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QMM
A Quarterly Macroeconomic Model of the Icelandic Economy
Version 3.0

By

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Abstract

This Handbook contains an updated version of the Quarterly Macroeconomic Model of the Central Bank of Iceland (QMM). QMM and the underlying quarterly database have been under construction since 2001 at the Research and Forecasting Division of the Economics and Monetary Policy Department at the Bank and was first implemented in the forecasting round for the *Monetary Bulletin* 2006/1 in March 2006. QMM is used by the Bank for forecasting and various policy simulations and therefore plays a key role as an organisational framework for viewing the medium-term future when formulating monetary policy at the Bank. This paper is mainly focused on the short and medium-term properties of QMM. Steady state properties of the model are documented in a paper by Daníelsson (2009).

*† Economics and Monetary Policy Department of the Central Bank of Iceland. ‡ Former employee of the Central Bank of Iceland. A number of people have assisted with the data. Their help, and comments and suggestions from many others, are gratefully acknowledged. None of them is, however, responsible for any errors or omissions in this study.

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Part I
Model Overview

1. Introduction to QMM

This Handbook documents and describes the Quarterly Macroeconomic Model of the Central Bank of Iceland (QMM). QMM and the underlying quarterly database has been under construction since 2001 at the Research and Forecasting Division of the Economics and Monetary Policy Department at the Bank and was first implemented in the forecasting round for the *Monetary Bulletin* 2006/1 published in March 2006. QMM is used by the Bank for forecasting and various policy simulations and therefore plays a key role as an organisational framework for viewing the medium-term future when formulating monetary policy at the Bank.

Those familiar with the models used by the Bank of England will immediately see the likeness of QMM and the Medium-term Macro Model (MTMM) of the Bank of England (1999, 2000).[1] This is no coincidence as the structure of MTMM was used for constructing the original version of QMM. We would like to thank the Bank of England for making their work public and for their hospitality during a visit to the Bank in February 2001. The Bank of England is, however, in no way responsible for any part of QMM or this Handbook.

This Handbook documents an update to Version 2.2 of QMM, published on the Bank's homepage in November 2011. Version 2.0 of QMM is described in the Bank's *Working Paper* no. 41, from February 2009. The original version of QMM (Version 1.0) can be found in *Working Paper* no. 32 from December 2006.

1.1. The role of QMM

QMM is used in the Central Bank of Iceland to assist in analysing the current economic situation, making economic projections, assessing the effects of alternative policies and shocks, evaluating risks, handling uncertainty and with communication both within and outside the Bank. No single model can, however, fulfil all these roles. All models are imperfect as they are unavoidably a simplification of reality. Forecasts at the Central Bank of Iceland are therefore a result of a thorough procedure which involves a combination of judgement and projections from various models. QMM represents the core model of the Central Bank's forecasting system shown in Figure 1.1, which illustrates the relationship between models, judgement, forecasts and policy advice. The functioning of the system is very dependent on having a well-suited core model which can serve as a primary organisational framework to change mechanical model projections and judgement into forecasts and policy advice. In order to fulfil this role the core model must incorporate the Bank's assessments of the most important relationships in the economy and capture the essence of the transmission mechanism of monetary policy. In this respect, QMM marks a significant improvement from previously models used by the Bank.

[1] Other macroeconomic models that influenced the construction of QMM include the AQM of the Austrian Nationalbank, the MEP of the Central Bank of Chile, Christopher Murphy's Model (MM) and the Swedish Riksbank's BASMOD.

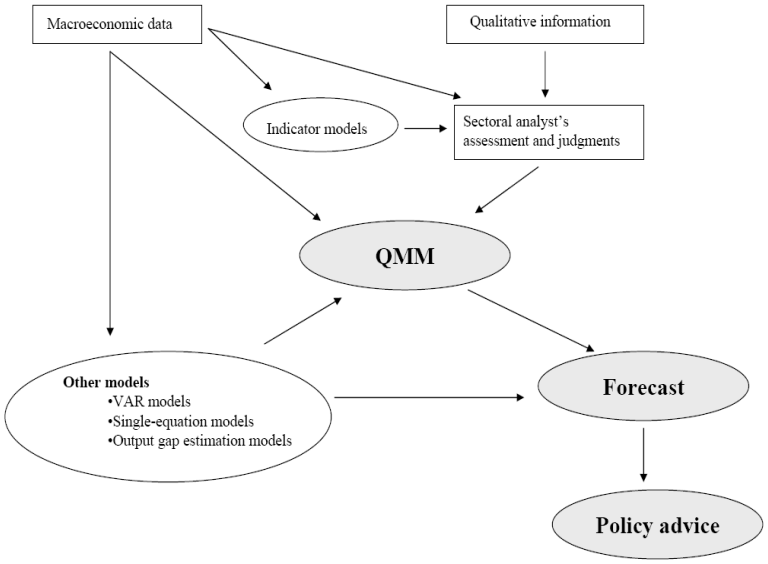

Figure 1.1. Overview of QMM's role in the Central Bank of Iceland's forecasting process

1.2. The structure of the Handbook

The remainder of this Handbook is organised as follows. **Chapter 2** gives a short overview of QMM, discussing the demand and supply sides of the model, the nominal and real dichotomy of the model and its dynamic behaviour. Future modelling developments are also discussed. **Chapter 3** discusses the data used in QMM and the general approach to estimation of individual equations of the model.

The second part of the Handbook describes QMM in detail. **Chapter 4** contains the financial system in the model, describing how interest rates and other asset prices are determined. The demand for money and the definition of household wealth are also described. **Chapter 5** describes the determination of the major demand components, i.e. consumption, investment, stockbuilding and net trade. The chapter concludes with a description of potential output and the output gap. **Chapter 6** describes the labour market in QMM, covering wage determination, labour demand and supply, and unemployment. **Chapter 7** describes price determination and inflation in QMM, covering the implicit price deflators of the national accounts components and other important prices. **Chapter 8** discusses fiscal policy and **Chapter 9** the household income accounts in the model. Finally, **Chapter 10** contains backward looking versions of the forward looking part of the model.

The third part of the Handbook reports some important model properties. **Chapter 11** discusses how monetary policy works in QMM, highlighting the main transmission channels in the model. The chapter concludes with an illustrative example of the transmission lags and the size of the effects of an unanticipated monetary policy shock. **Chapter 12** continues to analyse the model's properties by analysing effects of a number of other interesting shocks.

The fourth and final part of the Handbook contains appendices. **Chapter 13** lists all the variables in QMM and cross-references of all variables to each equation they enter. The final chapter, **Chapter 14**, contains a detailed description of the data, its sources and methods used to generate it.

2. Overview of QMM

2.1. The level of aggregation

QMM is a one-sector representation of the Icelandic economy, containing 28 empirically estimated behavioural relations and 119 other equations, such as accounting identities and definitions. Thus, the model contains 147 endogenous variables and adding the 54 exogenous variables, gives a total of 201 variables.

The level of aggregation in QMM is low compared to core models used in major central banks today. The level of aggregation is though quite high compared to the old model that it replaced in 2006. QMM contains all the key transmission mechanisms of monetary policy and has a standard description of all the main components of aggregate demand and supply and their interactions over the medium and long-run. Thus, information and assumptions on specific prices or sectors of the economy can easily be handled outside the model and fed into QMM in each forecasting round.

2.2. The overall structure of QMM

The construction of the model is based on standard macroeconomic theory. This implies, e.g. that the long-run path for the real economy is independent of nominal variables. Hence, QMM displays both nominal neutrality (the long-run real equilibrium is independent of the nominal price level) and inflation neutrality (the long-run real equilibrium is independent of the rate of inflation). The nominal equilibrium is determined by monetary policy which determines the path for nominal prices and the rate of inflation. Finally, QMM displays nominal and real inertia, thus allowing a short-run trade-off between the real economy and inflation.

2.2.1. The supply side

The supply side of QMM is characterised by a constant-returns-to-scale Cobb-Douglas production function with diminishing marginal returns on the factor inputs, labour and capital, plus exogenous technological progress, (5.64).

The constant factor shares property of the Cobb-Douglas production function imposes long-run restrictions on wage developments and capital formation. The marginal product condition with respect to capital gives the capital-output share as a function of the real cost of capital, which imposes a long-run restriction on business investment (5.10). The marginal product condition with respect to labour gives real unit labour costs equal to the constant labour share in value added, which imposes a long-run restriction on wage developments (6.1). Short-run wage developments are given by a Phillips curve relationship, with real unit labour costs determined by

deviations of the unemployment rate from its natural rate (NAIRU), deviations of the real exchange rate from its steady state value, a price wedge between output and consumer prices and deviations from the estimated long run wage share (6.2).

Developments of the unemployment rate in QMM are given by an Okun's type relation between deviations of unemployment from NAIRU and deviations of actual output growth from potential output growth (6.6). Labour supply is determined by an exogenously given population at working age and the participation rate, which is given by a simple dynamic adjustment process with cyclical responses to output growth and the unemployment rate (6.8). Average hours are given as a function of the unemployment rate, with short-run effects of output growth (6.10). Finally, labour demand is given as a residual (6.12).

2.2.2. The demand side

The demand side of QMM reflects the open economy nature of the Icelandic economy. Its full detail comes from aggregating the separate expenditure components of GDP:

- In the long-run, private consumption (5.1) is given by real disposable income, real household wealth and the real short-term interest rate, capturing intertemporal substitution effects and interest rate effects on household debt burden. In the short-run (5.2) there are also effects from the unemployment rate, capturing influences of precautionary saving.

- Real government consumption is exogenous in QMM. This implies that nominal government consumption is given by real government consumption and the endogenous development of the implicit price deflator for government consumption (5.4).

- Long-run regular business investment (5.11) (excluding the aluminium sector and irregular airplane and ship investment), through the standard stock-flow condition (5.8), is consistent with the marginal product condition (5.7) which determines the stock of capital. Adding the exogenously given aluminium, airplane and ship investment gives total business investment (5.12).

- Residential housing investment (5.15) is given as a function of a Q-type ratio between house prices and the cost of building, with short-run acceleration-type and real interest rate effects.

- Total fixed investment (5.5) is the sum of business investment, housing investment and exogenous government investment.

- Exports of goods (5.26) are given as the sum of exogenously determined exports of aluminium, marine goods, and ships and airplanes on one hand and the exports of other goods, which are determined by world trade and relative exports prices, on the other (5.35). Exports of services (5.27) are given as the sum of the exogenously determined exports of manufacturing services and other service exports, which are determined by world trade and relative prices (5.38).

- Imports of goods (5.42) are given as the sum of the exogenously determined imports of aluminium imports and ships and airplanes on one hand and the imports of other goods, which are determined by import weighted domestic demand and relative prices (5.48). Imports of services (5.51) are given as a function of import weighted domestic demand and relative prices. The rising share of imports of services to domestic demand is modelled as a function of increasing globalisation of trade, proxied as the ratio of world trade to world GDP.

2.2.3. Nominal variables, inflation and monetary policy

In QMM, the rate of inflation in the short-term is tied down by monetary policy. Hence, monetary policy provides the nominal anchor in the model. This again implies that in the long run, inflation is a 'monetary phenomena', i.e. sustained increases in prices cannot occur without excessively loose monetary policy.

In simulations QMM uses a forward-looking Taylor (1993) rule where the short-term interest rate reacts to expected future deviations of underlying inflation from the Central Bank of Iceland inflation target and deviation of actual output from potential output (the output gap), (4.1).[2]

Long-term interest rates are estimated by the average of the current and expected short-term rates, in line with the expectations hypothesis (4.6), using rational (or model consistent) expectations. Long-term indexed rates (or real rates) are determined by the standard Fisher-relation (4.7).

Since the Central Bank uses the short-term interest rate as its policy instrument, money demand determines the quantity of money in circulation. In QMM, real money holdings (4.28) are estimated as a function of output, real net household wealth and the opportunity cost of money (approximated by the long-term interest rate and the return on equity). It should be noted that this formulation of monetary policy implies that money has no causal role in QMM. However, in the absence of persistent shocks to velocity, the money supply will move in line with nominal output in the long-run nominal equilibrium.

Underlying consumer price inflation is given by a standard expectations-augmented Phillips curve, allowing for temporary real exchange rate and real unit labour cost shocks (7.1) and (7.2). Some price setters are assumed to form their expectations in a forward-looking way using rational (or model consistent) expectations, while the other part of price setters are assumed to model their expectations in a backward-looking manner. The specification imposes dynamic homogeneity to ensure a vertical long-run Phillips curve. Headline inflation then adds the effects of indirect tax changes to underlying inflation.

Other prices are determined by mark-up pricing over marginal costs:

- Prices of imports of goods excluding aluminium-related goods and imports of airplanes and ships are given as a function of international prices in domestic

[2]It should be emphasised that this policy rule is not meant to be an exact description of actual policy formulation at the Central Bank of Iceland.

currency (non-oil commodity prices, oil prices and world export prices) and a domestic component given by unit labour costs (7.4). Prices of imported services are assumed to follow world consumer prices (7.5), while aggregate import prices are also influenced by the prices of imported aluminium goods, determined by the exogenously given aluminium export prices (7.6).

- Prices of exports of goods excluding marine and aluminium products as well as airplanes and ships are given as a function of world export prices (7.7). Export price of services is determined similarly by world consumer prices (7.8). Prices of marine goods are a function of world non-oil commodity prices and world demand (7.9), while aggregate export prices are also influenced by the exogenously given international prices of aluminium goods (7.10).

- The private consumption deflator (7.11) is assumed to grow at the same rate as consumer prices, allowing for different seasonal patterns and different short-run responses to exchange rate shocks due to the slightly different import densities of the two price indices.

- The government consumption deflator (7.12) is assumed to evolve in line with unit labour costs and consumer prices.

- Prices of investment goods are given as a function of building costs and import prices in domestic currency, reflecting the large share of imported capital goods in Iceland (7.13).

- Housing investment costs are assumed to grow in line with general building costs (7.14).

- The government investment deflator evolves in line with general building costs and investment prices (7.15).

- The domestic output deflator is the residual price series and is given as the ratio between nominal and real GDP (7.16).

- Residential house prices are determined by an inverted housing demand function, with real house prices given as a function of the ratio of the housing stock to disposable labour income and the real interest rate (7.18).

- Building costs are given as a function of consumer prices and unit labour costs (7.19).

- The real exchange rate is given by the standard risk-adjusted UIP condition, assuming that some investors form their expectations in a forward-looking way using rational (or model consistent) expectations, while the other part of investors are assumed to model their expectations in a backward-looking manner (4.16). The nominal exchange rate is derived from the standard definition of the real exchange rate (4.10).

2.2.4. Dynamic adjustment

In the long-run, real prices, such as the real exchange rate and the real interest rate, should ensure that in the real long-run equilibrium, aggregate demand grows in line with trend output growth along a balanced growth path, which in turn, is determined by technological progress and available factor supplies. The long-run nominal equilibrium on the other hand is determined by monetary policy.

As discussed above, there is a complete long-run dichotomy between the paths of nominal and real variables. Hence, there is no long-run trade-off between inflation, on the one hand, and unemployment or output, on the other hand. The long-run Phillips curve is vertical and it is impossible to achieve persistently higher output or lower unemployment by tolerating higher inflation.[3]

In the short-to-medium term there is however sluggish adjustment towards the long-run equilibrium. It therefore takes time for the economy to respond to exogenous shocks that move it away from equilibrium.[4] There are two types of inertia:

- Real inertia, where real variables respond sluggishly. This could involve costs of adjusting employment and stock levels. This type of sluggish behaviour is reflected in all the expenditure equations and the labour market in QMM.
- Nominal inertia, where nominal variables respond sluggishly. This could involve prices (price inertia), e.g. due to menu costs, and wages (wage inertia), e.g. due to overlapping wage contracts. The wage-price dynamics in QMM reflect both types of inertia.

The sluggish behaviour of real and nominal variables in QMM implies that aggregate demand can deviate from potential output in the short to medium term. This is captured in QMM by the output gap which measures capacity utilisation in the economy, or the level of goods market pressure (5.69), and the deviations of the unemployment rate from an exogenous NAIRU, for measuring labour market pressures, (6.6).

This property of QMM also implies that there is a short-run trade-off between inflation and the real economy: Inflation will generally rise as pressures of demand on capacity build up and fall when these pressures ease. Hence, although the long-run Phillips curve is vertical, the short-run curve is upward sloping (in inflation output gap space), thus offering the possibility that monetary policy can try to reduce fluctuations in the real economy over the business cycle at the same time it attempts to anchor inflation expectations to the inflation target.

2.3. Changes to QMM in the current version

Since the publication of Version 2.2 of QMM the model has been re-estimated and individual equations have been revised.

[3] Although not captured in QMM, empirical evidence suggests that high inflation is more likely to be damaging to the real economy and economic welfare.

[4] There are many reasons possible for this sluggish behaviour, including physical adjustment costs, information costs, learning and institutional factors.

The main changes in Version 3.0 are:

- The estimation period has been extended in most cases to 2012Q4 (instead of 2006 in the previous version) and the base year has been changed from 2000 to 2005 for chain-linked volume data.
- Historical data in QMM has been updated with the new national accounts standards ESA2010, which was implemented by Statistics Iceland and the Central Bank of Iceland in September 2014. This has led to some revisions in model equations and data treatment.
  - Statistics Iceland values the private sector housing stock at market price of housing (PH) but investment in housing at cost price (PIH). In 2005 the difference between these two prices was very large leading to two problems in QMM when switching the base year from 2000 to 2005: firstly, keeping the housing stock at 2005 prices constant requires investment in housing at constant 2005 prices to be well above its historical average as a share of GDP. Second, this leads to a large increase in the capital-output ratio compared to earlier periods when the national account variables were valued at year 2000 prices. Because of this, the housing stock (KH) in QMM is obtained by scaling the Statistics Iceland data on the housing stock at 2005 prices down by dividing each data point in the series by 1.37. KH is therefore multiplied with 1.37 when measured at current prices in (4.21). The factor 1.37 is determined roughly so that the capital-output ratio in this version of QMM is similar to that in the previous version.
  - An exogenous adjustment factor, $IHEX$, is added to private sector housing stock (5.21) multiplied with GDP to top up the investment in housing based on an equation which reflects historical levels of investment in housing in Iceland. Even if actual data on the housing stock have been scaled down by the division with 1.37 additional investment are needed to ensure that the housing stock grows at the equilibrium rate of growth. The value of $IHEX$ is derived from the balanced growth version of the model (see Daníelsson, 2009).
  - Goods for processing that are imported to Iceland for further processing and then re-exported without change in ownership are no longer included in trade in goods in the national accounts. Instead, the value-added is included in export of services (manufacturing services). A new exogenous variable, $EXSMAN$, was therefore added to represent this. The nominal export of manufacturing services is given by (5.40).
  - Inventories in the national accounts were revised historically due to improved data collection and to general standardising of how its subcomponents are treated. Changes in inventories (II and IIN) are now treated as exogenous in QMM and assumed to converge relatively rapidly to its equilibrium growth rate of zero.

- Weights for household asset and debt revaluations terms (4.25 and 4.26) have been revised in line with recent developments of household balance sheets. Furthermore, equations describing the household financial wealth and debt have been revised (4.23 and 4.24).

- Import weighted domestic demand, DDA (5.24), is added to better describe the import weighted domestic demand in import volume of other goods (5.48) and import volume of services (5.51).

- New variables are added to the net trade part of the model. They sum up the export chain-linked volume of goods (5.26), the export chain-linked volume of services (5.27), and the import chain-linked volume of goods (5.42).

- A new variable reflecting quarterly trend GDP growth, estimated from the production function (5.65), has been added and the augmented estimate of potential output (5.67) is now given as a simple average of three different estimates (instead of previously by four different estimates).

- Version 3.0 of QMM exclusively uses data from the Statistics Iceland labour market survey for modelling the labour market. A new equation (6.10) describing the average hours per worker has been added to the labour market set-up. The definition of trend labour productivity (6.17) has also been changed and is now given as a four-quarter moving average of quarterly labour productivity (6.16), with a corresponding change in the definition of trend unit labour costs (6.4). Finally, the treatment of the exogenous natural rate of unemployment, $NAIRU$, has been changed. $NAIRU$ is now time-varying instead of being a constant and is estimated using the Kalman filter. See Einarsson and Sigurdsson (2013).

- The definition of building costs (7.19) has been revised and is now calibrated according to the weights of material and labour costs used by Statistics Iceland.

- A lagged value is added to the equation specifying break-even inflation expectations (7.26) with a 85% weight, allowing for some smoothing.

- An exogenous variable, $DPENS$, was added to model changes to real household post-tax income (9.6) when the proportion of employee's payment in pensions funds and third-pillar savings changes.

These changes improve the fit of the model and its dynamic simulation properties, but the overall behaviour of the model remains similar to those reported in previous versions of QMM.

2.4. Future modelling developments

QMM is not derived from fully specified optimisation problems of private agents in the economy but is mainly based on empirically estimated error correction relationships. The degree of empirical coherence is therefore given some precedence over the degree of full theoretical coherence in Pagan's (2003) terms. It therefore follows that the model may not automatically converge to a steady-state solution in the long run. To ensure convergence to steady state three conditions must be fulfilled. First, all nominal variables must grow in line with the Central Bank's inflation target. Second, real variables must converge to a balanced growth path equal to the growth rate of potential output (equal to the sum of the growth rates of population and technology). Finally, the long-run dichotomy between nominal and real variables must be fulfilled. The current version of QMM fulfils the first and last condition but some further restrictions are needed in order to meet the second requirement, see Daníelsson (2009) for further details. The fact that QMM is basically an estimated error correction model makes it also exposed to the Lucas critique which somewhat limits its use for policy and welfare analysis.

Given the lack of fully specified microeconomic foundations for the behavioural relations in QMM, the next logical step in the Bank's modelling work is to build a relatively small DSGE model as many central banks have been working on lately.[5] These models represent an ambitious attempt to combine the latest progress in macroeconomic theory, structural forecasting and practical monetary policy making. Although many issues remain unsolved,[6] work has begun and a small stylised New-Keynesian model based on the work of Hunt (2006) is already being used and a prototype version of a new DSGE model, called DYNIMO, is now available and is being further developed (see Seneca, 2010). These models could contribute to improve the forecasting and analytical abilities of the Bank with direct benefits for policy making.

3. Data and estimation approach

3.1. The data

Statistics Iceland has published time series for quarterly national accounts data for Iceland going back to 1997. For the period before 1997 Statistics Iceland provides only annual data. For other variables, e.g. balance sheet variables, official data are annual only. This means that to obtain sufficiently long time series of quarterly data the modelling team had to estimate quarterly data from annual data and some information on related variables that are available at quarterly frequency using the ECOTRIM software developed by Eurostat. Given the large structural changes in the Icelandic economy in recent decades, especially during the 1980s and early 1990s,

[5] These include the new Bank of England BEQM, Bank of Canada's TOTEM, Bank of Norway's NEMO, Bank of Finland's AINO, and MAS from the Central Bank of Chile.

[6] These include the microeconomic foundations of imperfections in various markets, price setting, expectations and open-economy issues. Another issue relates to estimation approaches, where some prefer classical or Bayesian estimation approaches, while others favour calibrating methods. Finally, forecast performance of these models needs more testing. For further detail, see Ólafsson (2006).

using time-series that start before 1990 is frequently not wise. For these reasons the estimation period usually starts in 1992. Detailed description of the data, its sources and, where applicable, the methods used for generating the quarterly observations is in Chapter 14 in the Appendix.

3.2. Estimation of long-run relations

A detailed analysis of the long-run properties of each economic relationship in QMM is beyond the scope of this Handbook. It suffices to say that the long-run solutions reported are estimated using the simple Engle-Granger approach for estimating cointegrating relationships. Although more sophisticated estimation methods are available it should be pointed out that most of the long-run estimation results in QMM are based on well established empirical findings in Iceland, generally using these more sophisticated methods. Table 3.1 reports the most important references.

The long-run solutions in QMM typically define the particular quantity variable as a ratio to aggregate output, with this long-run path possibly affected by relative prices. Given these long-run paths, the short-run dynamics are estimated within the standard error correction framework as mentioned above. This reflects the underlying inertia in the economy, where the long-run relationships only assert themselves gradually in the face of shocks to demand or supply. To highlight this interaction between the long-run equilibrium and the short-run dynamics, long-run solutions are given in square-brackets.

Table 3.1. Papers analysing long-run properties of economic relations in QMM

Money demand	Pétursson (2000)
Consumption	Baldursson (1993), Central Bank of Iceland (2004)
Investment	Hauksson (2005)
Housing market	Central Bank of Iceland (2004), Elíasson and Pétursson (2009)
Imports	Meacci and Turner (2001)
Wages	Pétursson (2002)

It is important to note that equations of the model are developed as a part of the overall structure of QMM. Hence, the particular choice of empirically estimated equations and the variables entering those equations have all been dictated by the overall structure of the model. Furthermore, the selection of a particular equation and the short-run and long-run restrictions imposed in that equation is based not only on statistical inference and economic logic but also on its impact on the overall simulation properties of QMM. Each equation of the model does therefore not necessarily represent the 'best' single-equation estimate of the particular variable, but should rather be interpreted within the context of QMM. This also implies that equations or parts of QMM may regularly be replaced by something that is viewed to better represent the current structure of the Icelandic economy. A macroeconomic model can therefore never be viewed as final, but rather as an ongoing project. Updated versions of QMM will therefore regularly be made available to the public.

3.3. Notational conventions

Several conventions are used in this Handbook to present the empirical results of QMM. Upper-case letters denote the original variables, while lower-case letters denote natural logarithms of the same variables. The subscript t denotes time, while upper-case T denotes a linear time trend (set equal to zero in 1970:Q1). The superscript Y denotes a calendar year. $Q1$, $Q2$, $Q3$ and $Q4$ denote quarterly centered seasonal dummies (equal to 3/4 in the relevant quarter and -1/4 otherwise), while impulse dummy variables are denoted by D and shift dummy variables by S (see Table 13.3 in the Appendix for a summary of dummy variables in QMM). Year-on-year changes are denoted as Δ_4, i.e. $\Delta_4 x_t = x_t - x_{t-4}$ and quarterly differences as Δ, i.e. $\Delta x_t = x_t - x_{t-1}$. Δ^2 denotes double differences, i.e. $\Delta^2 x_t = \Delta x_t - \Delta x_{t-1}$, or the acceleration of x_t. Finally, tables reporting single-equation analysis of estimated equations give the value O/S when the effect of a shock to a given explanatory variable overshoot its long-run value.

3.4. Statistical information

T-values for the null hypothesis that a given variable is statistically significant from zero are given in brackets below each parameter estimate. Information on empirical fit (using degrees of freedom adjusted R^2) and equation standard error is given with empirical results on the most important equations. In cases where the estimated equation involves forward-looking variables, the equation is estimated with GMM, with a J-test giving additional information on model fit. Otherwise, standard OLS estimates are used.

Also shown are standard diagnostic tests for first-order residual autocorrelation (the Breusch-Godfrey F-test), residual normality (the Jarque-Bera χ^2-test) and a general form of residual heteroscedasticity (the White F-test). Where relevant, a F-test for the static long-run restriction imposed is also presented. To account for the non-stationarity properties of the data, the dynamic OLS method (DOLS) is used with the long-run test statistics corrected as described in Hamilton (1994). Finally, a F-test for dynamic homogeneity or other types of coefficient restrictions are also presented where relevant. The test statistics values are given with probability values in square brackets.

For the most important equations the empirical fit is also shown graphically, along with single-equation impulse response analysis and the steady-state solution to the equation. In all cases are the variables entering a given equation explicitly documented with cross-references to equations. An overview of all the variables and the cross-references to equations is given in Chapter 13 in the Appendix.

Part II
Model Details

4. Financial markets

This part of QMM describes the financial sector of the economy and the formulation of monetary policy. This includes interest rate setting and asset price determination, the demand for financial assets and definitions of wealth.

4.1. Interest rates and asset prices

4.1.1. Short-term interest rates (RS)

The monetary policy instrument, RS, is assumed to be set such as to minimise deviations of underlying inflation from the inflation target and the deviations of output from its potential. To obtain this goal the following forward-looking version of the standard Taylor (1993) rule is assumed (allowing for some interest rate smoothing, for example reflecting the view that large and frequent interest rate changes can undermine financial stability):[7]

$$RS_t = 0.6RS_{t-1} + 0.4\left[(RRN_t + IT_t) + 1.5(INFUL_{t+4} - IT_t) + 0.5GAPAV_t\right] \quad (4.1)$$

where:

RS	Short-term interest rate (4.1).
RRN	Real neutral interest rate (exogenous).
IT	Central Bank of Iceland 2.5% inflation target (exogenous).
$INFUL$	Underlying four-quarter CPI inflation rate (7.22).
$GAPAV$	Annual average of output gap (5.70).

To arrive at this forecast-base rule specification of monetary policy, a number of different policy rules and parameter values were tried.[8] Model simulations using different rules suggest that (4.1) dominates in terms of standard deviations of inflation and output trade-offs.[9] Most importantly, it strongly dominates the standard Taylor rule using current inflation instead of expected future inflation, used in previous versions of QMM.

[7] The Taylor rule includes the neutral policy rate RRN which is currently assumed to equal 3%, down from its 4.5% pre-crisis level.

[8] For example, monetary policy rules suggested by Orphanides et al. (2000) and Husebø et al. (2004). Adding the real exchange rate (either quarterly changes or deviations from the equilibrium real exchange rate) do not seem to improve the policy tradeoffs: fluctuations in the real exchange rate are reduced, but only at the cost of increasing the volatility of inflation, output and interest rates. This is consistent with findings from many other small open economies, cf. West (2003) for New Zealand.

[9] Levin et al. (2003) also find that a rule of this type is robust to model uncertainty. Hunt (2006) uses the same type of policy rule for analysing efficient policy frontiers for Iceland and obtains almost identical parameter values using Bayesian estimation techniques (0.63 for the lagged interest rate, 1.39 for the inflation gap and 0.47 for the output gap).

4.1.2. Long-term interest rates (RL)

Long-term interest rates (RL) are assumed to be determined by the average of the current and expected future short rates (RS), in addition to an exogenous term premium ($TERM$), according to the expectations hypothesis of the term structure. The specification of RL also allows for an overweight on the current short rate reflecting the fact that long rates tend to move more closely with the current short rate over the business cycle than would be suggested by the simple expectations hypothesis (see Black et al., 1997, for a similar idea).

With the long rate proxied by a bond with roughly 5 year maturity, the expectations hypothesis gives the following relationship between RL and RS as:

$$RL_t = \frac{1}{20}\sum_{j=0}^{19} RS^e_{t+j} + TERM_t \tag{4.2}$$

where RS^e denotes rational expectations of RS based on information at time t (i.e. RS^e_{t+j} denotes $E_t RS_{t+j}$). $TERM_t$ denotes exogenous term premium between approximately 5 year interest rates RL_t and the average expected future short term interest rates $\frac{1}{20}\sum_{j=0}^{19} RS^e_{t+j}$ over that same same period. To allow for overweight of the current short term interest rates, we weight in the short rates by λ_{rl}:

$$RL_t = \lambda_{rl} RS_t + (1-\lambda_{rl})(\frac{1}{20}\sum_{j=0}^{19} RS^e_{t+j}) + TERM_t \tag{4.3}$$

To estimate the relative weights of the current short rate and the long rate consistent with the expectations hypothesis, it is useful to rewrite (4.3) as:

$$\begin{aligned} RL_t &= RL_{t-1} + \lambda_{rl}(RS_t - RS_{t-1}) + (1-\lambda_{rl})(RS^e_{t+19} - RS_{t-1})/20 \\ &\quad + TERM_t - TERM_{t-1} \end{aligned} \tag{4.4}$$

The following equation is therefore estimated with GMM with three lags of RS and RL as instruments:[10]

$$\begin{aligned} RL_t &= RL_{t-1} + \underset{(6.0)}{0.415}(RS_t - RS_{t-1}) \\ &\quad + (1-0.415)\left[(RS_{t+19} - RS_{t-1})/20\right] + TERM_t - TERM_{t-1} \end{aligned} \tag{4.5}$$

Estimation method	GMM
Adjusted R^2	0.840
Equation standard error	0.52%
Coefficient restrictions (F-test)	5.60 [0.02]
J-test for over-identifying restrictions (χ^2-test)	9.25 [0.06]
Normality test (χ^2-test)	1.04 [0.60]
Sample period	1997:Q1-2008:Q4 ($T = 48$)

[10] The equation is estimated using data until 2013:Q4. The estimation period ends in 2008:Q4 due to the inclusion of RS_{t+19} as a regressor. The homogeneity restriction is accepted at 2% and the J-test does not reject the over-identifying restrictions.

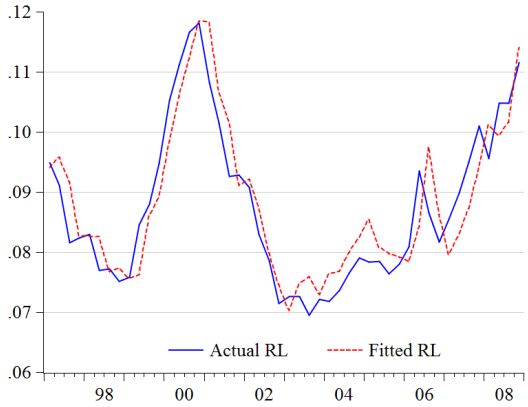

Figure 4.1. Fitted and actual RL_t

The specification of RL used in QMM is given as:

$$RL_t = 0.415RS_t + (1 - 0.415)\sum_{j=0}^{19} RS_{t+j}/20 + TERM_t \tag{4.6}$$

where:

RL	Long-term interest rate (4.6).
RS	Short-term interest rate (4.1).
$TERM$	Term premium (exogenous).

4.1.3. Long-term indexed interest rates (RLV)

Long-run indexed interest rates are given by the Fisher relation and an inflation risk premium:

$$RLV_t = \frac{(1 + RL_t)}{(1 + INFE_t)\,(1 + PRISK_t)} - 1 \tag{4.7}$$

where:

RLV	Long-term indexed interest rate (4.7).
RL	Long-term interest rate (4.6).
$INFE$	Break-even inflation expectations (7.26).
$PRISK$	Inflation risk premium (exogenous).

4.1.4. Real cost of capital (RCC)

Investment is affected by the real cost of capital, RCC, which in turn is given by the long-term real interest rate (RLV), the depreciation rate of capital ($DELTA$) and a corporate risk premium ($PRBUS$):

$$RCC_t = (RLV_t + PRBUS_t)/4 + DELTA_t \tag{4.8}$$

where:

RCC	Real cost of capital (4.8).
RLV	Long-term indexed interest rate (4.7).
$PRBUS$	Business premium on risk-free interest rate (exogenous).
$DELTA$	Depreciation rate for total capital stock (exogenous).

4.1.5. Real interest rate differential (RID)

The quarterly gross risk adjusted real interest rate differential is given as:

$$RID_t = \frac{(1 + RS_t/4)/(1 + INFUL_t/4)}{[(1 + WRS_t/4)/(1 + WINF_t/4)]\,(1 + RISK/4)} \tag{4.9}$$

where:

RID	Real interest rate differential (4.9).
RS	Short-term interest rate (4.1).
$INFUL$	Underlying four-quarter CPI inflation rate (7.22).
WRS	Foreign short-term interest rate (exogenous).
$WINF$	Four-quarter world inflation rate (7.24).
$RISK$	Exchange rate risk premium (exgogenous).

4.1.6. Nominal exchange rate (EER, EUR and EUS)

The nominal effective exchange rate is derived from the real exchange rate expression:

$$EER_t = \frac{CPI_t}{REX_t \times WCPI_t} \tag{4.10}$$

where:

EER	Exchange rate index of foreign currency (4.10).
CPI	Consumer price index (7.2).
$WCPI$	World consumer prices (exogenous).
REX	Real exchange rate (4.16).

Changes in the US dollar and euro exchange rates are simply assumed to follow that of the effective exchange rate index:

$$\Delta eus_t = \Delta eer_t \quad (4.11)$$
$$\Delta eur_t = \Delta eer_t \quad (4.12)$$

where:

EUS	USD exchange rate (4.11).
EUR	Euro exchange rate (4.12).
EER	Exchange rate index of foreign currency (4.10).

4.1.7. Real exchange rate (REX, $REXX$ and $REXM$)

A general measure of the real exchange rate is given by relative consumer prices defined as $REX = CPI/(EER \times WCPI)$. It is assumed that REX is determined by the real interest rate differential and the expected real exchange rate, but allowing for some inertia and a weight on the exogenous equilibrium real exchange rate, $REXEQ$:

$$(rex_t - rexeq_t) = \alpha_{rex}(rex_{t-1} - rexeq_{t-1}) + \beta_{rex}(rex^e_t - rexeq_t) + rid_t \quad (4.13)$$

where RID is the quarterly risk adjusted gross real interest rate differential and REX^e is the expected real exchange rate, which is given as a weighted average of the past and future values of REX and the current $REXEQ$:[11]

$$(rex^e_t - rexeq_t) = \gamma_{rex}(rex_{t-1} - rexeq_{t-1}) + \phi_{rex}(rex_{t+1} - rexeq_{t+1}) \quad (4.14)$$

Equations (4.13) and (4.14) can be solved jointly to obtain an estimatable equation for REX as:

$$\begin{aligned}(rex_t - rexeq_t) &= (\alpha_{rex} + \beta_{rex}\gamma_{rex})(rex_{t-1} - rexeq_{t-1}) \\ &\quad +\beta_{rex}\phi_{rex}(rex_{t+1} - rexeq_{t+1}) + rid_t\end{aligned} \quad (4.15)$$

Direct estimation of (4.15) gives coefficients on the backward- and forward-looking terms of roughly 0.5. (Version 2.2 of QMM uses values 0.552 and 0.435 on the backward- and forward-looking terms, respectively). Parameter estimates that give a sum of the parameters very close to unity sometimes lead to model instability with an implausibly large exchange rate effects of relatively small shocks. We therefore choose to calibrate the parameters to improve the overall behaviour of the model. The real exchange rate equation used is therefore given as:

[11] Thus γ_{rex} denotes the share of investors forming expectations in a backward-looking manner, whereas ϕ_{rex} denotes the share of investors forming expectations rationally. This has become standard in the literature (cf. Berg et al., 2006, and Isard and Laxton, 2000).

$$(rex_t - rexeq_t) = 0.65(rex_{t-1} - rexeq_{t-1}) + 0.3(rex_{t+1} - rexeq_{t+1}) + rid_t \quad (4.16)$$

where:

REX	Real exchange rate (4.16).
$REXEQ$	Equilibrium real exchange rate (exogenous).
RID	Real interest rate differential (4.9).

The competitive position of the exporting industry is measured by the exporters' real exchange rate:

$$REXX_t = \frac{PX_t}{EER_t \times WPX_t} \quad (4.17)$$

where:

$REXX$	Exporters' real exchange rate (4.17).
PX	Export price deflator (7.10).
EER	Exchange rate index of foreign currency (4.10).
WPX	World export prices (exogenous).

The competitive position of domestic competitive industry is measured by the importers' real exchange rate:

$$REXM_t = \frac{PM_t}{PGDP_t} \quad (4.18)$$

where:

$REXM$	Importers' real exchange rate (4.18).
PM	Import price deflator (7.6).
$PGDP$	GDP price deflator (7.16).

4.1.8. Equity prices (EQP)

Equity prices are simply assumed to grow in line with GDP inflation:

$$\Delta eqp_t = \Delta pgdp_t \quad (4.19)$$

where:

EQP	Equity prices (4.19).
$PGDP$	GDP price deflator (7.16).

4.2. Money and wealth

4.2.1. Household sector wealth (WEL, HW, NFW, GFW, DH, $REVA$ and $REVD$)

Household sector wealth (WEL) consists of housing wealth (HW) and net financial wealth (NFW):

$$WEL_t = HW_t + NFW_t \tag{4.20}$$

where:

WEL	Household sector wealth (4.20).
HW	Housing wealth (4.21).
NFW	Net financial wealth (4.22).

Housing wealth is defined as:[12]

$$HW_t = 1.37PH_t \times KH_t \tag{4.21}$$

where:

HW	Gross housing wealth (4.21).
PH	House prices (7.18).
KH	Private sector housing stock (5.21).

Net financial wealth is given as the difference between gross financial wealth and household debt:

$$NFW_t = GFW_t - DH_t \tag{4.22}$$

where:

NFW	Net financial wealth (4.22).
GFW	Gross financial wealth (4.23).
DH	Household debt (4.24).

Assuming a stable gross financial wealth-to-debt ratio equal to ω_w, gives gross financial wealth as (this ratio has remained stable around 0.5 in recent years):

$$\begin{aligned} GFW_t &= REVA_t \times GFW_{t-1} + \left(\frac{\omega_w}{\omega_w - 1}\right)[PC_t \times RHPI_t - CN_t \\ &\quad -PH_t \times IH_t] \end{aligned} \tag{4.23}$$

and household debt as:

[12] The factor 1.37 is used because of difficulties encountered when applying the stock-flow relationships between the capital stock of housing and housing investment. See Section 5.2.5 below.

$$DH_t = REVD_t \times DH_{t-1} + \left(\frac{1}{\omega_w - 1}\right)[PC_t \times RHPI_t - CN_t - PH_t \times IH_t] \quad (4.24)$$

where:

GFW	Gross financial wealth (4.23).
DH	Household debt (4.24).
PC	Private consumption deflator (7.11).
$RHPI$	Real household post-tax income (9.6).
CN	Nominal private consumption (5.3).
PH	House prices (7.18).
IH	Private sector housing investment (5.15).
$REVA$	Household assets revaluation term (4.25).
$REVD$	Household debt revaluation term (4.26).

The revaluation terms are given as:

$$REVA_t = 0.58 + 0.10\left(\frac{EQP_t}{EQP_{t-1}}\right) + 0.32\left(\frac{CPI_t}{CPI_{t-1}}\right) \quad (4.25)$$

and

$$REVD_t = 0.19 + 0.01\left(\frac{EER_t}{EER_{t-1}}\right) + 0.80\left(\frac{CPI_t}{CPI_{t-1}}\right) \quad (4.26)$$

where:

$REVA$	Household assets revaluation term (4.25).
$REVD$	Household debt revaluation term (4.26).
EQP	Equity prices (4.19).
CPI	Consumer price index (7.2)
EER	Exchange rate index of foreign currency (4.10).

The asset and liabilities weights in $REVA$ and $REVD$ are derived from the household balance sheet and reflect the weight of assets and debt in bonds, interest bearing deposits, stocks and foreign assets.[13]

[13]The weights in the household assets and debt revaluation terms are based on shares of the different types of financial assets and liabilities of households as of December 2014. The constants reflect the shares of nominal interest rate assets and liabilities. On the asset side, the 58% weight reflects the share of non-indexed-linked assets, 32% weight reflects share of indexed-linked assets and the 10% weight reflects the share of equities. On the liabilities side, the 19% weight reflects the share of non-indexed-linked loans, 80% reflects the indexed-linked loans, while the 1% share reflects the share of foreign currency denominated loans. Note that both the revaluation terms ignore the direct capital gains from interest rate changes for two reasons. First, it can be argued that households do not incorporate these effects when making consumption decisions, at least when the effects are expected to be temporary. Second, incorporating these capital gains can lead to large and implausible swings in the revaluation terms when measured from low interest rate levels.

4.2.2. Broad money demand ($M3$)

Steady state money demand gives real money balances as a function of output, net wealth and the opportunity cost of holding money, given by the long-run interest rate and stock market return, with money demand homogenous with respect to output and wealth:

$$(m3 - pgdp) = \alpha_m + \beta_m gdp + (1 - \beta_m)(wel - pgdp) - \phi_m RL - \theta_m \Delta_4 eqp \quad (4.27)$$

where $M3/PGDP$ are real money holdings, GDP is the scale variable, $WEL/PGDP$ is real wealth RL is the long-term interest rate and EQP is equity price. The short-run dynamics of real money balances are also negatively affected by the acceleration of inflation:[14]

$$\begin{aligned}
\Delta(m3_t - pgdp_t) \;=\; & \underset{(3.0)}{0.079} - \underset{(-1.0)}{0.010}Q1 + \underset{(2.0)}{0.018}Q2 + \underset{(1.3)}{0.013}Q3 + \underset{(7.6)}{0.126}D0723 \\
& + \underset{(2.4)}{0.058}D084 + \underset{(5.0)}{0.425}\Delta(m3_{t-2} - pgdp_{t-2}) \\
& + \underset{(2.2)}{0.138}\Delta(wel_{t-4} - pgdp_{t-4}) - \underset{(-5.6)}{0.873}\Delta^2 pgdp_t - \underset{(-3.8)}{0.569}\Delta^2 pgdp_{t-1} \\
& - \underset{(-2.9)}{0.057}\,[(m3_{t-1} - pgdp_{t-1}) - 0.544\ gdp_{t-1} \\
& - 0.456(wel_{t-1} - pgdp_{t-1}) + 13.220RL_{t-1} \\
& + 0.267\Delta_4 eqp_{t-1} - 0.402D08]
\end{aligned} \quad (4.28)$$

Estimation method	OLS
Adjusted R^2	0.733
Equation standard error	2.21%
Long-run restrictions (F-test)	41.50 [0.00]
LM test for serial correlation (F-test)	0.40 [0.53]
Normality test (χ^2-test)	3.41 [0.18]
White test for heteroscedasticity (F-test)	0.43 [0.93]
Sample period	2000:Q2-2012:Q4 ($T = 51$)

where:

[14] The long-run restrictions are imposed on the equation to ensure desirable steady-state properties of the model despite the apparent rejection by the data.

$M3$	Broad money (4.28).
$PGDP$	GDP price deflator (7.16).
GDP	GDP (5.62).
EQP	Equity prices (4.19).
WEL	Household sector wealth (4.20).
RL	Long-term interest rate (4.6).
$D0723$	Dummy variable: 1 2007:Q2-2007:Q3 and zero otherwise.
$D084$	Dummy variable: 1 2008:Q4 and zero otherwise.
$D08$	Dummy variable: 1 2008:Q1-2008:Q4 and zero otherwise.
$Q1$-$Q3$	Centered seasonal dummies.

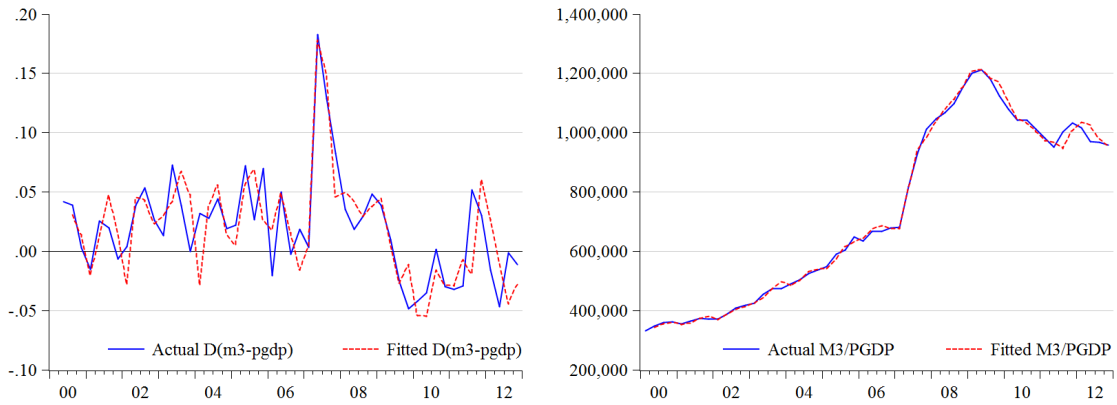

Figure 4.3. Fitted and actual $\Delta(m3 - pgdp)_t$ *and* $M3_t/PGDP_t$

Single equation dynamic responses of (4.28):

Table 4.1. Responses of $(m3 - pgdp)$ to a 1% increase in RHS variables

Quarters	$pgdp$	gdp	$wel - pgdp$	RL	$\Delta_4 eqp$
Simultaneous	−0.87	0.00	0.00	0.00	0.00
One quarter ahead	−0.52	0.03	0.03	−0.75	−0.02
Four quarters ahead	−0.02	0.14	0.25	−3.36	−0.07
Eight quarters ahead	0.13	0.28	0.42	−6.88	−0.14
Long run	0.00	0.54	0.46	−13.22	−0.27
50% of long-run effect	-	8Q	4Q	8Q	8Q
90% of long-run effect	-	21Q	8Q	20Q	20Q

Steady state solution:
$(m3 - pgdp - gdp) = const + 0.456(wel - pgdp - gdp) - 13.220RL - 0.267\Delta_4 eqp$

5. Demand and output

This part of QMM describes the expenditure and production side of the model. This includes public and private demand, net trade and the evolution of the production possibilities of the economy.

5.1. Private and public consumption

5.1.1. Private consumption (C and CN)

Private consumption expenditure is determined in the long-run by household disposable income, wealth and the real interest rate:

$$c = \alpha_c + \beta_c rhpi + (1 - \beta_c)(wel - pc) - \phi_c(RS - INFE) \tag{5.1}$$

where C is consumption, $RHPI$ is real disposable income, WEL/PC is real wealth, RS is the short-term interest rate and $INFE$ is break-even inflation expectations. The short-run dynamics also allow for effects from the unemployment rate, reflecting precautionary saving effects:[15]

$$\begin{aligned}\Delta c_t \;=\; & \underset{(3.9)}{0.023} - \underset{(-2.7)}{0.043}Q1 + \underset{(2.7)}{0.039}Q2 - \underset{(-2.0)}{0.028}Q3 - \underset{(-5.6)}{0.088}D0824 \\ & + \underset{(1.9)}{0.201}\Delta c_{t-4} + \underset{(2.2)}{0.141}\Delta(wel_t - pc_t) \; \underset{(-2.2)}{-0.983}\,\Delta UR_{t-1} \\ & - \underset{(-3.1)}{0.222}[c_{t-1} - 0.966 rhpi_{t-1} - 0.034(wel_{t-1} - pc_{t-1}) + 0.975(RS_{t-1} - INFE_{t-1})]\end{aligned} \tag{5.2}$$

Estimation method	OLS
Adjusted R^2	0.848
Equation standard error	2.17%
Long-run restrictions (F-test)	18.52 [0.00]
LM test for serial correlation (F-test)	0.61 [0.44]
Normality test (χ^2-test)	1.58 [0.45]
White test for heteroscedasticity (F-test)	1.51 [0.18]
Sample period	2001:Q1-2012:Q4 ($T = 48$)

where:

[15] The long-run restrictions are imposed on the equation to ensure desirable steady-state properties of the model despite the apparent rejection by the data.

C	Private consumption (5.2).
$RHPI$	Real household post-tax income (9.6).
WEL	Household sector wealth (4.20).
PC	Private consumption deflator (7.11).
RS	Short-term interest rate (4.1).
UR	Unemployment rate (6.6).
$INFE$	Break-even inflation expectations (7.26).
$D0824$	Dummy variable: 1 2008:Q2-2008:Q4 and zero otherwise.
$Q1$-$Q3$	Centered seasonal dummies.

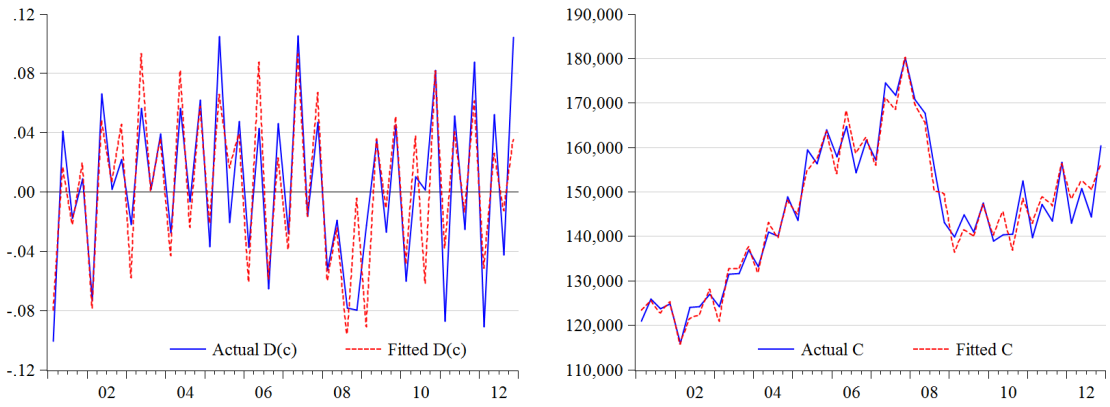

Figure 5.1. Fitted and actual Δc_t and C_t

Single equation dynamic responses of (5.2):[16]

Table 5.1. Responses of c to a 1% increase in RHS variables

Quarters	$rhpi$	$wel - pc$	UR	$RS - INFE$
Simultaneous	0.00	0.14	0.00	0.00
One quarter ahead	0.21	0.12	−0.98	−0.22
Four quarters ahead	0.61	0.10	−0.46	−0.62
Eight quarters ahead	0.92	0.06	−0.18	−0.93
Long run	0.97	0.03	0.00	−0.97
50% of long-run effect	3Q	O/S	-	3Q
90% of long-run effect	7Q	O/S	-	7Q

Steady state solution:
$(c - rhpi) = const + 0.034(wel - pc - rhpi) - 0.975(RS - INFE)$

[16]Note that a permanent increase in income will eventually boost wealth. Hence, a permanent 1% increase in income will eventually lead to a 1% rise in consumption. In model simulations an exogenous constant is added so that the ratio of private consumption to GDP converges to a consumption share that is consistent with a sustainable balanced growth path (cf. Daníelsson, 2009) but is different from the long-term average share based on historical data.

Nominal private consumption is given as:

$$CN_t = PC_t \times C_t \tag{5.3}$$

where:

CN	Nominal private consumption (5.3).
PC	Private consumption deflator (7.11).
C	Private consumption (5.2).

5.1.2. Government consumption (GN)

In forecasting with QMM, real government consumption is given exogenously. Nominal government consumption is therefore obtained as:

$$GN_t = PG_t \times G_t \tag{5.4}$$

where:

GN	Nominal government consumption (5.4).
G	Government consumption (exogenous).
PG	Government consumption deflator (7.12).

5.2. Fixed investment and the capital stock

5.2.1. Fixed investment (I and IN)

Fixed investment consists of business investment, housing investment and government investment:

$$I_t = IBUS_t + IH_t + IG_t \tag{5.5}$$

where:

I	Fixed investment (5.5).
$IBUS$	Business investment (5.12).
IH	Private sector housing investment (5.15).
IG	Government investment (exogenous).

Nominal investment is given by:

$$IN_t = PI_t \times I_t \tag{5.6}$$

where:

IN	Nominal fixed investment (5.6).
PI	Investment goods price deflator (7.13).
I	Fixed investment (5.5).

5.2.2. Business investment ($IBREG$, $IBUS$ and $IBUSN$)

Assuming constant-returns-to-scale CES production function, profit maximisation gives that:

$$(k - gdp) = \sigma_{ib} \log(1 - \beta_g) - \sigma_{ib} rcc \tag{5.7}$$

where σ_{ib} is the elasticity of substitution between capital and labour, β_g is the labour share in the production function, K is the capital stock, GDP is output and RCC is the real cost of capital. In the case of the Cobb-Douglas production technology assumed in QMM (5.64) $\sigma_{ib} = 1$. Assuming also that the business sector capital stock is a constant share of the total capital stock along a steady state path $KBUS/K = \vartheta_{ib}$ gives:

$$kbus - gdp = \log(\vartheta_{ib}) + \log(1 - \beta_g) - rcc \tag{5.8}$$

The stock-flow identity (5.20) gives the equilibrium investment-capital ratio on a balanced growth path as:

$$ibus - kbus = \zeta_{ib} = \log(\gamma + \delta) - \log(1 + \gamma) \tag{5.9}$$

where $IBUS$ is investment, γ is the steady state rate of growth and δ is the steady state rate of depreciations. Combining (5.8) and (5.9) gives:

$$ibus = (\log(\vartheta_{ib}) + \log(1 - \beta_g) + \zeta_{ib}) + gdp - rcc \tag{5.10}$$

This steady state investment-output relation is used as a long-term equilibrium condition for regular business investment (business investment excluding the aluminium sector and irregular investment in airplanes and ships), $IBREG$, with the short-run dynamics given as:

$$\begin{aligned} \Delta ibreg_t \;=\; & \underset{(-2.1)}{-0.451} + \underset{(0.3)}{0.009} Q1 + \underset{(0.2)}{0.005} Q2 - \underset{(-0.9)}{0.022} Q3 \\ & + \underset{(4.2)}{0.278} D981 - \underset{(-4.3)}{0.286} D021 - \underset{(-6.4)}{0.304} D084091 + \underset{(2.0)}{0.178} \Delta ibreg_{t-3} \\ & - \underset{(-2.2)}{0.077} [ibreg_{t-1} - gdp_{t-1} + rcc_{t-1}] \end{aligned} \tag{5.11}$$

Estimation method	OLS
Adjusted R^2	0.647
Equation standard error	6.25%
Long-run restrictions (F-test)	0.07 [0.94]
LM test for serial correlation (F-test)	0.24 [0.62]
Normality test (χ^2-test)	1.77 [0.41]
White test for heteroscedasticity (F-test)	1.25 [0.29]
Sample period	1997:Q1-2010:Q4 ($T = 56$)

where:

$IBREG$	Regular business investment (5.11).
GDP	GDP (5.62).
RCC	Real cost of capital (4.8).
$D981$	Dummy variable: 1 1998:Q1 and zero elsewhere.
$D021$	Dummy variable: 1 2002:Q1 and zero elsewhere.
$D084091$	Dummy variable: 1 2008:Q4 - 2009Q1 and zero elsewhere.
$Q1$-$Q3$	Centered seasonal dummies.

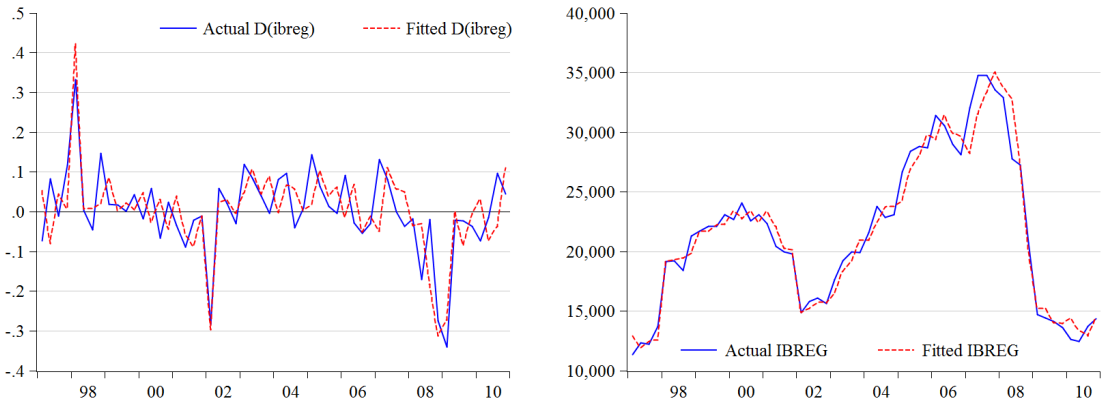

Figure 5.2. Fitted and actual $\Delta ibreg_t$ and $IBREG_t$

Single equation dynamic responses of (5.11):

Table 5.2. Responses of *ibreg* to a 1% increase in RHS variables

Quarters	*gdp*	*rcc*
Simultaneous	0.00	0.00
One quarter ahead	0.08	−0.08
Four quarters ahead	0.29	−0.29
Eight quarters ahead	0.53	−0.53
Long run	1.00	−1.00
50% of long-run effect	8Q	8Q
90% of long-run effect	23Q	23Q
Steady state solution:		
$(ibreg - gdp) = const - rcc$		

Total business sector investment is given by:

$$IBUS_t = IBREG_t + IBALU_t + IBAIR_t \tag{5.12}$$

where:

$IBUS$	Business investment (5.12).
$IBREG$	Regular business investment (5.11).
$IBALU$	Aluminium sector investment (exogenous).
$IBAIR$	Investment in airplanes and ships (exogenous).

Nominal business investment is given by:

$$IBUSN_t = IN_t - IHN_t - IGN_t \tag{5.13}$$

where:

$IBUSN$	Nominal business investment (5.13).
IN	Nominal fixed investment (5.6).
IHN	Nominal housing investment (5.16).
IGN	Nominal government investment (5.17).

5.2.3. Private sector housing investment (IH and IHN)

Using the same argument as for $IBREG$ above, the housing investment-output ratio can be written as a function of the opportunity cost of investment, which in this case is given by a Tobin's Q price ratio between house prices (PH) and the cost of housing construction, given by the housing investment deflator (PIH):

$$(ih - gdp) = \alpha_{ih} + \beta_{ih}(ph - pih) \tag{5.14}$$

where IH is housing investment, GDP is output and PH/PIH is the Q ratio. This gives the following dynamic equation for housing investment, allowing for short-run effects of GDP growth and RLV:[17]

$$\begin{aligned} \Delta ih_t \;=\; & \underset{(-2.5)}{-0.313} - \underset{(-8.0)}{0.144}Q1 - \underset{(-1.6)}{0.036}Q2 - \underset{(-1.0)}{0.018}Q3 - \underset{(-9.5)}{0.546}D091 \\ & + \underset{(2.2)}{0.163}\Delta ih_{t-1} + \underset{(1.7)}{0.319}\Delta gdp_t - \underset{(-1.3)}{1.478}\Delta RLV_{t-4} \\ & - \underset{(-2.4)}{0.108}[(ih_{t-1} - gdp_{t-1}) - 0.369(ph_{t-1} - pih_{t-1}) + 0.897\ S091_{t-1}] \end{aligned} \tag{5.15}$$

[17] The long-run solution is estimated for the time period 1987Q1 to 2010Q4, while the short run solution is estimated for 1990Q1 to 2012Q4.

Estimation method	OLS
Adjusted R^2	0.760
Equation standard error	5.26%
Long-run restrictions (F-test)	3.37 [0.04]
LM test for serial correlation (F-test)	1.37 [0.25]
Normality test (χ^2-test)	14.77 [0.00]
White test for heteroscedasticity (F-test)	2.15 [0.04]
Sample period	1990:Q1-2012:Q4 ($T = 92$)

where:

IH	Private sector housing investment (5.15).
GDP	GDP (5.62).
PH	House prices (7.18).
PIH	Housing investment deflator (7.14).
RLV	Long-term indexed interest rate (4.7).
$D091$	Dummy variable: 1 2009:Q1 and zero elsewhere.
$S091$	Shift dummy variable: 1 from 2009:Q1 and zero before.
$Q1$-$Q3$	Centered seasonal dummies.

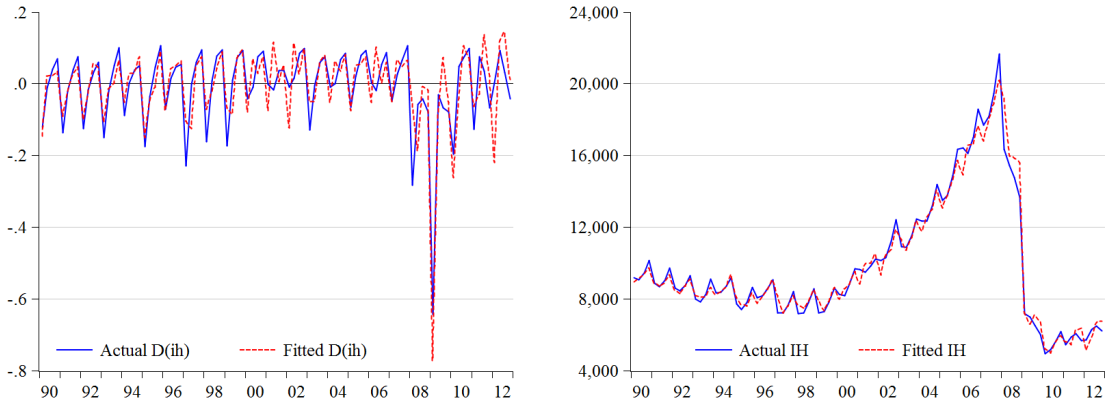

Figure 5.3. Fitted and actual Δih_t and IH_t

Single equation dynamic responses of (5.15):

Table 5.3. Responses of ih to a 1% increase in RHS variables

Quarters	gdp	ph	pih	RLV
Simultaneous	0.32	0.00	0.00	0.00
One quarter ahead	0.44	0.04	−0.04	0.00
Four quarters ahead	0.64	0.15	−0.15	−1.48
Eight quarters ahead	0.80	0.25	−0.25	−1.06
Long run	1.00	0.37	−0.37	0.00
50% of long-run effect	2Q	6Q	6Q	-
90% of long-run effect	13Q	17Q	17Q	-
Steady state solution:				
$(ih - gdp) = const + 0.369(ph - pih)$				

Nominal housing investment is given by:

$$IHN_t = PIH_t \times IH_t \tag{5.16}$$

where:

IHN	Nominal housing investment (5.16).
PIH	Housing investment deflator (7.14).
IH	Private sector housing investment (5.15).

5.2.4. Government investment (IGN and $IGNNET$)

Real government investment in QMM is given exogenously. Nominal government investment is therefore given as:

$$IGN_t = PIG_t \times IG_t \tag{5.17}$$

where:

IGN	Nominal government investment (5.17).
IG	Government investment (exogenous).
PIG	Government investment deflator (7.15).

As expenditure on depreciation is included in government consumption, government investment net of depreciation is needed in the equation on public sector net borrowing (8.21). Hence, nominal net government investment is given as:

$$IGNNET_t = IGN_t - PIG_t \times DELTAG_t(K_{t-1} - KBUS_{t-1} - KH_{t-1}) \tag{5.18}$$

where:

$IGNNET$	Nominal net government investment (5.18).
IGN	Nominal government investment (5.17).
PIG	Government investment deflator (7.15).
$DELTAG$	Depreciation rate for government capital stock (exogenous).
K	Total capital stock (5.19).
$KBUS$	Business capital stock (5.20).
KH	Private sector housing stock (5.21).

5.2.5. Capital stock (K, $KBUS$, KH and $IHEX$)

The capital stock is the previous period's stock, allowing for depreciation, plus the current investment:

$$K_t = (1 - DELTA_t)K_{t-1} + I_t \tag{5.19}$$

$$KBUS_t = (1 - DELTAB_t)KBUS_{t-1} + IBUS_t \tag{5.20}$$

$$KH_t = (1 - DELTAH_t)KH_{t-1} + IH_t + IHEX_t \times GDP_t \tag{5.21}$$

where:

K	Total capital stock (5.19).
$KBUS$	Business capital stock (5.20).
KH	Private sector housing stock adjusted as described below (5.21).
I	Fixed investment (5.5).
$IBUS$	Business investment (5.12).
IH	Private sector housing investment (5.15).
$DELTA$	Depreciation rate for total capital stock (exogenous).
$DELTAB$	Depreciation rate for business capital stock (exogenous).
$DELTAH$	Deprecation rate for housing stock (exogenous).
$IHEX$	Adjustment factor (exogenous).
GDP	GDP (5.62).

An adjustment factor $IHEX$ needs to be added to the housing stock equation (5.21) due to the fact that the housing stock data from Statistics Iceland are not stock-flow consistent i.e. they deviate substantially from the perpetuity identity.[18]

[18]During 1991-2014 the housing investment averaged 4.3% of GDP and depreciation of the housing stock averaged 4.5% so net housing investment averaged -0.2% of GDP. During the same period the increase in the housing stock at fixed prices averaged 2.4% of GDP. Part of the problem is that Statistics Iceland valuates the housing stock at market prices but housing investment at cost prices. In 2005, which is the present base-year for national accounts data, market prices were very high relative to building costs, which not only aggravate the problem with stock-flow consistency noted above but also created another problem because the high valuation of the housing stock at 2005 prices increased the capital-output ratio from 11-12 to 14-16 (at quarterly frequency). By scaling down the housing stock as valued by Statistics Iceland at constant prices by dividing through

5.3. Domestic demand (DD, DDN and DDA)

Domestic demand is given as the sum of private and government consumption, investment and stockbuilding adjusted with the chain-volume approach, relating the current value of a variable to the preceding calendar year value. Price indices for the previous calendar year are denoted with a $Y-1$ superscript. Domestic demand can thus be written as:

$$\begin{aligned} DD_t &= \left[PC_t^{Y-1} \times C_t + PG_t^{Y-1} \times G_t + PI_t^{Y-1} \times I_t \right. \\ &\quad \left. + (IIN/II)_t^{Y-1} \times II_t \right] \times \left(\frac{DD}{DDN} \right)_t^{Y-1} \end{aligned} \tag{5.22}$$

where:

DD	Domestic demand (5.22).
C	Private consumption (5.2).
PC	Private consumption deflator (7.11).
G	Government consumption (exogenous).
PG	Government consumption deflator (7.12).
I	Fixed investment (5.5).
PI	Investment goods price deflator (7.13).
II	Net stockbuilding (exogenous).
IIN	Nominal net stockbuilding (exogenous).
DDN	Nominal domestic demand (5.23).

Nominal domestic demand is given by a corresponding accounting identity:

$$DDN_t = CN_t + GN_t + IN_t + IIN_t \tag{5.23}$$

where:

DDN	Nominal domestic demand (5.23).
CN	Nominal private consumption (5.3).
GN	Nominal government consumption (5.4).
IN	Nominal fixed investment (5.6).
IIN	Nominal net stockbuilding (exogenous).

Import weighted domestic demand is given by a corresponding identity:[19]

with 1.37 the capital-output ratio was brought back to the 11-12 average at the same time as the problem with stock-flow consistency was reduced somewhat. The average increase in the housing stock after this rescaling was 1.8%. The adjustment term $IHEX \times GDP$ in (5.21) is explained by this difference between the stock-flow consistent formula and the available data. The value of $IHEX$ is derived from the balanced growth version of the model (see Danielsson, 2009).

[19] The relative weights in DDA should reflect the individual import shares of each individual expenditure items from input-output tables. Unfortunately there are no new estimates available on imports shares of domestic demand from Statistics Iceland, with the lates input-output tables available over two decades old (from the now defunct National Economic Institute). The weights used are close to those estimates and information from the Bank's sectoral experts.

$$DDA_t = 0.35C_t + 0.13G_t + 0.50I_t \tag{5.24}$$

where:

DDA	Import weighted domestic demand (5.24).
C	Private consumption (5.2).
G	Government consumption (exogenous).
I	Fixed investment (5.5).

5.4. Net trade

5.4.1. Export volume of goods and services (EX, EXN, $EXAIRN$, $EXOTH$, $EXOTHN$, EXS, $EXSN$, EXG, $EXGN$, $EXSMANN$, $EXALUN$, $EXMARN$, $EXSOTH$ and $EXSOTHN$)

Export volume of goods and services is given as the sum of export of goods and export of services adjusted with the chain-volume approach, relating the current value of a variable to the preceding calendar year value. Price indices for the previous calendar year are denoted with a $Y-1$ superscript:

$$\begin{aligned} EX_t &= \left[EXG_t \times \left(\frac{EXGN}{EXG} \right)_t^{Y-1} \right. \\ &\quad \left. + EXS_t \times \left(\frac{EXSN}{EXS} \right)_t^{Y-1} \right] \times \left(\frac{EX}{EXN} \right)_t^{Y-1} \end{aligned} \tag{5.25}$$

where:

EX	Export volume of goods and services (5.25).
EXG	Export volume of goods (5.26).
EXS	Export volume of services (5.27).
$EXGN$	Nominal export of goods (5.29).
$EXSN$	Nominal export of services (5.30).
EXN	Nominal export of goods and services (5.28).

Export volume of goods is the sum of export of aluminium, of marine products, of ships and airplanes and other goods adjusted with the chain-volume approach:

$$\begin{aligned} EXG_t &= \left[EXALU_t \times EUS_t^{Y-1} \times PXALU_t^{Y-1} \right. \\ &\quad + EXMAR_t \times EER_t^{Y-1} \times PXMAR_t^{Y-1} \\ &\quad + EXAIR_t \times \left(\frac{EXAIRN}{EXAIR} \right)_t^{Y-1} \\ &\quad \left. + EXOTH_t \times PXOTH_t^{Y-1} \right] \times \left(\frac{EXG}{EXGN} \right)_t^{Y-1} \end{aligned} \tag{5.26}$$

where:

EXG	Export volume of goods (5.26).
EUS	USD exchange rate (4.11).
$PXALU$	Price of aluminium products in USD (exogenous).
$EXALU$	Export volume of aluminium products (exogenous).
EER	Exchange rate index of foreign currency (4.10).
$PXMAR$	Price of marine products in foreign currency (exogenous).
$EXMAR$	Export volume of marine products (exogenous).
$EXAIRN$	Nominal export of airplanes and ships (5.31).
$EXAIR$	Export volume of airplanes and ships (exogenous).
$PXOTH$	Export price deflator for other goods (7.7).
$EXOTH$	Export volume of other goods (5.35).
$EXGN$	Nominal export of goods (5.29).

Export volume of services is the sum of export of manufacturing services and other services adjusted with the chain-volume approach, relating the current value of a variable to the preceding calendar year value:

$$\begin{aligned} EXS_t &= \left[EXSMAN_t \times PXS_t^{Y-1}\right. \\ &\quad \left.+EXSOTH_t \times PXS_t^{Y-1}\right] \times \left(\frac{EXS}{EXSN}\right)_t^{Y-1} \end{aligned} \tag{5.27}$$

where:

EXS	Export volume of services (5.27).
PXS	Export price deflator for services (7.8).
$EXSMAN$	Export volume of manufacturing services (exogenous).
$EXSOTH$	Export volume of other services (5.38).
$EXSN$	Nominal export of services (5.30).

Nominal export is definded as:

$$EXN_t = EXGN_t + EXSN_t \tag{5.28}$$

where:

EXN	Nominal export of goods and services (5.28).
$EXGN$	Nominal export of goods (5.29).
$EXSN$	Nominal export of services (5.30).

Nominal export of goods consists of aluminium production export, exports of marine products, exports of ships and airplanes and exports of other goods:

$$\begin{aligned} EXGN_t &= EXALUN_t + EXMARN_t + EXAIRN_t \\ &\quad +EXOTHN_t \end{aligned} \tag{5.29}$$

where:

$EXGN$	Nominal export of goods (5.29).
$EXALUN$	Nominal export of aluminium products (5.32).
$EXMARN$	Nominal export of marine products (5.33).
$EXAIRN$	Nominal export of airplanes and ships (5.31).
$EXOTHN$	Nominal export of other goods (5.36).

Nominal export of services consists of export of manufacturing services and export of other services:

$$EXSN_t = EXSMANN_t + EXSOTHN_t \tag{5.30}$$

where:

$EXSN$	Nominal export of services (5.30).
$EXSMANN$	Nominal export of manufacturing services (5.40).
$EXSOTHN$	Nominal export of other services (5.39).

Nominal export of airplanes and ships is defined as:

$$EXAIRN_t = PI_t \times EXAIR_t \tag{5.31}$$

where:

$EXAIRN$	Nominal export of airplanes and ships (5.31).
PI	Investment goods price deflator (7.13).
$EXAIR$	Export volume of ships and airplanes (exogenous).

Nominal export of aluminium products is defined as:

$$EXALUN_t = PXALU_t \times EUS_t \times EXALU_t \tag{5.32}$$

where:

$EXALUN$	Nominal export of aluminium products (5.32).
$PXALU$	Price of aluminium products in USD (exogenous).
EUS	USD exchange rate (4.11).
$EXALU$	Exports of aluminium products (exogenous).

Nominal export of marine products is defined as:

$$EXMARN_t = PXMAR_t \times EER_t \times EXMAR_t \tag{5.33}$$

where:

$EXMARN$	Nominal export of marine products (5.33).
$PXMAR$	Price of marine products in foreign currency (exogenous).
EER	Exchange rate index of foreign currency (4.10).
$EXMAR$	Exports of marine products (exogenous).

In the long-run, exports of other goods are determined by international demand (proxied by world trade) and relative prices, with unit income elasticity:

$$exoth = \alpha_{exoth} + trade - \beta_{exoth}(pxoth - (eer + wcpi)) \tag{5.34}$$

where $EXOTH$ are export volume of other goods, $TRADE$ denotes world trade, $PXOTH$ is the export price deflator for other goods, EER is the exchange rate index of foreign currency and $WCPI$ is world consumer prices.

This gives the following dynamic equation:

$$\begin{aligned} \Delta exoth_t \;=\; & \underset{(4.8)}{6.214} - \underset{(-2.9)}{0.143}Q1 - \underset{(-4.3)}{0.175}Q2 - \underset{(-3.9)}{0.143}Q3 \\ & + \underset{(3.3)}{0.309}D041 + \underset{(4.0)}{0.168}S093 - \underset{(-6.7)}{1.171}\Delta(pxoth_t - (eer_t + wcpi_t)) \\ & - \underset{(-4.8)}{0.677}[exoth_{t-1} - trade_{t-1} + 0.996(pxoth_{t-1} - (eer_{t-1} + wcpi_{t-1}))] \end{aligned} \tag{5.35}$$

Estimation method	OLS
Adjusted R^2	0.795
Equation standard error	8.59%
Long-run restrictions (F-test)	7.44 [0.01]
LM test for serial correlation (F-test)	0.02 [0.88]
Normality test (χ^2-test)	3.28 [0.19]
White test for heteroscedasticity (F-test)	1.44 [0.22]
Sample period	2002:Q1-2012:Q4 ($T = 44$)

where:

$EXOTH$	Export volume of other goods (5.35).
$TRADE$	World trade (exogenous).
EER	Exchange rate index of foreign currency (4.10).
$PXOTH$	Export prices deflator for other goods (7.7).
$WCPI$	World consumer prices (exogenous).
$D041$	Dummy variable: 1 2004:Q1 and zero elsewhere.
$S093$	Shift dummy variable: 1 from 2009:Q3 and zero before.
$Q1$-$Q3$	Centered seasonal dummies.

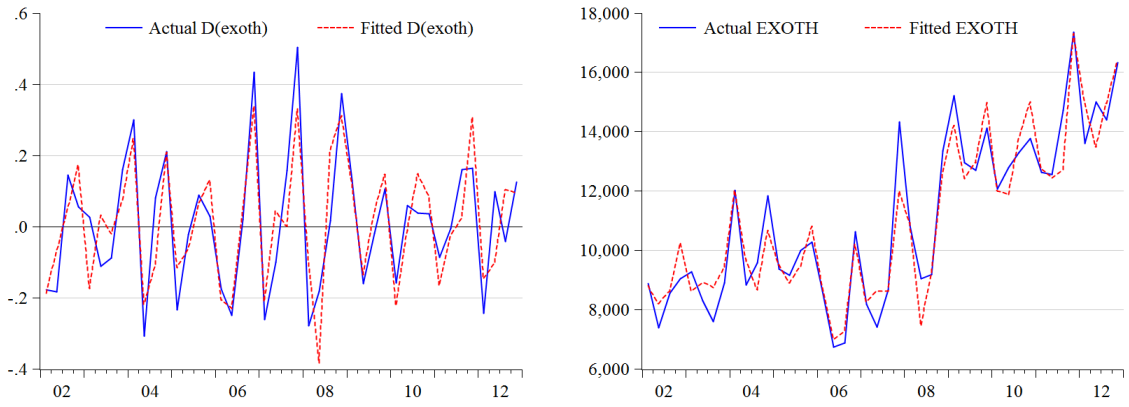

Figure 5.4. Fitted and actual $\Delta exoth_t$ and $EXOTH_t$

Single equation dynamic responses of (5.35):

Table 5.4. Responses of *exoth* to a 1% increase in RHS variables

Quarters	*trade*	$pxoth - (eer + wcpi)$
Simultaneous	0.00	−1.17
One quarter ahead	0.68	−1.05
Four quarters ahead	0.99	−1.00
Eight quarters ahead	1.00	−1.00
Long run	1.00	−1.00
50% of long-run effect	1Q	O/S
90% of long-run effect	3Q	O/S
Steady state solution:		
$(exoth - trade) = const - 0.996(pxoth - (eer + wcpi))$		

Nominal export of other goods is defined as:

$$EXOTHN_t = PXOTH_t \times EXOTH_t \tag{5.36}$$

where:

$EXOTHN$	Nominal export of other goods (5.36).
$PXOTH$	Export price deflator for other goods (7.7).
$EXOTH$	Export of other goods (5.35).

In the long-run, exports of other services are determined as other goods exports by international demand (proxied by world trade) and relative prices, with unit income elasticity:

$$exsoth = \alpha_{exs} + trade - \beta_{exs}(pxs - (eer + wcpi)) \tag{5.37}$$

where $EXSOTH$ are exports of other services, $TRADE$ denotes world trade, PXS is the export price deflator for services, EER is the exchange rate index of foreign currency and $WCPI$ is world consumer prices.

This gives the following dynamic equation:[20]

$$\begin{aligned} \Delta exsoth_t &= \underset{(2.9)}{2.992} + \underset{(3.5)}{0.176}Q1 + \underset{(8.4)}{0.471}Q2 + \underset{(15.0)}{0.578}Q3 \\ &\quad \underset{(-2.9)}{-0.290}[exsoth_{t-1} - trade_{t-1} + 0.663(pxs_{t-1} - (eer_{t-1} + wcpi_{t-1}))] \end{aligned} \tag{5.38}$$

Estimation method	OLS
Adjusted R^2	0.935
Equation standard error	7.06%
Long-run restrictions (F-test)	3.97 [0.06]
LM test for serial correlation (F-test)	2.28 [0.14]
Normality test (χ^2-test)	0.55 [0.76]
White test for heteroscedasticity (F-test)	3.40 [0.02]
Sample period	2000:Q1-2012:Q4 ($T = 52$)

where:

$EXSOTH$	Exports of other services (5.38).
$TRADE$	World trade (exogenous).
EER	Exchange rate index of foreign currency (4.10).
$WCPI$	World consumer prices (exogenous).
PXS	Export price deflator for services (7.8).
$Q1$-$Q3$	Centered seasonal dummies.

[20] The long-run solution is estimated for the time period 2002Q1 to 2010Q4, while the short run solution is estimated for 2000Q1 to 2012Q4.

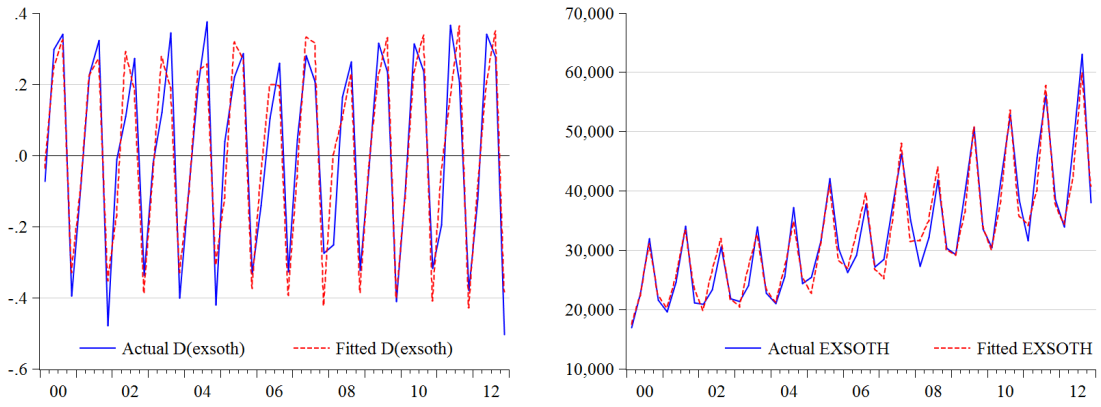

Figure 5.5. Fitted and actual $\Delta exsoth_t$ and $EXSOTH_t$

Single equation dynamic responses of (5.38):

Table 5.5. Responses of $exsoth$ to a 1% increase in RHS variables

Quarters	$trade$	$pxs-(eer+wcpi)$
Simultaneous	0.00	0.00
One quarter ahead	0.29	−0.19
Four quarters ahead	0.75	−0.49
Eight quarters ahead	0.94	−0.62
Long run	1.00	−0.66
50% of long-run effect	3Q	3Q
90% of long-run effect	7Q	7Q
Steady state solution:		
$(exsoth-trade)=const-0.663(pxs-(eer+wcpi))$		

Nominal export of other services is defined as:

$$EXSOTHN_t = PXS_t \times EXSOTH_t \tag{5.39}$$

where:

$EXSOTHN$	Nominal exports of other services (5.39).
PXS	Export price deflator for services (7.8).
$EXSOTH$	Export of other services (5.38).

Nominal export of manufacturing services is defined as:

$$EXSMANN_t = PXS_t \times EXSMAN_t \tag{5.40}$$

where:

$EXSMANN$	Nominal exports of manufacturing services (5.40).
PXS	Export price deflator for services (7.8).
$EXSMAN$	Export of manufacturing services (exogenous).

5.4.2. Import volume of goods and services (IMP, $IMPG$, $IMPN$, $IMPGN$, $IMPALUN$, $IMPAIRN$, $IMPOTH$, $IMPOTHN$, $IMPS$, $IMPSN$ and $SPEC$)

Import volume of goods and services is given as the sum of import of goods and import of services adjusted with the chain-volume approach, relating the current value of a variable to the preceding calendar year value. Price indices for the previous calendar year are denoted with a $Y-1$ superscript:

$$\begin{aligned} IMP_t &= \left[IMPG_t \times \left(\frac{IMPGN}{IMPG} \right)_t^{Y-1} \right. \\ &\quad \left. + IMPS_t \times \left(\frac{IMPSN}{IMPS} \right)_t^{Y-1} \right] \times \left(\frac{IMP}{IMPN} \right)_t^{Y-1} \end{aligned} \tag{5.41}$$

where:

IMP	Import volume of goods and services (5.41).
$IMPG$	Import volume of goods (5.42).
$IMPS$	Import volume of services (5.51).
$IMPGN$	Nominal import of goods (5.44).
$IMPSN$	Nominal import of services (5.52).
$IMPN$	Nominal import of goods and services (5.43).

Import volume of goods is given as the sum of imports for aluminium production, imports of ships and airplanes, imports of other goods and imports of services adjusted with the chain-volume approach, relating the current value of a variable to the preceding calendar year value. Price indices for the previous calendar year are denoted with a $Y-1$ superscript:

$$\begin{aligned} IMPG_t &= [PMALU_t^{Y-1} \times EUS_t^{Y-1} \times IMPALU_t \\ &\quad + \left(\frac{IMPAIRN}{IMPAIR} \right)_t^{Y-1} \times IMPAIR_t \\ &\quad + PMOTH_t^{Y-1} \times IMPOTH_t] \times \left(\frac{IMPG}{IMPGN} \right)_t^{Y-1} \end{aligned} \tag{5.42}$$

where:

$IMPG$	Import volume of goods (5.42).
$IMPALU$	Import volume of goods for aluminium production (exogenous).
$PMALU$	Import price deflator for aluminium production in USD (7.3).
EUS	USD exchange rate (4.11).
$IMPAIRN$	Nominal import of airplanes and ships (5.46).
$IMPAIR$	Import volume of airplanes and ships (exogenous).
$IMPOTH$	Import volume of other goods (5.48).
$PMOTH$	Import price deflator for other goods (7.4).
$IMPGN$	Nominal import of goods (5.44).

Nominal import of goods and services is given as:

$$IMPN_t = IMPGN_t + IMPSN_t \tag{5.43}$$

where:

$IMPN$	Nominal import of goods and services (5.43).
$IMPGN$	Nominal import of goods (5.44).
$IMPSN$	Nominal import of services (5.52).

Nominal imports of goods consists of imported goods for aluminium production, imports of airplanes and ships, and imports of other goods:

$$IMPGN_t = IMPALUN_t + IMPAIRN_t + IMPOTHN_t \tag{5.44}$$

where:

$IMPGN$	Nominal import of goods (5.44).
$IMPALUN$	Nominal import of goods for aluminium production (5.45).
$IMPAIRN$	Nominal import of airplanes and ships (5.46).
$IMPOTHN$	Nominal import of other goods (5.49).

Nominal import of goods for aluminium production, $IMPALUN$ is defined as:

$$IMPALUN_t = IMPALU_t \times PMALU_t \times EUS_t \tag{5.45}$$

where:

$IMPALUN$	Nominal import of goods for aluminium production (5.45).
$IMPALU$	Import volume of goods for aluminium production (exogenous).
$PMALU$	Import price deflator for aluminium production in USD (7.3).
EUS	USD exchange rate (4.11).

Nominal import of airplanes and ships is defined as:

$$IMPAIRN_t = PI_t \times IMPAIR_t \tag{5.46}$$

where:

$IMPAIRN$	Nominal import of airplanes and ships (5.46).
PI	Investment goods price deflator (7.13).
$IMPAIR$	Import volume of airplanes and ships (exogenous).

In the long-run, imports of other goods are determined by import weighted domestic demand and relative prices, with unit income elasticity:

$$impoth = \alpha_{impoth} + dda - \beta_{impoth}(pmoth - cpi) \tag{5.47}$$

where $IMPOTH$ are the imports of other goods, DDA is import weighted domestic demand and $PMOTH$ is the import price deflator for other goods, and CPI is the consumer price index. In the dynamic equation, different short-run elasticities of domestic demand sub-components are allowed for:

$$\begin{aligned} \Delta impoth_t \;=\; & \underset{(-4.8)}{-0.212} - \underset{(-0.8)}{0.018}Q1 + \underset{(4.8)}{0.105}Q2 + \underset{(1.3)}{0.024}Q3 \\ & \underset{(-6.3)}{-0.343}D084 + \underset{(4.6)}{0.679}\Delta dda_t + \underset{(1.3)}{0.170}\Delta dda_{t-1} \\ & \underset{(-5.0)}{-0.514}[impoth_{t-1} - dda_{t-1} + 0.595(pmoth_{t-1} - cpi_{t-1})] \end{aligned} \tag{5.48}$$

Estimation method	OLS
Adjusted R^2	0.811
Equation standard error	4.8%
Long-run restrictions (F-test)	0.29 [0.59]
LM test for serial correlation (F-test)	0.22 [0.64]
Normality test (χ^2-test)	1.18 [0.56]
White test for heteroscedasticity (F-test)	2.58 [0.02]
Sample period	1997:Q3-2012:Q4 ($T = 62$)

where:

$IMPOTH$	Import volume of other goods (5.48).
DDA	Import weighted domestic demand (5.24).
$PMOTH$	Import price deflator for other goods (7.4).
CPI	Consumer price index (7.2).
$D084$	Dummy variable: 1 2008:Q4 and zero elsewhere.
$Q1$-$Q3$	Centered seasonal dummies.

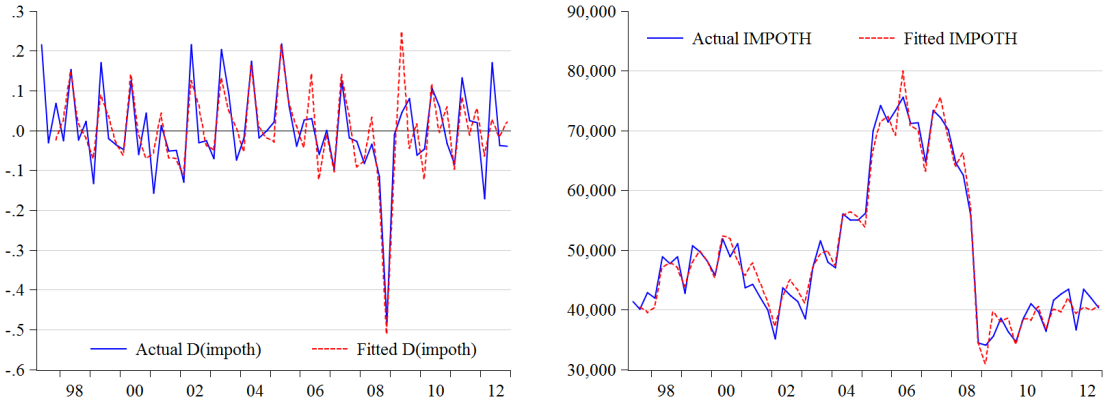

Figure 5.6. Fitted and actual $\Delta impoth_t$ and $IMPOTH_t$

In the long run, subcomponents of domestic demand only influence *impoth* through their share in DDA. Single equation dynamic responses of (5.48) are thus:

Table 5.6. Responses of *impoth* to a 1% increase in RHS variables

Quarters	c	g	i	dda	$pmoth - cpi$
Simultaneous	0.40	0.06	0.22	0.68	0.00
One quarter ahead	0.59	0.10	0.33	1.01	−0.31
Four quarters ahead	0.58	0.09	0.32	1.00	−0.56
Eight quarters ahead	0.58	0.09	0.32	1.00	−0.59
Long run	0.58	0.09	0.32	1.00	−0.60
50% of long-run effect	O/S	O/S	O/S	O/S	1Q
90% of long-run effect	O/S	O/S	O/S	O/S	4Q

Steady state solution:
$(impoth - dda) = const - 0.595(pmoth - cpi)$

Nominal import of other goods is defined as:

$$IMPOTHN_t = PMOTH_t \times IMPOTH_t \tag{5.49}$$

where:

$IMPOTHN$	Nominal import of other goods (5.49).
$PMOTH$	Import price deflator for other goods (7.4).
$IMPOTH$	Imports of other goods (5.48).

In the long-run, import volume of services is determined by domestic demand and relative prices, with unit income elasticity. The long-run relationship also allows

for an upward trend, reflecting increased trade specialisation in international trade (captured by the ratio between world trade and world output):

$$imps = \alpha_{imps} + dda - \beta_{imps}(pms - cpi) + \phi_{imps} spec \tag{5.50}$$

where $IMPS$ is import volume of services, DDA is import weighted domestic demand, PMS is the import price deflator for services, CPI is the consumer price index, and $SPEC$ is trade specialisation term. In the dynamic equation, different short-run elasticities of domestic demand sub-components are allowed for:[21]

$$\begin{aligned} \Delta imps_t \;=\; & \underset{(-2.3)}{-0.293} + \underset{(0.4)}{0.013} Q1 + \underset{(4.1)}{0.148} Q2 + \underset{(4.7)}{0.139} Q3 + \underset{(3.1)}{0.725} \Delta dda_t \\ & \underset{(-2.4)}{-0.295} [imps_{t-1} - dda_{t-1} + 0.305(pms_{t-1} - cpi_{t-1}) - 0.841 spec_{t-1}] \end{aligned} \tag{5.51}$$

Estimation method	OLS
Adjusted R^2	0.617
Equation standard error	8.11%
Long-run restrictions (F-test)	6.28 [0.02]
LM test for serial correlation (F-test)	3.56 [0.06]
Normality test (χ^2-test)	0.79 [0.67]
White test for heteroscedasticity (F-test)	3.41 [0.01]
Sample period	1997:Q2-2012:Q4 ($T = 63$)

where:

$IMPS$	Import volume of services (5.51).
DDA	Import weighted domestic demand (5.24).
PMS	Import price deflator for services (7.5).
CPI	Consumer price index (7.2).
$SPEC$	Trade specialisation (5.53).
$Q1$-$Q3$	Centered seasonal dummies.

[21] The long-run solution is estimated for the time period 1997Q1 to 2006Q4, while the short run solution is estimated for 1997Q2 to 2012Q4.

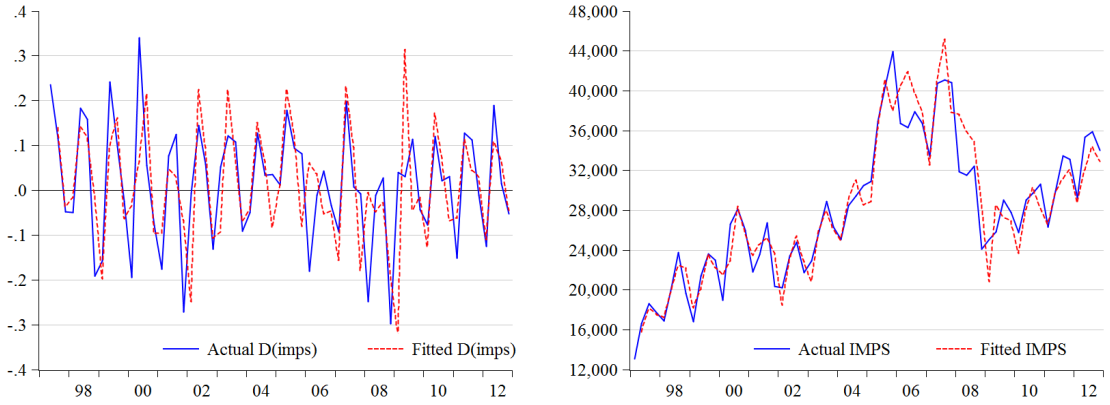

Figure 5.7. Fitted and actual $\Delta imps_t$ and $IMPS_t$

Single equation dynamic responses of (5.51):

Table 5.7. Responses of *imps* to a 1% increase in RHS variables

Quarters	c	g	i	dda	$pms - cpi$	$spec$
Simultaneous	0.25	0.09	0.36	0.73	0.00	0.00
One quarter ahead	0.28	0.10	0.40	0.81	−0.09	0.25
Four quarters ahead	0.33	0.12	0.47	0.93	−0.23	0.63
Eight quarters ahead	0.34	0.13	0.49	0.98	−0.29	0.79
Long run	0.35	0.13	0.50	1.00	−0.31	0.84
50% of long-run effect	0Q	0Q	0Q	0Q	2Q	2Q
90% of long-run effect	3Q	3Q	3Q	3Q	7Q	7Q

Steady state solution:
$(imps - dda) = const + 0.305(pms - cpi) - 0.841 spec$

Nominal import of services is defined as:

$$IMPSN_t = PMS_t \times IMPS_t \tag{5.52}$$

where:

$IMPSN$	Nominal import of services (5.52).
PMS	Import price deflator for services (7.5).
$IMPS$	Import volume of services (5.51).

The trade specialisation variable is defined as:

$$SPEC_t = TRADE_t / WGDP_t \tag{5.53}$$

where:

$SPEC$	Trade specialisation (5.53).
$TRADE$	World trade (exogenous).
$WGDP$	World GDP (exogenous).

5.4.3. Balance of payments (BAL, $BALT$, $BALGOOD$, $BALSERV$ and $BIPD$)

The balance of trade is given as:

$$BALT_t = BALGOOD_t + BALSERV_t \tag{5.54}$$

where:

$BALT$	Balance of trade (5.54).
$BALGOOD$	Balance of goods (5.55).
$BALSERV$	Balance of services (5.56).

The balance of goods identity is given as:

$$BALGOOD_t = EXGN_t - IMPGN_t \tag{5.55}$$

where:

$BALGOOD$	Balance of goods (5.55).
$EXGN$	Nominal export of goods (5.29).
$IMPGN$	Nominal import of goods (5.44).

The service balance is given as the identity:

$$BALSERV_t = EXSN_t - IMPSN_t \tag{5.56}$$

where:

$BALSERV$	Balance of services (5.56).
$EXSN$	Nominal export volume of services (5.30).
$IMPSN$	Nominal import of services (5.52).

The balance of interest payments, dividends and profits ($BIPD$) is proxied as by the product of the sum of an exogenous foreign nominal interest rate (WRS) and a risk premium ($BIPDF$), and the average net foreign assets (NFA) over the current and past quarter:[22]

$$BIPD_t = \left(\frac{WRS_t + BIPDF_t}{4}\right)\left(\frac{NFA_t + NFA_{t-1}}{2}\right) \tag{5.57}$$

where:

[22]The risk premium $BIPDF$ is not a pure interest rate premium since it can be negative when return on equity is low. It is the difference on returns of all net foreign assets (including equity).

$BIPD$	Balance of interest, salaries, dividends and profits (5.57).
WRS	Foreign short-term interest rate (exogenous).
$BIPDF$	Risk premium on world interest rate (exogenous).
NFA	Net foreign assets (5.59).

The current account balance is determined by an accounting identity:

$$BAL_t = BALT_t + BIPD_t + BTRF_t \tag{5.58}$$

where:

BAL	Current account balance (5.58).
$BALT$	Balance of trade (5.54).
$BIPD$	Balance of interest, salaries, dividends and profits (5.57).
$BTRF$	Balance of transfers (exogenous).

5.4.4. Net foreign assets (NFA, ISA and FOH)

Net foreign assets are defined as the difference between gross Icelandic holdings of foreign assets and foreign holdings of Icelandic assets:

$$NFA_t = ISA_t - FOH_t \tag{5.59}$$

where:

NFA	Net foreign assets (5.59).
ISA	Icelandic holdings of foreign assets (5.60).
FOH	Foreign holdings of Icelandic assets (5.61).

Both Icelandic and foreign asset holdings are modelled using a simple stock-flow framework. Domestic holdings of foreign assets is revalued according to changes in world equity prices, with the stock growing at an quarterly rate of $QDGDPT$, which is the steady state growth rate, thus ensuring that the asset holdings grow at a long-run rate consistent with a balance growth rate path:

$$\begin{aligned} ISA_t &= ISA_{t-1}\frac{EER_t}{EER_{t-1}}\left(0.8 + 0.2\frac{WEQP_t}{WEQP_{t-1}}\right) \times \\ &\quad (1 + QDGDPT_t) \end{aligned} \tag{5.60}$$

Foreign holdings of domestic assets are given as (the revalue term reflects that foreign holdings of domestic assets are in the form of loans in foreign currency):

$$\begin{aligned} FOH_t &= FOH_{t-1}\left(\frac{EER_t}{EER_{t-1}}\right) - BAL_t + ISA_{t-1} \times QDGDPT_t \times \\ &\quad \left[0.8\left(\frac{EER_t}{EER_{t-1}}\right) + 0.2\left(\frac{EER_t}{EER_{t-1}} \times \frac{WEQP_t}{WEQP_{t-1}}\right)\right] \end{aligned} \tag{5.61}$$

where:

ISA	Icelandic holdings of foreign assets (5.60).
FOH	Foreign holdings of Icelandic assets (5.61).
EER	Exchange rate index of foreign currency (4.10).
$WEQP$	World equity prices (exogenous).
BAL	Current account balance (5.58).
$QDGDPT$	Quarterly trend GDP growth rate (5.66).

5.5. Output

5.5.1. Gross domestic production (GDP and $GDPN$)

Expenditure-based GDP is an accounting identity including domestic demand, exports and imports adjusted with the chain-volume approach, which relates current value of a variable to the preceding calendar year value. Price indices for the previous calendar year are denoted with a $Y-1$ superscript:

$$\begin{aligned} GDP_t &= \big[PC_t^{Y-1} \times C_t + PG_t^{Y-1} \times G_t + PI_t^{Y-1} \times I_t \\ &\quad + (IIN/II)_t^{Y-1} \times II_t + PX_t^{Y-1} \times EX_t \\ &\quad - PM_t^{Y-1} \times IMP_t\big] \times \left(\frac{1}{PGDP_t^{Y-1}}\right) \end{aligned} \tag{5.62}$$

where:

GDP	GDP (5.62).
C	Private consumption (5.2).
PC	Private consumption deflator (7.11).
G	Government consumption (exogenous).
PG	Government consumption deflator (7.12).
I	Fixed investment (5.5).
PI	Investment goods price deflator (7.13).
II	Net stockbuilding (exogenous).
IIN	Nominal net stockbuilding (exogenous).
EX	Export volume of goods and services (5.25).
PX	Export price deflator (7.10).
IMP	Import volume of goods and services (5.41).
PM	Import price deflator (7.6).
$PGDP$	GDP price deflator (7.16).

Nominal GDP is determined by an accounting identity:

$$GDPN_t = DDN_t + EXN_t - IMPN_t \tag{5.63}$$

where:

$GDPN$	Nominal GDP (5.63).
DDN	Nominal domestic demand (5.23).
EXN	Nominal exports of goods and services (5.28).
$IMPN$	Nominal imports of goods and services (5.43).

5.5.2. Potential output and the output gap ($GDPT$, $QDGDPT$, $GDPTF$, $GDPTX$, GAP and $GAPAV$)

Potential output is described with a constant-returns-to-scale Cobb-Douglas production function and an exogenous labour-augmenting technical progress:

$$gdpt_t = \log \alpha_g + \beta_g(\gamma_g T) + \beta_g empht_t + (1 - \beta_g)k_t \tag{5.64}$$

where $GDPT$ is potential output, $EMPHT$ is trend total hours, K is the capital stock, β_g is the labour share and $\gamma_g T$ is the labour-augmenting technical progress, captured with a linear time trend. The capital stock is assumed to be fully employed and trend total hours is given by (6.15). By setting the shares of production factors exogenously according to historical income shares and the results from the analysis of the steady state properties of QMM (see Daníelsson, 2009), the estimated equation reduces to (estimated for the period 2003:Q2-2013:Q4):

$$gdpt_t = \underset{(-54.3)}{-3.293} + 0.60 \times \underset{(6.3)}{0.004126T} + 0.60 empht_t + 0.40 k_t \tag{5.65}$$

where:

$GDPT$	Potential output (5.65).
$EMPHT$	Trend total hours (6.15).
K	Capital stock (5.19).
T	Linear time trend.

Equation (5.65) gives quarterly trend productivity growth equal to 0.4%, or an annual rate of growth equal to 1.7%. Assuming an annual trend population growth of 1%, this gives quarterly trend GDP growth (or "steady state" growth) equal to 0.7%, which is equivalent to a 2.7% annual growth rate. This value is used in baseline simulations of QMM and enters in several equations of the model:

$$QDGDPT_t = (1 + 1\%)^{(1/4)} \times \exp(0.004126) - 1 = 0.7\% \tag{5.66}$$

where:

$QDGDPT$	Quarterly trend GDP growth rate (5.66).

Due to the considerable uncertainty surrounding the estimation of potential output, the simple production function (5.65) is augmented by an average of three exogenous estimates of potential output. All three are based on the same Cobb-Douglas production technology as in (5.65), but allow for more flexible measures of

trend values using a Hodrick-Prescott filtered trend of the technological progress and three different estimates of trend total hours: one using a Hodrick-Prescott filtered trend on $EMPH$ directly, and two different estimates of $NAIRU$ to generate trend total hours from (6.15) (a Hodrick-Prescott filtered unemployment rate, and one exogenously given $NAIRU$ value).

The summary measure $GDPTX$ is given as a simple average of the three different estimates:

$$GDPTX_t = \frac{\exp\left(HP\left[tfp_t\right]\right)}{3} \times \left\{ \begin{array}{c} \exp\left(HP\left[emph_t\right]\right)^{\beta_g} K_t^{1-\beta_g} \\ + \left\{PAT_t POWA_t (1 - HP\left[UR_t\right]) AVHT_t\right\}^{\beta_g} K_t^{1-\beta_g} \\ + \left\{PAT_t POWA_t (1 - NAIRU_t) AVHT_t\right\}^{\beta_g} K_t^{1-\beta_g} \end{array} \right\} \tag{5.67}$$

where TFP denotes total factor productivity (or the Solow residual) given as $\frac{GDP}{EMPH^{\beta_g} K^{1-\beta_g}}$, and $HP\left[\cdot\right]$ denotes the Hodrick-Prescott filter, and:

$GDPTX$	Augmented estimate of potential output (5.67).
GDP	GDP (5.62).
$EMPH$	Total hours (6.13).
$AVHT$	Trend average hours per worker (6.11).
UR	Unemployment rate (6.6).
$NAIRU$	Natural rate of unemployment (exogenous).
PAT	Trend participation rate (6.9).
$POWA$	Population at working age (16-74 years old) (exogenous).
K	Capital stock (5.19).

The final estimate of potential output is given as a weighted average of $GDPT$ and $GDPTX$:

$$GDPTF_t = GDPT_t^{0.3} \times GDPTX_t^{0.7} \tag{5.68}$$

where:

$GDPTF$	Final estimate of potential output (5.68).
$GDPT$	Potential output (5.65).
$GDPTX$	Augmented estimate of potential output (5.67).

The output gap is defined as the difference between actual and potential output:

$$GAP_t = GDP_t / GDPTF_t - 1 \tag{5.69}$$

where:

GAP	Output gap (5.69).
GDP	GDP (5.62).
$GDPTF$	Final estimate of potential output (5.68).

An annual average of the output gap is used as a measure of demand pressure in the inflation equation (7.1) and as the measure of future inflation pressures in the monetary policy rule (4.1):

$$GAPAV_t = \left(\frac{GAP_t + GAP_{t-1} + GAP_{t-2} + GAP_{t-3}}{4} \right) \tag{5.70}$$

where:

$GAPAV$	Annual average of output gap (5.70).
GAP	Output gap (5.69).

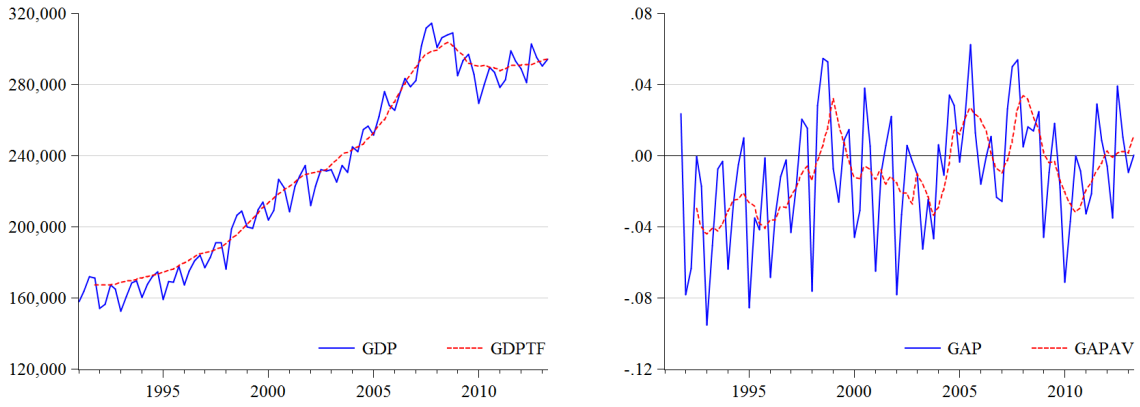

Figure 5.8. Actual and potential output and the output gap

6. Labour market

This section describes the labour market in QMM. Wage setting is assumed to take place in a monopolistic competition setting, with cyclically sensitive labour supply and long-run labour demand derived from the production function of the economy.

6.1. Wages and labour costs

6.1.1. Wages (W)

It follows from profit maximisation and the production function (5.64) that the wage share should be constant in the long run:[23]

$$(w + rem - prodt - pgdp) = (ulct - pgdp) = \log \beta_g \tag{6.1}$$

[23] The firm's decision problem is given as maximising $GDPT - (W \times REM/PGDP) \times EMPT - RCC \times K$, which gives the first order condition (6.1).

where W is the nominal wage rate, REM is the employers' wage related cost, $PRODT$ is trend labour productivity, $PGDP$ is the output price and β_g is the wage share from the production function (5.65).

The wage equation is specified in terms of real unit labour costs (or the wage share), $(W \times REM/PRODT)/PGDP = ULCT/PGDP$ (see equation 6.4), with the short run dynamics characterised by a Phillips curve where the wage share is affected by its deviations from its long-run value which is determined by the estimation of the short-run equation, deviations of unemployment from a time-varying $NAIRU$, deviations of the real exchange rate from its equilibrium rate, and the price wedge between output and consumer prices:

$$\begin{aligned}\Delta(ulct_t - pgdp_t) \;=\; & \underset{(6.2)}{1.164} + \underset{(4.1)}{0.021}Q1 + \underset{(2.1)}{0.010}Q2 + \underset{(0.1)}{0.0004}Q3 \\ & + \underset{(2.8)}{0.017}S0207 - \underset{(-2.3)}{0.013}S9299 - \underset{(-4.7)}{1.010}(UR_t - NAIRU_t) \\ & - \underset{(-6.0)}{0.664}\Delta(pgdp_t - cpi_t) + \underset{(2.0)}{0.058}(rex_t - rexeq_t) \\ & - \underset{(-6.2)}{0.347}[ulct_{t-1} - pgdp_{t-1}]\end{aligned} \tag{6.2}$$

Estimation method	OLS
Adjusted R^2	0.545
Equation standard error	1.46%
LM test for serial correlation (F-test)	8.18 [0.01]
Normality test (χ^2-test)	3.53 [0.17]
White test for heteroscedasticity (F-test)	0.42 [0.92]
Sample period	1993:Q1-2013:Q4 ($T = 84$)

where:

$ULCT$	Trend unit labour costs (6.4).
$PGDP$	GDP price deflator (7.16).
CPI	Consumer price index (7.2).
UR	Unemployment rate (6.6).
$NAIRU$	Natural rate of unemployment (exogenous).
REX	Real exchange rate (4.16).
$REXEQ$	Equilibrium real exchange rate (exogenous).
$S0207$	Shift dummy variable: 1 2002:Q1-2007:Q4 and zero elsewhere
$S9299$	Shift dummy variable: 1 1992:Q1-1999:Q4 and zero elsewhere.
$Q1$-$Q3$	Centered seasonal dummies.

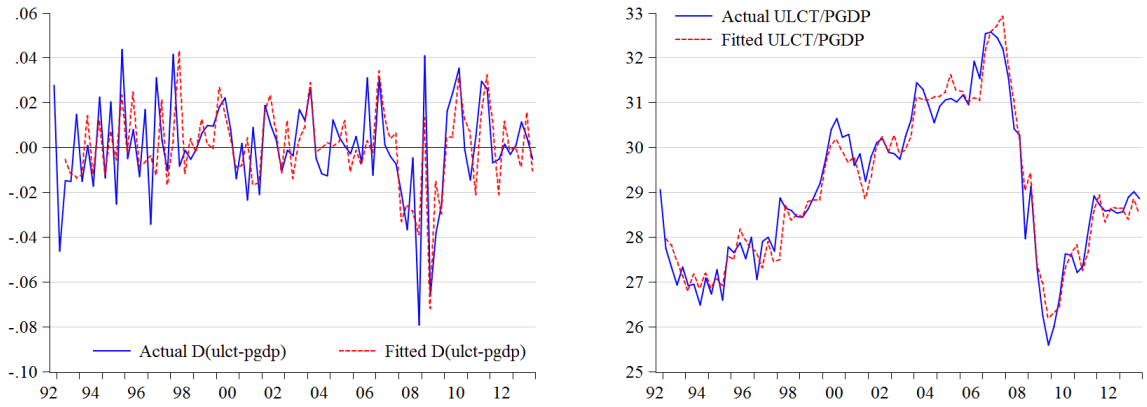

Figure 6.1. Fitted and actual $\Delta(ulct - pgdp)_t$ and $ULCT_t/PGDP_t$

Single equation dynamic responses of (6.2):[24]

Table 6.1. Responses of w to a 1% increase in RHS variables

Quarters	rem	$prodt$	$pgdp$	cpi	$UR - NAIRU$	$rex - rexeq$
Simultaneous	−1.00	1.00	0.34	0.66	−1.01	0.06
One quarter ahead	−1.00	1.00	0.57	0.43	−1.67	0.10
Four quarters ahead	−1.00	1.00	0.88	0.12	−2.56	0.15
Eight quarters ahead	−1.00	1.00	0.98	0.02	−2.85	0.16
Long run	−1.00	1.00	1.00	0.00	−2.91	0.17
50% of long-run effect	0Q	0Q	1Q	-	1Q	1Q
90% of long-run effect	0Q	0Q	5Q	-	5Q	5Q
Steady state solution: $(w + rem - prodt - pgdp) = (ulct - pgdp) = const$						

6.1.2. Unit labour costs (ULC, $ULCT$ and $RULCT$)

Overall unit labour costs are given by the following identity:

$$ULC_t = \frac{W_t \times REM_t}{PROD_t} \tag{6.3}$$

where:

[24]Note that the equation is dynamically homogenous as the sum of the $PGDP$ and CPI impacts is always unity. Note also that in a steady state $UR = NAIRU$. Hence, although the table reports 'long-run' effects of $UR - NAIRU$ and $rex - rexeq$, the effects on wages are only temporary.

ULC	Unit labour costs (6.3).
W	Wages (6.2).
REM	Employers' wage-related cost (exogenous).
$PROD$	Labour productivity (6.16).

Trend unit labour costs are given by the following identity:

$$ULCT_t = \left(\frac{W_t \times REM_t}{PRODT_t} \right) \tag{6.4}$$

where:

$ULCT$	Trend unit labour costs (6.4).
W	Wages (6.2).
REM	Employers' wage-related cost (exogenous).
$PRODT$	Trend labour productivity (6.17).

Finally, real (consumption) trend unit labour costs are given as:

$$RULCT_t = \frac{ULCT_t}{CPI_t} \tag{6.5}$$

where:

$RULCT$	Real trend unit labour costs (6.5).
$ULCT$	Trend unit labour costs (6.4).
CPI	Consumer price index (7.2).

6.2. Unemployment and labour participation

6.2.1. Unemployment (UN and UR)

The unemployment rate is modelled as an Okun-type relation:

$$\begin{aligned} \Delta UR_t \;=\; & \underset{(0.5)}{0.002}Q1 + \underset{(2.3)}{0.012}Q2 \underset{(-3.1)}{-0.017}\,Q3 + \underset{(2.1)}{0.320}\Delta UR_{t-1} \\ & \underset{(-2.3)}{-0.093}(\Delta gdp_t - \log(1 + QDGDPT_t)) \\ & \underset{(-3.4)}{-0.141}(\Delta gdp_{t-3} - \log(1 + QDGDPT_{t-3})) - \underset{(-3.7)}{0.390}[UR_{t-1} - NAIRU_{t-1}] \end{aligned} \tag{6.6}$$

Estimation method	OLS
Adjusted R^2	0.776
Equation standard error	0.62%
LM test for serial correlation (F-test)	1.24 [0.27]
Normality test (χ^2-test)	0.79 [0.67]
White test for heteroscedasticity (F-test)	1.54 [0.19]
Sample period	2003:Q3-2012:Q4 ($T = 38$)

where:

UR	Unemployment rate (6.6).
$NAIRU$	Natural rate of unemployment (exogenous).
GDP	GDP (5.62).
$QDGDPT$	Quarterly trend GDP growth rate (5.66).
$Q1$-$Q3$	Centered seasonal dummies.

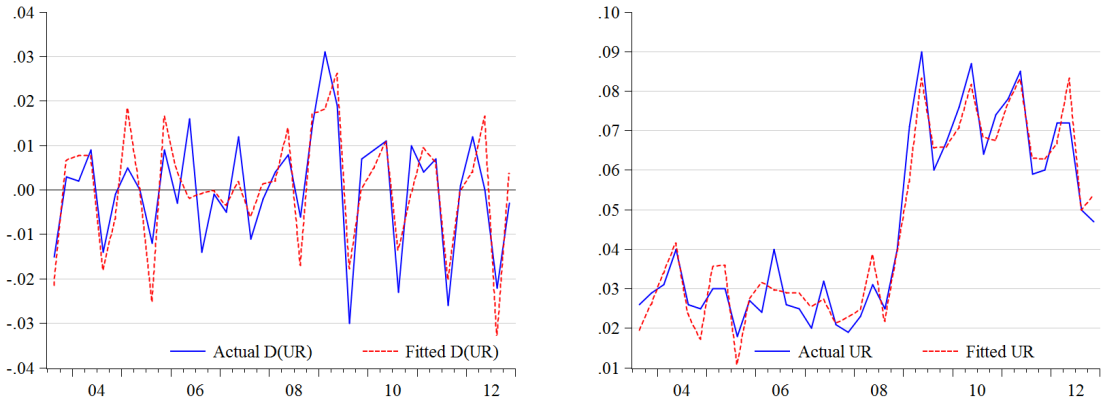

Figure 6.2. Fitted and actual ΔUR_t and UR_t

Single equation dynamic responses of (6.6):[25]

Table 6.2. Responses of UR to a 1% increase in RHS variables

Quarters	$NAIRU$	$\Delta gdp - \log(1 + QDGDPT)$
Simultaneous	0.00	−0.09
One quarter ahead	0.39	−0.18
Four quarters ahead	1.05	−0.52
Eight quarters ahead	1.00	−0.61
Long run	1.00	−0.60
50% of long-run effect	O/S	O/S
90% of long-run effect	O/S	O/S
Steady state solution: $UR = NAIRU$		

The level of unemployment is defined as:

[25] Although the table reports the 'long-run' effects of an output growth shock, UR equals $NAIRU$ in steady state.

$$UN_t = PA_t \times POWA_t \times UR_t \tag{6.7}$$

where:

UN	Level of unemployment (6.7).
PA	Participation rate (6.8).
$POWA$	Population at working age (16-74 years old) (exogenous).
UR	Unemployment rate (6.6).

6.2.2. Participation rate (PA and PAT)

The labour participation rate is assumed to respond to cyclical fluctuations in UR and GDP growth as follows:

$$\begin{aligned} PA_t &= \underset{(3.4)}{0.204} + \underset{(5.7)}{0.014}Q1 + \underset{(17.6)}{0.050}Q2 + \underset{(9.1)}{0.016}Q3 + \underset{(10.4)}{0.753}PA_{t-1} \\ &\quad \underset{(-1.6)}{-0.071}UR_{t-3} + \underset{(2.0)}{0.030}\Delta_4 gdp_{t-1} \end{aligned} \tag{6.8}$$

Estimation method	OLS
Adjusted R^2	0.910
Equation standard error	0.54%
LM test for serial correlation (F-test)	0.50 [0.48]
Normality test (χ^2-test)	3.87 [0.14]
White test for heteroscedasticity (F-test)	1.90 [0.09]
Sample period	1992:Q1-2012:Q4 ($T = 84$)

where:

PA	Participation rate (6.8).
GDP	GDP (5.62).
UR	Unemployment rate (6.6).
$Q1$-$Q3$	Centered seasonal dummies.

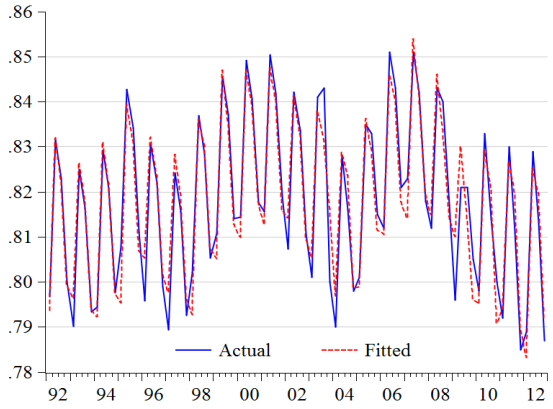

Figure 6.3. Fitted and actual PA_t

Single equation dynamic responses of (6.8):

Table 6.3. Responses of PA to a 1% increase in RHS variables

Quarters	$\Delta_4 gdp$	UR
Simultaneous	0.00	0.00
One quarter ahead	0.03	0.00
Four quarters ahead	0.08	−0.12
Eight quarters ahead	0.11	−0.24
Long run	0.12	−0.29
50% of long-run effect	3Q	5Q
90% of long-run effect	9Q	11Q
Steady state solution:		
$PA = const + 0.121\Delta_4 gdp - 0.288UR$		

Trend participation rate smoothes out the seasonal fluctuations in PA and serves as an input in trend employment (6.14). It is given as a four-quarter moving average of PA:

$$PAT_t = \left(\frac{PA_t + PA_{t-1} + PA_{t-2} + PA_{t-3}}{4} \right) \tag{6.9}$$

where:

PAT Trend participation rate (6.9).
PA Participation rate (6.8).

6.3. Hours per worker, employment and labour productivity

6.3.1. Hours per worker (AVH and $AVHT$)

Average hours per worker is a declining function of the unemployment rate, with short-term responses to output growth:[26]

$$\begin{aligned}\Delta avh_t &= \underset{(0.8)}{0.005}Q1 + \underset{(9.3)}{0.063}Q2 + \underset{(6.9)}{0.035}Q3 - \underset{(-10.1)}{0.042}D971 - \underset{(-8.8)}{0.032}D054 \\ &\quad - \underset{(-11.3)}{0.046}D084 - \underset{(-2.2)}{0.168}(avh_{t-1} - avha_{t-1}) \\ &\quad + \underset{(2.3)}{0.088}(\Delta_4 gdp_t - 4 \times \log(1 + QDGDPT_t))\end{aligned} \tag{6.10}$$

Estimation method	OLS
Adjusted R^2	0.864
Equation standard error	1.22%
LM test for serial correlation (F-test)	2.26 [0.14]
Normality test (χ^2-test)	0.00 [0.99]
White test for heteroscedasticity (F-test)	4.96 [0.00]
Sample period	1996:Q1-2012:Q4 ($T = 68$)

where:

AVH	Average hours per worker (6.10).
$AVHA$	Average hours per worker over 1991-2012 (exogenous).
GDP	GDP (5.62).
$QDGDPT$	Quarterly trend GDP growth rate (5.66).
$D971$	Dummy variable: 1 1997:Q1 and zero elsewhere.
$D054$	Dummy variable: 1 2005:Q4 and zero elsewhere.
$D084$	Dummy variable: 1 2008:Q4 and zero elsewhere.
$Q1$-$Q3$	Centered seasonal dummies.

[26] Due to the apparent residual heteroscedasticity, the equation reports White heteroscedasticity-consistent t-values in brackets.

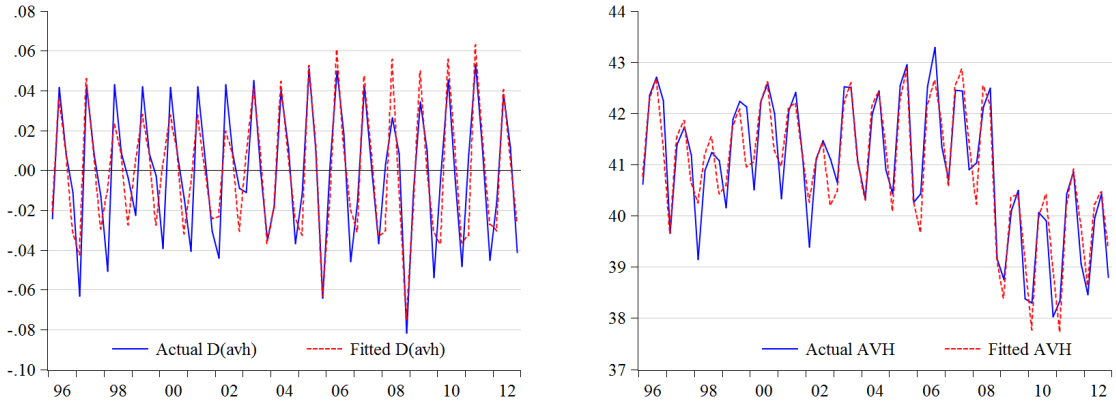

Figure 6.4. Fitted and actual Δavh_t and AVH_t

Single equation dynamic responses of (6.10):[27]

Table 6.3. Responses of avh to a 1% increase in RHS variables

Quarters	$avha$	$\Delta_4 gdp - 4 \times \log(1 + QDGDPT)$
Simultaneous	0.00	0.09
One quarter ahead	0.17	0.16
Four quarters ahead	0.52	0.32
Eight quarters ahead	0.77	0.43
Long run	1.00	0.53
50% of long-run effect	4Q	3Q
90% of long-run effect	13Q	12Q
Steady state solution: $avh = avha$		

Trend average hours per worker smoothes out the seasonal fluctuations in AVH and is defined as a four-quarter moving average of AVH:

$$AVHT_t = \left(\frac{AVH_t + AVH_{t-1} + AVH_{t-2} + AVH_{t-3}}{4} \right) \tag{6.11}$$

where:

$AVHT$	Trend average hours per worker (6.11).
AVH	Average hours per worker (6.10).

[27] Although the table reports the 'long-run' effects of an output growth shock, avh equals $avha$ in steady state.

6.3.2. Employment (EMP, $EMPH$, $EMPT$ and $EMPHT$)

Employment in man-years is defined as:

$$EMP_t = PA_t \times POWA_t \times (1 - UR_t) \tag{6.12}$$

where:

EMP	Level of employment in man-years (6.12).
PA	Participation rate (6.8).
$POWA$	Population at working age (16-74 years old) (exogenous).
UR	Unemployment rate (6.6).

Total hours is defined as:

$$EMPH_t = EMP_t \times AVH_t \tag{6.13}$$

where:

$EMPH$	Total hours (6.13).
EMP	Level of employment in man-years (6.12).
AVH	Average hours per worker (6.10).

Trend employment is given as:

$$EMPT_t = PAT_t \times POWA_t \times (1 - NAIRU_t) \tag{6.14}$$

where:

$EMPT$	Trend employment (6.14).
PAT	Trend participation rate (6.9).
$POWA$	Population at working age (16-74 years old) (exogenous).
$NAIRU$	Natural rate of unemployment (exogenous).

Trend total hours is defined as:

$$EMPHT_t = EMPT_t \times AVHT_t \tag{6.15}$$

where:

$EMPHT$	Trend total hours (6.15).
$EMPT$	Trend employment (6.14).
$AVHT$	Trend average hours per worker (6.11).

6.3.3. Labour productivity ($PROD$ and $PRODT$)

Labour productivity is given by the following identity:

$$PROD_t = \frac{GDP_t}{EMPH_t} \tag{6.16}$$

where:

$PROD$	Labour productivity (6.16).
GDP	GDP (5.62).
$EMPH$	Total hours (6.13).

Trend productivity smoothes out the seasonal fluctuations in $PROD$ and is given as a four-quarter moving average of $PROD$:

$$PRODT_t = \left(\frac{PROD_t + PROD_{t-1} + PROD_{t-2} + PROD_{t-3}}{4} \right) \tag{6.17}$$

where:

$PRODT$	Trend labour productivity (6.17).
$PROD$	Labour productivity (6.16).

7. Price setting and inflation

This section describes price setting in QMM. Underlying consumer price inflation is modelled as an expectations-augmented Phillips curve and other prices as a mark-up over marginal costs, with marginal costs in each case reflecting the inputs relevant for each sector.

7.1. Different price indices

7.1.1. Consumer price index excluding indirect taxes ($CPIUL$)

Underlying consumer price inflation, i.e. CPI inflation excluding the effects of indirect taxes, is given by an expectations-augmented Phillips curve. The forward-looking Phillips curve also allows for effects of temporary real exchange rate and real unit labour costs shocks. The equation imposes dynamic homogeneity on the coefficients (which is not rejected by the data) to ensure a vertical long-run Phillips curve and, hence, that no long-run trade-off between inflation and output exists. Due to the forward-looking part in the equation, the GMM method is used with two lags of $\Delta_4 cpiul_t$, $\Delta_4 rexm_t$ and a single lag of $\Delta_4 rulct_t$ and $GAPAV_{t-1}$ as instruments. The J-test does not reject the over-identifying restrictions:[28]

$$\begin{aligned} \Delta_4 cpiul_t \;=\; & \underset{(7.9)}{0.655}\Delta_4 cpiul_{t-1} + \underset{(4.3)}{0.179}\Delta_4 cpi_{t+8} \\ & + (1 - 0.655 - 0.179)\log(1 + IT_t) + \underset{(4.1)}{0.068}\Delta_4 rexm_{t-1} \\ & + \underset{(2.0)}{0.080}\Delta_4 rulct_{t-4} + \underset{(2.0)}{0.081} GAPAV_{t-1} \end{aligned} \tag{7.1}$$

[28] The equation is estimated using data until 2008:Q4. The estimation period ends in 2006:Q4 due to the inclusion of $\Delta_4 cpi_{t+8}$ as a regressor. Observations following the 2008 financial crisis are therefore excluded from the estimation.

Estimation method	GMM
Adjusted R^2	0.838
Equation standard error	0.82%
Dynamic homogeneity (F-test)	2.12 [0.15]
J-test for over-identifying restrictions (χ^2-test)	2.08 [0.15]
Normality test (χ^2-test)	2.63 [0.27]
Sample period	1994:Q1-2006:Q4 ($T = 52$)

where:

$CPIUL$	Consumer price index excluding indirect taxes (7.1).
CPI	Consumer price index (7.2).
IT	Central Bank of Iceland 2.5% inflation target (exogenous).
$GAPAV$	Annual average of output gap (5.70).
$REXM$	Importers' real exchange rate (4.18).
$RULCT$	Real trend unit labour costs (6.5).

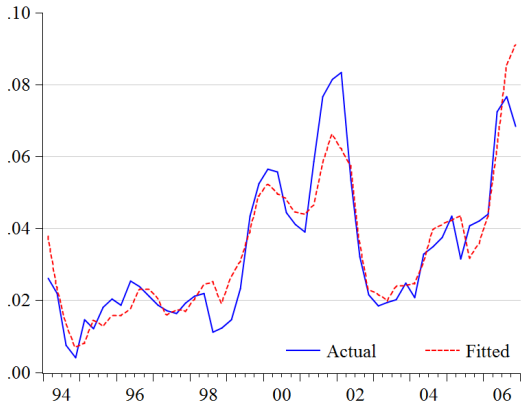

Figure 7.1. Fitted and actual $\Delta_4 cpiul_t$

Single equation dynamic responses of (7.1):[29]

[29]Note that the steady state solutions for $GAPAV$, $\Delta_4 rexm$ and $\Delta_4 rulct$ are zero. Hence, although the table reports 'long-run' effects of these variables, their effects on inflation are only temporary. The steady state solution for $\Delta_4 cpiul$ is therefore $\Delta_4 cpiul = \log(1+IT)$, which implies that $INFUL = IT$ in steady state, where $INFUL$ is year-on-year percentage changes in the $CPIUL$ level.

Table 7.1. Responses of $\Delta_4 cpiul$ to a 1% increase in RHS variables

Quarters	$\log(1+IT)$	$\Delta_4 rexm$	$\Delta_4 rulct$	$GAPAV$
Simultaneous	0.34	0.14	0.08	0.09
One quarter ahead	0.57	0.23	0.14	0.22
Four quarters ahead	0.88	0.36	0.30	0.41
Eight quarters ahead	0.98	0.40	0.45	0.47
Long run	1.00	0.41	0.48	0.49
50% of long-run effect	1Q	1Q	4Q	2Q
90% of long-run effect	5Q	5Q	8Q	6Q
Steady state solution: $\Delta_4 cpiul = \log(1+IT)$				

7.1.2. Consumer price index (CPI)

The headline CPI level is obtained by adding the estimated effects of indirect taxes to the $CPIUL$ level:

$$\frac{CPI_t}{CPI_{t-1}} = \frac{CPIUL_t}{CPIUL_{t-1}} + INFTAX_t \tag{7.2}$$

where:

CPI	Consumer price index (7.2).
$CPIUL$	Consumer price index excluding indirect taxes (7.1).
$INFTAX$	Effects of indirect taxes on the CPI (exogenous).

7.1.3. Import price deflators ($PMALU$, $PMOTH$, PMS and PM)

The price deflator for imported goods used in aluminium production is determined by export aluminium prices:[30]

$$\Delta pmalu_t = \underset{(7.3)}{0.505}\Delta pmalu_{t-1} + \underset{(6.8)}{0.374}\Delta pxalu_t + (1-0.505-0.374)\Delta pxalu_{t-1} \tag{7.3}$$

Estimation method	OLS
Adjusted R^2	0.792
Equation standard error	2.91%
Dynamic homogeneity (F-test)	6.56 [0.02]
LM test for serial correlation (F-test)	1.24 [0.28]
Normality test (χ^2-test)	0.68 [0.71]
White test for heteroscedasticity (F-test)	1.81 [0.19]
Sample period	2009:Q1-2014:Q4 ($T = 24$)

[30]The equation is estimated using data from 2009:Q1 to 2014:Q4, due to a break occurring in 2008.

where:

$PMALU$	Import price deflator for aluminium production in USD (7.3).
$PXALU$	Price of aluminium products in USD (exogenous).

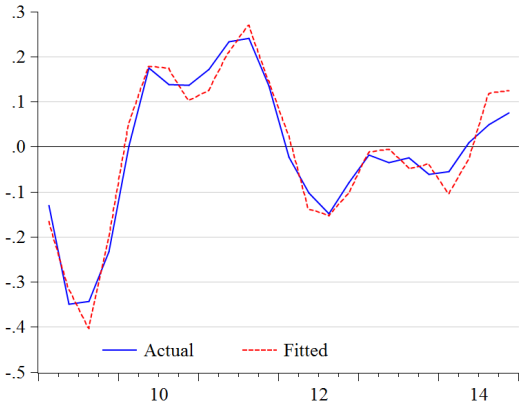

Figure 7.2. Fitted and actual $\Delta pmalu_t$

Single equation dynamic responses of (7.3):

Table 7.2. Responses of $\Delta pmalu$ to a 1% increase in RHS variables

Quarters	$\Delta pxalu$
Simultaneous	0.37
One quarter ahead	0.68
Four quarters ahead	0.96
Eight quarters ahead	1.00
Long run	1.00
50% of long-run effect	1Q
90% of long-run effect	3Q
Steady state solution:	
$\Delta pmalu = \Delta pxalu$	

Import prices of other goods are determined by the main components of other imports, i.e. other goods, oil and non-oil commodities. There are also effects of domestic labour costs, reflecting the influence of domestic price pressures on importers' mark-ups:

$$\begin{aligned}\Delta pmoth_t &= \underset{(-2.1)}{-0.116}\Delta pmoth_{t-1} + \underset{(24.7)}{0.883}\Delta(wpx_t + eer_t) \\ &\quad + \underset{(2.3)}{0.109}\Delta ulct_{t-2} + \underset{(4.3)}{0.079}\Delta(poil_{t-1} + eus_{t-1}) + \underset{(2.6)}{0.131}\,\Delta(pcom_{t-1} + eus_{t-1}) \\ &\quad + (1 + 0.116 - 0.883 - 0.109 - 0.079 - 0.131)\Delta(pcom_{t-2} + eus_{t-2})\end{aligned} \tag{7.4}$$

Estimation method	OLS
Adjusted R^2	0.917
Equation standard error	1.75%
Dynamic homogeneity (F-test)	5.29 [0.03]
LM test for serial correlation (F-test)	0.08 [0.78]
Normality test (χ^2-test)	1.88 [0.39]
White test for heteroscedasticity (F-test)	0.18 [0.97]
Sample period	1997:Q4-2012:Q4 ($T = 61$)

where:

$PMOTH$	Import price deflator for other goods (7.4).
WPX	World export prices (exogenous).
EER	Exchange rate index of foreign currencies (4.10).
$ULCT$	Trend unit labour costs (6.4).
$POIL$	Oil prices in USD (exogenous).
EUS	USD exchange rate (4.11).
$PCOM$	Non-oil commodity prices in USD (exogenous).

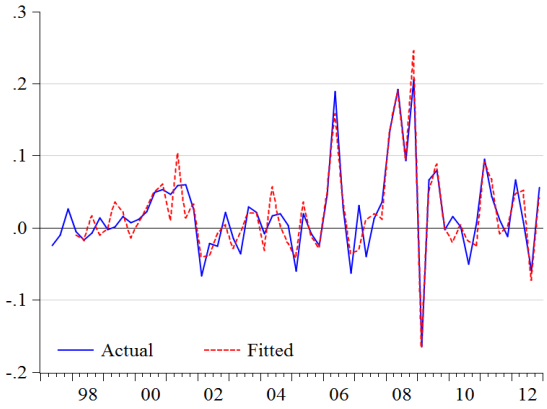

Figure 7.3. Fitted and actual $\Delta pmoth_t$

Single equation dynamic responses of (7.4):

Table 7.3. Responses of $\Delta pmoth$ to a 1% increase in RHS variables

Quarters	$\Delta(wpx + eer)$	$\Delta ulct$	$\Delta(poil + eus)$	$\Delta(pcom + eus)$
Simultaneous	0.88	0.00	0.00	0.00
One quarter ahead	0.78	0.00	0.08	0.13
Four quarters ahead	0.79	0.10	0.07	0.04
Eight quarters ahead	0.79	0.10	0.07	0.04
Long run	0.79	0.10	0.07	0.04
50% of long-run effect	O/S	O/S	O/S	O/S
90% of long-run effect	O/S	O/S	O/S	O/S

Steady state solution:
$\Delta pmoth = 0.791\Delta(wpx + eer) + 0.098\Delta ulct + 0.071\Delta(poil + eus)$
$+0.040\Delta(pcom + eus)$

The price deflator for imported service is given as:

$$\Delta pms_t = \Delta(wcpi_t + eer_t) \tag{7.5}$$

PMS	Import price deflator for services (7.5).
$WCPI$	World consumer prices (exogenous).
EER	Exchange rate index of foreign currencies (4.10).

The import price deflator is defined:

$$PM_t = \frac{IMPN_t}{IMP_t} \tag{7.6}$$

where:

PM	Import price deflator (7.6).
$IMPN$	Nominal imports of goods and services (5.43).
IMP	Imports of goods and services (5.41).

7.1.4. Export price deflators ($PXOTH$, PXS, $PXMAR$ and PX)

The price deflator $PXOTH$ consists of all exported goods excluding aluminium and marine products as well as airplanes and ships. It is assumed to be determined by world export prices:

$$\Delta pxoth_t = \underset{(-4.3)}{-0.336}\Delta pxoth_{t-2} + (1 + 0.336)\Delta(wpx_t + eer_t) \tag{7.7}$$

Estimation method	OLS
Adjusted R^2	0.607
Equation standard error	6.85%
Dynamic homogeneity (F-test)	0.28 [0.60]
LM test for serial correlation (F-test)	0.08 [0.78]
Normality test (χ^2-test)	4.05 [0.13]
White test for heteroscedasticity (F-test)	0.67 [0.42]
Sample period	1997:Q3-2012:Q4 ($T = 62$)

where:

$PXOTH$	Export prices of other goods (7.7).
WPX	World export prices (exogenous).
EER	Exchange rate index of foreign currencies (4.10).

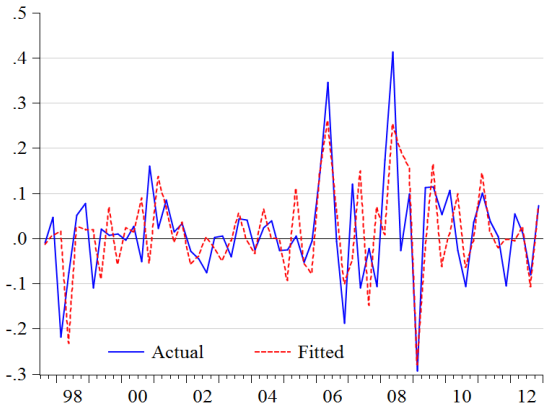

Figure 7.4. Fitted and actual $\Delta pxoth_t$

Single equation dynamic responses of (7.7):

Table 7.4. Responses of $\Delta pxoth$ to a 1% increase in RHS variables

Quarters	$\Delta(wpx + eer)$
Simultaneous	1.34
One quarter ahead	1.34
Four quarters ahead	1.04
Eight quarters ahead	1.00
Long run	1.00
50% of long-run effect	O/S
90% of long-run effect	O/S
Steady state solution:	
$\Delta pxoth = \Delta(wpx + eer)$	

The price deflator for exported service is assumed to follow world and domestic consumer prices:

$$\Delta pxs_t = \underset{(9.5)}{0.786}\Delta(wcpi_t + eer_t) + (1 - 0.786)\Delta cpi_t - \underset{(-2.9)}{0.100}D084 \qquad (7.8)$$

Estimation method	OLS
Adjusted R^2	0.691
Equation standard error	2.92%
Dynamic homogeneity (F-test)	0.06 [0.80]
LM test for serial correlation (F-test)	6.72 [0.01]
Normality test (χ^2-test)	184.51 [0.00]
White test for heteroscedasticity (F-test)	3.67 [0.03]
Sample period	1997:Q4-2012:Q4 ($T = 61$)

where:

PXS	Export prices of services (7.8).
$WCPI$	World consumer prices (exogenous).
EER	Exchange rate index of foreign currencies (4.10).
CPI	Consumer price index (7.2).
$D084$	Dummy variable: 1 2008:Q4 and zero elsewhere.

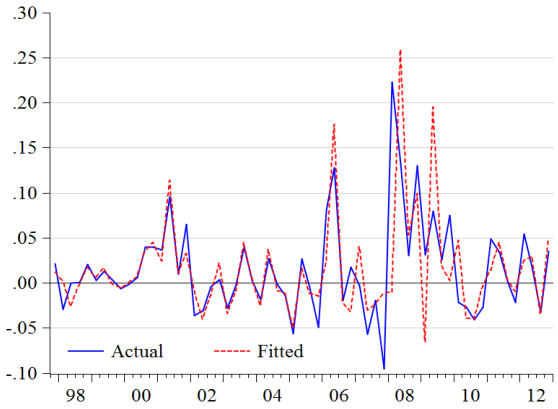

Figure 7.5. Fitted and actual Δpxs_t

Single equation dynamic responses of (7.8):

Table 7.5. Responses of Δpxs to a 1% increase in RHS variables

Quarters	$\Delta(wcpi + eer)$	Δcpi
Simultaneous	0.79	0.21
One quarter ahead	0.79	0.21
Four quarters ahead	0.79	0.21
Eight quarters ahead	0.79	0.21
Long run	0.79	0.21
50% of long-run effect	0Q	0Q
90% of long-run effect	0Q	0Q
Steady state solution:		
$\Delta pxs = 0.786\Delta(wcpi + eer) + 0.214\Delta cpi$		

The price of marine products in foreign currency is assumed to follow non-oil commodity prices with short-run effects of world GDP growth:[31]

$$\begin{aligned}\Delta pxmar_t \;=\; & \underset{(-0.8)}{-0.009}Q1 \underset{(-3.1)}{-0.043}Q2 \underset{(-2.5)}{-0.030}Q3 + \underset{(3.0)}{0.074}D0924 \\ & \underset{(2.7)}{+0.235}\Delta(pcom_{t-1} + eus_{t-1} - eer_{t-1}) \\ & \underset{(2.6)}{+0.236}\Delta(pcom_{t-2} + eus_{t-2} - eer_{t-2}) \\ & +(1 - 0.235 - 0.236)\Delta pxmar_{t-3} + \underset{(2.3)}{0.588}(\Delta_4 wgdp_t - \gamma_y)\end{aligned} \tag{7.9}$$

Estimation method	OLS
Adjusted R^2	0.466
Equation standard error	2.61%
Dynamic homogeneity (F-test)	4.28 [0.05]
LM test for serial correlation (F-test)	0.36 [0.55]
Normality test (χ^2-test)	0.28 [0.87]
White test for heteroscedasticity (F-test)	0.84 [0.56]
Sample period	2003:Q1-2012:Q4 ($T = 40$)

where:

$PXMAR$	Price of marine products in foreign currency (7.9).
$PCOM$	Non-oil commodity prices in USD (exogenous).
EER	Exchange rate index of foreign currencies (4.10).
EUS	US dollar exchange rate (4.11).
$WGDP$	World GDP (exogenous).
$D0924$	Dummy variable: 1 2009:Q2-2009:Q4 and zero elsewhere.
$Q1$-$Q3$	Centered seasonal dummies.

[31] γ_y is the steady state output growth rate for world GDP, equal to 2.6%.

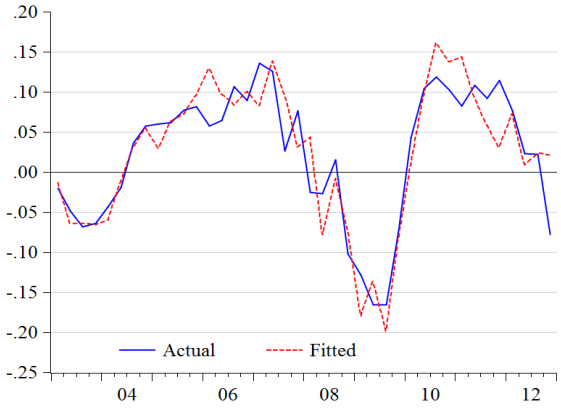

Figure 7.6. Fitted and actual $\Delta pxmar_t$

Single equation dynamic responses of (7.9):[32]

Table 7.6. Responses of $\Delta pxmar$ to a 1% increase in RHS variables

Quarters	$\Delta(pcom + eus - eer)$	$\Delta_4 wgdp$
Simultaneous	0.00	0.59
One quarter ahead	0.24	0.59
Four quarters ahead	0.60	0.90
Eight quarters ahead	0.85	1.06
Long run	1.00	1.25
50% of long-run effect	3Q	3Q
90% of long-run effect	11Q	9Q
Steady state solution: $\Delta pxmar = \Delta(pcom + eus - eer)$		

The export price deflator is defined:

$$PX_t = \frac{EXN_t}{EX_t} \tag{7.10}$$

where:

PX	Export price deflator (7.10).
EXN	Nominal exports of goods and services (5.28).
EX	Exports of goods and services (5.25).

[32]Note that the steady state growth rate, γ_y, is subtracted from $\Delta_4 wgdp$ in the equation but the shock only applies for $\Delta_4 wgdp$ for one quarter. Although the table reports 'long-run' effects of $\Delta_4 wgdp$, the effects are only temporary.

7.1.5. Private consumption deflator (PC)

The growth rate of the private consumption deflator depends on CPI inflation, but allowing for different seasonal patterns and different short-run responses of PC and CPI inflation rates to exchange rate shocks, due to slightly different import densities of these indices:

$$\begin{aligned}\Delta pc_t &= \underset{(0.4)}{0.001}Q1 + \underset{(1.5)}{0.004}Q2 + \underset{(0.2)}{0.001}Q3 + \underset{(1.7)}{0.190}\Delta pc_{t-1} + \underset{(7.1)}{0.896}\Delta cpi_t \\ &\quad +(1-0.190-0.896)\Delta cpi_{t-3} + \underset{(2.6)}{0.045}\Delta eer_t - \underset{(-1.2)}{0.086}\left[pc_{t-1} - cpi_{t-1}\right]\end{aligned} \tag{7.11}$$

Estimation method	OLS
Adjusted R^2	0.802
Equation standard error	0.65%
Dynamic homogeneity (F-test)	1.05 [0.31]
LM test for serial correlation (F-test)	1.26 [0.27]
Normality test (χ^2-test)	1.10 [0.58]
White test for heteroscedasticity (F-test)	1.73 [0.13]
Sample period	1999:Q4-2010:Q4 ($T = 45$)

where:

PC	Private consumption deflator (7.11).
CPI	Consumer price index (7.2).
EER	Exchange rate index of foreign currencies (4.10).
$Q1$-$Q3$	Centered seasonal dummies.

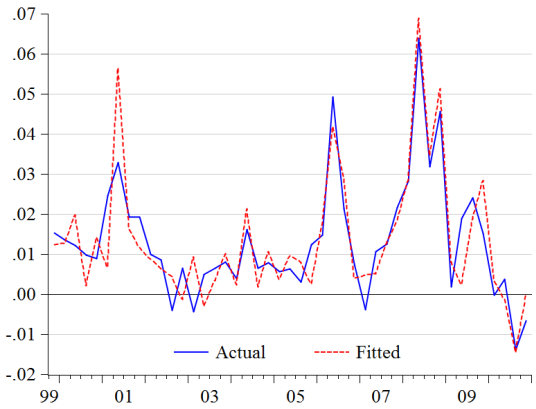

Figure 7.7. Fitted and actual Δpc_t

Single equation dynamic responses of (7.11):

Table 7.7. Responses of pc to a 1% increase in RHS variables

Quarters	*cpi*	*eer*
Simultaneous	0.90	0.05
One quarter ahead	1.07	0.05
Four quarters ahead	1.00	0.04
Eight quarters ahead	0.99	0.02
Long run	1.00	0.00
50% of long-run effect	O/S	-
90% of long-run effect	O/S	-
Steady state solution:		
$pc = const + cpi$		

7.1.6. Government consumption deflator (PG)

The government consumption deflator is determined by unit labour costs and consumer prices:

$$\begin{aligned}\Delta pg_t &= \underset{(3.7)}{0.024}Q1 - \underset{(-2.3)}{0.016}Q2 - \underset{(0.1)}{0.001}Q3 - \underset{(-2.7)}{0.035}D063 \\ &\quad + \underset{(2.1)}{0.020}D0834 + \underset{(3.2)}{0.153}\Delta ulc_t + (1 - 0.153)\Delta cpi_t\end{aligned} \tag{7.12}$$

Estimation method	OLS
Adjusted R^2	0.590
Equation standard error	1.26%
Dynamic homogeneity (F-test)	0.15 [0.70]
LM test for serial correlation (F-test)	0.19 [0.67]
Normality test (χ^2-test)	3.20 [0.20]
White test for heteroscedasticity (F-test)	2.21 [0.06]
Sample period	1997:Q1-2010:Q4 ($T = 56$)

where:

PG	Government consumption deflator (7.12).
ULC	Unit labour costs (6.3).
CPI	Consumer price index (7.2).
$D063$	Dummy variable: 1 2006:Q3 and zero elsewhere
$D0834$	Dummy variable: 1 2008:Q3-2008:Q4 and zero elsewhere
$Q1$-$Q3$	Centered seasonal dummies.

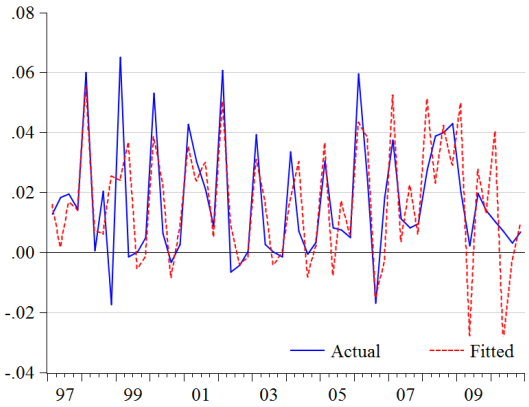

Figure 7.8. Fitted and actual Δpg_t

Single equation dynamic responses of (7.12):

Table 7.8. Responses of Δpg to a 1% increase in RHS variables

Quarters	Δulc	Δcpi
Simultaneous	0.15	0.85
One quarter ahead	0.15	0.85
Four quarters ahead	0.15	0.85
Eight quarters ahead	0.15	0.85
Long run	0.15	0.85
50% of long-run effect	0Q	0Q
90% of long-run effect	0Q	0Q
Steady state solution:		
$\Delta pg = 0.153\Delta ulc + 0.847\Delta cpi$		

7.1.7. Investment goods price deflator (PI)

The price of investment goods is determined by building costs and import prices, the latter reflecting the large share of imported capital goods:

$$\begin{aligned}\Delta pi_t \;=\; & \underset{(0.8)}{0.003}Q1 - \underset{(-2.9)}{0.011}Q2 - \underset{(-2.6)}{0.010}Q3 - \underset{(-2.2)}{0.167}\Delta pi_{t-2} \\ & + \underset{(5.6)}{0.260}\Delta pi_{t-4} + \underset{(8.1)}{0.478}\Delta bc_t + \underset{(13.1)}{0.335}\Delta pm_t \\ & + (1 + 0.167 - 0.260 - 0.478 - 0.335)\Delta pm_{t-2}\end{aligned} \tag{7.13}$$

Estimation method	OLS
Adjusted R^2	0.772
Equation standard error	1.22%
Dynamic homogeneity (F-test)	3.68 [0.06]
LM test for serial correlation (F-test)	0.01 [0.96]
Normality test (χ^2-test)	4.77 [0.09]
White test for heteroscedasticity (F-test)	1.07 [0.39]
Sample period	1987:Q1-2012:Q4 ($T = 104$)

where:

PI	Investment goods price deflator (7.13).
BC	Building costs (7.19).
PM	Import price deflator (7.6).
$Q1$-$Q3$	Centered seasonal dummies.

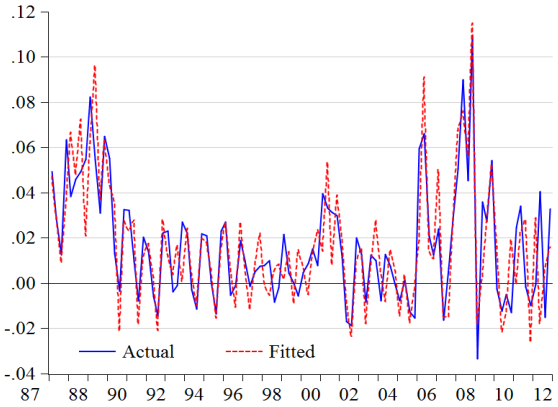

Figure 7.9. Fitted and actual Δpi_t

Single equation dynamic responses of (7.13):

Table 7.9. Responses of Δpi to a 1% increase in RHS variables

Quarters	Δbc	Δpm
Simultaneous	0.48	0.34
One quarter ahead	0.48	0.34
Four quarters ahead	0.54	0.45
Eight quarters ahead	0.53	0.47
Long run	0.53	0.47
50% of long-run effect	O/S	0Q
90% of long-run effect	O/S	4Q
Steady state solution:		
$\Delta pi = 0.526\Delta bc + 0.474\Delta pm$		

7.1.8. Housing investment deflator (PIH)

The housing investment deflator is simply given as:

$$\Delta pih_t = \Delta bc_t \tag{7.14}$$

where:

PIH	Housing investment deflator (7.14).
BC	Building costs (7.19).

7.1.9. Government investment deflator (PIG)

The price of government investment is determined by building costs and the general price of investment goods:

$$\begin{aligned} \Delta pig_t \;=\; & \underset{(5.1)}{0.012}Q1 - \underset{(-0.5)}{0.001}Q2 - \underset{(-1.0)}{0.003}Q3 + \underset{(5.9)}{0.037}D0934 \\ & \underset{(-2.5)}{-0.154}\Delta pig_{t-1} + \underset{(3.3)}{0.141}\Delta pig_{t-2} + \underset{(9.0)}{0.603}\Delta bc_t \\ & +(1 + 0.154 - 0.141 - 0.603)\Delta pi_t \end{aligned} \tag{7.15}$$

Estimation method	OLS
Adjusted R^2	0.833
Equation standard error	0.81%
Dynamic homogeneity (F-test)	0.31 [0.58]
LM test for serial correlation (F-test)	0.20 [0.65]
Normality test (χ^2-test)	51.30 [0.00]
White test for heteroscedasticity (F-test)	0.91 [0.50]
Sample period	1990:Q1-2012:Q4 ($T = 92$)

where:

PIG	Government investment deflator (7.15).
BC	Building costs (7.19).
PI	Investment goods price deflator (7.13).
$D0934$	Dummy variable: 1 2009:Q3, -1 2009:Q4 and zero elsewhere
$Q1$-$Q3$	Centered seasonal dummies.

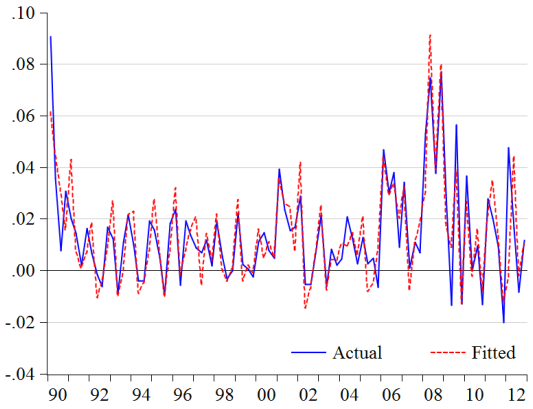

Figure 7.10. Fitted and actual Δpig_t

Single equation dynamic responses of (7.15):

Table 7.10. Responses of Δpig to a 1% increase in RHS variables

Quarters	Δbc	Δpi
Simultaneous	0.60	0.41
One quarter ahead	0.51	0.35
Four quarters ahead	0.60	0.41
Eight quarters ahead	0.60	0.40
Long run	0.60	0.40
50% of long-run effect	O/S	O/S
90% of long-run effect	O/S	O/S
Steady state solution:		
$\Delta pig = 0.596\Delta bc + 0.404\Delta pi$		

7.1.10. GDP price deflator ($PGDP$)

The GDP price deflator is the residual price level from the income accounting identity and is given as:

$$PGDP_t = \frac{GDPN_t}{GDP_t} \tag{7.16}$$

where:

$PGDP$	GDP price deflator (7.16).
$GDPN$	Nominal GDP (5.63).
GDP	GDP (5.62).

7.1.11. House prices (PH)

The demand for housing can be written as a positive function of household income and a negative function of real house prices and interest rates. By inverting the demand function a long-run solution for real house prices can be written as:

$$(ph - cpi) = \alpha_{ph} - \beta_{ph}(kh - ly) - \phi_{ph} RLV \tag{7.17}$$

where PH are house prices, CPI is the general price level, KH is the housing stock, LY is real household disposable labour income and RLV is the real long-term interest rate:[33]

$$\begin{aligned} \Delta(ph_t - cpi_t) \;=\; & \underset{(2.3)}{0.182} + \underset{(2.2)}{0.015} Q1 + \underset{(1.8)}{0.012} Q2 + \underset{(0.5)}{0.003} Q3 + \underset{(2.8)}{0.055} D051 \\ & + \underset{(4.2)}{0.428} \Delta(ph_{t-1} - cpi_{t-1}) - \underset{(-2.0)}{0.963} \Delta RLV_t \\ & - \underset{(-2.2)}{0.054} \left[(ph_{t-1} - cpi_{t-1}) + 1.469(kh_{t-1} - ly_{t-1}) + 1.763 RLV_{t-1} \right] \end{aligned} \tag{7.18}$$

Estimation method	OLS
Adjusted R^2	0.375
Equation standard error	1.88%
Long-run restrictions (F-test)	0.88 [0.42]
LM test for serial correlation (F-test)	2.53 [0.12]
Normality test (χ^2-test)	0.44 [0.80]
White test for heteroscedasticity (F-test)	0.65 [0.71]
Sample period	1991:Q1-2007:Q4 ($T = 68$)

where:

[33] The equation is estimated over the time period 1991Q1 to 2007Q4, excluding the 2008 financial crisis and observations following, to get sensible coefficients.

PH	House prices (7.18).
CPI	Consumer price index (7.2).
KH	Private sector housing stock (5.21).
LY	Real post-tax labour income (9.7)
RLV	Long-term indexed interest rate (4.7).
$D051$	Dummy variable: 1 2005:Q1 and zero elsewhere.
$Q1$-$Q3$	Centered seasonal dummies.

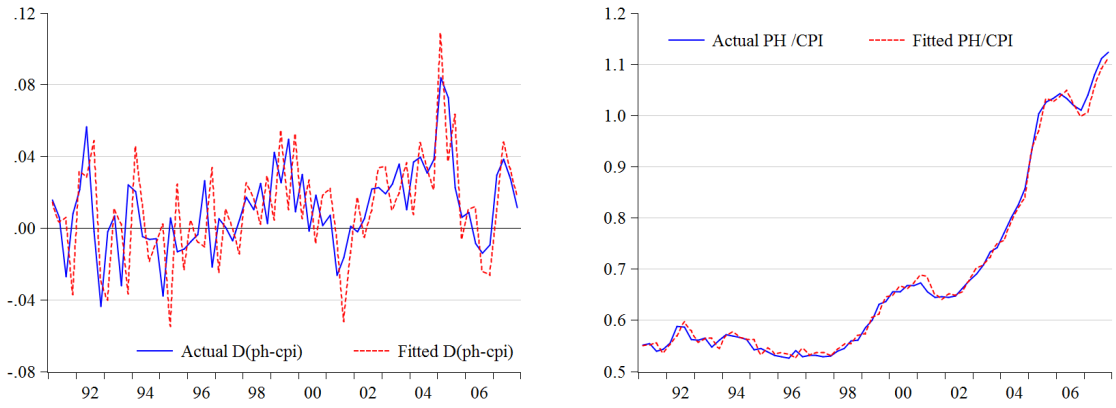

Figure 7.11. Fitted and actual $\Delta(ph_t - cpi_t)$ and PH_t/CPI_t

Single equation dynamic responses of (7.18):

Table 7.11. Responses of $ph - cpi$ to a 1% increase in RHS variables

Quarters	kh	ly	RLV
Simultaneous	0.00	0.00	−0.96
One quarter ahead	−0.08	0.08	−1.42
Four quarters ahead	−0.41	0.41	−1.77
Eight quarters ahead	−0.78	0.78	−1.80
Long run	−1.47	1.47	−1.76
50% of long-run effect	8Q	8Q	O/S
90% of long-run effect	23Q	23Q	O/S
Steady state solution:			
$(ph - cpi) = const - 1.469(kh - ly) - 1.763RLV$			

7.1.12. Building costs (BC)

Building costs are determined by consumer prices and unit labour costs:[34]

[34]The relative weights in BC reflect the weights of material and labour costs in the calculation of the building cost index by Statistics Iceland.

$$\Delta bc_t = 0.70\Delta cpi_t + 0.30\Delta ulct_t \tag{7.19}$$

where:

BC	Building costs (7.19).
CPI	Consumer price index (7.2).
$ULCT$	Trend unit labour costs (6.4).

7.2. Inflation

7.2.1. Quarterly and annual inflation rates ($INFULQ$, $INFUL$, $INFQ$, INF and $WINF$)

Quarterly inflation is calculated as:

$$INFULQ_t = CPIUL_t/CPIUL_{t-1} - 1 \tag{7.20}$$
$$INFQ_t = CPI_t/CPI_{t-1} - 1 \tag{7.21}$$

and year-on-year inflation as:

$$INFUL_t = CPIUL_t/CPIUL_{t-4} - 1 \tag{7.22}$$
$$INF_t = CPI_t/CPI_{t-4} - 1 \tag{7.23}$$

where:

$INFULQ$	Underlying quarterly CPI inflation rate (7.20).
$INFQ$	Quarterly CPI inflation rate (7.21).
$INFUL$	Underlying four-quarter CPI inflation rate (7.22).
INF	Four-quarter CPI inflation rate (7.23).
$CPIUL$	Consumer price index excluding indirect taxes (7.2).
CPI	Consumer price index (7.2).

Similarly, year-on-year world inflation is given as:

$$WINF_t = WCPI_t/WCPI_{t-4} - 1 \tag{7.24}$$

where:

$WINF$	Four-quarter world inflation rate (7.24).
$WCPI$	World consumer prices (exogenous).

7.3. Inflation expectations

Inflation expectations in QMM contain a backward- and a forward-looking component, with the forward-looking part based on rational (model consistent) expectations (obtained from (7.2) using the Fair-Taylor algorithm).

7.3.1. Break-even inflation expectations ($INFE$)

Historical data on break-even inflation expectations in QMM are obtained from the interest rate spread between nominal and indexed bonds, taking account of an inflation risk premium, cf. equation (4.7):

$$INFE_t = \frac{(1 + RL_t)}{(1 + RLV_t)(1 + PRISK_t)} - 1 \tag{7.25}$$

For forecasting, break-even inflation expectations are given as the five year average of the model-consistent expected inflation rate:

$$INFE_t = 0.85\ INFE_{t-1} + 0.15 \left[\frac{1}{20} \sum_{j=0}^{19} INF_{t+j} \right] \tag{7.26}$$

where:

$INFE$	Break-even inflation expectations (7.25).
RL	Long-term interest rate (4.6).
RLV	Long-term indexed interest rate (4.7).
$PRISK$	Inflation risk premium (exogenous).
INF	Four-quarter CPI inflation rate (7.23).

8. Fiscal policy

The fiscal part mainly comprises accounting identities and adding-up constraints using exogenous tax rates.

8.1. Government income

8.1.1. Taxation receipts (TAX)

Total taxation receipts are an accounting identity:

$$TAX_t = TJ_t + TC_t + TE_t \tag{8.1}$$

where:

TAX	Total tax receipts (8.1).
TJ	Household tax payments (8.2).
TC	Corporate tax payments (8.6).
TE	Total taxes on production and imports (8.11).

8.1.2. Household tax payments (TJ, TJY, TI and TJO)

Household tax payments are given by the sum of receipts from taxes on household income, financial income and other taxes paid by households:

$$TJ_t = TJY_t + TI_t + TJO_t \tag{8.2}$$

where:

TJ	Household tax payments (8.2).
TJY	Household income tax (8.3).
TI	Household financial income tax (8.4)
TJO	Other household tax payments (8.5).

Household income tax payments are given as:

$$\begin{aligned} TJY_t &= RJY_t \times (YE_t \times (1 - DPENS_t) + CJT_t + YICT_t \\ &\quad + SPENS_t + UNPM_t) - ALLOW_t \times POWA_t \end{aligned} \tag{8.3}$$

where:

TJY	Household income tax (8.3).
RJY	Household income tax rate (exogenous).
YE	Wages, salaries and self-employed income (9.2).
CJT	Current grants to the household sector subject to taxation (8.17).
$UNPM$	Unemployment benefits (8.19).
$YICT$	Households' other income subject to taxation (9.4).
$SPENS$	Withdrawal from third-pillar pension savings (exogenous)
$ALLOW$	Personal allowances (exogenous).
$DPENS$	Changes in proportion of employee's payment in pension funds and third pillar savings (exogenous).
$POWA$	Population at working age (16-64 years old) (exogenous).

Tax payments on financial income as a ratio to nominal GDP are given as a function of real equity prices and long-term nominal interest rates:[35]

$$\begin{aligned} TI_t/GDPN_t &= 0.00106 - \underset{(0.3)}{0.0001}Q1 - \underset{(-2.4)}{0.0006}Q2 - \underset{(-0.8)}{0.0002}Q3 \\ &\quad + \underset{(13.1)}{1.476}TI_{t-1}/GDPN_{t-1} - \underset{(-4.5)}{0.505}TI_{t-2}/GDPN_{t-2} \\ &\quad + \underset{(2.3)}{0.0004}(eqp_{t-4} - pgdp_{t-4}) - \underset{(-2.0)}{0.014}\Delta_4 RL_{t-4} - \underset{(-2.6)}{0.001}D073083 \end{aligned} \tag{8.4}$$

[35]The equation estimate is based on a dataset which spans 1998-2011. This estimate gives sensible coefficients but a constant that brings the $TI/GDPN$ ratio to a negative ratio shortly after the simulations starts. The constant was, therefore, calibrated to give the 2009-2013 average ratio of $TI/GDPN$ which is approximately 0.75%.

Estimation method	OLS
Adjusted R^2	0.976
Equation standard error	0.06%
LM test for serial correlation (F-test)	3.68 [0.06]
Normality test (χ^2-test)	1.78 [0.41]
White test for heteroscedasticity (F-test)	3.19 [0.01]
Sample period	1998:Q3-2011:Q4 ($T = 56$)

where:

TI	Household financial income tax (8.4)
$GDPN$	Nominal GDP (5.63).
EQP	Equity prices (4.19).
$PGDP$	GDP price deflator (7.16).
RL	Long-term interest rate (4.6).
$D073083$	Dummy variable: 1 2007:Q3-2008Q3 and zero elsewhere.
$Q1$-$Q3$	Centered seasonal dummies.

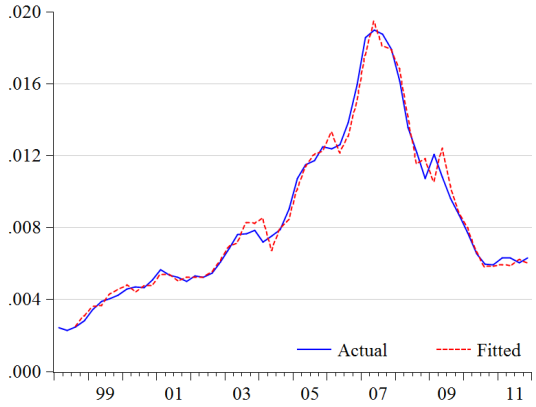

Figure 8.1. Fitted and actual $TI_t/GDPN_t$

Single equation dynamic responses of (8.4):

Table 8.1. Responses of $TI/GDPN$ to a 1% increase in RHS variables

Quarters	$(eqp - pgdp)$	RL
Simultaneous	0.00	0.00
One quarter ahead	0.00	0.00
Four quarters ahead	0.00	−0.01
Eight quarters ahead	0.00	−0.09
Long run	0.01	0.00
50% of long-run effect	15Q	-
90% of long-run effect	38Q	-
Steady state solution: $TI/GDPN = const + 0.014(eqp - pgdp)$		

Other household direct taxes are given as:

$$TJO_t = RJO_t \times GDPN_t \tag{8.5}$$

where:

TJO	Other household tax payments (8.5).
RJO	Household other tax rate (exogenous).
$GDPN$	Nominal GDP (5.63).

8.1.3. Corporate tax payments (TC, TCI, TCP, TIC and TWC)

Corporate tax payments are given by the sum of receipts from corporate income and property taxes:

$$TC_t = TCI_t + TCP_t + TIC_t + TWC_t \tag{8.6}$$

where:

TC	Corporate tax payments (8.6).
TCI	Corporate income tax payments (8.7).
TCP	Corporate property tax payments (8.8).
TIC	Other tax payments (8.9).
TWC	Corporate wage cost tax payments (8.10).

Corporate income tax receipts are given as:

$$TCI_t = RCI_t \times GDPN_{t-4} \tag{8.7}$$

where:

TCI	Corporate income tax payments (8.7).
RCI	Corporate income tax rate (exogenous).
$GDPN$	Nominal GDP (5.63).

Corporate property tax receipts are given as:

$$TCP_t = RCP_t \times GDPN_t \tag{8.8}$$

where:

TCP	Corporate property tax payments (8.8).
RCP	Corporate property tax rate (exogenous).
$GDPN$	Nominal GDP (5.63).

Other tax payments are given as:

$$TIC_t = RFIC_t \times GDPN_t \tag{8.9}$$

where:

TIC	Other tax payments (8.9).
$RFIC$	Tax rate for other payments (exogenous).
$GDPN$	Nominal GDP (5.63).

Corporate wage costs tax payments are given as:

$$TWC_t = RWC_t \times YE_t \tag{8.10}$$

where:

TWC	Corporate wage cost tax payments (8.10).
RWC	Corporate wage cost tax rate (exogenous).
YE	Wages, salaries and self-employed income (9.2).

8.1.4. Taxes on expenditure (TE, $TVAT$, TSD and $TIMP$)

Total taxes on production and imports are given as the sum of value-added taxation receipts, tarriffs and other import taxes, and other expenditure taxation receipts:

$$TE_t = TVAT_t + TIMP_t + TSD_t \tag{8.11}$$

where:

TE	Total taxes on production and imports (8.11).
$TVAT$	Value-added taxation receipts (8.12).
$TIMP$	Tariffs and other taxes on imports (8.13).
TSD	Other expenditure taxation receipts (8.14).

Value-added taxation receipts are given as:

$$TVAT_t = RVAT_t \times CN_t \tag{8.12}$$

where:

$TVAT$	Value-added taxation receipts (8.12).
$RVAT$	Value-added tax rate (exogenous).
CN	Nominal private consumption (5.3).

Tariffs and other taxes on imports are given as:

$$TIMP_t = RIMP_t \times IMPN_t \tag{8.13}$$

where:

$TIMP$	Tariffs and other taxes on imports (8.13).
$RIMP$	Tax rate on imports (exogenous).
$IMPN$	Nominal imports of goods and services (5.43).

Other expenditure tax receipts are given as:

$$TSD_t = RSD_t \times CN_t \tag{8.14}$$

where:

TSD	Other expenditure taxation receipts (8.14).
RSD	Other expenditure tax rate (exogenous).
CN	Nominal private consumption (5.3).

8.2. Government expenditure and net borrowing

8.2.1. Subsidies ($SUBS$)

Government subsidies on production are given as:

$$SUBS_t = RTS_t \times GDPN_t \tag{8.15}$$

where:

$SUBS$	Government subsidies (8.15).
RTS	Effective subsidies rate (exogenous).
$GDPN$	Nominal GDP (5.63).

8.2.2. Other public sector expenditure (CJ, CJT, $UNCOST$, $UNPM$ and DI)

Besides government consumption and investment, government expenditure includes current grants to the household sector, unemployment benefits and interest rate payments on general government debt.

The ratio of grants to households (predominantly social security payments) to nominal GDP is assumed to be negatively related to the output gap:

$$\begin{aligned} CJ_t/GDPN_t &= \underset{(2.4)}{0.009} + \underset{(1.5)}{0.001}Q1 - \underset{(-2.5)}{0.002}Q2 - \underset{(-3.2)}{0.002}Q3 + \underset{(4.5)}{0.008}D091 \quad (8.16) \\ &\quad + \underset{(12.9)}{0.840}CJ_{t-1}/GDPN_{t-1} - \underset{(-2.2)}{0.028}GAPAV_t \end{aligned}$$

Estimation method	OLS
Adjusted R^2	0.830
Equation standard error	0.17%
LM test for serial correlation (F-test)	2.53 [0.12]
Normality test (χ^2-test)	4.75 [0.09]
White test for heteroscedasticity (F-test)	1.48 [0.20]
Sample period	1997:Q1-2012:Q4 ($T = 64$)

where:

CJ	Current grants to the household sector (8.16).
$GDPN$	Nominal GDP (5.63).
$GAPAV$	Annual average of output gap (5.70).
$D091$	Dummy variable: 1 2009:Q1 and zero elsewhere.
$Q1$-$Q3$	Centered seasonal dummies.

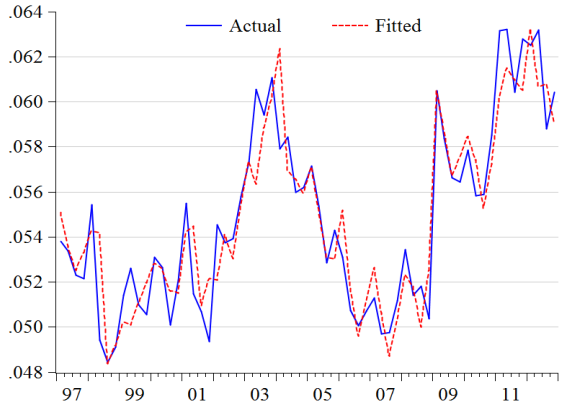

Figure 8.2. Fitted and actual $CJ_t/GDPN_t$

Single equation dynamic responses of (8.16):[36]

[36]Note that the steady state solutions for $GAPAV$ is zero. Hence, although the table reports 'long-run' effects, its effects on $CJ/GDPN$ is only temporary.

Table 8.2. Responses of $CJ/GDPN$ to a 1% increase in RHS variables

Quarters	$GAPAV$
Simultaneous	−0.03
One quarter ahead	−0.05
Four quarters ahead	−0.10
Eight quarters ahead	−0.14
Long run	−0.18
50% of long-run effect	3Q
90% of long-run effect	13Q
Steady state solution: $CJ/GDPN = const$	

Part of current grants to the household sector is subject to taxation. The taxed part is defined as the last calendar year percentage of CJ subject to taxation. In 2014 an estimated 75.1% of CJ was taxable according to Statistics Iceland sectoral accounts:

$$CJT_t = 0.751 \times CJ_t \tag{8.17}$$

CJT Current grants to the household sector subject to taxation (8.17).
CJ Current grants to the household sector (8.16).

The cost of each unemployed worker is assumed to grow at the same rate as wages:

$$UNCOST_t = \left(\frac{W_t}{W_{t-1}}\right) UNCOST_{t-1} \tag{8.18}$$

$UNCOST$ Cost of each unemployed worker (8.18).
W Wages (6.2).

Unemployment benefits paid out to the household sector evolve in accordance to unemployment and cost of each unemployed worker:

$$UNPM_t = UN_t \times UNCOST_t \tag{8.19}$$

$UNPM$ Unemployment benefits (8.19).
UN Level of unemployment (6.7).
$UNCOST$ Cost of each unemployed worker (8.18).

Interest payments on government domestic debt changes according to (8.20) below. 38% of debt are pension liabilities and indexed debt, 43% is non-indexed debt and 19% is debt in foreign currencies:[37]

[37] The weights are for 2014 and are obtained from Statistics Iceland.

$$\Delta DI_t = \left[0.38\left(\frac{0.04}{4}\right) + 0.43\left(\frac{RL_t}{4}\right) + 0.19\left(\left(\frac{EER_t}{EER_{t-1}}\right)\left(1+\frac{WRS_t}{4}\right)-1\right)\right] PSNB_t \quad (8.20)$$

where:

DI	General government debt interest payments (8.20).
RL	Long-term interest rate (4.6).
EER	Exchange rate index of foreign currency (4.10).
WRS	Foreign short-term interest rate (exogenous).
$PSNB$	Public sector net borrowing (8.21).

8.2.3. Public sector net borrowing ($PSNB$)

Public sector net borrowing is the sum of expenditure items less taxation receipts:

$$PSNB_t = (GN_t + IGNNET_t + CJ_t + UNPM_t + DI_t + SUBS_t) - TAX_t \quad (8.21)$$

where:

$PSNB$	Public sector net borrowing (8.21).
GN	Nominal government consumption (exogenous).
$IGNNET$	Nominal net government investment (5.18).
CJ	Current grants to the household sector (8.16).
$UNPM$	Unemployment benefits (8.19).
DI	General government debt interest payments (8.20).
$SUBS$	Government subsidies (8.15).
TAX	Total tax receipts (8.1).

9. Household income accounting

This final section closes QMM by defining the household income accounting identities.

9.1. Total household pre-tax income (YJ, YE, YIC, $YICT$ and $YDIJ$)

Total household sector pre-tax income is given by the identity:

$$YJ_t = YE_t \times (1 - DPENS_t) + CJ_t + UNPM_t + YIC_t + YDIJ_t + SPENS_t \quad (9.1)$$

where:

YJ	Total household pre-tax income (9.1).
YE	Wages, salaries and self-employed income (9.2).
CJ	Current grants to the household sector (8.16).
$UNPM$	Unemployment benefits (8.19).
YIC	Households' other income (9.3).
$YDIJ$	Other household non-labour income (9.5).
$SPENS$	Withdrawal from third-pillar pension savings (exogenous).
$DPENS$	Changes in proportion of employee's payment in pensions funds and third-pillar savings (exogenous).

Total wages, salaries and self-employed income is assumed to grow in line with nominal wages and employment:

$$\Delta ye_t = \Delta w_t + \Delta emph_t \tag{9.2}$$

where:

YE	Wages, salaries and self-employed income (9.2).
W	Wages (6.2).
$EMPH$	Total hours (6.13).

Households' other income is given as a constant ratio to wage income:

$$YIC_t = RIC_t \times YE_t \tag{9.3}$$

where:

YIC	Households' other income (9.3).
RIC	Ratio of households' other income to YE (exogenous).
YE	Wages, salaries and self-employed income (9.2).

Part of households' other income bears income tax. The fraction of YIC subject to taxation is estimated each calendar year, using the most recent data from Statistics Iceland sectoral accounts. In the year 2014 an estimated 73.9% of YIC was subject to income tax:

$$YICT_t = 0.739 \times YIC_t \tag{9.4}$$

where:

$YICT$	Households' other income subject to taxation (9.4).
YIC	Households' other income (9.3).

The share of households' (nominal) net financial income in nominal GDP is assumed to be determined by the slope of the yield curve ($RL - RS$), the short-term real interest rate ($RS - 4INFQ$) and the long-term real interest rate (RLV):[38]

[38]Following the 2008 financial crisis the $YDIJ/GDPN$ ratio falls significantly. Estimating the equation on a dataset which spans 1994-2006 gives sensible coefficients but a high constant. This high constant returns the $YDIJ/GDPN$ ratio in simulations quickly to the pre-2008 level, which

$$
\begin{aligned}
YDIJ_t/GDPN_t \;=\; & 0.001 - \underset{(-0.1)}{0.00003}Q1 + \underset{(2.4)}{0.001}Q2 - \underset{(0.1)}{0.00002}Q3 \\
& + \underset{(18.4)}{1.568}YDIJ_{t-1}/GDPN_{t-1} - \underset{(-7.9)}{0.675}YDIJ_{t-2}/GDPN_{t-2} \\
& - \underset{(-3.9)}{0.056}(RL_{t-1} - RS_{t-1}) - \underset{(-1.7)}{0.013}(RS_{t-1} - 4INFQ_{t-1}) \\
& - \underset{(-4.2)}{0.088}RLV_{t-1}
\end{aligned} \tag{9.5}
$$

Estimation method	OLS
Adjusted R^2	0.991
Equation standard error	0.11%
LM test for serial correlation (F-test)	0.00 [0.99]
Normality test (χ^2-test)	0.64 [0.73]
White test for heteroscedasticity (F-test)	2.49 [0.03]
Sample period	1994:Q3-2006:Q4 ($T = 50$)

where:

$YDIJ$	Other household non-labour income (9.5).
$GDPN$	Nominal GDP (5.63).
RS	Short-term interest rate (4.1).
RL	Long-term interest rate (4.6).
RLV	Long-term indexed interest rate (4.7).
$INFQ$	Quarterly CPI inflation rate (7.21).
$Q1$-$Q3$	Centered seasonal dummies.

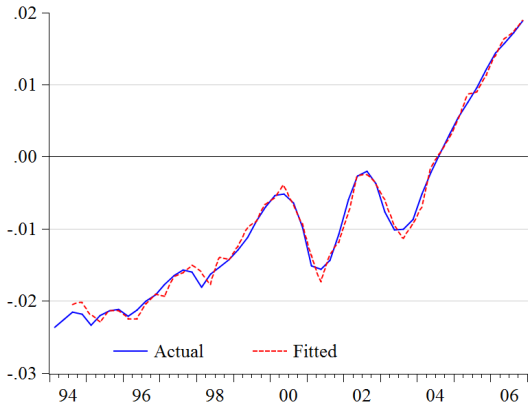

Figure 9.1. Fitted and actual $YDIJ_t/GDPN_t$

increases the disposable income quickly when simulations start. The constant was, therefore, calibrated to the 2009-2013 average level to avoid surging household financial income immediately after simulations start.

Single equation dynamic responses of (9.5):

Table 9.1. Responses of $YDIJ/GDPN$ to a 1% increase in RHS variables

Quarters	$RL-RS$	$RS-4INFQ$	RLV
Simultaneous	0.00	0.00	0.00
One quarter ahead	−0.06	−0.01	−0.09
Four quarters ahead	−0.34	−0.08	−0.53
Eight quarters ahead	−0.58	−0.14	−0.90
Long run	−0.53	−0.12	−0.82
50% of long-run effect	O/S	O/S	O/S
90% of long-run effect	O/S	O/S	O/S

Steady state solution:
$YDIJ/GDPN = const - 0.527(RL-RS) - 0.124(RS-4INFQ) - 0.819RLV$

9.2. Real household post-tax income ($RHPI$ and LY)

Real household post-tax income is defined as total household sector pre-tax income less tax deductions from household income, all deflated with the private consumption price deflator:

$$RHPI_t = \left[\frac{(YJ_t - TJ_t)/PC_t}{(YJ_{t-1} - TJ_{t-1})/PC_{t-1}}\right] RHPI_{t-1} \tag{9.6}$$

where:

$RHPI$	Real household post-tax income (9.6)
YJ	Total household pre-tax income (9.1).
TJ	Household tax payments (8.2).
PC	Private consumption deflator (7.11).

Real post-tax labour income is defined as:

$$LY_t = \frac{(YJ_t - YDIJ_t) - (TJ_t - TI_t)}{PC_t} \tag{9.7}$$

where:

LY	Real post-tax labour income (9.7)
YJ	Total household pre-tax income (9.1).
$YDIJ$	Other household non-labour income (9.5).
TJ	Household tax payments (8.2).
TI	Household financial income tax (8.4)
PC	Private consumption deflator (7.11).

10. Backward-looking version of QMM

Although the forward-looking version of QMM is generally used, a backward-looking version is also available. These are equations for the monetary policy rule (4.1), nominal long-term interest rates (4.6), the real exchange rate (4.16), and underlying inflation (7.1) and inflation expectations (7.26).

10.1. Short-term interest rates (RS)

The backward-looking version of the policy rule is given as:

$$RS_t = 0.6RS_{t-1} + 0.4\left[(RRN_t + IT_t) + 1.5(INFUL_t - IT_t) + 0.5GAPAV_t\right] \quad (10.1)$$

10.2. Long-term interest rates (RL)

The backward-looking version of the nominal long-term interest rate is given as:

$$\begin{aligned}\Delta RL_t \;=\; & \underset{(2.3)}{0.249}\Delta RL_{t-1} + \underset{(4.5)}{0.310}\Delta RS_t - \underset{(-2.4)}{0.164}\Delta RS_{t-1} - \underset{(-3.2)}{0.014}D063 \\ & -\underset{(-4.4)}{0.022}D091 - \underset{(-2.9)}{0.012}D102 - \underset{(-2.0)}{0.034}[RL_{t-1} - TERM_{t-1} - RS_{t-1}]\end{aligned} \quad (10.2)$$

Estimation method	OLS
Adjusted R^2	0.546
Equation standard error	0.40%
LM test for serial correlation (F-test)	0.02 [0.88]
Normality test (χ^2-test)	1.32 [0.52]
White test for heteroscedasticity (F-test)	0.31 [0.95]
Sample period	1997:Q1-2013:Q4 ($T = 68$)

where:

RL	Long-term interest rate (4.6).
RS	Short-term interest rate (4.1).
$TERM$	Term premium (exogenous).
$D063$	Dummy variable: 1 2006:Q3 and zero elsewhere.
$D091$	Dummy variable: 1 2009:Q1 and zero elsewhere.
$D102$	Dummy variable: 1 2010:Q2 and zero elsewhere.

10.3. Real exchange rate (REX)

The backward-looking version of the real exchange rate equation is given as:

$$(rex_t - rexeq_t) = \underset{(20.2)}{0.899}(rex_{t-1} - rexeq_{t-1}) + rid_t \quad (10.3)$$

Estimation method	OLS
Adjusted R^2	0.848
Equation standard error	4.43%
LM test for serial correlation (F-test)	0.37 [0.55]
Normality test (χ^2-test)	3.19 [0.20]
White test for heteroscedasticity (F-test)	3.88 [0.05]
Sample period	1997:Q1-2013:Q4 ($T = 68$)

where:

REX	Real exchange rate (4.16).
$REXEQ$	Equilibrium real exchange rate (exogenous).
RID	Real interest rate differential (4.9).

10.4. Inflation and inflation expectations ($CPIUL$ and $INFE$)

The backward-looking version of the inflation equation is given as:[39]

$$\begin{aligned}\Delta_4 cpiul_t &= \underset{(17.3)}{0.816}\Delta_4 cpiul_{t-1} + (1-0.816)\log(1+INFE_t) \\ &\quad + \underset{(6.6)}{0.070}\Delta_4 rexm_{t-1} + \underset{(3.3)}{0.114}\Delta_4 rulct_{t-4} + \underset{(3.3)}{0.165}GAPAV_{t-1}\end{aligned} \tag{10.4}$$

Estimation method	OLS
Adjusted R^2	0.941
Equation standard error	0.84%
Dynamic homogeneity (F-test)	3.70 [0.06]
LM test for serial correlation (F-test)	0.90 [0.35]
Normality test (χ^2-test)	5.12 [0.08]
White test for heteroscedasticity (F-test)	4.38 [0.00]
Sample period	1996:Q3-2009:Q4 ($T = 54$)

In the backward-looking version inflation expectations are assumed to be given as a weighted average of an adaptive expectations term and the inflation target, with the standard value of the weight on the adaptive expectations term, ω_{pe}, equal to 0.6 and the error correction in the adaptive expectations term, η_{pe}, given as 0.5:[40]

$$INFE_t = \omega_{pe}\left\{INFE_{t-1} + \eta_{pe}(INF_{t-1} - INFE_{t-1})\right\} + (1-\omega_{pe})IT_t \tag{10.5}$$

where:

[39] Due to the apparent residual heteroscedasticity, the equation reports White heteroscedasticity-consistent t-values in brackets.

[40] This implies that current inflation expectations are given by past expectations with a weight of 0.3, past inflation with a weight of 0.3 and the inflation target with a weight of 0.4.

$CPIUL$	Consumer price index excluding indirect tax effects (7.1).
$INFE$	Break-even inflation expectations (7.25).
$GAPAV$	Annual average of output gap (5.70).
$REXM$	Importers' real exchange rate (4.18).
$RULCT$	Real trend unit labour costs (6.5).
INF	Four-quarter CPI inflation rate (7.23).
IT	Central Bank of Iceland 2.5% inflation target (exogenous).

Part III
Model Properties

11. Monetary policy transmission mechanism in QMM

The propagation of monetary policy shocks throughout the economy is fairly standard in QMM. The model incorporates all the main channels of monetary policy, i.e. an interest rate channel, an asset price channel, an exchange rate channel, and an expectations channel. Through these channels the monetary policy shock propagates to aggregate demand, and from there to inflation. Figure 11.1 gives a simplified overview over these main transmission channels.[41]

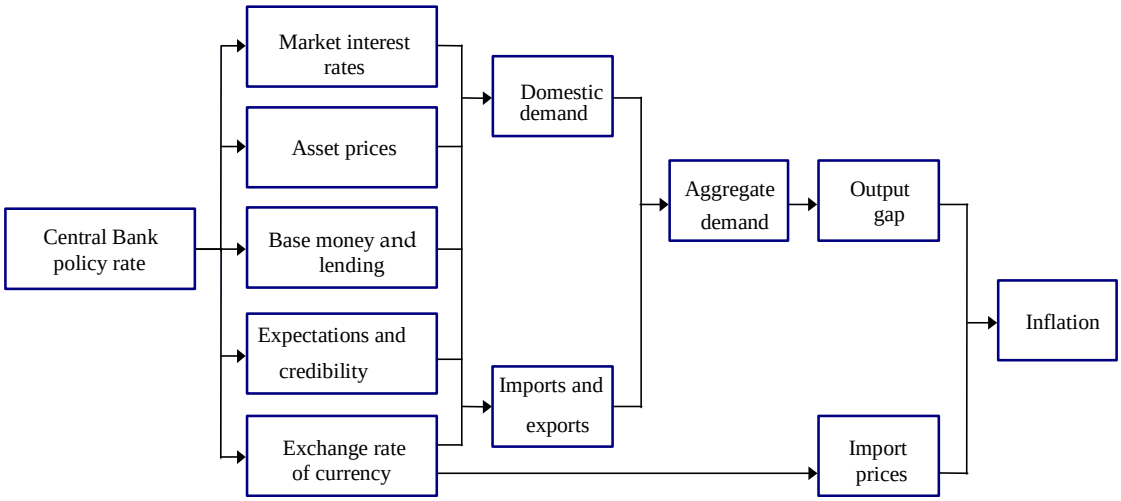

Figure 11.1. The transmission mechanism of monetary policy (Pétursson, 2001b)

11.1. Interest rate channel

In QMM, monetary policy actions are conducted through changes in the short-term interest rate (4.1). A rise in the policy rate affects the slope of the yield curve through long-term interest rates (4.6). If inflation expectations are sufficiently anchored, this will also raise the long-term real interest rates (4.7) and the real cost of capital (4.8). This has a first round effect on various expenditure items, such as consumption (5.2) and business investment (5.11), thus dampening domestic demand and easing capacity pressures as measured by the output gap (5.69). This further dampens demand for imported goods and services (5.41), increases unemployment (6.6), and reduces the demand for housing (7.18). Easing demand pressures reduces pressure on prices of domestic (7.2) and imported goods (7.6), and nominal assets, such as housing (7.18), and labour (6.2).

The second round effects are equally important (if not more so). For example, as demand in goods and labour markets falls, household labour income also declines (9.7), leading to a fall in total household disposable income (9.6). This further reduces private consumption and aggregate demand in the economy.

[41] From Pétursson (2001b), which gives a detailed discussion of these channels, with some structural VAR estimation results for Iceland. The credit channel, shown in Figure 11.1, does not really play a prominent role in QMM.

11.2. Asset price channel

Through its effect on asset prices, the monetary policy shock will also affect household net wealth and private sector balance sheets. A rise in the short-term interest rate will dampen the demand for money (4.28) and the subsequent rise in long-term interest rates and fall in nominal income will lead to a fall in equity prices (4.19) and rise in household debt (4.24). The rising debt and the fall in equity prices and in the market value of long-term bonds will reduce the net financial wealth of households (4.22) and the market value of firms. In addition, the fall in house prices will reduce housing investment (5.15), and both will reduce the housing wealth of households (4.21). Total household wealth (4.20) will therefore fall, reducing private consumption and aggregate demand further.

11.3. Exchange rate channel

An important channel for monetary policy in small open economies like Iceland is the working of monetary policy through changes in the exchange rate. The rise in short-term interest rates will usually lead to a currency appreciation (4.10), which will lead to a temporary real exchange rate appreciation (4.16) as domestic nominal prices adjust slowly. The competitive position of the export industry (4.17) will therefore weaken temporarily with export volumes (5.35) and export prices in domestic currency (7.10) declining. The competitive position of sectors competing with imported goods will also weaken as import prices in domestic currency (7.6) fall, thus pushing relative import prices (4.18) down and import volumes (5.41) up, hence shifting demand out of the economy. This increase in demand for imported goods will somewhat counteract the fall in imports stemming from falling domestic demand discussed above and may even lead to a worsening of the trade balance (5.54). The worsening of the competitive position of the export and domestic competitive sectors and the shift of demand out of the country will reduce overall output and dampen inflationary pressures. The ability of the business sector to pay wages and offer jobs will also be hurt, dampening wage pressures with identical second round effects through falling private sector incomes and demand as discussed above.

There is also a direct, supply effect of exchange rate changes to domestic prices through import prices. As import prices fall, imported goods become cheaper, leading directly to a fall in consumer prices (7.1) and output prices for goods using imported intermediate goods for production (7.13). This further dampens wage pressures with a further second round effect on prices through falling unit labour costs (6.4).

11.4. Expectations channel

Finally, the effects of monetary policy are strengthened further through its effects on private sector expectations. Long-term nominal interest rates (4.6) depend directly on expectations of future policy rate developments. The real exchange rate (4.16) and inflation (7.1) depend on expectations about its own future development and, hence, also on the expectations of future monetary policy. Expectations of a sustained tight

monetary policy can therefore affect demand and inflation over and above the direct effect of the current policy stance described above.

11.5. An illustration: A temporary 1 percentage point rise in the policy interest rate

To illustrate how monetary policy works in QMM, this section shows how an unanticipated 1 percentage point rise in the policy rate affects the economy over a ten years, or 40 quarters, period. The shock is assumed to last for one quarter but beyond that the short-term interest rate is assumed to follow the forward-looking Taylor rule (4.1).[42] As can be seen in Figure 11.2, the policy rate remains above baseline for five quarters, moving temporarily below the baseline in the sixth quarter as inflation falls below target, before returning to its pre-shock level within four years after the shock.

11.5.1. The effects on output and inflation

As shown in Figure 11.2, the immediate effects of the interest rate hike on inflation and output are rather small. However, output starts to fall markedly from baseline from the second quarter, with the peak effect occurring in the fifth quarter with output 0.27% below the baseline scenario. The inflationary effect takes similar time to emerge, with the peak effect occurring in the fourth quarter, with inflation 0.11 percentage points lower than in the baseline scenario. Both output and inflation are close to their baseline values after five to six years.

11.5.2. The transmission of the policy shock through the economy

Figure 11.2 also shows how the policy shock is transmitted through the economy to the final effects on output and inflation described above. The nominal long-term interest rate immediately rises by 46 basis points. This effect is relatively large compared to results in Pétursson (2001a), who uses a structural VAR analysis, and results from a similar analysis using other macroeconomic models, such as the Federal Reserve's FRB/US model reported in Brayton and Tinsley (1996). Since the nominal long-term rate rises by less than the policy rate, the typical inverted yield curve is obtained. As nominal prices are sticky, this leads to a similar rise in real long-term interest rates. Furthermore, as the interest rate differential vis-à-vis abroad rises, the nominal exchange rate immediately appreciates by 0.48% (or 1.9% in annual terms). Due to nominal price stickiness, this also leads to an appreciation of the real exchange rate with the real exchange rate peaking in the third quarter, before gradually returning to baseline. The QMM profile is however consistent with

[42] It is also assumed that the inflation target remains unchanged as do private agents' expectations of the target. The shock can therefore be thought of as a 'modest' intervention (cf. Leeper and Zha, 2003). Note also that the simulation results reported here only provide an illustration of the properties of QMM and cannot be used mechanically to predict how the economy reacts to monetary policy in reality, as all simulation exercises are highly stylised and are based on a number of simplifying assumptions.

international evidence from structural VAR analysis, cf. Eichenbaum and Evans (1995) and similar structural VAR results from Pétursson (2001b). The exchange rate response is also similar to what is found in similar experiments using the other country models, such as the TOTEM II model of Bank of Canada (Dorich et al., 2013), the NEMO model of Norges Bank (Brubakk et al., 2006) and the MOISE model of Bank of Israel (Argov et al., 2012).

Asset prices also fall immediately after the policy shock, with household net wealth immediately declining by 0.78 percentages points below the baseline (year-on-year) before fading out over the next six years.

Higher real interest rates and the real appreciation of the currency lead to a rise in the real cost of borrowing for investment and worsening of the competitive position of the export industry, leading to declining demand for labour. Thus, unemployment gradually starts to rise with the peak effect of roughly 0.03 percentages points occurring after one and a half year. The effects are similar to what is found in other models, such as the MOSES model of Riksbank (Bårdsen et al., 2011). With falling demand for labour, nominal wages start to decline below baseline, with year-on-year wage inflation falling 0.29 percentages points below the baseline scenario in the fifth quarter. The reduction in wage inflation is larger than the reduction in overall inflation, implying that real wages fall following the interest rate hike. The year-on-year growth in the real wage falls to 0.20 percentages points below baseline in the fifth quarter.

The rise in the real interest rates and exchange rate, together with declining private sector net wealth, lead to a fall in domestic demand. Consumption falls 0.39% below baseline in the sixth quarter and remains below baseline for three and a half year before moving above the baseline scenario, as real disposable income rises slightly and the real exchange rate appreciates, until they fade out. The effects on business investment are, however, much stronger than on private consumption. Business investment falls 0.68% below baseline in the fifth to sixth quarter. The effects on total investment are much more mooted as overall investment includes government, aluminium investment and investment in ships and airplanes, all of which are exogenous in QMM. The relative contribution of private consumption and investment to the contraction in domestic demand after a monetary policy shock in QMM is similar to what was found in the previous version of QMM, although with a higher contribution from private consumption and a somewhat lower from investment.

Finally, exports of goods and services start to contract in the third quarter as the real exchange rate appreciates, which increases the foreign currency export price and reduces export demand, with peak effect in the eighth quarter with exports 0.05% below baseline. The appreciation of the exchange rate puts downward pressure on import prices which leads to substitution towards imported goods in the short run. However, the effect from lower consumption and investment will nevertheless produce a fall in imports. Thus, the income effect from lower domestic demand is initially stronger than the relative price effect before the effect of lower import prices starts to dominate. A trade deficit emerges that peaks at 0.04% of baseline nominal GDP after one year.

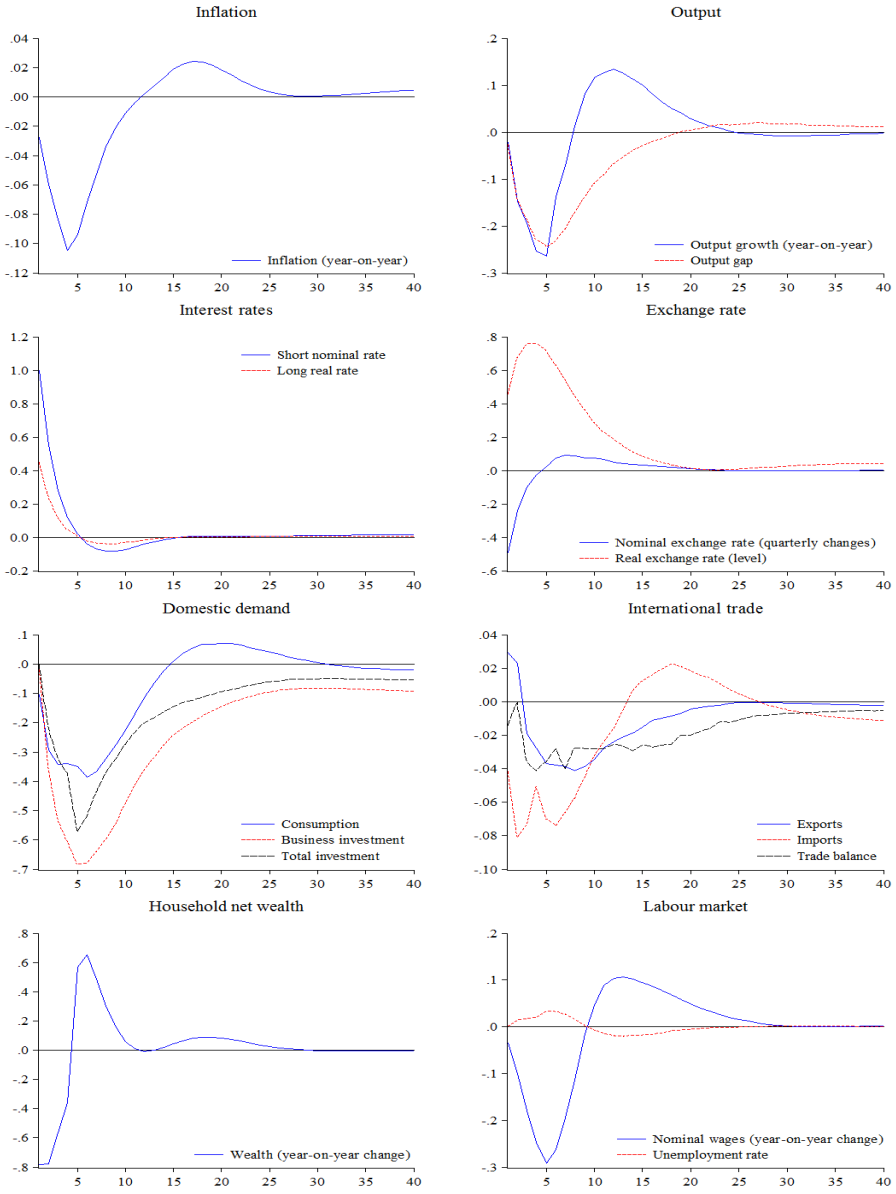

Figure 11.2. A monetary policy shock (deviations from baseline)

11.5.3. Comparison with international evidence

As Figure 11.2 illustrates, QMM generates the persistent and hump shaped impulse responses typically found in the empirical literature (cf. Christiano et al., 1999). Similar impulse responses are also found in euro area models (cf. Christoffel et al., 2008 and Adolfson et al., 2007) as well as models centred on other small economies (Beneš et al., 2009). The time lags and size of the monetary policy impulses are also quite similar to what is typically found in other macroeconomic models used at other

central banks, such as the COMPASS model of Bank of England (Burgess et al., 2013), Federal Reserve's FRB/US model (Brayton and Tinsley, 1996), the TOTEM II model of Bank of Canada (Dorich et al., 2013), the NEMO model of Norges Bank (Brubakk et al., 2006) and the MOISE model of Bank of Israel (Argov et al., 2012). The results are also in line with the survey results of various country models. For example, in a sample of twelve inflation targeting countries, Schmidt-Hebbel and Tapia (2002) find a peak decline in output for the median country to be 0.27% which is the same as in QMM, with 50% of the peak output effect attained in two quarters in both cases. They also find a peak decline in year-on-year inflation of 0.12 percentage points in the median country which is almost identical to the 0.11 percentage points decline found in QMM. The results in QMM are also similar to those found in Fagan and Morgan (2005) in a survey of euro area models. The results are also broadly similar to those found in Pétursson (2001b) using a structural VAR model.

11.5.4. Comparison with previous version of QMM

Since the forward-looking behaviour was introduced into QMM in Version 2.0, the dynamic properties of the model have greatly improved with a substantial decrease in the inherent oscillating behaviour. This continues to be the case for Version 3.0. For a more detailed comparison of previous versions of QMM see Daníelsson et al. (2009).

12. Other types of shocks

Whereas the previous section served to illustrate how a monetary policy shock propagates through the model economy, the shocks discussed in this section are designed to highlight different aspects of QMM and explain some important properties of the model in more detail.

Before proceeding, it is however worth noting some points concerning the interpretation of these shocks and their effects. First, the shocks analysed are assumed to be unanticipated by economic agents, but once they hit they are immediately recognised and acted upon. This also applies to the monetary policy authority, who uses the simple monetary policy rule assumed in QMM to counteract the initial shock to ensure that inflation expectations are anchored to the inflation target.[43] Second, the simulations assume that the economy is hit by a single isolated shock at a time. This is clearly a simplification as in reality the economy is typically hit simultaneously by multiple, and possibly interacting, shocks. For the purpose of exploring the properties of QMM, however, it is useful to keep things simple and look at different shocks individually.

We start by analysing two fiscal policy shocks that serve to highlight how fiscal policy can influence aggregate demand directly and through consumption decisions.

[43]Note that the monetary policy shock in the previous section is somewhat different in nature to the shocks in this section as the policy rate is an endogenous variable. The policy shock therefore reflects a temporary deviation from normal policy behaviour, while the shocks in this section represent shocks to exogenous variables.

They are also of importance as they give an idea of the size of the automatic fiscal stabilisers in QMM.[44] The third shock analysed is an exchange rate shock (e.g. stemming from a shock to the exogenous exchange rate risk premium). One interesting aspect of this shock is that it gives an idea of the level of the exchange rate pass-through in QMM. The fourth shock is a terms of trade shock which is obviously of interest in a small, open, and resource based economy such as Iceland. For similar reasons, the fifth shock − a world demand shock − is obviously of interest. The final shock is a domestic total factor productivity shock, which serves to highlight how demand and policy respond to a supply shock in QMM.

The results from the simulation exercises below are consistent with typical findings from the literature and are broadly in line with findings from other macroeconomic models, such as the COMPASS model of Bank of England (Burgess et al, 2013), Federal Reserve's FRB/US model (Brayton and Tinsley, 1996) (Laforte and Roberts, 2014), the TOTEM II model of Bank of Canada (Murchison and Rennison, 2006) (Dorich et al., 2013), the NEMO model of Norges Bank (Brubakk et al., 2006) and the macroeconomic model of Bank of Israel (Argov et al., 2007).

12.1. A government expenditure shock

Figure 12.1 illustrates the effect of a shock to the exogenously given government expenditure (G), amounting to a rise in nominal government expenditure equivalent to 1% of nominal GDP for four quarters. This rise in government expenditure directly raises domestic demand with output rising immediately by around 1.0% above baseline in the first four quarters, before fading out after six years. The increased demand for domestic goods and services leads to lower unemployment and higher wages, thus raising real disposable income. Asset prices also rise, and therefore net wealth as well, all contributing to a persistent rise in private consumption. There is also a small increase in investment reflecting the acceleration properties of business investment in QMM.

The rise in domestic demand leads to building up of inflationary pressures that monetary policy must counteract. It is assumed that the monetary policy authority immediately identifies the shock and responds to it by raising the short-term interest rate according to the monetary policy rule in the model. The following rise in real interest rates eventually contributes to some crowding-out of the initial government spending shock. The higher real interest rate also leads to a real exchange rate appreciation which leads to further crowding-out as exports decline compared to the baseline scenario. The biggest impact of the appreciation, however, is to direct a part of the increased expenditure towards imported goods and services, leading to a significant trade deficit.

[44] Note, however, that the analysis of these two fiscal shocks ignores the future fiscal implications of the shocks, i.e. how the current increase in expenditure or cut in taxes needs to be financed in the future. In a Ricardian setup the expectations of future financing fully crowds out the expansionary effects of the fiscal shock as private agents increase their savings to meet the future increases in taxes. Most research suggests, however, that this Ricardian equivalence effect is less than perfect (see, for example, Masson et al., 1995).

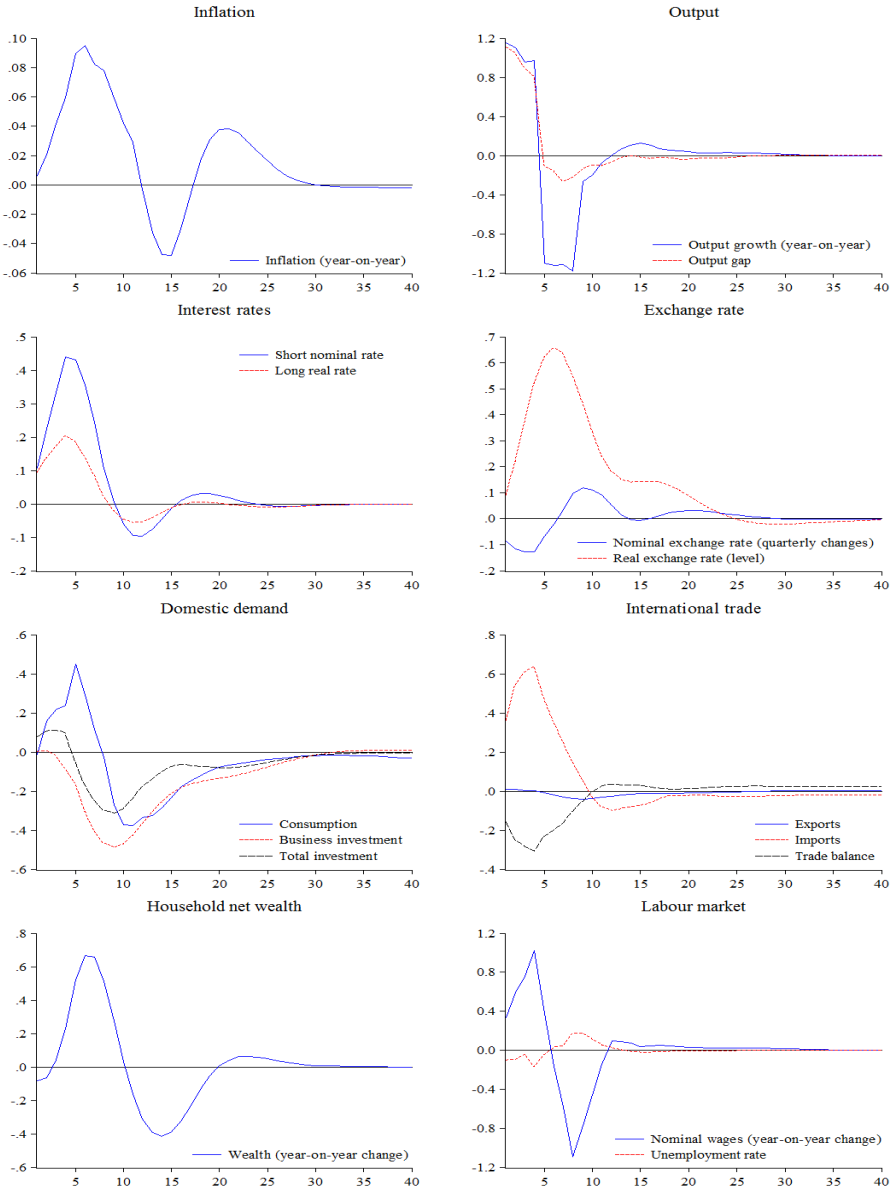

Figure 12.1. A government expenditure shock (deviations from baseline)

The rise in real interest rates and the real exchange appreciation eventually leads to a small negative output gap. This, together with the fact that private agents have perfect foresight about the temporary nature of the shock, also serves to limit the inflationary impact of the spending shock, with inflation straying only mildly from target.

The effects of a government expenditure shock in QMM are similar to those found in the literature, cf. Hemming et al. (2002) who find that the short-run fiscal expenditure multipliers are usually between 0.6 and 1.4 compared to 0.9 in QMM. The

short-run expenditure multiplier in small, open economies are usually found to be in the lower part of the range reported in Hemming et al. (2002) due to crowding-out effect of the real exchange rate appreciation and the 'leakage' effect through demand for imports. The short-run expenditure multiplier in QMM is somewhat higher than those found in other small, open economies such as New Zealand (Dunstan et al., 2007) and Denmark (Danmarks Nationalbank, 2003), but smaller than what is typically found in larger economies such as the United States (Reifschneider et al., 1999), the United Kingdom (Church et al., 2000) and the euro area (Fagan and Morgan, 2005).

12.2. An income tax shock

Figure 12.2 shows the effects of a temporary cut in the income tax rate (RJY), corresponding to 1% of nominal GDP for four quarters. This is equivalent to a $1\frac{2}{3}$ percentage point cut in the tax rate. The tax cut leads to increased supply of labour as labour income increases. This increase in labour income raises consumption and overall demand. However, the output effect of this shock takes a longer time to emerge compared to the government expenditure shock in the previous section as the tax cut only affects output indirectly through private sector spending decisions and is not a direct part of aggregate demand, as public consumption is. Thus, output rises only gradually and peaks at close to 0.45% above baseline in the fifth quarter, mainly through rising private consumption, before fading out.

The effect of the tax cut on inflation, the real exchange rate and interest rates is comparable to the effect of the government expenditure shock, again leading to crowding-out and leakage effects, thus eventually offsetting the output stimulation. The short-run tax multiplier is similar to those reported in Hemming et al. (2002), who report tax multipliers ranging from 0.3 to 0.8, compared to 0.45 found in QMM. They are also similar to the findings for the United States (Reifschneider et al., 1999) and the United Kingdom (Church et al., 2000), but somewhat larger than Dunstan et al. (2007) find for New Zealand.

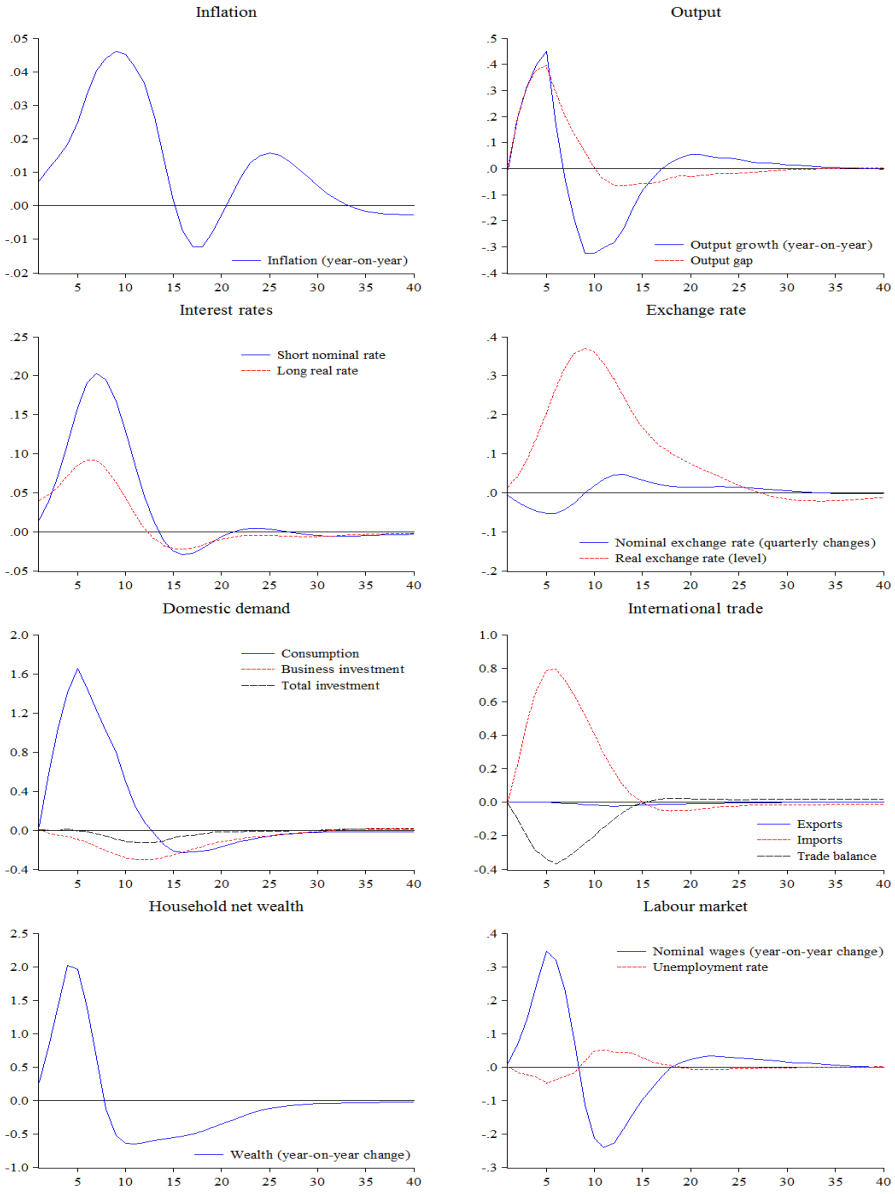

Figure 12.2. An income tax shock (deviations from baseline)

12.3. An exchange rate shock

Figure 12.3 illustrates the effects of a 1% temporary nominal exchange rate shock that is specified as a temporary increase in the exogenous currency risk premium ($RISK$). This negative portfolio shock is assumed to last for four quarters before returning to baseline. The nominal exchange rate immediately depreciates by 1% as the relative return on foreign assets rises in comparison with returns on domestic assets. The exchange rate continues to depreciate for a year. The real exchange rate

is likewise around 1% weaker for four quarters compared to the baseline scenario.

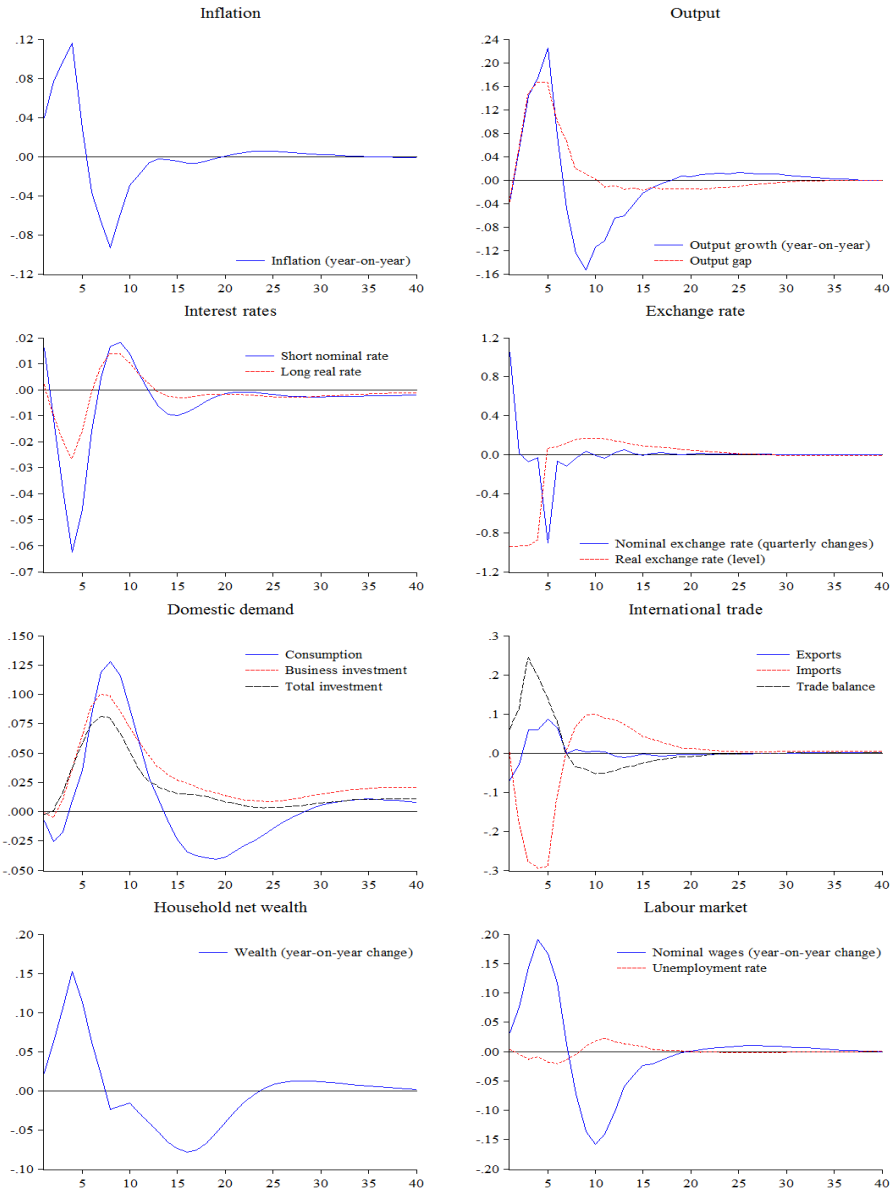

Figure 12.3. An exchange rate shock (deviations from baseline)

The depreciation puts upward pressure on inflation, both directly through rising import prices and indirectly through the opening up of a positive output gap. The central bank therefore raises the policy rate but the effects on real long-term rates are rather small due to the temporary nature of the shock.[45] Rising interest rates

[45] As the monetary policy rule assumed in QMM is forward-looking and responds to expected future inflation, the policy rates reacts less to an exchange rate shock than if the Taylor rule is specified in terms of current inflation.

lead initially to a contraction in consumption and investment but a positive output gap emerges due to a strong increase in net exports, which mainly comes from a contraction in demand for imported goods and services following the contraction in domestic demand and the depreciation of the currency. Finally, with inflation rising, other nominal prices, such as asset prices and wages follow.

This shock can also be analysed in terms of the rate of exchange rate pass-through, an issue of great importance in a small, open economy like Iceland. Thus, based on the above analysis, a 1% depreciation of the exchange rate gives a peak impact on inflation of roughly 0.11 percentage points, indicating a level of pass-through equal to 0.11. This is smaller than previous studies of exchange rate pass-through in Iceland have found (see *Monetary Bulletin* 2008/2, pp. 44-46) and Pétursson (2008, 2010), and smaller than found in previous versions of QMM (e.g. Daníelsson et al., 2009). A smaller pass-through than found in previous studies could reflect the fact that monetary policy is here allowed to respond to the depreciation of the currency and the fact that expectations here are forward-looking which dampens the inflationary effect of a temporary shock such as the one analysed here. A smaller pass-through could also reflect an improving anchoring of inflation expectations over time, which a number of studies have found that leads to a declining exchange rate pass-through (cf. Pétursson, 2008, 2010). But a smaller estimated pass-through could also simply reflect that the sample period used here includes the large exchange rate depreciation which coincided with a banking crisis and a large contraction in the real economy, which should have served in dampening the inflation effect of the collapsing currency.

12.4. A terms of trade shock

Figure 12.4 illustrates the effects of a 1% positive terms of trade shock driven by an exogenous increase in export prices for aluminium ($PXALU$). As import prices of alumina ($PMALU$) is a function of $PXALU$, $PMALU$ is assumed exogenous and to follow its baseline path in this exercise. The shock is assumed to last for four quarters before returning to baseline.

The improvement in terms of trade implies that domestic output is more valuable relative to world production. Domestic wealth and labour income therefore rise, which induces an increase in consumption. A large share of the increased consumption expenditure is however directed towards imported goods and services that are now relatively cheaper as the real exchange rate appreciates. Although the improvements in the terms of trade increase overall domestic demand, investment contracts due to the rise in the real interest rate and appreciation of the exchange rate which weakens the competitive position of industries excluding the aluminium.[46] The increased domestic demand following the terms of trade improvement increases output initially and opens up a positive output gap. The real exchange appreciation eventually leads to an offsetting contraction in exports and the negative contribution of net exports leads to a reduction in output.

[46]Note that aluminium exports are treated as exogenous in QMM. The positive terms of trade shock does therefore not induce an increase in production of these products in this exercise.

The appreciation of the domestic currency reduces inflation in the short run, and the central bank responds to a positive output gap by raising interest rates.

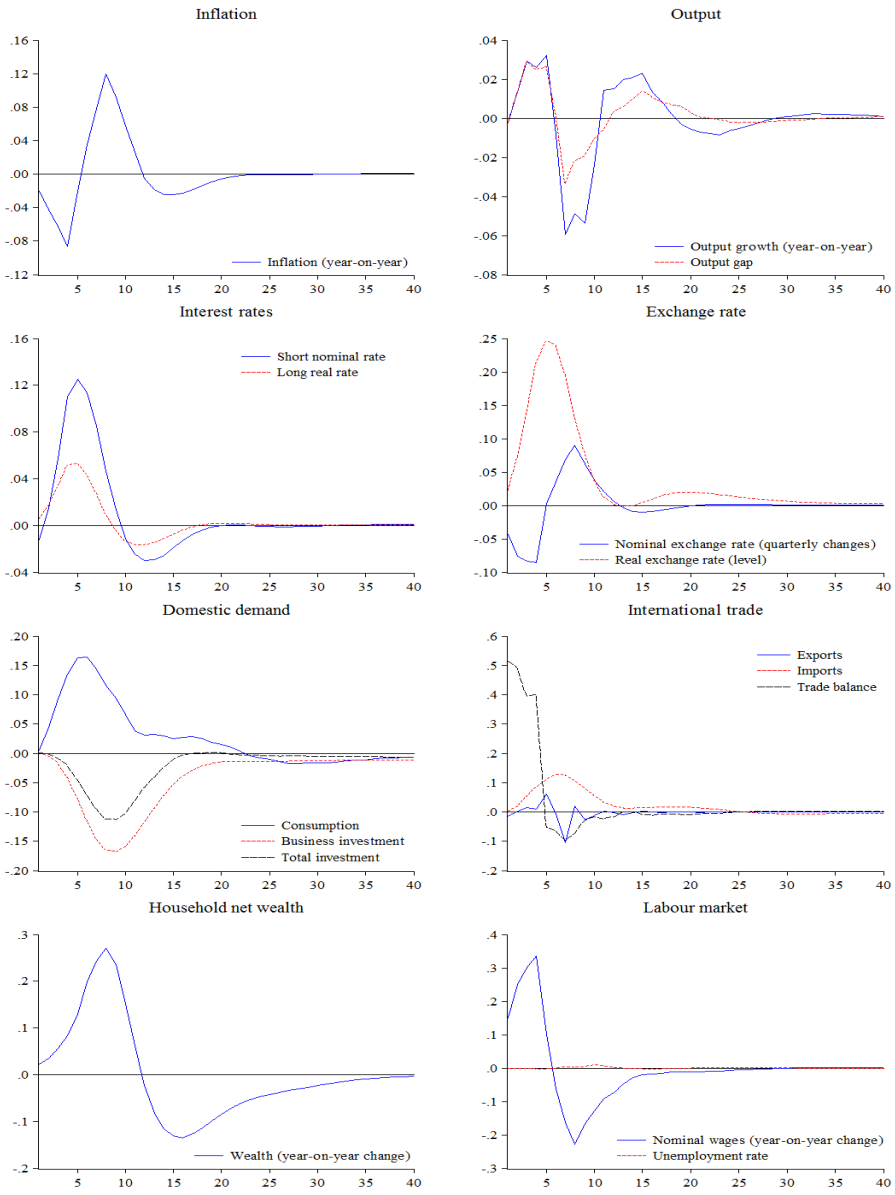

Figure 12.4. A terms of trade shock (deviations from baseline)

12.5. A world demand shock

The next experiment shows how a shock to world demand for Icelandic exports propagates through the economy. The shock is given by a 1% exogenous increase in both trade weighted world output ($WGDP$) and world trade ($TRADE$) and is assumed to last for four quarters before returning to baseline. The shock increases exports of

goods and services ($EXOTH$ and EXS) outside the two resources constraint items (exports of marine and aluminium goods and the related manufacturing services).

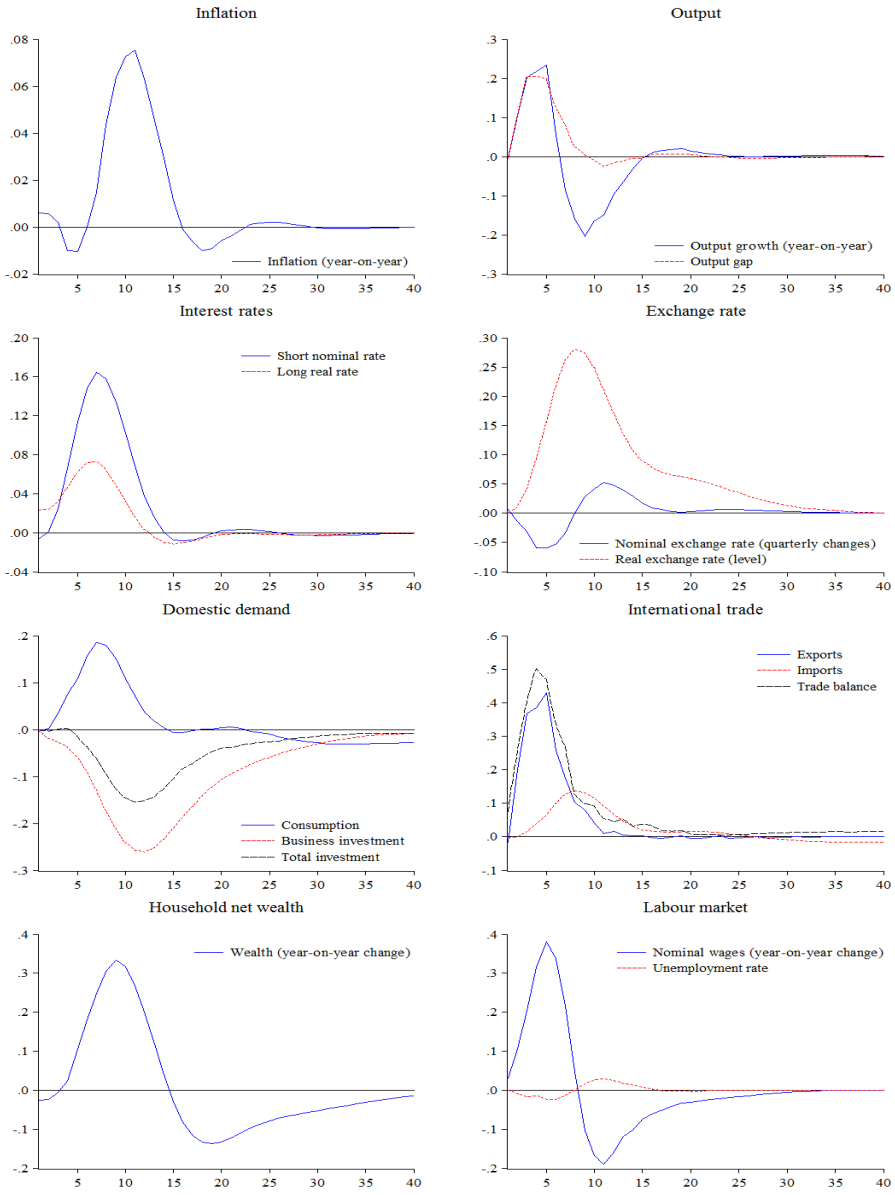

Figure 12.5. A world demand shock (deviations from baseline)

As Figure 12.5 illustrates, an increase in the demand for Icelandic exports leads to rising exports, with a peak effect in the fifth quarter when exports are 0.45% above baseline. The increase in demand for exports leads to an appreciation of the domestic currency, as a positive output gap creates expectations of future interest rate hikes, and increased demand for domestic factors of production, which puts upward pressures on employment and wages. As domestic incomes start rising, asset

prices move up, boosting household wealth and consumption expenditure. Investment expenditure falls due to higher real interest rate costs, however.

The increase in domestic demand and net exports lead to a positive output gap. Although inflation initially stays relatively flat due to the exchange rate appreciation, inflation starts rising as inflationary pressures gradually emerge. This is met with tightening of monetary policy that ensures that a negative output gap eventually opens up which is sufficient to return inflation to target.

12.6. A productivity shock

The last shock analysed is an exogenous 1% increase in total factor productivity, lasting for one year before returning to baseline (shown in Figure 12.6). This positive productivity shock increases potential output for given inputs of labour and capital and thus increases the output slack immediately by 1 percentage point.

This positive supply shock puts downward pressure on inflation which the central bank responds to by lowering interest rates. The fall in real interest rates leads to a depreciation of the currency which weighs against the disinflationary effect of the negative output gap. Nominal wages rise in line with improving productivity, thus adding to the boost from lower interest rates on private consumption. Furthermore, as real interest rates fall, investment starts to increase. The depreciation of the currency also boosts exports and imports rise despite the falling exchange rate as the positive income effect outweighs the negative substitution effect. As the increase in imports is larger than the increase in exports the trade deficit eventually opens up.

Finally, as domestic demand increases, output starts to rise which ensures that the negative output gap is eventually closed and a positive gap emerges so that the disinflation effect of the productivity shock is reversed.

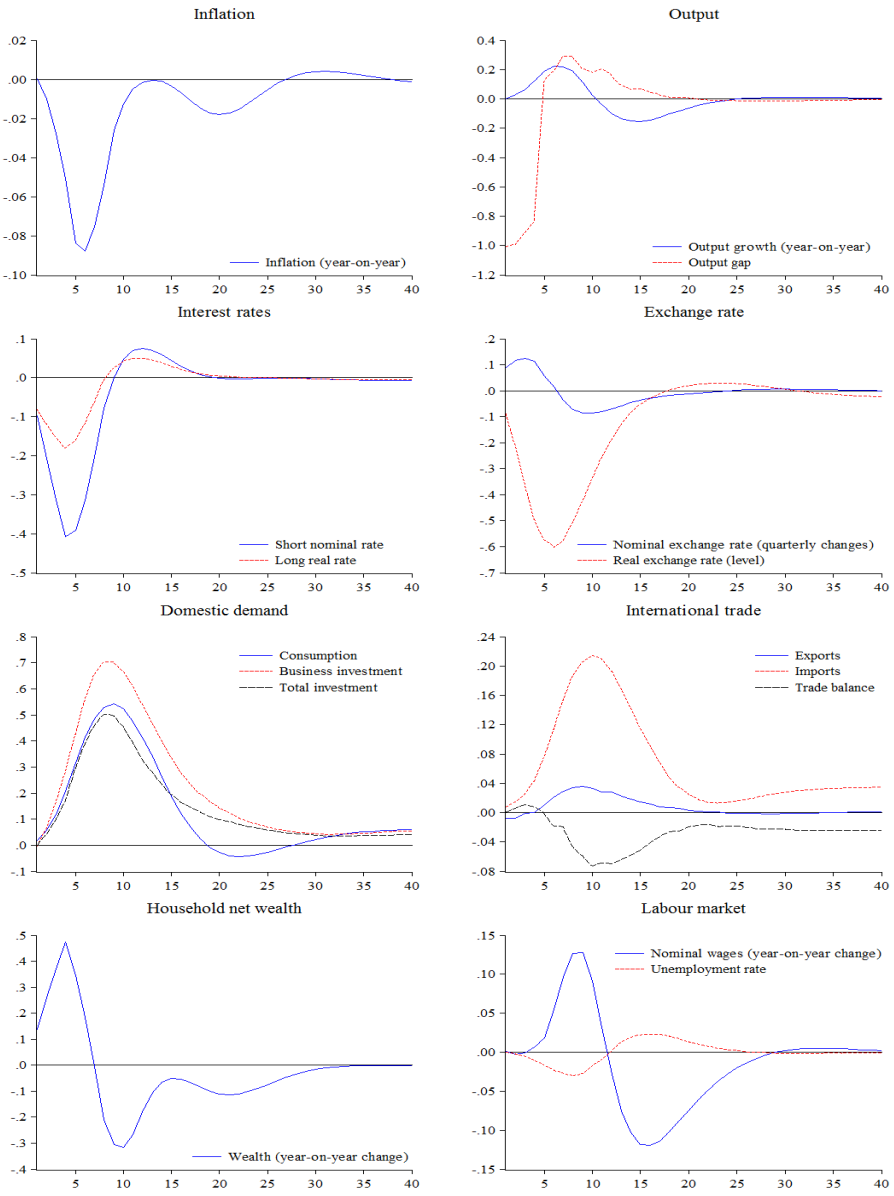

Figure 12.6. A productivity shock (deviations from baseline)

Part IV
Appendices

13. Variables listing

Table 13.1. List of variables

Name	Description	Type	Equations
ALLOW	Personal allowances	X	(8.3)
AVH	Average hours per worker	B	(**6.10**), (6.11), (6.13)
AVHA	Average hours per worker over 1991-2012	X	(6.10)
AVHT	Trend average hours per worker	D	(5.67), (**6.11**), (6.15)
BAL	Current account balance	I	(**5.58**), (5.61)
BALGOOD	Balance of goods	I	(5.54), (**5.55**)
BALSERV	Balance of services	I	(5.54), (**5.56**)
BALT	Balance of trade	I	(**5.54**), (5.58)
BC	Building costs	B	(7.13), (7.14), (7.15), (**7.19**)
BIPD	Balance of interest, salaries, dividends and profits	T	(**5.57**), (5.58)
BIPDF	Risk premium on world interest rate	X	(5.57)
BTRF	Balance of transfers	X	(5.58)
C	Private consumption	B	(**5.2**), (5.3), (5.22), (5.24), (5.62)
CJ	Current grants to the household sector	B	(**8.16**), (8.17), (8.21), (9.1)
CJT	Current grants to the household sector subject to income tax	T	(8.3), (**8.17**)
CN	Nominal private consumption	D	(4.23), (4.24), (**5.3**), (5.23), (8.12), (8.14)
CPI	Consumer price index	D	(4.10), (4.25), (4.26), (5.48), (5.51), (6.2), (6.5), (7.1), (**7.2**), (7.8), (7.11), (7.12), (7.18), (7.19), (7.21), (7.23)
CPIUL	Consumer price index excluding indirect taxes	B	(**7.1**), (7.2), (7.20), (7.22)
DD	Domestic demand	D	(**5.22**)
DDA	Import weighted domestic demand	D	(**5.24**), (5.48), (5.51)
DDN	Nominal domestic demand	I	(5.22), (**5.23**), (5.63)
DELTA	Depreciation rate for total capital stock	X	(4.8), (5.19)
DELTAB	Depreciation rate for business capital stock	X	(5.20)
DELTAG	Depreciation rate for government capital stock	X	(5.18)
DELTAH	Depreciation rate for housing stock	X	(5.21)
DH	Financial debt of households	T	(4.22), (**4.24**)
DI	General government debt interest payments	T	(**8.20**), (8.21)

Table 13.1. List of variables (continued)

Name	Description	Type	Equations
DPENS	Changes in proportion to employee's payment in pensions funds and third-pillar savings	X	(8.3), (9.1)
EER	Exchange rate index of foreign currency	D	(**4.10**), (4.11), (4.12), (4.17), (4.26), (5.26), (5.33), (5.35), (5.38), (5.60), (5.61), (7.4), (7.5), (7.7), (7.8), (7.9), (7.11), (8.20)
EMP	Level of employment in man-years	T	(**6.12**), (6.13)
EMPH	Total hours	D	(5.67), (**6.13**), (6.16), (9.2)
EMPHT	Trend total hours	D	(5.65), (**6.15**)
EMPT	Trend employment	D	(**6.14**), (6.15)
EQP	Equity prices	T	(**4.19**), (4.25), (4.28), (8.4)
EUR	Euro exchange rate	T	(**4.12**)
EUS	US dollar exchange rate	T	(**4.11**), (5.26), (5.32), (5.42),(5.45), (7.4), (7.9)
EX	Export volume of goods and services	D	(**5.25**), (5.62), (7.10)
EXAIR	Export volume of airplanes and ships	X	(5.26), (5.31)
EXAIRN	Nominal exports of airplanes and ships	D	(5.26), (5.29), (**5.31**)
EXALU	Exports of aluminium products	X	(5.26), (5.32)
EXALUN	Nominal exports of aluminium products	D	(5.29), (**5.32**)
EXG	Export volume of goods	D	(5.25), (**5.26**)
EXGN	Nominal exports of goods	I	(5.25), (5.26), (5.28), (**5.29**), (5.55)
EXMAR	Exports of marine products	X	(5.26), (5.33)
EXMARN	Nominal exports of marine products	D	(5.29), (**5.33**)
EXN	Nominal exports of goods and services	I	(5.25), (**5.28**), (5.63), (7.10)
EXOTH	Export volume of other goods	B	(5.26), (**5.35**), (5.36)
EXOTHN	Nominal export of other goods	D	(5.29), (**5.36**)
EXS	Export volume of services	D	(5.25), (**5.27**)
EXSMAN	Export volume of manufacturing services	X	(5.27), (5.40)
EXSMANN	Nominal exports of manufacturing services	D	(5.30), (**5.40**)
EXSN	Nominal exports of services	I	(5.25), (5.27), (5.28), (**5.30**), (5.56)

Table 13.1. List of variables (continued)

Name	Description	Type	Equations
EXSOTH	Export volume of other services	B	(5.27), (**5.38**), (5.39)
EXSOTHN	Nominal exports of other services	D	(5.30), (**5.39**)
FOH	Foreign holdings of Icelandic assets	T	(5.59), (**5.61**)
G	Government consumption	X	(5.4), (5.22), (5.24), (5.62)
GAP	Output gap	D	(**5.69**), (5.70),
GAPAV	Annual average of output gap	D	(4.1), (**5.70**), (7.1), (8.16)
GDP	GDP	D	(4.28), (5.11), (5.15), (5.21), (**5.62**), (5.67), (5.69), (6.6), (6.8), (6.10), (6.16), (7.16)
GDPN	Nominal GDP	I	(**5.63**), (7.16), (8.4), (8.5), (8.7), (8.8), (8.9), (8.15), (8.16), (9.5)
GDPT	Potential output	B	(**5.65**), (5.68)
GDPTF	Final estimate of potential output	D	(**5.68**), (5.69)
GDPTX	Augmented estimate of potential output	B	(**5.67**), (5.68)
GFW	Gross financial wealth	T	(4.22), (**4.23**)
GN	Nominal government consumption	D	(**5.4**), (5.23), (8.21)
HW	Housing wealth	D	(4.20), (**4.21**)
I	Fixed investment	I	(**5.5**), (5.6), (5.19), (5.22), (5.24), (5.62)
IBAIR	Investment in airplanes and ships	X	(5.12)
IBALU	Aluminium sector investment	X	(5.12)
IBREG	Regular business investment	B	(**5.11**), (5.12)
IBUS	Business investment	I	(5.5), (**5.12**), (5.20)
IBUSN	Nominal business investment	I	(**5.13**)
IG	Government investment	X	(5.5), (5.17)
IGN	Nominal government investment	D	(5.13), (**5.17**), (5.18)
IGNNET	Nominal net government investment	D	(**5.18**), (8.21)
IH	Private sector housing investment	B	(4.23), (4.24), (5.5), (**5.15**), (5.16), (5.21)
IHEX	Adjustment factor for private sector housing stock	X	(5.21)
IHN	Nominal housing investment	D	(5.13), (**5.16**)
II	Net stockbuilding	X	(5.22), (5.62)
IIN	Nominal net stockbuilding	X	(5.22), (5.23), (5.62)

Table 13.1. List of variables (continued)

Name	Description	Type	Equations
IMP	Imports of goods and services	D	(**5.41**), (5.62), (7.6)
IMPAIR	Import volume of airplanes and ships	X	(5.42), (5.46)
IMPAIRN	Nominal imports of airplanes and ships	D	(5.42), (5.44), (**5.46**)
IMPALU	Import volume of goods for aluminium production	X	(5.42), (5.45)
IMPALUN	Nominal import of goods for aluminium production	D	(5.44), (**5.45**)
IMPG	Import volume of goods	D	(5.41), (**5.42**)
IMPGN	Nominal import of goods	I	(5.41), (5.42), (5.43), (**5.44**), (5.55)
IMPN	Nominal import of goods and services	I	(5.41), (**5.43**), (5.63), (7.6), (8.13)
IMPOTH	Import volume of other goods	B	(5.42), (**5.48**), (5.49)
IMPOTHN	Nominal import of other goods	D	(5.44), (**5.49**)
IMPS	Import volume of services	B	(5.41), (**5.51**), (5.52)
IMPSN	Nominal import of services	D	(5.41), (5.43), (**5.52**), (5.56)
IN	Nominal fixed investment	D	(**5.6**), (5.13), (5.23)
INF	Four-quarter CPI inflation rate	D	(**7.23**), (7.26)
INFE	Break-even inflation expectations	B	(4.7), (5.2), (**7.26**)
INFQ	Quarterly CPI inflation rate	D	(**7.21**), (9.5)
INFTAX	Effects of indirect taxes on the CPI	X	(7.2)
INFUL	Underlying four-quarter CPI inflation rate	D	(4.1), (4.9), (**7.22**)
INFULQ	Underlying quarterly CPI inflation rate	D	(**7.20**)
ISA	Icelandic holdings of foreign assets	T	(5.59), (**5.60**), (5.61)
IT	Central Bank of Iceland inflation target	X	(4.1), (7.1)
K	Total capital stock	I	(5.18), (**5.19**), (5.65), (5.67)
KBUS	Business capital stock	I	(5.18), (**5.20**)
KH	Private sector housing stock	I	(4.21), (5.18), (**5.21**), (7.18)
LY	Real post-tax labour income	D	(7.18), (**9.7**)
M3	Broad money	B	(**4.28**)
NAIRU	Natural rate of unemployment	X	(5.67), (6.2), (6.6), (6.14)
NFA	Net foreign assets	I	(5.57), (**5.59**)
NFW	Net financial wealth	I	(4.20), (**4.22**)
PA	Participation rate	B	(6.7), (**6.8**), (6.9), (6.12)
PAT	Trend participation rate	D	(5.67), (**6.9**), (6.14)

Table 13.1. List of variables (continued)

Name	Description	Type	Equations
PC	Private consumption deflator	B	(4.23), (4.24), (5.2), (5.3), (5.22), (5.62), (**7.11**), (9.6), (9.7)
PCOM	Non-oil commodity prices in USD	X	(7.4), (7.9)
PG	Government consumption deflator	B	(5.4), (5.22), (5.62), (**7.12**)
PGDP	GDP price deflator	D	(4.18), (4.19), (4.28), (5.62), (6.2), (**7.16**), (8.4)
PH	House prices	B	(4.21), (4.23), (4.24), (5.15), (**7.18**)
PI	Investment goods price deflator	B	(5.6), (5.22), (5.31), (5.46), (5.62), (**7.13**), (7.15)
PIG	Government investment deflator	B	(5.17), (5.18), (**7.15**)
PIH	Housing investment price deflator	B	(5.15), (5.16), (**7.14**)
PM	Import price deflator	D	(4.18), (5.62), (**7.6**), (7.13)
PMALU	Import price deflator for alumnium production in USD	B	(5.42), (5.45), (**7.3**)
PMOTH	Import price deflator for other goods	B	(5.42), (5.48), (5.49), (**7.4**)
PMS	Import price deflator for services	B	(5.51), (5.52), (**7.5**)
POIL	Oil prices in USD	X	(7.4)
POWA	Population at working age (16-74)	X	(5.67), (6.7), (6.12), (6.14), (8.3)
PRBUS	Business premium on risk-free interest rate	X	(4.8)
PRISK	Inflation risk premium	X	(4.7)
PROD	Labour productivity	D	(6.3), (**6.16**), (6.17),
PRODT	Trend labour productivity	D	(6.4), (**6.17**)
PSNB	Public sector net borrowing	I	(8.20), (**8.21**)
PX	Export price deflator	D	(4.17), (5.62),(**7.10**)
PXALU	Price of aluminium products in US dollars	X	(5.26), (5.32), (7.3)
PXMAR	Price of marine products in foreign currency	B	(5.26), (5.33), (7.9)
PXOTH	Export prices of other goods	B	(5.26), (5.35), (5.36), (**7.7**)
PXS	Export prices of services	B	(5.27), (5.38), (5.39), (5.40), (**7.8**)
QDGDPT	Quarterly trend GDP growth rate	D	(5.60), (5.61), (**5.66**), (6.6), (6.10)

Table 13.1. List of variables (continued)

Name	Description	Type	Equations
RCC	Real cost of capital	D	(**4.8**), (5.11)
RCI	Corporate income tax rate	X	(8.7)
RCP	Corporate property tax rate	X	(8.8)
REM	Employers' wage-related cost	X	(6.3), (6.4)
REVA	Household assets revaluation term	T	(4.23), (**4.25**)
REVD	Household debt revaluation term	T	(4.24), (**4.26**)
REX	Real exchange rate	B	(4.10), (**4.16**), (6.2)
REXEQ	Equilibrium real exchange rate	X	(4.16), (6.2)
REXM	Importers' real exchange rate	D	(**4.18**), (7.1)
REXX	Exporters' real exchange rate	D	(**4.17**)
RFIC	Tax rate for other payments	X	(8.9)
RHPI	Real household post-tax income	D	(4.23), (4.24), (5.2), (**9.6**)
RIC	Ratio of households' other income to YE	X	(9.3)
RID	Real interest rate differential	D	(**4.9**), (4.16)
RIMP	Tax rate on imports	X	(8.13)
RISK	Exchange rate risk premium	X	(4.9)
RJO	Household other tax rate	X	(8.5)
RJY	Household income tax rate	X	(8.3)
RL	Long-term interest rate	B	(**4.6**), (4.7), (4.28), (8.4), (8.20), (9.5)
RLV	Long-term indexed interest rate	T	(**4.7**), (4.8), (5.15), (7.18), (9.5)
RRN	Real neutral interest rate	X	(4.1)
RS	Short-term interest rate	B	(**4.1**), (4.6), (4.9), (5.2), (9.5)
RSD	Other expenditure tax rate	X	(8.14)
RTS	Effective subsidies rate	X	(8.15)
RULCT	Real trend unit labour costs	D	(**6.5**), (7.1)
RVAT	Value-added tax rate	X	(8.12)
RWC	Corporate wage cost tax rate	X	(8.10)
SPEC	Trade specialisation	D	(5.51), (**5.53**)
SPENS	Withdrawal from third-pillar pension savings	X	(8.3), (9.1)
SUBS	Government subsidies	T	(**8.15**), (8.21)
TAX	Total tax receipts	I	(**8.1**), (8.21)
TC	Corporate tax payments	I	(8.1), (**8.6**)
TCI	Corporate income tax payments	T	(8.6), (**8.7**)

Table 13.1. List of variables (continued)

Name	Description	Type	Equations
TCP	Corporate property tax payments	T	(8.6), (**8.8**)
TE	Total taxes on production and imports	I	(8.1), (**8.11**)
TERM	Term premium	X	(4.6)
TI	Household financial income tax	B	(8.2), (**8.4**), (9.7)
TIC	Other tax payments	T	(8.6), (**8.9**)
TIMP	Tarriffs and other taxes on imports	T	(8.11), (**8.13**)
TJ	Household tax payments	I	(8.1), (**8.2**), (9.6), (9.7)
TJO	Other household tax payments	T	(8.2), (**8.5**)
TJY	Household income tax	T	(8.2), (**8.3**)
TRADE	World trade	X	(5.35), (5.38), (5.53)
TSD	Other expenditure taxation receipts	T	(8.11), (**8.14**)
TVAT	Value-added taxation receipts	T	(8.11), (**8.12**)
TWC	Corporate wage cost tax payments	T	(8.6), (**8.10**)
ULC	Unit labour costs	D	(**6.3**), (7.12)
ULCT	Trend unit labour costs	D	(6.2), (**6.4**), (6.5), (7.4), (7.19)
UN	Level of unemployment	D	(**6.7**), (8.19)
UNCOST	Cost of each unemployed worker	T	(**8.18**), (8.19)
UNPM	Unemployment benefits	D	(8.3), (**8.19**), (8.21), (9.1)
UR	Unemployment rate	B	(5.2), (5.67), (6.2), (**6.6**), (6.7), (6.8), (6.12)
W	Wages	B	(**6.2**), (6.3), (6.4), (8.18), (9.2)
WCPI	World consumer prices	X	(4.10), (5.35), (5.38), (7.5), (7.8), (7.24)
WEL	Household sector wealth	I	(**4.20**), (4.28), (5.2)
WEQP	World equity prices	X	(5.60), (5.61)
WGDP	World GDP	X	(5.53), (7.9)
WINF	Four-quarter world inflation rate	D	(4.9), (**7.24**)
WPX	World export prices	X	(4.17), (7.4), (7.7)
WRS	Foreign short-term interest rate	X	(4.9), (5.57), (8.20)
YDIJ	Other household non-labour income	B	(9.1), (**9.5**), (9.7)

Table 13.1. List of variables (continued)

Name	Description	Type	Equations
YE	Wages, salaries and self-employed income	T	(8.3), (8.10), (9.1), (**9.2**), (9.3)
YIC	Households' other income	T	(9.1), (**9.3**), (9.4)
YICT	Households' other income subject to taxation	T	(8.3), (**9.4**)
YJ	Total household pre-tax income	I	(**9.1**), (9.6), (9.7)
Summary			
	Total number of variables		201
	Number of behavioural variables	(B)	35
	Number of technical variables	(T)	28
	Number of definitions	(D)	58
	Number of identities	(I)	26
	Number of exogenous variables	(X)	54

Equations where variables are defined are in bold. D denotes definitions, B denotes behavioural variables, I denotes identities, T denotes technical definitions and X denotes exogenous variables.

Table 13.2. List of empirically estimated equations

Number of estimated equations		28	
Variable	Mnemonic	Equation number	Page number
Long-term interest rates	RL	4.6	21
Broad money demand	M3	4.28	28
Private consumption	C	5.2	30
Regular business investment	IBREG	5.11	33
Private sector housing investment	IH	5.15	35
Export volume of other goods	EXOTH	5.35	43
Export volume of other services	EXSOTH	5.38	45
Import volume of other goods	IMPOTH	5.48	49
Import volume of services	IMPS	5.51	51
Potential output	GDPT	5.65	56
Wages	W	6.2	59
Unemployment rate	UR	6.6	61
Participation rate	PA	6.8	63
Average hours per worker	AVH	6.10	65
Consumer price index excluding indirect taxes	CPIUL	7.1	68
Import price deflator for alumnium production in USD	PMALU	7.3	70
Import price deflator for other goods	PMOTH	7.4	72
Export prices of other goods	PXOTH	7.7	73
Export prices of services	PXS	7.8	75
Price of marine products in foreign currency	PXMAR	7.9	76
Private consumption deflator	PC	7.11	78
Government consumption deflator	PG	7.12	79
Investment goods price deflator	PI	7.13	80
Government investment deflator	PIG	7.15	82
House prices	PH	7.18	84
Household financial income tax	TI	8.4	88
Current grants to the household sector	CJ	8.16	93
Other household non-labour income	YDIJ	9.5	97

Table 13.3. Dummy variables in QMM

Dummy variable	Period equal to one	Equation that dummy variable enters
D971	1997:Q1	AVH (6.10)
D981	1998:Q1	IBREG (5.11)
D021	2002:Q1	IBREG (5.11)
D041	2004:Q1	EXOTH (5.35)
D051	2005:Q1	PH (7.18)
D054	2005:Q4	AVH (6.10)
D063	2006:Q3	PG (7.12)
D0723	2007:Q2-2007:Q3	M3 (4.28)
D073083	2007:Q3-2008:Q3	TI (8.4)
D08	2008:Q1-2008:Q4	M3 (4.28)
D0824	2008:Q2-2008:Q4	C (5.2)
D0834	2008:Q3-2008:Q4	PG (7.12)
D084	2008:Q4	M3 (4.28), IMPOTH (5.48), AVH (6.10), PXS (7.8)
D084091	2008:Q4-2009:Q1	IBREG (5.11)
D091	2009:Q1	IH (5.15), CJ (8.16)
D0924	2009:Q2-2009:Q4	PXMAR (7.9)
D0934	1 2009:Q3, -1 2009:Q4	PIG (7.15)
S9299	From: 1992Q1-1999Q4	W (6.2)
S0207	From: 2002Q1-2007Q4	W (6.2)
S091	From: 2009Q1	IH (5.15)
S093	From: 2009Q3	EXOTH (5.35)

14. Data description

In this section is a detailed description of the data used in QMM. The information includes the beginning of the series, the data source and unit, and any explanation of the data necessary. This might include how higher frequency observations are averaged to quarterly observations, how quarterly data was calculated in cases where only annual observations are available and how data from different sources was linked together.

The main data sources are the following:

Mnemonic	Institution	Icelandic
CBI	Central Bank of Iceland	Seðlabanki Íslands
DOL	Directorate of Labour	Vinnumálastofnun
MB	Macrobond	-
FIN	Ministry of Finance	Fjármálaráðuneytið
OMX	Nasdaq OMX Iceland	Kauphöll Íslands
ILMS	Institute of Labour Market Research	Kjararannsóknarnefnd
IMF	International Monetary Fund	Alþjóðagjaldeyrissjóðurinn
ISD	Icelandic Securities Depository	Verðbréfaskráning Íslands
RI	Registers Iceland	Þjóðskrá Íslands
NEI	National Economic Institute	Þjóðhagsstofnun
OECD	OECD	-
STATICE	Statistics Iceland	Hagstofa Íslands
DIR	Director of Internal Revenue	Ríkisskattstjóri

Name: $ALLOW$. **Short description:** Personal allowances. **Beginning of series:** 1988Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **Comment:** Defined as $(RJY \times (YE * (1 - DPENS) + CJT + YICT + SPENS + UNPM) - TJY)/POWA$.

Name: AVH. **Short description:** Average hours per worker. **Beginning of series:** 1991Q1. **Source:** STATICE/CBI. **Unit:** Weekly working hours. **Comment:** Since 1991 Statistics Iceland has reported number of average working hours based on its labour market survey, first biannually, i.e. in April and November, but quarterly since 2003. In order to generate continuous quarterly series for the whole period the biannual series was interpolated such that the series would have the same seasonal variation as the series after 2003.

Name: $AVHA$. **Short description:** Average hours per worker over 1991-2012. **Beginning of series:** 1991Q1. **Source:** STATICE/CBI. **Unit:** Weekly working hours. **Comment:** Defined as the average of AVH over the time period 1991-2012.

Name: $AVHT$. **Short description:** Trend average hours per worker. **Beginning of series:** 1991Q4. **Source:** STATICE/CBI. **Unit:** Weekly working hours. **Comment:** Defined as four-quarter moving average of AVH, (6.11).

Name: BAL. **Short description:** Current account balance. **Beginning of series:** 1978Q1. **Source:** CBI. **Unit:** Millions of kronas at current prices. **Comment:** With the implementation of the new standard ESA2010 in September 2014 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. An accounting identity defined as $BAL = BALT + BIPD + BTRF$.

Name: $BALGOOD$. **Short description:** Balance of goods. **Beginning of series:** 1995Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **Comment:** Defined as $EXGN - IMPGN$.

Name: $BALSERV$. **Short description:** Balance of services. **Beginning of series:** 1995Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **Comment:** Defined as $EXSN - IMPSN$.

Name: $BALT$. **Short description:** Balance of trade. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **Comment:** Defined as $BALGOOD + BALSERV$. Before 1997Q1 defined as $EXN - IMPN$.

Name: BC. **Short description:** Building costs. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Index, 2005 = 1. **Comment:** Measures changes in building costs of a specified block of flats. The index is normalised so that the average index of the quarters of year 2005 equals 1. **Detailed description:** Simple average of official monthly observations from 1976. Estimated series from CBI used prior to 1976.

Name: $BIPD$. **Short description:** Balance of interest, salaries, dividends and profits. **Beginning of series:** 1978Q1. **Source:** CBI/STATICE. **Unit:** Millions of kronas at current prices. **Comment:** Quarterly data available since 1978. With the implementation of the new standard ESA2010 in September 2014 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. **Detailed description:** From 1990Q1 to 1994Q4 the CBI figures for $BIPD$ are corrected for FISIM. In the national account of STATICE a part of what CBI categorises as $BIPD$ is put into the service account. In order to correct for this, the difference between STATICE and CBI service account is subtracted from $BIPD$. This difference is called FISIM (Financial intermediation services indirectly measured).

Name: $BIPDF$. **Short description:** Risk premium on world interest rate. **Beginning of series:** 1970Q2. **Source:** CBI. **Unit:** Fraction. **Detailed descrip-**

tion: This is a factor that makes $BIPD$ consistent with equation (5.57) in historical data. If net foreign assets would only consist of bonds it could be viewed as a pure interest rate premium. However, since $BIPD$ also includes equity holdings it is not a pure interest rate premium but rather a more general risk premium. It is obtained as $8BIPD_t/(NFA_t + NFA_{t-1}) - WRS_t$ in historical data but is generally treated as exogenous from the last observed value in forecasts and simulations.

Name: $BTRF$. **Short description:** Balance of transfers. **Beginning of series:** 1978Q1. **Source:** CBI. **Unit:** Millions of kronas at current prices. **Comment:** Quarterly data available from 1978. With the implementation of the new standard ESA2010 in September 2014 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995.

Name: C. **Short description:** Private consumption. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **ECOTRIM:** Flow AR(1) Max Log Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** *Period from 1970 to 1979:* The annual value is divided between the quarters such that the growth rate in each quarter is the same and the growth over the year fits with the annual values. Seasonal variation derived from the period 1997 to 2003 is added. The difference between the annual value and the sum of the quarters is then distributed evenly between the quarters. *Period from 1979 to 1990:* 40% of annual values is split between the quarters using a simple disaggregation algorithm (minimizing the sum of squared residuals). The rest of the annual values is disaggregated using an auxiliary series for the quarterly variation. This series shows quarterly sales for consumption goods and private cars. *Period from 1990 to 1996:* This is disaggregated in the same way as the previous period, except the additional (quarterly) series for the 60% of consumption uses VAT reports as an indication of sales volume. These reports are bi-monthly. Quarterly values were constructed simply by dividing every other period in half, thus splitting it evenly between the previous and the following period.

Name: CJ. **Short description:** Current grants to the household sector. **Beginning of series:** 1980Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow Boot, Feibes and Lisman – FD. **Comment:** The main items are social security payments, financial support from local government, payment for parental leave, child benefits and interest rate subsidies (the last two items are linked to income so they are in a way a negative part of the income tax). **Detailed description:** Annual data obtained from the sector accounts (*Disposable income from the household sector*) from STATICE. Quarterly data obtained with ECOTRIM using no reference series.

Name: CJT. **Short description:** Current grants to the household sector subject to taxation. **Beginning of series:** 1980Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **Comment:** The item in CJ currently subject to income tax is social security payments, financial support from local government and payment for parental leave. Before the year 2000 housing benefits were taxed with income tax. **Detailed description:** Annual data obtained from the sector accounts (*Disposable income from the household sector*) from STATICE. Quarterly data obtained by finding the taxed part of CJ for each calendar year and multiply it to the quarterly series of CJ. For the period 1980 to 1993 data is estimated using a fixed ratio subject to income tax in 1994 (found as CJ/CJT).

Name: CN. **Short description:** Nominal private consumption. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow AR(1) Max Log Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** *Period from 1970 to 1996:* Annual data on nominal private consumption from STATICE was disaggregated using ECOTRIM, using quarterly data on $CPI \times C$ as a related series.

Name: CPI. **Short description:** Consumer price index. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Index, 2005 = 1. **Comment:** Prior to 2008 CPI measurements were conducted by STATICE during the first two working days of each month. Quarterly data was obtained by using centralised quarterly averages using monthly observations of the headline CPI. For example, the fourth-quarter value was calculated as $[0.5CPI_{OCT} + CPI_{NOV} + CPI_{DEC} + 0.5CPI_{JAN}]/3$. Since January 2008, CPI measurements are conducted for a one-week period during the middle of each month. Therefore, since 2008Q1 quarterly data is obtained as simple quarterly averages of monthly observations of headline CPI. The index is normalised so that the average index of the quarters of the year 2005 equals 1.

Name: $CPIUL$. **Short description:** Consumer price index excluding indirect taxes. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Index, 2005 = 1. **Comment:** CPI excluding estimated effects of indirect taxes.

Name: DD. **Short description:** Domestic demand. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **ECOTRIM:** Flow AR(1) Max Log Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between

1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** *Period from 1970 to 1996:* Annual data on domestic demand from STATICE was disaggregated using ECOTRIM, using quarterly data on domestic demand from the income identity $DD = C + G + I + II$ at constant 1990 prices as a related series.

Name: DDA. **Short description:** Import weighted domestic demand. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** DDA is the sum of an estimated imported part of private consumption, government consumption and investment and is calculated as $DDA = 0.35C + 0.13G + 0.5I$.

Name: DDN. **Short description:** Nominal domestic demand. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **Comment:** With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. Defined from the income identity $DDN = CN + GN + IN + IIN$.

Name: $DELTA$. **Short description:** Depreciation rate for total capital stock. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Fraction. **ECOTRIM:** Flow AR(1) MaxLogPar: -.99 to .99. **Comment:** With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. The historical values of the depreciation rate are calculated using the STATICE annual data on depreciation which are disaggregated using ECOTRIM with quarterly data on K, constructed using the dynamic equation for the capital stock and lagged one period, as a reference series.

Name: $DELTAB$. **Short description:** Depreciation rate for business capital stock. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Fraction. **ECOTRIM:** Flow AR(1) MaxLogPar: -.99 to .99. **Comment:** With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. The historical values of the depreciation rate are calculated using the STATICE annual data on depreciation which are disaggregated using ECOTRIM with quarterly data on $KBUS$, constructed using the dynamic equation for the capital stock and lagged one period, as a reference series.

Name: $DELTAG$. **Short description:** Depreciation rate of government capital stock. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Fraction. **ECOTRIM:** Flow AR(1) MaxLogPar: -.99 to .99. **Comment:** With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. The historical values of the depreciation rate are calculated using the STATICE annual data on depreciation which are disaggregated using ECOTRIM with quarterly data on $K - KBUS - KH$, constructed using the dynamic equation for the capital stock and lagged one period, as a reference series.

Name: $DELTAH$. **Short description:** Depreciation rate of housing stock. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Fraction. **ECOTRIM:** Flow AR(1) Max Log Par : -.99 to .99. **Comment:** With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. The historical values of the depreciation rate are calculated using the STATICE annual data on depreciations which are disaggregated using ECOTRIM using quarterly data on KH, constructed using the dynamic equation for the capital stock and lagged one period, as a reference series.

Name: DH. **Short description:** Financial debt of households. **Beginning of series:** 1986Q1. **Source:** CBI. **Unit:** Millions of kronas at current prices (average prices during the period). **ECOTRIM:** StockL Boot, Feibes and Lisman - FD. **Detailed description:** Financial debt of households is obtained from quarterly data produced by the CBI (credit system, assets, loans and domestic securities holdings, individuals) from 1991Q4. Quarterly data for earlier periods have been estimated with ECOTRIM. The CPI is used to transform end-of-year data at end-of-year prices to average price during the period.

Name: DI. **Short description:** General government debt interest payments. **Beginning of series:** 1980Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow Boot, Feibes and Lisman - FD. **Detailed description:** Quarterly data on net general government debt interest rate payments obtained with ECOTRIM.

Name: $DPENS$. **Short description:** Changes in proportion of employee‘s payment in pensions funds and third-pillar savings. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Fraction. **Detailed description:** $DPENS$ treated as changes in proportion of employee's payment in pensions funds and third-pillar savings. Otherwise when historical data is available for real household post-tax

income (9.6) $DPENS$ is equal to zero.

Name: EER. **Short description:** Exchange rate index of foreign currency. **Beginning of series:** 1972Q1. **Source:** CBI. **Unit:** Index, 2005 = 1. **Comment:** Quarterly average of monthly average observations. The index is normalised so that the average index of the quarters of year 2005 equals 1. **Detailed description:** *Period from January 2009*: Official narrow trade exchange rate index, recalculated so that, on January 2, 2009, it was assigned a value equivalent to that of the discontinued trade-weighted exchange rate index. *Period from 1993 to 2008*: Trade-weighted exchange rate index, using trade and services weights from previous year bilateral trade (adjusted for third-country effects). The index includes the United States, Great Britain, Canada, Denmark, Norway, Sweden, Switzerland, Euro area and Japan, with the weights updated each year. *Period from 1980 to 1992:* From 1980 to 1992 the previous year bilateral trade and services weights are used. *Period from 1972 to 1979:* Up to 1980 the trade weights for 1980 are used.

Name: EMP. **Short description:** Level of employment in man-years. **Beginning of series:** 1991Q1. **Source:** CBI/STATICE. **Unit:** Heads measured in man-years. **Comment:** Calculated using official data on PA, $POWA$ and UR as described in equation (6.12).From 2003Q1 obtained from STATICE labour market survey by taking quarterly average of monthly values on number employed.

Name: $EMPH$. **Short description:** Total hours. **Beginning of series:** 1991Q1. **Source:** CBI. **Unit:** Total hours worked. **Comment:** Defined as $EMPH = EMP \times AVH$.

Name: $EMPHT$. **Short description:** Trend total hours. **Beginning of series:** 1991Q4. **Source:** CBI. **Unit:** Trend total hours worked. **Comment:** Defined as $EMPHT = EMPT \times AVHT$.

Name: $EMPT$. **Short description:** Trend employment. **Beginning of series:** 1991Q4. **Source:** CBI. **Unit:** Heads measured in man-years. **Comment:** Defined as $EMPT = PAT \times POWA \times (1 - NAIRU)$.

Name: EQP. **Short description:** Equity prices. **Beginning of series:** 1987Q1. **Source:** OMX/CBI. **Unit:** Index, 2005 = 1. **Comment:** Quarterly averages of end-of-month data from 1987 to 1993 and quarterly averages of daily data from 1993 onwards. **Detailed description:** From 1987Q1 to 1992Q4 the HMARK index published by VÍB was used as no official stock index data existed. From 1993Q1 to 2003Q4 ICEX-MAIN stock index was used. From 2004Q1 the OMXIPI index published by ISD is used. The index is normalised so that the average index of the quarters of year 2005 equals 1.

Name: EUR. **Short description:** Euro exchange rate. **Beginning of series:** 1999Q1. **Source:** CBI. **Unit:** Index, 2005 = 1. **Comment:** Icelandic kronas per 1

Euro. Quarterly data found by taking the average of monthly averages.

Name: EUS. **Short description:** US dollar exchange rate. **Beginning of series:** 1972Q3. **Source:** CBI. **Unit:** Index, 2005 = 1. **Comment:** Icelandic kronas per 1 US dollar (adjusted for krona re-denomination in 1980). Quarterly data found by taking the average of monthly averages.

Name: EX. **Short description:** Export volume of goods and services. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **ECOTRIM:** Flow AR(1) Max Log Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** *Period from 1970 to 1996:* Quarterly data obtained with ECOTRIM by disaggregating annual values using EXN/PX at constant 1990 prices as a related series. Annual data for the period 1970 to 1979 are calculated from the volume index.

Name: $EXAIR$. **Short description:** Export volume of airplanes and ships. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Detailed description:** Quarterly export of airplanes and ships in FOB value as computed by STATICE.

Name: $EXAIRN$. **Short description:** Nominal exports of airplanes and ships. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **Detailed description:** Nominal quarterly export of airplanes and ships in FOB value as computed by STATICE.

Name: $EXALU$. **Short description:** Export volume of aluminium products. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Detailed description:** Quarterly export of aluminium as computed by STATICE from the FOB value of aluminium exports and the price index for aluminium.

Name: $EXALUN$. **Short description:** Nominal exports of aluminium products. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **Detailed description:** Nominal quarterly export of aluminium as computed by STATICE in FOB value.

Name: EXG. **Short description:** Export volume of goods. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of

kronas at constant 2005 prices. **Comment:** Quarterly data available since 1997Q1 from STATICE.

Name: $EXGN$. **Short description:** Nominal exports of goods. **Beginning of series:** 1995Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **Comment:** Quarterly data available since 1997Q1 from STATICE. Defined as $EXGN = EXAIRN + EXALUN + EXMARN + EXOTHN$. **Detailed description:** *Period from 1995 to 1996:* Nominal exported goods are obtained from the CBI.

Name: $EXMAR$. **Short description:** Export volume of marine products. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Detailed description:** Quarterly export of aluminium as computed by STATICE from the FOB value of exported marine products and the price index for marine products.

Name: $EXMARN$. **Short description:** Nominal exports of marine products. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **Detailed description:** Nominal quarterly export of aluminium as computed by STATICE in FOB value.

Name: EXN. **Short description:** Nominal exports of goods and services. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow AR(1) Max Log Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** *Period from 1970 to 1977:* Exported goods are obtained from STATICE. Exported services were disaggregated using exported services as recorded by an older definition by STATICE as an indicator series. *Period from 1978 to 1996:* Exported goods and services are obtained from the CBI.

Name: $EXOTH$. **Short description:** Export volume of goods, excluding aluminium and marine products as well as exports of airplanes and ships. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** Consists of all exported goods excluding $EXALU$, $EXMAR$ and $EXAIR$.

Name: $EXOTHN$. **Short description:** Nominal exports of goods, excluding aluminium and marine products as well as nominal exports of airplanes and ships. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **Comment:** Consists of all nominal exported goods excluding $EXALUN$, $EXMARN$ and $EXAIRN$.

Name: EXS. **Short description:** Export volume of services. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Detailed description:** Quarterly export of services as calculated by STATICE.

Name: $EXSMAN$. **Short description:** Export volume of manufacturing services. **Beginning of series:** 1997Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** $EXSMANN$ is deflated with PXS to obtain $EXSMAN$.

Name: $EXSMANN$. **Short description:** Nominal exports of manufacturing services. **Beginning of series:** 1997Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **Comment:** With the implementation of the new standard ESA2010 in September 2014, goods for processing that are imported to Iceland for further processing and then re-exported without change in ownership are no longer included in trade in goods in the national accounts. Instead, they are included with value-added services trade (manufacturing services). **Detailed description:** *Period from 1997 to 2012:* Nominal exports of manufacturing services is obtained as the difference between exported goods for or after processing without change in ownership and imported goods for or after processing without change in ownership in the transition table published by STATICE. After 2012 STATICE has published a sub-category for manufacturing services, i.e. manufacturing services on physical inputs owned by others.

Name: $EXSN$. **Short description:** Nominal exports of services. **Beginning of series:** 1995Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **Comment:** Quarterly data available since 1997Q1 from STATICE. Defined as $EXSN = EXSMANN + EXSOTHN$. **Detailed description:** *Period from 1995 to 1996:* Nominal exported services are obtained from the CBI.

Name: $EXSOTH$. **Short description:** Export volume of other services. **Beginning of series:** 1997Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** Consists of exported services excluding $EXSMAN$.

Name: $EXSOTHN$. **Short description:** Nominal exports of other services. **Beginning of series:** 1997Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **Comment:** Consists of nominal exported services excluding $EXSMANN$.

Name: FOH. **Short description:** Foreign holdings of Icelandic assets. **Beginning of series:** 1989Q4. **Source:** CBI. **Unit:** Millions of kronas at current prices. **Comment:** Foreign holdings of Icelandic assets are from the balance of payments and external positions statistics (in the International investment positions table).

With the implementation of the new standard ESA2010 in September 2014 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. **Detailed description:** FOH equals Direct investment in Iceland + Portfolio investment liabilities + Financial derivatives liabilities + Other capital liabilities.

Name: G. **Short description:** Government consumption. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** *Period from 1970 to 1996:* Quarterly data obtained with ECOTRIM by disaggregating annual values using GN/PG at constant 1990 prices as a related series. Annual data for the period 1970 to 1979 are calculated from the volume index.

Name: GAP. **Short description:** Output gap. **Beginning of series:** 1991Q4. **Source:** CBI. **Unit:** Fraction. **Comment:** Defined as the deviation of GDP from potential output, given by (5.68).

Name: $GAPAV$. **Short description:** Annual average of output gap. **Beginning of series:** 1992Q3. **Source:** CBI. **Unit:** Fraction. **Comment:** Annual average of GAP defined in equation (5.70).

Name: GDP. **Short description:** Gross domestic production. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **ECOTRIM:** Flow AR(1) Max Log Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** *Period from 1970 to 1996:* Quarterly data obtained with ECOTRIM by disaggregating annual values using $DD + EX - IMP$ at constant 1990 prices as a related series. Annual data for the period 1970 to 1979 are calculated from the volume index.

Name: $GDPN$. **Short description:** Nominal gross domestic production. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data

before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** Defined from the income identity $GDPN = DDN + EXN - IMPN$.

Name: $GDPT$. **Short description:** Potential output. **Beginning of series:** 1991Q4. **Source:** CBI. **Unit:** Millions of kronas at constant 2005 prices. **Comment:** Potential (trend) output calculated from a Cobb-Douglas production function in equation (5.65).

Name: $GDPTF$. **Short description:** Final estimate of potential output. **Beginning of series:** 1991Q4. **Source:** CBI. **Unit:** Millions of kronas at constant 2005 prices. **Comment:** A weighted average of $GDPT$ and $GDPTX$ (5.68).

Name: $GDPTX$. **Short description:** Augmented estimate of potential output. **Beginning of series:** 1991Q4. **Source:** CBI. **Unit:** Millions of kronas at constant 2005 prices. **Comment:** Estimate of potential output based on the Cobb-Douglas production function in equation (5.65) using Hodrick-Prescott filtered measure of total factor productivity and four different estimates of trend employment (5.67).

Name: GFW. **Short description:** Gross financial wealth. **Beginning of series:** 1987Q1. **Source:** DIR/CBI/ISD. **Unit:** Millions of kronas at current prices (average prices during the period). **ECOTRIM**: StockL Fernandez Par : -.99 to .99 and StockL Boot, Feibes and Lisman – SD. **Comment:** Total household holding of bonds, bank deposits and equities. **Detailed description:** GFW consists of deposits with banks, bonds and equities. The CBI provides direct observations on deposits owned by households since 2003Q4. These data exist at a quarterly frequency. Data on the households ownership of bonds are annual data on bonds declared to the DIR. ECOTRIM is used to create quarterly data (StockL Fernandez Par : -.99 to .99) using data from CBI on changes in aggregate deposits as a related series. The CPI is used to transform end-of-quarter data at end-of-quarter prices to average prices during the period. Data on equity-ownerships by households are obtained from ISD. These are daily data and the quarterly value is obtained as the end-of-quarter value. EQP is used to transform end-of-quarter data at end-of-quarter prices to average prices during the period.

Before 2003Q4 quarterly data for the sum of deposits, bonds and equities were estimated from the sum of deposits and bonds as declared by the households to DIR using ECOTRIM to disaggregate the annual data (StockL Boot, Feibes and Lisman – SD) and from estimates from ISD of the end-of month value of registered shares owned by households. Estimates of equity owned by households was not available from ISD prior to 1999, therefore these earlier quarters were estimated from share prices and nominal share holdings of households as declared to the DIR. ECOTRIM (StockL Boot, Feibes and Lisman – SD) was used to estimate quarterly data on nominal share holdings of households. The two series (before 2003Q4 and after 2003Q4) for the sum of deposits, bonds and equities are linked so that the values

before 2003Q4 are increased by the factor between the two estimates of the sum for 2003Q4.

Name: GN. **Short description:** Nominal government consumption. **Beginning of series:** 1970Q1. **Source:** STATICE/FIN/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow AR(1) Max Log Par: -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** *Period from 1970 to 1996:* Monthly information on a part of government consumption for 1970 to 1996 is from FIN. To generate quarterly data for 1970-1996, information on wages were distributed evenly over the year, and changes within the year assumed to follow changes in the STATICE wage index. Wages were estimated at 2/3 of total government consumption. Government consumption, other than wages from above, was assumed to fluctuate within the year according to the monthly data. This constituted on average about 53% of total government consumption (varying between 47% and 60% in individual years). Other government consumption was disaggregated without the use of additional data.

Name: HW. **Short description:** Housing wealth. **Beginning of series:** 1970Q1. **Source:** STATICE/RI/CBI. **Unit:** Millions of kronas at current prices. **Comment:** Before 1998 the annual estimates of HW do not agree with STATICE data as they used BC to estimate price changes prior to 1998 instead of PH. **Detailed description:** Defined as $HW = 1.37 \times PH \times KH$. STATICE values the private sector housing stock at market price of housing (PH) but investment in housing at cost price (PIH). In 2005 the difference between these two prices were very large leading to two problems in QMM: Firstly, keeping the housing stock at constant 2005 prices requires investment in housing at constant 2005 prices to be much above its historical average as a share of GDP. The second problem was that the capital-output ratio increased very much compared to earlier periods when the national account variables were valued at year 2000 prices. Because of this, it was decided to scale KH at constant 2005 prices down by dividing each data point in the series by 1.37. KH is therefore multiplied with 1.37 when measured at current prices (HW).

Name: I. **Short description:** Fixed investment. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **ECOTRIM:** Flow Boot, Feibes and Lisman - FD and Flow AR(1) Max Log Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same

as was before the new standard implementation. **Detailed description:** Quarterly data for the period before 1997Q1 is obtained by: (1) Estimating quarterly data from annual data with ECOTRIM (Flow Boot, Feibes and Lisman - FD) using no reference series; (2) Estimate the seasonality factors in the quarterly series from 1997Q1 using STAMP and then adding these seasonality factors to the series constructed in (1); and (3) Using ECOTRIM (Flow AR(1) Max Log Par : -.99 to .99) to estimate quarterly data from annual data before 1997Q1 using the reference series constructed in (2).

Name: $IBAIR$. **Short description:** Investment in airplanes and ships. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** Quarterly data obtained from STATICE.

Name: $IBALU$. **Short description:** Aluminium sector investment. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **ECOTRIM:** Flow Boot, Feibes and Lisman - FD. **Comment:** Fixed investment in energy-intensive industries; i.e. investment in the production of metals (mostly aluminium) and in the production and distribution of electricity and (hot and cold) water. **Detailed description:** Quarterly data obtained from STATICE. With the implementation of the new standard ESA2010 in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997.

Name: $IBREG$. **Short description:** Regular business investment. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Detailed description:** Quarterly data before 1997Q1 is obtained as a residual series according to $IBREG = IBUS - IBALU - IBAIR$.

Name: $IBUS$. **Short description:** Business investment. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **ECOTRIM:** Flow Boot, Feibes and Lisman - FD and Flow AR(1) Max Log Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** Quarterly data for the period before 1997Q1 is obtained by: (1) Estimating quarterly data from annual data with ECOTRIM (Flow Boot, Feibes and Lisman - FD) using no reference series.; (2) Estimate the seasonality factors in the quarterly series from 1997Q1 using STAMP and then adding these seasonality factors to the series constructed in (1); and (3) Using ECOTRIM (Flow AR(1) Max Log Par : -.99 to .99) to estimate quarterly data from annual data before 1997Q1 using the reference

series constructed in (2).

Name: $IBUSN$. **Short description:** Nominal business investment. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **Comment:** With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** Obtained as a residual series according to $IBUSN = IN - IGN - IHN$.

Name: IG. **Short description:** Government investment. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **ECOTRIM:** Flow Boot, Feibes and Lisman - FD and Flow AR(1) MaxLog Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** Quarterly data for the period before 1997Q1 is obtained by: (1) Estimating quarterly data from annual data with ECOTRIM (Flow Boot, Feibes and Lisman - FD) using no reference series, (2) Estimate the seasonality factors in the quarterly series from 1997Q1 using STAMP and then adding these seasonality factors to the series constructed in (1); and (3) Using ECOTRIM (Flow AR(1) MaxLog Par : -.99 to .99) to estimate quarterly data from annual data before 1997Q1 using the reference series constructed in (2).

Name: IGN. **Short description:** Nominal government investment. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow Fernandez Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** Before 1997 the annual values from STATICE are disaggregated in ECOTRIM (Flow Fernandez Par : -.99 to .99) with quarterly data $BC \times IG$ as a reference series.

Name: $IGNNET$. **Short description:** Nominal net government investment. **Beginning of series:** 1990Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow AR(1) Max Log Par : -.99 to .99. **Comment:** Obtained as IGN minus depreciation of public capital at current prices, which was obtained from annual data using ECOTRIM, with $PIG \times DELTAG \times (K - KH -$

$KBUS$)) as a reference series.

Name: IH. **Short description:** Private sector housing investment. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **ECOTRIM:** Flow Boot, Feibes and Lisman - FD and Flow AR(1) Max Log Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** Quarterly data for the period before 1997Q1 is obtained by: (1) Estimating quarterly data from annual data with ECOTRIM (Flow Boot, Feibes and Lisman - FD) using no reference series; (2) Estimate the seasonality factors in the quarterly series from 1997Q1 using STAMP and then adding these seasonality factors to the series constructed in (1); and (3) Using ECOTRIM (Flow AR(1) Max Log Par : -.99 to .99) to estimate quarterly data from annual data before 1997Q1 using the reference series constructed in (2).

Name: $IHEX$. **Short description:** An adjustment factor for private sector housing stock. **Beginning of series:** 1970Q1. **Source:** CBI. **Unit:** A fixed value. **Comment:** The value of $IHEX$ is derived from the balanced growth version of the model (see Daníelsson, 2009).

Name: IHN. **Short description:** Nominal housing investment. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow AR(1) Max Log Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** Before 1997 the annual values from STATICE are disaggregated in ECOTRIM (Flow AR(1) Max Log Par : -.99 to .99) with quarterly data $BC \times IH$ as a reference series.

Name: II. **Short description:** Net stockbuilding. **Beginning of series:** 1980Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **ECOTRIM:** Flow AR(1) Max Log Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** Prior to 1997 annual net stockbuilding data was

disaggregated in ECOTRIM with changes in EX as a related series.

Name: IIN. **Short description:** Nominal net stockbuilding. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow AR(1) (minimum sum of squared residuals). **Comment:** Quarterly data available since 1997. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** Prior to 1997, annual net stockbuilding data was disaggregated in ECOTRIM with changes in EXN as a related series.

Name: IMP. **Short description:** Import volume of goods and services. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **ECOTRIM:** Flow AR(1) Max Log Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** *Period from 1970 to 1996:* Quarterly data obtained with ECOTRIM by disaggregating annual values using $IMPN/PM$ at constant 1990 prices as a related series. Annual data for the period 1970 to 1979 are calculated from the volume index.

Name: $IMPAIR$. **Short description:** Import volume of airplanes and ships. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** Quarterly data available since 1997Q1 from STATICE.

Name: $IMPAIRN$. **Short description:** Nominal imports of airplanes and ships. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **Comment:** Quarterly data available since 1997Q1 from STATICE. $IMPAIRN$ is forecasted as $IMPAIRN = PI \times IMPAIR$. This equation does not hold for historical data as STATICE uses a different price deflator than PI for this component.

Name: $IMPALU$. **Short description:** Import volume of goods for aluminium production. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** Quarterly data available since 1997Q1 from STATICE.

Name: $IMPALUN$. **Short description:** Nominal import of goods for aluminium production. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:**

Millions of kronas at current prices. **Comment:** Quarterly data available since 1997Q1 from STATICE.

Name: $IMPG$. **Short description:** Import volume of goods. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** Quarterly data available since 1997Q1 from STATICE.

Name: $IMPGN$. **Short description:** Nominal import of goods. **Beginning of series:** 1995Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **Comment:** Quarterly data available since 1997Q1 from STATICE. Defined as $IMPGN = IMPAIRN + IMPALUN + IMPOTHN$. **Detailed description:** *Period from 1995 to 1996:* Nominal imported goods are obtained from the CBI.

Name: $IMPN$. **Short description:** Nominal imports of goods and services. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow AR(1) Max Log Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** Imported goods and services from 1978 to 1996 are taken from the CBI, statistics department. Imported goods from 1970 to 1977 are from STATICE. Imported services from 1970 to 1977 were disaggregated using imported services as recorded by an older definition by STATICE as an indicator series.

Name: $IMPOTH$. **Short description:** Import volume of other goods. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** Quarterly data available since 1997Q1 from STATICE. Consists of all imported goods excluding $IMPALU$ and $IMPAIR$.

Name: $IMPOTHN$. **Short description:** Nominal imports of other goods. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **Comment:** Quarterly data available since 1997Q1 from STATICE. Consists of all imported goods excluding $IMPALUN$ and $IMPAIRN$.

Name: $IMPS$. **Short description:** Import volume of services. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** Quarterly data available since 1997Q1 from STATICE.

Name: $IMPSN$. **Short description:** Nominal imports of services. **Beginning of series:** 1995Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at

current prices. **Comment:** Quarterly data available since 1997Q1 from STATICE. **Detailed description:** *Period from 1995 to 1996:* Nominal imported services are obtained from the CBI.

Name: IN. **Short description:** Nominal fixed investment. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow Fernandez Par : -.99 to .99. **Comment:** Quarterly data available since 1997Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** Before 1997 the annual values from STATICE are disaggregated in ECOTRIM with quarterly data on $BC \times I$ as a reference series.

Name: INF. **Short description:** Four-quarter CPI inflation rate. **Beginning of series:** 1971Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Variable defined in equation (7.23).

Name: $INFE$. **Short description:** Break-even inflation expectations. **Beginning of series:** 1994Q1. **Source:** CBI. **Unit:** Fraction. **Detailed description:** Historical data obtained as $(1 + RL)/((1 + RLV) \times (1 + PRISK)) - 1$. Forecasted data obtained using model consistent expectations, cf. (7.26).

Name: $INFQ$. **Short description:** Quarterly CPI inflation rate. **Beginning of series:** 1970Q2. **Source:** CBI. **Unit:** Fraction. **Comment:** Variable defined in equation (7.21).

Name: $INFTAX$. **Short description:** Effects of indirect taxes on the CPI. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Fraction. **Comment:** Exogenous measure of effects of changes in indirect taxes on CPI.

Name: $INFUL$. **Short description:** Underlying four-quarter CPI inflation rate. **Beginning of series:** 1971Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Variable defined in equation (7.22).

Name: $INFULQ$. **Short description:** Underlying quarterly CPI inflation rate. **Beginning of series:** 1970Q2. **Source:** CBI. **Unit:** Fraction. **Comment:** Variable defined in equation (7.20).

Name: ISA. **Short description:** Icelandic holdings of foreign assets. **Beginning of series:** 1989Q4. **Source:** CBI. **Unit:** Millions of kronas at current prices. **Comment:** Icelandic holdings of foreign assets are from the balance of payments and external positions statistics (in the International investment positions table). With

the implementation of the new standard ESA2010 in September 2014 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. **Detailed description:** ISA equals Direct investment abroad + Portfolio investment assets + Financial derivatives assets + Other capital assets + Central Bank's reserve of foreign currencies.

Name: IT. **Short description:** Central Bank of Iceland inflation target. **Source:** CBI. **Unit:** Fraction. **Comment:** Inflation target currently defined in terms of annual CPI inflation and is equal to 2.5%.

Name: K. **Short description:** Total capital stock. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at constant 2005 prices. **ECOTRIM:** StockL Fernandez Par : -.99 to .99. **Comment:** Only annual data available from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** Quarterly data obtained using ECOTRIM with a quarterly series constructed using the stock-flow identity as a reference series.

Name: $KBUS$. **Short description:** Business capital stock. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at constant 2005 prices. **ECOTRIM:** StockL Fernandez Par : -.99 to .99. **Comment:** Only annual data available from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** Quarterly data obtained from ECOTRIM with a quarterly series constructed using the stock-flow identity as a reference series.

Name: KH. **Short description:** Private sector housing stock. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at constant 2005 prices. **ECOTRIM:** StockL Fernandez Par : -.99 to .99. **Comment:** Only annual data available from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997, causing a structural break in the time series between 1996 and 1997. The break is corrected by adjusting the level of data before 1997 so that the annual change in 1997 is the same as was before the new standard implementation. **Detailed description:** Quarterly data is estimated with ECOTRIM using a series estimated from quarterly data on investment in apartments and the stock-flow identity as a reference series. STATICE values the private sector housing stock at market price of housing (PH) but investment in housing at cost price (PIH). In 2005 the difference between these two prices were very large leading to two problems in QMM: Firstly, keeping the

housing stock at constant 2005 prices requires investment in housing at constant 2005 prices to be much above its historical average as a share of GDP. The second problem was that the capital-output ratio increased very much compared to earlier periods when the national account variables were valued at year 2000 prices. Because of this, it was decided to scale KH at constant 2005 prices down by dividing each data point in the series by 1.37.

Name: LY. **Short description:** Real post-tax labour income. **Beginning of series:** 1987Q4. **Source:** CBI. **Unit:** Millions of kronas at constant 2005 prices. **Comment:** Calculated as $LY = [(YJ - YDIJ) - (TJ - TI)]/PC$.

Name: $M3$. **Short description:** Broad money. **Beginning of series:** 1970Q1. **Source:** CBI. **Unit:** Millions of kronas at current prices. **Comment:** Quarterly average of monthly values. **Detailed description:** Contains notes and coins in circulation and deposit money banks demand deposits, demand savings deposits and time savings deposits.

Name: $NAIRU$. **Short description:** Natural rate of unemployment. **Source:** CBI. **Unit:** Fraction. **Comment:** Time-varying NAIRU estimated using the Kalman filter. For a detailed discussion see Einarsson & Sigurðsson (2013).

Name: NFA. **Short description:** Net foreign assets. **Beginning of series:** 1989Q4. **Source:** CBI. **Unit:** Millions of kronas at current prices. **Comment:** The difference between Icelandic holdings of foreign assets and foreign holdings of Icelandic assets, defined as $NFA = ISA - FOH$.

Name: NFW. **Short description:** Net financial wealth. **Beginning of series:** 1987Q1. **Source:** DIR/CBI/ISD. **Unit:** Millions of kronas at current prices. **Comment:** Data derived from GFW and DH as $NFW = GFW - DH$.

Name: PA. **Short description:** Participation rate. **Beginning of series:** 1991Q1. **Source:** STATICE/CBI. **Unit:** Fraction. **Comment:** Calculated as $PA = EMP/(POWA \times (1 - UR))$. **Detailed description:** For the time period 1991 to 2002 STATICE has reported the participation rate based on its labour market survey biannually, i.e. in April and November. In order to generate continuous quarterly series for the whole period it is assumed that the average of the biannual series is equal to the annual value. The annual values are lowered by 0.4 so that the average participation rate 1991-2002 equals the average participation rate 2003-2013. Seasonal variation from the series after 2003 is added to obtain quarterly values for 1991 to 2002.

Name: PAT. **Short description:** Trend participation rate. **Beginning of series:** 1991Q4. **Source:** STATICE. **Unit:** Fraction. **Comment:** Calculated as a four-quarter moving average of PA, (6.9).

Name: PC. **Short description:** Private consumption deflator. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Index, 2005 = 1. **Detailed description:** Defined as $PC = CN/C$.

Name: $PCOM$. **Short description:** Non-oil commodity prices in USD. **Beginning of series:** 1980Q2. **Source:** IMF. **Unit:** Index, 2005 = 1. **Comments**: Index of market prices of non-fuel commodities. The index is normalised so that the average index of the quarters of year 2005 equals 1.

Name: PG. **Short description:** Government consumption deflator. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Index, 2005 = 1. **Detailed description:** Defined as $PG = GN/G$.

Name: $PGDP$. **Short description:** GDP price deflator. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Index, 2005 =1. **Detailed description:** Defined as $PGDP = GDPN/GDP$.

Name: PH. **Short description:** House prices. **Beginning of series:** 1970Q1. **Source:** RI/STATICE. **Unit:** Index, 2005 = 1. **ECOTRIM:** Index Fernandez Par : -.99 to .99. **Comment:** Annual values obtained implicitly from STATICE series on the housing stock at fixed and current prices. **Detailed description:** Implicit annual prices for apartments are calculated from the STATICE data. Quarterly values are estimated with ECOTRIM. Following the practice at the STATICE a series composed of the building cost index (BC) before 1997 and the RI series on prices of apartments after that was used as a reference series in the estimation of the quarterly data.

Name: PI. **Short description:** Investment goods price deflator. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Index, 2005 = 1. **Detailed description:** Defined as $PI = IN/I$.

Name: PIG. **Short description:** Government investment deflator. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Index, 2005 = 1. **Detailed description:** Defined as $PIG = IGN/IG$.

Name: PIH. **Short description:** Housing investment deflator. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Index, 2005 = 1. **Detailed description:** Defined as $PIH = IHN/IH$.

Name: PM. **Short description:** Import price deflator. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Index. **Detailed description:** Defined as $PM = IMPN/IMP$.

Name: $PMALU$. **Short description:** Import price deflator for aluminium production in USD. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Index.

Detailed description: Defined as $PMALU = (IMPALUN/IMPALU)/EUS$.

Name: $PMOTH$. **Short description:** Import price deflator for other goods. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Index. **Detailed description:** Defined as $PMOTH = IMPOTHN/IMPOTH$.

Name: PMS. **Short description:** Import price deflator for services. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Index. **Detailed description:** Defined as $PMS = IMPSN/IMPS$.

Name: $POIL$. **Short description:** Oil prices in USD. **Beginning of series:** 1970Q4. **Source:** IMF. **Unit:** Index, 2005 = 1. **Comment:** Petroleum (simple average of three spot prices), US$ per barrel, obtained from IMF. The index is normalised so that the average index of the quarters of year 2005 equals 1.

Name: $POWA$. **Short description:** Population of working age. **Beginning of series:** 1991Q1. **Source:** STATICE/CBI. **Unit:** Heads. **Comment:** Working age defined as 16-74 years old. From 2003Q1 obtained from STATICE labour market survey by taking quarterly average of monthly values. **Detailed description:** For the time period 1991 to 2002, POWA is estimated using data on participation rate and labour force from STATICE labour market survey biannually, i.e. in April and November. In order to generate continuous series for this period the biannual series was interpolated by assuming the same monthly change between each month. Quarterly values are obtained by taking average of monthly values.

Name: $PRBUS$. **Short description:** Business premium on risk-free interest rate. **Source:** CBI. **Unit:** Fraction. **Comment:** Currently assumed fixed at 2%.

Name: $PRISK$. **Short description:** Inflation risk premium. **Source:** CBI. **Unit:** Fraction. **Comment:** Currently fixed and set equal to 0.5%.

Name: $PROD$. **Short description:** Labour productivity. **Beginning of series:** 1991Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Labour productivity defined as $PROD = GDP/EMPH$.

Name: $PRODT$. **Short description:** Four quarter average labour productivity. **Beginning of series:** 1991Q4. **Source:** CBI. **Unit:** Fraction. **Comment:** Four quarter average labour productivity defined in equation (6.17).

Name: $PSNB$. **Short description:** Public sector net borrowing. **Beginning of series:** 1990Q1. **Source:** CBI. **Unit:** Millions of kronas at current prices. **Comment:** Accounting identity defined as $PSNB = (GN + IGNNET + CJ + UNPM + DI + SUBS) - TAX$.

Name: PX. **Short description:** Export price deflator. **Beginning of series:** 1970Q1. **Source:** STATICE/CBI. **Unit:** Index. **Detailed description:** Defined as $PX = EXN/EX$.

Name: $PXALU$. **Short description:** Price of aluminium products in USD. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Index. **Detailed description:** Defined as $PXALU = (EXALUN/EXALU)/EUS$.

Name: $PXMAR$. **Short description:** Price of marine products in foreign currency. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Index. **Detailed description:** Defined as $PXMAR = (EXMARN/EXMAR)/EER$.

Name: $PXOTH$. **Short description:** Export price deflator for other goods. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Index. **Detailed description:** Defined as $PXOTH = EXOTHN/EXOTH$.

Name: PXS. **Short description:** Export price deflator for services. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Index. **Detailed description:** Defined as $PXS = EXSN/EXS$.

Name: $QDGDPT$. **Short description:** Quarterly trend GDP growth rate. **Beginning of series:** 1991Q4. **Source:** CBI. **Unit:** A fixed value. **Detailed description:** Defined as $QDGDPT_t = (1 + 1\%)^{(1/4)} \times \exp(0.004126) - 1 = 0.7\%$.

Name: RCC. **Short description:** Real cost of capital. **Beginning of series:** 1980Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Real user cost of capital is calculated with a Hall-Jorgenson type formula on a quarterly basis using equation (4.8).

Name: RCI. **Short description:** Corporate income tax rate. **Beginning of series:** 1990Q1. **Source:** CBI. **Unit:** Fraction. **Detailed description:** Obtained as $TCI/GDPN_{t-4}$ in historical data but treated exogenous from last observed value in forecasts and simulations.

Name: RCP. **Short description:** Corporate property tax rate. **Beginning of series:** 1990Q1. **Source:** CBI. **Unit:** Fraction. **Detailed description:** Obtained as $TCP/GDPN$ in historical data but treated exogenous from last observed value in forecasts and simulations.

Name: REM. **Short description:** Employers' wage-related cost. **Beginning of series:** 1980Q1. **Source:** ILMS/CBI. **Unit:** Fraction. **ECOTRIM:** Boot, Feibes and Lisman - FD. **Comment:** ILMS estimates various taxes that are linked to wages once a year, usually for the month of July. For convenience the employees' contribution to the pension funds is included. This contribution is compulsory. The entitlements that household have in the pension funds are treated as a part of the

household's decision problem. **Detailed description:** The tax rate is a simple average calculated for different types of manual labourers covered in the ILMS surveys. Quarterly data obtained with ECOTRIM by disaggregating annual values.

Name: $REVA$. **Short description:** Household assets revaluation term. **Beginning of series:** 1987Q2. **Source:** CBI. **Unit:** Fraction. **Comment:** Obtained with different equations in historical data but defined with equation (4.25) in forecasts and simulations.

Name: $REVD$. **Short description:** Household debt revaluation term. **Beginning of series:** 1980Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Obtained with different equations in historical data but defined with equation (4.26) in forecasts and simulations.

Name: REX. **Short description:** Real exchange rate. **Beginning of series:** 1972Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Historical data defined as $REX = CPI/(EER \times WCPI)$ and forecasted data obtained from equation (4.16).

Name: $REXEQ$. **Short description:** Equilibrium real exchange rate. **Source:** CBI. **Unit:** Fraction. **Comment:** Currently fixed and equal to 0.7814.

Name: $REXM$. **Short description:** Importers' real exchange rate. **Beginning of series:** 1971Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Defined as $REXM = PM/PGDP$.

Name: $REXX$. **Short description:** Exporters' real exchange rate. **Beginning of series:** 1972Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Defined as $REXX = PX/(EER \times WPX)$.

Name: $RFIC$. **Short description:** Tax rate on other payments. **Beginning of series:** 1998Q1. **Source:** CBI. **Unit:** Fraction. **Detailed description:** Obtained as $TIC/GDPN$ in historical data but treated as exogenous from last observed value in forecasts and simulations.

Name: $RHPI$. **Short description:** Real household post-tax income. **Beginning of series:** 1994Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at constant 2005 prices. **Comment:** Quarterly data on nominal disposable income deflated by the private consumption deflator, (9.6).

Name: RIC. **Short description:** Ratio of households' other income to YE. **Beginning of series:** 1980Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Obtained as YIC/YE in historical data but treated as exogenous from last observed value in forecasts and simulations.

Name: RID. **Short description:** Real interest rate differential. **Beginning of series:** 1987Q4. **Source:** CBI. **Unit:** Fraction. **Comment:** Defined as (4.9).

Name: $RIMP$. **Short description:** Tax rate on imports. **Beginning of series:** 1990Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Obtained as $TIMP/IMPN$ in historical data but treated as exogenous from last observed value in forecasts and simulations.

Name: $RISK$. **Short description:** Exchange rate risk premium. **Source:** Bloomberg. **Unit:** Fraction. **Comment:** From 1970Q1 to 2007Q3 fixed equal to 1.5%. After 2007Q3 it is set equal to the Government's 5 year CDS spread, as quarterly average of daily values.

Name: RJO. **Short description:** Household other tax rate. **Beginning of series:** 1987Q1. **Source:** CBI. **Unit:** Fraction. **Detailed description:** Obtained as $TJO/GDPN$ in historical data but treated as exogenous from last observed value in forecasts and simulations.

Name: RJY. **Short description:** Household income tax rate. **Beginning of series:** 1988Q1. **Source:** CBI. **Unit:** Fraction. **Detailed description:** Obtained as $(TJY + ALLOW \times POWA)/(YE * (1 - DPENS) + CJT + YICT + UNPM + SPENS)$ in historical data but treated as exogenous from last observed value in forecasts and simulations.

Name: RL. **Short description:** Long-term interest rate. **Beginning of series:** 1994Q1. **Source:** CBI/OMX. **Unit:** Fraction. **Detailed description:** Before 1996Q2 Treasury notes were quoted by the Central Bank, but from 1996Q2 until 2001Q1 the yields are quotes from ICEX. From 2001Q2 5 year interest rates is estimated from bond market yields (Nelson-Siegel approach).

Name: RLV. **Short description:** Long-term indexed interest rate. **Beginning of series:** 1980Q1. **Source:** CBI/OMX. **Unit:** Fraction. **Comment:** Quarterly averages of end-of-month values. **Detailed description:** Long-term yield on indexed bonds. Data for 1980-1987 are chain linked with data from Economic Statistics published by the CBI. A data break in 1984Q4 is interpolated. Data until 2000Q4 are five year government indexed bond. From 2001Q1 a 5 year indexed interest rates is estimated from bond market yields (Nelson-Siegel approach). Data used as a basis for these calculations are five year government indexed bond until 2002Q2. From 2002Q2 to 2004Q3 the RIKS15 government index bond was used as the five year bond was no longer active in 2003. From 2004Q4 to 2009Q4 the HFF14 indexed housing loan fund bond (which has a government guarantee) is used because the government bought back the RIKS15 bond.

Name: RRN. **Short description:** Real neutral interest rate. **Source:** CBI. **Unit:** Fraction. **Comment:** Currently fixed and equal to 3.0%. Before 2008Q4 it

was fixed at 4.5%.

Name: RS. **Short description:** Short-term interest rate. **Beginning of series:** 1987Q4. **Source:** CBI. **Unit:** Fraction. **Comment:** Quarterly averages of end-of-month values. **Detailed description:** Central Bank of Iceland monetary policy rate measured in annual yields. From March 1998 this is the interest rate on 14-day repurchase agreements (7-day from June 2004) between the Central Bank and domestic financial institutions. Before March 1998 this is the interest rate on tap sales.

Name: RSD. **Short description:** Other expenditure tax rate. **Beginning of series:** 1990Q1. **Source:** CBI. **Unit:** Fraction. **Detailed description:** Obtained as TSD/CN in historical data but treated as exogenous from last observed value in forecasts and simulations.

Name: RTS. **Short description:** Effective subsidies rate. **Beginning of series:** 1980Q1. **Source:** CBI. **Unit:** Fraction. **Detailed description:** Obtained as $SUBS/GDPN$ in historical data but treated as exogenous from last observed value in forecasts and simulations.

Name: $RULCT$. **Short description:** Real trend unit labour costs. **Beginning of series:** 1991Q4. **Source:** CBI. **Unit:** Fraction. **Detailed description:** Defined as $RULCT = ULCT/CPI$.

Name: $RVAT$. **Short description:** Value-added tax rate. **Beginning of series:** 1990Q1. **Source:** CBI. **Unit:** Fraction. **Detailed description:** Obtained as $TVAT/CN$ in historical data but treated as exogenous from last observed value in forecasts and simulations.

Name: RWC. **Short description:** Corporate wage cost tax rate. **Beginning of series:** 1990Q1. **Source:** CBI. **Unit:** Fraction. **Detailed description:** Obtained as TWC/YE in historical data but treated as exogenous from last observed value in forecasts and simulations.

Name: $SPEC$. **Short description:** Trade specialisation. **Beginning of series:** 1970Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Defined as $SPEC = TRADE/WGDP$.

Name: $SPENS$. **Short description:** Withdrawal from third-pillar pension savings. **Beginning of series:** 2009Q2. **Source:** STATICE/DIR. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow Boot, Feibes and Lisman - FD. **Comment:** Describes withdrawal from third-pillar pension funds that have been temporary allowed for people under 60 years old. **Detailed description:** Annual data available from STATICE from the sector accounts. Quarterly data obtained

with ECOTRIM using data collected from DIR as a reference series. When annual data are not available data from DIR are used.

Name: $SUBS$. **Short description:** Government subsidies. **Beginning of series:** 1980Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow Boot, Feibes and Lisman - FD. **Comment:** Net production subsidies, i.e. net production subsidies and financial transfers of government income from assets, dividends and rent. The term transfers to households subtracted by CJ are added to $SUBS$ as well. **Detailed description:** Quarterly data obtained from ECOTRIM.

Name: TAX. **Short description:** Total tax receipts. **Beginning of series:** 1990Q1. **Source:** CBI. **Unit:** Millions of kronas at current prices. **Comment:** Accounting identity given as $TAX = TJ + TC + TE$.

Name: TC. **Short description:** Corporate tax payments. **Beginning of series:** 1990Q1. **Source:** CBI. **Unit:** Millions of kronas at current prices. **Comment:** Accounting identity given as $TC = TCI + TCP + TIC + TWC$.

Name: TCI. **Short description:** Corporate income tax payments. **Beginning of series:** 1990Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow Boot, Feibes and Lisman - FD. **Detailed description:** Quarterly data obtained with ECOTRIM.

Name: TCP. **Short description:** Corporate property tax payments. **Beginning of series:** 1990Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow Boot, Feibes and Lisman - FD. **Detailed description:** Quarterly data obtained with ECOTRIM.

Name: TE. **Short description:** Total taxes on production and imports. **Beginning of series:** 1990Q1. **Source:** CBI. **Unit:** Millions of kronas at current prices. **Comment:** Accounting identity given as $TE = TVAT + TIMP + TSD$.

Name: $TERM$. **Short description:** Term premium. **Source:** CBI. **Unit:** Fraction. **Comment:** Currently fixed and set equal to 0.5%.

Name: TI. **Short description:** Household financial income tax. **Beginning of series:** 1998Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow Boot, Feibes and Lisman - FD. **Comment:** Quarterly data obtained from annual data using ECOTRIM.

Name: TIC. **Short description:** Other tax payments. **Beginning of series:** 1998Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow Boot, Feibes and Lisman - FD. **Detailed description:** There is discrepancy in the data for household tax payments from STATICE depending on

whether the data is obtained from the sectoral accounts or public finance accounts. The household taxpayments in QMM are obtained from the sectoral accounts, that is *Disposable income of the household sector*. Therefore in order for total tax receipts in QMM to add up to the government's total tax revenues from the public finance accounts the discrepancy between the sector accounts and the public finance accounts is captured by the variable TIC.

Name: $TIMP$. **Short description:** Tariffs and other taxes on imports. **Beginning of series:** 1990Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow AR(1)Max Log Par : -.99 to .99. **Detailed description:** Quarterly data obtained with ECOTRIM using $IMPN$ as auxiliary information.

Name: TJ. **Short description:** Household tax payments. **Beginning of series:** 1987Q4. **Source:** CBI. **Unit:** Millions of kronas at current prices. **Comment:** Accounting identity given as $TJ = TJY + TI + TJO$.

Name: TJO. **Short description:** Other household tax payments. **Beginning of series:** 1987Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **Detailed description:** Total household tax payments are obtained from the sectoral accounts (*Disposable income from the household sector*) from STATICE. The variable TJO is in fact a residual and is derived as: Total household tax payments – Household income tax – Household financial income tax. Quarterly data is obtained by dividing the annual data equally into four.

Name: TJY. **Short description:** Household income tax. **Beginning of series:** 1979Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow AR(1)Max Log Par : -.99 to .99. **Detailed description:** Quarterly data obtained with ECOTRIM using YE as auxiliary information.

Name: $TRADE$. **Short description:** World trade. **Beginning of series:** 1970Q1. **Source:** IMF/CBI. **Unit:** Index, 2005 = 1. **Comment:** The index is normalised so that the average of the quarters of year 2005 equals 1. **Detailed description:** Trade weighted import volumes in Iceland's main trading partners, i.e. Canada, Denmark, Euro area, Japan, Norway, Sweden, Switzerland, UK and US. China became a trading partner in 2007 and Brazil in 2012 according to the weights of currencies in the exchange rate index and are therefore included from that time. The weights are revised annually on the basis of the previous year trade in goods and services, using the same weights (recalculated to sum to 1) as in the official exchange rate index (EER).

Name: TSD. **Short description:** Other expenditure taxation receipts. **Beginning of series:** 1990Q1. **Source:** FIN/ STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow AR(1) Max Log Par :-.99 to .99. **Detailed**

description: Quarterly data obtained with ECOTRIM using CN as auxiliary information.

Name: $TVAT$. **Short description:** Value added taxation receipts. **Beginning of series:** 1990Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow AR(1) Max Log : -.99 to .99. **Detailed description:** Quarterly data obtained with ECOTRIM using CN as auxiliary information.

Name: TWC. **Short description:** Corporate wage cost tax payments. **Beginning of series:** 1990Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow AR(1) Max Log : -.99 to .99. **Detailed description:** Quarterly data obtained with ECOTRIM using $W \times EMPH$ as auxiliary information.

Name: ULC. **Short description:** Unit labour costs. **Beginning of series:** 1991Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Defined as $ULC = W \times REM/PROD$.

Name: $ULCT$. **Short description:** Trend unit labour costs. **Beginning of series:** 1991Q4. **Source:** CBI. **Unit:** Fraction. **Comment:** Defined as $ULCT = W \times REM/PRODT$.

Name: UN. **Short description:** Level of unemployment. **Beginning of series:** 1991Q1. **Source:** STATICE. **Unit:** Number of heads. **Comment:** Defined as $UN = PA \times POWA \times UR$.

Name: $UNCOST$. **Short description:** Cost of each unemployed worker. **Beginning of series:** 1980Q1. **Source:** STATICE/DOL. **Unit:** Millions of kronas at current prices. **Comment:** Annual data for $UNCOST$ obtained from annual data on $UNPM$ and UN, defined as $UNPM/UN$. Quarterly data obtained by dividing yearly $UNCOST$ equally between quarters. Data before 1994Q1 is obtained from DOL.

Name: $UNPM$. **Short description:** Unemployment benefits. **Beginning of series:** 1991Q1. **Source:** STATICE/DOL. **Unit:** Millions of kronas at current prices. **Comment:** Annual data for households income from unemployment benefits is available in sector accounts published by STATICE, i.e. *Disposable income of the household sector*. Quarterly data obtained with ECOTRIM using $UNCOST \times UN$.

Name: UR. **Short description:** Unemployment rate. **Beginning of series:** 1991Q1. **Source:** STATICE/DOL/CBI. **Unit:** Fraction. **Comment:** Quarterly averages of monthly unemployment rate data from STATICE. **Detailed description:** For the time period 1991 to 2002, STATICE reported the unemployment rate based on its labour market survey biannually, i.e. in April and November. In order to generate continuous time series for this period the biannual series was interpolated

by using monthly data available from DOL. The series is constructed so that it has the same seasonal variation as the monthly series from DOL. Quarterly values are obtained by taking average of monthly values.

Name: W. **Short description:** Wages. **Beginning of series:** 1989Q1. **Source:** STATICE. **Unit:** Index, 2005 = 1. **ECOTRIM:** AR(1) Max Log Par : -.99 to .99. **Comment:** The index is normalised so that the average index of the quarters of year 2005 equals 1. **Detailed description:** Annual data on wage cost is given in the national accounts. REM is used to estimate the indirect wage cost and $EMPH$ to calculate the wage cost per hour. The wage index produced by STATICE is used as a reference series when annual data is disaggregated using ECOTRIM.

Name: $WCPI$. **Short description:** World consumer prices. **Beginning of series:** 1970Q1. **Source:** IMF/CBI. **Unit:** Index, 2005 = 1. **Comment:** The index is normalised so that the average index of the quarters of year 2005 equals 1. **Detailed description:** Trade weighted average of consumer prices in Iceland's main trading partners, i.e. Canada, Denmark, Euro area, Japan, Norway, Sweden, Switzerland, UK and US. China became a trading partner in 2007 and Brazil in 2012 according to the weights of currencies in the exchange rate index and are therefore included from that time. The weights are revised annually on the basis of the previous year trade in goods and services, using the same weights (recalculated to sum to 1) as in the official exchange rate index (EER).

Name: WEL. **Short description:** Household sector wealth. **Beginning of series:** 1987Q1. **Source:** CBI. **Unit:** Millions of kronas at current prices. **Comment:** Defined as $WEL = HW + NFW$.

Name: $WEQP$. **Short description:** World equity prices. **Beginning of series:** 1970Q1. **Source:** MB. **Unit:** Index, 2005 = 1. **Comment:** Morgan Stanley Capital International (MSCI) Index from MB. The index is normalised so that the average of the quarters of year 2005 equals 1.

Name: $WGDP$. **Short description:** World GDP. **Beginning of series:** 1970Q1. **Source:** OECD/CBI. **Unit:** Index, 2005 = 1. **Comment:** The index is normalised so that the average index of the quarters of year 2005 equals 1. **Detailed description:** Trade weighted real GDP levels in Iceland's main trading partners, i.e. Canada, Denmark, Euro area, Japan, Norway, Sweden, Switzerland, UK and US. China became a trading partner in 2007 and Brazil in 2012 according to the weights of currencies in the exchange rate index and are therefore included from that time. The weights are revised annually on the basis of the previous year trade in goods and services, using the same weights (recalculated to sum to 1) as in the official exchange rate index (EER). *Period from 1970 to 1996:* Quarterly data obtained from Economic Outlook database. After 1996 quarterly data obtained from the Main Economic Indicator database.

Name: $WINF$. **Short description:** Four-quarter world inflation rate. **Beginning of series:** 1971Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Variable defined in equation (7.24).

Name: WPX. **Short description:** World export prices. **Beginning of series:** 1970Q1. **Source:** OECD/CBI. **Unit:** Index, 2005 = 1. **Comment:** The index is normalised so that the average index of the quarters of year 2005 equals 1. **Detailed description:** Trade weighted foreign currency export price deflators (obtained as the ratio of nominal and real exports of goods and services data) of Iceland's main trading partners, i.e. Canada, Denmark, Euro area, Japan, Norway, Sweden, Switzerland, UK and US. China became a trading partner in 2007 and Brazil in 2012 according to the weights of currencies in the exchange rate index and are therefore included from that time. The weights are revised annually on the basis of the previous year trade in goods and services, using the same weights (recalculated to sum to 1) as in the official exchange rate index (EER).

Name: WRS. **Short description:** Foreign short-term interest rate. **Beginning of series:** 1970Q1. **Source:** OECD/CBI. **Unit:** Fraction. **Comment:** Trade weighted foreign 3 month Treasury Bill interest rates of Iceland's main trading partners (Canada, Denmark, Euro area, Japan, Norway, Sweden, Switzerland, UK and US). The weights are revised annually on the basis of the previous year trade in goods and services, using the same weights (recalculated to sum to 1) as in the official exchange rate index (EER).

Name: $YDIJ$. **Short description:** Other household non-labour income. **Beginning of series:** 1994Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **Comment:** The variable contains nominal interest incomes, including dividends and nominal interest rate outlays. For the indexed loans the indexation cost is included. For the foreign exchange denominated loans the interest cost in Icelandic kronas is included.

Name: YE. **Short description:** Wages, salaries and self-employed income. **Beginning of series:** 1979Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow AR(1) Max Log Par : -.99 to .99. **Detailed description:** Annual data on income from wages and salaries are obtained from STATICE from the sectoral accounts (*Disposable income from the household sector*). Payments of employees, to social security contributions, pension funds and other current transfer is subtracted from employees income and operating surplus. Quarterly data obtained with ECOTRIM using $W \times EMPH$ as a reference series.

Name: YIC. **Short description:** Households' other income. **Beginning of series:** 1980Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow AR(1) Max Log Par : -.99 to .99. **Detailed description:** Includes income from pension funds and accident-compensation. Annual data available from STATICE from the sector accounts, i.e. *Disposable income from the household*

sector. Quarterly data obtained with ECOTRIM using YE as a reference series.

Name: $YICT$. **Short description:** Households' other income subject to income tax. **Beginning of series:** 1980Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **Detailed description:** Includes income from pension funds. Annual data available from STATICE from the sector accounts. Quarterly data obtained by finding the taxed part of YIC for each calendar year and multiply it to the quarterly series of YIC. For the period 1980 to 1993 data is estimated using a fixed ratio subject to income tax in 1994 (found as $YIC/YICT$).

Name: YJ. **Short description:** Total household pre-tax income. **Beginning of series:** 1994Q1. **Source:** STATICE/DIR. **Unit:** Millions of kronas at current prices. **Detailed description:** Calculated as $YJ = YE * (1 - DPENS) + CJ + UNPM + YIC + YDIJ + SPENS$.

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