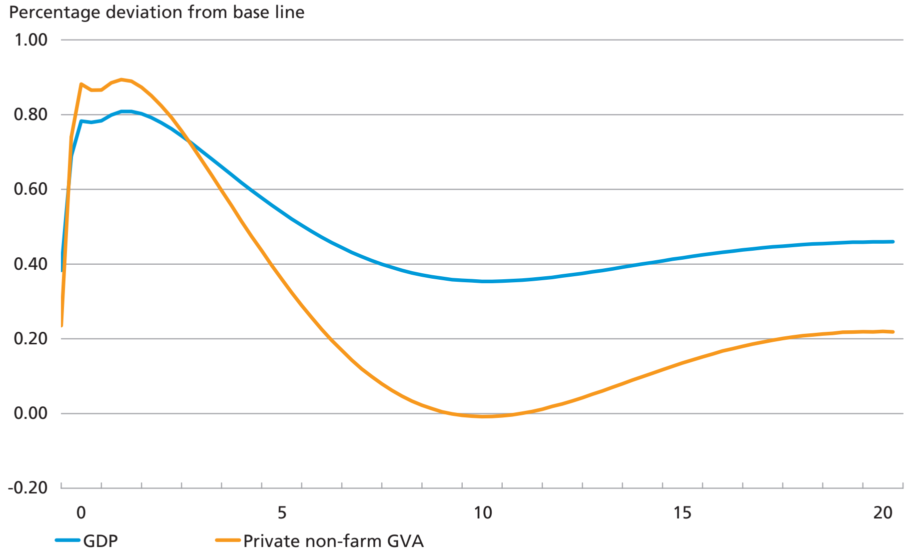


Output

The GDP reaction reflects the sum of the demand elements. During the first couple of years the GDP effect increases and peaks. Then the effect is redressed, cf. also the crowding-out mechanism, and moves towards equilibrium. In relation to the working of the model, gross value added, GVA, is just as important as GDP. Particularly the GVA of the private non-farm sector affects the utilisation of labour and capital.

The difference between GDP and GVA relates to the treatment of indirect taxes and subsidies. GDP includes indirect taxes net, while GVA excludes product-related indirect taxes net. Most indirect taxes can be related to goods or services, and especially the reaction in the product-related indirect taxes reflects changes in consumption, for this is where indirect taxes are primarily found. On the other hand, there are hardly any indirect taxes on exports, so the purchase-of-goods experiment's composition shift towards increased public purchase of goods and private consumption, as well as lower exports, entails a tax-driven net effect on GDP. Only in the first couple of years is the percentage change in

EFFECT ON GDP AND PRIVATE NON-FARM GVA Chart IV.1.15



private non-farm GVA larger than in overall GDP, even though the latter includes exogenous elements such as the public sector, agriculture and energy. In the long term the percentage GDP effect is strongest, cf. Chart IV.1.15.

Viewed over the long term, GVA can be determined as a function of the output factors, and GDP follows by adding net indirect taxes at constant prices. Specifically, there is a model variable for net indirect taxes at constant prices, determined as the demand components at constant 1995-prices multiplied by a coefficient for the indirect-tax element in 1995.

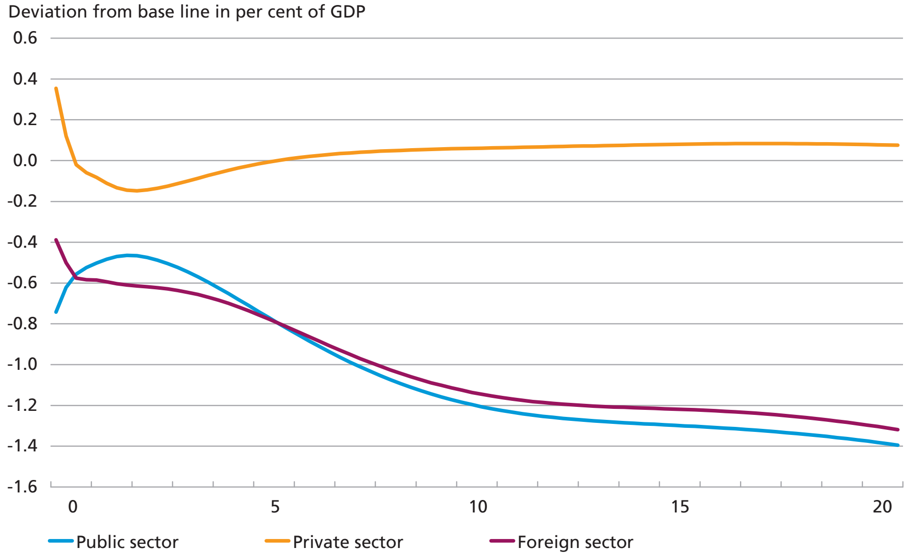
The moderate positive long-term effect on GVA reflects that, as mentioned, labour productivity increases when capital becomes relatively cheap, and capital intensity increases.

It is perhaps easier to understand the effect of the experiment on GVA, but GDP is the most widely used output measure, so the GDP effect must also be described.

Public finances

Higher expenditure for public purchase of goods will *ceteris paribus* increase public expenditure and reduce the government balance correspondingly. However, the indirect-tax element in the public purchase of goods dampens the immediate effect on the balance, and more interestingly higher income and increased private consumption also lead to higher tax receipts, while lower unemployment reduces expenditure for unemployment benefits.

EFFECT ON NET LENDING Chart IV.1.16



This activity-driven or indirect positive impact on the public balance is the counterpart of the role of public finances as an automatic stabiliser. The positive impact modifies the deterioration of the public balance, but does not change the sign. The overall effect on the public balance is negative, both in the short term and – particularly – in the long term.

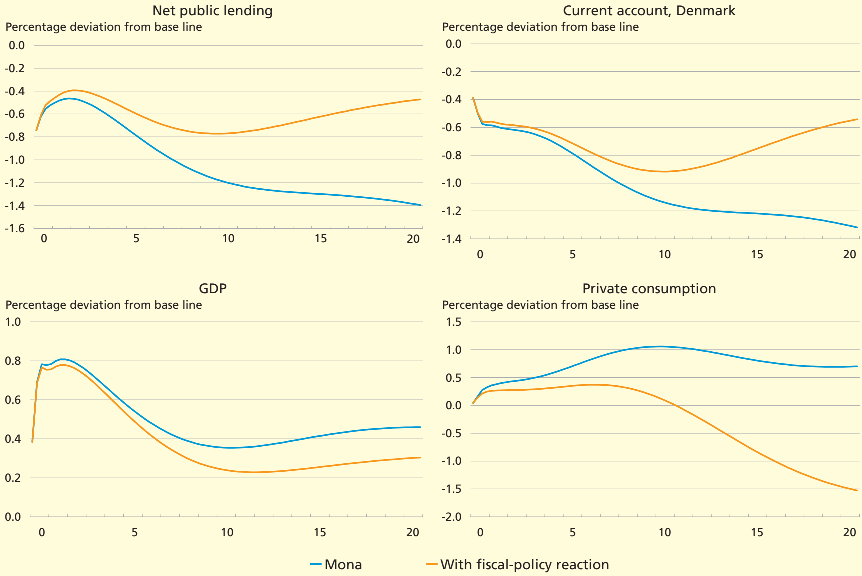
It should be noted that the major part of public expenditure in the model is linked to the wage and price level, while e.g. receipts from specific taxes is not regulated nominally. All in all the model shows a moderate tendency for a higher level of wages and prices to have a negative impact on the public balance. What is most significant in the long run, however, is that the deterioration of the public balance entails mounting public debt and thus increased public interest expenditure. Increased interest expenditure has a negative impact on the balance, and a development is seen with a rapidly decreasing public balance and increasing debt relative to the base line.

The decreasing public balance and increasing debt are reflected by a decreasing balance of payments and increasing foreign debt. In the long term developments are increasingly governed by accumulated interest payments.

The savings balance of the private sector is mainly affected in the short term where higher private income increases savings and the savings balance. In the longer term the development in the private savings balance is controlled by the impact of wealth on private consumption and savings. When savings are too large, wealth increases more than income, FISCAL-POLICY REACTION — Box IV.1.5

As mentioned in Chapter III it is possible to activate a relation that sets the unit-tax rate on private consumption so that the public balance in the long term stabilises as a ratio of GDP. If this relation is activated, indirect taxes are increased to neutralise the increased purchase of goods. This removes the declining trend in the public balance and balance of payments. Private consumption is now pushed down, which reduces the adjustment requirement for exports and the wage level. In conclusion, with the fiscal-policy reaction it will be an entirely different experiment, which will serve as an example of the balanced budget's multiplier.

WITH AND WITHOUT FISCAL-POLICY REACTION



and this gradually reduces savings. The effect on private, public and foreign net lending is shown in Chart IV.1.16.

The systematic increase in public debt and foreign debt does not prevent the model's other variables from eventually finding a steady state. An explosive trend in public finances and foreign debt is, however, not sustainable in practice. At some point creditors will draw the line.

It is natural to limit the development in the public balance by some automatic reaction. The experiment has therefore been repeated with a relation which adjusts the rate for specific taxes on private consumption to stabilise the public balance as a ratio of GDP, cf. Box IV.1.5.

As stated in Chapter III, the total dynamics in the model are taken into account in the construction of the relation for the fiscal reaction. Consequently the relation implies that specific taxes are gradually adapted until the target is reached.

FORWARD-LOOKING EXPECTATIONS Box IV.1.6

In a macroeconomic model the expectations are rational if they correspond to the forecasts generated by the model. The question is whether the agents use an equivalent amount of resources on making decisions, but as an example we have examined what the purchase-of-goods experiment yields if some of the expectations are formed by the model. An obvious example, which is used here, is inflation expectations that enter the determination of investments and house prices together with the long-term yield. Specifically the model includes an expression of expected increases in house prices, *dkpe,* and in the private consumption deflator, *dpcpe*. Both are included in the house-price relation. In addition, an expression of the expected increase in the GVA deflator, *dpyfbxe*, is included in the user-cost expressions relating to machinery and buildings. For example, the expectations of the GVA deflator are modelled as follows:

$$dpyfbxe = \quad dpybw\left(0{,}8 \cdot dpyfbxe_{-1} + 0{,}2 \cdot 0{,}5 \cdot \log\left(\frac{pyfbx}{pyfbx_{-4}}\right)\right) + (1 - dpybw)\frac{\log\left(\frac{pyfbx_{+40}}{pyfbx}\right)}{10}$$

where the *dpybw* variable can have the value 0 or 1, and *pyfbx* is the GVA deflator. If *dpybw* equals 1, inflation expectations are equal to a weighted average of inflation expectations in the preceding period and actual inflation. Inflation expectations thus only depend on the lagged values of inflation (adaptive expectations). As a principle, Mona is estimated with *dpybw* equal to 1. Alternatively *dpybw* can be set at 0, whereby inflation expectations will depend on future inflation for 10 years (model-consistent expectations) rather than on lagged values. Introduction of forward-looking expectations in this manner is naturally on an ad-hoc basis. A more satisfactory, but also more complex method would be to estimate the actual equation with forward-looking expectations.

The Chart below shows the effect of an increase in the public purchase of goods when inflation expectations are adaptive and model consistent, respectively.[1]

It can be seen that the model-consistent expectations of the increase in the GVA deflator are somewhat more stable. In addition, the economic effect is generally stronger (faster) at the beginning when expectations are forward-looking than when they are backward-looking. For a few variables there is also a tendency for the cycles to even out, which is particularly evident for house prices. Since house prices affect consumption via a wealth effect, a more stable development is also seen in consumption. At the same time the more rapid adaptation of the capital stock entails that

continued overleaf

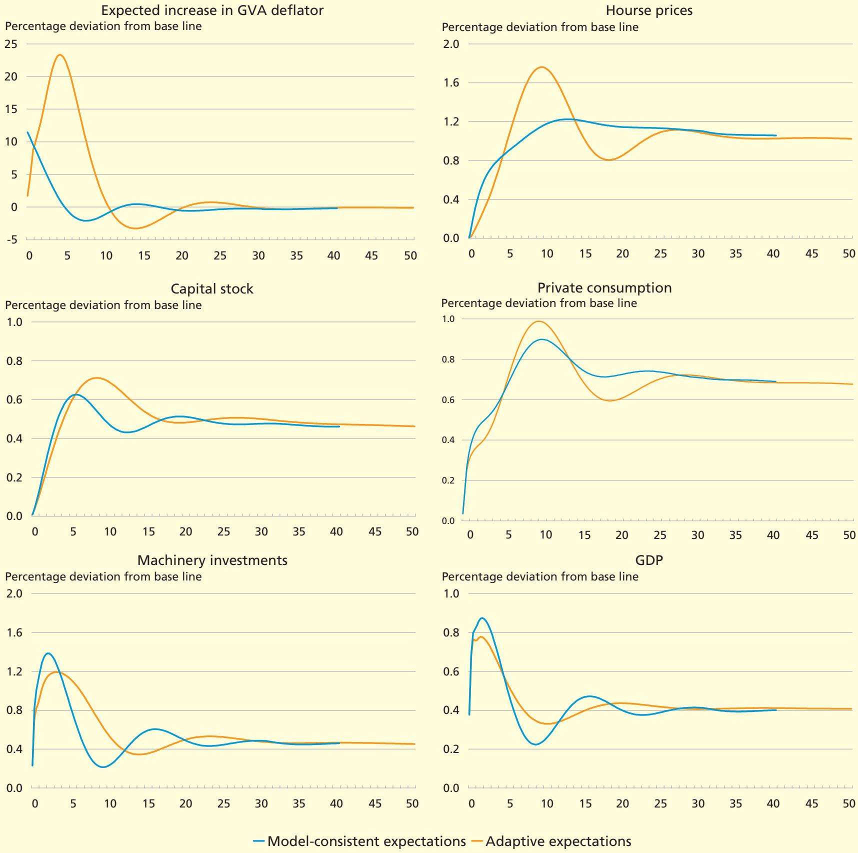
On the formation of expectations

Generally, the model's relations are estimated and set up including adaptive formation of expectations, so that the expected value of a variable is determined by its historical values. Concerning the model's main use for short-term forecasts this is presumably a sufficient starting point, and for such forecasts one could also argue in favour of exogenous expectations. In any case expectations are always uncertain, and in addition the highly expectation-related financial variables such as long-

CONTINUED Box IV.1.6

fluctuations in investments increase and extra cycles are also seen. The larger cycles in e.g. investments entail that fluctuations in output (and unemployment) increase.

PURCHASE-OF-GOODS MULTIPLIER WITH AND WITHOUT FORWARD-LOOKING EXPECTATIONS



[1] The model with forward-looking expectations as solved using Troll software. The trajectory with backward-looking expectations is used for the terminal conditions in the model with forward-looking expectations, so that the two simulations converge towards the same level.

term interest rates and exchange rates are not modelled. They are included as exogenous input, so there is no basis for model-consistent expectations concerning long-term interest rates and the effective exchange rate, which we assume to be independent of short-term developments in the Danish economy.

For other variables such as expected inflation the model's forecast may, however, be used to form forward-looking expectations. Some examples are shown in Box IV.1.6.

SHOCKS TO INTEREST RATES AND EXCHANGE RATES 2

Since interest rates and exchange rates are exogenous in Mona, it is easy to conduct experiments where the rate of interest or exchange rate is changed by 1 percentage point or by 1 per cent. Such calculations may indicate the effect of this kind of external shocks, cf. e.g. the calculation examples in Danmarks Nationalbank (2003). However this cannot be taken to be a reaction to a given monetary-policy change.

To calculate the effect of an actual monetary shock, we must look further than the Danish economy and apply a shock originating in the euro area. In other words, the ECB decides to change its interest rate, and Danmarks Nationalbank follows suit. The monetary shock and its consequences to the euro area are described in more detail in van Els (2001), and these results are used as exogenous input for the Mona calculation.

Monetary-policy interest rates in the euro area and Denmark are increased by 1 percentage point over two years whereafter they return to their initial level. There are forward-looking expectations in the financial markets, and the long-term yield immediately increases by 0.20 percentage points. The krone follows the euro and immediately appreciates by 2 per cent vis-à-vis all other currencies than the euro. The effective krone rate thus appreciates by 0.85 per cent. Both the long-term yield and the effective krone are back at the initial level after the two years. In addition, demand and price effects in the euro area are included in the input to Mona.

In the first quarters of the calculation period, private consumption increases, cf. Table IV.2.1. This is a result of the immediate improvement in

EFFECT OF MONETARY SHOCK — Table IV.2.1

	1st year				2nd year						
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	3rd year	4th year	5th year
	Percentage deviation from base line										
Private consumption ...	0.07	0.06	0.01	-0.03	-0.07	-0.10	-0.13	-0.16	-0.16	-0.15	-0.12
Residential investm. ...	0.00	-0.42	-0.82	-1.12	-1.32	-1.45	-1.50	-1.48	-1.17	-0.56	0.00
Business investments .	-0.11	-0.21	-0.32	-0.44	-0.52	-0.57	-0.60	-0.59	-0.49	-0.30	-0.15
Stockbuilding[1]	0.04	-0.04	-0.02	-0.02	-0.03	-0.03	-0.03	-0.03	-0.01	0.01	0.01
Exports	-0.36	-0.33	-0.38	-0.38	-0.35	-0.35	-0.31	-0.27	-0.17	-0.08	-0.02
Imports	-0.03	-0.18	-0.28	-0.33	-0.36	-0.40	-0.40	-0.38	-0.26	-0.11	-0.02
GDP	-0.08	-0.13	-0.14	-0.17	-0.21	-0.22	-0.23	-0.22	-0.18	-0.12	-0.07
Consump. deflator	-0.15	-0.22	-0.23	-0.23	-0.22	-0.21	-0.20	-0.18	-0.16	-0.17	-0.19
Wage costs	0.00	-0.01	-0.03	-0.06	-0.09	-0.11	-0.13	-0.15	-0.21	-0.28	-0.33

[1] Per cent of GDP.

the terms of trade. In the first quarter stocks increase. This reflects output balancing. After the immediate stimulus the effect on domestic demand is negative. The higher long-term yield leads to lower house prices, which affects private consumption via the wealth channel. Exports are reduced by the immediate appreciation, and the effect on exports remains negative for the first five years if the lower demand in the euro area is taken into account, cf. the spill-over channel. The effect on GDP is negative for the first five years.

Prices fall immediately as a result of the appreciation. The negative effect on the consumption deflator is weakest in year 3 when the exchange-rate effect fades out. After that the negative effect on the consumption deflator strengthens again as a result of declining wages.

The deflationary process represents an adjustment in which a lower wage level and consequently improved wage competitiveness pull activity and employment back towards the base line. When the contractive effect of the monetary shock recedes after two years, the wage level in both domestic and foreign currency is below the base line, and the wage level continues to decrease as long as activity and employment are below the base line. This is a sluggish process.

The improved competitiveness not only pulls GDP back to the base line, but for some years it even pulls it up above the base line. The resulting pressure on the labour market pushes the wage level back towards the base line. This adjustment pattern is necessary to make all variables concerned return to the base line.

The monetary shock can be broken down into five transmission channels. An *exchange-rate channel* that reflects solely the effects of the higher effective krone rate. This channel has the quickest effect by far on prices. In spite of an immediate positive effect on real income and consumption, it also has the fastest negative effect on GDP.

There is also a *user-cost channel* that reflects interest-rate effects on residential investments and business investments. The latter investment component is the largest. However, residential investments are more sensitive to interest rates. The user-cost channel is less significant than the exchange-rate channel, presumably because of the assumed limited effect on long-term interest rates. Short-term interest rates are not important in Mona.

A *wealth channel* can be identified that also works via long-term interest rates. The wealth effect works via the reaction in house prices, which affect private-sector wealth. The impact of the wealth channel on private consumption is relatively stronger than that of the other channels. There is no specific substitution effect on consumption. Interest rates only affect private consumption directly via the wealth channel.

DECOMPOSITION OF EFFECT OF MONETARY SHOCK ON GDP					Table IV.2.2
	1st year	2nd year	3rd year	4th year	5th year
Channel	*Percentage deviation from base line*				
- Exchange rate	-0.07	-0.08	-0.06	-0.03	0.00
- User cost	-0.03	-0.06	-0.05	-0.03	-0.01
- Wealth	-0.01	-0.02	-0.02	-0.01	0.00
- Income	-0.01	-0.01	-0.01	-0.01	0.00
- Spill-over	-0.02	-0.04	-0.05	-0.05	-0.05
Total GDP effect	-0.13	-0.22	-0.18	-0.12	-0.07

A fourth channel is an *income channel* that concerns the interest income from the public sector and abroad. The effect is relatively small. Finally, there is a *spill-over channel* that reflects lower demand in the euro area, which affects exports. The effects of the channels are shown in Table IV.2.2.

SHOCKS TO THE PARTICIPATION RATE 3

Changes in public consumption and interest rates represent demand shocks where the effect on employment is crowded out in the long term. In the following we will consider a supply shock which expands the labour force and in the long term also increases employment correspondingly. To be more specific, the participation rate is permanently lifted by 1 per cent. The participation rate is endogenous and procyclical in Mona, but this relation has been omitted from the current calculation so that the participation rate is exogenous.

The higher participation rate expands the labour force by 1 per cent relative to the base line. Unemployment immediately rises, and in the first quarters the increased labour force reduces employment slightly due to a negative effect on consumption from higher unemployment, cf. Table IV.3.1 and Chart IV.3.1. This negative effect on consumption is perhaps more evident on a reduction of employment than on an increase in the labour force as in this case.

In any case it is more important that higher unemployment reduces wage increases, and that lower wages relative to abroad boost exports. This in turn stimulates activity and employment, and after 6-7 years employment has risen by just as much as the labour force, and unemployment is back at the baseline level. It should be noted that the long-term rise in employment is constant in per cent, cf. Table IV.3.1. The increase in activity and employment has been achieved via lower wages and prices vis-à-vis abroad. The terms-of-trade loss reduces real income, and

EFFECT OF INCREASED PARTICIPATION RATE — Table IV.3.1

	1st year										
	Q1	Q2	Q3	Q4	2nd year	5th year	10th year	15th year	20th year	25th year	50th year
	Percentage deviation from base line										
Private consumption	-0.42	-0.71	-0.44	-0.21	0.14	-0.21	-0.68	-0.13	-0.02	-0.12	0.01
Residential investm.	0.00	0.05	0.12	0.21	0.53	1.51	1.19	0.32	0.89	1.10	0.96
Business investments	-0.07	-0.13	-0.11	-0.05	0.00	0.00	1.13	1.33	1.07	1.09	1.16
Stockbuilding[1]	0.04	-0.01	-0.08	-0.03	0.03	0.04	0.00	-0.01	0.01	0.01	0.00
Exports	0.00	0.04	0.10	0.19	0.44	1.86	2.32	1.70	1.69	1.84	1.83
Imports	-0.19	-0.46	-0.40	-0.19	0.18	0.28	0.14	0.21	0.30	0.29	0.33
GDP	-0.10	-0.19	-0.11	0.02	0.24	0.68	0.90	0.85	0.87	0.92	0.97
Employment	-0.03	-0.06	-0.06	-0.01	0.13	0.85	1.45	1.24	1.11	1.16	1.16
Unemployment[2]	0.95	0.97	0.97	0.93	0.82	0.25	-0.23	-0.06	0.04	0.00	0.00
	Deviation from base line in per cent of GDP										
Private savings bal.	0.35	0.53	0.51	0.40	0.20	-0.09	-0.07	-0.09	-0.10	-0.07	-0.07
Public savings bal.	-0.28	-0.36	-0.34	-0.30	-0.18	0.41	0.72	0.66	0.69	0.78	1.14
Balance of payments	0.07	0.17	0.16	0.11	0.03	0.31	0.65	0.57	0.59	0.70	1.07
	Percentage deviation from base line										
Consump.deflator	0.00	-0.01	-0.04	-0.06	-0.13	-0.56	-0.89	-0.80	-0.78	-0.84	-0.89
Wage costs	0.00	-0.20	-0.40	-0.60	-1.06	-2.63	-2.57	-0.80	-1.80	-1.92	-1.81
Productivity	-0.06	-0.10	-0.02	0.09	0.18	-0.13	-0.61	-0.47	-0.28	-0.26	-0.21
Terms of trade	0.01	-0.01	-0.05	-0.08	-0.19	-0.65	-0.66	-0.49	-0.53	-0.58	-0.59
	Deviation from base line in percentage points										
Consumption ratio	-0.46	-0.64	-0.49	-0.38	-0.16	0.08	-0.27	-0.16	-0.10	-0.16	-0.14
Wage ratio	0.03	-0.03	-0.12	-0.23	-0.39	-0.61	-0.30	-0.11	-0.17	-0.19	-0.15

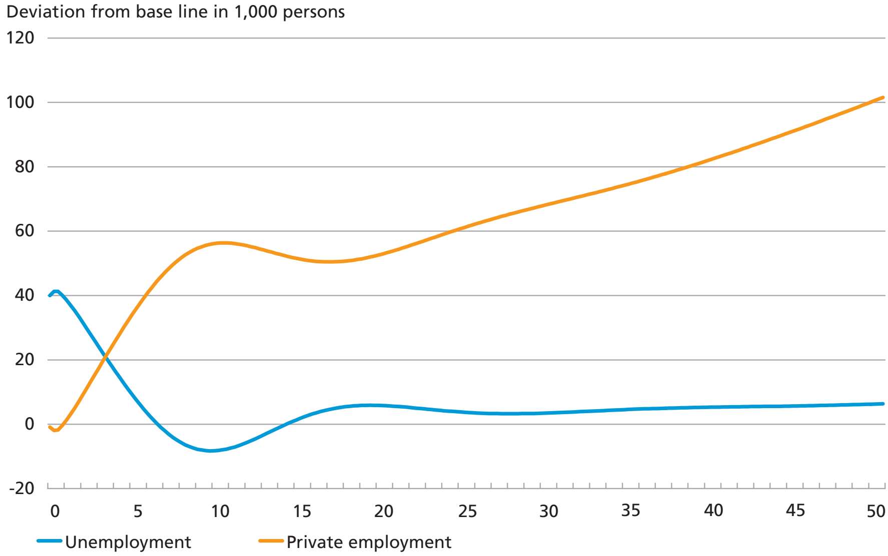
[2] Per cent of GDP.
[3] Percentage points.

while exports have increased, consumption has fallen below the base line, cf. Chart IV.3.2 showing consumption and Chart IV.3.3 showing exports.

As in the purchase-of-goods experiment the steady state has not been reached after 6-7 years. The adjustment is not complete. For instance, wages have overshot by decreasing more than they do in the long term. In the subsequent years employment increases further so that unemployment falls below the base line, and wages begin to rise towards the base line. In the long term there is no effect on employment, so the increased supply of labour is converted into permanently higher employment.

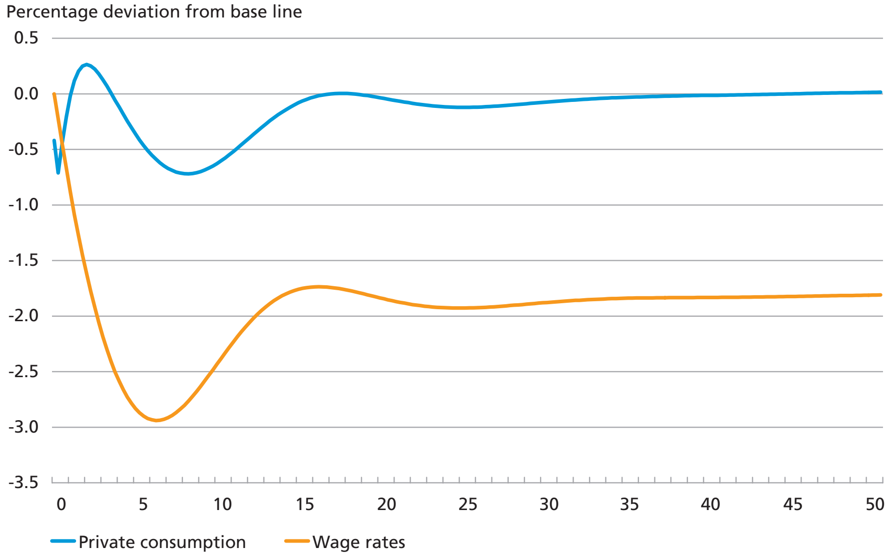
In the long term the negative effect of the terms-of-trade loss on private consumption is increasingly offset by increased income after tax. However, the potential increase in consumption is not fully reflected in the calculated effect on private consumption. It should be taken into

EFFECT ON LABOUR MARKET OF INCREASED PARTICIPATION RATE — Chart IV.3.1

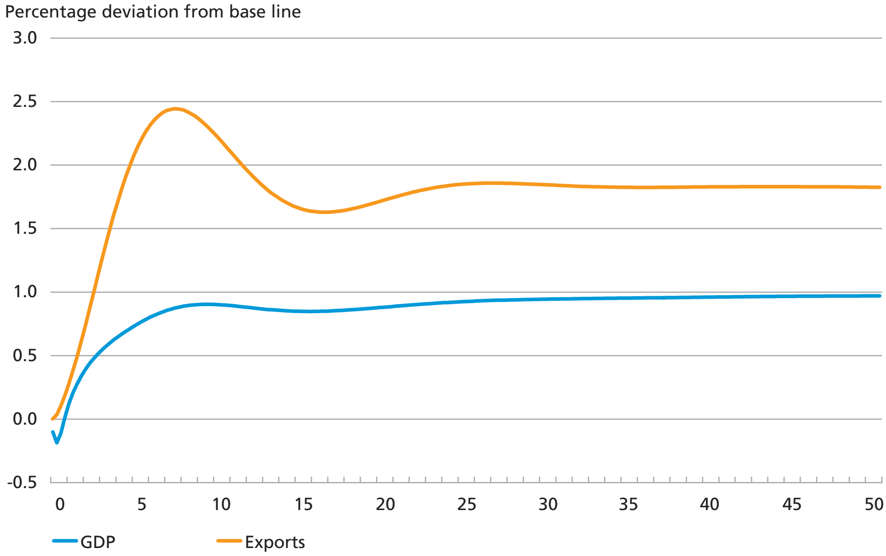


account that the balance of payments and the public balance improve on an ongoing basis. This means that the higher labour force provides for easing fiscal policy by e.g. cutting taxes to stimulate private consumption.

EFFECT ON PRIVATE CONSUMPTION AND WAGES OF INCREASED PARTICPATION RATE — Chart IV.3.2



EFFECT ON GDP AND EXPORTS OF INCREASED PARTICIPATION RATE Chart IV.3.3



SERIES OF SHOCKS TO THE CONSUMPTION AND WAGE RELATIONS 4

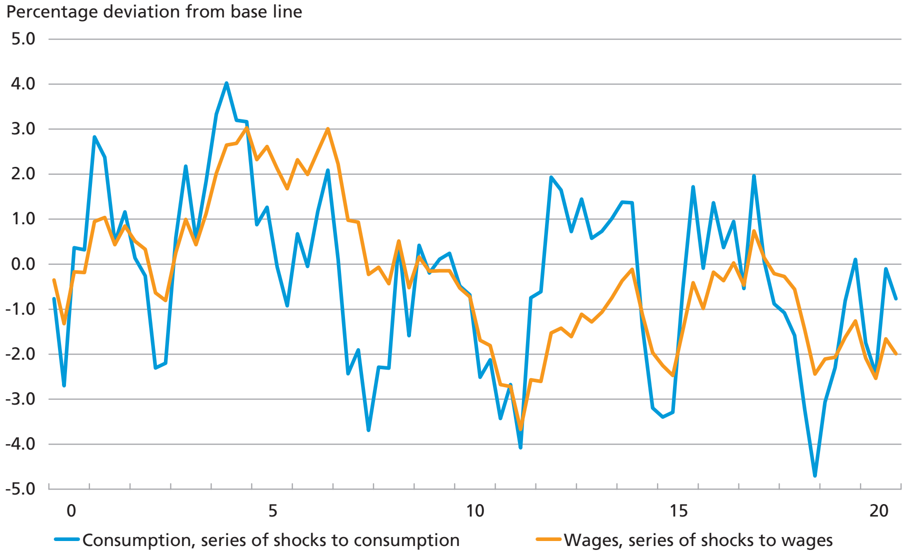
The above sections gave examples of shocks to the model where one or a few variables are changed according to a fixed and simple format. The effect of random or stochastic shocks to central relations can also be illustrated. It is possible to shock all behavioural relations simultaneously, but for reasons of simplicity two relations have been selected here: the consumption relation and the wage relation, i.e. one relation on the demand side and one on the supply side, and the shocks are applied to one relation at a time, so there are two model experiments.

To be more specific, 80 random figures are drawn using an Aremos random generator. In the first experiment they are scaled so their standard deviation corresponds to that of the consumption relation in the estimation period. After scaling the random figures are inserted as adjustment terms in the consumption relation for a period of 20 years. Then the model is solved. The difference from the base line, where the adjustment term is zero, describes the effect of the series of shocks to the consumption relation. That is the first experiment.

In the second experiment the same set of random figures is applied, but now scaled to reflect the standard deviation of the wage relation. The scaled series is inserted into this relation as the adjustment term, and the model is solved.

Both the consumption and wage relations have the variable difference on their left-hand side. This means that the shocks are immediately ac-

EFFECT ON CONSUMPTION AND WAGES Chart IV.4.1



cumulated in the levels, and to begin with the reaction in the consumption level in the first experiment resembles the reaction in the wage level in the second one, measured by standard deviations. The immediate percentage reaction in consumption is stronger, since the standard deviation in the consumption relation in log units is twice that of the wage relation.

After a couple of years, however, one can see a more pronounced adjustment of the consumption level than the wage level towards the base line. Over the 20 years, the reaction in consumption to the random shocks is on average more modest and less persistent compared to the reaction in the wage level. Note for instance that the sign of the consumption reaction changes more frequently, cf. Chart IV.4.1. The adjustment towards the base line is mainly driven by the consumption relation itself, which includes the lagged consumption level.

There is no wage level in the wage relation, so seen in isolation the random shocks accumulate to a "random walk" that can take the wage level anywhere and far from the base line. However, the full Mona also includes an adjustment mechanism for wages, i.e. the crowding-out process. High wages have a negative impact on exports, the level of activity falls, and unemployment rises, and the weaker labour market dampens wages.

The problem is that this is a slow process. The shocks must clearly have pushed wages up above or down below the base line in order for the crowding-out mechanism to gain momentum.

EFFECT ON PRIVATE EMPLOYMENT Chart IV.4.2

The difference between shocking consumption and shocking wages is also reflected in the impact on employment. Private consumption is a large demand component, while the activity effect of the wage shocks emerges more slowly, so initially fluctuations in employment are clearly greatest for shocks to the consumption relation. After some years it is important that the wage effect has the same sign for relatively long periods so that the employment effect approaches a relatively long cycle with a mostly negative sign in the first 10-year period and a positive sign in the last 10 years. When the consumption relation is shocked, the employment effect fluctuates more between positive and negative, cf. Chart IV.4.2.

The result shows that the crowding-out process is sluggish, and that it takes time to neutralise wage shocks. This can also be seen from a historical simulation using the model, cf. Chapter V.

V: Simulations on a Historical Period

Mona has been designed mainly for forecasts and general analysis of the business cycle. The model's ability to describe economic cycles is therefore a natural focal point.

It might be said that the construction and estimation of the model's behavioural relations test the model's descriptive properties, relation by relation. It is, however, also necessary to consider how a relation interacts with the rest of the model before choosing to incorporate it in the model. The multiplier calculations in the preceding Chapter give an impression of the model's interactions, but it is also natural to examine how the model can recreate the historical development.

Mona is first simulated over the 26-year period 1975-2000. Such a long period illustrates some of the model's stability properties. On the other hand, 26 years is not the normal horizon. Consequently, a number of short-term projections have also been made within the period 1975-2001, up to 4 quarters ahead. This forms the basis for a discussion of the use of adjustment terms.

HISTORICAL SIMULATION 1975-2000 1

By letting the model calculate the development during a historical period it is possible to see how accurate it is. Specifically, the exercise is to let all exogenous variables assume their actual 1975-2000 values, while all key estimated behavioural relations run freely, i.e. with their residual (adjustment term) set at zero. The adjustment term is, however, maintained in the more technical relations where e.g. one price is made proportional to another or tax proceeds reflect a tax base, etc.

The calculation can be seen as a forecast of the past based on the actual exogenous variables and the estimated relations. At the same time, setting the behavioural relations' adjustment terms at zero provides a set of shocks which must, by definition, lie within the possible range. The question is not only how great the deviation is from the actual course, but also how quickly the model stabilises around the actual course. If the model deviates significantly because of the shocks, it is presumably unstable as regards the variables in question.

Obviously the model's fit over a historical period is not the only thing that matters. It is an artificial situation when relations are estimated on the period explained and the exogenous variables are known. The latter means that the less behaviour a model tries to explain, the better it fits. The fit of a historical simulation can be improved by simply omitting to explain e.g. investments and removing the associated behavioural relations. Investments thus become exogenous and assume their actual value.

The fact that the estimation periods to a considerable degree overlap the simulated period means that the positive deviations in the individual relations carry just as much weight as the negative ones, whereby the simulated variables do not permanently deviate from the actual ones, cf. Pagan (1989). In other words no great significance should be attached to a simulated variable being close to its actual value in 1997, since the relations are typically estimated from between 1971 and 1975 and up to 1997.

The general impression from the historical simulation is that the Mona-calculated variables broadly follow the actual ones, but naturally the fit is not perfect, and at times there are significant deviations. There are also signs of stability problems towards the end of the period, when e.g. a significant deviation is accumulated in the wage level.

Simulated and actual GDP

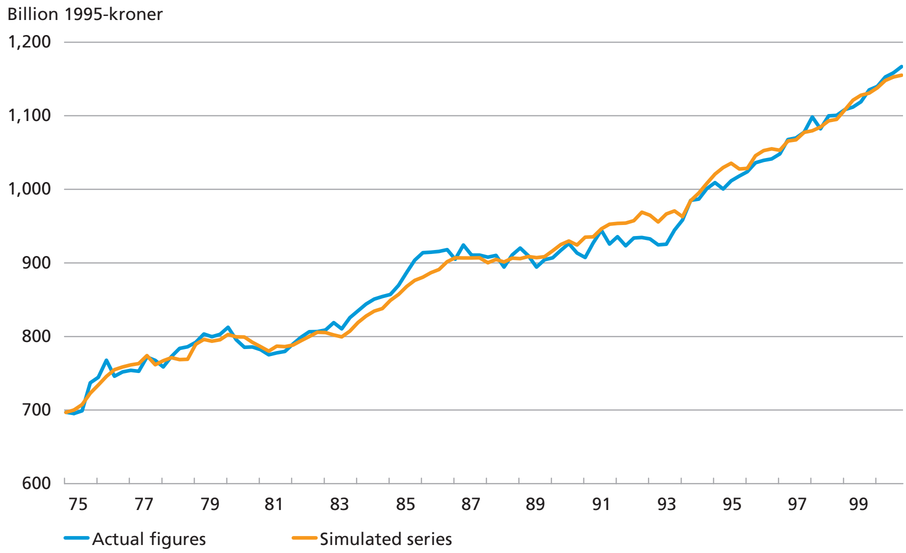
We will first concentrate on the model's fit for GDP at constant prices. There is an average differential or error of 1.6 per cent between calculated and actual GDP in the 104 quarters in 1975-2000. The error is calculated as the square root of the average of the squared deviations (mean square error). There are both positive and negative deviations. Measured over the entire period, GDP is overestimated on average, but only by 1 per mille.

Calculated on the basis of the equivalent 26 annual averages, the error declines from 1.6 per cent for the quarters to 1.4 per cent. It is natural that the error is lower for annual observations where positive and negative deviations during a calendar year's quarters offset each other. The gap would have been even greater than from 1.6 to 1.4 per cent if the calculated quarterly GDP had been distributed more randomly around actual GDP. The deviations between calculated and actual GDP are, however, not random noise. Actual and simulated GDP are shown in Chart V.1.1.

Positive deviations from GDP are mainly followed by positive deviations, and negative deviations by negative ones, so that calculated GDP moves in waves around actual GDP. This is normal, even if the residuals in the estimated relations are random noise.

The autocorrelation in the model error reflects the behavioural relations' gradual adaptation of the actual level to the desired one. If e.g. model-calculated business investments have become too high, it is likely

REAL GDP, ACTUAL AND SIMULATED | Chart V.1.1



that they are also too high in the following quarter because the lagged investments are included with a large weight in the associated relations. To a great extent this also applies to other demand components: private consumption, residential investments, exports, etc.

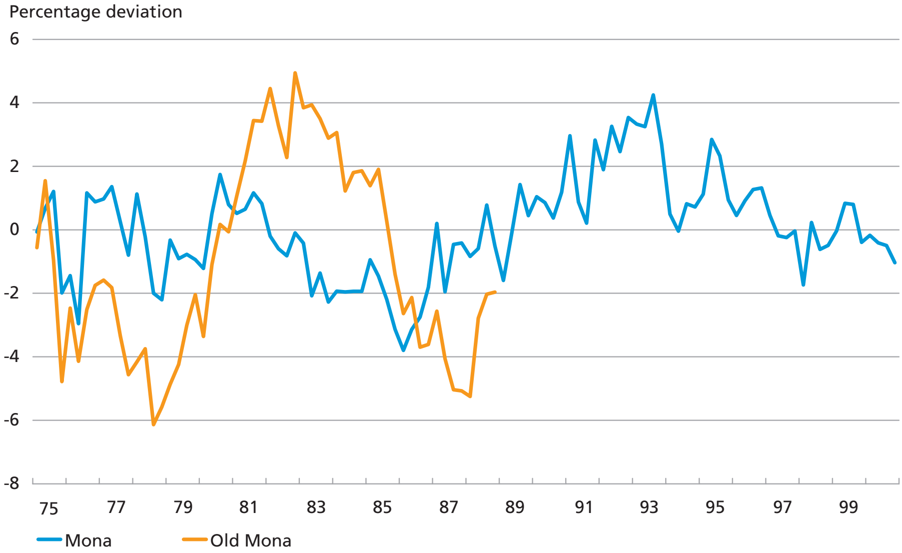
Comparison with the first version of Mona

It is difficult to assess whether an average error on GDP of 1.6 per cent is too large. The model's explanatory power and its degree of stability must also be taken into account. There are no other Danish quarterly models for comparison, but we can compare with the original version of Mona. On a historical simulation the GDP error at that time was 3.2 per cent for the 56 quarters in 1975-88, and the average underestimation was 1 per cent of GDP for this period, cf. Christensen and Knudsen (1992). With the present calculation the GDP error for 1975-88 is 1.5 per cent, and the average underestimation is 0.7 per cent of GDP. The GDP deviations then and now are shown in Chart V.1.2.

The tendency for the model to underestimate the GDP level in the period 1975-1988 relates to the upswing in the mid-1980s, the full strength of which is not captured by the model. The reason may be that the development included an element of expectation or a bubble that is not captured by the estimated behavioural relations.

While the tendency to underestimate GDP (the bias) for the period in question only decreased from 1 to 0.7 per cent, the GDP error (mean square error) more than halved from 3.2 to 1.5 per cent, cf. above.

REAL GDP, SIMULATED LESS ACTUAL AS A PERCENTAGE OF ACTUAL Chart V.1.2



The error reduction reflects e.g. an endogenous bond yield in the old model calculation. In principle, an endogenous bond yield may reduce the GDP error: too high GDP pushes the yield up, and the higher yield limits the excess fluctuation in GDP. This stabilising effect was, however, overshadowed by the impact of the estimation residuals of the bond-yield equation. Now the bond yield is exogenous, so errors of estimation no longer have an impact on the yield in the historical simulation. Exogenisation of the yield is a natural choice after a period of fixed-exchange-rate policy, but this hardly constitutes an improvement of the model.

More significant stabilisation of the simulation properties has been achieved in that the ratio between income and price elasticity for housing demand has been lowered. The relatively stronger price sensitivity means that an increase in income generates a considerably lower increase in house prices now than in the original model. Thus, GDP errors now create less self-sustained concurrence in house prices than in the first version of Mona.

In addition, foreign trade now has a more stabilising effect. A more direct capacity effect is seen in both the import and export relations, and the import-price relation in particular is no longer a pure change relation, but includes and determines the price level.

We will not go into further detail as regards differences from the original model, but instead examine more closely the simulation with the new model.

HISTORICAL SIMULATION 1975-2000, AVERAGE ERRORS — Table V.1.1

	Root M.S.E.	Bias
GDP	1.60	0.23
GVA in private non-farm sector	2.62	0.29
Private consumption	1.88	0.55
Residential investments	9.73	1.73
Machinery investments	11.92	1.72
Fixed investments	11.79	2.82
Stockbuilding, contribution to GDP	1.01	0.05
Domestic demand	2.55	0.58
Industrial exports	4.88	0.69
Imports of goods	4.06	1.28
Net exports, contribution to GDP	1.40	-0.32
Employment in private non-farm sector	4.17	0.76
Hourly wages	5.53	1.56
Private consumption, deflator	1.37	0.09
Residual factor	1.74	-0.32
Capital expenditure, deflator	3.71	1.08
Machinery investments, deflator	4.77	0.68
Industrial exports, deflator	2.22	0.40
Imports of goods, deflator	2.62	0.85
House prices	5.16	1.73

Note: The relationship between Root M.S.E. and Bias is expressed by the formula below, where $\bar{x}$ with a bar is the average and S_x is the standard deviation of x_t.

$$\frac{1}{T}\sum_{t=1}^{T} x_t^2 = \frac{1}{T}\sum_{t=1}^{T}(x_t - \bar{x})^2 + \bar{x}^2 \quad \Leftrightarrow \quad \text{M.S.E.} = S_x^2 + \text{Bias}^2$$

Each time series x_t is defined as the relative deviation between the simulated and the actual figures. Exceptions are "Stockbuilding, contribution to GDP" and "Net exports, contribution to GDP", where the deviation is seen in relation to actual GDP.

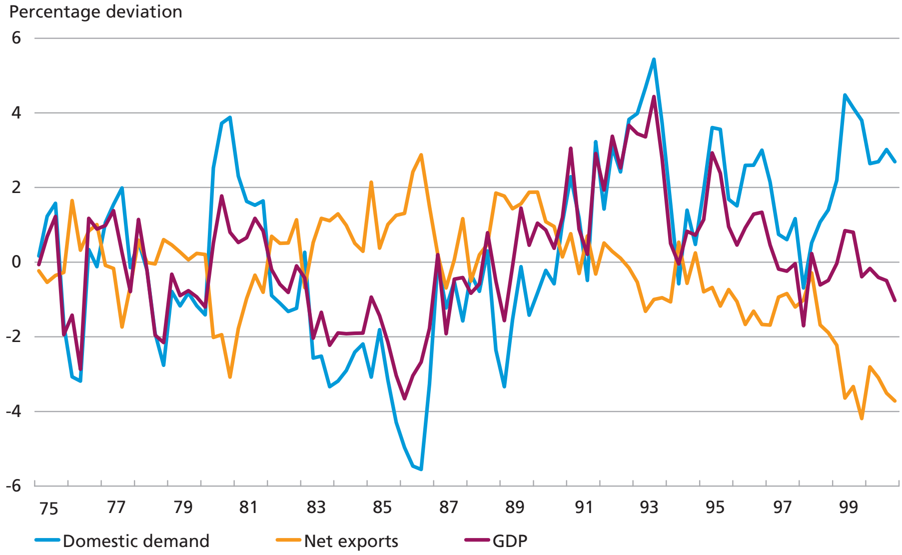
Errors in other variables

GDP is a natural starting point for assessing simulation errors, but of course the model also includes other significant variables. We will not consider all Mona's endogenous variables one by one, but look at some main characteristics.

Not all variables are described equally well. Some variables show particularly strong variation, and some are just very difficult to model. For instance, the error for machinery investments is as high as 11.9 per cent for 1975-2000, while total private consumption at 1.9 per cent is closer to the 1.6 per cent for total GDP. Table V.1.1 shows an overview of model errors for the most important endogenous variables.

The model creates a correlation between the errors. An error in just one equation can generate errors in many variables when the model is solved, and in some cases the errors can amplify each other. For example, a positive adjustment term of 2 per cent in the consumption relation may result in an error of more than 2 per cent on consumption via the effect on activity and income. However, the interaction in the model does not generally amplify errors. The model's crowding-out mechanism

SIMULATED LESS ACTUAL AS A PERCENTAGE OF ACTUAL Chart V.1.3



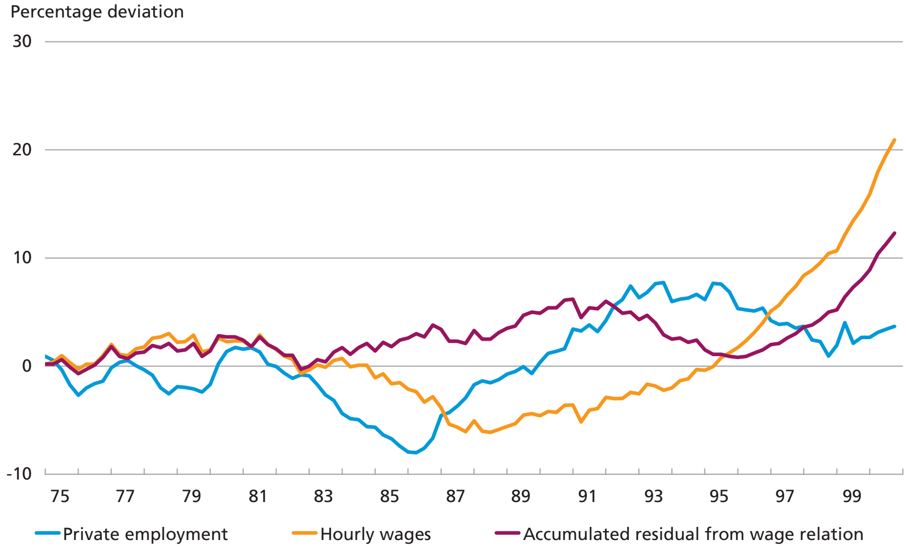
can thus correct and reduce deviations when activity and employment reach a very high or very low level.

Measured in relation to GDP, i.e. as a GDP contribution, the error on total domestic demand is 2.4 per cent. The error on the contribution to GDP from foreign trade is 1.4 per cent of GDP. As mentioned, the error on GDP is 1.6 per cent and thus close to the lower of the two figures. The relatively small GDP error reflects negative covariation between errors in the contribution to GDP from domestic demand and from foreign trade, cf. Chart V.1.3. The negative covariation is mainly attributable to the simple mechanism that increased domestic demand tends to boost imports.

In addition capacity utilisation has a relatively fast, but moderate effect on exports, but the major impact of the crowding-out effect is seen via wages. Since foreign wages and exchange rates are exogenous, all wage changes affect competitiveness and thus exports. High or low unemployment thus has a tendency to abolish itself, but it is a sluggish process.

It is also seen that the calculated value of wages is above or below the actual value for prolonged periods. This not only reflects the sluggishness in the wage response to unemployment, but also the sluggishness in the exports response to relative wages. The delayed pass-through to activity entails that there must be a significant and prolonged wage reaction before weak or strong activity and employment are crowded out. This slow adaptation pattern for the labour market is reflected in the result of the

SIMULATED LESS ACTUAL AS A PERCENTAGE OF ACTUAL Chart V.1.4



model simulation, where simulated wages are far higher than actual wages during the last years of the simulation period.

For comparison with the deviation between the simulated and actual development in wages, the same deviation is calculated on the basis of the wage relation only. Since the wage relation, cf. Chapter II, is an extended Phillips curve without any wage level, the difference between relation-calculated and actual wages merely reflects an accumulation over the residual of the wage relation. The estimation of the wage relation starts in 1974 and ends in 1997, and the accumulated residual from 1975 onwards creates a series which is close to zero around 1997.

It should be noted that wages simulated by the entire model deviate from actual wages in a course which – owing to few, large curves around the average – seems just as non-stationary as the accumulated residual from the wage relation, cf. the yellow and maroon curves in Chart V.1.4. This indicates that the stabilising mechanisms of the model are not sufficiently strong to give simulated less actual wages a clear stationary course. At any rate the stationarity is not seen in the calculation example of the historical simulation.

Sluggishness and overshooting can be part of a true picture of the economy. However, the fluctuations in wages and employment indicate that the model's crowding-out mechanism does not always ensure that unemployment remains above zero. In practice this means that the model's crowding-out mechanism must be supplemented by calculations close to the capacity limit.

More about the pattern in actual and modelled variables

We will now elaborate on model errors via a more general description of how the modelled course fits in with the actual one. To be more specific, we will compare the covariation pattern of the cyclical components[1].

This method may be used to assess theoretically well-founded models where the relations cannot be estimated. Instead they are calibrated. When the relations have not been estimated, they do not match the data particularly well. A cautious way of taking such a model to the data would be to check whether the average correlation pattern of the cyclical components has been captured. Focus is on the cyclical element whereby we avoid e.g. checks of long-run relations where the largest structural breaks are typically seen.

Since the most significant relations in Mona are estimated, there is no major formal need for such a correlation analysis. The relations should fit nicely. All the same, the analysis is presented here with a few selected variables as examples, to illustrate some of the correlations found in the data, captured in the estimation and mimed by the model.

In such analyses of the covariation or correlation pattern for cyclical variables, the cyclical component of GDP is often pivotal. We will assign this role to the gross value added, GVA, of the non-farm sector instead. In Mona e.g. the public element of GDP is exogenous and thus the same for actual and model-calculated data. A comparison of actual and model-calculated series should naturally concentrate on components calculated in the model.

The first Table, V.1.2, compares non-farm GVA with e.g. private consumption and investments. The upper part relates to the actual series, the lower part to the model-calculated series. A comparison of the two parts of the Table makes it possible to assess whether the Mona-simulated development resembles the actual one.

The first line in both parts of the Table illustrates the autocorrelation for non-farm GVA. The first line in the upper part (actual data) shows the autocorrelation in the cyclical component in the actual series. The first line in the lower part (model-calculated data) shows the autocorrelation in the Mona-calculated series. It can be seen that to a high degree GVA correlates positively with itself over a couple of quarters. The autocorrelation is slightly stronger in the modelled GVA. In the modelled series the auto-

[1] The cyclical component in a series should be taken to mean the deviation between the series and the HP-filtered series, cf. King and Rebelo (1993). The HP filter evens out a time series by creating a centred moving average. This is seen as the trend of the series, while the rest of the series is included in the cyclical component.

CORRELATION BETWEEN GVA IN THE PRIVATE NON-FARM SECTOR AND SELECTED VARIABLES

Table V.1.2

Correlation between GVA cycle and cyclical component in variable X with lags and leads	-8	-4	-2	-1	0	+1	+2	+4	+8
					Actual data				
GVA, private non-farm	-0.20	0.30	0.62	0.77	1.00	0.77	0.61	0.30	-0.17
Private consumption	0.12	0.41	0.67	0.74	0.69	0.51	0.39	0.07	-0.16
Machinery investments	0.05	0.27	0.66	0.75	0.75	0.63	0.56	0.22	-0.17
Building investments	-0.09	0.23	0.40	0.51	0.65	0.71	0.72	0.61	0.15
Industrial exports	-0.25	-0.48	-0.31	-0.13	0.07	0.05	0.15	0.05	-0.08
Market share, industrial exports	0.05	-0.32	-0.49	-0.53	-0.53	-0.56	-0.54	-0.49	-0.39
Unemployment	0.40	0.13	-0.29	-0.45	-0.55	-0.59	-0.56	-0.44	-0.15
Consumption deflator, year-on-year change	-0.23	-0.34	-0.49	-0.46	-0.37	-0.23	-0.08	0.02	0.33
Hourly wages, year-on-year change	-0.23	-0.36	-0.22	-0.12	-0.09	-0.02	0.08	0.27	0.41
					Mona-simulated data				
GVA, private non-farm	-0.30	0.26	0.67	0.86	1.00	0.85	0.65	0.25	-0.26
Private consumption	-0.00	0.38	0.67	0.70	0.68	0.59	0.45	0.12	-0.32
Machinery investments	-0.04	0.22	0.61	0.71	0.74	0.63	0.50	0.15	-0.25
Building investments	0.06	0.24	0.43	0.50	0.59	0.63	0.62	0.51	0.08
Industrial exports	-0.14	-0.26	-0.11	-0.01	-0.01	-0.08	-0.06	-0.13	-0.02
Market share, industrial exports	0.08	-0.33	-0.58	-0.65	-0.71	-0.72	-0.68	-0.54	-0.20
Unemployment	0.60	0.26	-0.18	-0.38	-0.53	-0.58	-0.55	-0.44	-0.01
Consumption deflator, year-on-year change	-0.17	-0.44	-0.43	-0.37	-0.25	-0.15	-0.07	-0.02	0.29
Hourly wages, year-on-year change	-0.15	-0.49	-0.34	-0.24	-0.16	-0.04	0.12	0.35	0.40

Note: The correlation coefficients in the upper part are based on cyclical components in actual series, in the lower part on cyclical components in model-simulated series. The correlation coefficients relate to the period 1975-98.

correlation can be created by the autocorrelation in the exogenous variables and particularly by the lags in the behavioural relations.

The second lines in the Table under actual and modelled data, respectively, show the correlation of private consumption with non-farm GVA. The correlation coefficients to the left of the 0 column show the correlation between lagged consumption and GVA in the quarter. The coefficients to the right of the 0 column show the correlation between non-farm GVA and consumption in the subsequent quarters. These variables are sluggish, cf. also the autocorrelation pattern for GVA, and it is natural to see correlation both backwards and forwards on covariation of sluggish variables. In addition, there are *a priori* arguments indicating that consumption drives activity, and that activity and income drive consumption.

CORRELATION BETWEEN PRIVATE CONSUMPTION AND SELECTED VARIABLES

Table V.1.3

Correlation between cyclical component in consumption and in variable X with lags and leads	-8	-4	-2	-1	0	+1	+2	+4	+8
					Actual data				
Private consumption	-0.03	0.30	0.64	0.75	1.00	0.75	0.64	0.31	-0.07
Disposable income................	-0.02	0.29	0.46	0.43	0.46	0.28	0.06	-0.24	-0.25
Private wealth	0.08	0.49	0.67	0.67	0.68	0.61	0.58	0.47	0.16
Consumption, deflator, quarterly change	-0.12	-0.29	-0.31	-0.20	-0.24	0.13	0.00	0.12	0.23
Unemployment, quarterly change	0.18	-0.16	-0.43	-0.45	-0.38	-0.24	-0.04	0.14	0.04
					Mona-simulated data				
Private consumption	-0.06	0.36	0.69	0.82	1.00	0.82	0.70	0.38	-0.10
Disposable income...............	-0.08	0.32	0.47	0.45	0.44	0.24	-0.00	-0.32	-0.35
Private wealth......................	0.38	0.76	0.85	0.80	0.73	0.63	0.55	0.32	-0.20
Consumption deflator, quarterly change	-0.12	-0.24	-0.30	-0.26	-0.33	0.10	0.05	0.12	0.26
Unemployment, quarterly change..................................	0.18	-0.17	-0.44	-0.45	-0.35	-0.21	-0.07	0.09	0.13

Note: Cf. Table V.1.2.

Apparently both the actual and the Mona-simulated data show the highest degree of correlation from consumption to non-farm GVA. It would seem that consumers have typically triggered cyclical developments.

Presumably consumption is seen to be driven to a lesser degree because non-farm GVA differs from consumption-determining variables such as disposable income and wealth.

To further illustrate the correlation pattern in relation to consumption, Table V.1.3 focuses on consumption and the immediate explanatory factors according to Mona's consumption relation, i.e. disposable income, wealth, price increases and changes in the unemployment rate. The consumption relation includes all these variables on the right-hand side, so e.g. the simple correlation between income and consumption might deviate from the explanatory contribution from income in the relation. However, the simple correlations seem to reflect the preceding sign and causality of the relation.

Specifically, the correlation mainly goes from the explanatory variable of the consumption relation to consumption, not only for the Mona-simulated data, but also for the actual data. The correlation for wealth in particular is seen more clearly in the model-calculated data than in the actual data, but the overall correlation pattern is the same in the upper and lower parts of the table.

It might be added that when the correlations in the Tables include both lags and leads, they capture any effects from expectations influencing the variables. It is of course possible that forward-looking expectations affect the correlation pattern in the actual series, but no explicit forward-looking expectations are included in the Mona simulation.

In lines three and four in Table V.1.2 for non-farm GVA versus other variables the covariation with machinery investments and building investments are shown. As expected, both types of business investments have a positive correlation to GVA, and just as for private consumption the correlation goes both ways: from GVA to investment, and from investment to GVA.

For machinery investments there is a slight overweight in the correlation from investments to GVA, while the opposite is the case for building investments. This difference between machinery investments and building investments is seen for actual and simulated data alike. The planning time is usually longer for building investments, so it is natural that they emerge later in the cycle. For machinery investments it could e.g. be the response to interest rates which entails that they react at a fairly early stage of the cycle and thus partially trigger the development in GVA.

In order to examine this more closely, Table V.1.4 compares machinery investments with the output/capital and capital cost/wage ratios. These are the two ratios included in Mona's relation for machinery investments.

Both for actual and simulated data the correlation from relative factor prices to investments show a longer lag than that applying to the output/capital ratio, which peaks at almost the same time as investments. This confirms that the correlation pattern between machinery

CORRELATION BETWEEN MACHINERY INVESTMENTS AND SELECTED VARIABLES

Table V.1.4

Correlation between cyclical component in machinery investments and variable X with lags and leads.	-8	-4	-2	-1	0	+1	+2	+4	+8
					Actual data				
Machinery investments......	-0.03	0.31	0.63	0.76	1.00	0.76	0.63	0.33	0.01
Output/capital	0.00	0.35	0.55	0.54	0.56	0.50	0.33	-0.09	-0.32
User cost/wages	-0.27	-0.45	-0.40	-0.32	-0.22	-0.11	0.01	0.10	-0.09
					Mona-simulated data				
Machinery investments......	-0.08	0.20	0.66	0.87	1.00	0.88	0.67	0.25	0.04
Output/capital	-0.24	0.29	0.52	0.59	0.63	0.57	0.41	0.05	-0.25
User cost/wages	-0.41	-0.54	-0.49	-0.37	-0.16	0.04	0.16	0.20	0.06

Note: Cf. Table V.1.2.

investments and non-farm GVA may reflect that capital costs help to drive GVA via machinery investments.

There is no major correlation coefficient between industrial exports and non-farm GVA, cf. Table V.1.2. The negative signs may reflect a capacity effect, but the time sequences suggest that large exports are followed by small output. It is easier to understand the correlation of the market share with non-farm GVA. This correlation is fairly simultaneous, and if there is a small delay, the direction of the effect is from large output to small market share, like a normal capacity effect. This applies to both actual and simulated data.

As can be expected, the correlation from non-farm activity to unemployment is negative, and there is a tendency for the negative correlation to be largest when activity lags slightly. This reflects the sluggishness of employment, cf. Table V.1.2.

Finally we will consider a couple of nominal variables. First the rate of increase of the consumption deflator, whose cyclical component apparently correlates negatively with the cyclical component of non-farm GVA, at least when the price increase lags. This could indicate an impact from supply shocks, e.g. from the oil-price changes in the calculation period, which also affect the simulated development via the exogenous oil price.

For the wage increase a negative correlation is also seen, and again the high wage increases seem to be followed by low output – both for actual and modelled data. In addition, there is a positive correlation between GVA and the wage increase in the following quarters, equivalent to a simple demand effect on wages.

In the model, wage formation goes via unemployment so it is natural to refer to cyclical unemployment rather than cyclical activity. This has been done in Table V.1.5, where there is a clear tendency for the wage

CORRELATION BETWEEN UNEMPLOYMENT AND WAGE INCREASE Table V.1.5

Correlation between cyclical component in unemployment and in variable X with lags and leads	-8	-4	-2	-1	0	+1	+2	+4	+8
					Actual data				
Unemployment	-0.42	0.24	0.70	0.91	1.00	0.92	0.74	0.31	-0.30
Hourly wages, year-on-year increase	0.35	0.42	-0.01	-0.22	-0.32	-0.37	-0.45	-0.58	-0.33
					Mona-simulated data				
Unemployment	-0.53	0.25	0.68	0.90	1.00	0.91	0.73	0.35	-0.48
Hourly wages, year-on-year increase	0.43	0.47	-0.03	-0.27	-0.39	-0.43	-0.53	-0.71	-0.24

Note: Cf. Table V.1.2.

increase to react to unemployment with a negative sign and a slight delay, both for modelled and actual data series.

USE OF ADJUSTMENT TERMS 2

As a quarterly model Mona is primarily used for short-term forecasts so in this connection the period 1975 to 2000 is unusually long. Nor is it normal to set all residuals of behavioural relations at zero, thus achieving a pure model forecast.

In all the model's behavioural relations there is an adjustment term called the "add factor" or "intercept correction". It shows the difference between the left-hand variable and the estimated right-hand expression and corresponds to the estimation residual in the estimation period.

If the adjustment term in a behavioural relation is e.g. systematically negative in the quarters up to the start of the forecast period, the relation has presumably broken down, and the adjustment term no longer has zero as its mean value. If a relation entails problems, it is naturally best to estimate another relation without problems, but this is not always possible. One may also choose to postpone any reestimation until it has been seen whether the final national accounts, which are available with some years' delay, confirm the preliminary figures or actually "save" the relation.

Irrespective of the reason for accepting a relation with systematic error terms up to the initial quarter of the forecast, any systematic bias in the adjustment term can justify setting the adjustment term at another value than zero in the projection period.

In addition, even if the residual looks like white noise, the model user may know something which is not included in the model and therefore wish to correct the model-calculated result. The extra source might be cyclical-indicator information compiled outside the model. It is usually easiest to make such corrections by letting the adjustment term deviate from zero.

The use of adjustment terms has previously attracted special interest, since adjustments may reflect the user's attempts to manipulate, see e.g. Christensen (1978). Today an estimate or a forecast hardly becomes more credible via a reference to a particular model, and the interest in adjustment terms has undoubtedly diminished. This certainly applies when some of the models used are so close to economic theory that they can scarcely be estimated, but must be supplied with calibrated coefficients.

It must also be key to an open process and professional discussion that someone takes responsibility for the result of using the model and explains it in the simplest possible way. We will not go further into this discussion of principles, but rather consider the application in practice of adjustment terms.

Below we will first explain the significance of adjustment terms in a single relation. Then model simulations on historical data are used to illustrate how the adjustment terms may affect forecasts using the entire model.

Adjustment terms in a relation

The example used is a simple relation with one variable that depends on itself lagged

$$X = 0.67 \cdot X_{-1} + \text{addterm} \tag{V.1}$$

The model's relations are usually more complex than (V.1), but if we ignore other explanatory variables, the difference equation in (V.1) resembles several of the model's relations. For example, (V.1) resembles the consumption relation, where the coefficient to lagged consumption is also close to 2/3 when the relation is written with the level on the left-hand side. This relation is in logarithms, and an adjustment term of 0.01 in a quarter means that consumption in that quarter is 1 per cent higher than the estimated consumption relation indicates, given the value of X_{-1}.

The lagged X is, however, a function of previous quarters' adjustment terms, so the impact of the adjustment term on a forecast with the relation over several quarters is not only the value of the adjustment term in the individual quarters. The impact on the forecast accumulates.

If 0.01 is maintained as the adjustment term throughout the projection, X ends up being 3 per cent higher than the relation indicates with zero as the adjustment term. In the first quarter, X will be 1 per cent higher than without the adjustment term, in the second quarter 1 + 2/3 per cent, in the third quarter 1 + 2/3 + 4/9 per cent, etc. The final effect is the sum of an infinite geometrical progression with 2/3 as the common ratio, 1/(1-2/3) = 3.

If the adjustment term is 0.01 in the first quarter of the calculation and zero thereafter, corresponding to a one-off correction, X increases relative to an uncorrected forecast by 1 per cent in the first quarter, by 2/3 per cent in the second quarter, 4/9 per cent in the third, etc. The effect gradually approaches zero. If the effect of the adjustment term of 0.01 is to disappear immediately after the first quarter, an adjustment term of -2/3 per cent is required in the second quarter.

All Mona's adjustment terms have the simple additive form seen in (V.1). This corresponds to adjustment via parallel displacement of the entire behavioural relation up or down via correction of the relation's constant term. The correction could also be made in other ways. For instance, if we are only interested in moving the variable *X* itself and not the relation's constant, this would be easier to handle if the adjustment term were included parallel with the variable rather than with the constant.

$$X - \text{adterm}' = 0.67 \cdot (X_{-1} - \text{addterm}'_{-1}) \quad \text{(V.2)}$$

With this formulation the development in the adjustment term is reflected one to one in the economic variable *X*. For instance, it might be obvious to attribute construction activity for a large bridge to certain quarters while avoiding the spillover implied by the dynamics of the investment relation. To that end the formulation in (V.2) would in principle be suitable. Whether (V.2) is the optimum solution is, however, uncertain. Another approach to the same problem is simply to segregate the relevant investment segment as an exogenous variable. In the bridge example the main issue is basically to avoid the behaviour-related adaptation pattern, since information on investment by quarters is available outside the model.

We have considered the adjustment term in a single stylised relation. When applying the model it is also necessary to take account of the interaction between the model's relations. For example, a permanent lift in the consumption function via the adjustment term will in the long term have a stronger impact on wealth creation than on consumption.

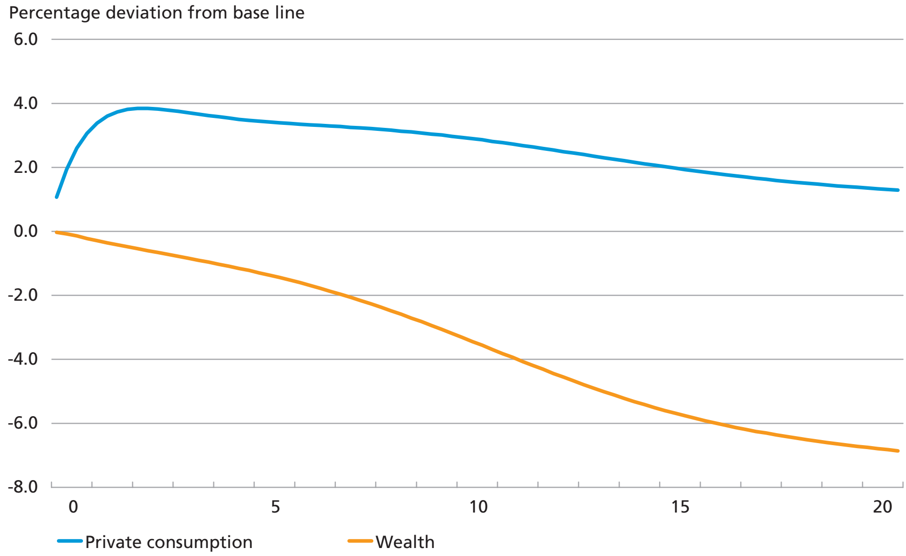
Consumption initially becomes 1 per cent higher than without an adjustment term of 1 per cent, and in the subsequent quarters consumption increases by more than 1 per cent over the base line. On the basis of the actual consumption relation with given income and wealth levels the long-term effect, as mentioned, is the sum of a geometric progression and lies in the range of 3 per cent. To this should be added the expansive effect on income.

In the long term, however, the consumption effect declines back towards zero. This reflects a deterioration of wealth owing to lower savings. In the long term the lift in the consumption relation particularly entails less wealth, cf. Chart V.2.1.

The model's adjustment terms are exogenous variables, and similar multiplier experiments can be made for all adjustment terms. This makes it possible to study the effect of adjustment terms when the entire model interacts. We will not go into further detail here, but rather use historical data to assess the various approaches to setting adjustment terms.

EFFECT OF 1-PER-CENT CHANGE IN THE CONSUMPTION RELATION'S ADJUSTMENT TERM

Chart V.2.1



Adjustment terms and model forecasts

When preparing a forecast, the value of the adjustment terms can be set on the basis of several different arguments. It may be a question of utilising specific information on the very closest or latest development, but general considerations may also be applied. For instance, it might be considered whether the adjustment terms in the estimated relations should be set at zero, i.e. at their average value during the estimation period, or whether they should be based on their latest values.

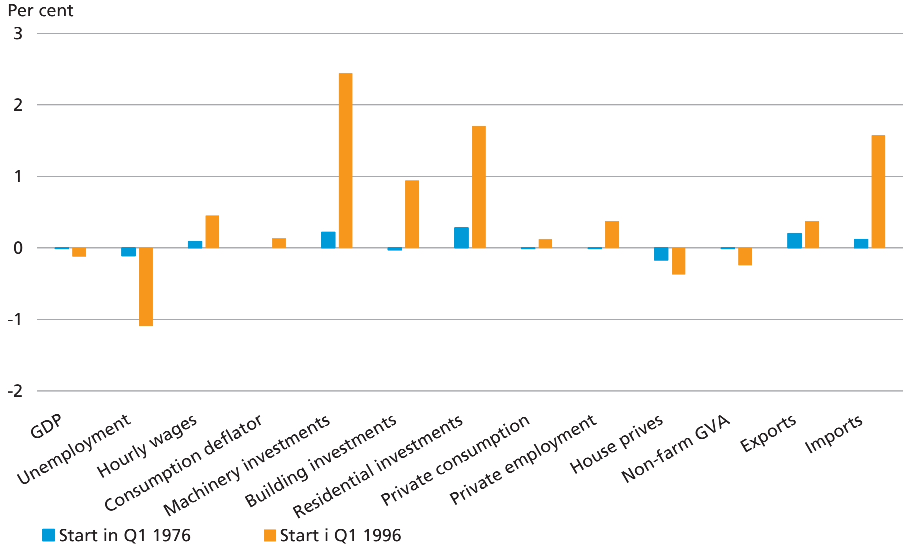
It can be difficult to reestimate Mona-relations. It is easier with pure time-series models where it is only necessary to look at changes, while the levels and structural relations between the variables can be ignored. The use of adjustment terms can be seen as a way of approaching the individual time-series models, cf. Clements and Hendry (2003), who point out that bias can be reduced by using the latest historical adjustment terms.

The problem can be illustrated via Mona calculations. Instead of solving the model over the entire period 1975-2000, a simulation on four quarters is started up in each of the quarters 1976Q1 to 1999Q4. This gives 96 simulations.

The simulations are made in three ways: with zero as the adjustment term for the behavioural relations as in the total simulation 1975-2000, with the adjustment term's value in the latest observation up to the start of the forecast, and with an average of the four observations up to

AVERAGE BIAS FOR FORECAST 1 QUARTER AHEAD, CALCULATION PERIOD

Chart V.2.2



Note: Adjustment term zero. The model has been started up every quarter in the period 1976-1999 and solved for a quarter. The blue bars are average biases for the entire period since 1976. The yellow bars are average biases for the period since 1996.

the start of the forecast. The latter requirement is the reason why the first calculation starts in 1976Q1. The calculations relate to a historical period, and all variables are set at their actual values up to the start of the forecast, from which point the endogenous variables are model-simulated.

Assessed on the basis of e.g. the GDP estimate one quarter ahead in all 96 simulations there are no major problems in terms of biased estimates. Naturally the estimates are not perfect matches, but on average over the 96 simulations there is no clear systematic over- or underestimation. This not only applies to GDP, but is exemplified via a calculation for 13 important economic variables. The absence of bias reflects that we are forecasting primarily on the actual estimation period.

In practice forecasting does not take place inside, but outside the estimation period, of course. If the period under review is limited to recent years, e.g. 1996-2000, the estimates become more biased, cf. Chart V.2.2. Since the relations are typically estimated up to and including 1997, the shorter sample 1996-2000 is closer to the conditions in a practical forecast situation.

Applying the value of the adjustment term prior to the start of the forecast, e.g. in the preceding quarter, means that if a relation hits below the mark prior to the start of the forecast, the same positive ad-

ADJUSTMENT TERMS FOR FORECASTS 1 QUARTER AHEAD, BIAS AND STANDARD DEVIATION

Table V.2.1

Per cent	Bias			Standard deviation		
	adjustment term zero	adjustment term from preceding quarter	adjustment term average of the four preceding quarters	adjustment term zero	adjustment term from preceding quarter	adjustment term average of the four preceding quarters
GDP	-0.12	-0.01	-0.04	0.62	0.77	0.75
Unemployment	-1.09	-0.59	-0.91	4.03	5.73	4.54
Hourly wages	0.45	0.06	0.17	0.33	0.36	0.26
Consumption deflator	0.13	0.03	0.06	0.19	0.22	0.19
Machinery investments	2.44	-0.21	0.20	3.88	5.07	4.09
Building investments	0.94	0.16	0.98	5.44	7.68	5.60
Residential investments	1.70	-0.77	-0.28	4.82	6.90	5.41
Private consumption	0.12	-0.11	-0.16	1.00	1.74	1.17
Private employment	0.37	0.06	0.03	1.09	1.76	1.28
House prices	-0.37	-0.09	-0.15	0.85	1.04	0.91
Non-farm GVA	-0.24	0.00	-0.04	1.05	1.34	1.26
Exports	0.37	0.00	0.15	1.40	1.95	1.62
Imports	1.57	0.26	0.42	2.01	3.00	2.13

Note: Bias and standard deviation are based on logarithmic deviations multiplied by 100. A positive bias of 1 means that the variable has on average been overestimated by 1 per cent in the calculation period. The table shows bias and standard deviation for some key variables.

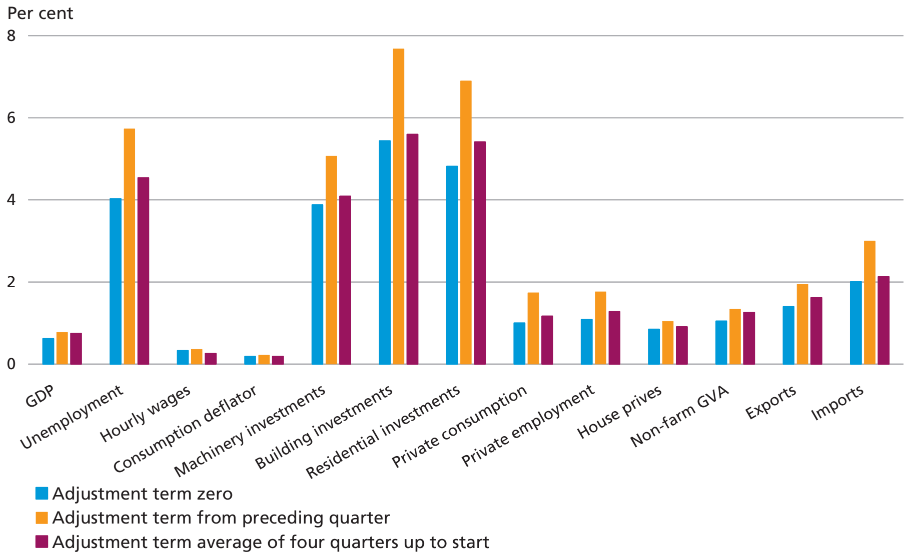
justment term is repeated in all four simulated quarters. It is an advantage if the relation systematically hits below the mark, since the adjustment term can correct this. However, the noise in the estimate increases if the adjustment term in the quarter before the start of the forecast is randomly distributed around zero.

It turns out that for the last years in the period corresponding to the forecast starting in the 1st quarter of 1996 to the 4th quarter of 1999, i.e. a total of 16 simulations, the estimates are typically less biased if the historical value of the adjustment term is used. However, the standard deviation is typically larger than if the adjustment term is kept at zero. The result of the 16 Mona calculations is illustrated in Table V.2.1, which shows both bias and standard deviation on forecasting 13 endogenous variables one quarter ahead.

Zero and the latest historical value are not the only options for the adjustment term. Another option is to apply an average of the last four quarters. This could be a good compromise where the largest biases are reduced and the largest increases in the standard deviation are avoided.

The results on the bias and standard deviation from Table V.2.1 are repeated in two Charts. Two other Charts show equivalent results for forecasts four quarters ahead.

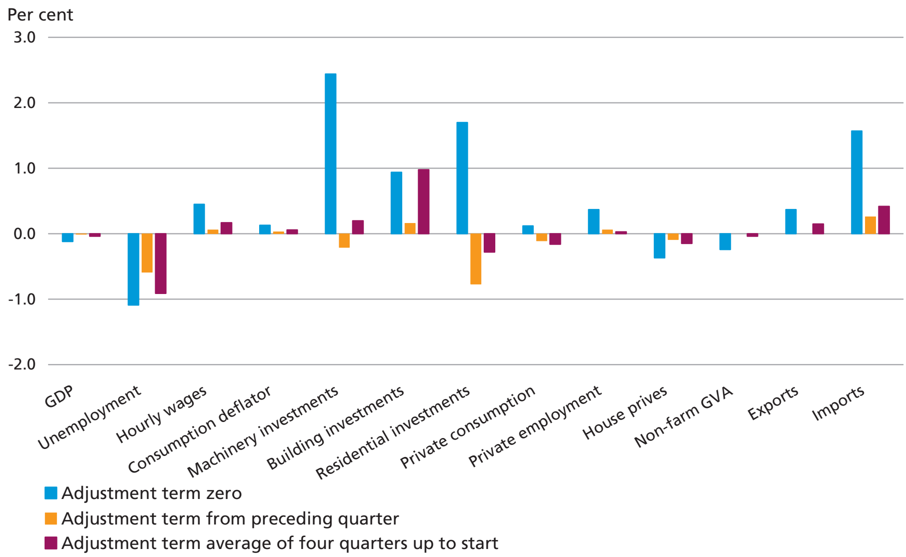
AVERAGE STANDARD DEVIATION ON FORECAST 1 QUARTER AHEAD Chart V.2.3



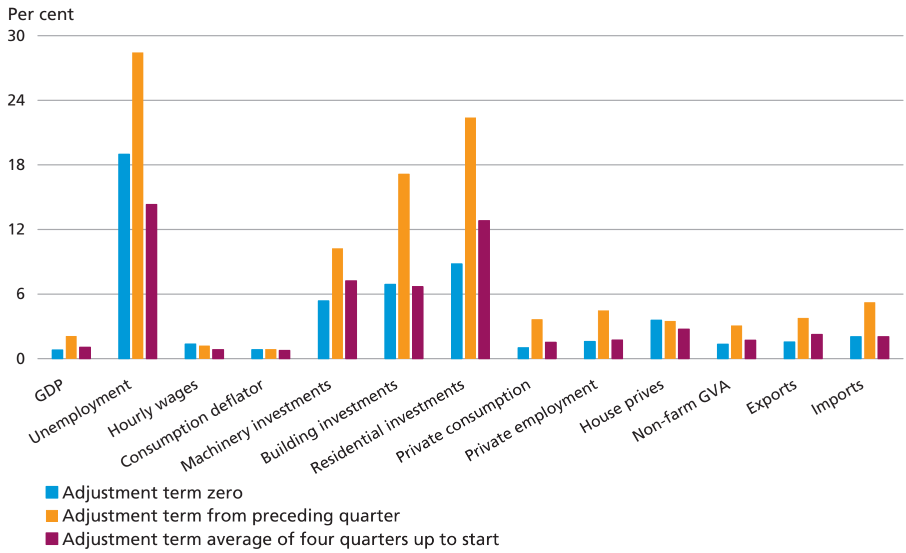
Note: Calculations underlying V.2.3 to V.2.6 start in Q1 1996.

We could go on and test a mechanical projection of the adjustment term using an autoregressive process, e.g. the ARIMA model. In principle this might capture systematic development in the adjustment term up to the start of the forecast period. However, this approach will not be examined here.

AVERAGE BIAS ON FORECAST 1 QUARTER AHEAD Chart V.2.4

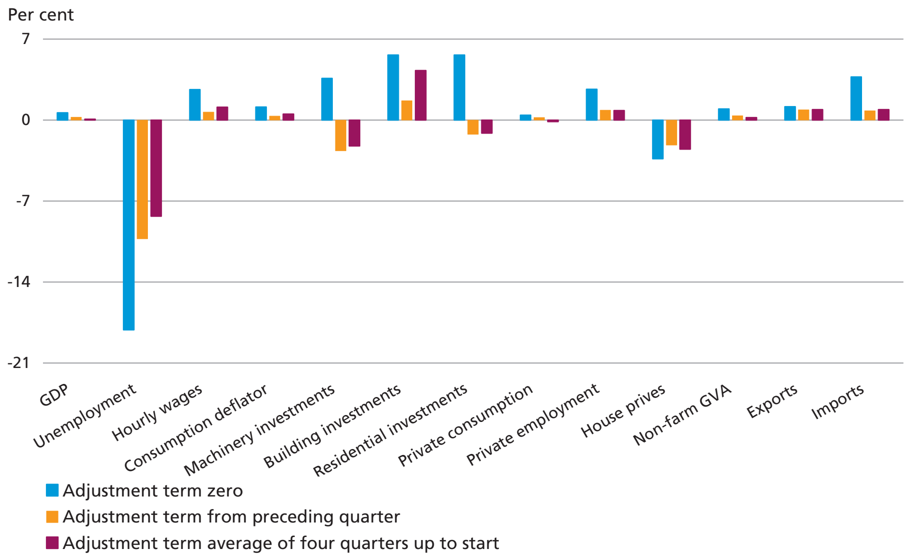


AVERAGE STANDARD DEVIATION ON FORECAST 4 QUARTERS AHEAD — Chart V.2.5



In practice one will try to include information from outside the model and generally apply a less mechanical approach to guessing the adjustment terms. How much better this is than setting all adjustment terms according to the same formula remains to be seen; but the model experiment just presented indicates that it improves the model's forecast to set the adjustment terms at other values than zero.

AVERAGE BIAS ON FORECAST 4 QUARTERS AHEAD — Chart V.2.6



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The Mona system of equations

Whenever a relation is normalized on another variable than the immediate left-hand-side variable, the right-hand-side expression of the relation is represented by an auxiliary variable called HS. This reflects a convention in the applied Aremos software, which also automatically assigns an additive adjustment term to the relations.

Some terms, including constants, are multiplied by the factor 0.001. This is done to furnish an Aremos-generated listing of relations with a sufficient number of decimal places for the coefficients. The listing of relations can be converted to an input for the Troll software package. Troll is capable of handling leads, and the conversion introduces a 40-quarter lead in the expected inflation terms.

The reporting of the system of equations is based on Aremos notation. The notation is standard for most arithmetical operators but you may note the following conventions.

**n	: Raised to the n'th power
[-n] & .n	: Lagged n periods
diff	: First order difference
dlog	: First order logarithmic difference

Exports

(1):	LOGFEIND		Industrial exports
	logfeind	=	HS+log(feind.1)
	HS	=	-0.25800*dlog(feind.1)-0.13457*dlog(feind.4)+0.90319*dlog(feu)+ 0.44312*dlog(pxudl/pxden)-0.20768*(log(feind.1/feu.1)- (1.19022*log(lonudl.1/(efkrks.1*lnio.1))+0.05891*dum903.1+ (-1.18221)*0.001*trend)) - 0.12979*log(tuc.1)+2.46065
(2):	FEIND		Industrial exports
	feind	=	exp(logfeind)
(3):	LOGFEANI		Agricultural products of animal origin, exports
	logfeani	=	-0.20*3.14*log(peani*efkrks/pxudl)+0.2*log(feu)+0.80*logfeani.1
(4):	FEANI		Agricultural products of animal origin, exports
	feani	=	exp(logfeani)
(5):	LOGFEKQD		Canned meat and milk, exports
	logfekqd	=	-0.20*3.14*log(pekqd*efkrks/pxudl)+0.2*log(feu)+ 0.80*logfekqd.1
(6):	FEKQD		Canned meat and milk, exports
	fekqd	=	exp(logfekqd)
(7):	LOGFEY		Exports of ships and aeroplanes
	logfey	=	-0.20*2.0*log(pey/(pxudl/efkrks))+0.2*log(feu)+0.8*logfey.1
(8):	FEY		Exports of ships and aeroplanes
	fey	=	exp(logfey)
(9):	LOGFES		Exports of services (besides travel receipts)
	logfes	=	-0.65*dlog(pes/((pship*eusd)**0.80*(lonudl/efkrks)**0.20))+ 0.20*0.3*log(pes.1/mulc.1)+0.2*log(feu)+0.8*logfes.1
(10):	FES		Exports of services (besides travel receipts)
	fes	=	exp(logfes)

(11):	LOGFET		Travel receipts
	logfet	=	-0.65*dlog(pet/(pxudl/efkrks))- 0.20*1.5*log(pet.1/(pxudl.1/efkrks.1))+0.2*log(feu)+0.80*logfet.1
(12):	FET		Travel receipts
	fet	=	exp(logfet)
(13):	FEAV		Exports of other goods
	feav	=	feav.1*((feani+feveg+fekqd+feind+febra+feol+fefsk+fepel+fey)/ (feani.1+feveg.1+fekqd.1+feind.1+febra.1+ feol.1+fefsk.1+fepel.1+fey.1))
(14):	FEV		Exports of goods
	fev	=	feani+feveg+fekqd+feind+febra+feol+fefsk+fepel+feav+fey
(15):	EV		Exports of goods
	ev	=	feani*peani+feveg*peveg+fekqd*pekqd+feind*peind+ febra*pebra+feol*peol+fefsk*pefsk+fepel*pepel+ feav*peav+fey*pey
(16):	FE		Exports of goods and services
	fe	=	feani+feveg+fekqd+feind+febra+feol+fefsk+fepel+feav+fey+ fet+fes
(17):	E		Exports of goods and services
	e	=	feani*peani+feveg*peveg+fekqd*pekqd+feind*peind+ febra*pebra+feol*peol+fefsk*pefsk+fepel*pepel+ feav*peav+fey*pey+fet*pet+fes*pes
(18):	LOGPXDEN		Foreign currency price of industrial exports
	logpxden	=	HS+log(pxden.1)+dlog(efkrks)
	HS	=	0.30742*dlog(pxudl/efkrks)+0.14286*dlog(efkrks)+ 0.36767*dlog(mulc)-0.30732*log(pxden.1/efkrks.1)+ 0.12074*log(pxudl.1/efkrks.1)+0.18658*log(mulc.1)- 3.13693*0.001*trend+5.48764
(19):	PXDEN		Foreign currency price of industrial exports
	pxden	=	exp(logpxden)

(20):	LOGPEIND		Industrial exports deflator
	logpeind	=	log(pxden/efkrks)
(21):	PEIND		Industrial exports deflator
	peind	=	exp(logpeind)
(22):	LOGPEBRA		Price on exports of energy products
	logpebra	=	HS+log(pebra.1)
	HS	=	0.16979*dlog(pebra)[-1]+0.54915*dlog(praoli*eusd)-0.44468*log(pebra.1)+0.41052*log(praoli.1*eusd.1)+0.03417*log(lonudl.1/efkrks.1)-1.74139
(23):	PEBRA		Price on exports of energy products
	pebra	=	exp(logpebra)
(24):	LOGPEOL		Bunkering deflator
	logpeol	=	log(pebra)
(25):	PEOL		Bunkering deflator
	peol	=	exp(logpeol)
(26):	LOGPEY		Deflator for exports of ships and aeroplanes
	logpey	=	log(peind)
(27):	PEY		Deflator for exports of ships and aeroplanes
	pey	=	exp(logpey)
(28):	LOGPEANI		Agricultural exports of animal origin deflator
	logpeani	=	log(peind)
(29):	PEANI		Agricultural exports of animal origin deflator
	peani	=	exp(logpeani)
(30):	LOGPEVEG		Deflator for agricultural exports of vegetable origin
	logpeveg	=	log(peind)
(31):	PEVEG		Deflator for agricultural exports of vegetable origin
	peveg	=	exp(logpeveg)

(32): LOGPEKQD Agricultural exports of canned meat and milk deflator
logpekqd = log(peind)

(33): PEKQD Agricultural exports of canned meat and milk deflator
pekqd = exp(logpekqd)

(34): PEAV Exports of other goods deflator
peav = peav.1*(((ev-peav*feav)/(fev-feav))/((ev.1-peav.1*feav.1)/(fev.1-feav.1)))

(35): PEV Exports of goods deflator
pev = ev/fev

(36): PE Exports of goods and services deflator
pe = e/fe

(37): LOGPES Deflator for exports of services besides travel receipts
logpes = HS+log(pes.1)

HS = 0.22333*dlog(pship*eusd)+0.53638*dlog(lonudl/efkrks)+
0.10259*log(eusd/eusd.4)-0.18806*log(pes.1)+
0.03781*log(pship.1*eusd.1)+ 0.15024*log(lonudl.1/efkrks.1)-
4.50486*0.001*trend+9.5148

(38): PES Deflator for exports of services besides travel receipts
pes = exp(logpes)

(39): LOGPET Travel receipts deflator
logpet = log(pcq)

(40): PET Travel receipts deflator
pet = exp(logpet)

Private consumption

(41): LOGFCP Private consumption
logfcp = HS+log(fcp.1)

HS = 0.09720*dlog((ydp-dalo-pyfe*fyfe)/pcp)+
0.11245*(log((ydp.1-ipv.1-pyfe.1*fyfe.1)/pcp.1) -log(fcp.1))+
0.16307*(log(realfor.1)-log(fcp.1))-3.42552*arblos2+
0.05283*d7734+0.03213*dmims-0.60351*dlogpcpt-0.35294

(42):	FCP		Private consumption
	fcp	=	exp(logfcp)
(43):	DLOGPCPT		Change in consumption deflator
	dlogpcpt	=	dlog(pcp)-HS
	HS	=	-1.35579*tttt+2.70651
(44):	REALFOR		Real value of private wealth
	realfor	=	(pqq1+0.6*(alop+abzk+obzk)+pqq5+pipm*km+pipb*kb)/pcp
(45):	PQQ1		Private stock of houses plus financial net wealth, market value
	pqq1	=	aih*kp+pdb+pdsb+pbzk+plob-blop-glop-elop-flpk-kbzr-alop
(46):	PBZK		Private bond holding, market value
	pbzk	=	pbzk.1*(kurss/kurss.1)+(pbzz-pbzz.1)
(47):	KURSG		Bond price, state bonds
	kursg	=	kursg.1*((1+ibz)/(1+ibz.1))**varg.1*(1-afsg)+afsg
(48):	KURSR		Bond price, mortgage bonds
	kursr	=	kursr.1*((1+ibz)/(1+ibz.1))**varr.1*(1-afsr)+afsr
(49):	KURSS		Bond price, Danish holdings average
	kurss	=	kurss.1*(bzgk+bzlk+kbzr-fbzk-diff(zbzg+zbzl+zbzr-fbzz))/ (bzgk.1+bzlk.1+kbzr.1-fbzk.1)
(50):	ARBLOS2		Unemployment term in the consumption function
	arblos2	=	0.5*((dagl-dagp)*(1-bsda)*(ul/(qo+qp+ul))/dagl- (dagl.2-dagp.2)*(1-bsda.2)* (ul.2/(qo.2+qp.2+ul.2))/dagl.2)
(51):	KBZR		Private bond debt, market value
	kbzr	=	kbzr.1*(kursr/kursr.1)+(zbzr-zbzr.1)
(52):	FLPK		Foreign lending to private sector, market value
	flpk	=	flpk.1*(efkrks.1/efkrks)+flp-flp.1
(53):	PQQ5		Imputed value of old-age pension scheme
	pqq5	=	0.25*(pensats*demografi+pensats.1*demografi.1+ pensats.2*demografi.2+pensats.3*demografi.3)*pcp

(54):	LOGPENSATS		Pension rate
	logpensats	=	log(lnf/pcp)
(55):	PENSATS		Pension rate
	pensats	=	exp(logpensats)
(56):	OBZK		Bond holdings of social security funds, market value
	obzk	=	obzk.1*(kurss/kurss.1)+obzz-obzz.1
(57):	ABZK		Bond holdings of insurance enterprises, market value
	abzk	=	abzk.1*(kurss/kurss.1)+abzz-abzz.1
(58):	IPV		Private reinvestment
	ipv	=	fipvm*pipm+fipvb*pipb+fihv*pih
(59):	DAGL		Average wage rate
	dagl	=	(yw-sbid-sdu)/(qo+qp)
(60):	DAGP		Average unemployment benefits
	dagp	=	tyd/ul
(61):	LOGFCH		Gross rents
	logfch	=	log(fwh.1)
(62):	FCH		Gross rents
	fch	=	exp(logfch)
(63):	LOGFCB		Car purchase
	logfcb	=	HS+log(fcb.1)
	HS	=	1.15787*dlog((ydp-ipv)/pcp)-0.29989*cofcb.1+0.00469
(64):	FCB		Car purchase
	fcb	=	exp(logfcb)
(65):	COFCB		Long run equation, car purchase
	cofcb	=	log(fcb)-HS
	HS	=	1.77950*log(fcp)-5.47173*rente-7.53397

(66):	FCQ		Other private consumption
	fcq	=	fcp-fcb-fch-fmt+fet

Housing market

(67):	FIH		Residential investments
	fih	=	(HS+fihn.1/fwh.2)*fwh.1+fihv
	HS	=	-0.14242*fihn.1/fwh.2-13.0775*0.001*log(fwh.1/fwhoe.1)+ 1.93278*0.001*log(kp.1/pih.1)+11.1547*0.001*d76q1+ 12.3992*0.001*d79q1+1.09060*0.001
(68):	FIHV		Residential reinvestments
	fihv	=	39.6827*0.001*fwh.1
(69):	FIHN		Residential net investments
	fihn	=	fih-fihv
(70):	AIH		Accumulated residential net investments deflated by house prices, kp
	aih	=	aih.1+(fih*pih-fihv*pih)/(4*kp)
(71):	FWH		Stock of houses
	fwh	=	fwh.1+0.25*fihn
(72):	FWHOE		Wanted stock of houses
	fwhoe	=	exp((log((ydp-ipv)/pcp)*(0.055380)+(-0.792720)*(rente+ssats+.01)+ (-0.102572)*log(pih/pcp)+(0.194941-0.25)*dkpe +(0.770918+0.307441/4)*dpcpe+(0.066329))/(0.055380))
(73):	LOGKP		House price
	logkp	=	HS+log(kp.1)
	HS	=	0.30744*dlog(pcp)-3.78106*diff(rente+ssats+0.01)- 0.77908* diff(rente.1+ssats.1+0.01)- 0.79272*(rente.1+ssats.1+0.01)+0.19494*dkpe.1+ 0.77092*dpcpe.1-0.10257*log(kp.1/pcp.1)+ 0.05538*(log((ydp.1-ipv.1)/pcp.1)-log(fwh.1))+0.06633
(74):	DKPE		Expected increase in house prices
	dkpe	=	dkpbw*log(kp/kp.12)/3+(1-dkpbw)*log(kp[+40]/kp)/10

(75):	DPCPE		Expected increase in private consumption deflator
	dpcpe	=	dpcpw*(0.8*dpcpe.1+0.2*0.5*log(pcp/pcp.4))+ (1-dpcpw)*(log(pcp[+40]/pcp))/10
(76):	KP		House price
	kp	=	exp(logkp)
(77):	RENTE		Interest rate after tax (bond borrowing)
	rente	=	ibz*(1-tsuih)

Capital stock and employment

(78):	FIPMXE		Business investments in machinery and transport equipment (exclusive of ships, aeroplanes and investments in energy extracting sector)
	fipmxe	=	4*(exp(HS+log(km.1))-km.1+dm*km.1)
	HS	=	0.47355*dlog(km.1)+0.18158*dlog(km.2)+ 35.9805*0.001*dlogfyfbx-13.9047*0.001*(log(km.1)-log(fyfbx.1))- 6.14967*0.001*log(rlnim.1)+4.86036*0.001
(79):	KM		Business stock of machinery
	km	=	km.1*(1-dm)+0.25*fipmxe
(80):	FYFBX		GVA in private non-farm sector exclusive of energy extracting and housing
	fyfbx	=	fyfpx-fyfla
(81):	FYFPX		GVA in private sector exclusive of energy extraction and housing
	fyfpx	=	fy-fsi-fyfo-fyfh-fyfe
(82):	RLNIM		De-trended user cost to wage ratio, machinery
	rlnim	=	(cum/lnio)/exp(-14.018014*0.001*trend+26.622594)
(83):	CUM		User cost, machinery
	cum	=	((1-tax*zmmask)/(1-tax))*pipm*((1-tax)*ibz-dpyfbxe+0.1600)
(84):	DPYFBXE		Expected increase in private GDP deflator
	dpyfbxe	=	dpybw*(0.8*dpyfbxe.1+0.2*0.5*log(pyfbx/pyfbx.4))+ (1-dpybw)*(log(pyfbx[+40]/pyfbx))/10

(85):	ZMMASK		Present tax value of writing off possibilities, machinery
	zmmask	=	zzmmask+zmn*(ibz-zibz)+zmt*(tax-ztax)+zmdpc*(dpc-zdpc)
(86):	DPC		Expected inflation, net retail prices
	dpc	=	dumdpc*(0.5*dpc.1+0.25*(ncp/ncp.4+ncp.1/ncp.5-2))
(87):	FIPVM		Business reinvestments, machinery
	fipvm	=	88.6110*0.001*km.1
(88):	FIPM		Business investments, machinery
	fipm	=	fipmxe+fiy+fiem
(89):	FIPNM		Business net investments, machinery
	fipnm	=	fipm-fipvm
(90):	FIY		Investments in ships and aeroplanes
	fiy	=	iy/piy
(91):	TUC		Capacity utilization in private sector
	tuc	=	exp(log(fyfbx)-log(km)-0.66011*0.67*log(rlnim))/0.980473
(92):	MULC		Marginal unit labour cost, private sector exc. agriculture, energy extraction and housing
	mulc	=	lnio/(((km/qbyx)**(1/0.66011))**0.33)
(93):	LOGQBYX		Private non-farm employment, hours (adjusted)
	logqbyx	=	HS+log(qbyx.1)
	HS	=	0.42480*dlogfyfbx+0.21489*(log(fyfbx.1)-0.67*log(qbyx.1)-0.33*log(km.1))-2.01823*0.001*trend+3.95039
(94):	DLOGFYFBX		Change in non-farm GDP, auxiliary term
	dlogfyfbx	=	dlog((fyfbx))
(95):	QBYX		Private non-farm employment, hours (adjusted)
	qbyx	=	exp(logqbyx)
(96):	QBY		Private non-farm employment, persons
	qby	=	1000*qbyx/maxtid**0.7

(97):	PROBX		Hourly productivity, private sector exc. agriculture, energy extracting and housing
	probx	=	10000*fyfbx/(maxtid*qby)
(98):	ULC		Unit labour cost, private sector exc. agriculture, energy extracting and housing
	ulc	=	ywby/fyfbx
(99):	QP		Private employment, persons
	qp	=	qby+qla
(100):	FIPBXE		Business investments in building and construction (exclusive of investments in energy extracting sector)
	fipbxe	=	4*(exp(HS+log(kb.1))-kb.1+db*kb.1)
	HS	=	0.80375*dlog((kb.1))-0.00069*log(rlnib.2)+ 0.00405*log(fyfbx.1/kb.1)+0.00432
(101):	KB		Business stock of buildings
	kb	=	kb.1*(1-db)+0.25*fipbxe
(102):	RLNIB		De-trended user cost to wage ratio, buildings
	rlnib	=	(cub/lnio)/exp(-0.041961*trend+81.071120)
(103):	CUB		User cost, buildings
	cub	=	((1-tax*zbbyg)/(1-tax))*pipb*((1-tax)*ibz-dpyfbxe+0.0200)
(104):	ZBBYG		Present tax value of writing off possibilities, buildings
	zbbyg	=	zzbbyg+zbn*(ibz-zibz)+zbt*(tax-ztax)+zbdpc*(dpc-zdpc)
(105):	FIPVB		Business reinvestments, buildings
	fipvb	=	21.3868*0.001*kb.1
(106):	FIPB		Business investments, buildings
	fipb	=	fipbxe+fieb
(107):	FIPNB		Business net investments, buildings
	fipnb	=	fipb-fipvb
(108):	FIB		Building investments
	fib	=	fipb+fih+fiob

(109):	FILBX		Private non-farm stockbuilding (exc. energy products)
	filbx	=	-(HS*demand.1)
	HS	=	0.28644*diff(demand)/demand.1+ 5.38229*0.01*log(stock.1/demand.1)- 0.63998*dlog(qbyx.1)+85.9256*0.001
(110):	STOCK		Stock of non-energy and non-farm products
	stock	=	stock.1+0.25*filbx
(111):	DEMAND		Final demand expression
	demand	=	fytr-filbx+fe-fmy-fmt-fms-fmbra-fmav-fsi-fyfo-fyfh-fyfe-fyfla
(112):	ILBX		Private non-farm stockbuilding (exc. energy products)
	ilbx	=	filbx*(mkv*0.48*pmvx+(1-mkv*0.48)*pyfbx)
(113):	FYTRX		Domestic demand for goods
	fytrx	=	fy+fm-filbx-file-fila-fyfo-fyfh-fmt-fms
(114):	PYTRX		Price on domestic demand for goods
	pytrx	=	ytrx/fytrx
(115):	YTRX		Domestic demand for goods
	ytrx	=	y+m-ilbx-pile*file-pila*fila-yfo-yfh-pmt*fmt-pms*fms

Imports

(116):	LOGFMVX		Imports of goods excluding fuel, ships, and aeroplanes
	logfmvx	=	HS+log(fmvx.1)
	HS	=	1.97801*dlogxfmvxk-0.32273*dlog((pmvx+tmvx)/mulc)- 0.53187*log(fmvx.1/xfmvx.1)- 0.26799*log((pmvx.1+tmvx.1)/mulc.1)+ 0.55116*(log(fyfbx.1)-0.33*log(km.1)-0.67*log(qbyx.1))- 6.09052*0.001*trend+12.0692
(117):	FMVX		Imports, excl. energy products and ships
	fmvx	=	exp(logfmvx)
(118):	DLOGXFMVXK		Short-run import demand change
	dlogxfmvxk	=	dlog(xfmvx-0.244269*filbx)

(119):	LOGFMT		Travel expenditures
	logfmt	=	log(fcp-fcb-fch)
(120):	FMT		Travel expenditures
	fmt	=	exp(logfmt)
(121):	XFMVX		Demand for imports
	xfmvx	=	0.16*fcq+0.24*fcov+0.033*fch+0.31*fcb+ 0.37*(fev-feani-feveg-fekqd-feol-febra-fefsk-fepel)+ 0.26*(feani+feveg+fekqd+fefsk+fepel)+0.038*(feol+febra)+ 0.13*fib+0.18*fit+0.03*file+0.24*fila+0.034*fes+0.48*filbx+ 0.40*(fipm+fiom-fiy)+0.11*fiy
(122):	LOGFMBRAK		Imports of energy products plus Danish energy extraction
	logfmbrak	=	HS+log(fmbrak.1)+dlog(xfmbra)
	HS	=	-0.27102*dlog(fmbrak.1/xfmbra.1)- 0.49383*log(fmbrak.1/xfmbra.1)- 0.04539*log(ter.1*(pmbra.1+tmbra.1)/lnio.1)- 12.9899*0.001*trend+25.9127
(123):	FMBRAK		Imports of energy products plus extraction
	fmbrak	=	exp(logfmbrak)
(124):	FMBRA		Imports of energy
	fmbra	=	(fmbrak-fyfe)
(125):	XFMBRA		Demand for energy products
	xfmbra	=	0.0019*fch+0.0015*fcb+0.016*fcq+0.015*fcov+0.008*fib+ 0.013*fit+0.0035*(fipm+fiom)+ 0.014*(feani+feveg+fekqd+fefsk+fepel)+0.66*(feol+febra)+ 0.0063*(fev-feani-feveg-fekqd-feol-febra-fefsk-fepel)+ 0.46*file+0.0031*filbx+0.0034*fila+0.042*fes
(126):	FXE		Gross output in energy extracting sector
	fxe	=	kfxe*fyfe
(127):	LOGFMS		Imports of services (besides travel expenditures)
	logfms	=	-0.05*dlog((pms/mulc))-0.20*0.30*log(pms.1/mulc.1)+ 0.2*log(fcp)+0.80*logfms.1

(128): FMS Imports of services (besides travel expenditures)
fms = exp(logfms)

(129): FMAV Imports of other goods
fmav = fmav.1*((fmvx+fmbra+fmy)/(fmvx.1+fmbra.1+fmy.1))

(130): FMV Imports of goods
fmv = fmbra+fmvx+fmy+fmav

(131): MV Imports of goods
mv = fmbra*pmbra+fmvx*pmvx+fmy*pmy+0*fmav

(132): FM Imports of goods and services
fm = fmbra+fmvx+fmy+fmt+fms+fmav

(133): M Imports of goods and services
m = fmbra*pmbra+fmvx*pmvx+fmy*pmy+fmt*pmt+fms*pms+0*fmav

GDP and domestic demand

(134): FY GDP
fy = fcp+fco+fipm+fipb+fih+fio+filbx+file+fila+fit+fe-fm

(135): Y GDP
y = pcp*fcp+pco*fco+pipm*fipm+pipb*fipb+pih*fih+pio*fio+ilbx+
pile*file+pila*fila+pit*fit+pe*fe-pm*fm

(136): FYTR Domestic demand
fytr = fy+fm-fe

(137): YTR Domestic demand
ytr = y+m-e

(138): YF GDP at factor prices
yf = y-siaf+sisub-sie

(139): LOGFYFH GVA at factor prices, housing
logfyfh = log(fch)

(140): FYFH GVA at factor prices, housing
fyfh = exp(logfyfh)

(141):	YFH		GVA at factor prices, housing
	yfh	=	fyfh*pyfh
(142):	FYFO		GVA at factor prices, public sector
	fyfo	=	fcow+fiov
(143):	YFO		GVA at factor prices, public sector
	yfo	=	pcow*fcow+iov
(144):	YFPX		GVA at factor prices, private sector exclusive of extration and dwellings
	yfpx	=	y-(siaf-siqej-siqv-siqam-siquab-siqr)+sisub-siqs-sie-yfo-yfh-fyfe*pyfe
(145):	PYFPX		GVA deflator, private sector
	pyfpx	=	yfpx/fyfpx
(146):	YFBX		GVA at factor prices, private non-farm sector
	yfbx	=	yfpx-fyfla*pyfla
(147):	PYFBX		GVA deflator, private non-farm sector
	pyfbx	=	yfbx/fyfbx

Labour market

(148):	LOGLNA		Hourly wages, private sector
	loglna	=	HS+log(lna.1)
	HS	=	0.17009*(dlog(pcp.2)+dlog(pcp.3))+0.08486*dlog(pyfbx.3/pcp.3)-0.23743*(ul.1/u.1)-0.68049*dlog(maxtid2)+0.02175*log(komp.1)+0.04347
(149):	LNA		Hourly wage rate, private non-farm sector
	lna	=	exp(loglna)
(150):	KOMP		Average unemployment replacement ratio
	komp	=	(1000000*tyd/(0.85*ul))/((1-arbsats)*maxtid*lna*58.91/0.83860)
(151):	LOGLNF		Monthly wage of salaried worker, private sector
	loglnf	=	log(maxtid2*lna)
(152):	LNF		Monthly wage of salaried worker, private sector
	lnf	=	exp(loglnf)

(153):	ERHFRK		Participation rate
	ERHFRK	=	exp(HS+log(erhfrk.1))
	HS	=	0.31082*dlogbeskfrk+0.18922 * (log(lntren.1)-log(erhfrk.1))-0.02460*(log(erhfrk.1)-log((qp.1+qo.1+qs.1+uel.1+orlov.1+udda.1)/b1574.1))+0.00276
(154):	DLOGBESKFRK		Change in employment rate
	dlogbeskfrk	=	dlog((qp+qo+qs+uel+orlov+udda)/b1574)
(155):	U		Labour force
	u	=	erhfrk*b1574
(156):	UL		Unemployment
	ul	=	u-qs-qo-qp-uel-orlov-udda
(157):	YW		Compensation of employees
	yw	=	ywby+ywla+ywo
(158):	LOGYWO		Public sector compensation of employees
	logywo	=	log(0.170572*qo*lo+(0.667*qo*atpst)/1000000+typri)
(159):	YWO		Public sector compensation of employees
	ywo	=	exp(logywo)
(160):	LOGYWBY		Private non-farm sector compensation of employees
	logywby	=	log(qby*maxtid*lnio*0.0001)
(161):	YWBY		Private non-farm sector compensation of employees
	ywby	=	exp(logywby)
(162):	LOGYWLA		Agricultural sector compensation of employees
	logywla	=	log(qla*maxtid*lnio*0.0001)
(163):	YWLA		Agricultural sector compensation of employees
	ywla	=	exp(logywla)
(164):	HLNIO		Compensation exclusive of social contributions
	hlnio	=	0.45*log(lna*maxtid)+0.45*log(lnf)+0.10*log(lo)+log(qp)

(165): LOGLNIO Hourly wage costs, private non-farm sector

loglnio = log(exp(hlnio)+(alba*(0.82*qp-45)+atpa*0.82*qp)/1000000+invb)-log(maxtid)-log(qp)

(166): LNIO Hourly wage costs, private non-farm sector

lnio = exp(loglnio)

Prices

(167): NCP Net retail prices

ncp = 0.3512*restx+0.1494*pimpor+0.0876*pener+0.2354*phusl+0.1397*pfodev+0.0367*poffyd

(168): LOGPHUSL Gross rent (dwellings)

logphusl = log(pch)

(169): PHUSL Gross rent (dwellings)

phusl = exp(logphusl)

(170): LOGPFODEV Food prices net of tax

logpfodev = log(mkv*0.278*pmvx+(1-mkv*0.278)*restx/2.124848)-6.29222*0.001*trend+13.1075

(171): PFODEV Food prices

pfodev = exp(logpfodev)

(172): LOGPENER Energy price (private consumption) net of tax

logpener = HS+log(pener.1)

HS = 0.39001*dlog(pmbra+tmbra)-0.10514*log(pener.1)+0.04763*log(mulc.1)+0.05751*(log(pmbra.1+tmbra.1))-0.13655*0.001*trend+0.31815

(173): PENER Energy price (private consumption) net of tax

pener = exp(logpener)

(174): LOGPOFFYD Price of public sales to households

logpoffyd = log(mkv*0.115*pmvx+(1-mkv*0.115)*0.706*lo+(1-mkv*0.115)*(1-0.706)*restx/2.124848)+11.7272*0.001*trend-22.5439

(175):	POFFYD		Price of public sales to households
	poffyd	=	exp(logpoffyd)
(176):	LOGPIMPOR		Import price (private consumption)
	logpimpor	=	log(pmvx+tmvx)
(177):	PIMPOR		Import price (private consumption)
	pimpor	=	exp(logpimpor)
(178):	LOGRESTX		Domestic market-determined part of net retail prices
	logrestx	=	HS+log(restx.1)
	HS	=	0.12827*dlog(lnio.1)-0.37772*dlog(pimpor)+ 0.21245*dlog(pimpor.1)+0.08429*dlog(pimpor.2)- 0.03674*(log(restx.1)-log(mulc.1))-0.86175*0.001*trend+ 0.02725*d7734+0.01904*d8081+1.76895
(179):	RESTX		Domestic market-determined part of net retail prices
	restx	=	exp(logrestx)
(180):	PCP		Private consumption deflator
	pcp	=	(pcq*fcq+pcb*fcb+pch*fch+pmt*fmt-pet*fet)/fcp
(181):	LOGPCH		Price of housing
	logpch	=	0.125*(log(ncp)+log(ncp.1)+log(ncp.2)+log(ncp.3)+log(ncp.4)+ log(ncp.5)+log(ncp.6)+log(ncp.7))
(182):	PCH		Price of housing
	pch	=	exp(logpch)
(183):	MKV		Import share
	mkv	=	((fmvx/xfmvx+fmvx.1/xfmvx.1+fmvx.2/xfmvx.2+ fmvx.3/xfmvx.3)/4)/1.007832
(184):	LOGQCQ		Basic price exclusive of rent and car purchase
	logqcq	=	log(0.199*(mkv/0.832)*pimpor+(1-0.199*(mkv/0.832))* (0.3512*restx+0.0876*pener+0.1397*pfodev+0.0367*poffyd- (1-(mkv/0.832)*0.584)*0.03097*qcb/0.224))
(185):	QCQ		Basic of consumption exclusive of rent and car purchase
	qcq	=	exp(logqcq)

(186):	PCQ		Price of consumption exclusive of rent and car purchase
	pcq	=	(1+btgq*tg)*(qcq+tpkq)
(187):	LOGQCB		Basic price of car purchase
	logqcb	=	log(mkv*0.584*pmvx+(1-mkv*0.584)*restx/2.124848)-0.42683*.001*trend-0.12502
(188):	QCB		Basic price of car purchase
	qcb	=	exp(logqcb)
(189):	PCB		Price of car purchase
	pcb	=	(1+btgb*tg)*(1+trb)*qcb
(190):	PCO		Price of public cosumption
	pco	=	(pcow*fcow+piov*fiov+pcov*fcov)/fco
(191):	PCOW		Price of public consumption of labour services
	pcow	=	ywo/fcow
(192):	LOGQCOV		Basic price of public purchase from the private sector
	logqcov	=	log(mkv*0.3728*pmvx+(1-mkv*0.3728)*(0+0.0196/(0.0196+0.6076))*(0.5*pmbra+0.5*pyfe)+(1-mkv*0.3728)*(0.6076/(0.0196+0.6076))*restx/2.124848)-5.08564*0.001*trend+9.9603
(193):	QCOV		Basic price of public purchase from the private sector
	qcov	=	exp(logqcov)
(194):	PCOV		Price of public purchase from the private sector
	pcov	=	(1+btgcov*tg)*(qcov+tpkcov)
(195):	PIO		Price of public investments
	pio	=	(piom*fiom+piob*fiob)/fio
(196):	LOGPIOB		Price of public investments, buildings
	logpiob	=	log(qib*(1+btgiob*tg))
(197):	PIOB		Price of public investments, buildings
	piob	=	exp(logpiob)

(198):	LOGPIOM		Price of public investments, machinery
	logpiom	=	log(qim*(1+btgiom*tg))
(199):	PIOM		Price of public investments, machinery
	piom	=	exp(logpiom)
(200):	PIOV		Price of public re-investments
	piov	=	exp(logpiov)
(201):	LOGPIOV		Price of public re-investments
	logpiov	=	log(pio)
(202):	LOGQIM		Basic price of investments in machinery
	logqim	=	HS+log(qim.1)
	HS	=	0.38118*dlog(pm7)-0.11925*(log(qim.1)-log(mkv.1*0.473*pm7.1+(1-mkv.1*0.473)* mulc.1/0.618923))-1.42020*0.001*trend+2.83683
(203):	QIM		Basic price of investments in machinery
	qim	=	exp(logqim)
(204):	LOGPIPM		Price of investments in machinery
	logpipm	=	log(qim*(1+btgipm*tg)*(1+tripm))
(205):	PIPM		Price of investments in machinery
	pipm	=	exp(logpipm)
(206):	LOGQIB		Basic price of investments in buildings
	logqib	=	HS+log(qib.1)
	HS	=	0.16139*dlog(qib.2)+0.37125*dlog(lnio)+0.20541*dlog(pmvx+tmvx)-0.07474*d88q1-0.14880*(log(qib.1)-log(0.177*mkv.1*(pmvx.1+tmvx.1)/1.008+(1-0.177*mkv.1)*mulc.1/0.618923))-0.29153*0.001*trend+0.58211
(207):	QIB		Basic price of investments in buildings
	qib	=	exp(logqib)
(208):	LOGPIPB		Price of investments in buildings
	logpipb	=	log(qib*(1+btgipb*tg))

(209):	PIPB		Price of investments in buildings
	pipb	=	exp(logpipb)
(210):	LOGPIH		Price of residential investments
	logpih	=	log(qib*(1+btgih*tg))
(211):	PIH		Price of residential investments
	pih	=	exp(logpih)
(212):	PILBX		Price of stockbuilding, private non-farm sector
	pilbx	=	ilbx/filbx
(213):	PYTR		Domestic demand deflator
	pytr	=	ytr/fytr
(214):	LOGPYFH		GVA deflator, dwellings
	logpyfh	=	log(restx)
(215):	PYFH		GVA deflator, dwellings
	pyfh	=	exp(logpyfh)
(216):	LOGPYFE		GVA deflator, energy extraction
	logpyfe	=	log(pmbra)
(217):	PYFE		GVA deflator, energy extraction
	pyfe	=	exp(logpyfe)
(218):	LOGPYFLA		GVA deflator, agriculture
	logpyfla	=	0.07*log(peveg)+1.30*log(peani)-0.37*log(pmvx)
(219):	PYFLA		GVA deflator, agriculture
	pyfla	=	exp(logpyfla)
(220):	LOGPMVX		Price of imports
	logpmvx	=	HS+log(pmvx.1)
	HS	=	0.80575 * dlog((pmudl)) + 0.53110* dlog((1/efkrks))+ 0.27601*dlog((mulc))-0.22858*(log(pmvx.1)-(0.863928)*log(pmudl.1/efkrks.1)-(0.136072)*log(mulc.1)-1*(-0.162593)*0.001*trend)-0.02648*dum761+1.00874

(221):	PMVX		Price of imports
	pmvx	=	exp(logpmvx)
(222):	LOGPM7		Price on imports of machinery
	logpm7	=	log(pmvx)
(223):	PM7		Price on imports of machinery
	pm7	=	exp(logpm7)
(224):	LOGPMBRA		Price on imports of energy products
	logpmbra	=	HS+log(pmbra.1)
	HS	=	0.16540*dlog(pmbra.1)+0.53880*dlog(praoli*eusd)-0.43634*log(pmbra.1)+0.39036*log(praoli.1*eusd.1)+0.04598*log(lonudl.1/efkrks.1)-1.62170
(225):	PMBRA		Price on imports of energy products
	pmbra	=	exp(logpmbra)
(226):	LOGPMT		Price of tourist expenditures
	logpmt	=	log(lonudl/efkrks)
(227):	PMT		Price of tourist expenditures
	pmt	=	exp(logpmt)
(228):	LOGPMS		Deflator for imports of services besides travel expenditures
	logpms	=	logpes
(229):	PMS		Deflator for imports of services besides travel expenditures
	pms	=	exp(logpms)
(230):	PM		Imports of goods and services deflator
	pm	=	m/fm
(231):	PMV		Imports of goods deflator
	pmv	=	mv/fmv

Government demand and transfers

(232):	FCO		Public consumption
	fco	=	fcov+fcow+fiov

(233):	IOV		Public reinvestments
	iov	=	fiov*piov
(234):	FIO		Public investments
	fio	=	fiom+fiob
(235):	LOGQO		Public employed
	logqo	=	log(fcow/otime)
(236):	QO		Public employed
	qo	=	exp(logqo)
(237):	LOGLO		Public monthly wage
	loglo	=	log((lnf.4+lnf.5+lnf.6+lnf.7)/4)
(238):	LO		Public monthly wage
	lo	=	exp(loglo)
(239):	LOGTYD		Unemployment benefits
	logtyd	=	log(0.000001*312*dagst*ul)
(240):	TYD		Unemployment benefits
	tyd	=	exp(logtyd)
(241):	LOGDAGST		Unemployment benefit rate
	logdagst	=	log((1-arbsats)*((lnf.4+lnf.5+lnf.6+lnf.7)/4))
(242):	DAGST		Unemployment benefit rate
	dagst	=	exp(logdagst)
(243):	LOGTYE		Early retirement benefits
	logtye	=	log(dagst*uel+dtye)
(244):	TYE		Early retirement benefits
	tye	=	exp(logtye)
(245):	LOGTYO		Leave benefits
	logtyo	=	log(dagst*orlov+dtyo)
(246):	TYO		Leave benefits
	tyo	=	exp(logtyo)

(247): LOGTYP Pensions and other social transfers
logtyp = log((lnf.4+lnf.5+lnf.6+lnf.7)/4)

(248): TYP Pensions and other social transfers
typ = exp(logtyp)

(249): ASKAT P.A.Y.E. personal taxes
askat = bsda*(yw+tyd+tye+tyo+typ+typi-sbid-sdu-topl-topk-
(b1574/1000)*pfrd)

(250): LOGPFRD Personal allowance
logpfrd = log(yw+tye+tyd+tyo+typ+typi-sbid-sdu-topl-topk)-log(b1574/1000)

(251): PFRD Personal allowance
pfrd = exp(logpfrd)

(252): DDSK Other personal taxes
ddsk = HS/(1-0.25*0.3*bsda)

HS = bsda*0.25*0.3*(ydp-ipv-ydmas+ydp.1-ipv.1-ydmas.1+ddsk.1+
ydp.2-ipv.2-ydmas.2+ddsk.2+ydp.3-ipv.3-ydmas.3+ddsk.3)

(253): SDS Corporate taxes
sds = tax*(0.7*(yfbx-ywby)+fyfe*pyfe-0.7*ipv)

(254): SDU Labour market tax
sdu = (qp+qo)*tdu+arbsats*1.1*yw

(255): SD Direct taxes
sd = askat+ddsk+rof+sds+sdv+sak+sdr+sdu

(256): YDMAS Disposable wage and transfer income
ydmas = yw-sbid+tye+tyd+tyo+typ+typi-askat-rof-sdu

(257): SBID Social contributions
sbid = qo*atpo/1000000+(1.17*albm*(fors+uel*dumuel)+atpst*
0.89*(qp+ul*dumul)+atpm*qo)/1000000+(alba*(0.89*qp-145)+
atpa*0.89*(qp+ul*dumul))/1000000+atpsats*yw+invb+typri

(258): SIAF Indirect taxes
siaf = sig+sir+pkafg+(1-deusim)*sim+siqv+siqej+siqam+siquab+siqr

(259): LOGSISUB   Subsidies
logsisub = log(yfpx)

(260): SISUB   Subsidies
sisub = exp(logsisub)

(261): LOGSIQS   Subsidies on production
logsiqs = log(yfpx)

(262): SIQS   Subsidies on production
siqs = exp(logsiqs)

(263): SIE   Indirect net taxes EU
sie = deusim*sim-sisubex

(264): SIG   VAT
sig = btgq*tg*fcq*pcq/(1+btgq*tg)+btgh*tg*fch*pch/(1+btgh*tg)+
btgb*tg*fcb*pcb/((1+btgb*tg)*(1+trb))+btgybx*tg*yfbx+
btgyh*tg*yfh+btgiom*tg*fiom*piom/(1+btgiom*tg)+
btgiob*tg*fiob*piob /(1+btgiob*tg)+
btgih*tg*fih*pih/(1+btgih*tg)+
btgipm*tg*fipm*pipm/((1+btgipm*tg)*(1+tripm))+
btgipb*tg*fipb*pipb/(1+btgipb*tg)+
btgcov*tg*fcov*pcov/(1+btgcov*tg)

(265): SIR   Registration duty on cars
sir = trb*fcb*pcb/(1+trb)+tripm*fipm*pipm/(1+tripm)

(266): PKAFG   Various indirect taxes
pkafg = tpkybx*fyfbx+tpkq*fcq+tpkcov*fcov

(267): LOGSIQEJ   Taxes on real property
logsiqej = log(kp.4*fwh.4)

(268): SIQEJ   Taxes on real property
siqej = exp(logsiqej)

(269): LOGSIQAM   Duty on wage and salary costs
logsiqam = log(qftj*lo)

(270): SIQAM Duty on wage and salary costs

siqam = exp(logsiqam)

(271): LOGSIQUAB Other labour contributions from employers

logsiquab = log(qp+qo)

(272): SIQUAB Other labour contributions from employers

siquab = exp(logsiquab)

(273): SIM Custom duties

sim = tmbra*fmbra+tmvx*fmvx+tmy*fmy

(274): LOGFSI Indirect taxes net, fixed prices

logfsi = log(0.4600*fcb+0.2240*fcq+0.0063*fch+0.2290*fcov+
0.1400*(fih+fio)-0.1070*feani+0.0170*fy)

(275): FSI Indirect taxes net, fixed prices

fsi = exp(logfsi)

Fiscal reaction

(276): tpkq Duty rate, privat consumption

tpkq = tpkq.1*(1-0.5*tfon.1/y.1-0.5*diff(tfon.1/y.1)+
0.5*diff(diff(tfon.1/y.1)))

Private income

(277): YDP Private disposable income

ydp = pind-pudg+pcp*fcp+pipb*fipb+fipm*pipm+pih*fih+file*pile+
fila*pila+ilbx+fit*pit+sak-tkon-tken

(278): PIND Private receipts

pind = tyd+tye+tyo+typ+typi+(tkon-tiov)+sisub+jten+tken-sie-tion+
tien+y-iov

(279): PUDG Private expenditures

pudg = siaf+sbid+sd+toi+pcp*fcp+pipb*fipb+fipm*pipm+pih*fih+
file*pile+fila*pila+ilbx+fit*pit

(280): TFPN Private net lending

tfpn = pind-pudg

Foreign net lending and net assets

(281):	TFEN		Current account, Denmark
	tfen	=	e-m+tien+ten
(282):	TEN		Net transfers from abroad besides investment income
	ten	=	tenoi-tenou-sie+jten+tken
(283):	TIEN		Net interest receipts from abroad
	tien	=	-ibz*(kursg/kursg.1)*fbzk.1-(kvusd.2*iusd.1+kvdem.2*ibodem.1)* ((fqqfk.1-fbzk.1)*(efkrks/efkrks.1)**.5)
(284):	ENL		Current account, Denmark
	enl	=	tfen+kobal-tken
(285):	FQQF		Foreign debt
	fqqf	=	fqqf.1-0.25*enl
(286):	FQQFK		Foreign debt, market value
	fqqfk	=	HS+fbzk
	HS	=	(fqqfk.1-fbzk.1)*(efkrks.1/efkrks)+diff(fqqf-fbzz)
(287):	FLOGK		Government foreign debt, market value
	flogk	=	flogk.1*(efkrks.1/efkrks)+diff(flog)
(288):	FLOLK		Local governments foreign debt, market value
	flolk	=	flolk.1*(efkrks.1/efkrks)+diff(flol)
(289):	FBZZ		Foreign holding of Danish bonds
	fbzz	=	fbzz.1+diff(fqqf)

Government net lending and net assets

(290):	OIND		Public receipts
	oind	=	siaf+sbid+sd+toi+tenoi+tion+iov
(291):	OUDG		Public expenditures
	oudg	=	tyd+tye+tyo+typ+typi+tenou+(tkon-tiov)+sisub+pco*fco+pio*fio
(292):	TFON		Public net lending
	tfon	=	oind-oudg

(293):	TIOV		Public capital transfers
	tiov	=	-(imm*bqqn.1)-(idi-0.02)*glon.1+ibz*(kurss/kurss.1)*nbzk.1
(294):	IUDLG		Average interest rate on foreign government debt
	iudlg	=	kvdem*ibodem+(1-kvdem)*iusd
(295):	TION		Net public interest receipts
	tion	=	ibz*(kurss/kurss.1)*(gbzk.1+lbzk.1+obzk.1)+idp*ldeb.1+ (idi-0.02)*glon.1-0.7*dren-ibz*(kursg/kursg.1)*(bzgk.1+bzlk.1)- ilo*blol.1-ilo*alol.1-iudlg*((flogk.1+flolk.1)*(efkrks.1/efkrks)**0.5)
(296):	ZBZG		Government bond debt
	zbzg	=	zbzg.1-(0.25*tfon-diff(lqql+obzz+oasf))+diff(gqqq+gbzz)
(297):	UBZZ		Bond supply
	ubzz	=	zbzg+zbzl-gbzz-lbzz-obzz-nbzz-hbzz-abzz-sbzz-rbzz

Other financial variables

(298):	NBZK		Central bank bond holding, market value
	nbzk	=	nbzk.1*(kurss/kurss.1)+nbzz-nbzz.1
(299):	GBZK		Government bond holding, market value
	gbzk	=	gbzk.1*(kurss/kurss.1)+gbzz-gbzz.1
(300):	LBZK		Local government bond holding, market value
	lbzk	=	lbzk.1*(kurss/kurss.1)+lbzz-lbzz.1
(301):	BZGK		Government bond debt, market value
	bzgk	=	bzgk.1*(kursg/kursg.1)+zbzg-zbzg.1
(302):	BZLK		Local government bond debt, market value
	bzlk	=	bzlk.1*(kursg/kursg.1)+zbzl-zbzl.1
(303):	FBZK		Foreign holding of Danish bonds, market value
	fbzk	=	fbzk.1*(kursg/kursg.1)+fbzz-fbzz.1

(304): PDB Money stock exc. Government debt certificates

pdb = HS*pytr

HS = 18.69611+(-(-47.61801-312.686-596.237)*idp-596.237*ilo-312.686*ibz-47.61801*(ibodem+dk)-(0-0.110428-0.286799)*fytr)*(1-0.711076)-10.61215*sea1-1.119519*sea2-9.074269*sea3+0.06355*ww/pytr+0*aipb/pytr+0*aihb/pytr+0.711076*(pdb.1-0.06355*ww.1-0*aipb.1-0*aihb.1)/pytr

(305): BLOP Bank loans to private non-financial sector

blop = HS*pytr

HS = -37.10313+(-596.237*idp-(-596.237+0-5.297777)*ilo+0*ibz-5.297777*(ibodem+dk)+0*fytr)*(1-0.711076)+4.409238*sea1-1.131977*sea2+4.140806*sea3+0.382773*ww/pytr-0.793374*aipb/pytr+0.398212*aihb/pytr+0.711076*(-blop.1-0.382773*ww.1+0.793374*aipb.1-0.398212*aihb.1)/pytr

(306): PBZZ Private bond holding

pbzz = HS*pytr+zbzr

HS = 14.60070+(-312.686*idp+0*ilo-(-312.686+0-33020.6473)*ibz-33020.6473*(ibodem+dk)-0.286799*fytr)*(1-0.711076)+5.040692*sea1+1.602059*sea2+2.272909*sea3+0.398633*ww/pytr-0.087746*aipb/pytr+(-1-0-0.398212-0)*aihb/pytr+0.711076*(pbzz.1-zbzr.1-0.398633*ww.1+0.087746*aipb.1-(-1-0-0.398212-0)*aihb.1)/pytr

(307): FLP Foreign loans to private sector

flp = HS*pytr

HS = -(18.69611-37.10313+14.60070)+(-47.61801*idp-5.297777*ilo-33020.6473*ibz-(-47.61801-33020.6473-5.297777)*(ibodem+dk)-0.110428*fytr)*(1-0.711076)-(-10.61215+4.409238+5.040692)*sea1-(-1.119519-1.131977+1.602059)*sea2-(-9.074269+4.140806+2.272909)*sea3+(1-0.06355-0.382773-0.398633)*ww/pytr+(-1-0+0.793374+0.087746)*aipb/pytr+0*aihb/pytr+0.711076*(-flp.1-(1-0.06355-0.382773-0.398633)*ww.1-(-1-0+0.793374+0.087746)*aipb.1-0*aihb.1)/pytr

(308):	ZBZR		Private bond debt
	zbzr	=	-(HS*pytr-0.087746*aipb-1.3982*aihb+0.711076*(-zbzr.1+ 0.087746*aipb.1-1.3982*aihb.1))
	HS	=	437.091*(ilo-ibz)-4.01653*sea1+4.60113*sea2+ 4.48229*sea3+195.984
(309):	WWX		Private net financial assets
	wwx	=	wwx.1+0.25*(tfpn-dalo)-diff(rbzz+hbzz+sbzz+pdsb+plob+ bqqb-alop-glop)
(310):	AIHB		Accumulated residential investments
	aihb	=	fwh*kp
(311):	AIPB		Accumulated business investments
	aipb	=	km*pipm+kb*pipb
(312):	WW		Private net financial assets plus cumulated investments
	ww	=	wwx+aipb+aihb
(313):	PCUN		Non-bank monetary base
	pcun	=	28.9109*0.001*ytr
(314):	ABZZ		Life assurance companies and pension funds bond holding
	abzz	=	abzz.1+0.25*dalo-diff(alop+alol)
(315):	LOGTOPK		Pension funds, contribution receipts
	logtopk	=	log(ydp)
(316):	TOPK		Pension funds, contribution receipts
	topk	=	exp(logtopk)
(317):	LOGTOPL		Life assurance premiums
	logtopl	=	log(ydp)
(318):	TOPL		Life assurance premiums
	topl	=	exp(logtopl)
(319):	TILKN		Interest receipts, pension schemes
	tilkn	=	ibz*(kurss/kurss.1)*abzk.1+ilo*alop.1

(320):	DALO		Total saving, pension schemes
	dalo	=	topl+topk+tilkn-sdr
(321):	BBZZ		Banks bond holding
	bbzz	=	ubzz-fbzz-pbzz+zbzr
(322):	BQQN		Banks net position vis-a-vis central bank
	bqqn	=	bwwb-bbzz-bvrf
(323):	BQQF		Banks "other" foreign assets
	bqqf	=	bvrf+flob
(324):	BWWB		Banks potential for placements (bonds plus net position)
	bwwb	=	bqqb-(bqqq+blop+blol+bcun)+(pdb-pcun+pdsb+ldeb+plob)
(325):	BCUN		Banks holding of notes and coins
	bcun	=	7.52394*0.001*(pdb-pcun+pdsb+ldeb)
(326):	FLOB		Foreign risk-bearing deposits
	flob	=	0.08*(blop+0.5*bqqf)-plob
(327):	PLOB		Domestic risk-bearing deposits
plob	=		0.08*(blop+0.5*bqqf)
(328):	IDP		Deposit rate
	idp	=	HS+idp.1
	HS	=	0.26725*diff(idp.1)+0.15488*diff(imm)-0.15721*coidp.1- 0.00039
(329):	COIDP		Deposit rate, long term equation
	coidp	=	idp-HS
	HS	=	0.30308*ibz+0.15021*(1-drad)*imm+0.77473*drad*idi+ 0.41384*(1-drad)*idi-0.02904*drad-0.00987
(330):	ILO		Lending rate
	ilo	=	HS+ilo.1
	HS	=	0.27689*diff(ilo.1)+0.13890*diff(imm)-0.17598* coilo.1-0.00061

(331):	COILO		Lending rate, long term equation
	coilo	=	ilo-HS
	HS	=	0.33457*ibz+0.22356*(1-dral)*imm+0.86251*dral*idi+ 0.17997*(1-dral)*idi-0.04724*dral-0.00331*renteml+ 0.07017*omkostled-0.09337
(332):	OMKOSTLED		Cost term
	omkostled	=	qftj*lo/(pdb-pcun+pdsb+ldeb+blop+blol)
(333):	NVRF		Offcial reserves
	nvrf	=	-fqqf-bvrf-glof+fbzz+flp-oasf+flog+flol
(334):	GLON		Government account with central bank
	glon	=	gqqg-gqqq-gbzz-gas+zbzg+flog-glop-glof
(335):	GQQG		Central government cumulated net lending
	gqqg	=	gqqg.1+0.25*tfon-diff(lqql+obzz+oasf)
(336):	LQQL		Local governments cumulated net lending
	lqql	=	lbzz+ldeb+lqqq-blol-zbzl-flol

List of variables

The naming of Mona's variables is inspired by the standard nomenclature of the Adam model developed by Statistics Denmark. For instance, variables in fixed prices typically start with an f, while deflators start with a p, and e.g. GDP in fixed prices is called fy as in Adam where the y indicates value added. Mona is a smaller model than Adam and also less disaggregated both concerning number of sectors and detailed categories. Unlike Adam, Mona does not have a systematic reference to neither total production nor intermediate consumption.

There are five industries in Mona, and the corresponding gross value added variables in fixed prices are: Agriculture, fyfla, extraction, fyfe, housing, fyfh, private non-farm (private excluding agriculture, extraction and housing), fyfbx, and public sector, fyfo.

The following conventions apply
c Consumption
e Exports
i Investments
m Imports
q Employment
s Taxes
t Transfers
u Labour force
y Value added, income
i Interest rate
l Wage rate
p Price
f Fixed price

Values are given in kroner. Billion, Bn, is 1000 millions. An endogenous variable is marked by the letter E for type plus the number of the relation normalised on the variable.

LIST OF VARIABLES

Name	Content	Unit	Type	Equa.No
abzk:	Life assurance companies etc, bond holding, market value	Bn. kr.	E	(57)
abzz:	Life assurance companies etc, bond holding	Bn. kr.	E	(314)
afsg:	Assumed quarterly redemption rate, government bonds		X	
afsr:	Assumed quarterly redemption rate, mortgage institution bonds		X	
aih:	Accumulated residential net investments	Bn. 95-kr.	E	(70)
aihb:	Accumulated residential gross investments	Bn. kr.	E	(310)
aipb:	Accumulated private business gross investments	Bn. kr.	E	(311)
alba:	Employers contribution, unemployment insurance	Kr.	X	
albm:	Employees contribution, unemployment insurance	Kr.	X	
alol:	Life assurance companies etc. loans to local governments	Bn. kr.	X	
alop:	Life assurance companies etc. loans to private sector	Bn. kr.	X	
arblos2:	Unemployment term in the consumption function		E	(50)
arbsats:	Labour market tax rate ("gross tax rate")		X	
askat:	P.A.Y.E. personal taxes	Bn. kr.	E	(249)
atpa:	Labour market pension fund contribution, private employers	Kr.	X	
atpm:	Labour market pension fund contribution, public employees	Kr.	X	
atpo:	Labour market pension fund contribution, public employers	Kr.	X	
atpsats:	ATP tax rate		X	
atpst:	Labour market pension fund contribution	Kr.	X	
b1574:	Population 15-74 years,	1000 persons	X	
bbzz:	Banks bond holding	Bn. kr.	E	(321)
bcun:	Banks holding of notes and coins	Bn. kr.	E	(325)
blol:	Banks loan to local governments	Bn. kr.	X	
blop:	Banks loan to private non-financial sector	Bn. kr.	E	(305)
bqqb:	Banks "capital"	Bn. kr.	X	
bqqf:	Banks "other" foreign assets	Bn. kr.	E	(323)
bqqn:	Banks net position vis-à-vis central bank	Bn. kr.	E	(322)
bqqq:	Banks other assets	Bn. kr.	X	
bsda:	P.A.Y.E. tax rate		X	
btgb:	VAT loading factor, car purchase		X	
btgcov:	VAT loading factor, public consumption		X	
btgh:	VAT loading factor, dwellings		X	
btgih:	VAT loading factor, residential investments		X	
btgiob:	VAT loading factor, public building investments		X	
btgiom:	VAT loading factor, public machinery investments		X	
btgipb:	VAT loading factor, private building investments		X	
btgipm:	VAT loading factor, private machinery investments		X	
btgq:	VAT loading factor, rest of consumption		X	
btgybx:	VAT loading factor, private GVA exclusive of agriculture, energy and housing		X	
btgyh:	VAT loading factor, GVA housing		X	
bvrf:	Banks net position vis-à-vis foreign sector	Bn. kr.	X	
bwwb:	Banks potential placements (bonds + net position)	Bn. kr.	E	(324)
bzgk:	Government bond debt, market value	Bn. kr.	E	(301)
bzlk:	Local government bond debt, market value	Bn. kr.	E	(302)
cofcb:	Residual of long run equation, car purchase		E	(65)
coidp:	Residual of long run equation, deposit rate		E	(329)
coilo:	Residual of long run equation, lending rate		E	(331)
cub:	User cost, private buildings		E	(103)
cum:	User cost, private machinery		E	(83)
d76q1:	Dummy, house price index, 1st quarter 1976		X	
d7734:	Dummy, consumption function 3rd and 4th quarter 1977		X	
d79q1:	Dummy, house price index, 1st quarter 1979		X	
d8081:	Dummy in the logrestx relation, 2nd and 3rd quarter 1980		X	
d88q1:	Dummy, logqib relation, 1st quarter 1988		X	
dagl:	Average wage rate	Mio kr.	E	(59)

LIST OF VARIABLES

Name	Content	Unit	Type	Equa.No
dagp:	Average unemployment benefits	Mio kr.	E	(60)
dagst:	Unemployment benefit rate	Kr.	E	(242)
dalo:	Savings in pension schemes etc	Bn. kr.	E	(320)
db:	Rate of depreciation for business building		X	
ddsk:	Other (than askat and rof) personal taxes	Bn. kr.	E	(252)
demand:	Final demand for private stock building equation	Bn. 95-kr.	E	(111)
demografi:	Demographic term in imputed value of pensions		X	
deusim:	EU costumes dummy in siaf relation		X	
dk:	Expected kr/deutschmark change		X	
dkpbw:	Dummy in dkpe relation		X	
dkpe:	Expected house price change		E	(74)
dlogpcpt:	Inflation term in consumption function		E	(43)
dm:	Rate of depreciation for business machinery		X	
dmims:	Dummy, consumption function, temporary VAT reduction 1975q4-1976q1		X	
dpc:	Expected annual change of net retail price index		E	(86)
dpcpe:	Expected consumer price change		E	(75)
dpcpw:	Dummy in dpcpe relation		X	
dpybw:	Dummy in dpyfbxe relation		X	
dpyfbxe:	Expected annual change of private non-farm deflator		E	(84)
drad:	Dummy deposit rate function, agreements on deposit rate		X	
dral:	Dummy lending rate function, agreements on lending rate		X	
dren:	Interest payments on "krone" bonds, net revenue from abroad		X	
dtye:	Auxiliary variable, early retirement benefits		X	
dtyo:	Auxiliary variable, leave benefits		X	
dum761:	Dummy in logpmvx relation		X	
dum903:	Dummy in logfeind relation, German reunification		X	
dumdpc:	Dummy for indexation of rules for depreciation		X	
dumuel:	Dummy concerning labour market contribution, early retired		X	
dumul:	Dummy concerning labour market contribution, unemployed		X	
e:	Exports of goods and services	Bn. kr.	E	(17)
efkrks:	Effective krone rate		X	
elop:	Export Financing Fund loans to private sector	Bn. kr.	X	
enl:	Current account (Denmark, Faroe Islands and Greenland)	Bn. kr.	E	(284)
erhfrk:	Participation rate		E	(153)
eusd:	krone/dollar exchange rate		X	
ev:	Exports of goods	Bn. kr.	E	(15)
fbzk:	Foreign holding of Danish bonds, market value	Bn. kr.	E	(303)
fbzz:	Foreign holding of Danish bonds	Bn. kr.	E	(289)
fcb:	Car purchase	Bn. 95-kr.	E	(64)
fch:	Gross rent	Bn. 95-kr.	E	(62)
fco:	Public consumption	Bn. 95-kr.	E	(232)
fcov:	Public consumption (purchase of goods and services)	Bn. 95-kr.	X	
fcow:	Public consumption (value-added in public sector, mostly wages)	Bn. 95-kr.	X	
fcp:	Private consumption	Bn. 95-kr.	E	(42)
fcq:	Other private consumption	Bn. 95-kr.	E	(66)
fe:	Exports of goods and services	Bn. 95-kr.	E	(16)
feani:	Agricultural exports of animal origin	Bn. 95-kr.	E	(4)
feav:	Exports of other goods	Bn. 95-kr.	E	(13)
febra:	Exports of energy products	Bn. 95-kr.	X	
fefsk:	Exports of fish etc.	Bn. 95-kr.	X	
feind:	Industrial exports	Bn. 95-kr.	E	(2)
fekqd:	Exports of canned meat and milk	Bn. 95-kr.	E	(6)
feol:	Bunkering receipts	Bn. 95-kr.	X	
fepel:	Exports of fur and skins	Bn. 95-kr.	X	
fes:	Exports of services (besides travel receipts)	Bn. 95-kr.	E	(10)

LIST OF VARIABLES

Name	Content	Unit	Type	Equa.No
fet:	Travel receipts	Bn. 95-kr.	E	(12)
feu:	Market for Danish industrial exports, index		X	
fev:	Exports of goods	Bn. 95-kr.	E	(14)
feveg:	Agricultural exports of vegetable origin	Bn. 95-kr.	X	
fey:	Exports of ships and aeroplanes	Bn. 95-kr.	E	(8)
fib:	Building investment	Bn. 95-kr.	E	(108)
fieb:	Building investment, energy extracting sector	Bn. 95-kr.	X	
fiem:	Machinery investment, energy extracting sector	Bn. 95-kr.	X	
fih:	Residential investment	Bn. 95-kr.	E	(67)
fihn:	Residential net investment	Bn. 95-kr.	E	(69)
fihv:	Residential reinvestment	Bn. 95-kr.	E	(68)
fila:	Stockbuilding, agricultural products	Bn. 95-kr.	X	
filbx:	Non-farm stockbuilding excluding energy products	Bn. 95-kr.	E	(109)
file:	Stockbuilding, energy products	Bn. 95-kr.	X	
fio:	Public investment	Bn. 95-kr.	E	(234)
fiob:	Public building investment	Bn. 95-kr.	X	
fiom:	Public machinery investment	Bn. 95-kr.	X	
fiov:	Public reinvestment	Bn. 95-kr.	X	
fipb:	Business building investment	Bn. 95-kr.	E	(106)
fipbxe:	Business building investment, excluding energy sector	Bn. 95-kr.	E	(100)
fipm:	Business machinery investments	Bn. 95-kr.	E	(88)
fipmxe:	Business machinery investments excluding energy sector end ships	Bn. 95-kr.	E	(78)
fipnb:	Business building net investments	Bn. 95-kr.	E	(107)
fipnm:	Business machinery net investments	Bn. 95-kr.	E	(89)
fipvb:	Business building reinvestments	Bn. 95-kr.	E	(105)
fipvm:	Business machinery reinvestments	Bn. 95-kr.	E	(87)
fit:	Change in breeding stock	Bn. 95-kr.	X	
fiy:	Investments in ships and aeroplanes	Bn. 95-kr.	E	(90)
flob:	Foreign risk bearing deposits	Bn. kr.	E	(326)
flog:	Foreign loans to government	Bn. kr.	X	
flogk:	Foreign loans to government, market value	Bn. kr.	E	(287)
flol:	Foreign loans to local government	Bn. kr.	X	
flolk:	Foreign loans to local government, market value	Bn. kr.	E	(288)
flp:	Foreign loans to private sector	Bn. kr.	E	(307)
flpk:	Foreign loans to private sector, market value	Bn. kr.	E	(52)
fm:	Imports of goods and services	Bn. 95-kr.	E	(132)
fmav:	Other imports, discrepancy term	Bn. 95-kr.	E	(129)
fmbra:	Imports of fuel	Bn. 95-kr.	E	(124)
fmbrak:	Imports of fuel plus Danish production of oil and gas	Bn. 95-kr.	E	(123)
fms:	Imports of services besides travel expenditures	Bn. 95-kr.	E	(128)
fmt:	Travel expenditures	Bn. 95-kr.	E	(120)
fmv:	Imports of goods	Bn. 95-kr.	E	(130)
fmvx:	Imports of goods excluding fuel, ships, and aeroplanes	Bn. 95-kr.	E	(117)
fmy:	Imports of ships and aeroplanes	Bn. 95-kr.	X	
fors:	Number insured against unemployment,	1000 persons	X	
fqqf:	Foreign debt	Bn. kr.	E	(285)
fqqfk:	Foreign debt, market value	Bn. kr.	E	(286)
fsi:	Indirect taxes net, fixed prices	Bn. 95-kr.	E	(275)
fwh:	Stock of houses	Bn. 95-kr.	E	(71)
fwhoe:	Wanted stock of houses	Bn. 95-kr.	E	(72)
fxe:	Gross output, energy extracting sector	Bn. 95-kr.	E	(126)
fy:	Total GDP	Bn. 95-kr.	E	(134)
fyfbx:	GVA, private sector excluding agriculture, energy and housing	Bn. 95-kr.	E	(80)
fyfe:	GVA, energy extracting	Bn. 95-kr.	X	
fyfh:	GVA, housing	Bn. 95-kr.	E	(140)

LIST OF VARIABLES

Name	Content	Unit	Type	Equa.No
fyfla:	GVA, agriculture	Bn. 95-kr.	X	
fyfo:	GVA, public sector	Bn. 95-kr.	E	(142)
fyfpx:	GVA, private sector excluding energy and housing	Bn. 95-kr.	E	(81)
fytr:	Domestic demand	Bn. 95-kr.	E	(136)
fytrx:	Domestic demand excluding services	Bn. 95-kr.	E	(113)
gas:	Government purchase of public enterprises accumulated	Bn. kr.	X	
gbzk:	Government bond holding, market value	Bn. kr.	E	(299)
gbzz:	Government bond holding	Bn. kr.	X	
glof:	Government loans to foreign sector	Bn. kr.	X	
glon:	Government account with central bank	Bn. kr.	E	(334)
glop:	Government loans to private	Bn. kr.	X	
gqqg:	Central government accumulated net lending	Bn. kr.	E	(335)
gqqq:	Government sundry assets	Bn. kr.	X	
hbzz:	Government mortgage bank (Hypotekbanken) bond holding	Bn. kr.	X	
hlnio:	Wages excluding employers social contribution (auxiliary variable)	Bn. kr.	E	(164)
ibodem:	German bond yield		X	
ibz:	Bond yield		X	
idi:	Official discount rate		X	
idp:	Deposit rate		E	(328)
ilbx:	Non-farm stockbuilding excluding energy products	Bn. kr.	E	(112)
ilo:	Lending rate		E	(330)
imm:	Overnight money market rate		X	
invb:	Sundry social contributions	Bn. kr.	X	
iov:	Public reinvestment	Bn. kr.	E	(233)
ipv:	Private reinvestment	Bn. kr.	E	(58)
iudlg:	Average interest rate on government foreign debt		E	(294)
iusd:	Three-month dollar rate		X	
iy:	Investments in ships and aeroplanes	Bn. kr.	X	
jten:	Add factor for foreign transfers	Bn. kr.	X	
kb:	Business building stock	Bn. 95-kr.	E	(101)
kbzr:	Private bond debt, market value	Bn. kr.	E	(51)
kfxe:	Proportionality factor, value added to production, energy sector		X	
km:	Business machinery stock	Bn. 95-kr.	E	(79)
kobal:	Current account adjustment for Faroe Islands and Greenland	Bn. kr.	X	
komp:	Average unemployment replacement ratio		E	(150)
kp:	House price (cash price)		E	(76)
kursg:	Government bond price		E	(47)
kursr:	Mortgage bond price		E	(48)
kurss:	Bond price (average of government and mortgage bond price)		E	(49)
kvdem:	Deutschmark share in foreign debt		X	
kvusd:	Dollar share in foreign debt		X	
lbzk:	Local governments bond holding, market value	Bn. kr.	E	(300)
lbzz:	Local governments bond holding	Bn. kr.	X	
ldeb:	Local governments bank deposits	Bn. kr.	X	
lna:	Hourly wage rate, private non-farm sector		E	(149)
lnf:	Monthly wage rate, salaried workers private sector		E	(152)
lnio:	Hourly wage costs, private non-farm sector		E	(166)
lntren:	Logistic trend		X	
lo:	Monthly wage rate, public sector		E	(238)
lonudl:	Foreign wage rate (weighting as in effective exchange rate)		X	
lqql:	Local governments accumulated net lending	Bn. kr.	E	(336)
lqqq:	Local governments sundry assets	Bn. kr.	X	
m:	Imports of goods and services	Bn. kr.	E	(133)
maxtid:	Working hours (maximum), hours per year		X	
maxtid2:	Working hours (adjusted auxiliary variable for the wage equation)		X	

LIST OF VARIABLES

Name	Content	Unit	Type	Equa.No
mkv:	Import share Index		E	(183)
mulc:	Marginal unit labour cost, private sector exc. agriculture, energy and housing		E	(92)
mv:	Imports of goods	Bn. kr.	E	(131)
nbzk:	Central bank bond holding, market value	Bn. kr.	E	(298)
nbzz:	Central bank bond holding	Bn. kr.	X	
ncp:	Net retail price index		E	(167)
nvrf:	Official reserves	Bn. kr.	E	(333)
oasf:	Public funds holding of foreign shares	Bn. kr.	X	
obzk:	Public funds bond holding, market value	Bn. kr.	E	(56)
obzz:	Public funds bond holding	Bn. kr.	X	
oind:	Public receipts	Bn. kr.	E	(290)
omkostled:	Cost term, auxiliary variable in lending rate equation		E	(332)
orlov:	Leave takers,	1000 persons	X	
otime:	Working time public sector, index		X	
oudg:	Public expenditures	Bn. kr.	E	(291)
pbzk:	Private bond holding, market value	Bn. kr.	E	(46)
pbzz:	Private bond holding	Bn. kr.	E	(306)
pcb:	Car purchase deflator		E	(189)
pch:	Housing deflator		E	(182)
pco:	Public consumption deflator		E	(190)
pcov:	Deflator of public consumption (purchase of goods and services)		E	(194)
pcow:	Deflator of public consumption (value added in public sector, mostly wages)		E	(191)
pcp:	Private consumption deflator		E	(180)
pcq:	Rest of consumption deflator		E	(186)
pcun:	Private sector holding of notes and coins	Bn. kr.	E	(313)
pdb:	Money stock	Bn. kr.	E	(304)
pdsb:	Private special savings deposits	Bn. kr.	X	
pe:	Exports of goods and services deflator		E	(36)
peani:	Agricultural exports of animal origin deflator		E	(29)
peav:	Exports of other goods deflator		E	(34)
pebra:	Fuel exports deflator		E	(23)
pefsk:	Fish exports deflator		X	
peind:	Industrial exports deflator		E	(21)
pekqd:	Agricultural exports of canned meat and milk deflator		E	(33)
pener:	Energy consumption price		E	(173)
pensats:	Average pension rate deflated	Bn. 95-kr.	E	(55)
peol:	Bunkering deflator		E	(25)
pepel:	Exports of fur and skins deflator		X	
pes:	Exports of services besides travel receipts deflator		E	(38)
pet:	Travel receipts deflator		E	(40)
pev:	Exports of goods deflator		E	(35)
peveg:	Agricultural exports of vegetable origin deflator		E	(31)
pey:	Exports of ships and aeroplanes deflator		E	(27)
pfodev:	Price of food consumption		E	(171)
pfrd:	Personal tax allowance	1000 Kr.	E	(251)
phusl:	Gross rent price index		E	(169)
pih:	Residential investments deflator		E	(211)
pila:	Agricultural stockbuilding deflator		X	
pilbx:	Non-farm stockbuilding excluding energy products deflator		E	(212)
pile:	Stockbuilding of energy products deflator		X	
pimpor:	Price of imports of consumer goods		E	(177)
pind:	Private receipts	Bn. kr.	E	(278)
pio:	Public investment deflator		E	(195)
piob:	Public building investment deflator		E	(197)
piom:	Public machinery investment deflator		E	(199)

LIST OF VARIABLES

Name	Content	Unit	Type	Equa.No
piov:	Public reinvestment deflator		E	(200)
pipb:	Business building investment deflator		E	(209)
pipm:	Business machinery investment deflator		E	(205)
pit:	Change in breeding stock deflator		X	
piy:	Investment in ships and aeroplanes deflator		X	
pkafg:	Various indirect taxes	Bn. kr.	E	(266)
plob:	Private risk bearing deposits	Bn. kr.	E	(327)
pm:	Imports of goods and services deflator		E	(230)
pm7:	Imports of machinery deflator		E	(223)
pmbra:	Fuel imports deflator		E	(225)
pms:	Imports of services besides travel expenditures deflator		E	(229)
pmt:	Travel expenditures deflator		E	(227)
pmudl:	Foreign price of import goods		X	
pmv:	Imports of goods deflator		E	(231)
pmvx:	Imports of goods deflator (excluding fuel, ships, and aeroplanes)		E	(221)
pmy:	Imports of ships and aeroplanes deflator		X	
poffyd:	Price of public services		E	(175)
pqq1:	Private stock of houses plus financial net wealth, market value	Bn. kr.	E	(45)
pqq5:	Imputed value of old age pension scheme	Bn. kr.	E	(53)
praoli:	Price of crude oil		X	
probx:	Hourly productivity, private sector exc. agriculture, energy and housing		E	(97)
pship:	Sea freight price index		X	
pudg:	Private expenditures	Bn. kr.	E	(279)
pxden:	Price of industrial exports, foreign currency		E	(19)
pxudl:	Price of OECD Europe industrial exports, foreign currency		X	
pyfbx:	GVA deflator, private non-farm sector		E	(147)
pyfe:	GVA deflator, energy extracting		E	(217)
pyfh:	GVA deflator, housing		E	(215)
pyfla:	GVA deflator, agriculture		E	(219)
pyfpx:	GVA deflator, private sector excluding energy and housing		E	(145)
pytr:	Domestic demand deflator		E	(213)
pytrx:	Domestic demand excluding services deflator		E	(114)
qby:	Private non-farm employment, thousand		E	(96)
qbyx:	Private non-farm employment adjusted hourly basis qby/maxtid**0.7		E	(95)
qcb:	Basic price deflator for car purchase		E	(188)
qcov:	Basic price deflator for public consumption (purchase of goods and services)		E	(193)
qcq:	Basic price deflator for rest of consumption		E	(185)
qftj:	Employment in financial sector,	100 persons	X	
qib:	Basic price deflator for building investment		E	(207)
qim:	Basic price deflator for machinery investment		E	(203)
qla:	Farm employment	1000 persons	X	
qo:	Public employment	1000 persons	E	(236)
qp:	Private employment	1000 persons	E	(99)
qs:	Self-employed	1000 persons	X	
rbzz:	Mortgage credit associations bond holding	Bn. kr.	X	
realfor:	Consumers wealth	Bn. 95-kr.	E	(44)
rente:	Bond yield after tax		E	(77)
renteml:	Dummy in lending rate equation, maximum on interest rate differential		X	
restx:	Danish market-determined part of net retail price index		E	(179)
rlnib:	Detrended usercost/wage ratio, buildings		E	(102)
rlnim:	Detrended usercost/wage ratio, machinery		E	(82)
rof:	Balance due to tax underpayment etc., personal tax	Bn. kr.	X	
sak:	Capital taxes	Bn. kr.	X	
sbid:	Social contributions	Bn. kr.	E	(257)
sbzz:	Non-life assurance companies bond holding	Bn. kr.	X	

LIST OF VARIABLES

Name	Content	Unit	Type	Equa.No
sd:	Direct taxes	Bn. kr.	E	(255)
sdr:	Tax on yield of pension scheme assets	Bn. kr.	X	
sds:	Corporate taxes	Bn. kr.	E	(253)
sdu:	Labour market "gross tax" (before 1994:AUD-contribution)	Bn. kr.	E	(254)
sdv:	Motor vehicle weight duty paid by households (direct tax)	Bn. kr.	X	
sea1:	Seasonal dummy		X	
sea2:	Seasonal dummy		X	
sea3:	Seasonal dummy		X	
siaf:	Indirect taxes	Bn. kr.	E	(258)
sie:	Indirect taxes minus subsidies, EU	Bn. kr.	E	(263)
sig:	VAT	Bn. kr.	E	(264)
sim:	Customs duties	Bn. kr.	E	(273)
siqam:	Duty on wage and salary costs	Bn. kr.	E	(270)
siqej:	Taxes on real property	Bn. kr.	E	(268)
siqr:	Other taxes linked to production	Bn. kr.	X	
siqs:	Subsidies, production	Bn. kr.	E	(262)
siquab:	Other labour market contributions total	Bn. kr.	E	(272)
siqv:	Motor vehicle weight duty paid by business (indirect tax)	Bn. kr.	X	
sir:	Registration duty	Bn. kr.	E	(265)
sisub:	Subsidies, public sector	Bn. kr.	E	(260)
sisubex:	Subsidies, EU	Bn. kr.	X	
ssats:	Tax on one-family houses and freehold flats, tax rate for user cost		X	
stock:	Stock of non-energy products in non-farm sector	Bn. 95-kr.	E	(110)
tax:	Corporation tax rate		X	
tdu:	Labour market training fund (AUD), contribution rate		X	
ten:	Transfers from abroad besides investment income	Bn. kr.	E	(282)
tenoi:	Public receipts from abroad	Bn. kr.	X	
tenou:	Public expenditures to abroad	Bn. kr.	X	
ter:	Energy tax rate in logforbrak relation		X	
tfen:	Total domestic net lending	Bn. kr.	E	(281)
tfon:	Government net lending	Bn. kr.	E	(292)
tfpn:	Private sector net lending	Bn. kr.	E	(280)
tg:	VAT rate		X	
tien:	Net investment income from abroad	Bn. kr.	E	(283)
tilkn:	Interest receipts for pension schemes etc.	Bn. kr.	E	(319)
tion:	Net public interest receipts	Bn. kr.	E	(295)
tiov:	Surplus from public enterprises	Bn. kr.	E	(293)
tken:	Net capital transfers from abroad	Bn. kr.	X	
tkon:	Net public capital transfers	Bn. kr.	X	
tmbra:	Customs duty rate, imports of fuel		X	
tmvx:	Customs duty rate, imports exc. fuel and ships		X	
tmy:	Customs duty rate, imports of ships and aeroplanes		X	
toi:	Other public receipts	Bn. kr.	X	
topk:	Contribution receipts, pension funds	Bn. kr.	E	(316)
topl:	Life assurance premiums	Bn. kr.	E	(318)
tpkcov:	Duty rate, public consumption (purchase of goods and services)		X	
tpkq:	Duty rate, rest of consumption		E	(276)
tpkybx:	Duty rate, GVA in private sector exc. agriculture, energy and housing		X	
trb:	Registration duty rate, household purchase of cars		X	
tripm:	Registration duty rate, business purchase of cars		X	
tsuih:	Tax rate on net capital expenditure of private households		X	
tttt:	Trend term in dlogpcpt equation		X	
tuc:	Capacity utilization		E	(91)
tyd:	Unemployment benefits	Bn. kr.	E	(240)
tye:	Early retirement benefits	Bn. kr.	E	(244)

LIST OF VARIABLES

Name	Content	Unit	Type	Equa.No
tyo:	Leave benefits	Bn. kr.	E	(246)
typ:	Pensions and other social transfers	Bn. kr.	E	(248)
typi:	Transfers to private institutions	Bn. kr.	X	
typri:	Imputed public social contribution	Bn. kr.	X	
u:	Labour force minus early retirement and leave takers	1000 persons	E	(155)
ubzz:	Bond supply	Bn. kr.	E	(297)
udda:	Education scheme, thousand persons		X	
uel:	Early retirement benefit receivers	1000 persons	X	
ul:	Unemployment	1000 persons	E	(156)
ulc:	Unit labour cost, private sector exc. agriculture, energy and housing		E	(98)
varg:	Duration, government bonds		X	
varr:	Duration, mortgage institution bonds		X	
ww:	Private sector wwx plus accumulated investments	Bn. kr.	E	(312)
wwx:	Private sector accumulated net lending	Bn. kr.	E	(309)
xfmbra:	Demand for fuel imports	Bn. 95-kr.	E	(125)
xfmvx:	Demand for imports of goods exc. fuel, ships, and aeroplanes	Bn. 95-kr.	E	(121)
y:	GDP	Bn. kr.	E	(135)
ydmas:	Disposable wage and transfer income	Bn. kr.	E	(256)
ydp:	Private disposable gross income	Bn. kr.	E	(277)
yf:	GDP at factor prices	Bn. kr.	E	(138)
yfbx:	GVA, private sector excluding agriculture, energy and housing	Bn. kr.	E	(146)
yfh:	GVA, housing	Bn. kr.	E	(141)
yfo:	GVA, public sector	Bn. kr.	E	(143)
yfpx:	GVA, private sector excluding energy extracting and housing	Bn. kr.	E	(144)
ytr:	Domestic demand	Bn. kr.	E	(137)
ytrx:	Domestic demand excluding services	Bn. kr.	E	(115)
yw:	Total compensation of labour	Bn. kr.	E	(157)
ywby:	Compensation, private sector exc. agriculture, energy and housing	Bn. kr.	E	(161)
ywla:	Compensation, agriculture	Bn. kr.	E	(163)
ywo:	Compensation, public sector	Bn. kr.	E	(159)
zbbyg:	Present value of tax depreciation, buildings		E	(104)
zbdpc:	Taylor 1st order coefficient of inflation, zbbyg		X	
zbn:	Taylor 1st order coefficient of interest rate, zbbyg		X	
zbt:	Taylor 1st order coefficient of tax rate, zbbyg		X	
zbzg:	Government bond debt	Bn. kr.	E	(296)
zbzl:	Local governments bond debt	Bn. kr.	X	
zbzr:	Private bond debt	Bn. kr.	E	(308)
zdpc:	Inflation rate in base solution for present tax value		X	
zibz:	Interest rate in base solution for present tax value		X	
zmdpc:	Taylor 1st order coefficient of inflation, zmmask		X	
zmmask:	Present value of tax depreciation, machinery		E	(85)
zmn:	Taylor 1st order coefficient of interest rate, zmmask		X	
zmt:	Taylor 1st order coefficient of tax rate, zmmask		X	
ztax:	Tax rate in base solution for present tax value		X	
zzbbyg:	Base solution for present tax value, buildings		X	
zzmmask:	Base solution for present tax value, machinery		X	