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QMM
A Quarterly Macroeconomic Model of the Icelandic Economy
Version 4.0

By
Ásgeir Daníelsson, Lúdvík Elíasson, Magnús F. Gudmundsson, Svava J. Haraldsdóttir, Lilja S. Kro, Thórarinn G. Pétursson, Thorsteinn S. Sveinsson

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Ásgeir Daníelsson, Lúdvík Elíasson, Magnús F. Gudmundsson, Svava J. Haraldsdóttir†, Lilja S. Kro, Thórarinn G. Pétursson, Thorsteinn S. Sveinsson

Economics and Monetary Policy Department

Central Bank of Iceland

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Abstract

This Handbook documents Version 4.0 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).

*A number of people have contributed to previous versions of the model and assisted with the data. Their help, and comments and suggestions from many others, are gratefully acknowledged.
†Handbook editor and corresponding author (email: svava.haraldsdottir@sedlabanki.is).

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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 3.0 of QMM, described in the Bank's *Working Paper* no. 71, from December 2015. 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 in particular, the Bank's DSGE model DYNIMO (Seneca, 2010, and Daníelsson et al., forthcoming). 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 earlier 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.

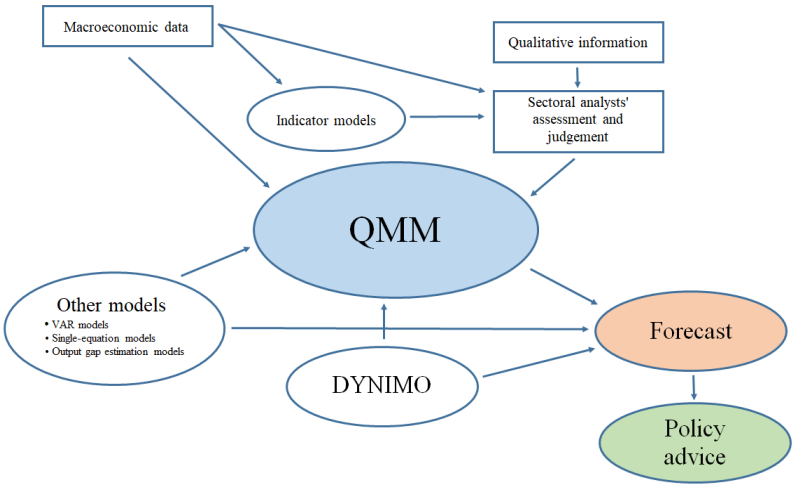

Figure 1.1. Overview of QMM's role in the Central Bank of Iceland's forecasting process

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 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 information on model variables and data. **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 26 empirically estimated behavioural relations and 127 equations based on accounting identities or definitions. Thus, the model contains 153 endogenous variables and adding the 59 exogenous variables, gives a total of 212 variables.

The level of aggregation in QMM is low compared to core models used by major central banks today but quite high compared to the 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 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, (5.63).

The constant factor shares property of this 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 between wages and deviations of the seasonally adjusted unemployment rate from its natural rate ($NAIRU$), accounting for productivity and terms of trade shocks (6.3).

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 (6.9). Average hours are given as a function of long-term average hours per worker, with short-run effects of output growth (6.11). Finally, labour demand is given as a residual (6.13).

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 (5.16) 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 (5.27) 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 trading partners' demand and relative exports prices, on the other (5.36). Exports of services (5.39) are determined by trading partners' demand and relative prices.

- Imports of goods (5.41) are given as the sum of the exogenously determined imports for aluminium production, and ships and airplanes, and the imports of other goods, which are determined by import weighted domestic demand and relative prices (5.47). Imports of services (5.50) 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 trading partners' imports and 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's inflation target and deviation of actual output from potential output (the output gap), (4.1).[2]

Long-term interest rates, both 5-year and 10-year rates, are estimated by the average of the current and expected short-term rates, in line with the expectations hypothesis (4.6 and 4.7), using rational (or model consistent) expectations. Long-term indexed rates (or real rates) are determined by the standard Fisher-relation (4.8 and 4.9).

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 (4.25) 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.

Consumer price inflation is given by a standard expectations-augmented Phillips curve, allowing for temporary real exchange rate shocks (7.4). 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. Inflation excluding indirect taxes is obtained by subtracting the estimated effects of indirect taxes from the consumer price inflation (7.5).

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

- Prices of imports of goods excluding goods for aluminium production and im-

[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.

ports of ships and airplanes are given as a function of international prices in domestic currency (non-oil commodity prices, oil prices and trading partners' export prices) and a domestic component given by unit labour costs (7.7). Prices of imported services are assumed to follow trading partners' consumer prices (7.8), while aggregate import prices are also influenced by the prices of imported goods for aluminium production, determined by the exogenously given aluminium export prices (7.9).

- Prices of exports of goods excluding marine and aluminium products as well as airplanes and ships are given as a function of trading partners' export prices (7.10). Export price of services is determined similarly by trading partners' consumer prices (7.11). Prices of marine goods are a function of trading partners' demand (7.12), while aggregate export prices are also influenced by the exogenously given international prices of aluminium goods (7.13).

- The private consumption deflator (7.14) 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 (7.15) is determined by unit labour costs, consumer prices and building costs.

- 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 (7.16).

- Housing investment costs are assumed to grow in line with general building costs (7.17).

- The government investment deflator evolves in line with general building costs and investment prices (7.18).

- The domestic output deflator is the residual price series and is given as the ratio between nominal and real GDP (7.19).

- 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 (7.21).

- Building costs are given as a function of consumer prices and unit labour costs (7.22).

- 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 (4.19). The nominal exchange rate is derived from the standard definition of the real exchange rate (4.13).

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 aggregate demand grows in line with trend output along a balanced growth path, which in turn, is determined by technological progress and available factor supplies. The long-run nominal equilibrium 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, and unemployment or output. 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 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 (5.68), 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 Version 4.0

Since the publication of Version 3.0 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 4.0 are:

- The estimation period has been extended to 2017Q4 (instead of 2012 in the previous version). The base year is still 2005 for chain-linked volume data.

- The estimate of the real neutral interest rate, RRN, has been revised from 2008Q3. In the previous versions RRN decreased from 4.5% (its pre-crisis value) to 3%. Now it is estimated that RRN decreased to 2% following the financial crisis. This number is now used in forecasts. For further discussion see Box 1, *Monetary Bulletin* 2019/4.

- Long-term interest rates are now both modelled as the 5-year interest rate (4.6) and the 10-year interest rate (4.7). The 5-year interest rate is estimated with the same method as before, given by the average of the current and expected short-term rates, in line with the expectations hypothesis, using rational expectations. Long-term indexed rates are determined by the standard Fisher-relation (4.8 and 4.9). Comparison of break-even inflation expectations and results from the Bank's surveys of inflation expectations of market agents indicate that the inflation risk premium, $PRISK$, is now assumed to be zero. Similarly to 5-year break-even inflation expectations, 10-year inflation expectations are given by the average of the current and expected year-on-year inflation over the next ten years (7.31).

- A new variable $RLVH$ (4.10) was added describing the long-term indexed mortgage rate and is assumed to move in line with the 5-year indexed interest rate $RLV5$. This is considered to improve the modelling of both residential housing investment (5.16) and residential house prices (7.21).

- An exogenous variable, CFM, was included in the equation for the interest rate differential (4.12) accounting for the effects of the capital flow management measure. This macroprudential instrument, which is managed by the Central Bank of Iceland, was introduced in June 2016. The framework is still in place but the levy on foreign investment into bonds and deposits was reduced to zero in early March 2019.

- The estimate of the equilibrium real exchange rate, $REXEQ$, has been revised from previous version. Now the balanced growth version of QMM described in Daníelsson (2009) is used to estimate the equilibrium real exchange rate.

- A variable, $REXW$, describing the real exchange rate given by relative unit labour costs has been added to the model (4.20). An exogenous variable, $WULC$, was added describing the trade weighted average of unit labour costs in Iceland's main trading partners.

- Data for household financial wealth and debt, GFW and DH, are now based on financial accounts released by Statistics Iceland and the equations (4.30 and 4.31) have been revised. Weights for household asset and debt revaluation

terms (4.32 and 4.33) have been revised in line with recent developments of household balance sheets.

- In autumn 2016, data for private consumption was revised back to 1997 due to a revised method and better source data by Statistics Iceland in the deflation of actual and imputed rentals for housing in private consumption. This, along with new data for household financial wealth and debt, led to a revision of the consumption equation (5.2).

- Fixed investment (5.5) and business investment (5.12) are now aggregated from its sub-components using the chain-volume approach, using year-2005 as a base year. In previous versions of QMM, I and $IBUS$ were aggregated using simple sums of sub-components. According to the chain-volume approach, volume changes are calculated so that values at annual prices are adjusted to the price level of the preceding calendar year. Annual chain-volume linking means that the sub-component investment items do not sum up to I and $IBUS$, except in the reference year for price indices and the year thereafter, i.e. in the years 2005 and 2006.

- An export item was added to import weighted domestic demand DDA (5.25) to show its import share but deducting the exports of aluminium products and export volume of ships and airplanes from EX since imports related to them are accounted for by other variables. This is done to better describe the import weighted domestic demand in import volume of other goods (5.47) and import volume of services (5.50).

- The equation describing exports of services EXS (5.39) was re-estimated with a trend variable to better capture the increase in the tourism industry in the period 2013-2016. As export volume of manufacturing services ($EXSMAN$) has dropped considerably and is almost zero, the model has been simplified and the variables $EXSMAN$, $EXSMANN$, $EXSOTH$ and $EXSOTHN$ have been excluded.

- The augmented estimate of potential output $GDPTX$ (5.66) is now given as a simple average of two different estimates (instead of previously by three different estimates) and an exogenous adjustment factor ADJ is used to incorporate non-model information to improve the final estimate of potential output (5.67).

- Nominal wage inflation is determined by past wage inflation, long-run trend productivity, long-run inflation expectations, cyclical unemployment and terms of trade shocks (6.3). In relation to this a new definition (4.23) is added describing the terms of trade, the long-term trend labour productivity is proxied by a 3-year moving average (6.19) and (6.8) gives the seasonally adjusted unemployment rate.

- The consumer price inflation (7.4) is given by a backward-forward looking hybrid Phillips curve specification as before. However, evidence suggest that

before 2012 the inflation target perceived by economic agents was higher than the official target, and that the official target has only become credible in the last five or six years. This is captured by a shift dummy variable SIT. The forward-looking part of the Phillips curve is measured by 10-year break-even inflation expectations. The backward looking part is determined by past inflation and the equation also allows for cyclical inflation pressures and import price inflation.

- The definition of government consumption deflator (7.15) has been revised and is now calibrated according to the weights of labour costs, material costs and depreciation used by Statistics Iceland.

- Due to difficulty in modelling households' net financial income ($YDIJ$), especially because of large variations in dividends and capital gains, the share of households' nominal net financial income to nominal GDP is calibrated so that the share converges to the value of 1%, which is the observed share in 2018 (9.5).

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

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 growing at the 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.

In recent years, central banks around the globe have increasingly added DSGE models to their repertoire.[5] These models rely on fully specified microeconomic foundations for their behavioral relations, unlike QMM, and are therefore better suited

[5]These include COMPASS by the Bank of England, Norges Bank´s NEMO, Sveriges Riksbanken's RAMSES II, Central Bank of Brazil's SAMBA and the European Central Bank's NAWM.

for counterfactual simulations and for analyzing policy changes, for example. These types of models are widely used in academic studies and are under constant development.[6] The Bank has also begun employing a DSGE model, called DYNIMO (see Seneca, 2010, and Daníelsson et al., forthcoming). Currently DYNIMO is mainly used as a cross-check on forecasts produced by QMM (see Box 3, *Monetary Bulletin* 2017/4).

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 1995. For the period before 1995 Statistics Iceland provides only annual data. For other variables, e.g. balance sheet variables, official data are annual only. This means that to obtain quarterly data for all time series 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, using time-series that start before 1990 is frequently not wise. Also national accounts are now based on ESA2010 standards, which were implemented by Statistics Iceland and the Central Bank of Iceland in September 2014. This has led to some revisions in data treatment.

- Due to the revision of the time series back to 1995 a structural break is present between 1994 and 1995. In the QMM database, the break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation.[7] For these reasons the estimation period typically starts later than 1995.

- 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 using the base year 2005.[8] First, the stock-flow consistency 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

[6] Recent developments include the modeling of the zero lower bound of interest rates, financial market imperfections as well as the explicit modeling of the energy sector and more complex labour markets. These models are also faced with several challenges, for example the assumption of full information rational expectations is quite strong, the interdepence of countries is not fully incorporated, and the results of the model may be hard to communicate to policy makers.

[7] For some data, e.g. the capital stock, the revision of data only goes back to 1997 with the implementation of the new ESA2010 standards. Where relevant the structural break is present between 1996 and 1997.

[8] In Version 3.0 the base year was switched from 2000 to 2005. In Version 4.0 the base year is still 2005.

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 (4.28). 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.

- Even if the housing stock is scaled down by dividing with 1.37 the increase in the stock exceed net investment in housing. For this reason an additional term, $IHEX \times GDP$, is added to net investment in housing when forecasting the housing stock (5.22). The value of $IHEX$ is derived from the balanced growth version of the model (see Daníelsson, 2009).

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 in the equation estimates in the second part of the Handbook.

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)

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.

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 subscript 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 $D1$, $D2$, $D3$ and $D4$ denote quarterly seasonal dummies (equal to 1 in the relevant quarter and 0 otherwise). 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 the variables entering a given equation are 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

4.1.1. Short-term interest rates (RS)

The monetary policy instrument, RS, is assumed to be set 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):[9]

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

where:

RS	Short-term interest rate (4.1).
RRN	Real neutral interest rate (exogenous).
IT	Central Bank of Iceland's 2.5% inflation target (exogenous).
$INFUL$	Underlying four-quarter CPI inflation rate (7.25).
$GAPAV$	Annual average of output gap (5.69).

To arrive at this forecast-base rule specification of monetary policy, a number of different policy rules and parameter values were tried.[10] Model simulations using different rules suggest that (4.1) dominates in terms of standard deviations of inflation and output trade-offs.[11] Most importantly, it strongly dominates the standard Taylor rule using current inflation instead of expected future inflation.

[9] The Taylor rule includes the neutral policy rate RRN which is currently assumed to equal 2%, down from its 4.5% pre-crisis level. The adjustment from 4.5% to 2% is based on a Bayesian estimation of an expectation augmented Laubach-Williams model of a small open economy (see Daníelsson et al., 2016).

[10] 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.

[11] 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 ($RL5$ and $RL10$)

Long-term interest rates ($RL5$ and $RL10$) are assumed to be determined by the average of the current and expected future short rates (RS), in addition to an exogenous term premium ($TERM5$ and $TERM10$), according to the expectations hypothesis of the term structure. The specification of long-term interest rates 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 $RL5$ and RS as:

$$RL5_t = \frac{1}{20}\sum_{j=0}^{19} RS^e_{t+j} + TERM5_t \tag{4.2}$$

where RS^e_{t+j} denotes expectations of RS_{t+j} based on information at time t (i.e. RS^e_{t+j} denotes $E_t RS_{t+j}$). If the expectations are model consistent or rational $RS^e_{t+j} = RS_{t+j}$. $TERM5_t$ denotes exogenous term premium between approximately 5 year interest rates $RL5_t$ and the average expected future short term interest rates $\frac{1}{20}\sum_{j=0}^{19} RS^e_{t+j}$ over that same period. To allow for overweight of the current short term interest rates, we weight in the short rates by λ_{rl}:

$$RL5_t = \lambda_{rl} RS_t + (1-\lambda_{rl})(\frac{1}{20}\sum_{j=0}^{19} RS^e_{t+j}) + TERM5_t \tag{4.3}$$

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:

$$\begin{aligned} RL5_t &= RL5_{t-1} + \lambda_{rl}(RS_t - RS_{t-1}) + (1-\lambda_{rl})(RS^e_{t+19} - RS_{t-1})/20 \\ &\quad + TERM5_t - TERM5_{t-1} \end{aligned} \tag{4.4}$$

The following equation is therefore estimated with GMM with two lags of RS and $RL5$ as instruments:[12]

$$\begin{aligned} RL5_t &= RL5_{t-1} + \underset{(3.9)}{0.407}(RS_t - RS_{t-1}) \\ &\quad + (1-0.407)\left[(RS_{t+19} - RS_{t-1})/20\right] + TERM5_t - TERM5_{t-1} \end{aligned} \tag{4.5}$$

[12]The equation is estimated using data until 2017:Q4. The estimation period ends in 2013:Q1 due to the inclusion of RS_{t+19} as a regressor. The homogeneity restriction is accepted at $p = 0.99$ and the J-test does not reject the over-identifying restrictions.

Estimation method	GMM
Adjusted R^2	0.850
Equation standard error	0.63%
Coefficient restrictions (F-test)	0.00 [0.99]
J-test for over-identifying restrictions (χ^2-test)	2.21 [0.70]
Normality test (χ^2-test)	20.45 [0.00]
Sample period	1997:Q1-2013:Q1 ($T = 65$)

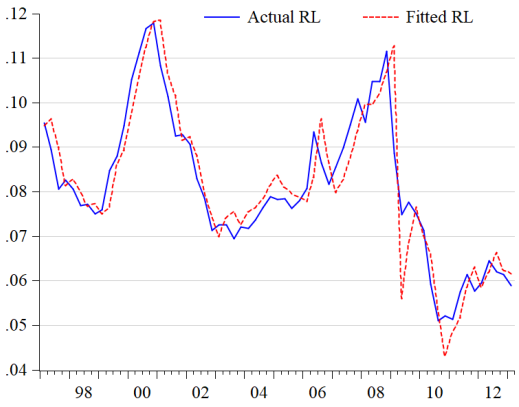

Figure 4.1. Fitted and actual $RL5_t$

The specification of $RL5$ used in QMM is therefore given as:

$$RL5_t = 0.407RS_t + (1 - 0.407)\sum_{j=0}^{19} RS_{t+j}/20 + TERM5_t \tag{4.6}$$

where:

$RL5$	5-year interest rate (4.6).
RS	Short-term interest rate (4.1).
$TERM5$	Term premium for 5-year interest rates (exogenous).

Similarly, the specification of $RL10$ used in QMM is given as:[13]

$$RL10_t = 0.407RS_t + (1 - 0.407)\sum_{j=0}^{39} RS_{t+j}/40 + TERM10_t \tag{4.7}$$

where:

[13]The estimated parameter from $RL5$ is also used for $RL10$ due to a short estimation period, whereas the inclusion of RS_{t+39} as a regressor would mean that the estimation period for $RL10$ would end in 2007:Q4.

$RL10$	10-year interest rate (4.7).
RS	Short-term interest rate (4.1).
$TERM10$	Term premium for 10-year interest rates (exogenous).

4.1.3. Indexed long-term interest rates ($RLV5$, $RLV10$ and $RLVH$)

Long-run indexed interest rates are given by the Fisher relation and an inflation risk premium:[14]

$$RLV5_t = \frac{(1 + RL5_t)}{(1 + INFE5_t)\,(1 + PRISK_t)} - 1 \tag{4.8}$$

$$RLV10_t = \frac{(1 + RL10_t)}{(1 + INFE10_t)\,(1 + PRISK_t)} - 1 \tag{4.9}$$

where:

$RLV5$	5-year indexed interest rate (4.8).
$RLV10$	10-year indexed interest rate (4.9).
$RL5$	5-year interest rate (4.6).
$RL10$	10-year interest rate (4.7).
$INFE5$	5-year break-even inflation expectations (7.28).
$INFE10$	10-year break-even inflation expectations (7.29).
$PRISK$	Inflation risk premium (exogenous).

Long-term indexed mortgage rate $RLVH$ is given as:[15]

$$\begin{aligned} \Delta RLVH_t \;=\; & 0.082\Delta RLV5_{t-1} + 0.465\Delta RLVH_{t-1} \\ & -0.027(RLVH_{t-1} - RLV5_{t-1} - 0.015) \end{aligned} \tag{4.10}$$

where:

$RLVH$	Long-term indexed mortgage rate (4.10).
$RLV5$	5-year indexed interest rate (4.8).

[14] Previous versions of equations for long-term real rates of interest included a positive inflation risk premium. The spread between the break-even rate and survey-based inflation expectations has been close to zero and even negative in recent years, presumably reflecting a spread between nominal and indexed market liquidity premia that is sufficiently negative to offset a positive inflation risk premium. The variable for the wedge between break-even inflation expectations and pure inflation expectations, $PRISK$, remains part of the model but it has presently been set to the value of 0 instead of 0.005 as was done previously.

[15] $RLVH$ is calibrated to equal $RLV5$ plus a spread of 1.5 percentage points (the 2012-2017 average). The short-run dynamics are estimated and are assumed to depend on past changes of $RLVH$ and $RLV5$. The impulse responses of $RLVH$ to a shock in $RLV5$ are similar to the findings which were presented in *Monetary Bulletin* 2018/4 Box 1.

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 5-year real interest rate ($RLV5$), the depreciation rate of capital ($DELTA$) and a corporate risk premium ($PRBUS$):

$$RCC_t = (RLV5_t + PRBUS_t)/4 + DELTA_t \tag{4.11}$$

where:

RCC	Real cost of capital (4.11).
$RLV5$	5-year indexed interest rate (4.8).
$PRBUS$	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:

$$RID_t = \frac{(1 + RS_t/4)/(1 + INFUL_t/4)}{[(1 + WRS_t/4)/(1 + WINF_t/4)]\,[1 + (RISK_t + CFM_t)/4]} \tag{4.12}$$

where:

RID	Real interest rate differential (4.12).
RS	Short-term interest rate (4.1).
$INFUL$	Underlying four-quarter CPI inflation rate (7.25).
WRS	Iceland's trading partner short-term interest rate (exogenous).
$WINF$	Iceland's trading partner four-quarter inflation rate (7.27).
$RISK$	Exchange rate risk premium (exogenous).
CFM	Capital flow management measure (exogenous).

4.2. Exchange rates and terms of trade

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

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

$$EER_t = \frac{CPI_t}{REX_t \times WCPI_t} \tag{4.13}$$

where:

EER	Exchange rate index of foreign currency (4.13).
CPI	Consumer price index (7.4).
REX	Real exchange rate (4.19).
$WCPI$	Iceland's trading partner consumer prices (exogenous).

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

$$\Delta eus_t = \Delta eer_t \tag{4.14}$$
$$\Delta eur_t = \Delta eer_t \tag{4.15}$$

where:

EUS	USD exchange rate (4.14).
EUR	Euro exchange rate (4.15).
EER	Exchange rate index of foreign currency (4.13).

4.2.2. Real exchange rate (REX, $REXW$, $REXX$ 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, $REXEQ$:

$$(rex_t - rexeq_t) = \alpha_{rex}(rex_{t-1} - rexeq_{t-1}) + \beta_{rex}(rex^e_t - rexeq_t) + rid_t \tag{4.16}$$

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 $REXEQ$:[16]

$$(rex^e_t - rexeq_t) = \gamma_{rex}(rex_{t-1} - rexeq_{t-1}) + \phi_{rex}(rex_{t+1} - rexeq_{t+1}) \tag{4.17}$$

Equations (4.16) and (4.17) can be solved jointly to obtain an estimable equation for REX as:

$$\begin{aligned}(rex_t - rexeq_t) = {} & (\alpha_{rex} + \beta_{rex}\gamma_{rex})(rex_{t-1} - rexeq_{t-1}) \\ & + \beta_{rex}\phi_{rex}(rex_{t+1} - rexeq_{t+1}) + rid_t\end{aligned} \tag{4.18}$$

Direct estimation of (4.18) gives coefficients on the backward- and forward-looking terms of roughly 0.5. 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. The parameters were therefore calibrated to

[16] 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 (cf. Berg et al., 2006, and Isard and Laxton, 2000).

improve the overall behaviour of the model. The real exchange rate equation used is therefore given as:[17]

$$(rex_t - rexeq_t) = 0.67(rex_{t-1} - rexeq_{t-1}) + 0.30(rex_{t+1} - rexeq_{t+1}) + rid_t \quad (4.19)$$

where:

REX	Real exchange rate (4.19).
$REXEQ$	Equilibrium real exchange rate (exogenous).
RID	Real interest rate differential (4.12).

A measure of the real exchange rate given by relative unit labour costs is defined as:

$$REXW_t = \frac{ULC_t}{EER_t \times WULC_t} \quad (4.20)$$

where:

$REXW$	Real exchange rate given relative unit labour costs (4.20).
ULC	Unit labour costs (6.4).
EER	Exchange rate index of foreign currency (4.13).
$WULC$	Iceland's trading partner unit labour costs (exogenous).

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

$$REXX_t = \frac{PX_t}{EER_t \times WPX_t} \quad (4.21)$$

where:

$REXX$	Exporters' real exchange rate (4.21).
PX	Export price deflator (7.13).
EER	Exchange rate index of foreign currency (4.13).
WPX	Iceland's trading partner export prices (exogenous).

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

$$REXM_t = \frac{PM_t}{PGDP_t} \quad (4.22)$$

where:

[17] Version 2.2 of QMM used estimated values 0.552 and 0.435 on the backward- and forward-looking terms. In Version 3.0 of QMM the parameters were calibrated with 0.65 on the backward-looking term and 0.30 on the forward-looking. In this version the forward-looking term is still 0.30 but the backward-looking term is raised to 0.67 to slow down the adjustment of the real exchange rate to its equilibrium real exchange rate ($REXEQ$).

$REXM$	Importers' real exchange rate (4.22).
PM	Import price deflator (7.9).
$PGDP$	GDP price deflator (7.19).

4.2.3. Terms of trade (TOT)

Terms of trade are given as the price of exports of goods and services relative to the price of imports of goods and services:

$$TOT_t = \frac{PX_t}{PM_t} \tag{4.23}$$

where:

TOT	Terms of trade (4.23).
PX	Export price deflator (7.13).
PM	Import price deflator (7.9).

4.3. Money, equity prices and wealth

4.3.1. 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:

$$(m3 - pgdp) = \alpha_m + \beta_m gdp + (1 - \beta_m)(wel - pgdp) - \phi_m RL5 - \theta_m \Delta_4 eqp \tag{4.24}$$

where $M3/PGDP$ are real money holdings, GDP is the scale variable, $WEL/PGDP$ is real wealth, $RL5$ is the 5-year interest rate and EQP is equity price. The short-run dynamics of real money balances are also negatively affected by the acceleration of inflation:

$$\begin{aligned}
\Delta(m3_t - pgdp_t) \;=\; & \underset{(2.7)}{0.065} - \underset{(-1.7)}{0.015}Q1 + \underset{(1.6)}{0.014}Q2 + \underset{(1.5)}{0.014}Q3 + \underset{(7.0)}{0.129}D0723 \\
& + \underset{(2.0)}{0.053}D084 + \underset{(4.9)}{0.411}\Delta(m3_{t-2} - pgdp_{t-2}) \\
& + \underset{(1.3)}{0.100}\Delta(wel_{t-4} - pgdp_{t-4}) - \underset{(-4.8)}{0.784}\Delta^2 pgdp_t - \underset{(-3.3)}{0.525}\Delta^2 pgdp_{t-1} \\
& - \underset{(-2.6)}{0.053}\,[(m3_{t-1} - pgdp_{t-1}) - 0.640\; gdp_{t-1} \\
& - 0.360(wel_{t-1} - pgdp_{t-1}) + 9.538RL5_{t-1} \\
& + 0.217\Delta_4 eqp_{t-1} - 0.359D08]
\end{aligned} \tag{4.25}$$

Estimation method	OLS
Adjusted R^2	0.647
Equation standard error	2.47%
Long-run restrictions (F-test)	0.54 [0.47]
LM test for serial correlation (F-test)	2.03 [0.16]
Normality test (χ^2-test)	28.34 [0.00]
White test for heteroscedasticity (F-test)	0.19 [1.00]
Sample period	2000:Q2-2017:Q4 ($T = 71$)

where:

$M3$	Broad money (4.25).
$PGDP$	GDP price deflator (7.19).
GDP	GDP (5.61).
EQP	Equity prices (4.26).
WEL	Household sector wealth (4.27).
$RL5$	5-year 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.

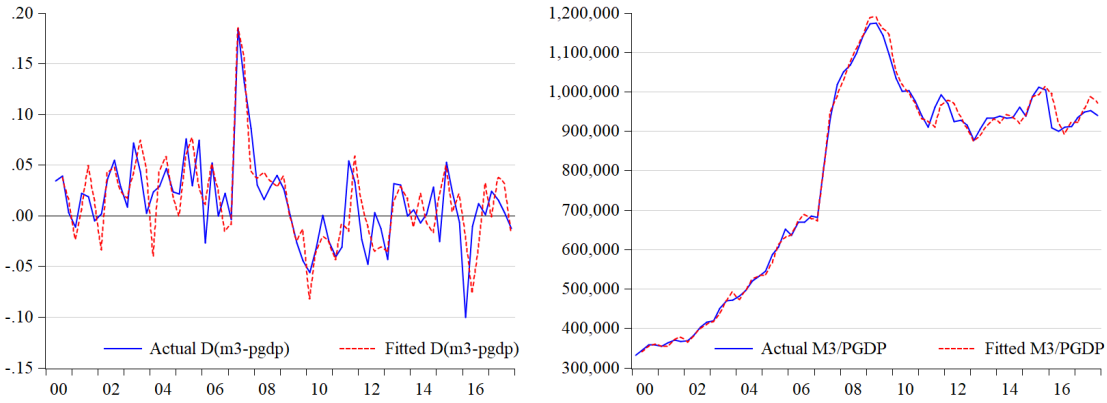

Figure 4.2. Fitted and actual $\Delta(m3 - pgdp)_t$ *and* $M3_t/PGDP_t$

Single equation dynamic responses of (4.25):

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

Quarters	$pgdp$	gdp	$wel - pgdp$	$RL5$	$\Delta_4 eqp$
Simultaneous	−0.78	0.00	0.00	0.00	0.00
One quarter ahead	−0.48	0.03	0.02	−0.50	−0.01
Four quarters ahead	−0.02	0.15	0.19	−2.25	−0.05
Eight quarters ahead	0.11	0.31	0.31	−4.63	−0.11
Long run	0.00	0.64	0.36	−9.54	−0.22
50% of long-run effect	-	9Q	4Q	9Q	9Q
90% of long-run effect	-	23Q	10Q	23Q	23Q

Steady state solution:
$(m3 - pgdp - gdp) = const + 0.360(wel - pgdp - gdp) - 9.538RL5 - 0.217\Delta_4 eqp$

4.3.2. Equity prices (EQP)

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

$$\Delta eqp_t = \Delta pgdp_t \tag{4.26}$$

where:

EQP	Equity prices (4.26).
$PGDP$	GDP price deflator (7.19).

4.3.3. 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):

$$WEL_t = HW_t + NFW_t \tag{4.27}$$

where:

WEL	Household sector wealth (4.27).
HW	Housing wealth (4.28).
NFW	Net financial wealth (4.29).

Housing wealth is defined as:[18]

$$HW_t = 1.37PH_t \times KH_t \tag{4.28}$$

where:

[18]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.

HW	Gross housing wealth (4.28).
PH	House prices (7.21).
KH	Private sector housing stock (5.22).

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

$$NFW_t = GFW_t - DH_t \tag{4.29}$$

where:

NFW	Net financial wealth (4.29).
GFW	Gross financial wealth (4.30).
DH	Household debt (4.31).

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):

$$\begin{aligned} GFW_t &= REVA_t \times GFW_{t-1} + \left(\frac{\omega_w}{\omega_w - 1}\right)[PC_t \times RHPI_t - CN_t \\ &\quad -PH_t \times (IH_t - DELTAH_t \times 1.37KH_{t-1})] \end{aligned} \tag{4.30}$$

and household debt as:

$$\begin{aligned} DH_t &= REVD_t \times DH_{t-1} + \left(\frac{1}{\omega_w - 1}\right)[PC_t \times RHPI_t - CN_t \\ &\quad -PH_t \times (IH_t - DELTAH_t \times 1.37KH_{t-1})] \end{aligned} \tag{4.31}$$

where:

GFW	Gross financial wealth (4.30).
DH	Household debt (4.31).
PC	Private consumption deflator (7.14).
$RHPI$	Real household post-tax income (9.6).
CN	Nominal private consumption (5.3).
PH	House prices (7.21).
IH	Private sector housing investment (5.16).
KH	Private sector housing stock (5.22).
$DELTAH$	Depreciation rate for housing stock (exogenous).
$REVA$	Household assets revaluation term (4.32).
$REVD$	Household debt revaluation term (4.33).

The revaluation terms are given as:

$$REVA_t = 0.67 + 0.06\left(\frac{EQP_t}{EQP_{t-1}}\right) + 0.27\left(\frac{CPI_t}{CPI_{t-1}}\right) \tag{4.32}$$

and

$$REVD_t = 0.26 + 0.01\left(\frac{EER_t}{EER_{t-1}}\right) + 0.73\left(\frac{CPI_t}{CPI_{t-1}}\right) \tag{4.33}$$

where:

$REVA$	Household assets revaluation term (4.32).
$REVD$	Household debt revaluation term (4.33).
EQP	Equity prices (4.26).
CPI	Consumer price index (7.4)
EER	Exchange rate index of foreign currency (4.13).

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.[19]

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:

$$c = \alpha_c + \beta_c rhpi + (1 - \beta_c)(wel - pc) - \phi_c(RS - INFE5) \tag{5.1}$$

where C is consumption, $RHPI$ is real disposable income, WEL/PC is real wealth, RS is the short-term interest rate and $INFE5$ is the 5-year break-even inflation expectations. The short-run dynamics also allow for effects from the unemployment rate, reflecting precautionary saving effects:[20]

[19] 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 2018. The constants reflect the shares of nominal interest rate assets and liabilities. On the asset side, the 67% weight reflects the share of non-indexed-linked assets, 27% weight reflects share of indexed-linked assets and the 6% weight reflects the share of equities. On the liabilities side, the 26% weight reflects the share of non-indexed-linked debt, 73% reflects the indexed-linked debt, while the 1% share reflects the share of foreign currency denominated debt. 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 interest rates are low.

[20] 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. A shift dummy $S131$ was added to the

$$\begin{aligned}\Delta c_t \;=\; & \underset{(3.4)}{0.012} - \underset{(-3.9)}{0.049}Q1 + \underset{(2.1)}{0.020}Q2 - \underset{(-2.6)}{0.025}Q3 - \underset{(-7.3)}{0.099}D0824 \\ & + \underset{(6.8)}{0.501}\Delta c_{t-4} + \underset{(2.4)}{0.125}\Delta(wel_t - pc_t) - \underset{(-2.0)}{0.723}\,\Delta UR_{t-1} - \underset{(-2.7)}{0.101}\,[c_{t-1} - 0.959 rhpi_{t-1} \\ & - 0.041(wel_{t-1} - pc_{t-1}) + 1.201(RS_{t-1} - INFE5_{t-1}) + 0.060\; S131_{t-1}]\end{aligned} \tag{5.2}$$

Estimation method	OLS
Adjusted R^2	0.896
Equation standard error	2.14%
Long-run restrictions (F-test)	34.01 [0.00]
LM test for serial correlation (F-test)	1.03 [0.31]
Normality test (χ^2-test)	0.33 [0.85]
White test for heteroscedasticity (F-test)	3.00 [0.01]
Sample period	1997:Q1-2017:Q4 ($T = 84$)

where:

C	Private consumption (5.2).
$RHPI$	Real household post-tax income (9.6).
WEL	Household sector wealth (4.27).
PC	Private consumption deflator (7.14).
RS	Short-term interest rate (4.1).
UR	Unemployment rate (6.6).
$INFE5$	5-year break-even inflation expectations (7.28).
$D0824$	Dummy variable: 1 2008:Q2-2008:Q4 and zero otherwise.
$S131$	Shift dummy variable: 1 from 2013:Q1 and zero otherwise.
$Q1$-$Q3$	Centered seasonal dummies.

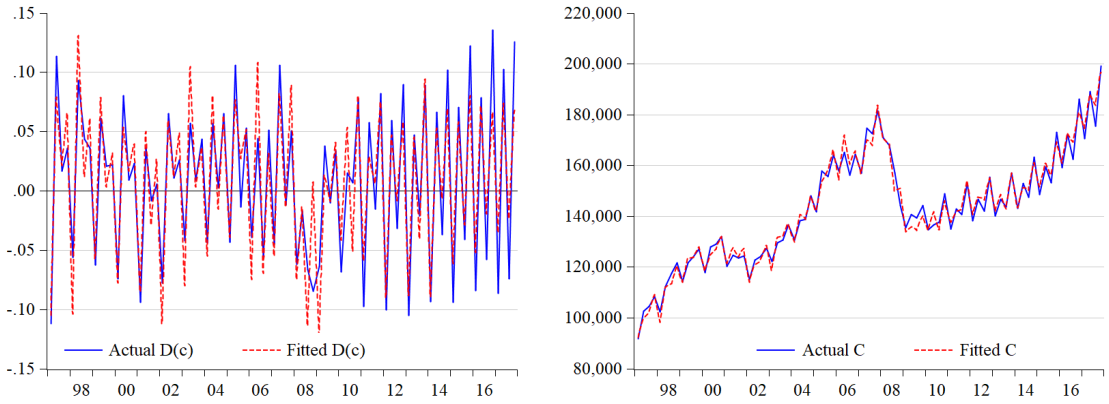

Figure 5.1. Fitted and actual Δc_t and C_t

long-run to capture a change in household saving propensity. The long-run solution is estimated for the time period 2003:Q1 to 2017:Q4, while the short-run solution is estimated for 1997:Q1 to 2017:Q4.

Single equation dynamic responses of (5.2):[21]

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

Quarters	$rhpi$	$wel - pc$	UR	$RS - INFE5$
Simultaneous	0.00	0.12	0.00	0.00
One quarter ahead	0.10	0.12	−0.72	−0.12
Four quarters ahead	0.33	0.16	−0.52	−0.42
Eight quarters ahead	0.69	0.14	−0.52	−0.87
Long run	0.96	0.04	0.00	−1.20
50% of long-run effect	6Q	O/S	-	6Q
90% of long-run effect	11Q	O/S	-	11Q

Steady state solution:
$(c - rhpi) = const + 0.041(wel - pc - rhpi) - 1.201(RS - INFE5)$

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 (7.14).
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 (7.15).

[21] 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.

5.2. Fixed investment and the capital stock

5.2.1. Fixed investment (I and IN)

Fixed investment is given as the sum of business investment, housing investment and government investment 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 $Y-1$ subscript. Fixed investment can thus be written as:

$$\begin{aligned} I_t &= \left[IBUS_t \times \left(\frac{IBUSN}{IBUS}\right)_{Y-1} + PIH_{Y-1} \times IH_t \right. \\ &\quad \left. + PIG_{Y-1} \times IG_t\right] \times \left(\frac{I}{IN}\right)_{Y-1} \end{aligned} \tag{5.5}$$

where:

I	Fixed investment (5.5).
$IBUS$	Business investment (5.12).
$IBUSN$	Nominal business investment (5.14).
IH	Private sector housing investment (5.16).
PIH	Housing investment deflator (7.17).
IG	Government investment (exogenous).
PIG	Government investment deflator (7.18).
IN	Nominal fixed investment (5.6).

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 (7.16).
I	Fixed investment (5.5).

5.2.2. Business investment ($IBREG$, $IBUS$, $IBREGN$ 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 (5.63) $\sigma_{ib} = 1$. 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 (5.21) 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 ships and airplanes), $IBREG$, with the short-run dynamics given as:[22]

$$\begin{aligned} \Delta ibreg_t \;=\; & -0.575 + \underset{(1.6)}{0.033}Q1 + \underset{(2.1)}{0.045}Q2 - \underset{(-0.8)}{0.016}Q3 \\ & -\underset{(-4.6)}{0.310}D021 - \underset{(-7.0)}{0.333}D084091 + \underset{(2.8)}{0.227}\Delta ibreg_{t-4} \\ & -\underset{(-2.4)}{0.096}[ibreg_{t-1} - gdp_{t-1} + rcc_{t-1} + 0.659\ S091_{t-1}] \end{aligned} \tag{5.11}$$

Estimation method	OLS
Adjusted R^2	0.541
Equation standard error	6.52%
Long-run restrictions (F-test)	2.09 [0.13]
LM test for serial correlation (F-test)	0.01 [0.93]
Normality test (χ^2-test)	10.88 [0.00]
White test for heteroscedasticity (F-test)	1.46 [0.19]
Sample period	1998:Q1-2017:Q4 ($T = 80$)

where:

$IBREG$	Regular business investment (5.11).
GDP	GDP (5.61).
RCC	Real cost of capital (4.11).
$D021$	Dummy variable: 1 2002:Q1 and zero elsewhere.
$D084091$	Dummy variable: 1 2008:Q4 - 2009Q1 and zero elsewhere.
$S091$	Shift dummy variable: 1 from 2009Q1 and from 2015Q1 decreases to zero over 20 quarters.
$Q1$-$Q3$	Centered seasonal dummies.

[22] The constant is calibrated so that the ratio of regular business investment to GDP converges to a share that is consistent with a sustainable balanced growth path (cf. Daníelsson, 2009). The shift dummy $S091$ is equal to one from 2009:Q1 but from 2015:Q1 it decreases slowly to zero over 20 quarters.

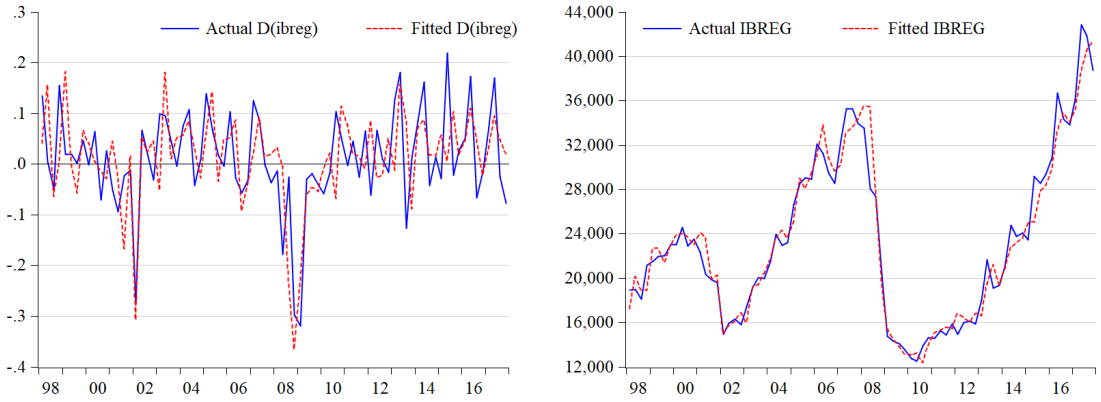

Figure 5.2. Fitted and actual $\Delta ibreg_t$ and $IBREG_t$

Single equation dynamic responses of (5.11):

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

Quarters	*gdp*	*rcc*
Simultaneous	0.00	0.00
One quarter ahead	0.10	−0.10
Four quarters ahead	0.33	−0.33
Eight quarters ahead	0.62	−0.62
Long run	1.00	−1.00
50% of long-run effect	7Q	7Q
90% of long-run effect	16Q	16Q
Steady state solution: $(ibreg - gdp) = const - rcc$		

Total business sector investment is given as the sum of regular business investment, aluminium sector investment and investment in ships and airplanes 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 $Y-1$ subscript. Total business sector investment can thus be written as:

$$IBUS_t = \left[IBREG_t \times \left(\frac{IBREGN}{IBREG}\right)_{Y-1} + IBALU_t \times \left(\frac{IBALUN}{IBALU}\right)_{Y-1} + IBAIR_t \times \left(\frac{IBAIRN}{IBAIR}\right)_{Y-1}\right] \times \left(\frac{IBUS}{IBUSN}\right)_{Y-1} \quad (5.12)$$

where:

$IBUS$	Business investment (5.12).
$IBREG$	Regular business investment (5.11).
$IBREGN$	Nominal regular business investment (5.13).
$IBALU$	Aluminium sector investment (exogenous).
$IBALUN$	Nominal aluminium sector investment (exogenous).
$IBAIR$	Investment in ships and airplanes (exogenous).
$IBAIRN$	Nominal investment in ships and airplanes (exogenous).
$IBUS$	Nominal business investment (5.14).

Nominal regular business investment is given by:

$$IBREGN_t = IBUSN_t - IBALUN_t - IBAIRN_t \tag{5.13}$$

where:

$IBREGN$	Nominal regular business investment (5.13).
$IBUSN$	Nominal business investment (5.14).
$IBALUN$	Nominal aluminium sector investment (exogenous).
$IBAIRN$	Nominal investment in ships and airplanes (exogenous).

Nominal business investment is given by:

$$IBUSN_t = IN_t - IHN_t - IGN_t \tag{5.14}$$

where:

$IBUSN$	Nominal business investment (5.14).
IN	Nominal fixed investment (5.6).
IHN	Nominal housing investment (5.17).
IGN	Nominal government investment (5.18).

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):

$$(ih - gdp) = \alpha_{ih} + \beta_{ih}(ph - pih) \tag{5.15}$$

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 the real mortgage rate $RLVH$:[23]

[23]The constant is calibrated so that the ratio of housing investment to GDP converges to a share that is consistent with a sustainable balanced growth path (cf. Daníelsson, 2009). The shift

$$
\begin{aligned}
\Delta ih_t \;=\; & -0.787 \underset{(-3.7)}{-0.100}Q1 \underset{(-1.9)}{-0.054}Q2 \underset{(-1.2)}{-0.040}Q3 \underset{(-6.6)}{-0.528}D091 \\
& \underset{(5.5)}{+0.429}D164 + \underset{(2.7)}{0.840}\Delta gdp_t \underset{(-2.3)}{-9.556}\Delta RLVH_{t-4} \\
& \underset{(-2.9)}{-0.257}[(ih_{t-1} - gdp_{t-1}) - 0.320(ph_{t-1} - pih_{t-1}) + 0.847\ S091_{t-1}]
\end{aligned}
\tag{5.16}
$$

Estimation method	OLS
Adjusted R^2	0.743
Equation standard error	7.09%
Long-run restrictions (F-test)	4.62 [0.01]
LM test for serial correlation (F-test)	1.67 [0.20]
Normality test (χ^2-test)	1.77 [0.41]
White test for heteroscedasticity (F-test)	2.61 [0.02]
Sample period	2001:Q1-2017:Q4 ($T = 68$)

where:

IH	Private sector housing investment (5.16).
GDP	GDP (5.61).
PH	House prices (7.21).
PIH	Housing investment deflator (7.17).
$RLVH$	Long-term indexed mortgage rate (4.10).
$D091$	Dummy variable: 1 2009:Q1 and zero elsewhere.
$D164$	Dummy variable: 1 2016:Q4 and zero elsewhere.
$S091$	Shift dummy variable: 1 from 2009:Q1 and from 2015Q1 decreases to zero over 20 quarters.
$Q1$-$Q3$	Centered seasonal dummies.

dummy $S091$ is equal to one from 2009:Q1 but from 2015:Q1 it decreases slowly to zero over 20 quarters. The long-run solution is estimated for the time period 1990:Q1 to 2017:Q4, while the short run solution is estimated for 2001:Q1 to 2017:Q4.

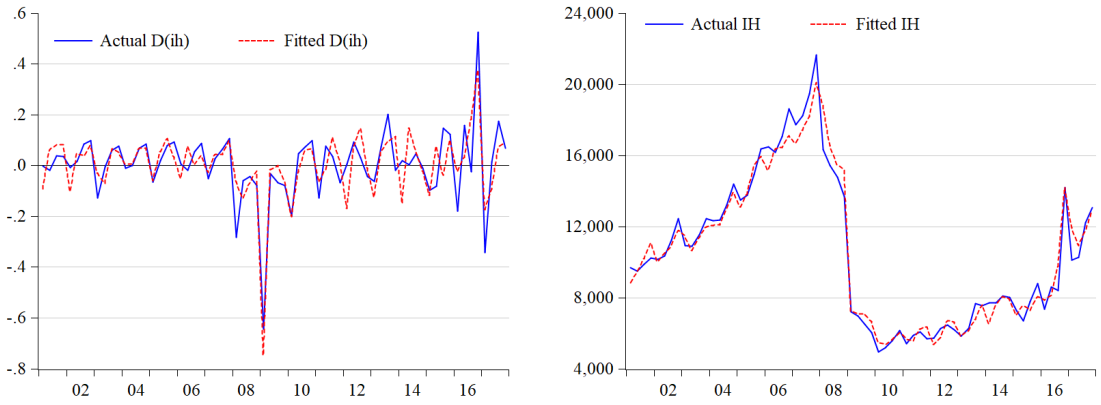

Figure 5.3. Fitted and actual Δih_t and IH_t

Single equation dynamic responses of (5.16):[24]

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

Quarters	gdp	ph	pih	$RLVH$
Simultaneous	0.84	0.00	0.00	0.00
One quarter ahead	0.88	0.08	−0.08	0.00
Four quarters ahead	0.95	0.22	−0.22	−9.56
Eight quarters ahead	0.99	0.29	−0.29	−2.92
Long run	1.00	0.32	−0.32	0.00
50% of long-run effect	0Q	3Q	3Q	-
90% of long-run effect	2Q	8Q	8Q	-
Steady state solution: $(ih - gdp) = const + 0.320(ph - pih)$				

Nominal housing investment is given by:

$$IHN_t = PIH_t \times IH_t \tag{5.17}$$

where:

IHN	Nominal housing investment (5.17).
PIH	Housing investment deflator (7.17).
IH	Private sector housing investment (5.16).

[24]The single equation estimate suggests that a permanent change in $RLVH$ does not have a long-run effect on housing investment, but in the overall model context this affect is working through the effect of $RLVH$ on GDP and PH/PIH.

5.2.4. Government investment (IGN and $IGNNET$)

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

$$IGN_t = PIG_t \times IG_t \tag{5.18}$$

where:

IGN	Nominal government investment (5.18).
IG	Government investment (exogenous).
PIG	Government investment deflator (7.18).

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:

$$IGNNET_t = IGN_t - PIG_t \times DELTAG_t(K_{t-1} - KBUS_{t-1} - KH_{t-1}) \tag{5.19}$$

where:

$IGNNET$	Nominal net government investment (5.19).
IGN	Nominal government investment (5.18).
PIG	Government investment deflator (7.18).
$DELTAG$	Depreciation rate for government capital stock (exogenous).
K	Total capital stock (5.20).
$KBUS$	Business capital stock (5.21).
KH	Private sector housing stock (5.22).

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:

$$K_t = (1 - DELTA_t)K_{t-1} + I_t \tag{5.20}$$

$$KBUS_t = (1 - DELTAB_t)KBUS_{t-1} + IBUS_t \tag{5.21}$$

$$KH_t = (1 - DELTAH_t)KH_{t-1} + IH_t + IHEX_t \times GDP_t \tag{5.22}$$

where:

K	Total capital stock (5.20).
$KBUS$	Business capital stock (5.21).
KH	Private sector housing stock adjusted as described below (5.22).
I	Fixed investment (5.5).
$IBUS$	Business investment (5.12).
IH	Private sector housing investment (5.16).
$DELTA$	Depreciation rate for total capital stock (exogenous).
$DELTAB$	Depreciation rate for business capital stock (exogenous).
$DELTAH$	Depreciation rate for housing stock (exogenous).
$IHEX$	Adjustment factor (exogenous).
GDP	GDP (5.61).

An adjustment factor $IHEX$ needs to be added to the housing stock equation (5.22) 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.[25]

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 $Y-1$ subscript. Domestic demand can thus be written as:

$$\begin{aligned} DD_t &= [PC_{Y-1} \times C_t + PG_{Y-1} \times G_t + PI_{Y-1} \times I_t \\ &\quad + (IIN/II)_{Y-1} \times II_t] \times \left(\frac{DD}{DDN}\right)_{Y-1} \end{aligned} \tag{5.23}$$

where:

[25] According to data from Statistics Iceland housing investment averaged 4.1% of GDP during 1991-2018, and depreciation of the housing stock averaged 4.3% so net housing investment averaged -0.2% of GDP during this period. During the same period the increase in the housing stock at fixed prices averaged 2.0% 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 aggravates the problem with stock-flow consistency noted above but created another problem as the high valuation of the housing stock at 2005 prices increased the capital-output significantly. By scaling down the housing stock as valued by Statistics Iceland at constant prices by dividing through with 1.37 the capital-output ratio was brought back to the average of roughly 12 for quarterly data. This reduced the problem with stock-flow consistency somewhat but didn‘t eliminate it. The adjustment term $IHEX \times GDP$ in (5.22) 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 Daníelsson, 2009) and kept constant.

DD	Domestic demand (5.23).
C	Private consumption (5.2).
PC	Private consumption deflator (7.14).
G	Government consumption (exogenous).
PG	Government consumption deflator (7.15).
I	Fixed investment (5.5).
PI	Investment goods price deflator (7.16).
II	Net stockbuilding (exogenous).
IIN	Nominal net stockbuilding (exogenous).
DDN	Nominal domestic demand (5.24).

Nominal domestic demand is given by a corresponding accounting identity:

$$DDN_t = CN_t + GN_t + IN_t + IIN_t \tag{5.24}$$

where:

DDN	Nominal domestic demand (5.24).
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:[26]

$$DDA_t = 0.35C_t + 0.13G_t + 0.50I_t + 0.22EXD_t \tag{5.25}$$

where:

DDA	Import weighted domestic demand (5.25).
C	Private consumption (5.2).
G	Government consumption (exogenous).
I	Fixed investment (5.5).
EXD	Exports excluding exports of aluminium, ships and airplanes (5.31).

[26]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 latest 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. The items $EXALU$ and $EXAIR$ are deducted from EX since imports related to them are accounted for by other variables.

5.4. Net trade

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

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 $Y-1$ subscript:

$$\begin{aligned} EX_t &= \left[EXG_t \times \left(\frac{EXGN}{EXG}\right)_{Y-1}\right. \\ &\quad \left. + EXS_t \times \left(\frac{EXSN}{EXS}\right)_{Y-1}\right] \times \left(\frac{EX}{EXN}\right)_{Y-1} \end{aligned} \tag{5.26}$$

where:

EX	Export volume of goods and services (5.26).
EXG	Export volume of goods (5.27).
EXS	Export volume of services (5.39).
$EXGN$	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:

$$\begin{aligned} EXG_t &= [EXALU_t \times EUS_{Y-1} \times PXALU_{Y-1} \\ &\quad + EXMAR_t \times EER_{Y-1} \times PXMAR_{Y-1} \\ &\quad + EXAIR_t \times \left(\frac{EXAIRN}{EXAIR}\right)_{Y-1} \\ &\quad + EXOTH_t \times PXOTH_{Y-1}] \times \left(\frac{EXG}{EXGN}\right)_{Y-1} \end{aligned} \tag{5.27}$$

where:

EXG	Export volume of goods (5.27).
EUS	USD exchange rate (4.14).
$PXALU$	Price of aluminium products in USD (exogenous).
$EXALU$	Export volume of aluminium products (exogenous).
EER	Exchange rate index of foreign currency (4.13).
$PXMAR$	Price of marine products in foreign currency (7.12).
$EXMAR$	Export volume of marine products (exogenous).
$EXAIRN$	Nominal export of ships and airplanes (5.32).
$EXAIR$	Export volume of ships and airplanes (exogenous).
$PXOTH$	Export price deflator for other goods (7.10).
$EXOTH$	Export volume of other goods (5.36).
$EXGN$	Nominal export of goods (5.29).

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 (5.33).
$EXMARN$	Nominal export of marine products (5.34).
$EXAIRN$	Nominal export of ships and airplanes (5.32).
$EXOTHN$	Nominal export of other goods (5.37).

Nominal export of services is given as:

$$EXSN_t = EXS_t \times PXS_t \tag{5.30}$$

where:

$EXSN$	Nominal export of services (5.30).
EXS	Exports of services (5.39).
PXS	Export price deflator for services (7.11).

Exports excluding exports of aluminium, ships and airplanes is given as:

$$EXD_t = EX_t - EXALU_t - EXAIR_t \tag{5.31}$$

where:

EXD	Exports excluding exports of aluminium, ships and airplanes (5.31).
$EXALU$	Exports of aluminium products (exogenous).
$EXAIR$	Export volume of ships and airplanes (exogenous).

Nominal export of ships and airplanes is defined as:

$$EXAIRN_t = PI_t \times EXAIR_t \tag{5.32}$$

where:

$EXAIRN$	Nominal export of ships and airplanes (5.32).
PI	Investment goods price deflator (7.16).
$EXAIR$	Export volume of ships and airplanes (exogenous).

Nominal export of aluminium products is defined as:

$$EXALUN_t = PXALU_t \times EUS_t \times EXALU_t \tag{5.33}$$

where:

$EXALUN$	Nominal export of aluminium products (5.33).
$PXALU$	Price of aluminium products in USD (exogenous).
EUS	USD exchange rate (4.14).
$EXALU$	Exports of aluminium products (exogenous).

Nominal export of marine products is defined as:

$$EXMARN_t = PXMAR_t \times EER_t \times EXMAR_t \tag{5.34}$$

where:

$EXMARN$	Nominal export of marine products (5.34).
$PXMAR$	Price of marine products in foreign currency (7.12).
EER	Exchange rate index of foreign currency (4.13).
$EXMAR$	Exports of marine products (exogenous).

In the long-run, exports of other goods (21% of total goods exports in 1997-2017) are determined by international demand (proxied by trading partners' imports) and relative prices, with unit income elasticity:

$$exoth = \alpha_{exoth} + trade - \beta_{exoth}(pxoth - (eer + wcpi)) \tag{5.35}$$

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

This gives the following dynamic equation:

$$\begin{aligned}\Delta exoth_t &= \underset{(5.3)}{5.352} - \underset{(-4.7)}{0.168}Q1 - \underset{(-4.9)}{0.151}Q2 - \underset{(-4.1)}{0.122}Q3 \\ &+\underset{(3.9)}{0.344}D041 + \underset{(4.3)}{0.130}S093 - \underset{(-7.1)}{1.129}\Delta(pxoth_t - (eer_t + wcpi_t)) \\ &-\underset{(-5.3)}{0.583}[exoth_{t-1} - trade_{t-1} + 0.983(pxoth_{t-1} - (eer_{t-1} + wcpi_{t-1}))]\end{aligned} \tag{5.36}$$

Estimation method	OLS
Adjusted R^2	0.747
Equation standard error	8.36%
Long-run restrictions (F-test)	2.19 [0.15]
LM test for serial correlation (F-test)	0.03 [0.86]
Normality test (χ^2-test)	3.73 [0.16]
White test for heteroscedasticity (F-test)	1.56 [0.17]
Sample period	2002:Q1-2017:Q4 ($T = 64$)

where:

$EXOTH$	Export volume of other goods (5.36).
$TRADE$	Iceland's trading partner imports (exogenous).
EER	Exchange rate index of foreign currency (4.13).
$PXOTH$	Export prices deflator for other goods (7.10).
$WCPI$	Iceland's trading partner 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.

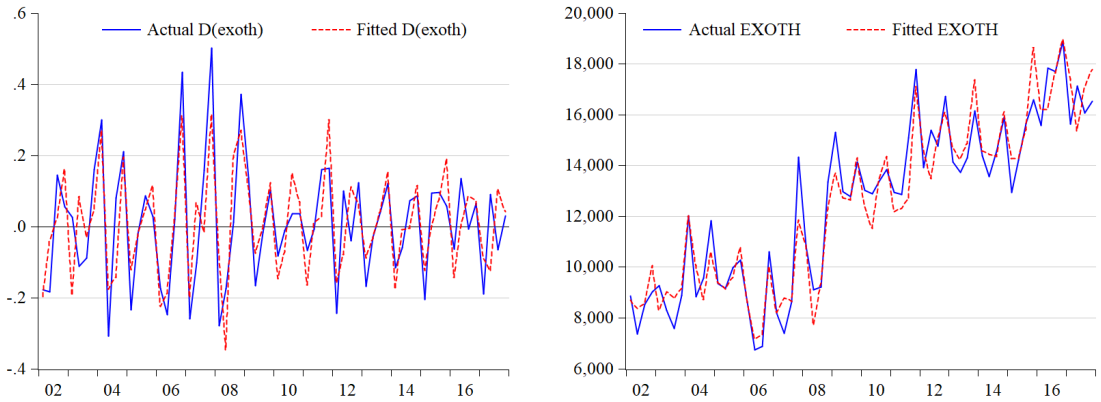

Figure 5.4. Fitted and actual $\Delta exoth_t$ and $EXOTH_t$

Single equation dynamic responses of (5.36):

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

Quarters	$trade$	$pxoth-(eer+wcpi)$
Simultaneous	0.00	−1.13
One quarter ahead	0.58	−1.04
Four quarters ahead	0.97	−0.99
Eight quarters ahead	1.00	−0.98
Long run	1.00	−0.98
50% of long-run effect	1Q	O/S
90% of long-run effect	3Q	O/S
Steady state solution: $(exoth-trade)=const-0.983(pxoth-(eer+wcpi))$		

Nominal export of other goods is defined as:

$$EXOTHN_t = PXOTH_t \times EXOTH_t \tag{5.37}$$

where:

$EXOTHN$	Nominal export of other goods (5.37).
$PXOTH$	Export price deflator for other goods (7.10).
$EXOTH$	Export of other goods (5.36).

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

$$exs = \alpha_{exs} + trade - \beta_{exs} rex \tag{5.38}$$

where EXS are exports of services, $TRADE$ denotes trading partners' demand and REX is the real exchange rate. This gives the following dynamic equation:[27]

$$\begin{aligned}\Delta exs_t \;=\; & \underset{(5.8)}{6.341} + \underset{(0.9)}{0.044}Q1 + \underset{(5.8)}{0.307}Q2 + \underset{(13.3)}{0.448}Q3 - \underset{(-4.1)}{0.114}D001044 \\ & \underset{(-5.8)}{-0.605}[exs_{t-1} - trade_{t-1} + 0.385 rex_{t-1}] + \underset{(5.5)}{0.020}T1316\end{aligned} \tag{5.39}$$

[27] $T1316$ is a linear time trend capturing an increase in tourism in Iceland. $T1316$ is zero until 2013:Q1 where it starts at 1 and increases linearly over 16 quarters to 16 in 2016:Q4 from where it holds unchanged going forward.

Estimation method	OLS
Adjusted R^2	0.929
Equation standard error	6.93%
Long-run restrictions (F-test)	4.42 [0.04]
LM test for serial correlation (F-test)	0.08 [0.78]
Normality test (χ^2-test)	1.10 [0.58]
White test for heteroscedasticity (F-test)	0.89 [0.50]
Sample period	2000:Q1-2017:Q4 ($T = 84$)

where:

EXS	Exports of services (5.39).
$TRADE$	Iceland's trading partner imports (exogenous).
REX	Real exchange rate (4.19).
$D001044$	Dummy variable: 1 2000:Q1-2004:Q4 and zero elsewhere.
$T1316$	Linear time trend starting 1 2013:Q1 up to 16 2016:Q4.
$Q1$-$Q3$	Centered seasonal dummies.

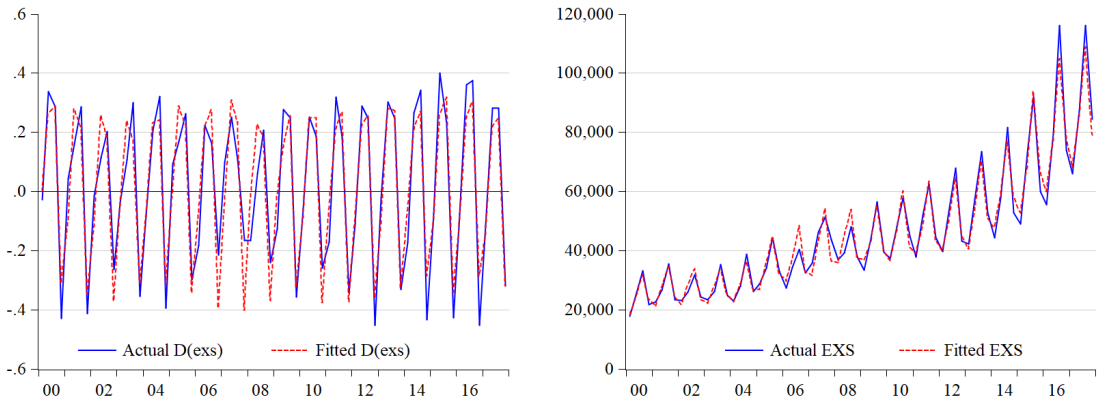

Figure 5.5. Fitted and actual Δexs_t and EXS_t

Single equation dynamic responses of (5.39):

Table 5.5. Responses of exs to a permanent 1% increase in RHS variables

Quarters	$trade$	rex
Simultaneous	0.00	0.00
One quarter ahead	0.61	−0.23
Four quarters ahead	0.98	−0.38
Eight quarters ahead	1.00	−0.38
Long run	1.00	−0.38
50% of long-run effect	1Q	1Q
90% of long-run effect	3Q	3Q
Steady state solution: $(exs - trade) = const - 0.385rex$		

5.4.2. Import volume of goods and services (IMP, $IMPALUN$, $IMPAIRN$, $IMPG$, $IMPN$, $IMPGN$, $IMPOTH$, $IMPOTHN$, $IMPS$, $IMPSN$ 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 $Y-1$ subscript:

$$\begin{aligned} IMP_t &= \left[IMPG_t \times \left(\frac{IMPGN}{IMPG}\right)_{Y-1}\right. \\ &\quad \left. + IMPS_t \times \left(\frac{IMPSN}{IMPS}\right)_{Y-1}\right] \times \left(\frac{IMP}{IMPN}\right)_{Y-1} \end{aligned} \tag{5.40}$$

where:

IMP	Import volume of goods and services (5.40).
$IMPG$	Import volume of goods (5.41).
$IMPS$	Import volume of services (5.50).
$IMPGN$	Nominal import of goods (5.43).
$IMPSN$	Nominal import of services (5.51).
$IMPN$	Nominal import of goods and services (5.42).

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 $Y-1$ subscript:

$$
\begin{aligned}
IMPG_t &= [PMALU_{Y-1} \times EUS_{Y-1} \times IMPALU_t \\
&\quad + \left(\frac{IMPAIRN}{IMPAIR}\right)_{Y-1} \times IMPAIR_t \\
&\quad + PMOTH_{Y-1} \times IMPOTH_t] \times \left(\frac{IMPG}{IMPGN}\right)_{Y-1}
\end{aligned} \tag{5.41}
$$

where:

$IMPG$	Import volume of goods (5.41).
$IMPALU$	Import volume of goods for aluminium production (exogenous).
$PMALU$	Import price deflator for aluminium production in USD (7.6).
EUS	USD exchange rate (4.14).
$IMPAIRN$	Nominal import of ships and airplanes (5.45).
$IMPAIR$	Import volume of ships and airplanes (exogenous).
$IMPOTH$	Import volume of other goods (5.47).
$PMOTH$	Import price deflator for other goods (7.7).
$IMPGN$	Nominal import of goods (5.43).

Nominal import of goods and services is given as:

$$
IMPN_t = IMPGN_t + IMPSN_t \tag{5.42}
$$

where:

$IMPN$	Nominal import of goods and services (5.42).
$IMPGN$	Nominal import of goods (5.43).
$IMPSN$	Nominal import of services (5.51).

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

$$
IMPGN_t = IMPALUN_t + IMPAIRN_t + IMPOTHN_t \tag{5.43}
$$

where:

$IMPGN$	Nominal import of goods (5.43).
$IMPALUN$	Nominal import of goods for aluminium production (5.44).
$IMPAIRN$	Nominal import of ships and airplanes (5.45).
$IMPOTHN$	Nominal import of other goods (5.48).

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

$$
IMPALUN_t = IMPALU_t \times PMALU_t \times EUS_t \tag{5.44}
$$

where:

$IMPALUN$	Nominal import of goods for aluminium production (5.44).
$IMPALU$	Import volume of goods for aluminium production (exogenous).
$PMALU$	Import price deflator for aluminium production in USD (7.6).
EUS	USD exchange rate (4.14).

Nominal import of ships and airplanes is defined as:

$$IMPAIRN_t = PI_t \times IMPAIR_t \tag{5.45}$$

where:

$IMPAIRN$	Nominal import of ships and airplanes (5.45).
PI	Investment goods price deflator (7.16).
$IMPAIR$	Import volume of ships and airplanes (exogenous).

In the long-run, imports of other goods (85% of total goods imports in 1997-2017) are determined by import weighted domestic demand and relative prices, with unit income elasticity:

$$impoth = \alpha_{impoth} + dda - \beta_{impoth}(pmoth - cpi) \tag{5.46}$$

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. This gives the following dynamic equation:

$$\begin{aligned} \Delta impoth_t \;=\; & \underset{(-5.4)}{-0.270} + \underset{(1.0)}{0.019}Q1 + \underset{(5.4)}{0.097}Q2 + \underset{(0.6)}{0.009}Q3 \\ & \underset{(-6.4)}{-0.324}D084 + \underset{(6.0)}{0.873}\Delta dda_t + \\ & \underset{(-5.6)}{-0.482}[impoth_{t-1} - dda_{t-1} + 0.710(pmoth_{t-1} - cpi_{t-1})] \end{aligned} \tag{5.47}$$

Estimation method	OLS
Adjusted R^2	0.831
Equation standard error	4.6%
Long-run restrictions (F-test)	0.17 [0.68]
LM test for serial correlation (F-test)	1.18 [0.28]
Normality test (χ^2-test)	4.38 [0.11]
White test for heteroscedasticity (F-test)	1.21 [0.31]
Sample period	1997:Q2-2017:Q4 ($T = 83$)

where:

$IMPOTH$	Import volume of other goods (5.47).
DDA	Import weighted domestic demand (5.25).
$PMOTH$	Import price deflator for other goods (7.7).
CPI	Consumer price index (7.4).
$D084$	Dummy variable: 1 2008:Q4 and zero elsewhere.
$Q1$-$Q3$	Centered seasonal dummies.

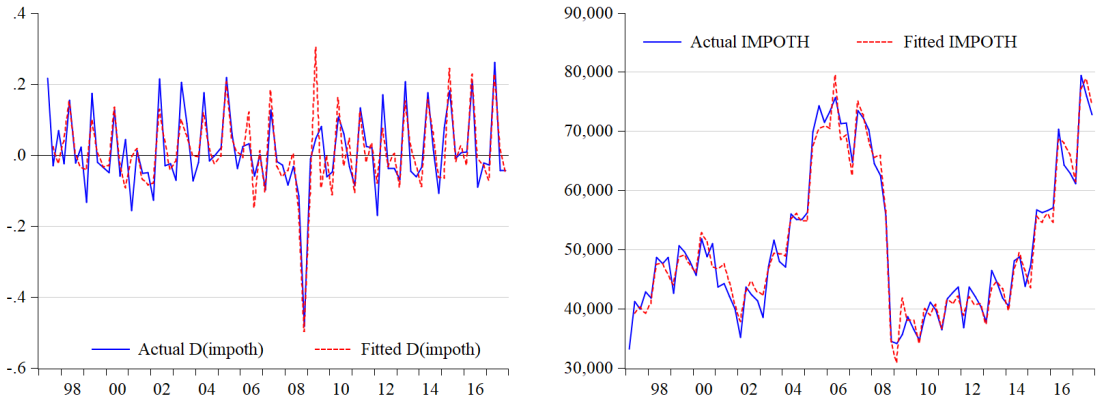

Figure 5.6. Fitted and actual $\Delta impoth_t$ and $IMPOTH_t$

In the long run, sub-components of domestic demand only influence *impoth* through their share in DDA. Single equation dynamic responses of (5.47) are thus:

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

Quarters	c	g	i	exd	dda	$pmoth - cpi$
Simultaneous	0.31	0.11	0.44	0.19	0.87	0.00
One quarter ahead	0.33	0.12	0.47	0.21	0.93	−0.34
Four quarters ahead	0.35	0.13	0.50	0.22	0.99	−0.66
Eight quarters ahead	0.35	0.13	0.50	0.22	1.00	−0.71
Long run	0.35	0.13	0.50	0.22	1.00	−0.71
50% of long-run effect	0Q	0Q	0Q	0Q	0Q	2Q
90% of long-run effect	1Q	1Q	1Q	1Q	1Q	4Q

Steady state solution:
$(impoth - dda) = const - 0.710(pmoth - cpi)$

Nominal import of other goods is defined as:

$$IMPOTHN_t = PMOTH_t \times IMPOTH_t \tag{5.48}$$

where:

$IMPOTHN$	Nominal import of other goods (5.48).
$PMOTH$	Import price deflator for other goods (7.7).
$IMPOTH$	Imports of other goods (5.47).

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 trading partners' imports and GDP):

$$imps = \alpha_{imps} + dda - \beta_{imps}(pms - cpi) + \phi_{imps} spec \tag{5.49}$$

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. This gives the following dynamic equation:

$$\begin{aligned} \Delta imps_t \;=\; & \underset{(-7.6)}{-1.015} - \underset{(-1.6)}{0.035} Q1 + \underset{(1.0)}{0.026} Q2 + \underset{(3.2)}{0.060} Q3 \\ & \underset{(-7.2)}{-0.151} D061084_t + \underset{(5.8)}{1.047} \Delta dda_t - \underset{(-7.8)}{0.887} [imps_{t-1} \\ & -dda_{t-1} + 0.247(pms_{t-1} - cpi_{t-1}) - 1.090 spec_{t-1}] \end{aligned} \tag{5.50}$$

Estimation method	OLS
Adjusted R^2	0.815
Equation standard error	5.59%
Long-run restrictions (F-test)	0.98 [0.32]
LM test for serial correlation (F-test)	0.03 [0.85]
Normality test (χ^2-test)	3.37 [0.19]
White test for heteroscedasticity (F-test)	1.95 [0.08]
Sample period	1997:Q2-2017:Q4 ($T = 83$)

where:

$IMPS$	Import volume of services (5.50).
DDA	Import weighted domestic demand (5.25).
PMS	Import price deflator for services (7.8).
CPI	Consumer price index (7.4).
$SPEC$	Trade specialisation (5.52).
$D061084$	Dummy variable: 1 2006:Q1-2008:Q4 and zero elsewhere.
$Q1$-$Q3$	Centered seasonal dummies.

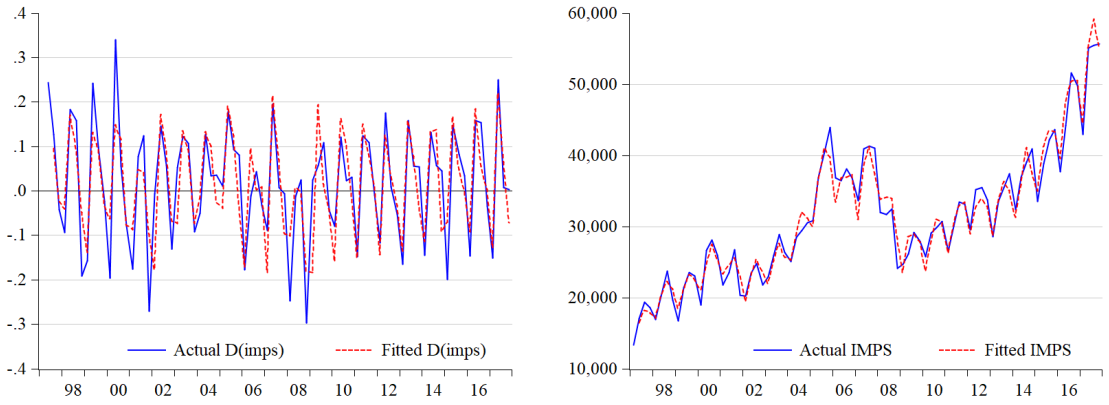

Figure 5.7. Fitted and actual $\Delta imps_t$ and $IMPS_t$

Single equation dynamic responses of (5.50):

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

Quarters	c	g	i	exd	dda	$pms - cpi$	$spec$
Simultaneous	0.37	0.14	0.52	0.23	1.05	0.00	0.00
One quarter ahead	0.35	0.13	0.50	0.22	1.01	−0.22	0.97
Four quarters ahead	0.35	0.13	0.50	0.22	1.00	−0.25	1.09
Eight quarters ahead	0.35	0.13	0.50	0.22	1.00	−0.25	1.09
Long run	0.35	0.13	0.50	0.22	1.00	−0.25	1.09
50% of long-run effect	0Q	0Q	0Q	0Q	0Q	1Q	1Q
90% of long-run effect	0Q	0Q	0Q	0Q	0Q	2Q	2Q

Steady state solution:
$(imps - dda) = const - 0.247(pms - cpi) + 1.090spec$

Nominal import of services is defined as:

$$IMPSN_t = PMS_t \times IMPS_t \tag{5.51}$$

where:

$IMPSN$	Nominal import of services (5.51).
PMS	Import price deflator for services (7.8).
$IMPS$	Import volume of services (5.50).

The trade specialisation variable is defined as:

$$SPEC_t = TRADE_t / WGDP_t \tag{5.52}$$

where:

$SPEC$	Trade specialisation (5.52).
$TRADE$	Iceland's trading partner imports (exogenous).
$WGDP$	Iceland's trading partner GDP (exogenous).

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

The balance of trade is given as:

$$BALT_t = BALGOOD_t + BALSERV_t \tag{5.53}$$

where:

$BALT$	Balance of trade (5.53).
$BALGOOD$	Balance of goods (5.54).
$BALSERV$	Balance of services (5.55).

The balance of goods identity is given as:

$$BALGOOD_t = EXGN_t - IMPGN_t \tag{5.54}$$

where:

$BALGOOD$	Balance of goods (5.54).
$EXGN$	Nominal export of goods (5.29).
$IMPGN$	Nominal import of goods (5.43).

The service balance is given as the identity:

$$BALSERV_t = EXSN_t - IMPSN_t \tag{5.55}$$

where:

$BALSERV$	Balance of services (5.55).
$EXSN$	Nominal export volume of services (5.30).
$IMPSN$	Nominal import of services (5.51).

The balance of interest payments, dividends and profits ($BIPD$) is proxied 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:[28]

$$BIPD_t = \left(\frac{WRS_t + BIPDF_t}{4}\right)\left(\frac{NFA_t + NFA_{t-1}}{2}\right) \tag{5.56}$$

where:

[28] 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 (5.56).
WRS	Iceland's trading partner short-term interest rate (exogenous).
$BIPDF$	Risk premium on Iceland's trading partner interest rate (exogenous).
NFA	Net foreign assets (5.58).

The current account balance is determined by an accounting identity:

$$BAL_t = BALT_t + BIPD_t + BTRF_t \tag{5.57}$$

where:

BAL	Current account balance (5.57).
$BALT$	Balance of trade (5.53).
$BIPD$	Balance of interest, salaries, dividends and profits (5.56).
$BTRF$	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:

$$NFA_t = ISA_t - FOH_t \tag{5.58}$$

where:

NFA	Net foreign assets (5.58).
ISA	Icelandic holdings of foreign assets (5.59).
FOH	Foreign holdings of Icelandic assets (5.60).

Both Icelandic and foreign asset holdings are modelled using a simple stock-flow framework. 20% of domestic holdings of foreign assets is revalued by the index of world equity prices ($WEQP$) giving the value in foreign currency. This sum is then multiplied by changes in the exchange rate (EER) to give the value in domestic currency. This is then multiplied by the steady state quarterly real growth of the economy ($QDGDPT$) and changes in trading partners' consumer prices ($WCPI$):

$$\begin{aligned} ISA_t &= ISA_{t-1}\frac{EER_t}{EER_{t-1}}\left(0.8 + 0.2\frac{WEQP_t}{WEQP_{t-1}}\right) \times \\ &\quad (1 + QDGDPT_t)\left(\frac{WCPI_t}{WCPI_{t-1}}\right) \end{aligned} \tag{5.59}$$

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

$$FOH_t = FOH_{t-1}\left(\frac{EER_t}{EER_{t-1}}\right) - BAL_t + ISA_{t-1} \times [(1 + QDGDPT_t) \left(\frac{WCPI_t}{WCPI_{t-1}}\right) - 1\Bigg] \left[0.8\left(\frac{EER_t}{EER_{t-1}}\right) + 0.2\left(\frac{EER_t}{EER_{t-1}} \times \frac{WEQP_t}{WEQP_{t-1}}\right)\right] \quad (5.60)$$

where:

ISA	Icelandic holdings of foreign assets (5.59).
FOH	Foreign holdings of Icelandic assets (5.60).
EER	Exchange rate index of foreign currency (4.13).
$WEQP$	World equity prices (exogenous).
$WCPI$	Iceland's trading partner consumer prices (exogenous).
BAL	Current account balance (5.57).
$QDGDPT$	Quarterly trend GDP growth rate (5.65).

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 $Y-1$ subscript:

$$\begin{aligned} GDP_t = {} & [PC_{Y-1} \times C_t + PG_{Y-1} \times G_t + PI_{Y-1} \times I_t \\ & + (IIN/II)_{Y-1} \times II_t + PX_{Y-1} \times EX_t \\ & - PM_{Y-1} \times IMP_t] \times \left(\frac{1}{PGDP_{Y-1}}\right) \end{aligned} \quad (5.61)$$

where:

GDP	GDP (5.61).
C	Private consumption (5.2).
PC	Private consumption deflator (7.14).
G	Government consumption (exogenous).
PG	Government consumption deflator (7.15).
I	Fixed investment (5.5).
PI	Investment goods price deflator (7.16).
II	Net stockbuilding (exogenous).
IIN	Nominal net stockbuilding (exogenous).
EX	Export volume of goods and services (5.26).
PX	Export price deflator (7.13).
IMP	Import volume of goods and services (5.40).
PM	Import price deflator (7.9).
$PGDP$	GDP price deflator (7.19).

Nominal GDP is determined by an accounting identity:

$$GDPN_t = DDN_t + EXN_t - IMPN_t \tag{5.62}$$

where:

$GDPN$	Nominal GDP (5.62).
DDN	Nominal domestic demand (5.24).
EXN	Nominal exports of goods and services (5.28).
$IMPN$	Nominal imports of goods and services (5.42).

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:

$$gdpt_t = \log \alpha_g + \beta_g(\gamma_g T) + \beta_g empht_t + (1 - \beta_g)k_t \tag{5.63}$$

where $GDPT$ is potential output, $EMPHT$ is short-run 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 short-run trend total hours is given by (6.16). The shares of production factors are set exogenously according to historical income shares and the results from the analysis of the steady state properties of QMM (see Daníelsson, 2009). Finally, the trend growth rate of the labour-augmented progress is assumed to have slowed from the mid-2000s resulting in the following representation of potential output:

$$gdpt_t = \left\{ \begin{array}{ll} \underset{(-91.7)}{-3.657} + 0.60 \times \underset{(14.6)}{0.008499}T + 0.60empht_t + 0.40k_t & \text{1992:Q1-2004:Q4} \\ \underset{(-54.3)}{-3.293} + 0.60 \times \underset{(6.3)}{0.004126}T + 0.60empht_t + 0.40k_t & \text{2005:Q1-} \end{array} \right\} \tag{5.64}$$

where:

$GDPT$	Potential output (5.64).
$EMPHT$	Short-run trend total hours (6.16).
K	Capital stock (5.20).
T	Linear time trend.

Equation (5.64) gives quarterly trend productivity growth equal to 0.4% after 2005:Q1, 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:

$$QDGDPT_t = (1 + 1\%)^{(1/4)} \times \exp(0.004126) - 1 = 0.7\% \tag{5.65}$$

where:

$QDGDPT$ Quarterly trend GDP growth rate (5.65).

Due to the considerable uncertainty surrounding the estimation of potential output, the simple production function (5.64) is augmented by an average of two additional estimates of potential output. Both are based on the same Cobb-Douglas production technology as in (5.64), but allow for more flexible measures of trend values using a Hodrick-Prescott filtered trend of the technological progress and two different estimates of trend total hours: one using a Hodrick-Prescott filtered trend on $EMPH$ directly, and the other a Hodrick-Prescott filtered unemployment rate as an estimate of natural rate of unemployment ($NAIRU$) to generate trend total hours from (6.16).

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

$$GDPTX_t = \frac{\exp\left(HP\left[tfp_t\right]\right)}{2} \times \left\{ \begin{array}{c} \exp\left(HP\left[emph_t\right]\right)^{\beta_g} K_t^{1-\beta_g} \\ + \left\{PAT_t POWA_t (1 - HP\left[UR_t\right]) AVHT_t\right\}^{\beta_g} K_t^{1-\beta_g} \end{array} \right\} \tag{5.66}$$

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 (5.66).
GDP	GDP (5.61).
$EMPH$	Total hours (6.14).
$AVHT$	Short-run trend average hours per worker (6.12).
UR	Unemployment rate (6.6).
PAT	Short-run trend participation rate (6.10).
$POWA$	Population at working age (16-74 years old) (exogenous).
K	Capital stock (5.20).

The final estimate of potential output is given as a weighted average of $GDPT$ and $GDPTX$, where ADJ is an adjustment factor:[29]

$$GDPTF_t = (GDPT_t + ADJ_t)^{0.3} \times GDPTX_t^{0.7} \tag{5.67}$$

where:

[29]The adjustment factor is used to incorporate non-model information in the estimation of potential output. This includes an adjustment to correct potential output in 2005-2007 to a revision in national accounts standards in 2014, to capture the recent rapid increase in imported labour that is not fully captured by the Labour Force Survey, to smooth out short-term volatility in the output gap, and to capture information from off-model indicators of resource utilisation.

$GDPTF$	Final estimate of potential output (5.67).
$GDPT$	Potential output (5.64).
$GDPTX$	Augmented estimate of potential output (5.66).
ADJ	Adjustment factor to potential output (exogenous).

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

$$GAP_t = GDP_t / GDPTF_t - 1 \tag{5.68}$$

where:

GAP	Output gap (5.68).
GDP	GDP (5.61).
$GDPTF$	Final estimate of potential output (5.67).

An annual average of the output gap is used as a measure of demand pressure in the inflation equation (7.4) and as the measure of future inflation pressures in the monetary policy rule (4.1):

$$GAPAV_t = \left(\frac{GAP_t + GAP_{t-1} + GAP_{t-2} + GAP_{t-3}}{4} \right) \tag{5.69}$$

where:

$GAPAV$	Annual average of output gap (5.69).
GAP	Output gap (5.68).

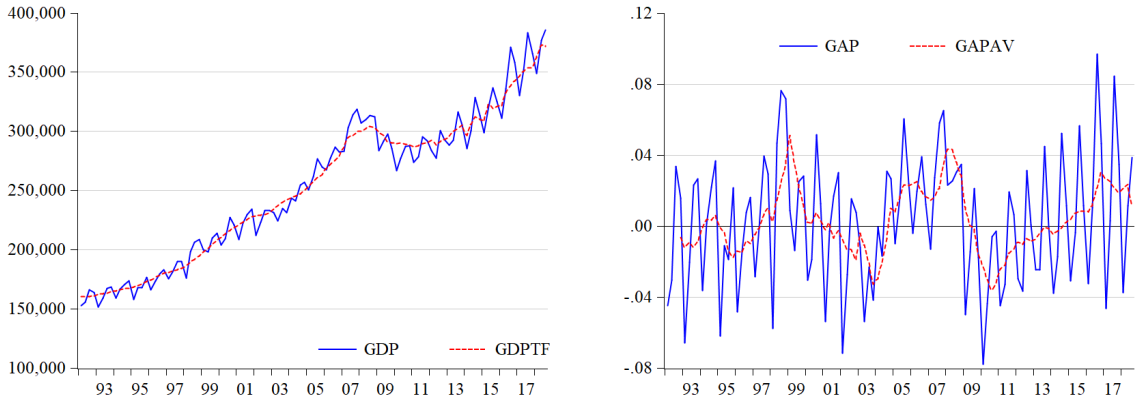

Figure 5.8. Actual and potential output and the output gap

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)

Wages are determined by a standard Phillips curve relation between wages and cyclical unemployment, accounting for productivity and terms of trade shocks:

$$\Delta w_t = \alpha \Delta prodtl_t + \beta \log(1 + INFE10_t)/4 + \gamma \Delta w_{t-1} - \phi(URSA_t - NAIRU_t) + \lambda \Delta tot_t \tag{6.1}$$

where W is the nominal wage rate, $PRODTL$ is the long-run trend of productivity, $INFE10$ is the 10-year break-even inflation rate used as a proxy for long-term inflation expectations (divided by 4 to make it comparable to the quarterly wage inflation measure), $URSA$ is the seasonally adjusted unemployment rate, $NAIRU$ is the natural rate of unemployment, and TOT are the terms of trade. Theory would predict that $\alpha = \beta = 1 - \gamma$ to ensure a vertical long-run wage Phillips curve, thus allowing 6.1 to be rewritten as:

$$\begin{aligned} \Delta w_t &= \beta(\Delta prodtl_t + \log(1 + INFE10_t)/4) + (1 - \beta)\Delta w_{t-1} \\ &\quad -\phi(URSA_t - NAIRU_t) + \lambda \Delta tot_t \end{aligned} \tag{6.2}$$

Nominal wage inflation is therefore determined by past wage inflation, long-run trend productivity, long-term inflation expectations, cyclical unemployment, and terms of trade shocks.

Estimating an unrestricted version of the wage Phillips curve (6.1) gives a value of $\alpha = 0.66$, $\beta = 0.64$ and $\gamma = 0.37$ with all parameters highly significant (p-values of 0.02 or less). The theoretical restrictions are therefore easily accepted (p-value = 0.98). The preferred specification of the wage Phillips curve is therefore given as:[30]

$$\begin{aligned} \Delta w_t &= \underset{(6.1)}{0.629}(\Delta prodtl_t + \log(1 + INFE10_t)/4) + (1 - 0.629)\Delta w_{t-1} \\ &\quad + \underset{(2.9)}{0.167}\Delta tot_t - \underset{(-2.8)}{0.412}(URSA_t - NAIRU_t) \\ &\quad + \underset{(3.7)}{0.013}Q1 + \underset{(0.3)}{0.001}Q2 + \underset{(0.8)}{0.003}Q3 + \underset{(3.8)}{0.025}D1123 + \underset{(2.5)}{0.017}D1523 \end{aligned} \tag{6.3}$$

[30] The wage equation includes dummy variables capturing the large wage increases in the centralised wage settlements in 2011 and 2015, which are not captured by the model.

Estimation method	OLS
Adjusted R^2	0.414
Equation standard error	0.90%
Dynamic homogeneity (F-test)	0.02 [0.98]
LM test for serial correlation (F-test)	0.96 [0.33]
Normality test (χ^2-test)	3.32 [0.19]
White test for heteroscedasticity (F-test)	1.04 [0.42]
Sample period	2003:Q1-2017:Q4 ($T = 60$)

where:

W	Wages (6.3).
$PRODTL$	Long-term trend labour productivity (6.19).
$INFE10$	10-year break-even inflation expectations (7.29).
TOT	Terms of trade (4.23).
$URSA$	Seasonally adjusted unemployment rate (6.8).
$NAIRU$	Natural rate of unemployment (exogenous).
$D1123$	Dummy variable: 1 2011:Q2-Q3 and zero elsewhere.
$D1523$	Dummy variable: 1 2015:Q2-Q3 and zero elsewhere.
$Q1$-$Q3$	Centered seasonal dummies.

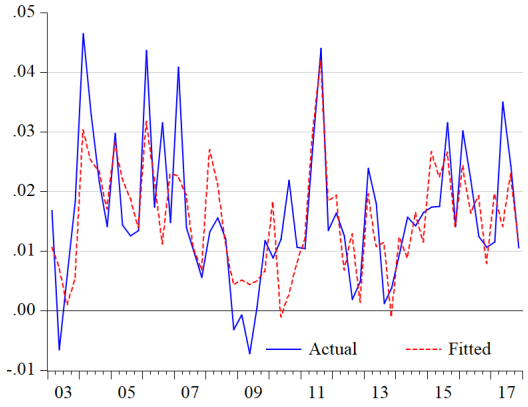

Figure 6.1. Fitted and actual Δw_t

Single equation dynamic responses of (6.3):[31]

[31] Note that the steady state solutions for $URSA - NAIRU$ and Δtot are zero. Hence, although the table reports 'long-run' effects of these variables, their effects on wage inflation are only temporary. In steady state wage inflation therefore equals the sum of productivity growth and long-term inflation expectations.

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

Quarters	$\Delta prodtl$	$\log(1+INFE10)/4$	$URSA-NAIRU$	Δtot
Simultaneous	0.63	0.63	−0.41	0.17
One quarter ahead	0.86	0.86	−0.56	0.23
Four quarters ahead	0.99	0.99	−0.65	0.26
Eight quarters ahead	1.00	1.00	−0.65	0.27
Long run	1.00	1.00	−0.65	0.27
50% of long-run effect	0Q	0Q	0Q	0Q
90% of long-run effect	2Q	2Q	2Q	2Q

Steady state solution:
$\Delta w = \Delta prodtl + \log(1 + INFE10)/4$

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

Overall unit labour costs are given by the following identity:

$$ULC_t = \frac{W_t \times REM_t}{PROD_t} \tag{6.4}$$

where:

ULC	Unit labour costs (6.4).
W	Wages (6.3).
REM	Employers' wage-related cost (exogenous).
$PROD$	Labour productivity (6.17).

Trend unit labour costs are given by the following identity:

$$ULCT_t = \left(\frac{W_t \times REM_t}{PRODT_t}\right) \tag{6.5}$$

where:

$ULCT$	Trend unit labour costs (6.5).
W	Wages (6.3).
REM	Employers' wage-related cost (exogenous).
$PRODT$	Short-run trend labour productivity (6.18).

6.2. Unemployment and labour participation

6.2.1. Unemployment (UN, UR and $URSA$)

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

$$\begin{aligned}\Delta UR_t &= \underset{(0.1)}{0.0004}Q1 + \underset{(2.4)}{0.009}Q2 \underset{(-2.7)}{-0.011}\,Q3 + \underset{(1.8)}{0.198}\Delta UR_{t-1} \\ &\quad \underset{(-1.8)}{-0.043}(\Delta gdp_t - \log(1 + QDGDPT_t)) \\ &\quad \underset{(-6.2)}{-0.606}(UR_{t-1} - NAIRU_{t-1}) - \underset{(-5.1)}{0.219}\Delta_4 GAPAV_t\end{aligned} \tag{6.6}$$

Estimation method	OLS
Adjusted R^2	0.828
Equation standard error	0.50%
LM test for serial correlation (F-test)	0.34 [0.56]
Normality test (χ^2-test)	0.25 [0.88]
White test for heteroscedasticity (F-test)	1.59 [0.16]
Sample period	2003:Q3-2017:Q4 ($T = 58$)

where:

UR	Unemployment rate (6.6).
$NAIRU$	Natural rate of unemployment (exogenous).
GDP	GDP (5.61).
$QDGDPT$	Quarterly trend GDP growth rate (5.65).
$GAPAV$	Annual average of output gap (5.69).
$Q1$-$Q3$	Centered seasonal dummies.

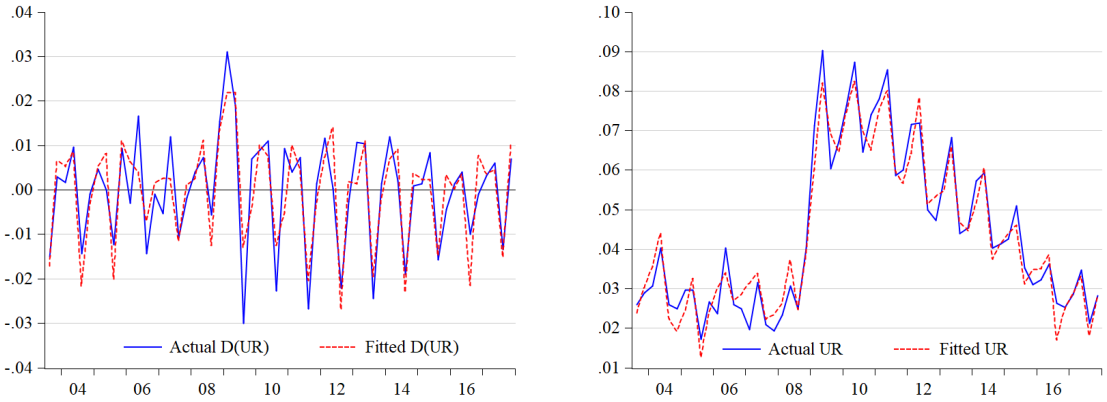

Figure 6.2. Fitted and actual ΔUR_t and UR_t

Single equation dynamic responses of (6.6):[32]

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

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

Quarters	$NAIRU$	$\Delta gdp-$ $\log(1+QDGDPT)$	$\Delta_4 GAPAV_t$
Simultaneous	0.00	−0.04	−0.22
One quarter ahead	0.61	−0.07	−0.35
Four quarters ahead	1.04	−0.07	−0.37
Eight quarters ahead	1.00	−0.07	−0.36
Long run	1.00	−0.07	−0.36
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: $UR = NAIRU$			

The level of unemployment is defined as:

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

where:

UN	Level of unemployment (6.7).
PA	Participation rate (6.9).
$POWA$	Population at working age (16-74 years old) (exogenous).
UR	Unemployment rate (6.6).

The seasonally adjusted unemployment rate is modelled as:[33]

$$URSA_t = UR_t - 0.0018D1 - 0.0100D2 + 0.0072D3 + 0.0045D4 \tag{6.8}$$

where:

$URSA$	Seasonally adjusted unemployment rate (6.8).
UR	Unemployment rate (6.6).
$D1$-$D4$	Seasonal dummies: 1 in relevant quarter and zero elsewhere.

6.2.2. Participation rate (PA and PAT)

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

$$\begin{aligned} PA_t &= \underset{(3.4)}{0.215} + \underset{(3.9)}{0.011}Q1 + \underset{(16.4)}{0.048}Q2 + \underset{(5.9)}{0.014}Q3 \\ &\quad + \underset{(9.6)}{0.736}PA_{t-1} + \underset{(2.4)}{0.047}\Delta_4 gdp_{t-1} \end{aligned} \tag{6.9}$$

[33] The seasonal scaling factors for $URSA$ are found by using seasonal adjustment moving average method.

Estimation method	OLS
Adjusted R^2	0.871
Equation standard error	0.65%
LM test for serial correlation (F-test)	0.55 [0.46]
Normality test (χ^2-test)	4.21 [0.12]
White test for heteroscedasticity (F-test)	1.59 [0.18]
Sample period	2001:Q1-2017:Q4 ($T = 68$)

where:

PA	Participation rate (6.9).
GDP	GDP (5.61).
$Q1$-$Q3$	Centered seasonal dummies.

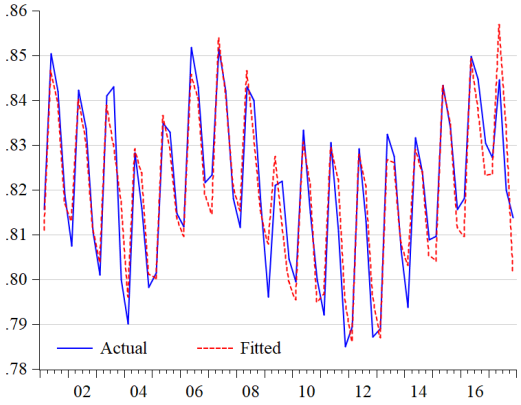

Figure 6.3. Fitted and actual PA_t

Single equation dynamic responses of (6.9):

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

Quarters	$\Delta_4 gdp$
Simultaneous	0.00
One quarter ahead	0.05
Four quarters ahead	0.13
Eight quarters ahead	0.16
Long run	0.18
50% of long-run effect	3Q
90% of long-run effect	8Q
Steady state solution: $PA = const + 0.178\Delta_4 gdp$	

Short-run trend participation rate smoothes out the seasonal fluctuations in PA and serves as an input in short-run trend employment (6.15). It is given as a four-quarter moving average of PA:

$$PAT_t = \left(\frac{PA_t + PA_{t-1} + PA_{t-2} + PA_{t-3}}{4} \right) \tag{6.10}$$

where:

PAT	Short-run trend participation rate (6.10).
PA	Participation rate (6.9).

6.3. Hours per worker, employment and labour productivity

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

Average hours per worker is a function of long-term average hours per worker, with short-term responses to output growth:

$$\begin{aligned} \Delta avh_t \;=\; & \underset{(11.3)}{0.035}Q1 + \underset{(26.3)}{0.085}Q2 + \underset{(18.9)}{0.052}Q3 - \underset{(-3.9)}{0.030}D084 \\ & \underset{(-3.3)}{-0.025}D173 - \underset{(-2.2)}{0.083}\left(avh_{t-1} - avha_{t-1}\right) \\ & \underset{(1.9)}{+0.044}(\Delta_4 gdp_t - 4\log(1 + QDGDPT_t)) \end{aligned} \tag{6.11}$$

Estimation method	OLS
Adjusted R^2	0.954
Equation standard error	0.73%
LM test for serial correlation (F-test)	1.46 [0.23]
Normality test (χ^2-test)	0.68 [0.71]
White test for heteroscedasticity (F-test)	1.04 [0.41]
Sample period	2003:Q1-2017:Q4 ($T = 60$)

where:

AVH	Average hours per worker (6.11).
$AVHA$	Average hours per worker over 2003-2018 (exogenous).
GDP	GDP (5.61).
$QDGDPT$	Quarterly trend GDP growth rate (5.65).
$D084$	Dummy variable: 1 2008:Q4 and zero elsewhere.
$D173$	Dummy variable: 1 2017:Q3 and zero elsewhere.
$Q1$-$Q3$	Centered seasonal dummies.

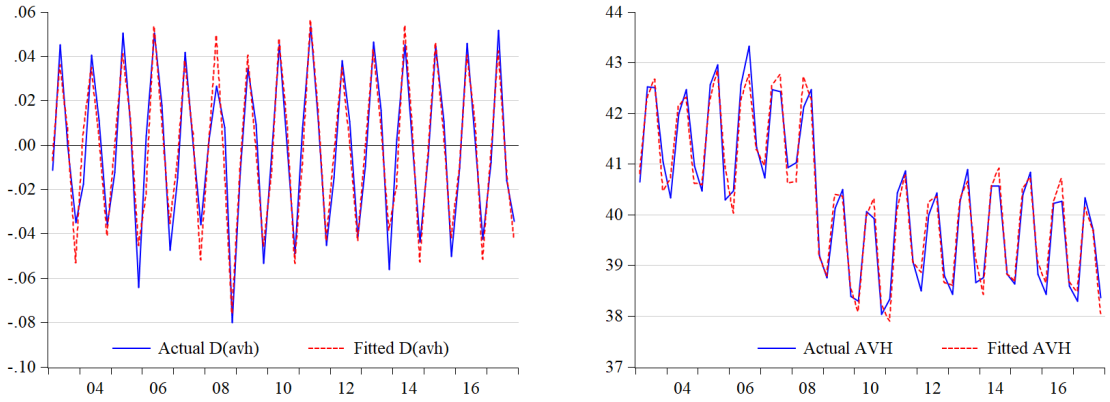

Figure 6.4. Fitted and actual Δavh_t and AVH_t

Single equation dynamic responses of (6.11):[34]

Table 6.4. Responses of avh to a permanent 1% increase in RHS variables

Quarters	$avha$	$\Delta_4 gdp - 4\log(1+QDGDPT)$
Simultaneous	0.00	0.04
One quarter ahead	0.08	0.08
Four quarters ahead	0.29	0.19
Eight quarters ahead	0.50	0.29
Long run	1.00	0.53
50% of long-run effect	8Q	7Q
90% of long-run effect	27Q	26Q
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:

$$AVHT_t = \left(\frac{AVH_t + AVH_{t-1} + AVH_{t-2} + AVH_{t-3}}{4} \right) \tag{6.12}$$

where:

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

$AVHT$	Short-run trend average hours per worker (6.12).
AVH	Average hours per worker (6.11).

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

Employment in man-years is defined as:

$$EMP_t = PA_t \times POWA_t \times (1 - UR_t) \tag{6.13}$$

where:

EMP	Level of employment in man-years (6.13).
PA	Participation rate (6.9).
$POWA$	Population at working age (16-74 years old) (exogenous).
UR	Unemployment rate (6.6).

Total hours is defined as:

$$EMPH_t = EMP_t \times AVH_t \tag{6.14}$$

where:

$EMPH$	Total hours (6.14).
EMP	Level of employment in man-years (6.13).
AVH	Average hours per worker (6.11).

Short-run trend employment is given as:

$$EMPT_t = PAT_t \times POWA_t \times (1 - NAIRU_t) \tag{6.15}$$

where:

$EMPT$	Short-run trend employment (6.15).
PAT	Short-run trend participation rate (6.10).
$POWA$	Population at working age (16-74 years old) (exogenous).
$NAIRU$	Natural rate of unemployment (exogenous).

Short-run trend total hours is defined as:

$$EMPHT_t = EMPT_t \times AVHT_t \tag{6.16}$$

where:

$EMPHT$	Short-run trend total hours (6.16).
$EMPT$	Short-run trend employment (6.15).
$AVHT$	Short-run trend average hours per worker (6.12).

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

Labour productivity is given by the following identity:

$$PROD_t = \frac{GDP_t}{EMPH_t} \tag{6.17}$$

where:

$PROD$	Labour productivity (6.17).
GDP	GDP (5.61).
$EMPH$	Total hours (6.14).

Two types of labour productivity trend measures are used: a four-quarter moving average that smoothes out seasonal fluctuations in $PROD$:

$$PRODT_t = \left(\frac{PROD_t + PROD_{t-1} + PROD_{t-2} + PROD_{t-3}}{4} \right) \tag{6.18}$$

and a three-year moving average that proxies the longer term trend in $PROD$:

$$PRODTL_t = \frac{1}{12} \sum_{j=0}^{11} PROD_{t-j} \tag{6.19}$$

where:

$PROD$	Labour productivity (6.17).
$PRODT$	Short-run trend labour productivity (6.18).
$PRODTL$	Long-term trend labour productivity (6.19).

7. Price setting and inflation

This section describes price setting in QMM. 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 (CPI)

As has become standard in the literature, quarterly consumer price inflation is assumed to be given by the following backward-forward looking hybrid Phillips curve specification:

$$\begin{aligned} \Delta cpi_t &= \beta \log(1 + INF_{t-1})/4 + \gamma \log(1 + INFE10_t)/4 \\ &\quad + \delta \log(1 + IT_t)/4 + \phi GAPAV_{t-1} + \kappa \Delta rexm_t + \lambda \Delta rexm_{t-1} \end{aligned} \tag{7.1}$$

where CPI is the consumer price index, INF is the year-on-year CPI inflation rate (or the four-quarter moving average of quarterly inflation rates), $INFE10$ is the 10-year break-even inflation rate used as a proxy for long-term inflation expectations, IT is the inflation target, $GAPAV$ is the output gap, and $REXM$ are relative import prices. Annual inflation, inflation expectations, and the inflation target are divided by 4 to make them comparable to the quarterly inflation measure.

Theory would predict that $\beta + \gamma + \delta = 1$ to ensure a vertical long-run Phillips curve, thus allowing (7.1) to be rewritten as:

$$\begin{aligned} \Delta cpi_t &= \beta \log(1 + INF_{t-1})/4 + \gamma \log(1 + INFE10_t)/4 \\ &\quad + (1 - \beta - \gamma) \log(1 + IT_t)/4 + \phi GAPAV_{t-1} + \kappa \Delta rexm_t + \lambda \Delta rexm_{t-1} \end{aligned} \tag{7.2}$$

or

$$\begin{aligned} [\Delta cpi_t - \log(1 + IT_t)/4] &= \beta \left[\log(1 + INF_{t-1}) - \log(1 + IT_t)\right]/4 \\ &\quad + \gamma \left[\log(1 + INFE10_t) - \log(1 + IT_t)\right]/4 \\ &\quad + \phi GAPAV_{t-1} + \kappa \Delta rexm_t + \lambda \Delta rexm_{t-1} \end{aligned} \tag{7.3}$$

Deviations of quarterly headline inflation from target are therefore determined by deviations of past annual inflation from target, devations of long-term inflation expectations from target, cyclical inflation pressures and import price inflation.

When estimating (7.1) directly, β and γ are found to be highly significant, while δ is found to be non-significant. Furthermore β and γ sum to more than 1 and imposing the restriction $\beta + \gamma + \delta = 1$ thus leads to a negative coefficient on $IT_t/4$. In addition, the sup$F$-test suggests a structural break in the Phillips curve in 2012:Q2. This is consistent with Pétursson (2018) who finds evidence of a structural break at the same time using year-on-year inflation rates. He estimates a non-linear Phillips curve using a Markov switching model, which suggests that credibility of the official inflation target was practically zero until early 2012 when it gradually starts increasing. This suggests that the inflation target perceived by economic agents was probably significantly higher than the official target for a large part of the inflation target period and that the official target has only become credible in the last five or six years (for further discussion, see Central Bank of Iceland, 2017, Pétursson, 2018).

To capture this, the preferred specification of the Phillips curve uses a shift dummy variable that is calibrated to replicate the smooth probability of being in the low inflation regime from the Markov switching model in Pétursson (2018), using a simple logistic trend model. The shift dummy variable, SIT_t, is scaled such that $SIT_t \times IT_t$ equals 6% (the average inflation rate in 2001-2011) until 2011, from which it gradually declines to the official 2.5% target (average inflation in 2012-2017 is 2.7%). Figure 7.1 shows the resulting shift dummy variable.

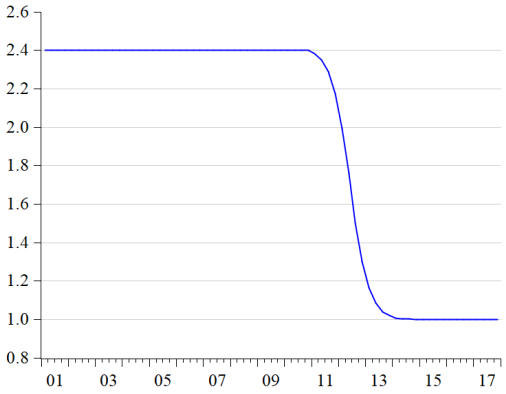

Figure 7.1. Shift dummy variable SIT_t

Replacing IT_t with $SIT_t \times IT_t$ in (7.1), gives a value of $\beta = 0.20$, $\gamma = 0.68$ and $\delta = 0.27$, with all parameters significant, and the homogeneity restriction is not rejected at the 1% critical level. The preferred specification of the Phillips curve is therefore given as:

$$\begin{aligned}\Delta cpi_t &= \underset{(2.7)}{0.226}\log(1+INF_{t-1})/4 + \underset{(4.0)}{0.416}\log(1+INFE10_t)/4 \\ &\quad +(1-0.226-0.416)\log(1+SIT_t \times IT_t)/4 + \underset{(3.2)}{0.095}GAPAV_{t-1} \\ &\quad +\underset{(6.7)}{0.078}\Delta rexm_t + \underset{(6.3)}{0.075}\Delta rexm_{t-1} + \underset{(4.2)}{0.021}D082 \\ &\quad -\underset{(-1.4)}{0.002}Q1 + \underset{(2.5)}{0.004}Q2 - \underset{(-2.8)}{0.004}Q3\end{aligned} \tag{7.4}$$

Estimation method	OLS
Adjusted R^2	0.855
Equation standard error	0.43%
Dynamic homogeneity (F-test)	4.65 [0.04]
LM test for serial correlation (F-test)	0.01 [0.94]
Normality test (χ^2-test)	2.85 [0.24]
White test for heteroscedasticity (F-test)	0.55 [0.83]
Sample period	2003:Q1-2017:Q4 ($T = 60$)

where:

CPI	Consumer price index (7.4).
INF	Four-quarter CPI inflation rate (7.26).
$INFE10$	10-year break-even inflation expectations (7.29).
$GAPAV$	Annual average of output gap (5.69).
$REXM$	Importers' real exchange rate (4.22).
IT	Central Bank of Iceland's 2.5% inflation target (exogenous).
SIT	Shift dummy variable scaled such that $SIT_t \times IT_t$ gradually declines from 6% to 2.5%.
$D082$	Dummy variable: 1 2008:Q2 and zero elsewhere.
$Q1$-$Q3$	Centered seasonal dummies.

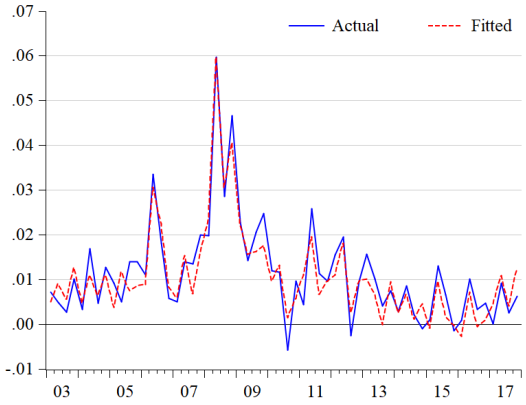

Figure 7.2. Fitted and actual Δcpi_t

Single equation dynamic responses of (7.4):[35]

[35]Note that the steady state solutions for $GAPAV$ and $\Delta rexm$ are zero. Hence, although the table reports 'long-run' effects of these variables, their effects on inflation are only temporary. Furthermore, from (7.29), inflation expectations are equal to actual inflation in steady state. Thus, the steady state solution to (7.4) gives that $\Delta cpi = \log(1 + INFE10)/4 = \log(1 + IT)/4$. A permanent shock to $INFE10$ shown in Table 7.1 would therefore always be accompanied by a corresponding change in IT, which would lead to an identical long-run change in actual inflation as shown in the table.

Table 7.1. Responses of Δcpi to a permanent 1% increase in RHS variables

Quarters	$\log(1+ INFE10)/4$	$\log(1+ IT)/4$	$[\log(1+INFE10) + \log(1+IT)]/4$	$\Delta rexm$	$GAPAV$
Simultaneous	0.42	0.36	0.77	0.08	0.00
One quarter ahead	0.44	0.38	0.82	0.16	0.09
Four quarters ahead	0.52	0.45	0.96	0.19	0.11
Eight quarters ahead	0.53	0.46	1.00	0.20	0.12
Long run	0.54	0.46	1.00	0.20	0.12
50% of long-run effect	0Q	0Q	0Q	1Q	1Q
90% of long-run effect	3Q	3Q	3Q	4Q	4Q
Steady state solution: $\Delta cpi = \log(1+IT)/4$					

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

CPI inflation excluding indirect taxes is obtained by subtracting the estimated effects of indirect taxes from the CPI:

$$\frac{CPIUL_t}{CPIUL_{t-1}} = \frac{CPI_t}{CPI_{t-1}} - INFTAX_t \tag{7.5}$$

where:

CPI	Consumer price index (7.4).
$CPIUL$	Consumer price index excluding indirect taxes (7.5).
$INFTAX$	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:[36]

$$\begin{aligned} \Delta pmalu_t &= \underset{(5.4)}{0.446}\Delta pmalu_{t-1} + \underset{(5.9)}{0.408}\Delta pxalu_t + \\ &\quad +(1-0.446-0.408)\Delta pxalu_{t-1} + \underset{(5.6)}{0.158}D1734 \end{aligned} \tag{7.6}$$

[36] The equation is estimated using data from 2009:Q1 to 2017:Q4, due to a break occurring in 2008.

Estimation method	OLS
Adjusted R^2	0.685
Equation standard error	3.89%
Dynamic homogeneity (F-test)	7.08 [0.01]
LM test for serial correlation (F-test)	5.78 [0.02]
Normality test (χ^2-test)	4.82 [0.09]
White test for heteroscedasticity (F-test)	0.35 [0.79]
Sample period	2009:Q1-2017:Q4 ($T = 36$)

where:

$PMALU$	Import price deflator for aluminium production in USD (7.6).
$PXALU$	Price of aluminium products in USD (exogenous).
$D1734$	Dummy variable: -1 2017:Q3, 1 2017:Q4 and zero elsewhere.

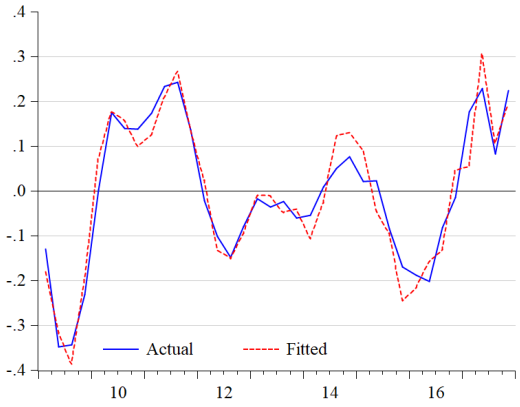

Figure 7.3. Fitted and actual $\Delta pmalu_t$

Single equation dynamic responses of (7.6):

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

Quarters	$\Delta pxalu$
Simultaneous	0.41
One quarter ahead	0.74
Four quarters ahead	0.98
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:

$$\begin{aligned}\Delta pmoth_t \;=\; & \underset{(-3.9)}{-0.196}\Delta pmoth_{t-1} - \underset{(-2.2)}{0.079}\Delta pmoth_{t-2} \\ & + \underset{(26.6)}{0.909}\Delta(wpx_t + eer_t) + \underset{(1.9)}{0.084}\Delta ulct_{t-1} + \underset{(4.0)}{0.067}\Delta(poil_{t-1} + eus_{t-1}) \\ & + (1 + 0.196 + 0.079 - 0.909 - 0.084 - 0.067)\Delta(pcom_{t-1} + eus_{t-1})\end{aligned} \tag{7.7}$$

Estimation method	OLS
Adjusted R^2	0.930
Equation standard error	1.61%
Dynamic homogeneity (F-test)	6.64 [0.01]
LM test for serial correlation (F-test)	2.72 [0.10]
Normality test (χ^2-test)	1.56 [0.46]
White test for heteroscedasticity (F-test)	0.26 [0.94]
Sample period	2000:Q1-2017:Q4 ($T = 72$)

where:

$PMOTH$	Import price deflator for other goods (7.7).
WPX	Iceland's trading partner export prices (exogenous).
EER	Exchange rate index of foreign currencies (4.13).
$ULCT$	Trend unit labour costs (6.5).
$POIL$	Oil prices in USD (exogenous).
EUS	USD exchange rate (4.14).
$PCOM$	Non-oil commodity prices in USD (exogenous).

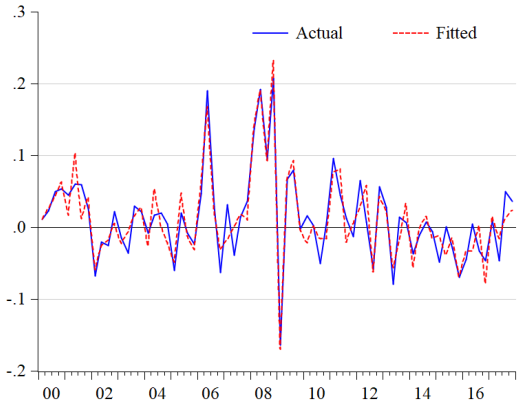

Figure 7.4. Fitted and actual $\Delta pmoth_t$

Single equation dynamic responses of (7.7):

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

Quarters	$\Delta(wpx + eer)$	$\Delta ulct$	$\Delta(poil + eus)$	$\Delta(pcom + eus)$
Simultaneous	0.91	0.00	0.00	0.00
One quarter ahead	0.73	0.08	0.07	0.21
Four quarters ahead	0.71	0.07	0.05	0.17
Eight quarters ahead	0.71	0.07	0.05	0.17
Long run	0.71	0.07	0.05	0.17
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:
$\Delta pmoth = 0.713\Delta(wpx + eer) + 0.066\Delta ulct + 0.053\Delta(poil + eus)$
$+0.168\Delta(pcom + eus)$

The price deflator for imported service is given as:

$$\Delta pms_t = \Delta(wcpi_t + eer_t) \tag{7.8}$$

PMS	Import price deflator for services (7.8).
$WCPI$	Iceland's trading partner consumer prices (exogenous).
EER	Exchange rate index of foreign currencies (4.13).

The import price deflator is defined:

$$PM_t = \frac{IMPN_t}{IMP_t} \tag{7.9}$$

where:

PM	Import price deflator (7.9).
$IMPN$	Nominal imports of goods and services (5.42).
IMP	Imports of goods and services (5.40).

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 ships and airplanes. It is assumed to be determined by trading partners' export prices:

$$\Delta pxoth_t = \underset{(-4.2)}{-0.280}\Delta pxoth_{t-2} + (1 + 0.280)\Delta(wpx_t + eer_t) \tag{7.10}$$

Estimation method	OLS
Adjusted R^2	0.608
Equation standard error	5.81%
Dynamic homogeneity (F-test)	0.15 [0.70]
LM test for serial correlation (F-test)	0.25 [0.62]
Normality test (χ^2-test)	6.08 [0.05]
White test for heteroscedasticity (F-test)	4.18 [0.04]
Sample period	1997:Q4-2017:Q4 ($T = 81$)

where:

$PXOTH$	Export prices of other goods (7.10).
WPX	Iceland's trading partner export prices (exogenous).
EER	Exchange rate index of foreign currencies (4.13).

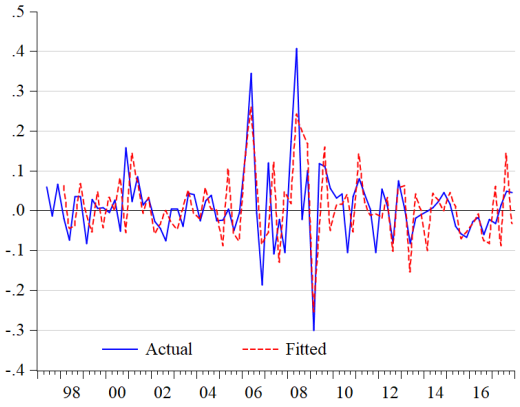

Figure 7.5. Fitted and actual $\Delta pxoth_t$

Single equation dynamic responses of (7.10):

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

Quarters	$\Delta(wpx + eer)$
Simultaneous	1.28
One quarter ahead	1.28
Four quarters ahead	1.02
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 foreign and domestic consumer prices:

$$\Delta pxs_t = \underset{(12.7)}{0.676}\Delta(wcpi_t + eer_t) + (1 - 0.676)\Delta cpi_t \tag{7.11}$$

Estimation method	OLS
Adjusted R^2	0.881
Equation standard error	0.91%
Dynamic homogeneity (F-test)	1.47 [0.24]
LM test for serial correlation (F-test)	0.76 [0.39]
Normality test (χ^2-test)	0.47 [0.79]
White test for heteroscedasticity (F-test)	0.01 [0.91]
Sample period	2012:Q1-2017:Q4 ($T = 24$)

where:

PXS	Export prices of services (7.11).
$WCPI$	Iceland's trading partner consumer prices (exogenous).
EER	Exchange rate index of foreign currencies (4.13).
CPI	Consumer price index (7.4).

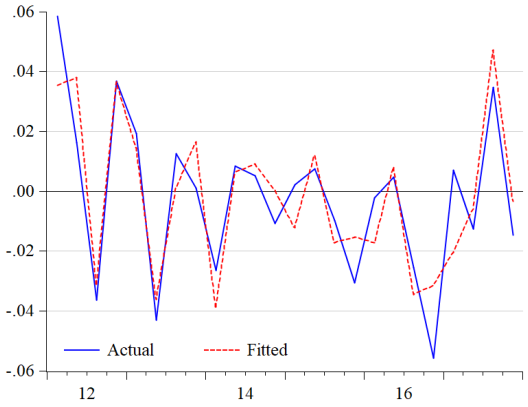

Figure 7.6. Fitted and actual Δpxs_t

Single equation dynamic responses of (7.11):

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

Quarters	$\Delta(wcpi + eer)$	Δcpi
Simultaneous	0.68	0.32
One quarter ahead	0.68	0.32
Four quarters ahead	0.68	0.32
Eight quarters ahead	0.68	0.32
Long run	0.68	0.32
50% of long-run effect	0Q	0Q
90% of long-run effect	0Q	0Q

Steady state solution:
$\Delta pxs = 0.676\Delta(wcpi + eer) + 0.324\Delta cpi$

The price of marine products in foreign currency is assumed to be determined by short-run effects of trading partners' GDP growth:[37]

$$\begin{aligned}\Delta_4 pxmar_t - \log(1+IT_t) &= \underset{(12.8)}{0.814}(\Delta_4 pxmar_{t-1} - \log(1+IT_t)) \\ &\quad \underset{(-5.1)}{-0.276}(\Delta_4 pxmar_{t-4} - \log(1+IT_t)) \\ &\quad \underset{(3.0)}{+0.663}(\Delta_4 wgdp_t - 4\log(1+QDGDPT_t))\end{aligned} \tag{7.12}$$

[37] $QDGDPT$ is the steady state output growth rate in the model and is also assumed to be the steady state growth for trading partners' GDP. The form of the equation is determined so that it follows a balanced growth path where prices are increasing by IT per year and domestic (GDP) and foreign output ($WGDP$) is increasing by $QDGDPT$ per quarter.

Estimation method	OLS
Adjusted R^2	0.778
Equation standard error	3.26%
Dynamic homogeneity (F-test)	2.45 [0.12]
LM test for serial correlation (F-test)	0.01 [0.92]
Normality test (χ^2-test)	0.10 [0.95]
White test for heteroscedasticity (F-test)	0.15 [0.93]
Sample period	1999:Q1-2017:Q4 ($T = 76$)

where:

$PXMAR$	Price of marine products in foreign currency (7.12).
$WGDP$	Iceland's trading partner GDP (exogenous).
$QDGDPT$	Quarterly trend GDP growth rate (5.65).
IT	Central Bank of Iceland's 2.5% inflation target (exogenous).

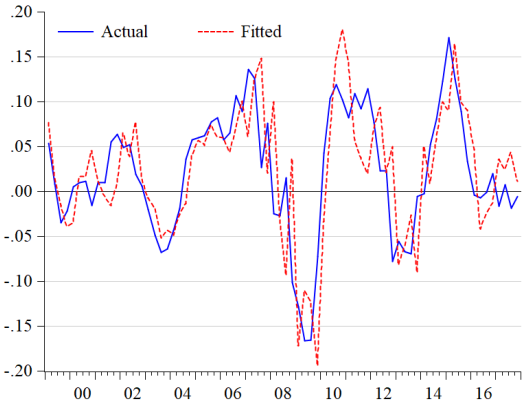

Figure 7.7. Fitted and actual $\Delta pxmar_t$

Single equation dynamic responses of (7.12):

Table 7.6. Responses of $\Delta_4 pxmar$ to a permanent 1% increase in RHS variables

Quarters	$\Delta_4 wgdp - 4\log(1+QDGDPT)$
Simultaneous	0.67
One quarter ahead	1.22
Four quarters ahead	2.13
Eight quarters ahead	1.43
Long run	1.45
50% of long-run effect	O/S
90% of long-run effect	O/S

Steady state solution:
$\Delta_4 pxmar - \log(1+IT) = 1.450(\Delta_4 wgdp - 4\log(1+QDGDPT))$

The export price deflator is defined:

$$PX_t = \frac{EXN_t}{EX_t} \tag{7.13}$$

where:

PX	Export price deflator (7.13).
EXN	Nominal exports of goods and services (5.28).
EX	Exports of goods and services (5.26).

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:

$$\begin{aligned}\Delta pc_t &= \underset{(5.9)}{0.013}Q1 + \underset{(2.7)}{0.006}Q2 + \underset{(0.1)}{0.001}Q3 + \underset{(3.4)}{0.276}\Delta pc_{t-1} \\ &\quad +(1-0.276)\Delta cpi_t + \underset{(4.1)}{0.049}\Delta^2 eer_t\end{aligned} \tag{7.14}$$

Estimation method	OLS
Adjusted R^2	0.793
Equation standard error	0.68%
Dynamic homogeneity (F-test)	2.82 [0.10]
LM test for serial correlation (F-test)	0.01 [0.91]
Normality test (χ^2-test)	2.30 [0.32]
White test for heteroscedasticity (F-test)	0.36 [0.87]
Sample period	1998:Q1-2017:Q4 ($T = 80$)

where:

PC	Private consumption deflator (7.14).
CPI	Consumer price index (7.4).
EER	Exchange rate index of foreign currencies (4.13).
$Q1$-$Q3$	Centered seasonal dummies.

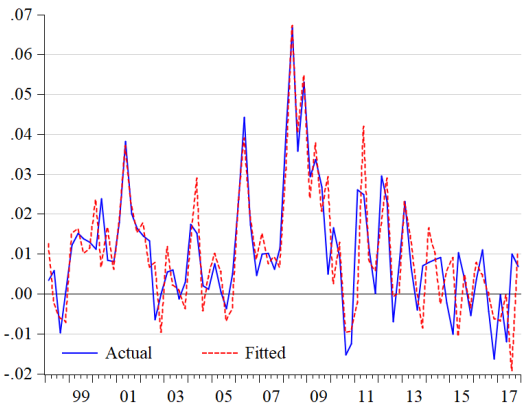

Figure 7.8. Fitted and actual Δpc_t

Single equation dynamic responses of (7.14):

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

Quarters	Δcpi	Δeer
Simultaneous	0.72	0.05
One quarter ahead	0.92	0.01
Four quarters ahead	1.00	0.00
Eight quarters ahead	1.00	0.00
Long run	1.00	0.00
50% of long-run effect	0Q	-
90% of long-run effect	0Q	-
Steady state solution: $\Delta pc = \Delta cpi$		

7.1.6. Government consumption deflator (PG)

The government consumption deflator is determined by unit labour costs, consumer prices and building costs:[38]

$$\Delta pg_t = 0.57\Delta ulct_t + 0.33\Delta cpi_t + 0.10\Delta bc_t \tag{7.15}$$

where:

PG	Government consumption deflator (7.15).
$ULCT$	Unit labour costs (6.5).
CPI	Consumer price index (7.4).
BC	Building costs (7.22).

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:

$$\begin{aligned} \Delta pi_t &= \underset{(-1.0)}{-0.004}Q1 - \underset{(-2.5)}{0.010}Q2 - \underset{(-2.4)}{0.009}Q3 + \underset{(17.9)}{0.734}\Delta bc_t \\ &\quad + \underset{(13.3)}{0.341}\Delta pm_t + (1 - 0.734 - 0.341)\Delta pm_{t-1} \end{aligned} \tag{7.16}$$

Estimation method	OLS
Adjusted R^2	0.753
Equation standard error	1.24%
Dynamic homogeneity (F-test)	4.42 [0.04]
LM test for serial correlation (F-test)	0.08 [0.78]
Normality test (χ^2-test)	1.19 [0.55]
White test for heteroscedasticity (F-test)	0.72 [0.61]
Sample period	1997:Q1-2017:Q4 ($T = 84$)

where:

PI	Investment goods price deflator (7.16).
BC	Building costs (7.22).
PM	Import price deflator (7.9).
$Q1$-$Q3$	Centered seasonal dummies.

[38] The relative weights in PG reflect the weights of labour costs, material costs and depreciation in the calculation of the government consumption deflator by Statistics Iceland.

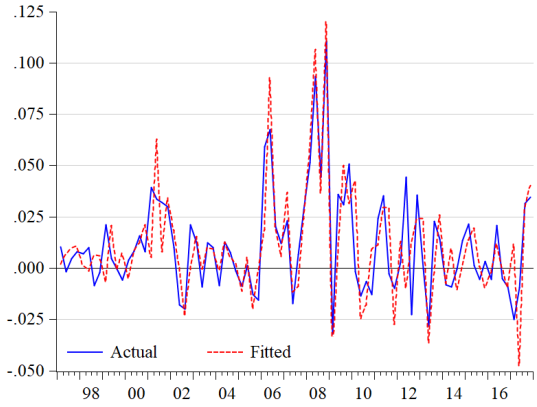

Figure 7.9. Fitted and actual Δpi_t

Single equation dynamic responses of (7.16):

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

Quarters	Δbc	Δpm
Simultaneous	0.73	0.34
One quarter ahead	0.73	0.27
Four quarters ahead	0.73	0.27
Eight quarters ahead	0.73	0.27
Long run	0.73	0.27
50% of long-run effect	O/S	0Q
90% of long-run effect	O/S	4Q
Steady state solution:		
$\Delta pi = 0.734\Delta bc + 0.266\Delta pm$		

7.1.8. Housing investment deflator (PIH)

The housing investment deflator is simply given as:

$$\Delta pih_t = \Delta bc_t \tag{7.17}$$

where:

PIH	Housing investment deflator (7.17).
BC	Building costs (7.22).

7.1.9. Government investment deflator (PIG)

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

$$\begin{aligned}\Delta pig_t &= \underset{(5.6)}{0.017}Q1 + \underset{(0.8)}{0.002}Q2 + \underset{(0.2)}{0.001}Q3 + \underset{(6.5)}{0.042}D0934 \\ &\quad \underset{(-2.3)}{-0.170}\Delta pig_{t-1} + \underset{(3.0)}{0.141}\Delta pig_{t-2} + \underset{(7.8)}{0.638}\Delta bc_t \\ &\quad +(1 + 0.170 - 0.141 - 0.638)\Delta pi_t\end{aligned} \tag{7.18}$$

Estimation method	OLS
Adjusted R^2	0.837
Equation standard error	0.81%
Dynamic homogeneity (F-test)	2.82 [0.10]
LM test for serial correlation (F-test)	0.64 [0.43]
Normality test (χ^2-test)	8.29 [0.02]
White test for heteroscedasticity (F-test)	0.87 [0.54]
Sample period	2001:Q1-2017:Q4 ($T = 68$)

where:

PIG	Government investment deflator (7.18).
BC	Building costs (7.22).
PI	Investment goods price deflator (7.16).
$D0934$	Dummy variable: 1 2009:Q3, -1 2009:Q4 and zero elsewhere.
$Q1$-$Q3$	Centered seasonal dummies.

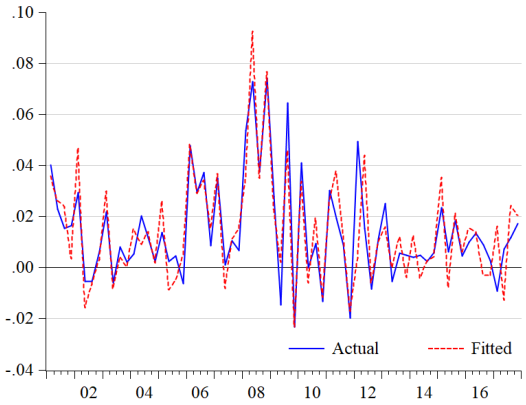

Figure 7.10. Fitted and actual Δpig_t

Single equation dynamic responses of (7.18):

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

Quarters	Δbc	Δpi
Simultaneous	0.64	0.39
One quarter ahead	0.53	0.32
Four quarters ahead	0.63	0.38
Eight quarters ahead	0.62	0.38
Long run	0.62	0.38
50% of long-run effect	O/S	O/S
90% of long-run effect	O/S	O/S
Steady state solution: $\Delta pig = 0.620\Delta bc + 0.380\Delta pi$		

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:

$$PGDP_t = \frac{GDPN_t}{GDP_t} \tag{7.19}$$

where:

$PGDP$	GDP price deflator (7.19).
$GDPN$	Nominal GDP (5.62).
GDP	GDP (5.61).

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 solution for real house prices can be written as:

$$(ph - cpi) = \alpha_{ph} - \beta_{ph}(kh - ly) - \phi_{ph} RLVH \tag{7.20}$$

where PH are house prices, CPI is the general price level, KH is the housing stock, LY is real household disposable labour income and $RLVH$ is the real mortgage rate:[39]

[39]The t-values reported are based on the White heteroscedasticity consistent standard errors.

$$\begin{aligned}\Delta(ph_t - cpi_t) &= \underset{(-1.7)}{-0.012}Q1 - \underset{(-5.6)}{0.062}Q2 - \underset{(-3.5)}{0.025}Q3 \\ &\quad + \underset{(6.7)}{0.584}\Delta(ph_{t-1} - cpi_{t-1}) - \underset{(-7.5)}{0.580}\Delta(kh_t - ly_t) \\ &\quad - \underset{(-2.5)}{3.896}\Delta RLVH_{t-1}\end{aligned} \tag{7.21}$$

Estimation method	OLS
Adjusted R^2	0.750
Equation standard error	1.45%
LM test for serial correlation (F-test)	3.52 [0.07]
Normality test (χ^2-test)	0.28 [0.87]
White test for heteroscedasticity (F-test)	3.62 [0.00]
Sample period	2001:Q3-2017:Q4 ($T = 66$)

where:

PH	House prices (7.21).
CPI	Consumer price index (7.4).
KH	Private sector housing stock (5.22).
LY	Real post-tax labour income (9.7)
$RLVH$	Long-term indexed mortgage rate (4.10).
$Q1$-$Q3$	Centered seasonal dummies.

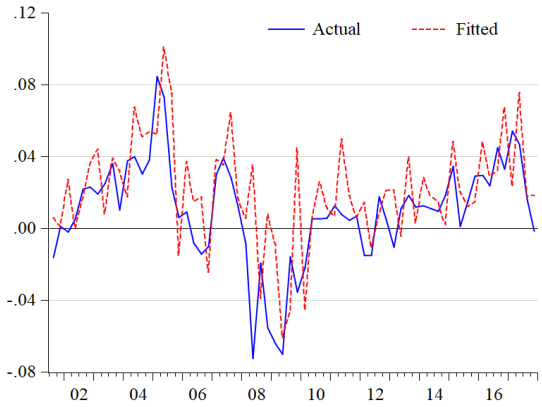

Figure 7.11. Fitted and actual $\Delta(ph_t - cpi_t)$

Single equation dynamic responses of (7.21):

Table 7.10. Responses of $\Delta(ph - cpi)$ to a permanent 1% increase in RHS variables

Quarters	Δkh	Δly	$\Delta RLVH$
Simultaneous	−0.58	0.58	0.00
One quarter ahead	−0.92	0.92	−3.90
Four quarters ahead	−1.30	1.30	−8.28
Eight quarters ahead	−1.38	1.38	−9.24
Long run	−1.39	1.39	−9.37
50% of long-run effect	2Q	2Q	2Q
90% of long-run effect	4Q	4Q	5Q
Steady state solution: $\Delta(ph - cpi) = -1.395\Delta(kh - ly) - 9.371\Delta RLVH$			

7.1.12. Building costs (BC)

Building costs are determined by consumer prices and unit labour costs:[40]

$$\Delta bc_t = 0.60\Delta cpi_t + 0.40\Delta ulct_t \tag{7.22}$$

where:

BC	Building costs (7.22).
CPI	Consumer price index (7.4).
$ULCT$	Trend unit labour costs (6.5).

7.2. Inflation

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

Quarterly inflation is calculated as:

$$INFULQ_t = CPIUL_t/CPIUL_{t-1} - 1 \tag{7.23}$$
$$INFQ_t = CPI_t/CPI_{t-1} - 1 \tag{7.24}$$

and year-on-year inflation as:

$$INFUL_t = CPIUL_t/CPIUL_{t-4} - 1 \tag{7.25}$$
$$INF_t = CPI_t/CPI_{t-4} - 1 \tag{7.26}$$

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

where:

$INFULQ$	Underlying quarterly CPI inflation rate (7.23).
$INFQ$	Quarterly CPI inflation rate (7.24).
$INFUL$	Underlying four-quarter CPI inflation rate (7.25).
INF	Four-quarter CPI inflation rate (7.26).
$CPIUL$	Consumer price index excluding indirect taxes (7.5).
CPI	Consumer price index (7.4).

Similarly, year-on-year trading partners' inflation is given as:

$$WINF_t = WCPI_t / WCPI_{t-4} - 1 \tag{7.27}$$

where:

$WINF$	Iceland's trading partner four-quarter inflation rate (7.27).
$WCPI$	Iceland's trading partner consumer prices (exogenous).

7.3. Inflation expectations

7.3.1. Break-even inflation expectations ($INFE5$ and $INFE10$)

Historical data on break-even inflation expectations in QMM are obtained from the interest rate spread between nominal and indexed bonds from equation (4.8 and 4.9), taking account of an inflation risk premium:[41]

$$INFE5_t = \frac{(1 + RL5_t)}{(1 + RLV5_t)(1 + PRISK_t)} - 1 \tag{7.28}$$

$$INFE10_t = \frac{(1 + RL10_t)}{(1 + RLV10_t)(1 + PRISK_t)} - 1 \tag{7.29}$$

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

$$INFE5_t = \frac{1}{20} \sum_{j=0}^{19} INF_{t+j} \tag{7.30}$$

$$INFE10_t = \frac{1}{40} \sum_{j=0}^{39} INF_{t+j} \tag{7.31}$$

[41] Previous versions of equations for break-even inflation expectations included a positive inflation risk premium. The spread between the break-even rate and survey-based inflation expectations has been close to zero and even negative in recent years, presumably reflecting a spread between nominal and indexed market liquidity premia that is sufficiently negative to offset a positive inflation risk premium. The variable for the wedge between break-even inflation expectations and pure inflation expectations, $PRISK$, remains part of the model but it has presently been set to the value of 0 instead of 0.005 as was done previously.

where:

$INFE5$	5-year break-even inflation expectations (7.28).
$INFE10$	10-year break-even inflation expectations (7.29).
$RL5$	5-year interest rate (4.6).
$RL10$	10-year interest rate (4.7).
$RLV5$	5-year indexed interest rate (4.8).
$RLV10$	10-year indexed interest rate (4.9).
$PRISK$	Inflation risk premium (exogenous).
INF	Four-quarter CPI inflation rate (7.26).

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:

$$TJY_t = RJY_t \times (YE_t \times (1 - DPENS_t) + CJT_t + YICT_t + SPENS_t + UNPM_t) - ALLOW_t \times POWA_t \quad (8.3)$$

where:

TJY	Household income tax (8.3).
RJY	Household effective 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)
$ALLOW$	Effective personal allowances (exogenous).
$DPENS$	Changes in proportion of employees' 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 short-term interest rates:

$$\begin{aligned} TI_t/GDPN_t = {} & \underset{(4.0)}{0.009} - \underset{(-1.8)}{0.0004}Q1 - \underset{(-3.1)}{0.001}Q2 - \underset{(-4.4)}{0.001}Q3 \\ & + \underset{(5.9)}{1.007}TI_{t-1}/GDPN_{t-1} - \underset{(-4.6)}{0.679}TI_{t-2}/GDPN_{t-2} \\ & + \underset{(3.9)}{0.002}(eqp_{t-4} - pgdp_{t-4}) + \underset{(2.5)}{0.041}RS_{t-4} \end{aligned} \quad (8.4)$$

Estimation method	OLS
Adjusted R^2	0.941
Equation standard error	0.03%
LM test for serial correlation (F-test)	0.51 [0.49]
Normality test (χ^2-test)	0.49 [0.78]
White test for heteroscedasticity (F-test)	3.03 [0.03]
Sample period	2012:Q1-2017:Q4 ($T = 24$)

where:

TI	Household financial income tax (8.4)
$GDPN$	Nominal GDP (5.62).
EQP	Equity prices (4.26).
$PGDP$	GDP price deflator (7.19).
RS	Short-term interest rate (4.1).
$Q1$-$Q3$	Centered seasonal dummies.

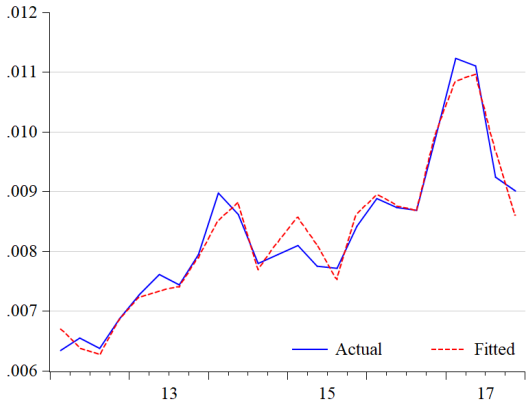

Figure 8.1. Fitted and actual $TI_t/GDPN_t$

Single equation dynamic responses of (8.4):

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

Quarters	$(eqp - pgdp)$	RS
Simultaneous	0.000	0.00
One quarter ahead	0.000	0.00
Four quarters ahead	0.002	0.04
Eight quarters ahead	0.004	0.06
Long run	0.004	0.06
50% of long-run effect	O/S	O/S
90% of long-run effect	O/S	O/S
Steady state solution: $TI/GDPN = const + 0.004(eqp - pgdp) + 0.061RS$		

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 (5.62).

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 (5.62).

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 (5.62).

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 (5.62).

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 (5.42).

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 (5.62).

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:

$$\begin{aligned} CJ_t/GDPN_t \;=\; & \underset{(2.9)}{0.011} + \underset{(1.9)}{0.001}Q1 - \underset{(-3.3)}{0.002}Q2 - \underset{(-4.8)}{0.003}Q3 \\ & + \underset{(3.8)}{0.007}D091 + \underset{(11.4)}{0.797}CJ_{t-1}/GDPN_{t-1} - \underset{(-1.7)}{0.021}GAPAV_t \end{aligned} \tag{8.16}$$

Estimation method	OLS
Adjusted R^2	0.759
Equation standard error	0.18%
LM test for serial correlation (F-test)	0.30 [0.59]
Normality test (χ^2-test)	26.22 [0.00]
White test for heteroscedasticity (F-test)	1.15 [0.34]
Sample period	1997:Q1-2017:Q4 ($T = 84$)

where:

CJ	Current grants to the household sector (8.16).
$GDPN$	Nominal GDP (5.62).
$GAPAV$	Annual average of output gap (5.69).
$D091$	Dummy variable: 1 2009:Q1 and zero elsewhere.
$Q1$-$Q3$	Centered seasonal dummies.

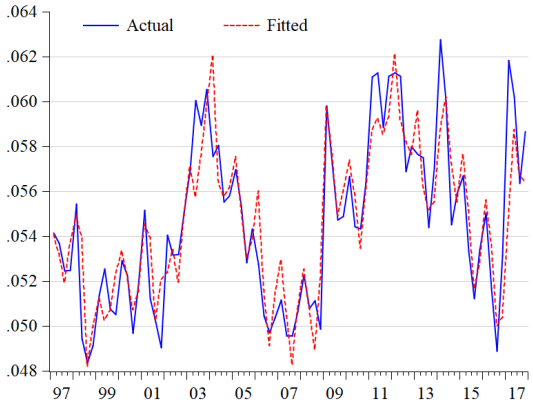

Figure 8.2. Fitted and actual $CJ_t/GDPN_t$

Single equation dynamic responses of (8.16):[42]

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

Quarters	$GAPAV$
Simultaneous	−0.02
One quarter ahead	−0.04
Four quarters ahead	−0.07
Eight quarters ahead	−0.09
Long run	−0.10
50% of long-run effect	3Q
90% of long-run effect	10Q
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 2018 an estimated 82.5% of CJ was taxable according to Statistics Iceland sectoral accounts:

$$CJT_t = 0.825 \times CJ_t \tag{8.17}$$

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

[42]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.

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 (6.3).

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). 57% of debt are pension liabilities and indexed debt, 37% is non-indexed debt and 6% is debt in foreign currencies:[43]

$$\begin{aligned} \Delta DI_t \;=\; & \left[0.57\left(\frac{0.04}{4}\right) + 0.37\left(\frac{RL5_t}{4}\right)\right. \\ & \left. +0.06\left(\left(\frac{EER_t}{EER_{t-1}}\right)\left(1+\frac{WRS_t}{4}\right)-1\right)\right] PSNB_t \end{aligned} \tag{8.20}$$

where:

DI	General government debt interest payments (8.20).
$RL5$	5-year interest rate (4.6).
EER	Exchange rate index of foreign currency (4.13).
WRS	Iceland's trading partner 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:

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

where:

[43] The weights are for 2017 and are obtained from Statistics Iceland.

$PSNB$	Public sector net borrowing (8.21).
GN	Nominal government consumption (exogenous).
$IGNNET$	Nominal net government investment (5.19).
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).
$YDIJ$	Households' net financial income (9.5).
$SPENS$	Withdrawal from third-pillar pension savings (exogenous).
$DPENS$	Changes in proportion of employees' 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 total hours worked:

$$\Delta ye_t = \Delta w_t + \Delta emph_t \quad (9.2)$$

where:

YE	Wages, salaries and self-employed income (9.2).
W	Wages (6.3).
$EMPH$	Total hours (6.14).

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

$$YIC_t = RIC_t \times YE_t \quad (9.3)$$

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 2018 an estimated 71.2% of YIC was subject to income tax:

$$YICT_t = 0.712 \times YIC_t \tag{9.4}$$

where:

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

Households' (nominal) net financial income can be divided into income due to financial assets and costs due to financial debts. It is very difficult to model households' net financial income, especially because of large variations in dividends and capital gains. Here the equation is calibrated so that households' net financial income as a share of nominal GDP converges to the value of 1%, which is the observed share in 2018. Households' nominal net financial income is therefore determined as:

$$\frac{YDIJ_t}{GDPN_t} = 0.90 \left(\frac{1}{4} \sum_{j=1}^{4} \frac{YDIJ_{t-j}}{GDPN_{t-j}} \right) + (1 - 0.90)0.01 \tag{9.5}$$

where:

$YDIJ$	Households' net financial income (9.5).
$GDPN$	Nominal GDP (5.62).

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 (7.14).

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).
$YDIJ$	Households' net financial income (9.5).
TJ	Household tax payments (8.2).
TI	Household financial income tax (8.4)
PC	Private consumption deflator (7.14).

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 5-year and 10-year interest rates (4.6 and 4.7), the real exchange rate (4.19), and 5-year and 10-year break-even inflation expectations (7.30 and 7.31).

10.1. Short-term interest rates (RS)

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

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

10.2. Long-term interest rates ($RL5$ and $RL10$)

The backward-looking version of the 5-year interest rate is given as:

$$\begin{aligned}\Delta RL5_t \;=\; & \underset{(2.0)}{0.219}\Delta RL5_{t-1} + \underset{(3.9)}{0.239}\Delta RS_t - \underset{(-1.9)}{0.097}\Delta RS_{t-1} - \underset{(-3.0)}{0.013}D063 \\ & - \underset{(-6.6)}{0.029}D091 - \underset{(-2.7)}{0.011}D102 - \underset{(-2.6)}{0.057}[RL5_{t-1} - TERM5_{t-1} - RS_{t-1}]\end{aligned} \tag{10.2}$$

Estimation method	OLS
Adjusted R^2	0.471
Equation standard error	0.41%
LM test for serial correlation (F-test)	0.01 [0.93]
Normality test (χ^2-test)	0.01 [0.99]
White test for heteroscedasticity (F-test)	0.48 [0.85]
Sample period	1997:Q1-2017:Q4 ($T = 84$)

and the backward-looking version of the 10-year interest rate is given as:

$$\Delta RL10_t = \Delta RL5_t \tag{10.3}$$

where:

$RL5$	5-year interest rate (4.6).
$RL10$	10-year interest rate (4.7).
RS	Short-term interest rate (4.1).
$TERM5$	Term premium for 5-year interest rate (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:

$$(rex_t - rexeq_t) = \underset{(29.4)}{0.932}(rex_{t-1} - rexeq_{t-1}) + rid_t \tag{10.4}$$

Estimation method	OLS
Adjusted R^2	0.927
Equation standard error	5.20%
LM test for serial correlation (F-test)	0.02 [0.89]
Normality test (χ^2-test)	8.45 [0.01]
White test for heteroscedasticity (F-test)	0.40 [0.53]
Sample period	2001:Q1-2017:Q4 ($T = 68$)

where:

REX	Real exchange rate (4.19).
$REXEQ$	Equilibrium real exchange rate (exogenous).
RID	Real interest rate differential (4.12).

10.4. Inflation expectations ($INFE5$ and $INFE10$)

In the backward-looking version 5-year 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:[44]

$$INFE5_t = \omega_{pe}\left\{INFE5_{t-1} + \eta_{pe}(INF_{t-1} - INFE5_{t-1})\right\} + (1 - \omega_{pe})IT_t \tag{10.5}$$

and the backward-looking version of the 10-year inflation expectations are given as:

[44]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.

$$\Delta INFE10_t = \Delta INFE5_t \tag{10.6}$$

where:

$INFE5$	5-year break-even inflation expectations (7.28).
$INFE10$	10-year break-even inflation expectations (7.29).
INF	Four-quarter CPI inflation rate (7.26).
IT	Central Bank of Iceland's 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.[45]

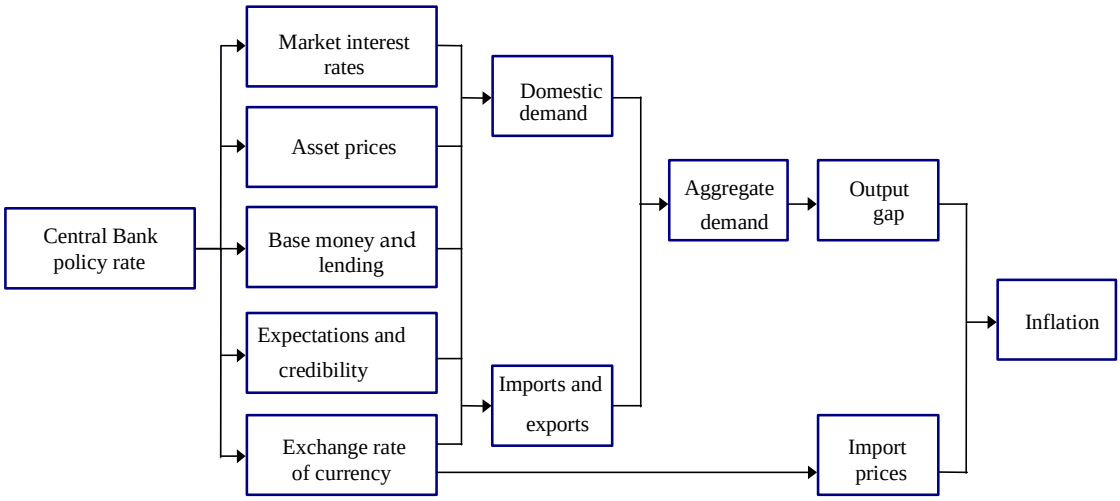

Figure 11.1. The transmission mechanism of monetary policy (Pétursson, 2001b)

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 and 4.7). If inflation expectations are sufficiently anchored, this will also raise the long-term real interest rates (4.8, 4.9 and 4.10) and the real cost of capital (4.11). This has a first round effect on various expenditure items, such as consumption (5.2), business investment (5.11), and residential investment (5.16) thus dampening domestic demand and easing capacity pressures as measured by the output gap (5.68). This affects demand for imported goods and services (5.40), increases unemployment (6.6), and reduces the demand for housing (7.21). Slower demand reduces pressure on prices of domestic (7.4) and imported goods (7.9), and nominal assets, such as housing (7.21), and labour (6.3).

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.

[45] 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 (4.25) and the subsequent rise in long-term interest rates and fall in nominal income will lead to a fall in equity prices (4.26) and rise in household debt (4.31). 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 (4.29) and the market value of firms. In addition, the fall in house prices will reduce housing investment (5.16), and both will reduce the housing wealth of households (4.28). Total household wealth (4.27) 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 (4.13), which will lead to a temporary real exchange rate appreciation (4.19) as domestic nominal prices adjust slowly. The competitive position of the export industry (4.21) will therefore weaken temporarily with export volumes (5.36) and export prices in domestic currency (7.13) declining. The competitive position of sectors competing with imported goods will also weaken as import prices in domestic currency (7.9) fall, thus pushing relative import prices (4.22) down and import volumes (5.40) up, hence shifting demand out of the economy. This increase in demand for imported goods will counteract the fall in imports stemming from falling domestic demand and may even lead to a worsening of the trade balance (5.53). 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 prices of imports in domestic currency fall, imported consumer goods become cheaper (7.4) and prices of goods produced with use of imported intermediate goods (7.16) decline. This further dampens wage pressures with a second round effect on prices through falling unit labour costs (6.5).

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 and 4.7) depend directly on expectations of future policy rate developments. The real exchange rate (4.19) and inflation (7.4) 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 ten years, or 40 quarters. 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).[46] As can be seen in Figure 11.2, the policy rate remains above baseline for one year, moving temporarily below the baseline in the fifth quarter as inflation falls below target, before returning close to its pre-shock level around 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 relatively small. However, output starts to fall markedly from baseline from the second quarter, with the peak effect occurring in the sixth quarter with output 0.35% below the baseline scenario. The inflationary effect takes similar time to emerge, with the peak effect occurring in the fourth quarter, with inflation 0.16 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 generating the final effects on output and inflation described above. The nominal 5-year interest rate immediately rises by 42 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) and Laforte (2018). 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 5-year real interest rates. Furthermore, as the interest rate differential vis-à-vis abroad rises, the nominal exchange rate immediately appreciates by 0.51% (or 2.1% in annualised terms). Due to nominal price stickiness, this also leads to an appreciation of the real exchange rate. The exchange rate response is consistent with international evidence from structural VAR analysis, cf. Eichenbaum and Evans (1995) and similar structural VAR results from Pétursson (2001b). It is also similar

[46] 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.

to what is found in 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).

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 0.10 percentages points occurring after one and a half year. The effects are similar to what is found in other models, such as the RAMSES II model of Riksbank (Adolfson et al., 2013). With falling demand for labour, nominal wages start to decline below baseline, with year-on-year wage inflation falling 0.29 percentage points below the baseline scenario in two years. 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 0.21 percentages points below baseline in the eighth quarter.

The rise in the real interest rates and exchange rate, together with declining nominal income and a deterioration in household wealth, lead to a fall in domestic demand. Year-on-year growth in private consumption falls 0.29 percentage points below baseline in the fifth quarter and remains below baseline for two and a half year before moving temporarily above the baseline scenario. The effects on business investment are much stronger than on private consumption. The year-on-year growth in business investment falls 0.82 percentage points below baseline in the fourth quarter. The effects on total investment are more mooted however as overall investment includes government, aluminium investment and investment in ships and airplanes, all of which are exogenous in QMM.

Finally, year-on-year growth in exports of goods and services falls below baseline in the second quarter as the real exchange rate appreciates, which increases the foreign currency export price and reduces export demand, with peak effect in the fifth quarter with export growth 0.17 percentage points 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. Thus, the year-on-year growth rate of imports of goods and services initially moves above baseline before gradually falling below baseline more than a year after the shock. The effect of lower relative import prices dominates the impact of lower domestic income on the demand for imports. Finally, a trade deficit opens up, which rises to 0.12% of baseline nominal GDP five years after the shock.

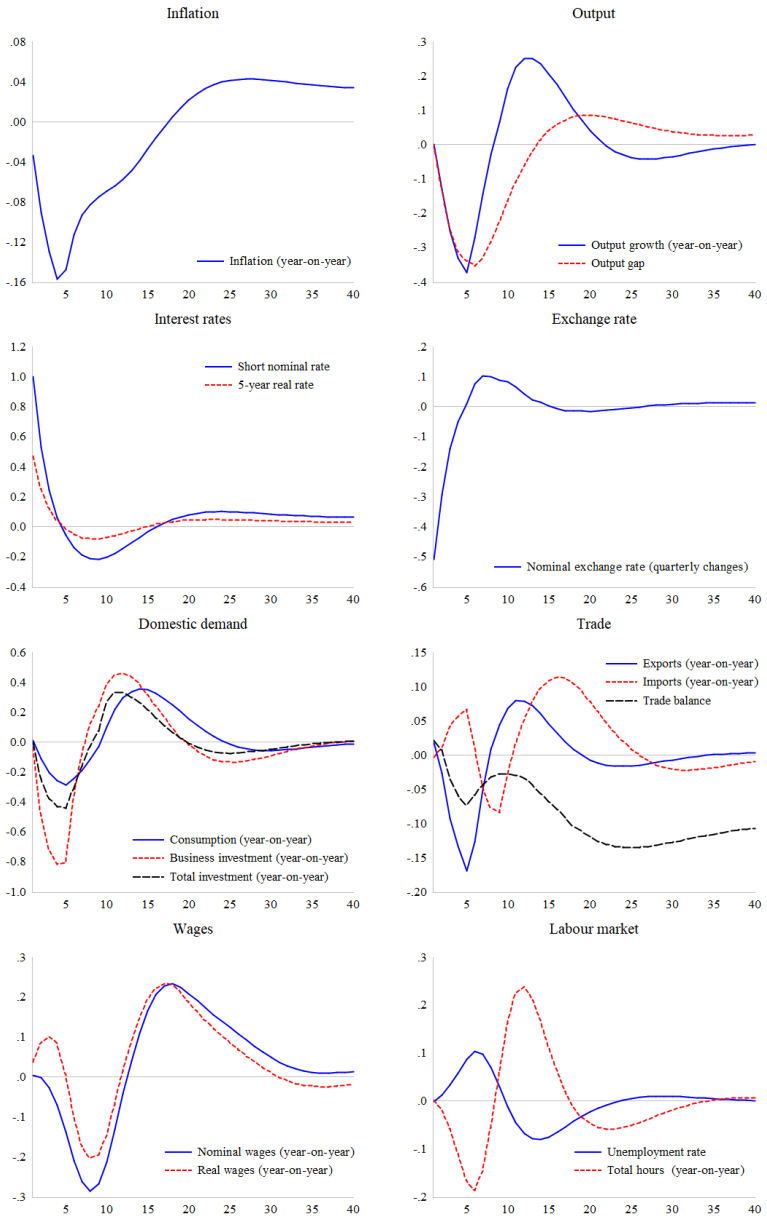

Figure 11.2. A monetary policy shock (deviations from baseline)

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 (e.g. Kamber et al., 2015). 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, and Laforte, 2018), the TOTEM II model of Bank of Canada (Dorich et al., 2013), the NEMO model of Norges Bank (Brubakk et al., 2006), the RAMSES II model of Riksbank (Adolfson et al., 2013), 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% compared to the 0.35% decline in QMM, with 50% of the peak output effect attained in two quarters after the shock 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 close to the 0.16 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 4.0. 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, which 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.[47] 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 the effects of different shocks individually.

[47] 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.

We start by analysing two fiscal policy shocks that serve to highlight how fiscal policy can influence aggregate demand directly and indirectly through its effect on household income and consumption. They are also of importance as they give an idea of the size of fiscal multipliers in QMM.[48] 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 − an external 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) (Laforte, 2018), 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), the RAMSES II model of Riksbank (Adolfson et al., 2013), 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 0.8% above baseline in the first four quarters, before turning negative in the fifth quarter and fading out after six years. The temporary increase in demand for domestic goods and services leads to a short-term increase in employment and wages, thus raising real disposable income. Asset prices also rise, and therefore net wealth as well, all contributing to a temporary rise in private consumption. There is also a small increase in investment growth reflecting the acceleration properties of investment in QMM.

The temporary 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 an exchange

[48] 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).

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 trade deficit.

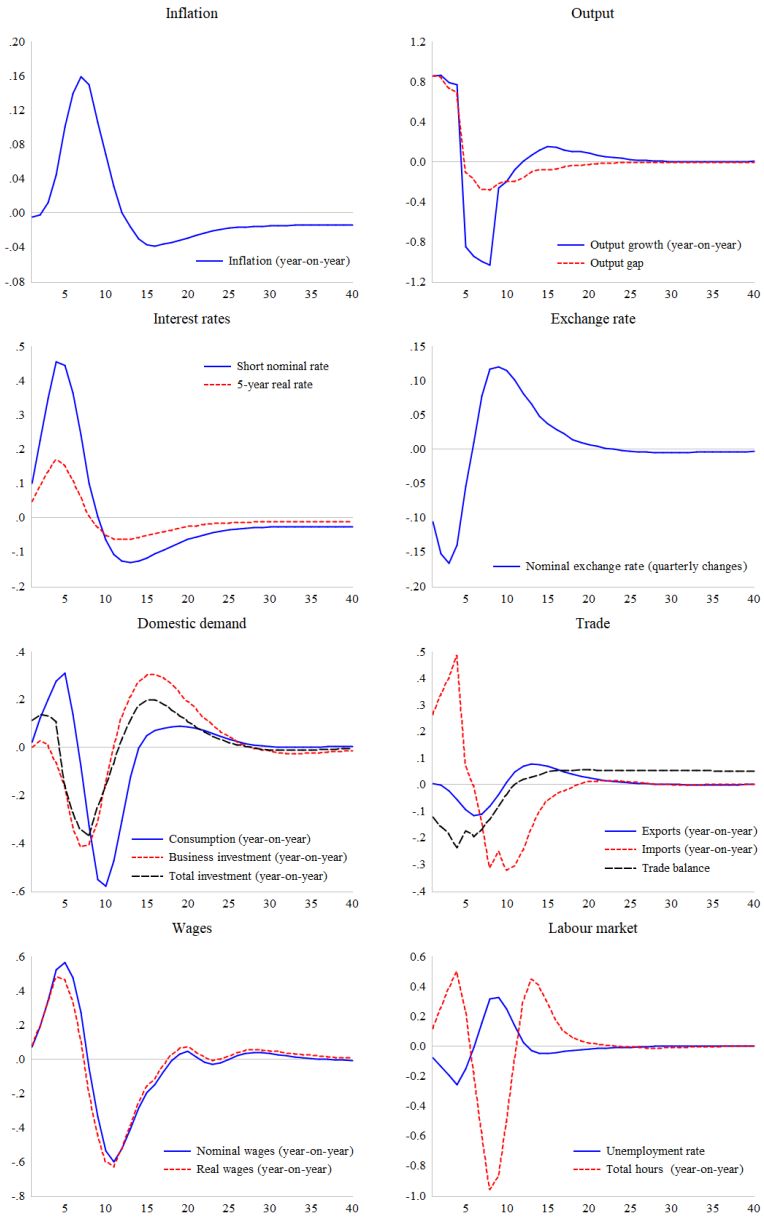

Figure 12.1. A government expenditure shock (deviations from baseline)

The rise in real interest rates and the exchange rate 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 0.8 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 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. Thus, output rises only gradually and peaks at close to 0.30% above baseline in the fourth quarter, mainly through rising private consumption, before gradually fading out.

The effect of the tax cut on inflation, the 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 boost to output. 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 0.30 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.

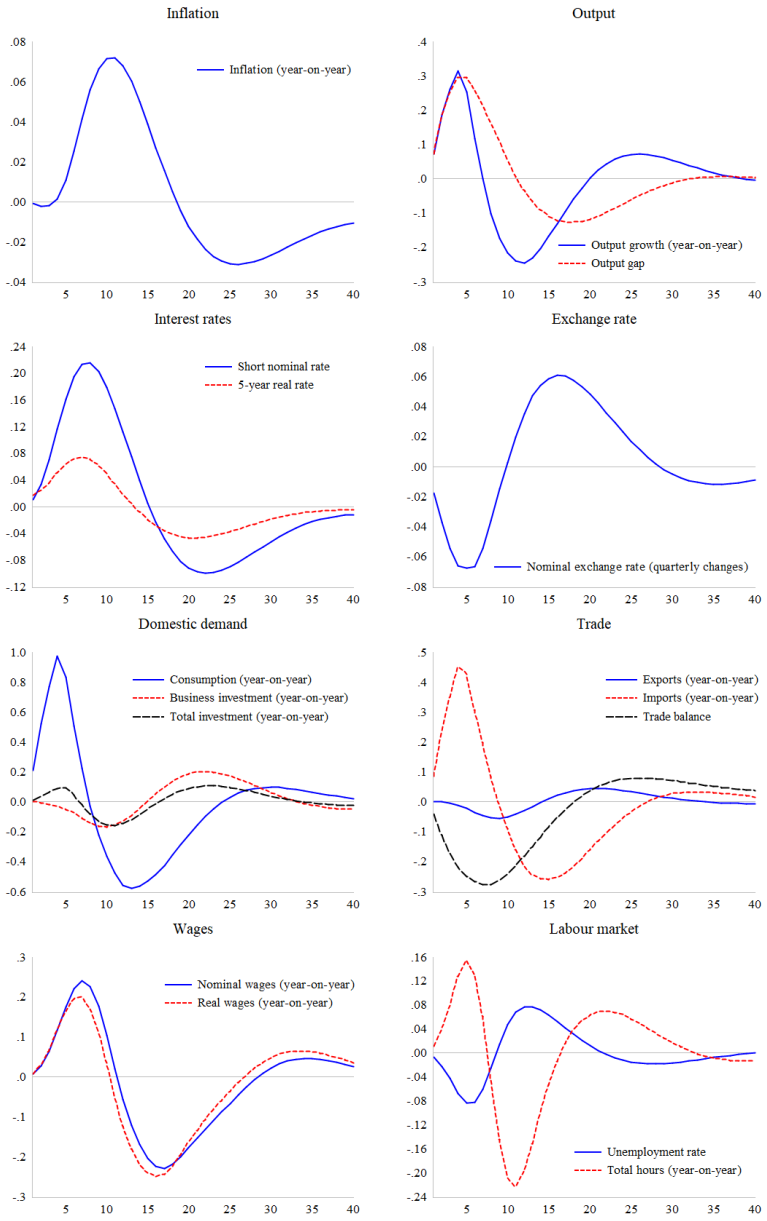

Figure 12.2. An income tax shock (deviations from baseline)

12.3. An exchange rate shock

Figure 12.3 illustrates the effects of a 1% temporary nominal exchange rate shock caused by a temporary increase in the exogenous currency risk premium ($RISK$). This negative portfolio shock is assumed to keep the nominal price of foreign currency (EER) 1% above the baseline for four quarters before returning it to baseline. The exchange rate thus immediately depreciates by 1% as the risk-adjusted relative return

on foreign assets rises relative to returns on domestic assets.

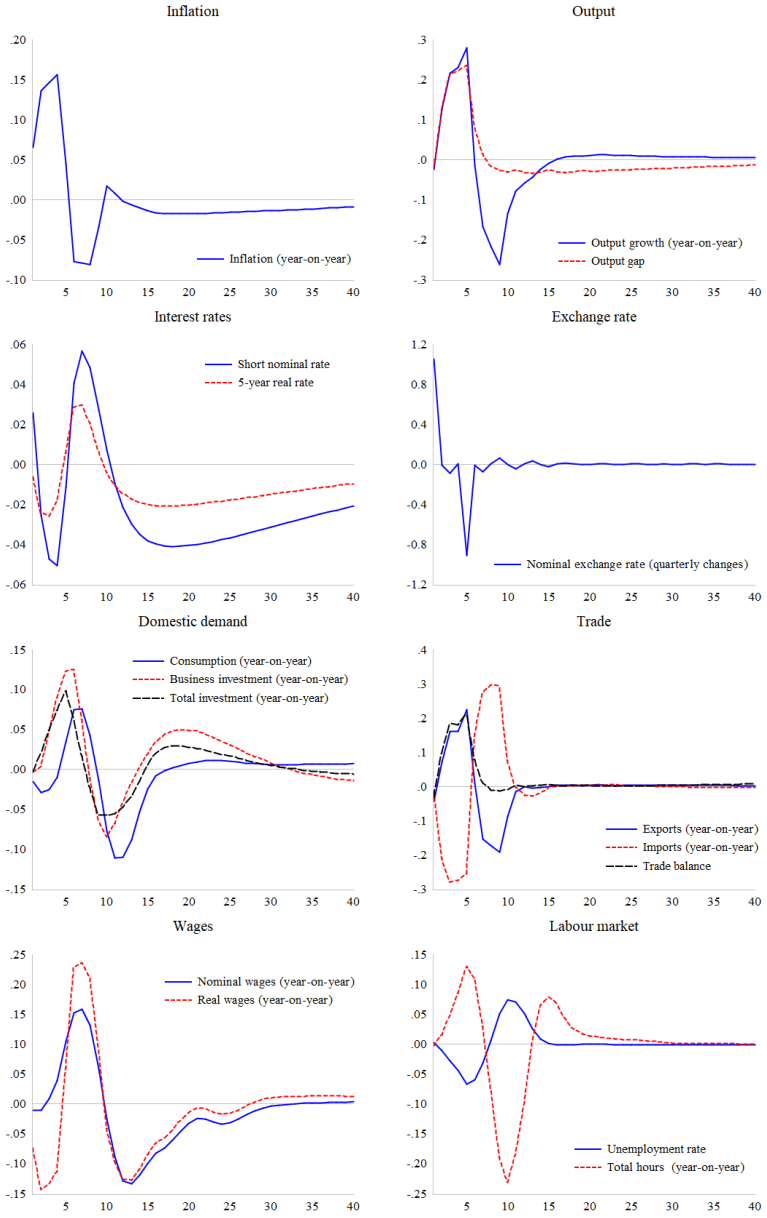

Figure 12.3. An exchange rate shock (deviations from baseline)

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 initial effects on real long-term rates are slightly negative due to the temporary nature of the shock.[49] Rising interest

[49] 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 it is specified in terms

rates initially pushes consumption growth below baseline but a positive output gap emerges due to a pick up in investment growth and an improvement in net exports, which comes from stronger exports and falling imports. The trade balance therefore gradually improves although it deteriorates at impact (thus, displaying the typical J-curve behaviour). 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 0.16 percentage points four quarters after the shock. This is slightly higher than in Version 3.0 of QMM, but smaller than previous studies of exchange rate pass-through in Iceland have found (see Box VIII-1 in *Monetary Bulletin* 2008/2, pp. 44-46) and Pétursson (2008, 2010). 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 improved anchoring of inflation expectations, which a number of studies have found (cf. Pétursson, 2008, 2010).

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 the export price for aluminium ($PXALU$). The import price of alumina ($PMALU$) is a function of $PXALU$ in the model. For this shock $PMALU$ is assumed exogenous and to follow its baseline path. 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 trading partners' output. Domestic wealth and labour income therefore rise, which induces an increase in consumption. Some of the boost in consumption expenditure is directed towards imported goods and services that are now relatively cheaper as the exchange rate appreciates. Although the improvements in the terms of trade increase overall domestic demand, investment growth falls below baseline due to the rise in the real interest rate and appreciation of the exchange rate which weakens the competitive position of the export sector other than the aluminium sector.[50] The increased domestic demand following the terms of trade improvement boosts output growth initially and opens up a positive output gap. The exchange appreciation eventually leads to an offsetting contraction in export growth and the negative contribution of net exports leads to a reduction in output and consumption.

The exchange rate appreciation leads to a decline in inflation in the short-run but inflation begins to rise above baseline in about a year as the initial effect of the

of current inflation.

[50]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.

appreciation disappears. Thus, while the central bank initially responds by lowering its policy rates, rates move above baseline after two quarters.

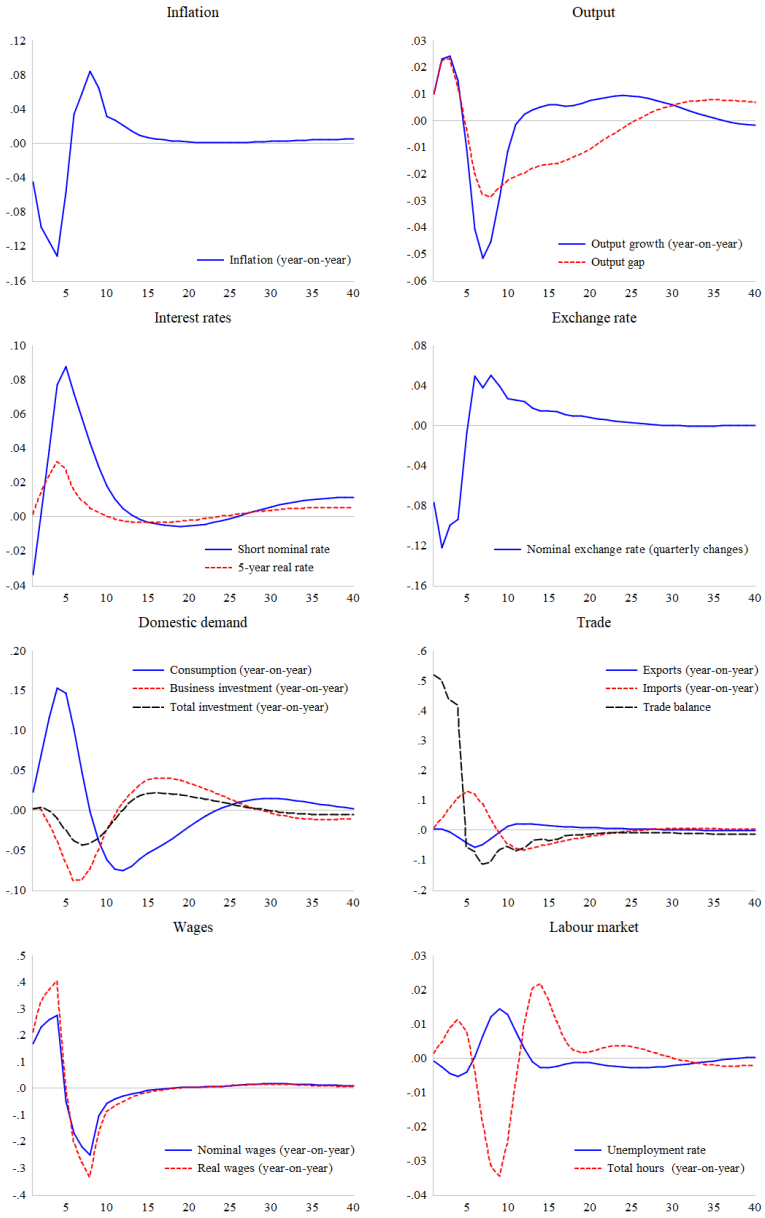

Figure 12.4. A terms of trade shock (deviations from baseline)

12.5. An external demand shock

The next experiment shows how a shock to trading partner demand for Icelandic exports propagates through the economy. The shock is given by a 1% exogenous increase in both trading partners' output ($WGDP$) and imports ($TRADE$) and is

assumed to last for four quarters before returning to baseline. The shock increases exports of sectors that are not resource constraint (i.e. other sectors than the marine and aluminium).

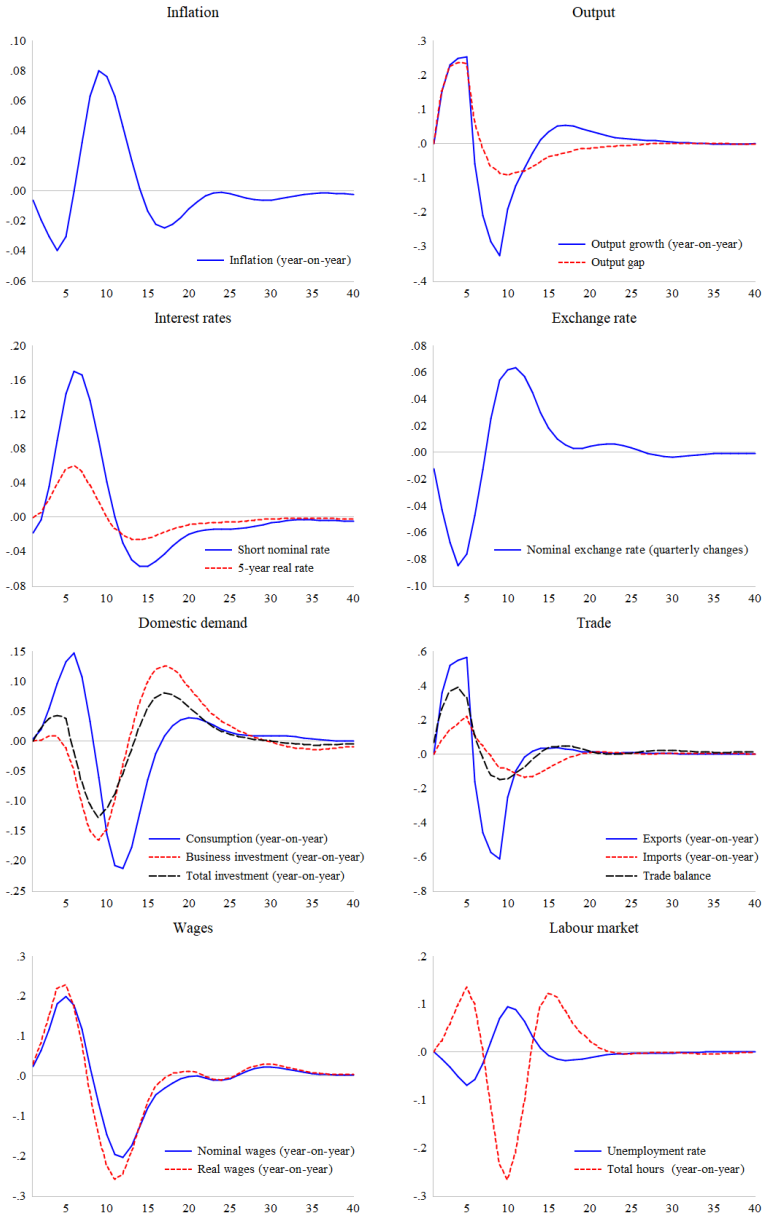

Figure 12.5. An external demand shock (deviations from baseline)

As Figure 12.5 illustrates, an increase in external demand leads to rising exports, with a peak effect in the fifth quarter when export growth is 0.56 percentage points 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. Domestic income starts rising, boosting consumption expenditure. Investment growth moves above baseline in the first year but then falls below baseline as the impact of the higher exchange rate and higher real cost of capital begin to dominate.

The increase in domestic demand and net exports lead to a positive output gap. Although inflation initially declines marginally due to the exchange rate appreciation, it 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 over the medium term.

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. The decline in inflation and inflation expectations initially push nominal wage inflation below baseline, but the positive productivity shock gradually pushes wage inflation above baseline. The productivity shock also leads to a reduced demand for labour in the short-run but employment growth moves above baseline after a year and unemployment declines below baseline, with a peak effect of 0.42 percentage points in quarter six. The short-run decline in employment and real wages therefore initially pushes consumption growth below baseline, while lower interest rates move investment growth above baseline. The depreciation of the currency also boosts exports while imports initially decrease due to negative substitution effect. Import growth gradually moves above baseline as the positive income effect emerge and as the increase in imports is larger than the increase in exports the trade deficit eventually opens up.

Finally, as domestic demand increases, output growth 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.

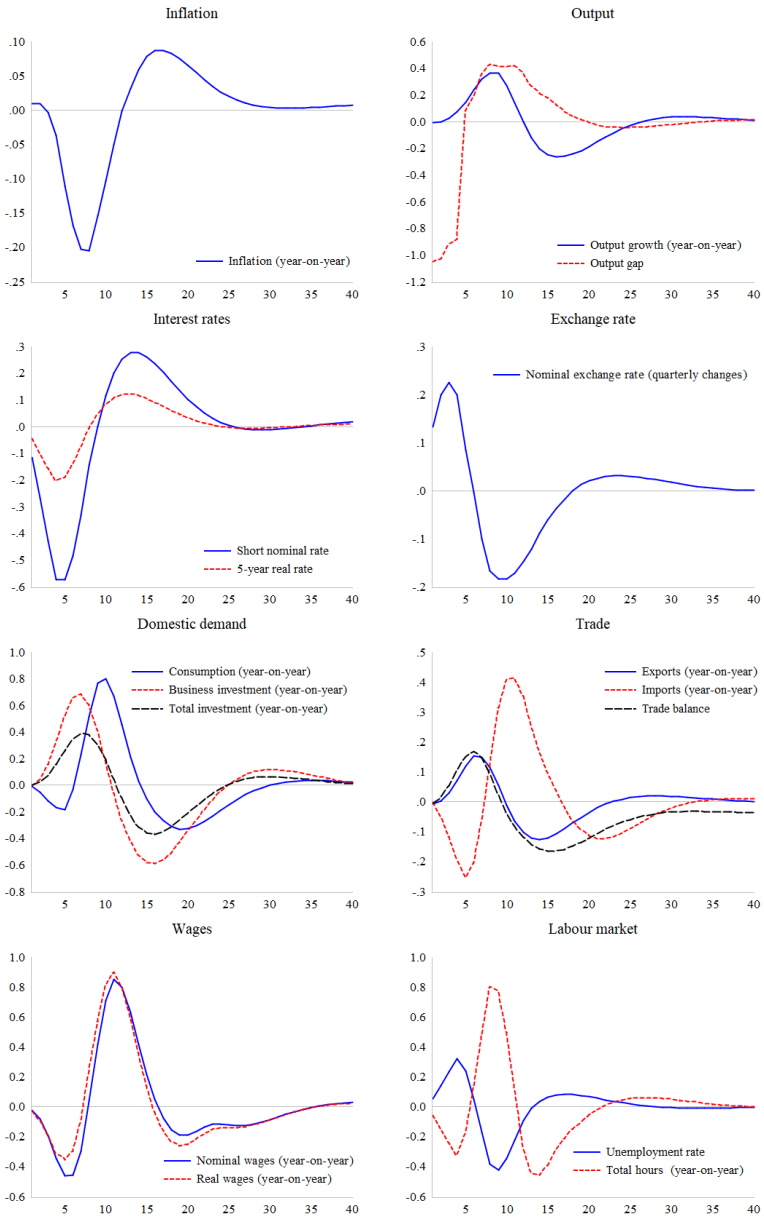

Figure 12.6. A productivity shock (deviations from baseline)

Part IV
Appendices

13. Variables listing

Table 13.1. List of variables

Name	Description	Type	Equations
ADJ	Adjustment factor to potential output	X	(5.67)
ALLOW	Effective personal allowances	X	(8.3)
AVH	Average hours per worker	B	(**6.11**), (6.12), (6.14)
AVHA	Average hours per worker over 2003-2018	X	(6.11)
AVHT	Short-run trend average hours per worker	D	(5.66), (**6.12**), (6.16)
BAL	Current account balance	I	(**5.57**), (5.60)
BALGOOD	Balance of goods	I	(5.53), (**5.54**)
BALSERV	Balance of services	I	(5.53), (**5.55**)
BALT	Balance of trade	I	(**5.53**), (5.57)
BC	Building costs	B	(7.15), (7.16), (7.17), (7.18), (**7.22**)
BIPD	Balance of interest, salaries, dividends and profits	T	(**5.56**), (5.57)
BIPDF	Risk premium on Iceland's trading partner interest rate	X	(5.56)
BTRF	Balance of transfers	X	(5.57)
C	Private consumption	B	(**5.2**), (5.3), (5.23), (5.25), (5.61)
CFM	Capital flow management measure	X	(4.12)
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	(4.30), (4.31), (**5.3**), (5.24), (8.12), (8.14)
CPI	Consumer price index	B	(4.13), (4.32), (4.33), (5.47), (5.50), (6.3), (**7.4**) , (7.5), (7.11), (7.14), (7.15), (7.21), (7.22), (7.24), (7.26)
CPIUL	Consumer price index excluding indirect taxes	D	(**7.5**), (7.23), (7.25)
DD	Domestic demand	D	(**5.23**)
DDA	Import weighted domestic demand	I	(**5.25**), (5.47), (5.50)
DDN	Nominal domestic demand	I	(5.23), (**5.24**), (5.62)
DELTA	Depreciation rate for total capital stock	X	(4.11), (5.20)
DELTAB	Depreciation rate for business capital stock	X	(5.21)
DELTAG	Depreciation rate for government capital stock	X	(5.19)
DELTAH	Depreciation rate for housing stock	X	(4.30), (4.31), (5.22)
DH	Financial debt of households	T	(4.29), (**4.31**)
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 employees' payment in pensions funds and third-pillar savings	X	(8.3), (9.1)
EER	Exchange rate index of foreign currency	D	(**4.13**), (4.14), (4.15), (4.20), (4.21), (4.33), (5.27), (5.34), (5.36), (5.59), (5.60), (7.7), (7.8), (7.10), (7.11), (7.14), (8.20)
EMP	Level of employment in man-years	T	(**6.13**), (6.14)
EMPH	Total hours	D	(5.66), (**6.14**), (6.17), (9.2)
EMPHT	Short-run trend total hours	D	(5.64), (**6.16**)
EMPT	Short-run trend employment	D	(**6.15**), (6.16)
EQP	Equity prices	B	(4.25), (**4.26**), (4.32), (8.4)
EUR	Euro exchange rate	B	(**4.15**)
EUS	US dollar exchange rate	B	(**4.14**), (5.27), (5.33), (5.41),(5.44), (7.7),
EX	Export volume of goods and services	D	(5.25), (**5.26**), (5.61), (7.13)
EXAIR	Export volume of ships and airplanes	X	(5.25), (5.27), (5.32)
EXAIRN	Nominal exports of ships and airplanes	D	(5.27), (5.29), (**5.32**)
EXALU	Exports of aluminium products	X	(5.25), (5.27), (5.33)
EXALUN	Nominal exports of aluminium products	D	(5.29), (**5.33**)
EXD	Exports excluding exports of aluminium, ships and airplanes	I	(5.25), (**5.31**)
EXG	Export volume of goods	D	(5.26), (**5.27**)
EXGN	Nominal exports of goods	I	(5.26), (5.27), (5.28), (**5.29**), (5.54)
EXMAR	Exports of marine products	X	(5.27), (5.34)
EXMARN	Nominal exports of marine products	D	(5.29), (**5.34**)
EXN	Nominal exports of goods and services	I	(5.26), (**5.28**), (5.62), (7.13)
EXOTH	Export volume of other goods	B	(5.27), (**5.36**), (5.37)
EXOTHN	Nominal export of other goods	D	(5.29), (**5.37**)
EXS	Export volume of services	B	(5.26), (5.30), (**5.39**)
EXSN	Nominal exports of services	I	(5.26), (5.28), (**5.30**), (5.55)
FOH	Foreign holdings of Icelandic assets	T	(5.58), (**5.60**)
G	Government consumption	X	(5.4), (5.23), (5.25), (5.61)

Table 13.1. List of variables (continued)

Name	Description	Type	Equations
GAP	Output gap	D	(**5.68**), (5.69),
GAPAV	Annual average of output gap	D	(4.1), (**5.69**), (6.6) (7.4), (8.16)
GDP	GDP	D	(4.25), (5.11), (5.16), (5.22), (**5.61**), (5.66), (5.68), (6.6), (6.9), (6.11), (6.17), (7.19)
GDPN	Nominal GDP	I	(**5.62**), (7.19), (8.4), (8.5), (8.7), (8.8), (8.9), (8.15), (8.16), (9.5)
GDPT	Potential output	B	(**5.64**), (5.67)
GDPTF	Final estimate of potential output	D	(**5.67**), (5.68)
GDPTX	Augmented estimate of potential output	B	(**5.66**), (5.67)
GFW	Gross financial wealth	T	(4.29), (**4.30**)
GN	Nominal government consumption	D	(**5.4**), (5.24), (8.21)
HW	Housing wealth	D	(4.27), (**4.28**)
I	Fixed investment	D	(**5.5**), (5.6), (5.20), (5.23), (5.25), (5.61)
IBAIR	Investment in ships and airplanes	X	(5.12)
IBAIRN	Nominal investment in ships and airplanes	X	(5.12), (5.13)
IBALU	Aluminium sector investment	X	(5.12)
IBALUN	Nominal aluminium sector investment	X	(5.12), (5.13)
IBREG	Regular business investment	B	(**5.11**), (5.12)
IBREGN	Nominal regular business investment	I	(5.12), (**5.13**)
IBUS	Business investment	D	(5.5), (**5.12**), (5.21)
IBUSN	Nominal business investment	I	(5.5), (5.12), (5.13), (**5.14**)
IG	Government investment	X	(5.5), (5.18)
IGN	Nominal government investment	D	(5.14), (**5.18**), (5.19)
IGNNET	Nominal net government investment	D	(**5.19**), (8.21)
IH	Private sector housing investment	B	(4.30), (4.31), (5.5), (**5.16**), (5.17), (5.22)
IHEX	Adjustment factor for private sector housing stock	X	(5.22)
IHN	Nominal housing investment	D	(5.14), (**5.17**)
II	Net stockbuilding	X	(5.23), (5.61)
IIN	Nominal net stockbuilding	X	(5.23), (5.24), (5.61)

Table 13.1. List of variables (continued)

Name	Description	Type	Equations
IMP	Imports of goods and services	D	(**5.40**), (5.61), (7.9)
IMPAIR	Import volume of ships and airplanes	X	(5.41), (5.45)
IMPAIRN	Nominal imports of ships and airplanes	D	(5.41), (5.43), (**5.45**)
IMPALU	Import volume of goods for aluminium production	X	(5.41), (5.44)
IMPALUN	Nominal import of goods for aluminium production	D	(5.43), (**5.44**)
IMPG	Import volume of goods	D	(5.40), (**5.41**)
IMPGN	Nominal import of goods	I	(5.40), (5.41), (5.42), (**5.43**), (5.54)
IMPN	Nominal import of goods and services	I	(5.40), (**5.42**), (5.62), (7.9), (8.13)
IMPOTH	Import volume of other goods	B	(5.41), (**5.47**), (5.48)
IMPOTHN	Nominal import of other goods	D	(5.43), (**5.48**)
IMPS	Import volume of services	B	(5.40), (**5.50**), (5.51)
IMPSN	Nominal import of services	D	(5.40), (5.42), (**5.51**), (5.55)
IN	Nominal fixed investment	D	(5.5), (**5.6**), (5.14), (5.24)
INF	Four-quarter CPI inflation rate	D	(7.4), (**7.26**), (7.30), (7.31)
INFE5	5-year break-even inflation expectations	B	(4.8), (5.2), (**7.30**)
INFE10	10-year break-even inflation expectations	B	(4.9), (6.3), (7.4), (**7.31**)
INFQ	Quarterly CPI inflation rate	D	(**7.24**)
INFTAX	Effects of indirect taxes on the CPI	X	(7.5)
INFUL	Underlying four-quarter CPI inflation rate	D	(4.1), (4.12), (**7.25**)
INFULQ	Underlying quarterly CPI inflation rate	D	(**7.23**)
ISA	Icelandic holdings of foreign assets	T	(5.58), (**5.59**), (5.60)
IT	Central Bank of Iceland inflation target	X	(4.1), (7.4)
K	Total capital stock	I	(5.19), (**5.20**), (5.64), (5.66)
KBUS	Business capital stock	I	(5.19), (**5.21**)
KH	Private sector housing stock	I	(4.28), (4.30), (4.31), (5.19), (**5.22**), (7.21)
LY	Real post-tax labour income	D	(7.21), (**9.7**)
M3	Broad money	B	(**4.25**)
NAIRU	Natural rate of unemployment	X	(6.3), (6.6), (6.15)
NFA	Net foreign assets	I	(5.56), (**5.58**)
NFW	Net financial wealth	I	(4.27), (**4.29**)
PA	Participation rate	B	(6.7), (**6.9**), (6.10), (6.13)

Table 13.1. List of variables (continued)

Name	Description	Type	Equations
PAT	Short-run trend participation rate	D	(5.66), (**6.10**), (6.15)
PC	Private consumption deflator	B	(4.30), (4.31), (5.2), (5.3), (5.23), (5.61), (**7.14**), (9.6), (9.7)
PCOM	Non-oil commodity prices in USD	X	(7.7)
PG	Government consumption deflator	B	(5.4), (5.23), (5.61), (**7.15**)
PGDP	GDP price deflator	D	(4.22), (4.25), (4.26), (5.61), (**7.19**), (8.4)
PH	House prices	B	(4.28), (4.30), (4.31), (5.16), (**7.21**)
PI	Investment goods price deflator	B	(5.6), (5.23), (5.32), (5.45), (5.61), (**7.16**), (7.18)
PIG	Government investment deflator	B	(5.5), (5.18), (5.19), (**7.18**)
PIH	Housing investment price deflator	B	(5.5), (5.16), (5.17), (**7.17**)
PM	Import price deflator	D	(4.22), (4.23), (5.61), (**7.9**), (7.16)
PMALU	Import price deflator for alumnium production in USD	B	(5.41), (5.44), (**7.6**)
PMOTH	Import price deflator for other goods	B	(5.41), (5.47), (5.48), (**7.7**)
PMS	Import price deflator for services	B	(5.50), (5.51), (**7.8**)
POIL	Oil prices in USD	X	(7.7)
POWA	Population at working age (16-74)	X	(5.66), (6.7), (6.13), (6.15), (8.3)
PRBUS	Business premium on risk-free interest rate	X	(4.11)
PRISK	Inflation risk premium	X	(4.8), (4.9)
PROD	Labour productivity	D	(6.4), (**6.17**), (6.18), (6.19)
PRODT	Short-run trend labour productivity	D	(6.5), (**6.18**)
PRODTL	Long-term trend labour productivity	D	(6.3), (**6.19**)
PSNB	Public sector net borrowing	I	(8.20), (**8.21**)
PX	Export price deflator	D	(4.21), (4.23), (5.61), (**7.13**)
PXALU	Price of aluminium products in US dollars	X	(5.27), (5.33), (7.6)
PXMAR	Price of marine products in foreign currency	B	(5.27), (5.34), (7.12)
PXOTH	Export prices of other goods	B	(5.27), (5.36), (5.37), (**7.10**)
PXS	Export prices of services	B	(5.30), (**7.11**)

Table 13.1. List of variables (continued)

Name	Description	Type	Equations
QDGDPT	Quarterly trend GDP growth rate	D	(5.59), (5.60), (**5.65**), (6.6), (6.11), (7.12)
RCC	Real cost of capital	D	(**4.11**), (5.11)
RCI	Corporate income tax rate	X	(8.7)
RCP	Corporate property tax rate	X	(8.8)
REM	Employers' wage-related cost	X	(6.4), (6.5)
REVA	Household assets revaluation term	T	(4.30), (**4.32**)
REVD	Household debt revaluation term	T	(4.31), (**4.33**)
REX	Real exchange rate	B	(4.13), (**4.19**), (5.39)
REXEQ	Equilibrium real exchange rate	X	(4.19)
REXM	Importers' real exchange rate	D	(**4.22**), (7.4)
REXW	Real exchange rate given by relative unit labour costs	D	(**4.20**)
REXX	Exporters' real exchange rate	D	(**4.21**)
RFIC	Tax rate for other payments	X	(8.9)
RHPI	Real household post-tax income	D	(4.30), (4.31), (5.2), (**9.6**)
RIC	Ratio of households' other income to YE	X	(9.3)
RID	Real interest rate differential	D	(**4.12**), (4.19)
RIMP	Tax rate on imports	X	(8.13)
RISK	Exchange rate risk premium	X	(4.12)
RJO	Household other tax rate	X	(8.5)
RJY	Household effective income tax rate	X	(8.3)
RL5	5-year interest rate	B	(**4.6**), (4.8), (4.25), (7.28), (8.20)
RL10	10-year interest rate	B	(**4.7**), (4.9), (7.29)
RLV5	5-year indexed interest rate	T	(**4.8**), (4.10), (4.11), (7.28)
RLV10	10-year indexed interest rate	T	(**4.9**), (7.29)
RLVH	Long-term indexed mortgage rate	B	(**4.10**), (5.16), (7.21), (9.5)
RRN	Real neutral interest rate	X	(4.1)
RS	Short-term interest rate	B	(**4.1**), (4.6), (4.7), (4.12), (5.2), (8.4) (9.5)
RSD	Other expenditure tax rate	X	(8.14)
RTS	Effective subsidies rate	X	(8.15)
RVAT	Value-added tax rate	X	(8.12)
RWC	Corporate wage cost tax rate	X	(8.10)
SPEC	Trade specialisation	D	(5.50), (**5.52**)
SPENS	Withdrawal from third-pillar pension savings	X	(8.3), (9.1)

Table 13.1. List of variables (continued)

Name	Description	Type	Equations
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**)
TCP	Corporate property tax payments	T	(8.6), (**8.8**)
TE	Total taxes on production and imports	I	(8.1), (**8.11**)
TERM10	Term premium for 10-year interest rates	X	(4.7)
TERM5	Term premium for 5-year interest rates	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**)
TOT	Terms of trade	D	(**4.23**), (6.3),
TRADE	Iceland's trading partner imports	X	(5.36), (5.39), (5.52)
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	(4.20), (**6.4**)
ULCT	Trend unit labour costs	D	(**6.5**), (7.7), (7.15), (7.22)
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), (5.66), (**6.6**), (6.7), (6.8), (6.13)
URSA	Seasonally adjusted unemployment rate	T	(6.3), (**6.8**)
W	Wages	B	(**6.3**), (6.4), (6.5), (8.18), (9.2)
WCPI	Iceland's trading partner consumer prices	X	(4.13), (5.36), (7.8) (7.11), (7.27)
WEL	Household sector wealth	I	(4.25), (**4.27**), (5.2)
WEQP	World equity prices	X	(5.59), (5.60)
WGDP	Iceland's trading partner GDP	X	(5.52), (7.12)
WINF	Iceland's trading partner four-quarter inflation rate	D	(4.12), (**7.27**)
WPX	Iceland's trading partner export prices	X	(4.21), (7.7), (7.10)
WRS	Iceland's trading partner short-term interest rate	X	(4.12), (5.56), (8.20)

Table 13.1. List of variables (continued)

Name	Description	Type	Equations
WULC	Iceland's trading partner unit labour costs	X	(4.20)
YDIJ	Households' net financial income	B	(9.1), (**9.5**), (9.7)
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		212
	Number of behavioural variables	(B)	41
	Number of technical variables	(T)	27
	Number of definitions	(D)	58
	Number of identities	(I)	27
	Number of exogenous variables	(X)	59

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		26	
Variable	Mnemonic	Equation number	Page number
5-year interest rates	RL5	4.6	23
Broad money demand	M3	4.25	29
Private consumption	C	5.2	34
Regular business investment	IBREG	5.11	37
Private sector housing investment	IH	5.16	40
Export volume of other goods	EXOTH	5.36	48
Export volume of services	EXS	5.39	49
Import volume of other goods	IMPOTH	5.47	53
Import volume of services	IMPS	5.50	55
Potential output	GDPT	5.64	60
Wages	W	6.3	63
Unemployment rate	UR	6.6	66
Participation rate	PA	6.9	67
Average hours per worker	AVH	6.11	69
Consumer price index	CPI	7.4	74
Import price deflator for alumnium production in USD	PMALU	7.6	76
Import price deflator for other goods	PMOTH	7.7	78
Export prices of other goods	PXOTH	7.10	80
Export prices of services	PXS	7.11	81
Price of marine products in foreign currency	PXMAR	7.12	82
Private consumption deflator	PC	7.14	84
Investment goods price deflator	PI	7.16	86
Government investment deflator	PIG	7.18	88
House prices	PH	7.21	90
Household financial income tax	TI	8.4	94
Current grants to the household sector	CJ	8.16	98

Table 13.3. Dummy variables in QMM

Dummy variable	Period equal to one	Equation that dummy variable enters
D001044	2000:Q1-2004:Q4	EXS (5.39)
D021	2002:Q1	IBREG (5.11)
D041	2004:Q1	EXOTH (5.36)
D061084	2006:Q1-2008:Q4	IMPS (5.50)
D0723	2007:Q2-2007:Q3	M3 (4.25)
D08	2008:Q1-2008:Q4	M3 (4.25)
D082	2008:Q2	CPI (7.4)
D084	2008:Q4	M3 (4.25), IMPOTH (5.47), AVH (6.11)
D0824	2008:Q2-2008:Q4	C (5.2)
D084091	2008:Q4-2009:Q1	IBREG (5.11)
D091	2009:Q1	IH (5.16), CJ (8.16)
D0934	1 2009:Q3, -1 2009:Q4	PIG (7.18)
D1123	2011:Q2-2011:Q3	W (6.3)
D1523	2015:Q2-2015:Q3	W (6.3)
D164	2016:Q4	IH (5.16)
D173	2017:Q3	AVH (6.11)
D1734	-1 2017:Q3, 1 2017:Q4	PMALU (7.6)
S091	1 2009:Q1-2014:Q4 and decreases to zero over 20 quarters	IBREG (5.11), IH (5.16)
S093	From: 2009:Q3	EXOTH (5.36)
S131	From: 2013:Q1	C (5.2)
T1316	Linear trend: 2013:Q1-2016:Q4	EXS (5.39)
SIT	Scaled such that SIT x IT gradually declines from 6% to 2.5%.	CPI (7.4)

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
DIR	Director of Internal Revenue	Ríkisskattstjóri
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
TR	Thomson Reuters	-
WB	World Bank	-

Name: ADJ. **Short description:** Adjustment factor to potential output. **Beginning of series:** 1992Q1. **Source:** CBI. **Unit:** Millions of kronas at constant 2005 prices. **Comment:** The adjustment factor is used to incorporate non-model information in the estimation of potential output (5.67).

Name: $ALLOW$. **Short description:** Effective personal allowances. **Beginning of series:** 1992Q1. **Source:** DIR/CBI. **Unit:** Millions of kronas at current prices. **Detailed description:** $ALLOW \times POWA$ is the sum of effective personal allowance ("persónuafsláttur") and various exceptions from the personal income tax in the tax code. To obtain $ALLOW$ this sum is divided by $POWA$. $ALLOW$ is calculated exogenously on an annual basis from data provided by the tax authority (DIR).

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 2003-2018. **Beginning of series:** 1991Q1. **Source:** STATICE/CBI. **Unit:** Weekly working hours. **Comment:** Defined as the average of AVH over the time period 2003-2018.

Name: $AVHT$. **Short description:** Short-run 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, (6.12).

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 1995Q1 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 Iceland's trading partner interest rate. **Beginning of series:** 1990Q1. **Source:** CBI. **Unit:** Fraction. **Detailed description:** This is a factor that makes $BIPD$ consistent with equation (5.56) 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/STATICE. **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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 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 1994:* 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: CFM. **Short description:** Capital flow management measure. **Beginning of series:** 1970Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** A special capital flow management measure. Introduced in June 2016 that entailed a 40% special reserve requirement (SRR) on new inflows of foreign currency for investment in high-yielding deposits and listed bonds and bills issued in krónur. The SSR was lowered to 20% in November 2018 and again lowered in March 2019 to zero.

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 benefits, financial assistance from local government, payment for parental leave, rent reimbursement, child benefits and interest 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 of 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 assistance from local government and payment for parental leave. Before the year 2000 rent reimbursement were taxed with income tax. **Detailed description:** Annual data obtained from the sector accounts (*Disposable income of 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 CJT/CJ).

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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** *Period from 1970 to 1994:* 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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** *Period from 1970 to 1994:* 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:** 1997Q1. **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, investment and export excluding exported aluminium products and ships and airplanes, and is calculated as $DDA = 0.35C + 0.13G + 0.50I + 0.22EXD$.

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. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 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:** STATICE/CBI. **Unit:** Millions of kronas at current

prices (average prices during the period). **ECOTRIM:** StockL Fernandez Par : -.99 to .99. **Detailed description:** *Period from 2003Q4*: Financial debt of households is obtained from yearly data from STATICE financial accounts. Quarterly data produced using ECOTRIM with a quarterly series from CBI as a reference series. *Period from 1991Q4 to 2003Q3:* Financial debt of households is obtained from quarterly data produced by the CBI (credit system, assets, loans and domestic securities holdings, individuals). 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. The two series (before and after 2003Q4) for financial debt of households are linked so that the values before 2003Q4 are increased by the factor between the two estimates for 2003Q4.

Name: DI. **Short description:** General government net 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 employees' 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 employees' 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 2 January 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 (6.13). 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:** Short-run trend total hours. **Beginning of series:** 1991Q4. **Source:** CBI. **Unit:** Short-run trend total hours worked. **Comment:** Defined as $EMPHT = EMPT \times AVHT$.

Name: $EMPT$. **Short description:** Short-run 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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** *Period from 1970 to 1994:* 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 ships and airplanes.

Beginning of series: 1997Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Detailed description:** Nominal quarterly data $EXAIRN$ deflated by PI to obtain export volume of ships and airplanes.

Name: $EXAIRN$. **Short description:** Nominal exports of ships and airplanes. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **Detailed description:** Nominal quarterly export of ships and airplanes in FOB value as computed by STATICE. $EXAIRN$ is forecasted as $EXAIRN = PI \times EXAIR$.

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: EXD. **Short description:** Exports excluding exports of aluminium, ships and airplanes. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Millions of kronas at constant 2005 prices. **Comment:** Defined as $EXD = EX - EXALU - EXAIR$.

Name: EXG. **Short description:** Export volume of goods. **Beginning of series:** 1995Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** Quarterly data available since 1995Q1 from STATICE.

Name: $EXGN$. **Short description:** Nominal exports of goods. **Beginning of series:** 1995Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **Comment:** Quarterly data available since 1995Q1 from STATICE. Defined as $EXGN = EXAIRN + EXALUN + EXMARN + EXOTHN$.

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 marine products 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 marine products 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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 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 1994:* 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 ships and airplanes. **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 ships and airplanes. **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:** 1995Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Detailed description:** Quarterly export of services as calculated by STATICE.

Name: $EXSN$. **Short description:** Nominal exports of services. **Beginning of series:** 1995Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **Comment:** Quarterly data available since 1995Q1 from STATICE. Defined as $EXSN = EXS \times PXS$.

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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation.. **Detailed description:** *Period from 1970 to 1994:* 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:** 1992Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Defined as the deviation of GDP from potential output, given by (5.67).

Name: $GAPAV$. **Short description:** Annual average of output gap. **Beginning of series:** 1992Q4. **Source:** CBI. **Unit:** Fraction. **Comment:** Annual average of GAP defined in equation (5.69).

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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** *Period from 1970 to 1994:* 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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995.

The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 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:** 1992Q1. **Source:** CBI. **Unit:** Millions of kronas at constant 2005 prices. **Comment:** Potential (trend) output calculated from a Cobb-Douglas production function in equation (5.64). **Detailed description:** Potential output is on the one hand estimated from 1992Q1 to 2004Q4 where quarterly trend productivity growth is considered to have been around 0.8%, and on the other hand estimated from 2005Q1 to present day, as the trend growth rate is assumed to have slowed from the mid-2000s.

Name: $GDPTF$. **Short description:** Final estimate of potential output. **Beginning of series:** 1992Q1. **Source:** CBI. **Unit:** Millions of kronas at constant 2005 prices. **Comment:** A weighted average of $GDPT$ and $GDPTX$, with ADJ as an adjustment factor (5.67).

Name: $GDPTX$. **Short description:** Augmented estimate of potential output. **Beginning of series:** 1992Q1. **Source:** CBI. **Unit:** Millions of kronas at constant 2005 prices. **Comment:** Estimate of potential output based on the Cobb-Douglas production function in equation (5.64) using Hodrick-Prescott filtered measure of total factor productivity and two different estimates of trend total hours (5.66).

Name: GFW. **Short description:** Gross financial wealth. **Beginning of series:** 1987Q1. **Source:** STATICE/ISD/DIR/CBI. **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 financial assets of households excluding insurance, pension and standardized guaranteed schemes. **Detailed description:** GFW consists of deposits with banks, equities and other financial assets. *Period from 2003Q4:* Financial assets of households is obtained from yearly data from STATICE financial accounts. Quarterly data for bank deposits obtained using ECOTRIM with a quarterly series on deposits from CBI as a reference series. The CPI is used to transform end-of-quarter data at end-of-quarter prices to average prices during the period. Quarterly data for other financial assets obtained using ECOTRIM without reference 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 montly 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.

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 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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** *Period from 1970 to 1994:* Monthly information on a part of government consumption for 1970 to 1994 is from FIN. To generate quarterly data for 1970-1994, 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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** Quarterly data for the period before 1995Q1 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 1995Q1 using the reference series constructed in (2).

Name: $IBAIR$. **Short description:** Investment in ships and airplanes. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** Quarterly data obtained from STATICE.

Name: $IBAIRN$. **Short description:** Nominal investment in ships and airplanes. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Millions of kronas at current 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. 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.

Name: $IBALUN$. **Short description:** Nominal aluminium sector investment. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **Comment:** Quarterly data obtained from STATICE.

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. **Comment:** Regular business investment

excludes investment in energy-intensive industry and in ships and airplanes. **Detailed description:** Quarterly data before 1997Q1 is obtained as a residual series according to $IBREG = IBUS - IBALU - IBAIR$.

Name: $IBREGN$. **Short description:** Nominal regular business investment. **Beginning of series:** 1997Q1. **Source:** STATICE/CBI. **Unit:** Millions of kronas at current prices. **Comment:** Nominal regular business investment excludes nominal investment in energy-intensive industry and ships and airplanes. **Detailed description:** Quarterly data is obtained as a residual series according to $IBREGN = IBUSN - IBALUN - IBAIRN$.

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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** Quarterly data for the period before 1995Q1 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 1995Q1 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. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in

the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** Quarterly data for the period before 1995Q1 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 1995Q1 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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** Before 1995 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 $IGN_t - PIG_t \times DELTAG_t \times (K_{t-1} - KH_{t-1} - KBUS_{t-1})$ (5.19). **Detailed description:** *Period from 1990 to 2005:* 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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** Quarterly data for the period before 1995Q1 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 quar-

terly data from annual data before 1995Q1 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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** Before 1995 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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** Prior to 1995 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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** Prior to 1995, 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. **Be-**

ginning 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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** *Period from 1970 to 1994:* 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 ships and airplanes. **Beginning of series:** 1997Q1. **Source:** STATICE/CBI. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** Nominal quarterly data $IMPAIRN$ deflated by PI to obtain import volume of ships and airplanes.

Name: $IMPAIRN$. **Short description:** Nominal imports of ships and airplanes. **Beginning of series:** 1997Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **Comment:** Nominal quarterly import of ships and airplanes in FOB value as computed by STATICE. $IMPAIRN$ is forecasted as $IMPAIRN = PI \times IMPAIR$.

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:** 1995Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** Quarterly data available since 1995Q1 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 1995Q1 from STATICE. Defined as $IMPGN = IMPAIRN + IMPALUN + IMPOTHN$.

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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** Imported goods and services from 1978 to 1994 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:** 1995Q1. **Source:** STATICE. **Unit:** Chain-volume measure. Millions of kronas at constant 2005 prices. **Comment:** Quarterly data available since 1995Q1 from STATICE.

Name: $IMPSN$. **Short description:** Nominal imports of services. **Beginning of series:** 1995Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **Comment:** Quarterly data available since 1995Q1 from STATICE.

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 1995Q1 from STATICE. With the implementation of the new standard ESA2010 by STATICE in September 2014 the time series was revised back to 1997. In May 2019 the time series was revised back to 1995, causing a structural break in the time series between 1994 and 1995. The break is corrected by adjusting the level of data before 1995 so that the annual change in 1995 is the same as was before the new standard implementation. **Detailed description:** Before 1995 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 (7.26).

Name: $INFE10$. **Short description:** 10-year break-even inflation expectations. **Beginning of series:** 2001Q1. **Source:** CBI. **Unit:** Fraction. **Detailed description:** Historical data obtained as $(1+RL10)/((1+RLV10)\times(1+PRISK))-1$. Forecasted data obtained using model consistent expectations, cf. (7.31).

Name: $INFE5$. **Short description:** 5-year break-even inflation expectations. **Beginning of series:** 1994Q1. **Source:** CBI. **Unit:** Fraction. **Detailed description:** Historical data obtained as $(1 + RL5)/((1 + RLV5) \times (1 + PRISK)) - 1$. Forecasted data obtained using model consistent expectations, cf. (7.30).

Name: $INFQ$. **Short description:** Quarterly CPI inflation rate. **Beginning of series:** 1970Q2. **Source:** CBI. **Unit:** Fraction. **Comment:** Variable defined in equation (7.24).

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 (7.25).

Name: $INFULQ$. **Short description:** Underlying quarterly CPI inflation rate. **Beginning of series:** 1970Q2. **Source:** CBI. **Unit:** Fraction. **Comment:** Variable defined in equation (7.23).

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's 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:** 1998Q1. **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. **Beginning of series:** 1991Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Time-varying NAIRU estimated using the Kalman filter. For a detailed discussion see Einarsson and Sigurdsson (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:** From 2003Q1 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:** Short-run trend participation rate. **Beginning of series:** 1991Q4. **Source:** STATICE. **Unit:** Fraction. **Comment:** Calculated as a four-quarter moving average of PA, (6.10).

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:** 1970Q1. **Source:** WB. **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 price 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 price 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:** 1995Q1. **Source:** STATICE. **Unit:** Index. **Detailed description:** Defined as $PMS = IMPSN/IMPS$.

Name: $POIL$. **Short description:** Oil prices in USD. **Beginning of series:** 1979Q1. **Source:** TR/WB. **Unit:** Index, 2005 = 1. **Comment:** Petroleum (Brent spot price), US$ per barrel, obtained from TR. The index is normalised so that the average index of the quarters of year 2005 equals 1. **Detailed description:** For the time period 1979 to 1988, the time series is extended with data from WB (crude oil, Brent).

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%.

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 moving average labour productivity defined in equation (6.18).

Name: $PRODTL$. **Short description:** Long-term trend labour productivity. **Beginning of series:** 1993Q4. **Source:** CBI. **Unit:** Fraction. **Comment:** Three-year moving average labour productivity defined in equation (6.19).

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:** 1995Q1. **Source:** STATICE. **Unit:** Index. **Detailed description:** Defined as $PXS = EXSN/EXS$.

Name: $QDGDPT$. **Short description:** Quarterly trend GDP growth rate. **Beginning of series:** 1992Q1. **Source:** CBI. **Unit:** A fixed value. **Detailed description:** Defined as $QDGDPT_t = (1+1\%)^{(1/4)} \times \exp(0.004126) - 1 = 0.7\%$. *Period from 1992Q1 to 2004Q4:* Defined as $QDGDPT_t = (1+1\%)^{(1/4)} \times \exp(0.008499) - 1 = 1.1\%$.

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 (4.11).

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. The employees contribution to the pension funds is included here. Alternatively this contribution could be included in the income tax (TJY) as it is compulsory it is not part of households' disposable income, but this would complicate the formulas for the government budget. 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 (4.32) 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 (4.33) 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 (4.19).

Name: $REXEQ$. **Short description:** Equilibrium real exchange rate. **Source:** CBI. **Unit:** Fraction. **Comment:** The balanced growth version of QMM described in Daníelsson (2009) has been used to estimate the real exchange rate that ensures an external balance which keeps net foreign assets (adjusted for the calculated revenues and expenses of the failed financial institutions for 2008-2015 and the pharmaceuticals company Actavis 2009-2012) as a share of GDP constant on the balanced growth path. The estimated $REXEQ$ from the balanced growth version is outlier filtered and smoothed by using a Hodrick-Prescott filter.

Name: $REXM$. **Short description:** Importers' real exchange rate. **Beginning of series:** 1970Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Defined as $REXM = PM/PGDP$.

Name: $REXW$. **Short description:** Real exchange rate given relative unit labour costs. **Beginning of series:** 1991Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Historical data defined as $REXW = ULC/(EER \times WULC)$ and forecasted data obtained from equation (4.20).

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 (4.12).

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 effective income tax rate. **Beginning of series:** 1992Q1. **Source:** STATICE/CBI. **Unit:** Fraction. **Detailed description:** RJY is a proxy of the weighted average effective tax rate of the official marginal tax rates. It is also affected by some differences between the definitions of taxable income by the tax authorities and the national accounts. In the historical database RJY is the solution to this equation for the personal income tax (TJY): $TJY = RJY \times (YE \times (1 - DPENS) + CJT + YICT + UNPM + SPENS) - ALLOW \times POWA$. In forecasts and simulations RJY is exogenous.

Name: $RL10$. **Short description:** 10-year interest rate. **Beginning of series:** 2001Q1. **Source:** CBI/OMX. **Unit:** Fraction. **Detailed description:** 10 year interest rate is estimated from bond market yields using the Nelson-Siegel approach on bid yields on the Icelandic Stock Exchange (ICEX)/Nasdaq OMX.

Name: $RL5$. **Short description:** 5-year interest rate. **Beginning of series:** 1994Q1. **Source:** CBI/OMX. **Unit:** Fraction. **Detailed description:** In 1994Q1-1997Q4 bid yields on RB00-1010 Treasury notes and in 1998Q1-2000Q1 bid yields on

RB03-1010 Treasury notes. Before 1996 Treasury notes were quoted by the Central Bank, but from 1996 the yields are bid quotes from Icelandic Stock Exchange (ICEX). From 2001Q2 and onwards the series is a 5 year interest rate estimated from bond market yields using the Nelson-Siegel approach on bid yields on the Icelandic Stock Exchange (ICEX)/Nasdaq OMX.

Name: $RLV10$. **Short description:** 10-year indexed interest rate. **Beginning of series:** 1987Q3. **Source:** CBI/OMX. **Unit:** Fraction. **Detailed description:** In 1987Q3-1995Q4 average of monthly data for Government Bonds (Spariskírteini Ríkisjóðs) with around 10 years to maturity. Government bonds were quoted by the Central Bank until end of 1995, but from 1996 the yields are bid quotes from Icelandic Stock Exchange (ICEX). From 2000Q4 a 10 year indexed interest rates is estimated from bond market indexed yields using the Nelson-Siegel approach on bid yields from the Icelandic Stock Exchange (ICEX)/Nasdaq OMX.

Name: $RLV5$. **Short description:** 5-year indexed interest rate. **Beginning of series:** 1980Q1. **Source:** CBI/OMX. **Unit:** Fraction. **Detailed description:** Data for 1980-1987 are chain linked from Economic Statistics published by the CBI. A break in the data (1984Q4) is interpolated. In 1987Q4-2000Q3 are average of monthly data for Government bonds (Spariskírteini Ríkissjóðs) with around 5 years to maturity. Government bonds were quoted by the Central Bank until end of 1995, but from 1996 the yields are bid quotes from Icelandic Stock Exchange (ICEX). From 2000Q4 a 5 year indexed interest rates is estimated from bond market indexed yields using the Nelson-Siegel approach on bid yields from the Icelandic Stock Exchange (ICEX)/Nasdaq OMX.

Name: $RLVH$. **Short description:** Long-term indexed mortgage rate. **Beginning of series:** 2001Q1. **Source:** CBI. **Unit:** Fraction. **Detailed description:** Weighted lowest registered fixed indexed rates offered for owner occupied housing lending. In 2001Q1-2004Q2 only mortgage rates offer by the Housing Finance Fund (HFF). From 2004Q3 it is weighted mortgage rates offered by the HFF, three banks (Arion, Íslandsbanki and Landsbanki) and seven pension funds (from 2004 Almenna lsj., Gildi lsj., Lsj. Verslunarmanna and Söfnunarsjóður lífeyrisréttinda and from 2010 also Festa lsj., Frjálsi lsj. and Lsj. starfsmanna ríkisins). Average rates within each group is a simple average but each group is weighted according to share in total mortgage lending. The HFF mortgage rates include a pay-up fee from 2005Q4, but no pay-up fee is included before that time.

Name: RRN. **Short description:** Real neutral interest rate. **Source:** CBI. **Unit:** Fraction. **Comment:** Currently fixed and equal to 2.0%. 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 data from 1987 to 1993 and quarterly averages of daily data from

1993 onwards. **Detailed description:** Central Bank of Iceland monetary policy rate is defined as follows: Before March 1998 the interest rate on tap sales is used. From March 1998 until 31 March 2009 the 7-day collateralised lending rate is used (14-day from March 1998 to May 2004), from 1 April 2009 to 30 September 2009 the rate on deposit institutions' current accounts with the Central Bank, from 1 October 2009 to 20 May 2014 the average of the current account rate and the rate on 28-day certificates of deposit, from 21 May 2014 and onwards the rate on 7-day term deposits is used.

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: $RVAT$. **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 were temporary allowed for people under 60 years old which took effect after the financial crisis of 2008. **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.

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 sub-

sidies, i.e. net production subsidies and capital transfers of government income from assets, dividends and rent. The income 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: $TERM10$. **Short description:** Term premium for 10-year interest rates. **Source:** CBI. **Unit:** Fraction. **Comment:** Currently fixed and set equal to 0.6%.

Name: $TERM5$. **Short description:** Term premium for 5-year interest rates. **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 of 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: TOT. **Short description:** Terms of trade. **Beginning of series:** 1970Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Defined as $TOT = PX/PM$.

Name: $TRADE$. **Short description:** Iceland's trading partner imports. **Beginning of series:** 1970Q1. **Source:** OECD/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 was included in the group of Iceland's main trading partners in 2007 and Brazil in 2012 according to the weights of currencies in the exchange rate index. 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: $URSA$. **Short description:** Seasonally adjusted unemployment rate. **Beginning of series:** 1991Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Seasonally adjusted unemployment rate is given by (6.8). The seasonal scaling factors for $URSA$ are found by using seasonal adjustment moving average method.

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:** Iceland's trading partner 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 was included in the group of Iceland's main trading partners in 2007 and Brazil in 2012 according to the weights of currencies in the exchange rate index. 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:** TR. **Unit:** Index, 2005 = 1. **Comment:** Morgan Stanley Capital International (MSCI) World index from TR. The index is normalised so that the average of the quarters of year 2005 equals 1.

Name: $WGDP$. **Short description:** Iceland's trading partner 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 was included in the group of Iceland's main trading partners in 2007 and Brazil in 2012 according to the weights of currencies in the exchange rate index. 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:** Iceland's trading partner four-quarter inflation rate. **Beginning of series:** 1971Q1. **Source:** CBI. **Unit:** Fraction. **Comment:** Variable defined in equation (7.27).

Name: WPX. **Short description:** Iceland's trading partner 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 was included in the group of Iceland's main trading partners in 2007 and Brazil in 2012 according to the weights of currencies in the exchange rate index. 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:** Iceland's trading partner short-term interest rates. **Beginning of series:** 1970Q1. **Source:** TR/CBI. **Unit:** Fraction. **Comment:** Trade weighted foreign policy rates in 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: $WULC$. **Short description:** Iceland's trading partner unit labour costs. **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 average of unit labour costs in Iceland's main trading partners, i.e. Canada, Denmark, Euro area, Japan, Norway, Sweden, Switzerland, UK and US. China was included in the group of Iceland's main trading partners in 2007 and Brazil in 2012 according to the weights of currencies in the exchange rate index. 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:** Households' net financial income. **Beginning of series:** 1994Q1. **Source:** STATICE. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow Boot, Feibes and Lisman - FD. **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 ex-

change denominated loans the interest cost in Icelandic kronas is included. **Detailed description:** Quarterly data obtained with ECOTRIM.

Name: YE. **Short description:** Wages, salaries and self-employed income. **Beginning of series:** 1980Q1. **Source:** STATICE/DIR. **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 of 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. *Period from 1980 to 1993:* Annual data on income from wages and saleries are from the National Accounts. Data on self-employed income are from DIR. STATICE's estimates of income from home-ownership and the statistical discrepancy between the estimates of the GDP from the production side and from the expenditure side are included.

Name: YIC. **Short description:** Households' other income. **Beginning of series:** 1980Q1. **Source:** STATICE/DIR. **Unit:** Millions of kronas at current prices. **ECOTRIM:** Flow AR(1) Max Log Par : -.99 to .99. **Detailed description:** Includes payments from pension funds and insurance claims. Annual data available from STATICE from the sector accounts, i.e. *Disposable income of the household sector*. Quarterly data obtained with ECOTRIM using YE as a reference series. *Period from 1980 to 1993:* Annual data obtained from DIR.

Name: $YICT$. **Short description:** Households' other income subject to taxation. **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 $YICT/YIC$).

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 $YJ = YE \times (1 - DPENS) + CJ + UNPM + YIC + YDIJ + SPENS$.

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