



Seðlabanki Íslands

Central Bank of Iceland's macromodel Revision with model consistent expectations

Ásgeir Daníelsson, Ásgerdur Ó. Pétursdóttir,
Magnús F. Gudmundsson, Rósa Sveinsdóttir, Svava J. Haraldsdóttir,
Thorvardur Tjörvi Ólafsson og Thórarinn G. Pétursson

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Introduction

QMM



- Handbook, database and necessary model files available at the Bank's homepage
- Several institutes analysing the Icelandic economy have started using the model
 - Ministry of Finance, Landsbanki, ASÍ and IMF
- A balanced-growth compatible version of QMM is currently under construction and will be available shortly

QMM



- New version of QMM
 - Re-estimation with additional data from 2005-6
 - Revisions and updates
 - Forward-looking (model consistent) expectations
- Although the new version includes rational expectations a version with backward-looking (adaptive) expectations is also included in the handbook



Overview of QMM structure



QMM: Structure and size

- QMM is basically an empirically estimated error-correction model
 - Structure, explanatory variables and model properties are, however, not only based on empirical fit but also on the overall structure and properties of the model
- **Number of variables: 152**
 - Endogenous variables: 107
 - Behavioural (30), technical (22), definitions (29) og identities (26)
 - Exogenous variables: 45
- **QMM database**
 - Quarterly data from 1990 for almost all variables and stretching back to the early 1970s for almost half of the variables

QMM: Level of aggregation



- QMM is a relatively simple, medium sized model of the Icelandic economy
 - Highly aggregated but sufficiently detailed to describe the most important parts of the macrostructure of the economy
 - Simple enough to manage the model and its database and to have sufficient understanding of its short and long-run properties
 - A drawback is that information of the finer details of the economy is lost
 - For the Central Bank, however, the key importance is that the model describes the main transmission channels of monetary policy in line with modern macroeconomic literature and research



QMM: Main sectors

- Financial system
 - Interest rates, asset prices and wealth
- Demand and production
 - Expenditure, net trade and potential output
- Labour market
 - Wages, productivity and employment
- Price setting
 - Prices of different expenditure items and inflation
- Public sector
 - Taxes, expenditure and net borrowing
- Household income accounts



Monetary policy in QMM



The monetary policy rule in QMM

- QMM assumes that monetary policy of the Central Bank is set in terms of a forward-looking Taylor rule
- The rule and its parameters were chosen from a large set of alternative policy rules
 - Chosen such as to minimise the variability of inflation and output

$$RS_t = 0.6RS_{t-1} + 0.4[(RRN_t + IT_t) + 1.5(INF_{t+4} - IT_t) + 0.5GAPAV_t]$$

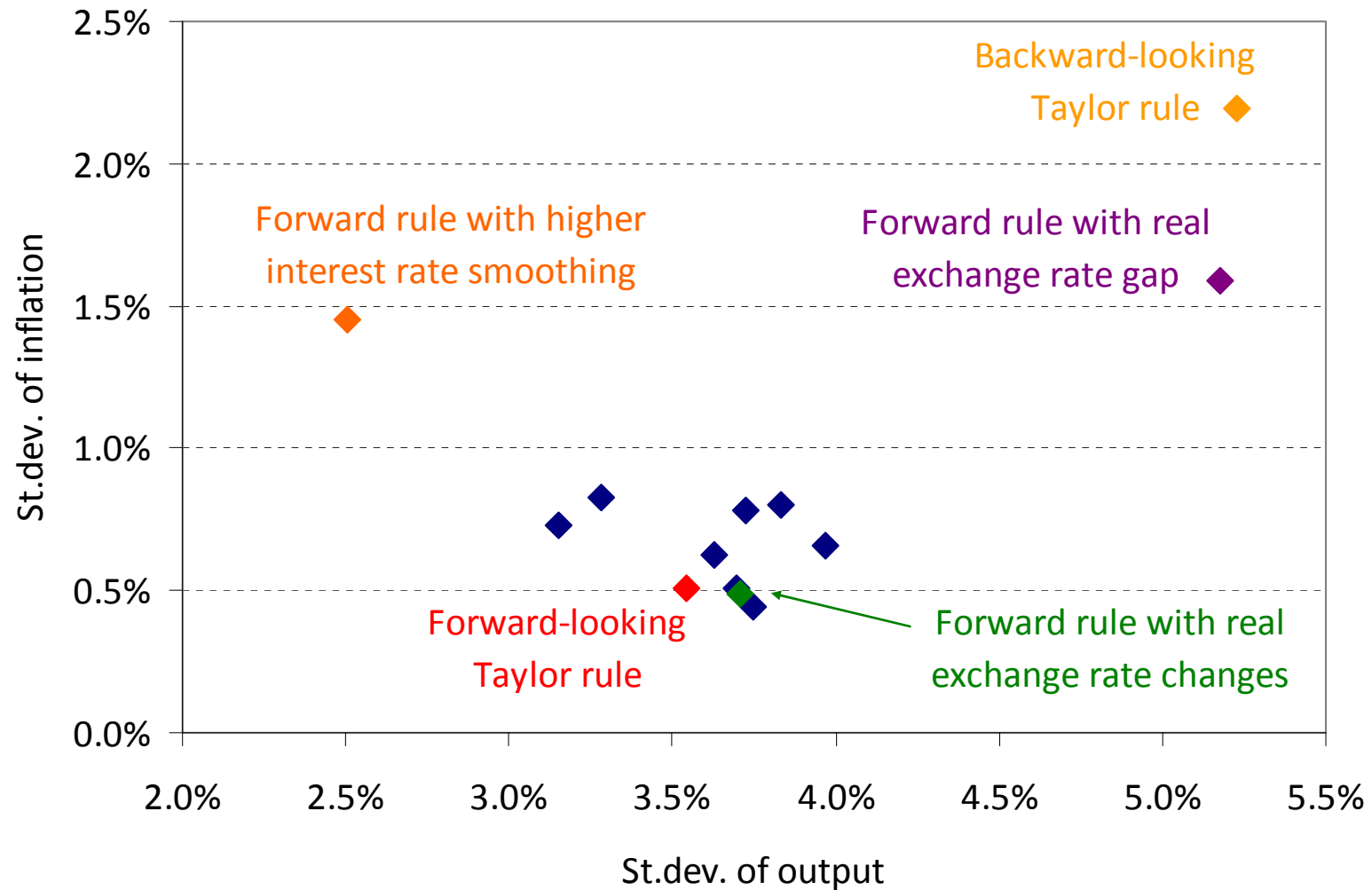
where:

<i>RS</i>	Short-term interest rate (4.1).
<i>RRN</i>	Real neutral interest rate (exogenous).
<i>IT</i>	Central Bank of Iceland 2.5% inflation target (exogenous).
<i>INF</i>	Four-quarter CPI inflation rate (7.15).
<i>GAPAV</i>	Annual average of output gap (5.44).

New policy rule improves trade-off



Inflation-output volatility trade-off





Other main changes in QMM



Long-term interest rates in QMM

- Long-term interest rates are determined by the expectations hypothesis but allowing the long rate to move more closely with the current short rate than is consistent with theory

$$RL_t = \frac{0.189}{(2195.5)}(RS_t + TERM_t) + (1 - 0.189) [RL_{t+1} + (RS_t - RS_{t+20})/20 + (TERM_{t+1} - TERM_t)] \quad (4.5)$$

Estimation method	GMM
Adjusted R^2	0.842
Equation standard error	0.58%
Coefficient restrictions (F -test)	0.00 [0.99]
J -test for over-identifying restrictions (χ^2 -test)	6.03 [0.74]
Normality test (χ^2 -test)	1.02 [0.60]
Sample period	1998:Q1-2003:Q4 ($T = 24$)

$$RL_t = 0.189RS_t + (1 - 0.189) \sum_{j=0}^{19} RS_{t+j}/20 + TERM_t$$



Long-term interest rates in QMM

- Long-term real interest rates are given by the Fisher relation

$$RLV_t = (RL_t - INFE_t) - PRISK_t$$

- Long-term inflation expectations (break-even inflation expectations) are given as the expected inflation rate over the next 5 years

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



Exchange rates in QMM

- The real exchange rate is given by the UIP relation where the real exchange rate depends on its expected value and the risk-adjusted real interest rate differential
 - But allows for backward-looking expectations by some investors

$$rex_t = \alpha_{rex} rex_{t-1} + \beta_{rex} rex_{t+1}^e + (1 - \alpha_{rex} - \beta_{rex}) rexeq_t + rid_t$$

$$rex_{t+1}^e = \gamma_{rex} rex_{t-1} + \phi_{rex} rex_{t+1} + (1 - \gamma_{rex} - \phi_{rex}) rexeq_t$$

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



Exchange rates in QMM

$$(rex_t - rexeq_t) = \underset{(5.7)}{0.552}(rex_{t-1} - rexeq_t) + \underset{(4.8)}{0.435}(rex_{t+1} - rexeq_t) + rid_t \quad (4.16)$$

Estimation method	GMM
Adjusted R^2	0.904
Equation standard error	2.67%
Coefficient restrictions (F -test)	0.05 [0.83]
J -test for over-identifying restrictions (χ^2 -test)	1.73 [0.42]
Normality test (χ^2 -test)	16.7 [0.00]
Sample period	1997:Q1-2007:Q4 ($T = 44$)

- The nominal exchange rate is then derived from the real exchange rate and relative price levels



Inflation in QMM

- Year-on-year inflation is determined by a forward-looking Phillips curve
 - Allows for backward-looking expectations by some agents and short-run supply shocks from the real exchange rate and real unit labour costs

$$\begin{aligned} \Delta_4 cpi_t = & \underset{(13.8)}{0.625} \Delta_4 cpi_{t-1} + \underset{(3.8)}{0.178} \Delta_4 cpi_{t+8} & (7.1) \\ & + (1 - 0.625 - 0.178) \log(1 + IT_t) + \underset{(3.8)}{0.111} \Delta_4 rexm_{t-1} \\ & + \underset{(2.4)}{0.077} \Delta_4 (ulct_{t-4} - cpi_{t-4}) + \underset{(2.6)}{0.083} GAPAV_{t-1} \end{aligned}$$

Estimation method	GMM
Adjusted R^2	0.883
Equation standard error	0.69%
Dynamic homogeneity (F -test)	1.17 [0.29]
J -test for over-identifying restrictions (χ^2 -test)	1.26 [0.26]
Normality test (χ^2 -test)	0.18 [0.91]
Sample period	1994:Q1-2006:Q3 ($T = 51$)

Other changes in QMM

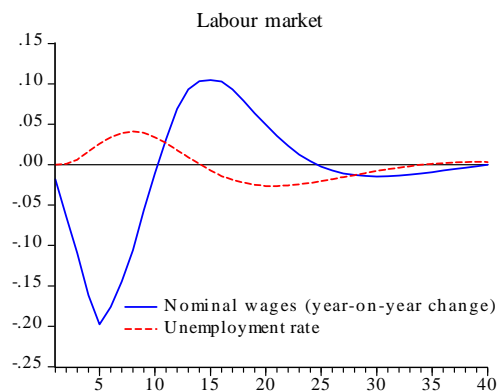
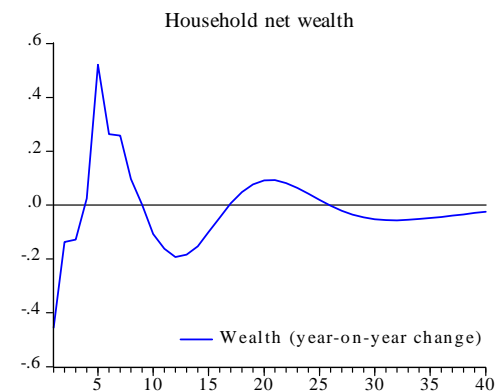
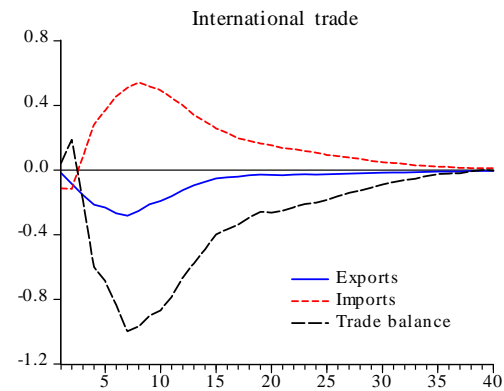
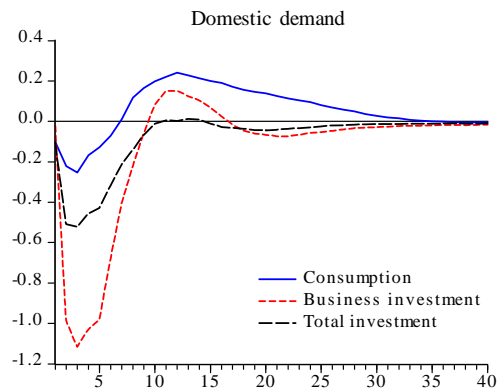
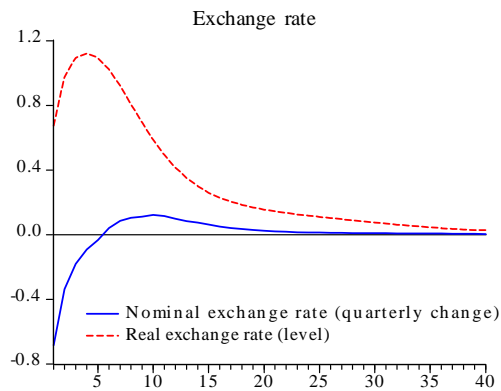
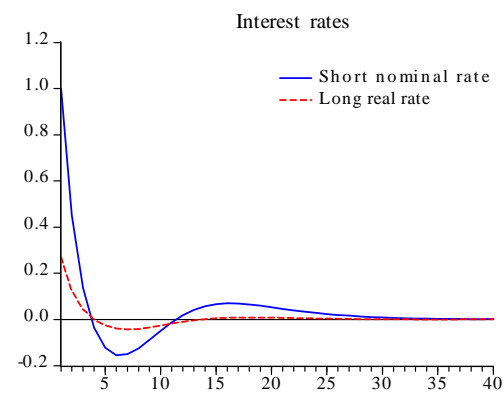
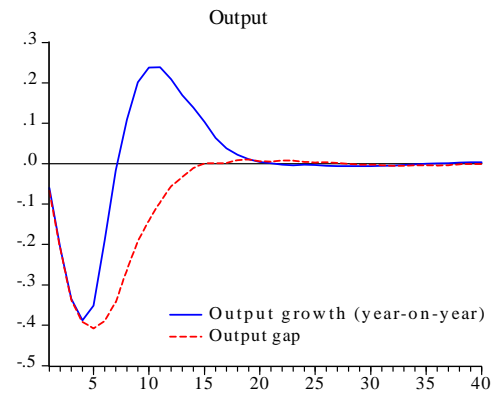
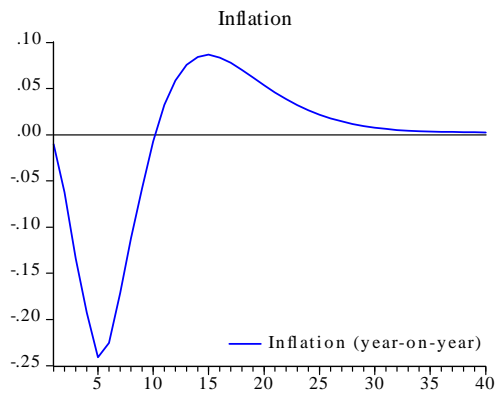


- All empirical equations have been re-estimated with data up to 2006
 - The consumption equation uses new data on disposable income from Statistics Iceland instead of the previous in-house version
 - No other major changes to empirical equations
 - A number of equations have, however, been revised to improve the overall properties of the model – especially to reduce the number of imaginary roots in the system and the resulting oscillatory behaviour found in previous versions
- A number of technical relations have been revised in light of new data



Model properties

Monetary policy shock



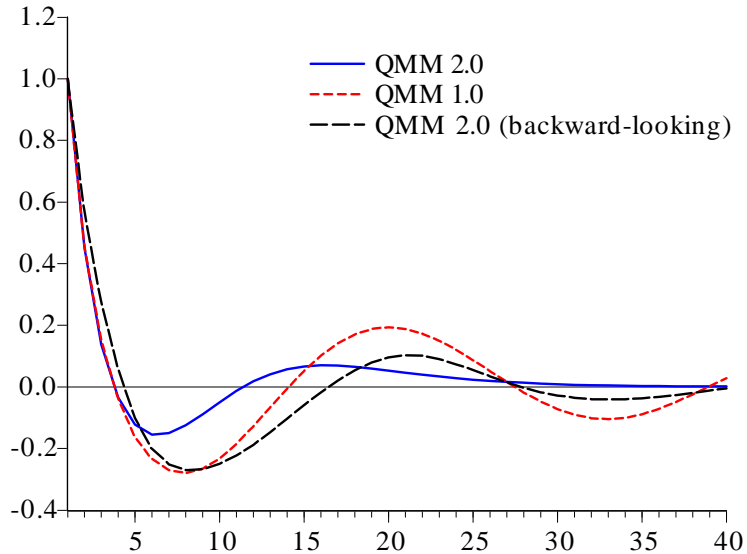
Monetary policy shock:

Unanticipated 1% rise in policy rate for 1 quarter; but follows Taylor rule after that

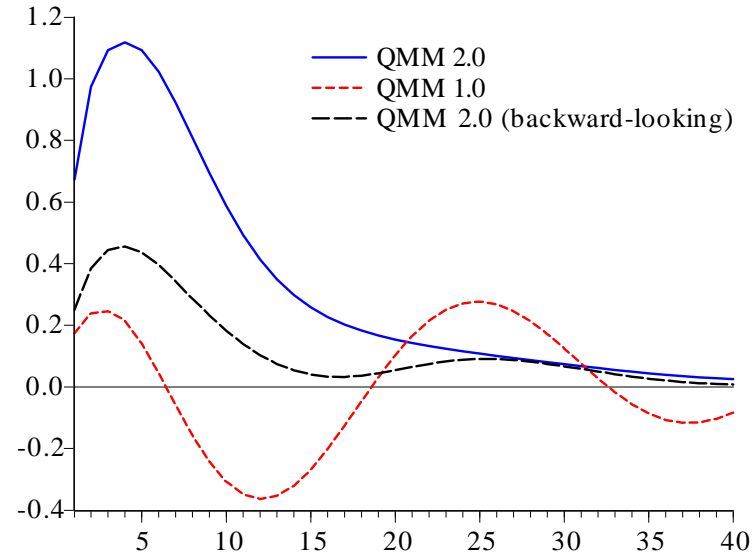
Comparison of policy shock in QMM 1.0



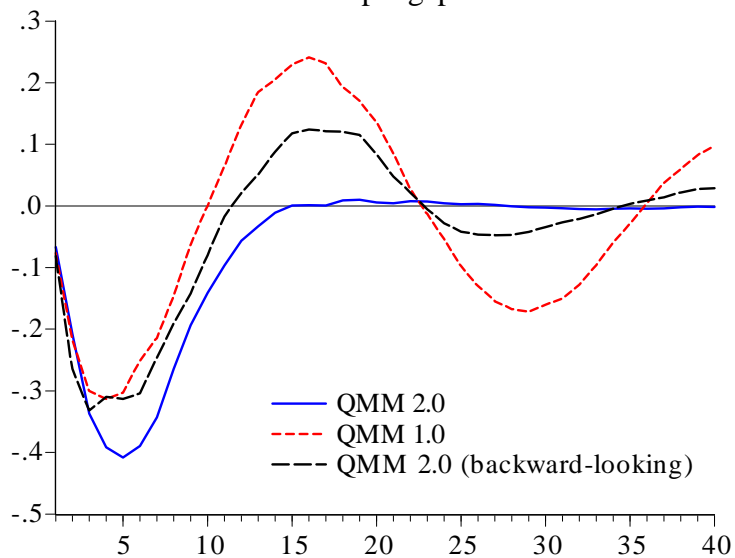
Short-term nominal interest rate



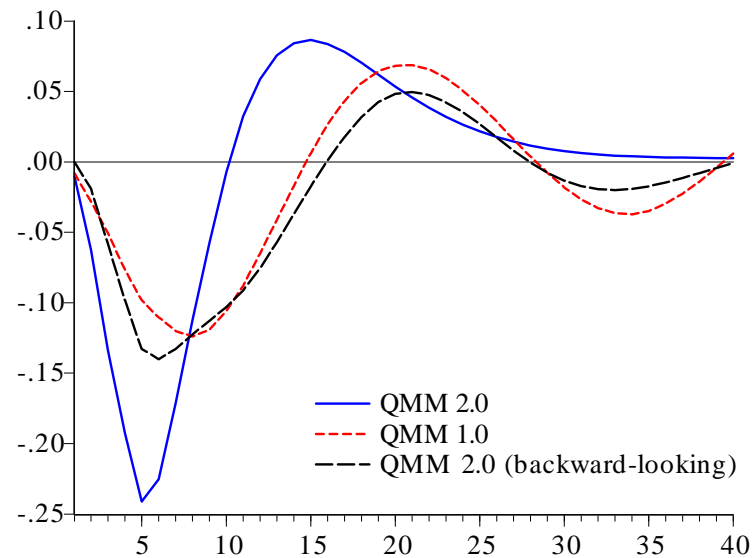
Real exchange rate



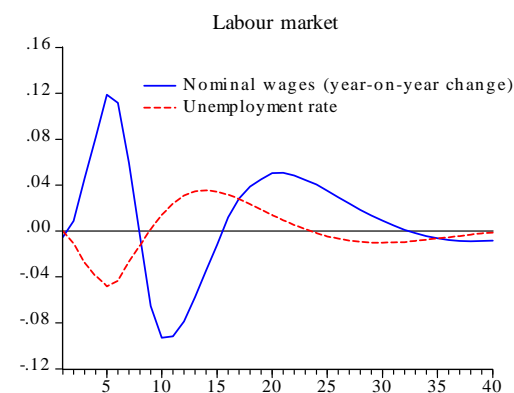
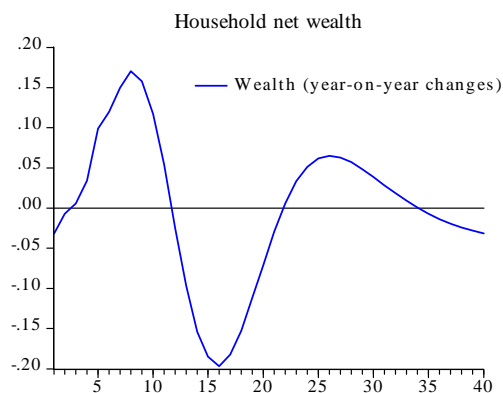
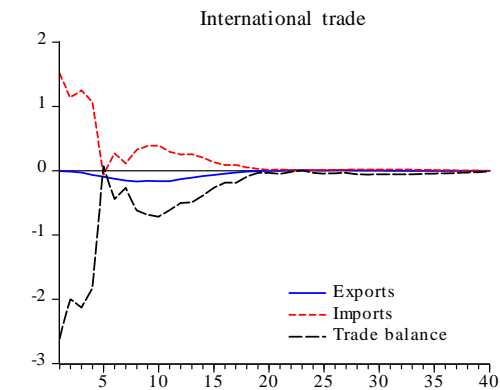
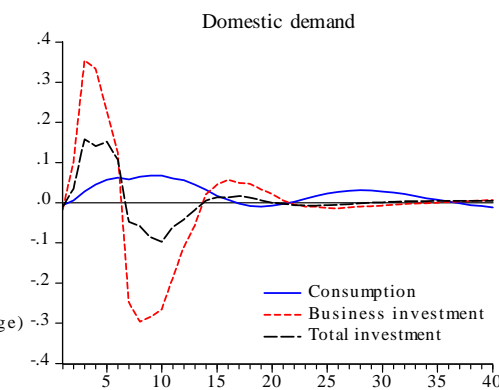
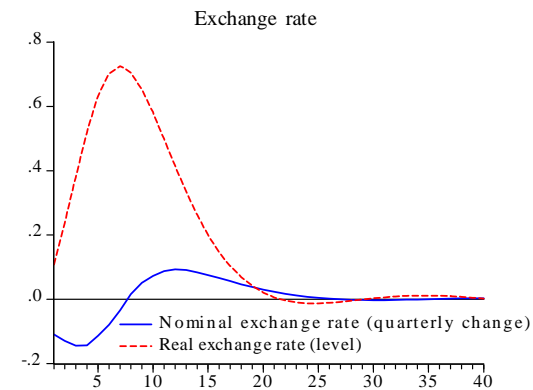
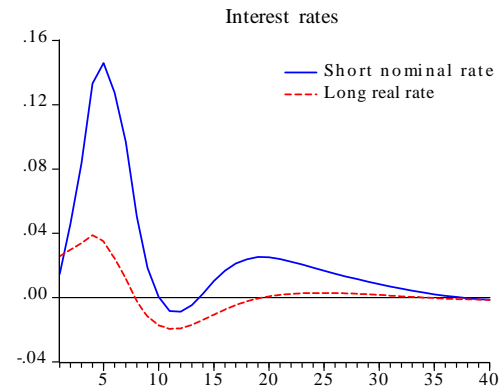
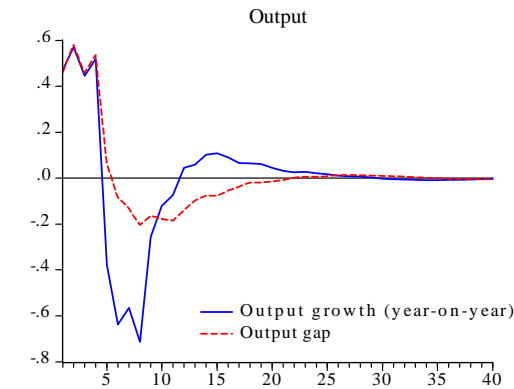
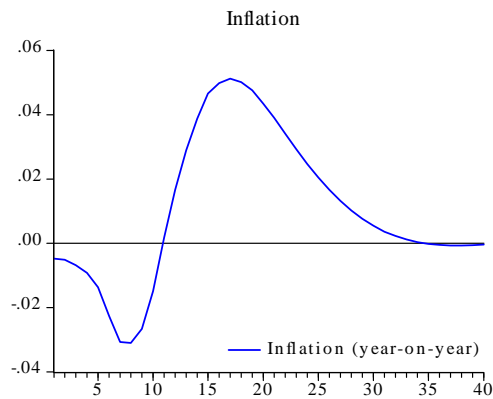
Output gap



Inflation



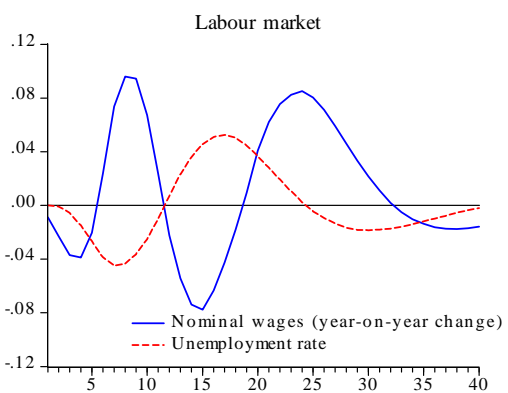
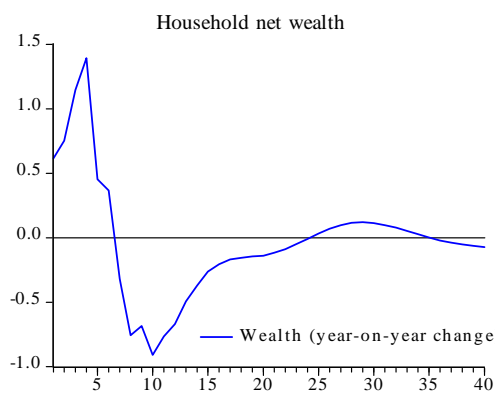
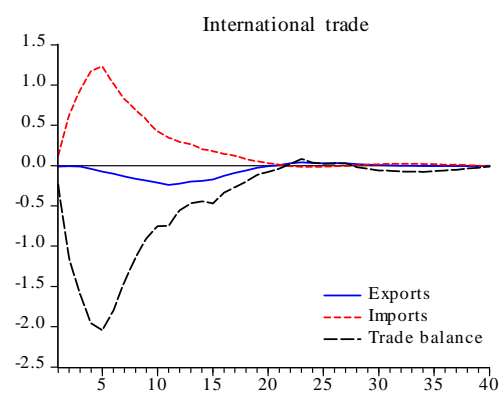
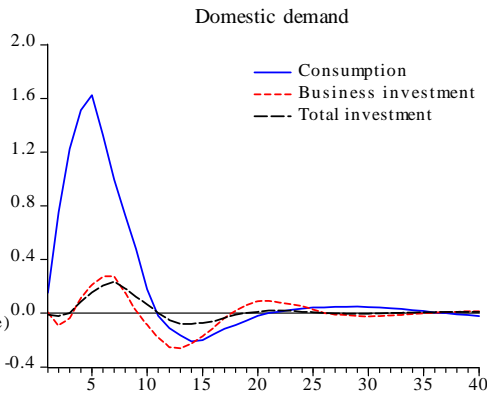
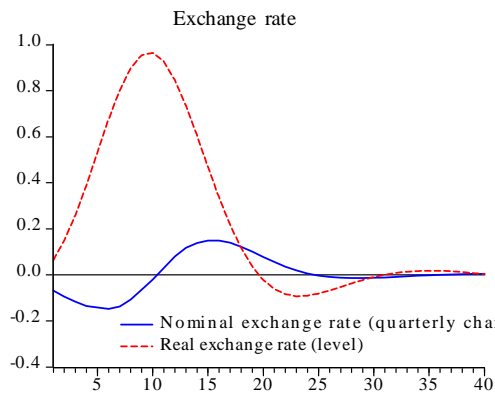
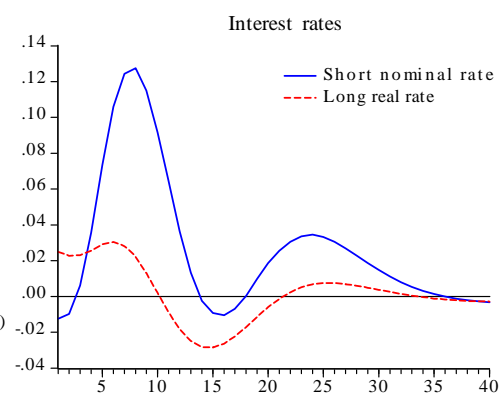
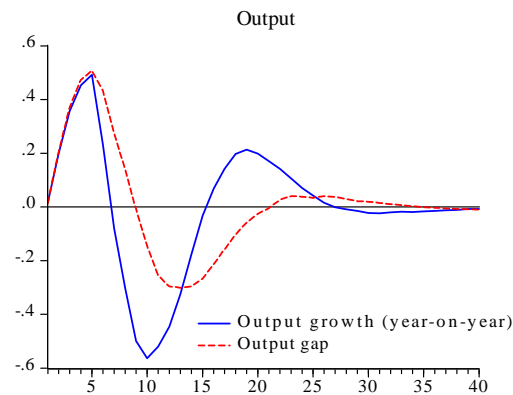
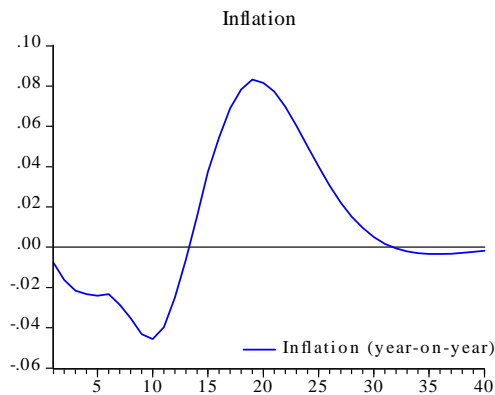
Government expenditure shock



Government expenditure shock:
Unanticipated rise government consumption equivalent to 1% of nominal GDP for 1 year



Income tax shock



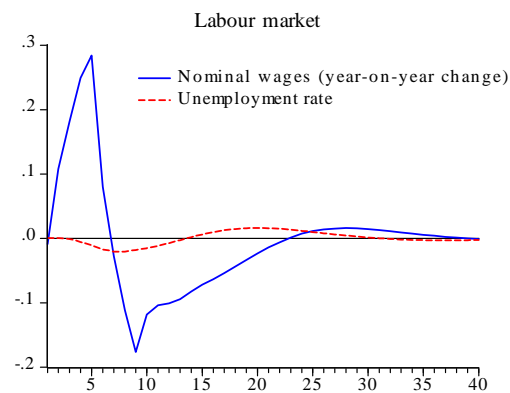
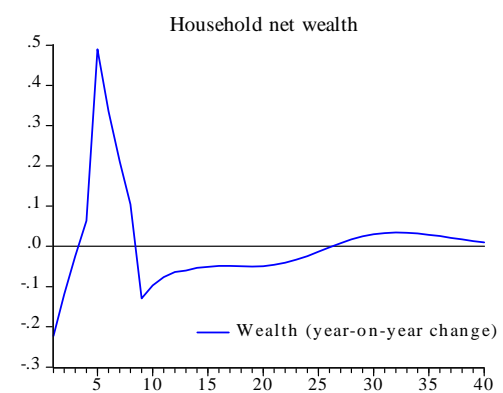
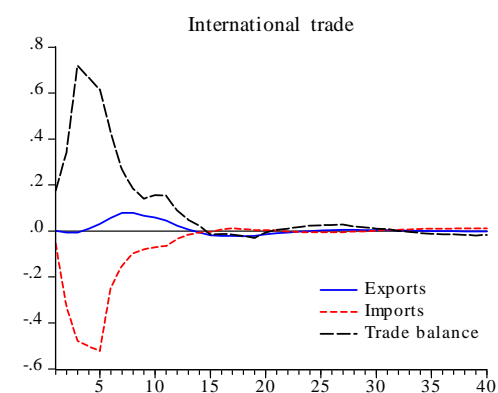
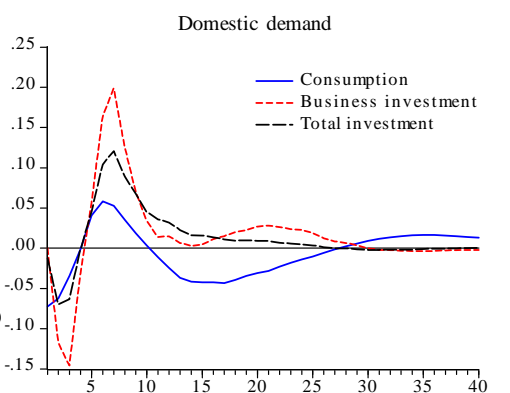
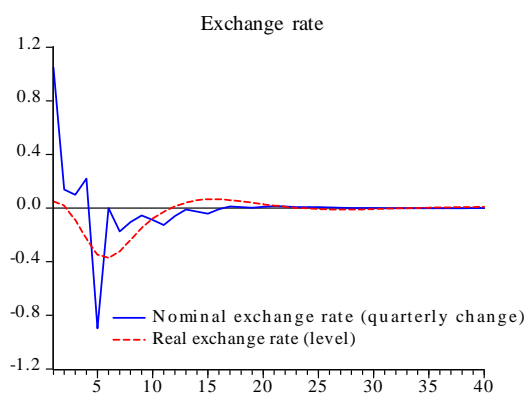
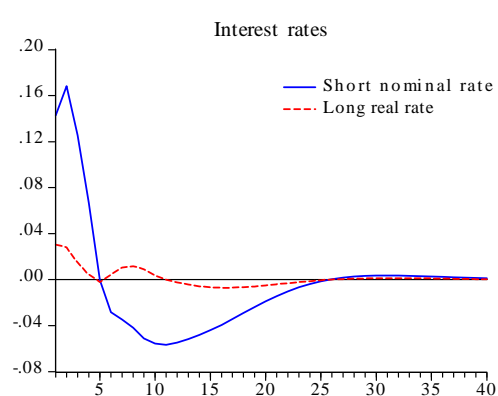
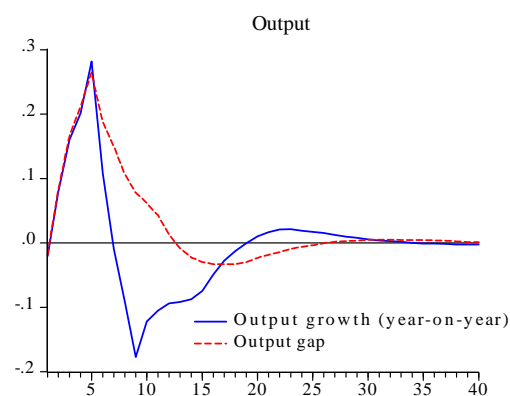
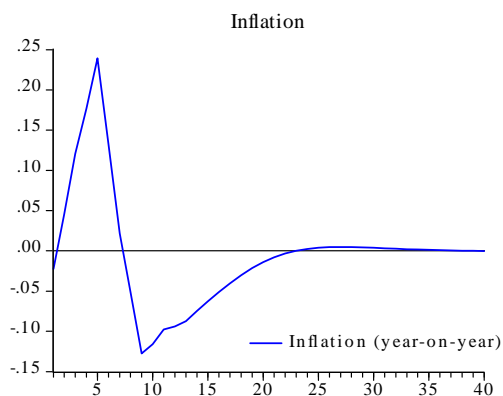
Income tax shock:

Unanticipated fall in income tax rate equivalent to 1% of nominal GDP for 1 year

Amounts to a $1\frac{2}{3}\%$ cut in tax rate



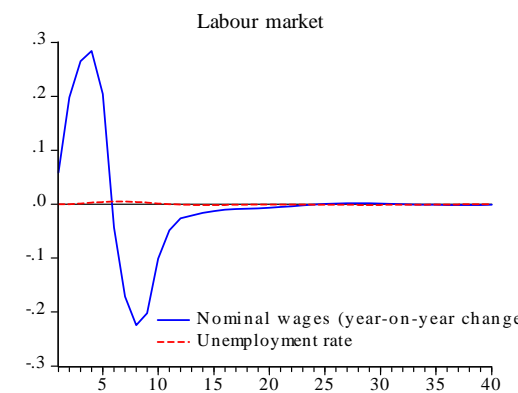
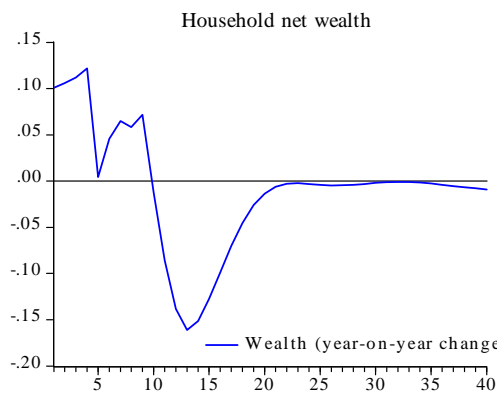
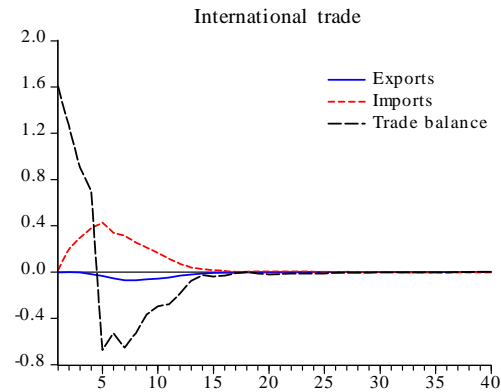
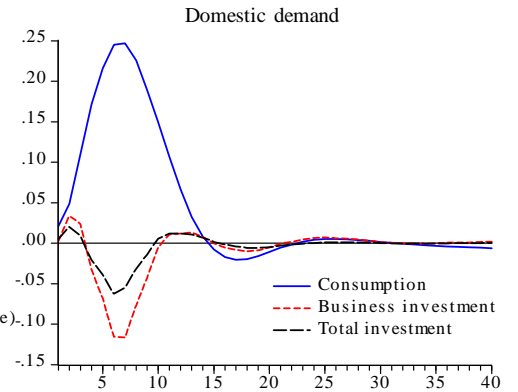
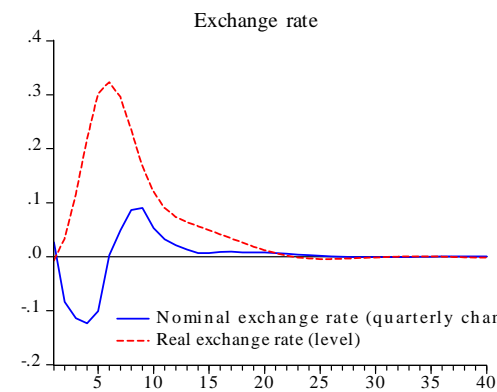
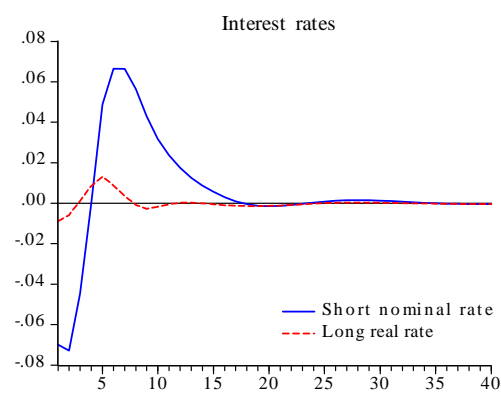
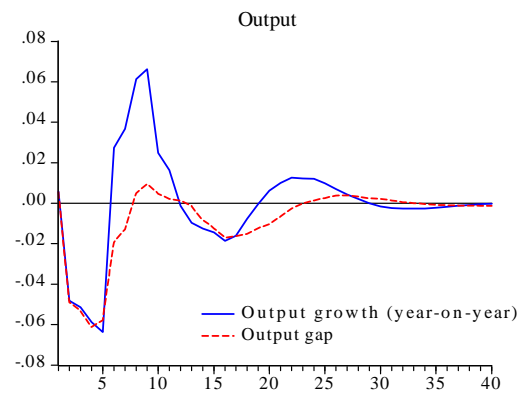
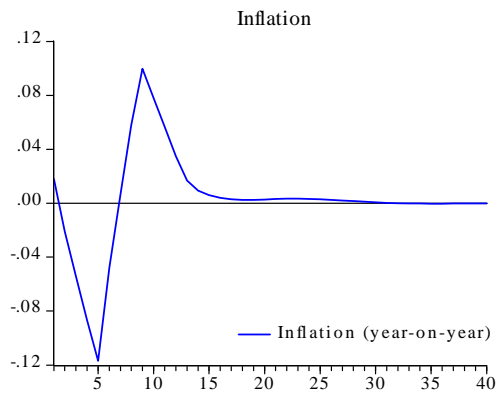
Exchange rate shock



Exchange rate shock:

Unanticipated 1% depreciation of nominal exchange rate that lasts for 1 year driven by a rise in the currency risk premium

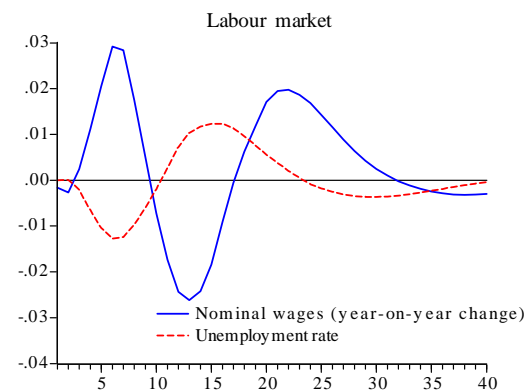
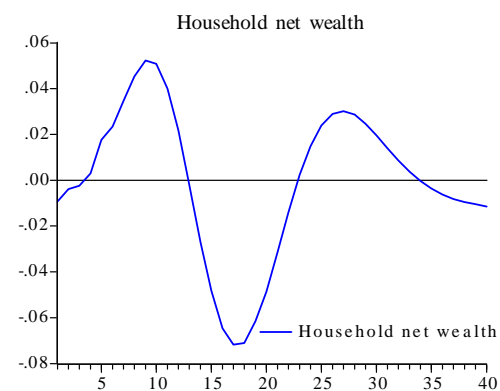
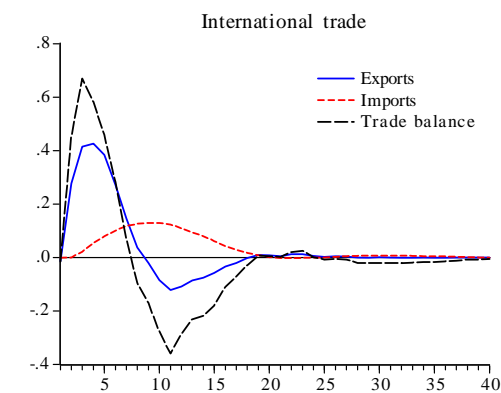
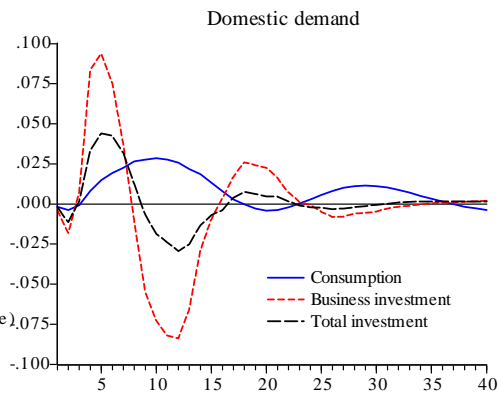
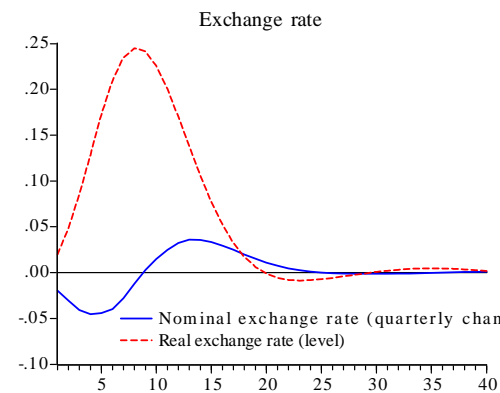
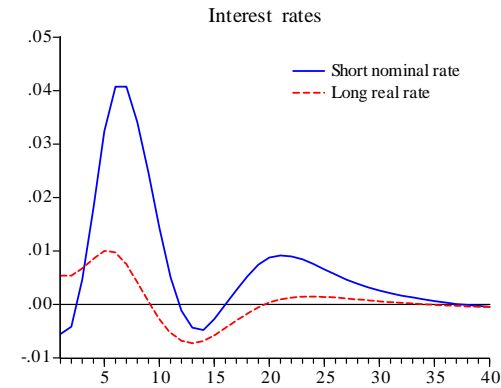
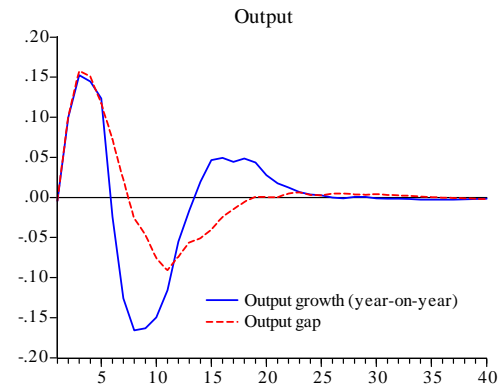
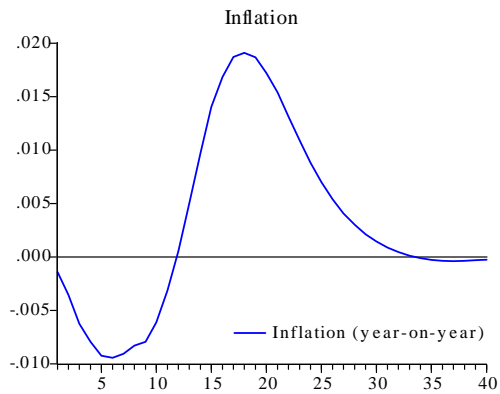
Terms of trade shock



Terms of trade shock:

Unanticipated 1% positive terms of trade shock for 1 year driven by a rise in the export price of aluminium and marine products

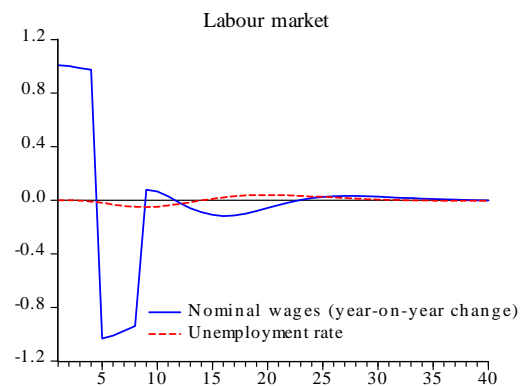
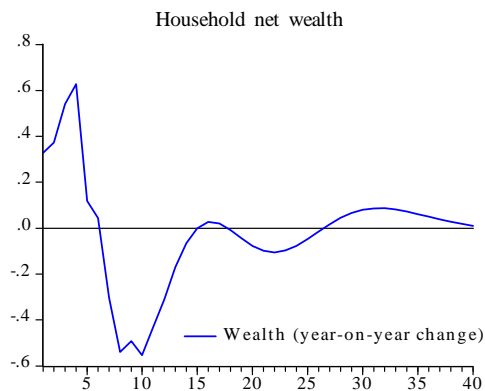
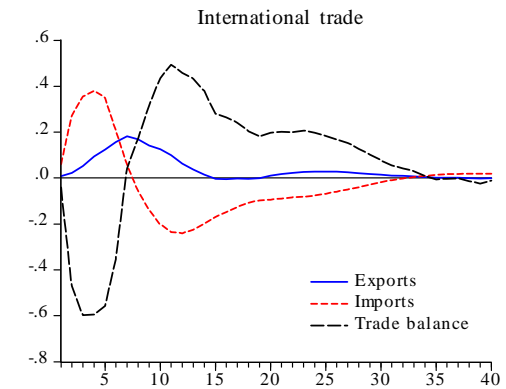
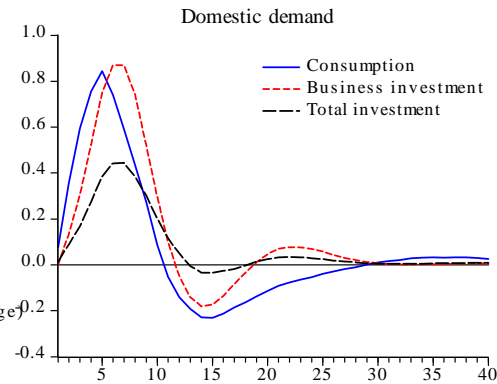
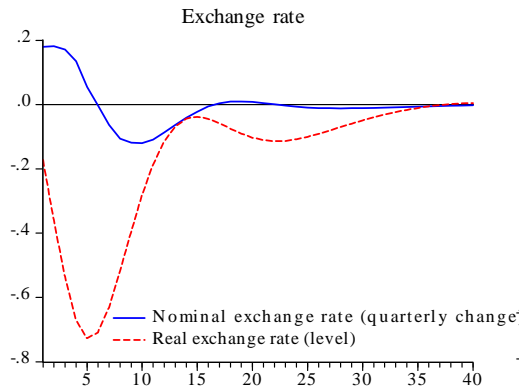
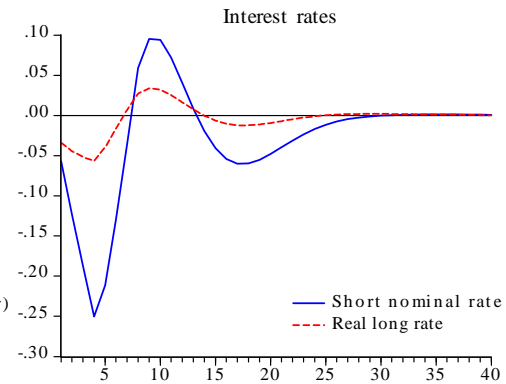
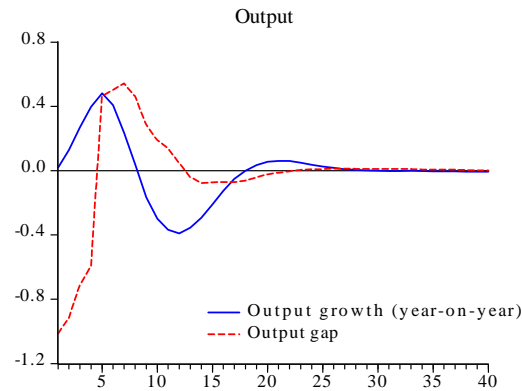
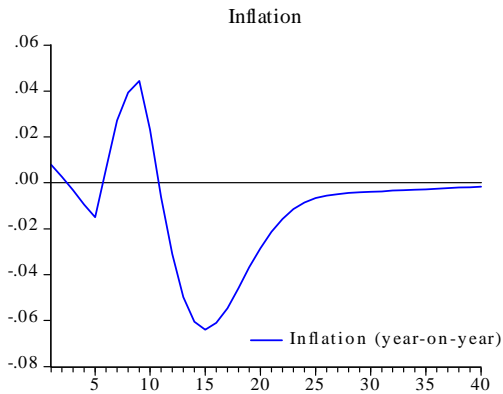
World demand shock



World demand shock:
Unanticipated 1% increase in world output and trade for 1 year



Productivity shock



Productivity shock:

Unanticipated 1% increase in the level of labour productivity for 1 year