ESSAYS IN AUSTRALIAN MACROECONOMIC POLICY

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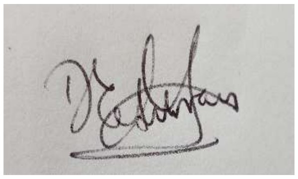
Declaration

I hereby declare that this thesis is entirely my own work. This thesis contains no material previously published by any other persons, except where due reference is made in the text of the thesis. This thesis has not been submitted for any other degree or used for other purposes.



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Various codes have been used in developing the codes in this thesis. These codes are: the replication code of the Blanchard and Perotti (2002) model developed by Jorge Restrepo for the IMF Online Course on Macroeconomic Forecasting 2017, the code of the Bernanke et al. (2005) model developed by Piotr Eliasz 2002 (November 9, 2002) and the code of the Blanchard and Quah (1989) model developed by Ouliaris, Pagan and Restrepo (2016).

I thank my parents and sisters who have been supportive of my endeavour.

Lastly, to my wife and children, for their patience during these years and for their unceasing encouragement and support, thanks so much.

Abstract

This thesis is a collection of three essays on macroeconomic policy for the Australian economy, which are contained in Chapters 2, 3 and 4.

This thesis makes three main contributions. First, the thesis presents the estimation of fiscal expenditure and net revenue multipliers, taking into account the external sector and the government budget constraint. The incorporation of the government budget constraint allows a better estimation of the effect of fiscal policy on the components of GDP. Second, this thesis contributes to the understanding of the interaction of monetary policy, asset prices and credit and the implications on real activity. Finally, the thesis decomposes total hours worked into average hours worked and employment in order to estimate the responses of output, average hours worked and employment to shocks that have permanent (technology shocks) and transitory (average hours worked and employment shocks) effects on output.

Chapter 2 analyses the effect of fiscal policy on real activity and debt dynamics using a SVAR model with short run restrictions. The estimates of government spending and net revenue multipliers are statistically significant. The model shows that the effect of fiscal policy on output is of short duration and takes place basically during the first quarter. When debt feedback is included in the model, the shock to government spending generates higher GDP on impact and over time as well as higher government revenue and exchange rate than the corresponding responses in the model without debt feedback. The GDP and net revenue responses in the model with debt feedback contribute to the gradual reduction of the debt-to-GDP ratio. The composition of the change of GDP is also affected with more investment and less net exports over time. The results also support the Keynesian view that a positive shock to government spending increases private consumption.

Chapter 3 assesses the relationship between monetary policy, credit and asset prices using a FAVAR model. The results indicate that a positive shock to the cash rate has a negative effect on asset prices. This chapter also presents estimates of the negative effects of this policy on GDP, GNE and employment, which should be taken into account in policy implementation. The effect of an increase in credit on asset prices is not statistically significant and is negative for share prices and positive for house prices. The response of the interest rate is almost zero for the whole projection period, which could be explained by an elastic supply of loans in Australia, as the international funds market is an important source

of financing for bank loans. This study also finds a statistically significant positive response of credit to an increase in share and housing prices, providing evidence that supports the financial accelerator hypothesis.

Chapter 4 analyses the responses of output and hours worked to shocks that have permanent and transitory effects on output. The permanent and transitory shocks are identified using an SVAR with long-run restrictions, assuming that only technological shocks can have a permanent effect on labour productivity and that hours worked per working-age population follows a stationary process. Hours worked is decomposed into average hours worked and employment. The results show a negative response of total hours to a positive, neutral technology shock and that total hours adjust mainly through employment. Additionally, when the model is extended to include the price of investment, a positive investment-specific technology shock produces a positive response of average hours worked and employment, with average hours having a more relevant role in the adjustment of total hours than in the case of the responses to a neutral technology shock. Labour productivity decreases temporarily after an average hours shock and increases after an employment shock.

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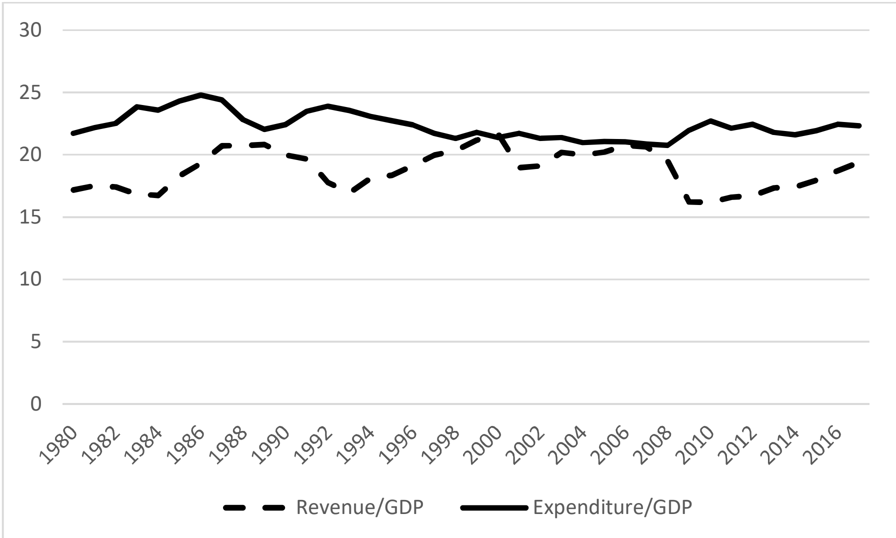
Chapter 1

Introduction

This thesis is a collection of three essays on macroeconomic policy for the Australian economy. These essays address both the short term and long term effects of policies and shocks on the Australian economy.

This thesis makes three main contributions. First, the thesis presents the estimation of fiscal expenditure and net revenue multipliers, taking into account the external sector and the government budget constraint. Second, this thesis also contributes to the understanding of the interaction of monetary policy, asset prices and credit. For example, the thesis presents the results of the estimation of the effect of monetary policy shocks on asset prices and the collateral effects of this policy on GDP and employment. Finally, the thesis estimates the effects of neutral and investment-specific technology shocks on output and hours worked. Hours worked is decomposed into employment and average hours worked, which have different responses depending on the types of technology shocks.

Chapter 2 focuses on the effects of fiscal policy on output. There is a renewed interest in the study of the effect of fiscal policy after the Global Financial Crisis as the effectiveness of monetary policy has been limited in bringing countries back to full employment. After the rapid decrease in interest rates in most developed economies, fiscal policy has been extensively used to increase economic activity. At the same time, the use of fiscal policy has increased public debt, raising questions about its sustainability. The Australian Government also implemented a fiscal stimulus package reflected in the reduction of net revenue in 2008 and 2009 shown in Figure 1.1.



Source: Australian Bureau of Statistics.
Revenue is net of subsidies and transfers.

Figure 1.1 Government net revenue and expenditure as a share of GDP, annual, 1980-2017 (per cent)

Chapter 2 assesses the effect of fiscal policy on real activity and debt dynamics in an SVAR model for Australia that includes the external sector. The data used are quarterly series from 1993Q2 to 2015Q3, with the starting date coinciding with the Reserve Bank of Australia adoption of the inflation targeting regime.

This chapter extends the structural vector autoregression models used by Blanchard and Perotti (2002) and Favero and Giavazzi (2007) to include an external sector. Blanchard and Perotti (2002) estimate the effect of fiscal policy on output based on an SVAR model with short term restrictions that includes output, government expenditure and government revenue. The model identifies fiscal policy shocks by exploiting lags in policy-making as it typically takes longer than a quarter for discretionary fiscal policy to respond to non-fiscal innovations. The model identification also takes advantage of out-of-the-model estimations of the elasticities of fiscal variables to other economic variables.

Favero and Giavazzi (2007) extend the Blanchard and Perotti model, pointing out the fact that this model overlooks the importance of the government budget constraint. They claim that the Blanchard and Perotti model fails to take into account the evolution of public debt after the tax or expenditure shock and, consequently, overlooks the response of the fiscal variables to the public debt dynamics. Hence, they include the components of the government budget constraint equation (primary government expenditure, primary revenue, output, inflation and the average cost of servicing debt) as endogenous variables in the SVAR and the lags of the ratio government debt-to-GDP as exogenous variables.

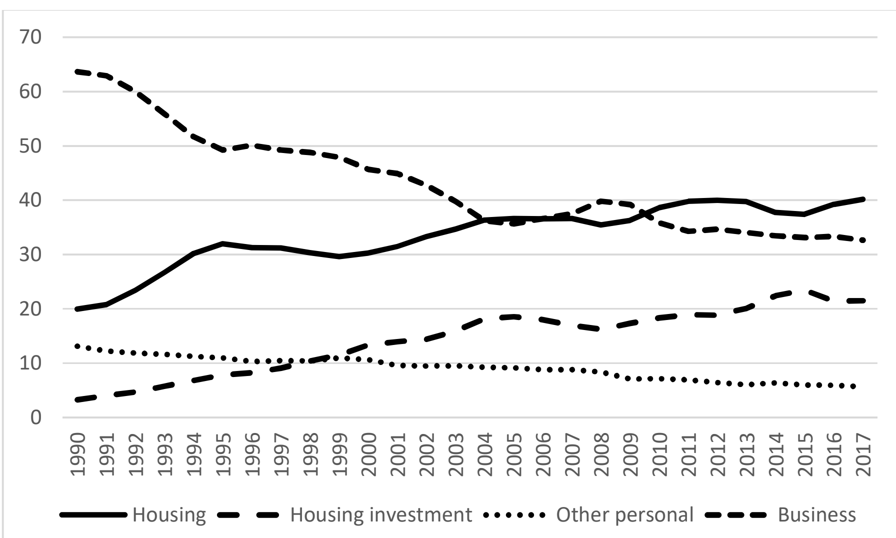
In order to include an external sector, in addition to the variables considered by Favero and Gavazzi (2007), the model in Chapter 2 incorporates the real exchange rate as an endogenous variable, and the terms of trade and US macroeconomic variables (GDP, inflation and interest rate) as exogenous variables. This model specification is based on the consideration that Australia is a small open economy and cannot influence global economic variables but is affected by the evolution of the global economy. The Gross National Expenditure (GNE) is included in the model by the incorporation of private consumption and private investment, the other two main components of GNE alongside government expenditure. The presence of GNE and GDP in the model is equivalent to model GDP and the balance of trade-to-GDP ratio (Dungey and Pagan, 2000).

The results include estimates of spending and net revenue multipliers for the 1993Q2-2015Q3 sample and the 1993Q2-2007Q4 sample. These multipliers are statistically significant. The model shows that the effect of fiscal policy is of short duration and takes place during the first quarter. When debt feedback is included in the model, the shock to government spending generates higher GDP on impact and over time as well as higher government revenue and exchange rate than the corresponding responses in the model without debt feedback. The GDP and net revenue responses in the model with debt feedback contribute to the gradual reduction of the debt-to-GDP ratio. The composition of the change of GDP is also affected with more investment and less net exports over time. The results also support the Keynesian view that a positive shock to government spending increases private consumption.

Chapter 3 assesses the relationship between monetary policy, credit and asset prices in Australia, a topic that has also drawn attention after the Global Financial Crisis, when the large fall in asset prices and high leverage occurred in a context of price stability. This experience has reignited the interest in the study of the interaction between macroeconomic and financial variables and, in particular, the debate on the appropriate policy response to achieve financial stability and to contain financial imbalances. There is an increasing consensus that it is desirable to respond to emerging signals of financial imbalances. However, it is also important to quantify the collateral effects of shocks to the variables in the model, such as interest rate, asset prices and credit on other macroeconomic variables. A change in policy variables to affect asset prices, for example, can also have significant negative effects on other macroeconomic variables. Assenmacher-Wesche and Gerlach (2008a) find that monetary policy to guard against financial stability by offsetting asset price movements in 17 OECD countries has sizable effects on economic activity. Dokko et al. (2009) find that tight monetary policy in the US sufficient to reduce housing prices would have resulted in an unemployment rate far higher than the realised unemployment rate. Svensson (2014) also finds evidence for Sweden that the monetary policy effect on household indebtedness is very small compared to the high costs of too-high unemployment and too-low inflation.

This chapter follows a FAVAR approach, which not only allows the study of the interaction between the interest rate, credit and asset prices but also shows the effect of the shocks to these variables on other variables such as GDP, employment, GNE and inflation rate. This approach is implemented for Australia using a quarterly sample of 236 economic series from 1993Q2 to 2017Q4.

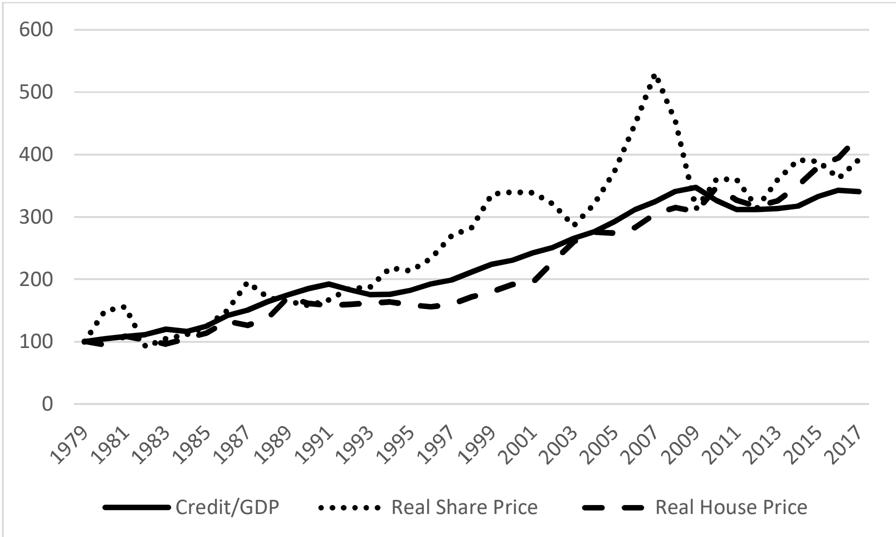
This study is relevant for Australia because the share of credit to housing has been increasing and has become the main component of the credit portfolio (Figure 1.2).



Source: Reserve Bank of Australia statistics.

Figure 1.2 Share of total credit, annual, 1990-2017 (per cent)

Also, although share prices are volatile, Figure 1.3 shows that the evolution of credit, housing prices and share prices seem to move together in the long run. The present study aims to shed light on the interactions of these variables.



Note: Credit and share prices are sourced from the RBA statistics, and GDP and house prices are sourced from the Australian Bureau of Statistics.

Figure 1.3 Asset prices and banking credit, annual, 1979-2017 (Index 1979=100)

The results of the study in Chapter 3 indicate that a positive shock to the cash rate has a negative effect on asset prices. This chapter also presents estimates of the negative effects of this policy on GDP, GNE and employment, which should be taken into account in policy implementation. The effect of an increase in credit on asset prices is not statistically significant and is negative for share prices and positive for house prices. The response of the interest rate is almost zero for the whole projection period, which could be explained by an elastic supply of loans in Australia, as the international funds market is an important source of financing for bank loans. This study also finds a statistically significant positive response of credit to an increase in share and housing prices, providing evidence that supports the financial accelerator hypothesis.

Chapter 4 analyses the responses of output and hours worked to shocks that have permanent and transitory effects on output. This research uses an SVAR model with long-run restrictions and Australian data from 1978Q4 to 2017Q4. In line with the Blanchard and Quah (1989) approach, the research interprets the first type of shock as a supply disturbance and the second type of shocks as a demand disturbance. The supply disturbance takes the form of a neutral technology shock and is later extended to include an investment-specific technology shock. One of the features of the models presented in this chapter is the decomposition of total hours worked into average hours and employment. These two components are not necessarily perfect substitutes as they make different contributions to the production process, and the costs attached to them are also different.

This analysis is performed using an SVAR with long-run restrictions. The base model includes three variables: labour productivity, average hours worked and employment. A neutral technology shock is identified as a permanent shock to labour productivity, in line with the approach followed by Galí (1999). In order to assess the robustness of the results, the analysis compares the results of the full sample period with the results for two periods: 1978Q4 to 1999Q4 and 2000Q1 to 2017Q4. Additionally, the initial model is expanded in two ways. The first extended model includes the investment price (in order to capture an investment-specific shock), the inflation rate and the interest rate. The second extended model additionally includes the terms of trade growth rate, the US GDP growth rate, and the US real interest rate as exogenous variables.

The results show a negative response of total hours to a positive, neutral technology shock and that total hours adjust mainly through employment. This result is verified for the whole sample period, for the two subsamples and extended models. Additionally, when the initial model is extended to include the price of investment, a positive investment-specific technology shock produces a positive response of average hours worked and employment, with average hours having a stronger response than the response to a neutral technology shock. After a positive shock to average hours worked, labour productivity temporarily decreases and employment temporarily increases taking longer than average hours to return to trend. The response to a shock to average hours can be interpreted as the response to an unexpected temporary demand shock, where firms are uncertain about the permanence of the shock as described by Hamermesh (1996). After a positive shock to employment, labour productivity and average hours worked temporarily increase; and during the adjustment process back to trend, average hours worked reduces faster than employment even to a level lower its trend for a period of time while employment is still in its adjustment process. The response to a shock to employment behaves as the response to a shock to demand generated by the expectation of consumers and investors of a permanent increase in productivity that finally does not occur as described by Lorenzoni (2006). The analysis of the variance decomposition of output shows that after the year 2000, employment and average hours worked explains almost half of output volatility on impact while productivity explains most of the output variance in the long-run. The extended model with investment-specific technology shock confirms that most of the variance of output in the long-run is explained by neutral technology shock.

This thesis is organised as follows. Chapter 2 assesses the effects of fiscal policy on output. Chapter 3 assesses the relationship between monetary policy, credit and asset prices in Australia. Chapter 4 analyses the responses of output and hours worked to shocks that have permanent and transitory effects on output. Chapter 5 summarises the main findings and suggests areas for further research.

Chapter 2

The effect of fiscal policy on real activity and debt dynamics

ABSTRACT

This chapter assesses the effect of fiscal policy on real activity and debt dynamics in an SVAR model for Australia that includes the external sector. The government expenditure multipliers on impact are 0.45 and 0.75 for the 1993Q2-2015Q3 and the 1993Q2-2007Q4 samples, respectively. The impact of a revenue shock on output is -0.20 and -0.26 for the 1993Q2-2015Q3 and the 1993Q2-2007Q4 samples, respectively. These results are statistically significant. The model shows that the effect of fiscal policy is of short duration and takes place basically during the first quarter. When debt feedback is included in the model, the shock to government spending generates higher GDP on impact and over time as well as higher government revenue and exchange rate than the corresponding responses in the model without debt feedback. The GDP and net revenue responses in the model with debt feedback contribute to the gradual reduction of the debt-to-GDP ratio. The composition of the change of GDP is also affected with more investment and less net exports over time. The results also support the Keynesian view that a positive shock to government spending increases private consumption.

2.1 Introduction

The study of the effect of fiscal policy has resurged after the Global Financial Crisis as conventional monetary policy was unable to bring countries back to full employment. After a rapid decrease in interest rates in most developed economies, fiscal policy has been extensively used to increase economic activity. At the same time, the use of fiscal policy has increased public debt, raising questions about its sustainability.

The aim of this study is to assess the effect of fiscal policy on real activity in an SVAR model for Australia that includes the external sector and allows the feedback of the government debt to the variables that determine the government's intertemporal budget constraint. This chapter extends the structural vector autoregression models used by Blanchard and Perotti (2002) and Favero and Giavazzi (2007) by including an external sector. This study shows that allowing debt feedback in the model as proposed by Favero and Giavazzi (2007) can affect the composition of the change in output.

Many empirical studies on the economic effects of fiscal policy use time series models with different identification approaches, which are surveyed by Perotti (2002), Favero and Karamysheva (2015) and Ramey (2016). These approaches summarised by Perotti (2002) include: (i) identification based on the revision of historical fiscal policy changes and the selection of the exogenous changes (narrative approach), e.g. those changes that are not motivated by short run economic conditions (Burnside et al., 2000; Burnside et al., 2003; Edelberg et al., 1998; Ramey and Shapiro, 1998; Ramey, 2011 and Romer and Romer, 2010), (ii) identification of fiscal shocks by sign restrictions on the impulse response functions (Mountford and Uhlig, 2008; Dungey and Fry, 2009 and 2010; and Chian Koh, 2017), (iii) identification based on a Cholesky ordering (Favero, 2002; and Fatás and Mihov, 2001), (iv) identification of fiscal policy shocks by exploiting lags in policymaking and information of the elasticities of fiscal variables to other economic variables (Blanchard and Perotti, 2002; Perotti, 2004; and Favero and Giavazzi, 2007).

The different approaches have advantages and disadvantages. The narrative approach is based on the selection of shocks that are exogenous and unanticipated; however, this selection requires judgement that can lead to measurement errors. Additionally, other events related to selected exogenous change of fiscal variables around the same time can pollute the identification of the exogenous shocks, for example, in the case of military spending, other events can occur at the same time, such as rationing, price controls or patriotic increases in labour supply. The sign-restrictions approach can address the issue of anticipated shocks but may rule out by assumption the direction of the response of variables where theories have conflicting views. The Blanchard and Perotti approach can identify the autonomous responses of fiscal variables. However, Ramey (2016) points out that this approach does not address the issue of anticipated shocks, while Mertens and Ravn (2012) provide support for the view that the anticipation effect of tax shocks are relevant for output but not for consumption. According to Ramey (2016), the use of the narrative approach tends to find that government spending and taxes have bigger effects on output and lower effects on consumption than the Blanchard and Perotti approach. More recent literature combines the SVAR approach with the narrative approach (Mertens and Ravn, 2014) or use instrumental variables to estimate the elasticities needed to implement the SVAR approach (Caldara and Kemps, 2017). This chapter is an extension of the Blanchard and Perotti approach incorporating public debt feedback in line with the approach followed by Favero and Giavazzi (2007) and an external sector for a small open economy such as Australia. Blanchard and Perotti use data from the US and include government spending, government revenue and output as endogenous variables. This study finds that government spending has an important and persistent effect on output. Given the characteristics of the US economy, these closed economy approaches are justifiable. However, the application of these approaches to a small open economy requires consideration of the external sector of the economy.

Empirical studies extending the Blanchard and Perotti approach include those performed by Perotti (2004), Perotti (2008) and Monacelli and Perotti (2010). Perotti (2004) includes the inflation rate and the 10-year nominal interest rate in a study for the US and four OECD countries and finds that the effects of fiscal policy on GDP tend to be small, with spending multipliers lower than one in most cases. Perotti (2008) includes consumption, investment, hours worked and wages, and concludes that government spending raises consumption and wages, supporting the New Keynesian view. Monacelli and Perotti (2010) include consumption, exports and the real exchange rate. They note that government spending induces a real exchange depreciation, a trade deficit and a rise in private consumption.

Another stream of the literature has applied the Blanchard and Perotti approach to study the fiscal multipliers across countries with different characteristics. For example, Ilzetzki et al. (2011) find that the fiscal multiplier is larger in developed economies, in countries with a predetermined exchange rate, in closed economies, and in low-debt countries.

The Blanchard and Perotti approach has also been extended to show that the fiscal multiplier depends on the state of the economy. Huidrom et al. (2016) shows that the fiscal multipliers tend to be larger when the fiscal position is strong while Auerbach and Gorodnichenko (2012) find that fiscal policy is more effective in recessions than in expansions.

Favero and Giavazzi (2007) extend the model developed by Blanchard and Perotti, pointing out the fact that this model and its extensions overlook the importance of the government budget constraint. They claim that SVAR models fail to take into account the evolution of public debt after a tax or expenditure shock, and consequently, those models overlook the response of the fiscal variables to the public debt dynamics. Hence, they include as endogenous variables in the SVAR the components of the government budget constraint equation (i.e., primary government expenditure, primary revenue, output, inflation, and the average cost of servicing debt) and as exogenous variables, the lags of the ratio government debt-to-GDP.

The Blanchard and Perotti approach has been applied to different small open economies such as Spain (De Castro and Hernandez de Cos, 2008) and Italy (Giordano et al., 2008), without the debt restriction, and New Zealand (Parkin et al., 2013), including the debt restriction. However, these studies do not include a foreign economy.

Caprioli and Momigliano (2011) implement an extended version of the Blanchard and Perotti approach, including output, inflation, the interest rate, government expenditure and revenue as endogenous variables. This model also follows Favero and Giavazzi's approach including the debt dynamics equation and lagged debt as an exogenous variable. Additionally, the model includes foreign demand as an exogenous variable, which follows an AR(1) process with a linear trend.

Some studies have estimated the fiscal multiplier for Australia using different methodologies obtaining a wide variety of results in terms of sign and size. Perotti (2004) uses an extended SVAR model to estimate that the spending multiplier varies between -0.14 and 0.38 for a one-year horizon, and from 0.69 to 1.42 for a three-year horizon. Carmignani (2014), using an SVAR model with output, government spending and employment, estimates an impact multiplier of 0.6 and a cumulative multiplier one quarter after the impulse of 1.1. IMF (2009a) uses the Global Integrated Monetary and Fiscal (GIMF) model to estimate a government consumption multiplier in the range of 1.1 to 1.3 and a government investment multiplier from 1.2 to 1.4. Li and Spencer (2016), using a DSGE model, estimate a spending multiplier of 0.9 on impact and 1.3 with one-year monetary accommodation.

This study extends the structural vector autoregression model used by Blanchard and Perotti (2002) and Favero and Giavazzi (2007) by including an external sector for Australia. The external sector is included because Australia is a small open economy and international trade can be a source of leakage of fiscal stimulus. For this purpose, in addition to the variables considered by Favero and Gavazzi (2007), this model incorporates consumption, investment (other components of GNE) and the real exchange rate as endogenous variables; and the terms of trade and US macroeconomic variables (GDP, inflation and interest rate) as exogenous variables, considering that Australia is a small open economy and cannot influence global economic variables but is affected by the evolution of the global economy (Dungey and Pagan, 2000 and 2009).

The main findings of this study can be summarised as follows. The government expenditure impact multipliers are 0.45 and 0.75 for the 1993Q2-2015Q3 sample and the 1993Q2-2007Q4 sample, respectively. The impact of a net revenue shock on output is -0.20 and -0.26 for the 1993Q2-2015Q3 sample and the 1993Q2-2007Q4 sample, respectively. These results are statistically significant. The model shows that the effect of fiscal policy is of short duration and takes place mainly during the quarter of the expenditure and revenue shocks. When debt feedback is included in the model, the shock to government spending generates a higher GDP on impact and over time and higher government revenue and exchange rate than the corresponding responses in the model without debt feedback. The GDP and net revenue responses in the model with debt feedback contribute to the gradual reduction of the debt-to-GDP ratio. The composition of the change of GDP is also affected with more investment and less net exports over time. The results also support the Keynesian view that a positive shock to government spending increases private consumption.

This chapter is organised as follows. Section 2.2 presents the structure of the model. Section 2.3 discusses the estimation and identification methods and the procedure to estimate the impulse response functions. Section 2.4 describes the data. Section 2.5 analyses the results from the shocks to the fiscal variables. Section 2.6 compares different model specifications. Section 2.7 concludes and summarises the main results from the analysis.

2.2 The model

This chapter extends the Blanchard and Perotti (2002) model by including the debt-to-GDP ratio as an exogenous variable, as the approach followed by Favero and Giavazzi (2007), and an external sector for Australia. The inclusion of debt requires that the SVAR include the interest rate and the inflation rate as components of the dynamics equation, in addition to output, net government revenue and government spending.

The incorporation of the external sector follows a different approach to the approach followed by Caprioli and Momigliano (2011). In the present model, the external sector is included by the incorporation of the real exchange rate as an endogenous variable, and the terms of trade and US variables as exogenous variables. GNE is included in the model by incorporating private consumption and private investment, the other two main components of GNE alongside government expenditure. The presence of GNE and GDP in the model is equivalent to model GDP and the balance of trade-to-GDP ratio (Dungey and Pagan, 2000).

To summarise, the model includes net government revenue (REV), government expenditure (SPE), GDP per capita (GDP), private consumption $(CONS)$, private investment (INV), the inflation rate (INF), the interest rate (INT) and the real exchange rate (LER) as endogenous variables. Additionally, the debt-to-GDP ratio $(debt)$, the terms of trade (*ltot*), US output (yus), the US inflation rate $(\inf\_us)$ and the US interest rate (i_us) are included as exogenous variables. The terms of trade and US variables are not affected by Australian domestic variables, as Australia is a small open economy and cannot influence global economic variables but is affected by the evolution of the global economy.

Government spending, government revenue, GDP, consumption, investment and US GDP are in real per-capita terms, seasonally adjusted and log-transformed. The domestic and US inflation rates are the quarterly growth rate of the domestic GDP and US GDP deflators, respectively. The interest rate is the quarterly yield of the 10-year government bond. The real exchange rate and the terms of trade are seasonally-adjusted and log-transformed.

The reduced-form VAR can be written as:

$$X_t = \sum_{i=1}^{k_1} C_i X_{t-i} + \sum_{i=0}^{k_2} C_i^* X_{t-i}^* + \sum_{i=1}^{k_3} \gamma_i debt_{t-i} + u_t, \tag{1}$$

where $k_1 = 1$, $k_2 = 1$, $k_3 = 4$, $X_t = (REV_t, SPE_t, GDP_t, CONS_t, INV_t, INF_t, INT_t, LER_t)$ and $X_t^* = (yus_t, \inf\_us_t, i\_us_t, ltot_t)$ are the vectors of endogenous and exogenous variables, respectively. The endogenous variables are included with one lag following the AIC criteria. The specification includes a constant, and linear, quadratic and cubic trends. According to equation (1), past values of the debt-to-GDP ratio influence the current value of fiscal and other macroeconomic variables, which affect the current value of the debt-to-GDP ratio according to the following equation:

$$debt_t = \frac{(1+INT_t)}{(1+INF_t)(1+\hat{y}_t)} debt_{t-1} + \frac{\exp(SPE_t) - \exp(REV_t)}{\exp(GDP_t)} + R_t, \quad (2)$$

where $\hat{y}$ is the growth rate of quarterly real GDP and R_t is the debt stock-flow adjustment residual that includes the use of asset sales, off-budget operations, valuation changes due to market price moves and errors and omissions (Abbas, et al., 2011).

Following Balnchard and Perotti (2002), the fiscal variable that is shocked is ordered first. The order of GDP, consumption and investment follow Perotti (2008), where the other demand components are affected by GDP but do not affect GDP contemporaneously. Inflation is ordered before the interest rate (e.g. Perotti, 2004) as the interest rate can respond contemporaneously to changes in the inflation rate and GDP in an inflation targeting regime. The real exchange rate is assumed to be affected by all variables contemporaneously and is ordered last.

2.3 Identification and impulse response estimation

The reduced form residuals u_t^{SPE} and u_t^{REV} from the SPE_t and REV_t equations in (1) can be thought as linear combinations of three components (Perotti, 2004):

1. The automatic response of taxes and government spending to innovations in non-fiscal variables, for instance, the anticipated changes in taxes in response to output innovations, for given tax rates;

2. The systematic discretionary response of policymakers to non-fiscal innovations; for instance, reductions in tax rates implemented systematically in response to recessions; and

3. Random discretionary shocks to fiscal policies; these are the structural fiscal shocks, which, unlike the reduced form residuals, are uncorrelated with all other structural shocks. This is the component of interest when estimating impulse responses to fiscal policy shocks.

Extending the Blanchard and Perotti approach, the reduced-form residuals u_t^{SPE} and u_t^{REV} can be expressed as a linear combination of the structural spending shock (e_t^{SPE}), the structural revenue shock (e_t^{REV}) and the reduced-form residuals of the other dependent variables in the VAR:

$$u_t^{SPE} = \alpha_{SPE,GDP} u_t^{GDP} + \alpha_{SPE,CONS} u_t^{CONS} + \alpha_{SPE,INV} u_t^{INV} + \alpha_{SPE,INF} u_t^{INF} + \alpha_{SPE,INT} u_t^{INT} + \alpha_{SPE,LER} u_t^{LER} + \beta_{SPE,REV} e_t^{REV} + e_t^{SPE}, \tag{3}$$

$$u_t^{REV} = \alpha_{REV,GDP} u_t^{GDP} + \alpha_{REV,CONS} u_t^{CONS} + \alpha_{REV,INV} u_t^{INV} + \alpha_{REV,INF} u_t^{INF} + \alpha_{REV,INT} u_t^{INT} + \alpha_{REV,LER} u_t^{LER} + \beta_{REV,SPE} e_t^{SPE} + e_t^{REV}, \tag{4}$$

where the coefficients $\alpha_{SPE,j}$ and $\alpha_{REV,j}$ represent the first two components of the reduced form residuals mentioned above: the automatic response and the systematic discretionary policy response of the fiscal variables to innovations in a non-fiscal variable *j*. Following Blanchard and Perotti, discretionary fiscal policy typically takes longer than a quarter to respond to non-fiscal innovations. Hence the systematic responses to non-fiscal shocks are absent in the quarterly data. This means that, for quarterly data, these coefficients capture only the automatic response of fiscal variables to non-fiscal variables and do not include the effect of a systematic discretionary fiscal policy response. These coefficients represent elasticities of government spending and revenue to non-fiscal variables. These coefficients need to be estimated outside of the model or are obtained using available external information.

It is assumed that $\alpha_{SPE,GDP} = 0$, $\alpha_{SPE,CONS} = 0$ and $\alpha_{SPE,INV} = 0$, meaning that there is no substantial automatic response of government spending to GDP (as described by Blanchard and Perotti, 2002), consumption and investment within a quarter. The price elasticity of government spending is assumed to be -0.5 $(\alpha_{SPE,INF} = -0.5)$ as in Perotti (2004).

Additionally, the interest rate elasticity of government spending is set to zero $(\alpha_{SPE,INT} = 0)$ as it excludes interest payments. The real exchange rate elasticity of government spending is assumed to be zero $(\alpha_{SPE,LER} = 0)$. In relation to the elasticities of government revenue, it is assumed that $\alpha_{REV,GDP} = 3.0$ (see Appendix 2.1) based on Price et al. (2015) and $\alpha_{REV,INF} = 1.01$, coefficient estimated by Perotti (2004) for Australia. The private consumption elasticity of net revenue is estimated as the product of the elasticity of consumption to indirect taxes (which is assumed to be one) and the share of indirect taxes in net revenue. This results in a coefficient of $\alpha_{REV,CONS} = 0.18$. The investment elasticity of revenue is assumed to be zero within a quarter $(\alpha_{REV,INV} = 0)$. The interest rate elasticity of government revenue is also assumed to be zero $(\alpha_{REV,INT} = 0)$ considering that interest revenue is excluded from net revenue and that the effect of interest rates on property income is relatively low. The real exchange rate elasticity of government revenue is estimated as the product of the imports elasticity of government revenue and the real exchange rate elasticity of imports. The first elasticity is estimated as the import elasticity of trade taxes (assumed to be one) times the share of trade taxes on net revenue (0.03). The real exchange rate elasticity of imports is estimated to be 0.51 (see Appendix 2.1). The product of these two elasticities results in an estimation of the real exchange rate elasticity of government revenue of 0.015 $(\alpha_{REV,LER} = 0.015)$.

The summary of the elasticities used in this study is shown in Table 2.1.

Table 2.1 Elasticities used in the structural VAR

	Spending	Revenue
GDP	0	3.00
Consumption	0	0.18
Investment	0	0
Inflation	-0.5	1.01
Interest rate	0	0
Exchange rate	0	0.015

Note: Elasticities of government spending and revenue with respect to non-fiscal endogenous variables.

Knowing these elasticities, it is possible to calculate the cyclically adjusted fiscal shock $u_t^{SPE,CA}$ and $u_t^{REV,CA}$, as defined below, which are a function of the structural spending and revenue shocks:

$$u_t^{SPE,CA} = u_t^{SPE} - (\alpha_{SPE,GDP} u_t^{GDP} + \alpha_{SPE,CONS} u_t^{CONS} + \alpha_{SPE,INV} u_t^{INV} + \alpha_{SPE,INF} u_t^{INF} + \alpha_{SPE,INT} u_t^{INT} + \alpha_{SPE,LER} u_t^{LER}) = \beta_{SPE,REV} e_t^{REV} + e_t^{SPE}, \tag{5}$$

and

$$u_t^{REV,CA} = u_t^{REV} - (\alpha_{REV,GDP} u_t^{GDP} + \alpha_{REV,CONS} u_t^{CONS} + \alpha_{REV,INV} u_t^{INV} + \alpha_{REV,INF} u_t^{INF} + \alpha_{REV,INT} u_t^{INT} + \alpha_{REV,LER} u_t^{LER}) = \beta_{REV,SPE} e_t^{SPE} + e_t^{REV}. \tag{6}$$

In order to identify the fiscal structural shocks, it is necessary to determine the ordering of the fiscal variables in the VAR. Assuming that revenue comes first (a revenue shock affects government expenditure, but not vice versa) $\beta_{REV,SPE} = 0$ and $e_t^{REV} = u_t^{REV,CA}$, then it is possible to estimate $\beta_{SPE,REV}$ from (5). A similar procedure is followed if $\beta_{SPE,REV} = 0$ is assumed. Under either ordering e_t^{REV} and e_t^{SPE} can be estimated and used as instruments to estimate the other structural shocks. As there are no theoretical reasons to prefer one order over the other, following Blanchard and Perotti, this study assumes $\beta_{SPE,REV} = 0$ to compute the responses to a government spending shock and $\beta_{REV,SPE} = 0$ to compute the responses to a net government revenue shock.

The order of the remaining variables of the VAR is GDP, private consumption, private investment, the inflation rate, the interest rate and the real exchange rate.

Specifically, under the assumption of $\beta_{SPE,REV} = 0$, the government spending structural shock is equal to the adjusted residual: $e_t^{SPE} = u_t^{SPE,CA}$, then $\beta_{REV,SPE}$ and e_t^{REV} in equation (6) can be estimated. The method to estimate the remaining structural residuals is described below.

The GDP structural residual e_t^{GDP} can be estimated using e_t^{REV} and e_t^{SPE} as instruments for u_t^{REV} and u_t^{SPE}

$$u_t^{GDP} = \gamma_{GDP,REV} u_t^{REV} + \gamma_{GDP,SPE} u_t^{SPE} + e_t^{GDP}. \tag{7}$$

Similarly, the structural residuals of the non-fiscal variables can be used to estimate the subsequent structural residuals in the following equations:

$$u_t^{CONS} = \gamma_{CONS,GDP} u_t^{GDP} + \gamma_{CONS,REV} u_t^{REV} + \gamma_{CONS,SPE} u_t^{SPE} + e_t^{CONS},$$

$$u_t^{INV} = \gamma_{INV,CONS} u_t^{CONS} + \gamma_{INV,GDP} u_t^{GDP} + \gamma_{INV,REV} u_t^{REV} + \gamma_{INV,SPE} u_t^{SPE} + e_t^{INV},$$

$$u_t^{INF} = \gamma_{INF,INV} u_t^{INV} + \gamma_{INF,CONS} u_t^{CONS} + \gamma_{INF,GDP} u_t^{GDP} + \gamma_{INF,REV} u_t^{REV} + \gamma_{INF,SPE} u_t^{SPE} + e_t^{INF},$$

$$u_t^{INT} = \gamma_{INT,INF} u_t^{INF} + \gamma_{INT,INV} u_t^{INV} + \gamma_{INT,CONS} u_t^{CONS} + \gamma_{INT,GDP} u_t^{GDP} + \gamma_{INT,REV} u_t^{REV}$$
$$+ \gamma_{INT,SPE} u_t^{SPE} + e_t^{INT},$$

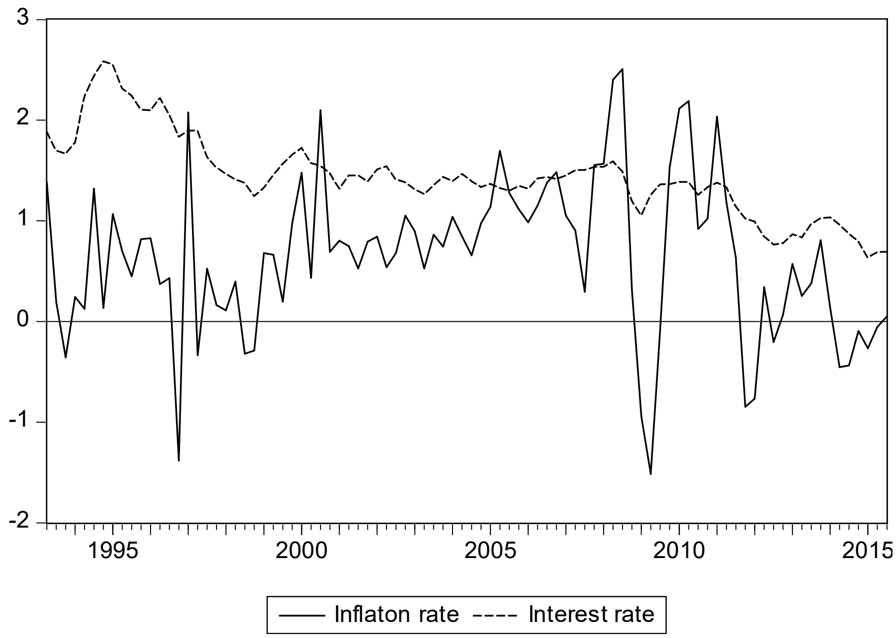
$$u_t^{LER} = \gamma_{LER,INT} u_t^{INT} + \gamma_{LER,INF} u_t^{INF} + \gamma_{LER,INV} u_t^{INV} + \gamma_{LER,CONS} u_t^{CONS} + \gamma_{LER,GDP} u_t^{GDP}$$
$$+ \gamma_{LER,REV} u_t^{REV} + \gamma_{LER,SPE} u_t^{SPE} + e_t^{LER}.$$

The estimation of the impulse response functions follows Favero and Giavazzi (2007) using the steps:

1. Generate a baseline simulation for all variables by solving (1) dynamically forward. This requires setting to zero all shocks for a number of periods equal to the horizon up to which impulse responses are needed.
2. Generate an alternative simulation for all variables by setting the structural shock of interest to one, for the first period of the simulation, and then dynamically solving the model forward up to the horizon used in the baseline simulation.
3. The impulse response function is estimated as the difference between forecasts based on equations (1) and (2) without an initial shock (baseline) and with an initial shock in 1993Q2.
4. Compute confidence intervals by using a bootstrap methodology. The procedure is as follows: (i) resample residuals from the original VAR and compute new endogenous variables and the corresponding debt-to GDP ratio; (ii) reestimate the VAR for the baseline simulation and the alternative simulation with a shock and compute the impulse responses as in step (3); (iii) repeat steps (i) and (ii) 500 times to obtain the bootstrapping distribution of impulse responses. The figures with confidence intervals in Section 2.5 and Appendix 2.2 show the results of the 16^{th}, 50^{th} and 84^{th} percentiles of the bootstrapped distributions of the impulse responses.

2.4 Data

The data are quarterly series from the second quarter of 1993 to the third quarter of 2015, with the starting date coinciding with the Reserve Bank of Australia adoption of the inflation targeting regime. The inflation rate is the log difference of the expenditure GDP deflator taken from the Australian National Accounts published by the Australian Bureau of Statistics. The interest rate is the 10-year government bond yield and is taken from the Reserve Bank of Australia Statistics. Both series are shown in Figure 2.1 below.



Note: The inflation rate is the quarterly growth rate of the GDP deflator sourced from the ABS and the interest rate is the quarterly average of the 10-year government bond yield sourced from the RBA Statistics.

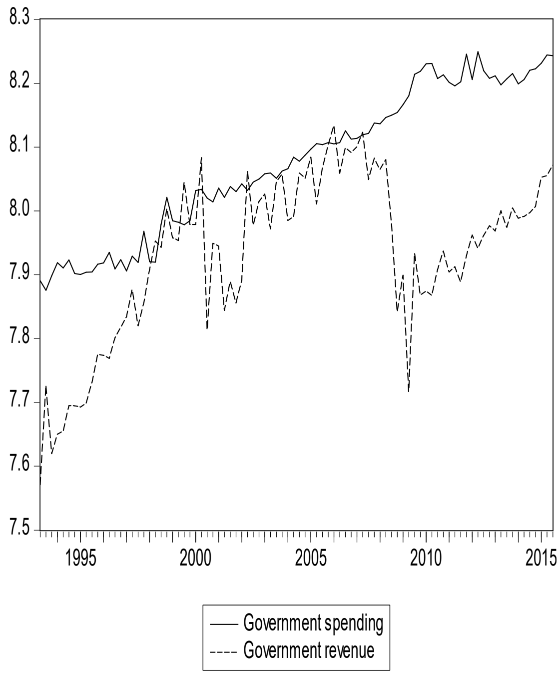
Figure 2.1 Interest rate and inflation rate, 1993Q2-2015Q3 (per cent)

The government net revenue and expenditure quarterly data are taken from the Australian National Accounts (Catalogue number 5206.0) published by the Australian Bureau of Statistics. These data are constructed on an accrual basis. Government expenditure is mainly Government consumption and Government investment. Government investment excludes the investment of public corporations. Net revenue is revenue less subsidies and transfers. Both government net revenue and expenditure exclude interest. The data correspond to the general government, including commonwealth, state and local governments. As shown in Figure 2.2, during the period of analysis, government net revenue is lower than government spending, especially before 1998 and after 2007. Given the significant change in government accounts in 2008 and 2009, estimation is also performed for the period 1993Q2 to 2007Q4, to show how the results change in comparison to the total sample period of 1993Q2 to 2015Q3.

The measure of gross debt is the sum of loans and securities issued by the Government taken from the ABS Catalogue 5232.0 Table 27. These data are used to estimate the debt residual. This residual term as a share of GDP is calculated by the difference between the actual debt-to-GDP ratio ($debt\_a_t$) and the calculated debt-to-GDP ratio without the contemporaneous residual (the term in brackets in Equation (8)), as follows:

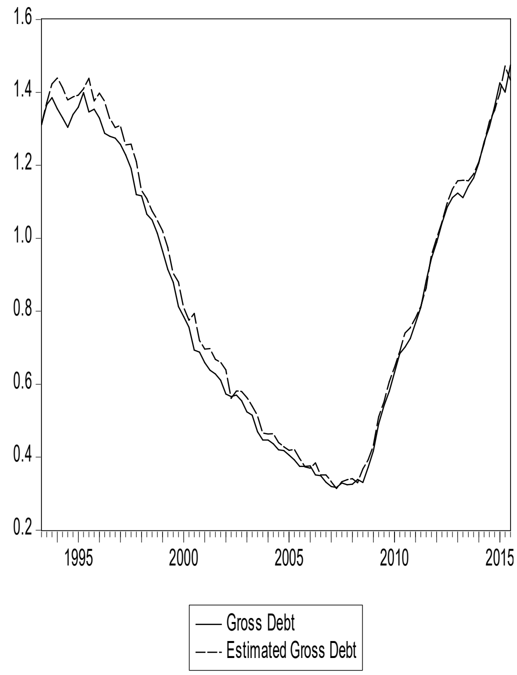
$$R_t = debt\_a_t - \left[\frac{(1+INT_t)}{(1+INF_t)(1+\hat{y}_t)} debt\_a_{t-1} + \frac{\exp(SPE_t) - \exp(REV_t)}{\exp(GDP_t)} \right], \tag{8}$$

Figure 2.2b shows the actual debt and the calculated debt without the contemporaneous residual (the term in brackets in the Equation (8)), both expressed as a share of GDP. The interest paid is estimated using the interest rate of 10-year government bonds. Both debt measures move closely over time and the difference between these two lines is the debt residual. As a share of GDP, the calclated debt is higher than the actual debt by 2.7 and 3.5 percentage points on average for the samples 1993Q2-2015Q3 and 1993Q2-2007Q4, respectively. Figure 2.2b shows a decline of the debt-to-GDP ratio until 2007 and an increase afterwards. The lower level of debt in 2007 allowed the Australian Government to pursue an expansionary fiscal policy during the years of the Global Financial Crisis, reducing the adverse effects of the crisis on the Australian economy and sustaining government services.



Note: Data sourced from the ABS Cat 5206.0 .
Government revenue is net of subsidies and transfers.

Figure 2.2a Net general government revenue and spending, 1993Q2-2015Q3 (logs of real per capita values)

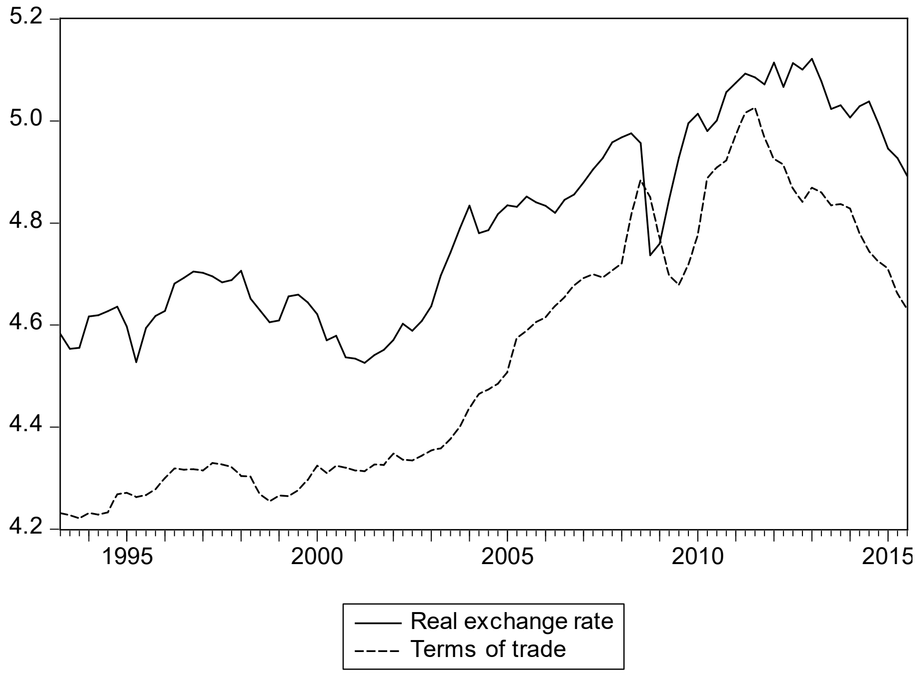


Note: Data sourced from the ABS Cat. 5232.0.

Figure 2.2b Ratio Government gross debt to GDP, 1993Q2-2015Q3

However, it is possible to argue that the government reacts to the level of net debt. The net debt in the ABS statistics is equal to the sum of deposits held, government securities, loans, and other borrowings, minus the sum of cash and deposits, advances paid and investments, loans, and placements. To test this scenario, an alternative construction of the debt is considered. The annual net debt 1999-2016 published by the ABS is completed using annual series of the commonwealth net debt from 1992 to 1998 and the quarterly data between two consecutive years is estimated by adding the quarterly government deficit. Any discrepancy due to valuation or other factors within a year can be allocated equally to the quarters of the year. By construction, the annual data corresponds to the official net debt. A similar construction can be found in Cherif and Hasanov (2012). The results under this option are presented in Appendix 2.2.

The data for GDP, private consumption, private investment, and the terms of trade are also taken from the Australian National Accounts published by the Australian Bureau of Statistics (ABS Catalogue number 5206.0). The real exchange rate is a trade-weighted exchange rate taken from the Reserve Bank of Australia statistics. Figure 2.3 shows the evolution of the terms of trade and the real exchange rate from 1993 to 2015. The US data are taken from the Federal Reserve Economic Data.



Note: The real exchange rate is sourced from the RBS Statistics and the terms of trade from the ABS.

Figure 2.3 Real exchange rate and terms of trade (in logs)

With the exception of government spending and domestic and foreign interest rates and inflation rates, all variables are I(1), according to the ADF test at a 5 per cent significance level. Blanchard and Perotti estimate the effects of fiscal shocks under two alternative assumptions concerning the nature of the trend in the variables of a deterministic trend and a stochastic trend. For the first case, they include time and time squared in the model, and for the second case, they take the difference of the variables. The present research follows the first approach and the variables in the model are in levels. This is consistent with Sims et al. (1990) who suggest that the practice of transforming models to stationary form by taking the difference of variables is, in many cases, unnecessary, as the relevant issue is the distribution of the estimated coefficients which are often unaffected by non-stationarity. Empirical models such as Favero and Giavazzi (2007), Parkyn and Vehbi (2013) and Mountford and Uhlig (2008) also use data in levels form in the specification in their models.

2.5 The responses to fiscal shocks

This section discusses the effect of fiscal shocks on economic activity based on the model described in Section 2.2. Subsection 2.5.1 presents estimations of fiscal multipliers. Subsections 2.5.2 and 2.5.3 discuss the effects of government spending and revenue shocks, respectively. The results are presented for the sample periods 1993Q2-2015Q3 and 1993Q2-2007Q4. The analysis of the results under these two sample periods allows the comparison of the estimation of the multipliers for the full sample with the estimates before the significant fiscal response during the Global Financial Crisis.

Subsection 2.5.2, Subsection 2.5.3, Section 2.6 and Appendix 2.2 show the impulse-response functions of the endogenous variables, debt and the real interest rate to shocks to government spending and revenue. The responses of government spending, government revenue, output, consumption and investment are transformations of the original per cent impulse-responses and give the dollar response to a dollar shock in one of the fiscal variables as in Blanchard and Perotti (2002). This transformation makes the response of output equivalent to the multiplier at different time horizons described in Subsection 2.5.1. The responses of the inflation rate, the interest rate, and the debt-to-GDP ratio are percentage point responses to a one per cent increase in one of the fiscal variables. The response of the exchange rate is the percentage change of the exchange rate to a one per cent increase in one of the fiscal variables. The confidence intervals are the 16^{th} and 84^{th} percentile bands of the bootstrapped distribution of impulse responses based on 500 replications.

2.5.1 Fiscal multipliers

Table 2.2 reports the fiscal multipliers at various time horizons and the cumulative multipliers, as defined in Spilimbergo et al. (2009). The multiplier at horizon N, which is used by Blanchard and Perotti (2002), is defined as follows:

$$\frac{\Delta Y(t+N)}{\Delta G(t)}. \qquad (9)$$

where $Y = \exp(GDP)$ and $G = \exp(SPE)$ for a government spending multiplier or $G = \exp(REV)$ for a government revenue multiplier. When N=0, the multiplier is called the impact multiplier.

The cumulative multiplier is defined as:

$$\frac{\sum_{j=0}^{N} \Delta Y(t+j)}{\sum_{j=0}^{N} \Delta G(t+j)}. \qquad (10)$$

Table 2.2 Fiscal multipliers

	Sample 1993Q2 - 2007Q4			
	Multiplier at horizon N		Cumulative multiplier	
N	Revenue	Spending	Revenue	Spending
1 qtr	-0.26	0.75	-0.26	0.75
4 qtrs	0.02	0.00	-0.45	0.54
8 qtrs	0.00	0.00	-0.75	0.55
12 qtrs	0.00	0.00	-0.80	0.54
	Sample 1993Q2 - 2015Q3			
	Multiplier at horizon N		Cumulative multiplier	
N	Revenue	Spending	Revenue	Spending
1 qtr	-0.20	0.45	-0.20	0.45
4 qtrs	0.01	0.00	-0.18	0.31
8 qtrs	-0.02	0.04	-0.38	0.44
12 qtrs	-0.01	0.03	-0.74	0.58

As mentioned in the introductory part of this section, the multiplier at different time horizons corresponds to the responses of output to a dollar change in the fiscal variables. These responses are analysed in the following subsections. Considering the results described below, the cumulative multipliers are mainly relevant for the spending multiplier for the sample 1993Q2-2015Q3, where the GDP response is statistically significant for most quarters after the first quarter.

2.5.2 The effect of a government spending shock

Figures 2.4 and 2.5 show the impulse response functions of the variables in the model to a shock in government spending for the 1993Q2-2015Q3 sample and the 1993Q2-2007Q4 sample, respectively. The response of GDP to government spending is also shown in Table 2.2. The impact spending multiplier is 0.45 in the 1993Q2-2015Q3 sample ("GDP" in Figure 2.4) and 0.75 in the 1993Q2-2007Q4 sample ("GDP" in Figure 2.5). Both are statistically significant. In both samples, the effect of a spending shock on output is close to zero in the following quarters. These results are lower and less persistent than the previous studies with similar models. A comparison of the results from different model specifications is discussed in Section 2.6. Table 2.2 shows that the cumulative multipliers are 0.31and 0.58 for the 1993Q2-2015Q3 sample after one and three years respectively, and 0.54 for the 1993Q2-2007Q4 sample at the same time horizons.

In the 1993Q2-2015Q3 sample, the initial increase in real government spending ("SPE") is funded initially by an increase in debt ("DEBT") as government revenue ("REV") decreases. In the following quarters, government revenue increases, contributing to the reduction of the debt-to-GDP ratio. In the 1993Q2-2015Q3 sample, the debt-to-GDP ratio increases by 0.16 per cent points of GDP on impact, reaches the peak in the second quarter (0.34 per cent points of GDP higher than the base scenario) and gradually decreases to become statistically not significant after the first 20 quarters. In the 1993Q2-2007Q4 sample model, the response of the debt-to-GDP ratio is lower (even statistically non-significant), and the convergence to the baseline is faster due to a positive response of net revenue and the higher impact on output. This is consistent with the decreasing levels of debt as a source of financing of the public sector during this period.

In the 1993Q2-2015Q3 sample scenario, there is an increase in consumption ("CONS") of 31 cents in response to a dollar increase in government spending. This effect is statistically significant and almost vanishes after 20 quarters. However, in the 1993Q2-2007Q4 sample, the increase in consumption is lower than in the 1993Q2-2015Q3 sample scenario and is not significant. This increase in consumption does not support the neoclassical theory that predicts that a positive shock to government spending reduces consumption and supports the Keynesian models that predicts a positive response of consumption, especially in the 1993Q2-2015Q3 sample scenario.

In the 1993Q2-2007Q4 sample, investment ("INV") increases by 48 cents on impact and reduces to almost zero after the third quarter. In the 1993Q2-2015Q3 sample, investment decreases in the first three quarters and increases afterwards to a peak of 0.12 cents in the ninth quarter and decreasing slowly afterwards. Although net exports are not included in the model, they should decrease significantly on impact, considering that the increase in output is lower than the aggregated response of consumption, investment and government spending.

Although there is a positive effect on the inflation rate ("INF") with a peak impact of approximately 0.02 and 0.04 per cent points in the 1993Q2-2015Q3 and 1993Q2-2007Q4 samples, respectively, this effect is not statistically significant and almost disappears after the fifth quarter. The interest rate increases in the first quarter between 0.6 and 1.7 basis points

("INT") due to the higher debt required by the government. This effect goes to almost zero after the 20th and 10th quarters, in the 1993Q2-2015Q3 and 1993Q2-2007Q4 sample scenarios, respectively. The response of the exchange rate ("LER") is statistically significant in the first sample and not significant in the second sample ("LER"). However, initially, the median exchange rate depreciates on impact in both samples, reflecting the effect of a reduction in net exports. In the following quarters, the exchange rate increases, which could be a response to incoming capital flows motivated by higher interest rates.

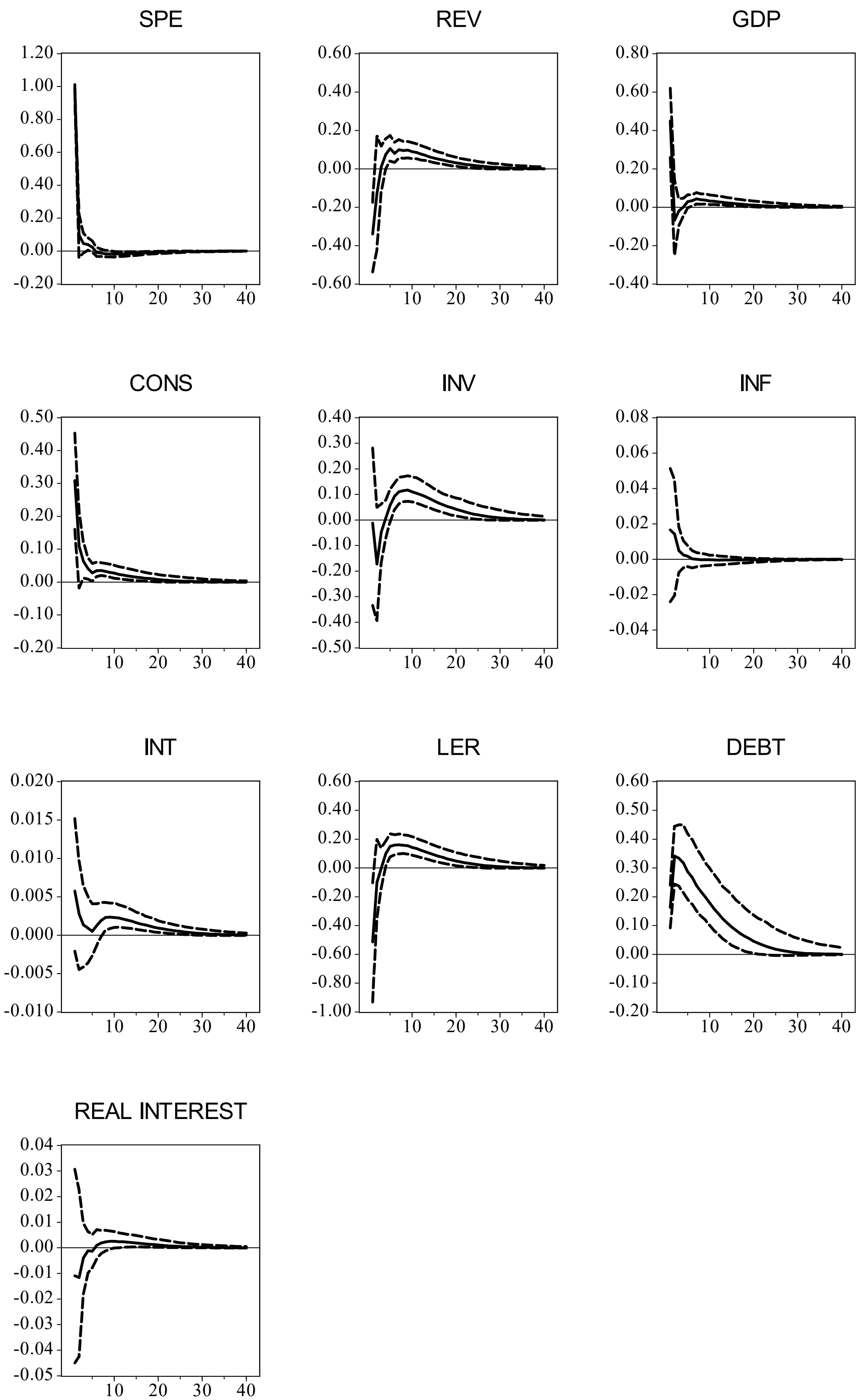


Figure 2.4 Response to a government spending shock of one dollar, 1993Q2 -2015Q3 sample

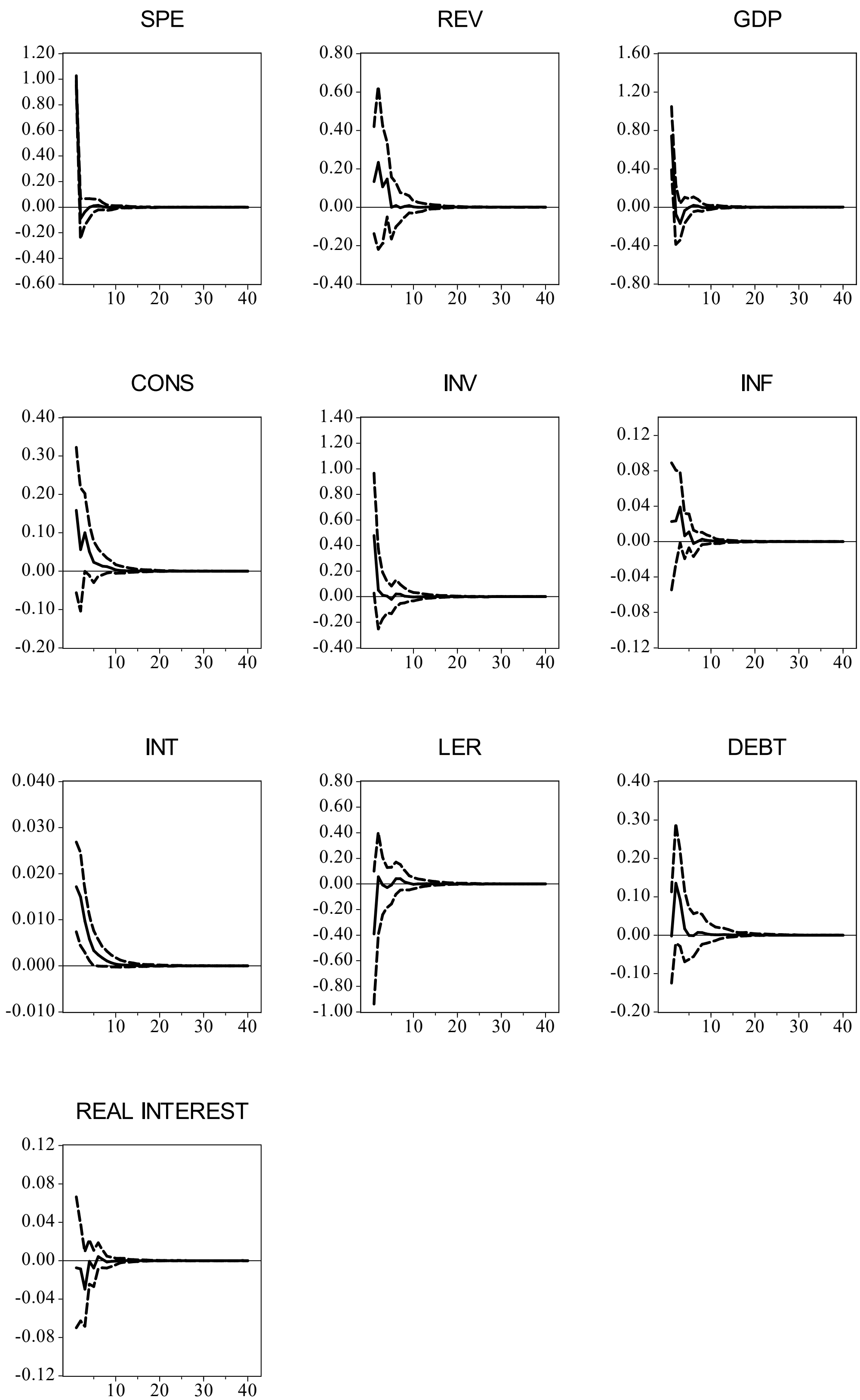


Figure 2.5. Response to a government spending shock of one dollar, 1993Q2 -2007Q4 sample

2.5.3 The effects of a government revenue shock

Figures 2.6 and 2.7 show the impulse response functions to a shock in government revenue for the 1993Q2-2015Q3 sample and the 1993Q2-2007Q4 sample, respectively. The response of GDP to government revenue is also shown in Table 2.2. For both samples, the impulse response of GDP to a shock in government revenue is statistically significant only for the first quarter. The median response shows that a dollar shock to government revenue produces a decrease in GDP on impact of 20 cents and 26 cents in the 1993Q2-2015Q3 and 1993Q2-2007Q4 sample scenarios, respectively. In the following 2 to 4 quarters, the GDP response becomes positive (up to 2 to 6 cents). This temporary positive effect is also found in other studies such as Parkyn and Vehbi (2013), De Castro and Hernandez de Cos (2008) and Fielding et al. (2011). De Castro and Hernandez de Cos (2008) explain this effect by the positive effect on government spending and Fielding et al. (2011) suggest that this effect could be explained by an increase in productivity after the revenue shock.

In the 1993Q2-2015Q3 sample scenario, the debt-to-GDP ratio decreases by 0.17 per cent points in the first three quarters and is approximately zero after 230 quarters. The initial decrease of the debt-to-GDP ratio is the result of the positive revenue shock and the initial decrease in the government spending response (12 cents). In the 1993Q2-2007Q4 sample, the decrease in the debt-to-GDP ratio is smaller than the decrease in the full sample case and the convergence to the initial value of the ratio is faster.

Private consumption decreases by 12 and 10 cents on impact as a response to a dollar increase in government revenue in the 1993Q2-2015Q3 and 1993Q2-2007Q4 sample scenarios, respectively. These responses are statistically significant. For the same increase in government revenue, investment decreases by 3 and 14 cents for the 1993Q2-2015Q3 and 1993Q2-2007Q4 samples, respectively and these responses are not statistically significant in both scenarios.

The response of the inflation rate is small and not statistically significant in both samples. The median response in both samples decrease, getting to the lowest point in the third quarter with a negative response of 0.004 and 0.013 per cent points for the 1993Q2-2015Q3 and 1993Q2-2007Q4 sample, respectively, returning to zero gradually in the following quarters. The nominal interest rate diminishes by around 0.3 basis points on impact in the full and short samples. The lower interest rate is associated with the lower debt required by the government. The impact response of real exchange rate is not significantly different from zero in the full sample; however, the temporary depreciation afterwards is statistically significant. The exchange rate response is not statistically significantly in the 1993Q2-2007Q4 sample in most quarters, although the median response shows a temporary depreciation.

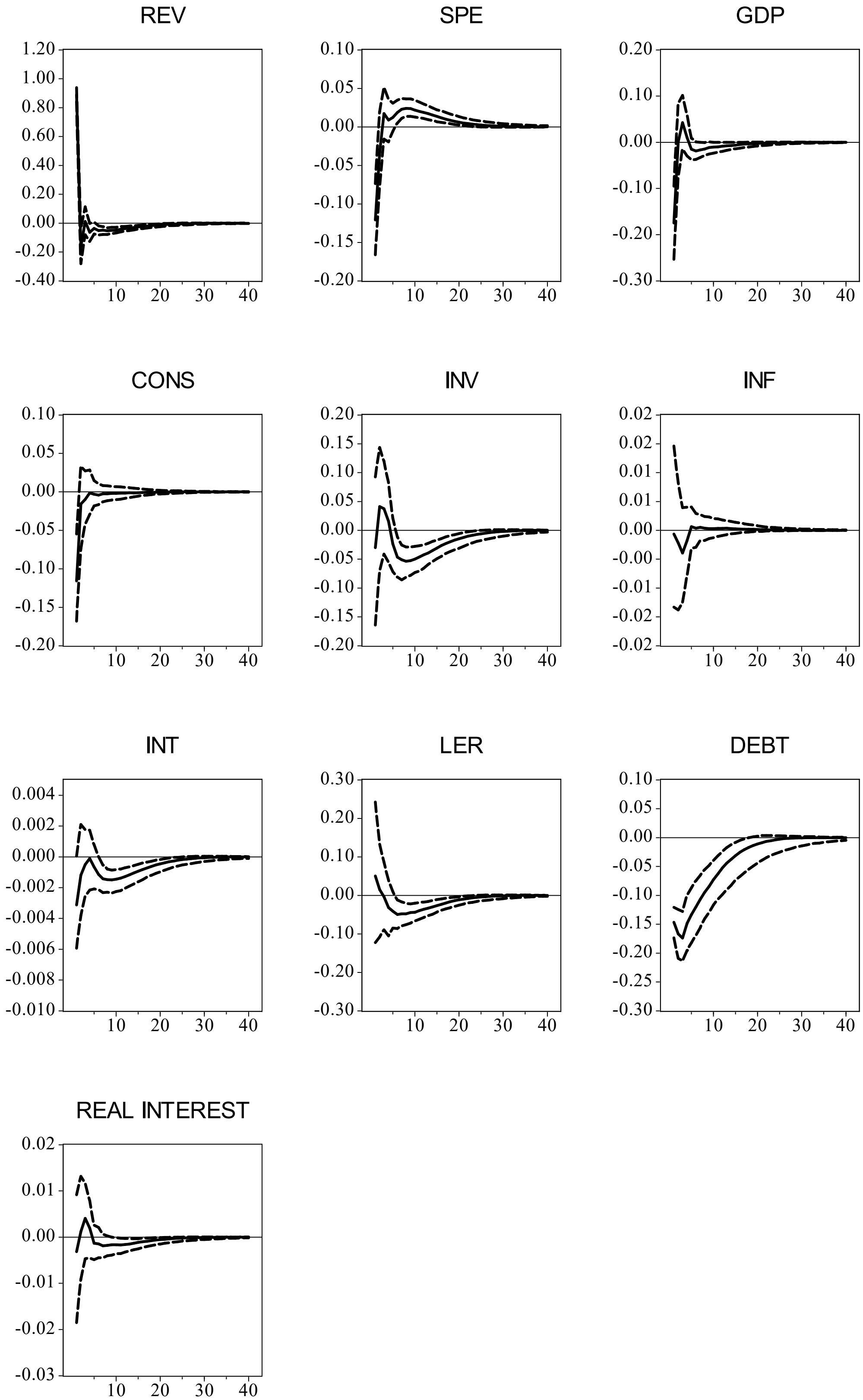


Figure 2.6 Response to a government revenue shock of one dollar, 1993Q2-2015Q3 sample

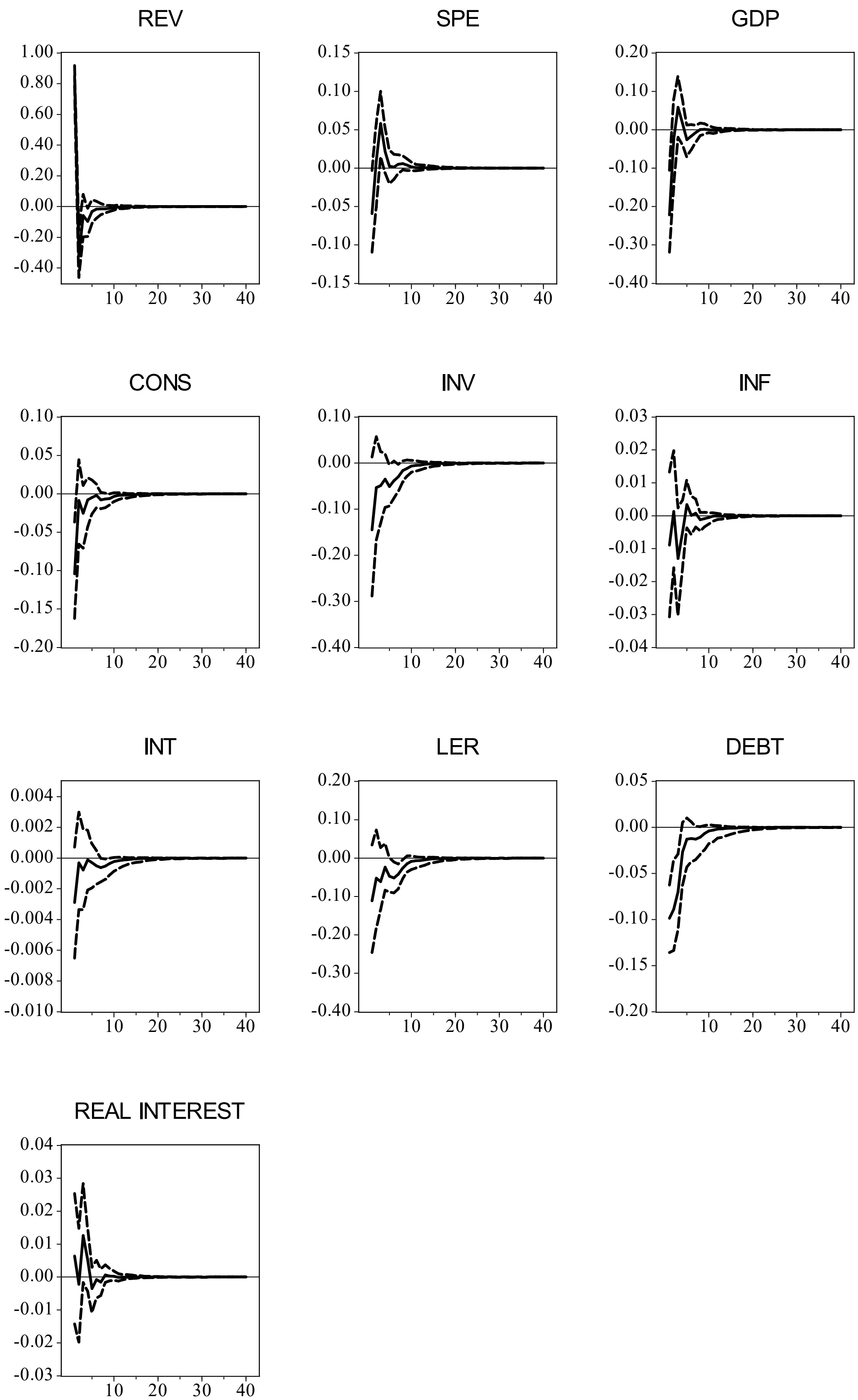


Figure 2.7 Response to a government revenue shock of one dollar, 1993Q2-2007Q4 sample

2.6 Comparison of different models

This section assesses how different model specifications affect the estimates of the effect of government spending on output for the sample 1993Q2-2015Q3. In particular, these specifications confirm that the effect of fiscal policy is not persistent and show the effect of modelling with debt feedback. The models compared in this section are summarized in Table 2.3.

Table 2.3 Model specifications (1 lag)

	Endogenous Variables	Exogenous variables	Debt feedback
Model 1	SPE, REV, GDP	Constant, trend, $trend^2$, $trend^3$	no
Model 2	SPE, REV, GDP, INF, INT	Constant, trend, $trend^2$, $trend^3$	no
Model 3	SPE, REV, GDP, CONS, INV, INF, INT, LER	Constant, trend, $trend^2$, $trend^3$, yus, yus(-1), i_us, i_us(-1), inf_us, inf_us(-1), i_us, i_us(-1), ltot, ltot(-1)	no
Model 4	SPE, REV, GDP, CONS, INV, INF, INT, LER	Constant, trend, $trend^2$, $trend^3$, yus, yus(-1), i_us, i_us(-1), inf_us, inf_us(-1), i_us, i_us(-1), debt(-1), debt(-2), debt(-3), debt(-4), ltot, ltot(-1)	yes

Figure 2.8 shows the dollar response to a unit government spending shock in the four models described in Table 2.3 for the 1993Q2-2015Q3 sample.

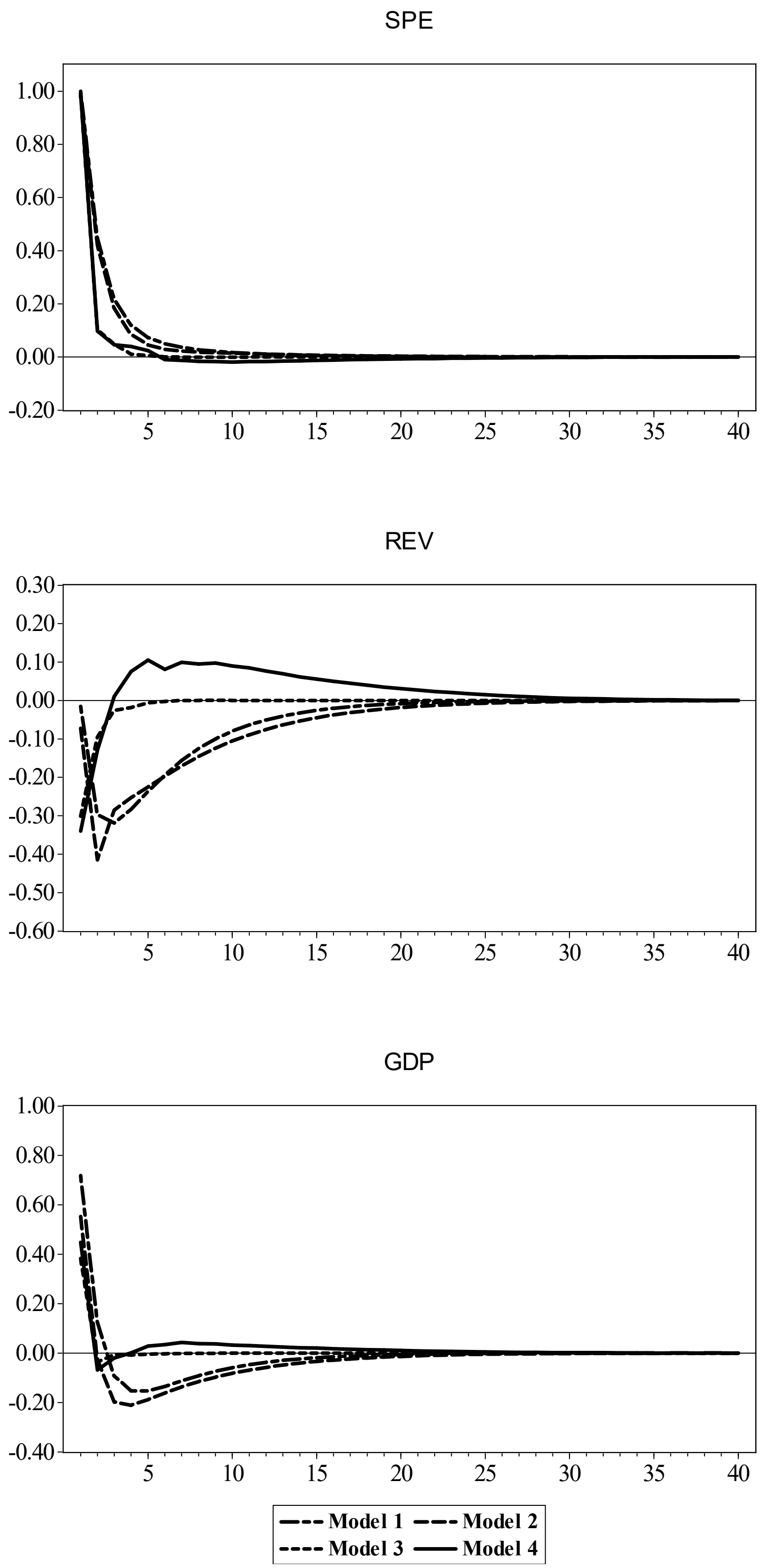


Figure 2.8 Response to a spending shock of one dollar under different model specifications, 1993Q2-2015Q3 sample.

Model 4 is the model discussed so far. Model 4 includes variables with one lag following the AIC criteria. The other models also include variables with one lag. The first model includes the same endogenous variables included in the Blanchard and Perotti (2002) model and the second model is similar to Perotti (2004). The impact multipliers are 0.72 and 0.55 in the first and second models, respectively. Net revenue contracts in both models for a long period of time. Model 3, in addition to the variables in Model 2, includes the real exchange rate as an endogenous variable and the US GDP, the US interest rate, the US inflation rate and the terms of trade as exogenous variables. The multiplier is 0.39, lower than the median multiplier in Model 2. These three models show that the fiscal shocks and the output response take place basically during the first quarter.

Model 4 includes the same endogenous and exogenous variables included in Model 3 and debt that evolves according to the government budget constraint in equation (2). Figure 2.9 shows the response of the endogenous variables, debt and real interest rate to a government spending shock for Model 3 and Model 4 using the 1993Q2-2015Q3 sample.

When debt feedback is excluded from the model, the debt-to-GDP ratio does not converge back to its initial level during the forecast period, while convergence does take place in the model with debt feedback, as described in Section 2.6. When debt feedback is included in the model, the shock to government spending generates a higher GDP multiplier on impact and over time. The cumulative multipliers are 0.28 and 0.44 after 2 years in models 3 and 4, respectively. Including debt feedback also results in higher government revenue and exchange rate than the corresponding responses in the model without debt feedback. The GDP and net revenue responses in the model with debt feedback contribute to the gradual reduction of the debt-to-GDP ratio. The composition of the change of GDP is also affected with more investment and less net exports over time in the model with debt feedback. The investment response is higher in the model with debt feedback, which could be associated with the higher income response and lower prices of investment due to the appreciation of the exchange rate. The changes in net exports can also be affected by a higher exchange rate.

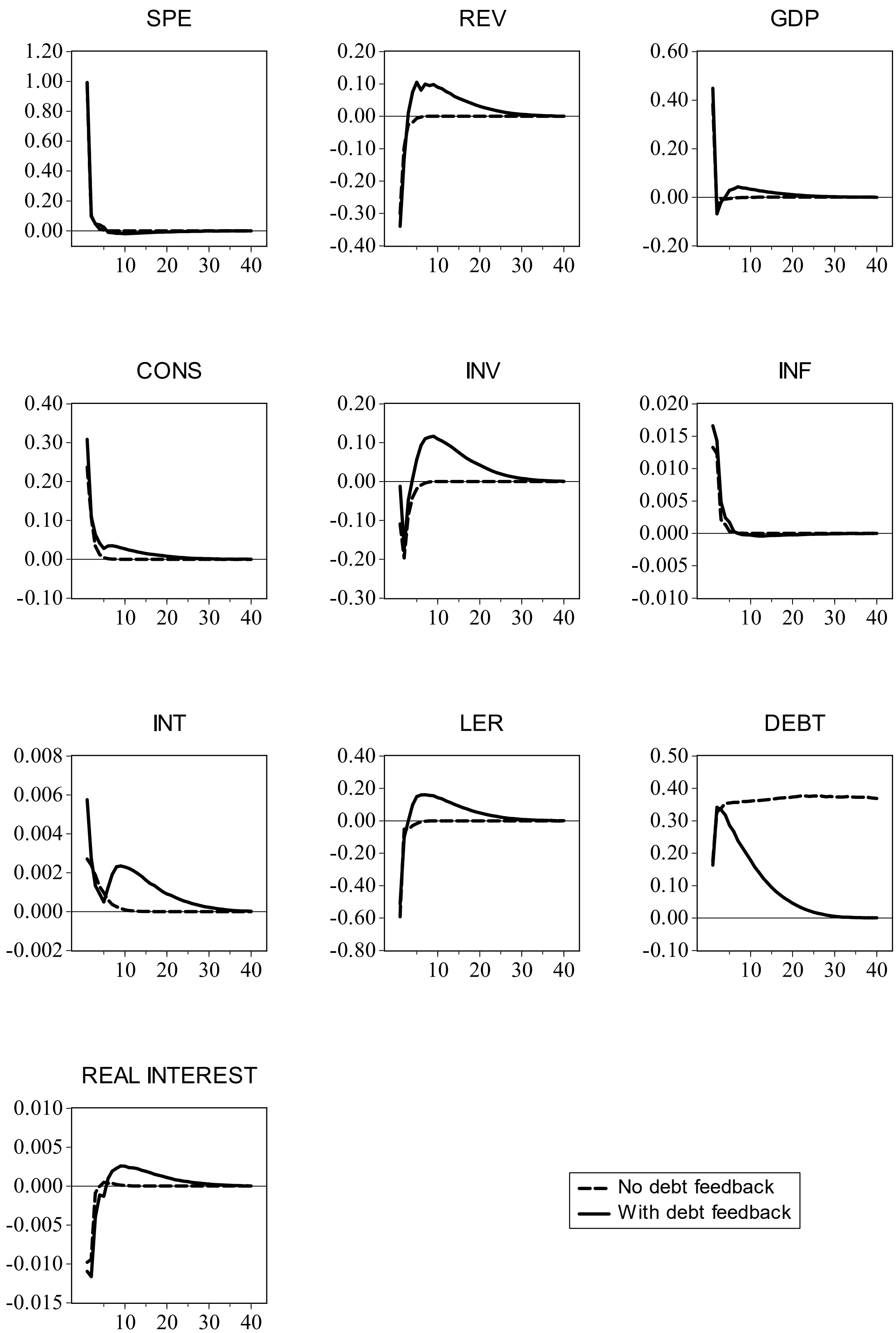


Figure 2.9 Response to a spending shock of one dollar with and without debt feedback, 1993Q2-2015Q3 sample.

2.7 Conclusions

This chapter has assessed the effect of fiscal policy on real activity and debt dynamics in an SVAR model for Australia that includes the external sector. The multipliers were estimated for two sample periods. Both sample periods start with the implementation of inflation targeting. The first sample period ends in 2015Q3, and the second sample period ends in 2007Q4, before the period of the global financial crisis. The impact spending multiplier is 0.45 for the sample of 1993Q2 to 2015Q3 and 0.75 for the sample of 1993Q2 to 2007Q4. The impact of a revenue shock on output is -0.20 for the sample 1993Q2 to 2015Q3 and -0.26 for the sample 1993Q2 to 2007Q4. These impact multipliers are statistically significant. The model shows that the effect of fiscal policy is of short duration and mainly takes place during the first quarter.

The positive shock to government spending increases private consumption for both samples considered. This result does not support the neoclassical theory that predicts that a positive shock to government spending reduces consumption, and supports the Keynesian models that predict the opposite effect, especially in the 1993Q2-2015Q3 sample scenario where the response of consumption is statistically significant.

Although net exports are not included in the model, they should be decreasing significantly on impact, considering the response of output, consumption and investment to a dollar increase in government spending. When debt feedback is included in the model, the shock to government spending generates a higher GDP on impact and over time as well as higher government revenue and exchange rate than the corresponding responses in the model without debt feedback. The GDP and net revenue responses in the model with debt feedback contribute to the gradual reduction of the debt-to-GDP ratio. The composition of the change of GDP is also affected with more investment and less net exports over time.

Appendix 2.1. Elasticities

The identification procedure depends on the elasticities used in the model, which are shown in Table 2.1. In order to assess the robustness of the results, the impulse response functions to a government spending shock were estimated, assuming tax elasticities of 50 per cent higher and lower than the elasticities assumed in Table 2.1. Overall, the impulse response functions are similar to the corresponding functions with the elasticities assumed in Table 2.1.

Table 2.4 shows the estimation of the elasticity of the real exchange rate of net government equivalent to 0.51. This elasticity multiplied by the imports elasticity of net revenue (0.03) results in the exchange rate elasticity of net revenue of 0.015.

Table 2.4 Estimation of the exchange rate elasticity of real imports

Dependent variable: Log of real imports
(Method of General Method of Moments)

Variables	coefficient	p-value
Log of real exchange rate	0.5084	0.0567
Log of real GDP	0.7846	0.0000
AR(1)	0.9925	0.0000
$R^2 = 0.997$		

Instrument variables: First lag of the log of the real exchange rate and the first and second lags of the log of real GDP.

Table 2.5 shows the calculation of the income elasticity of net revenue mainly based on Price et al., (2015) estimations for the OECD economies.

Table 2.5 Estimation of the income elasticity of net revenue

	Weight	Elasticities
Personal income tax	0.62	2.25
Corporate income tax	0.25	1.85
GVA	0.62	0.97
Transfers and subsidies (*)	-0.56	-1.00
Weighted average		3.00

Source: The elasticities are taken from Price et al. (2015).
The weights are estimated as the average share of net revenue for the period 1993Q2 – 2015Q3. The elasticity of other items of net revenue are assumed to have an elasticity of zero.
(*) Elasticity is approximated based on the income elasticity of social benefits.

Appendix 2.2 Responses to fiscal shocks using estimated quarterly net debt

Figures 2.10 and 2.11 show the response of the endogenous variables, debt, and real interest rate to fiscal shocks for the 1993Q2-2015Q3 sample, using the net debt estimations. The methodology to estimate net debt is described in Section 2.4. The shape of the responses is similar to the responses in Figures 2.4 and 2.6, although there are small differences in terms of the magnitude of the response. For example, the impact response of output to a unit spending shock is 0.35 (compared to 0.45 in Figure 2.4), and the response to a unit revenue shock is -0.18 (compared to -0.20 in Figure 2.6).

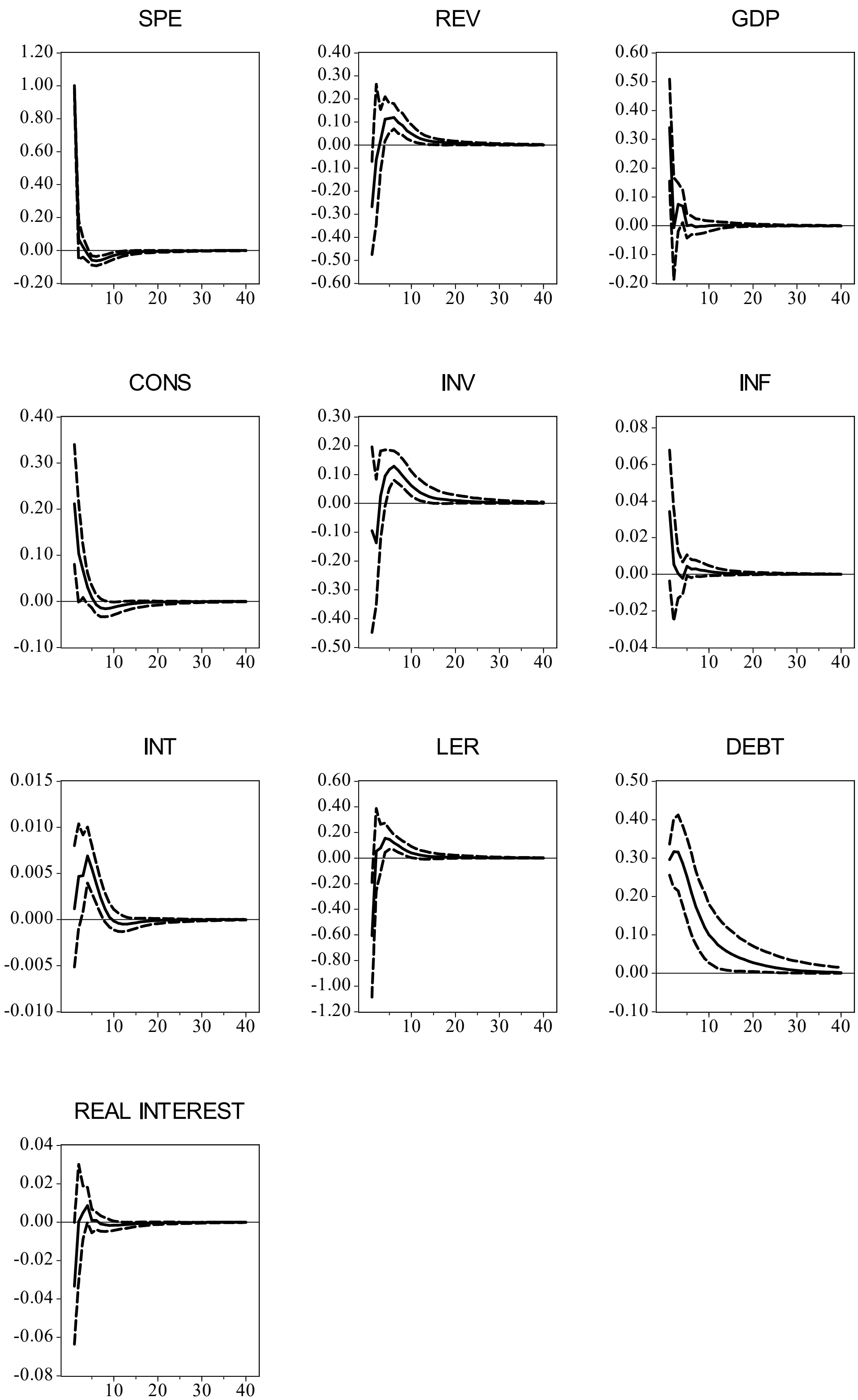


Figure 2.10 Response to a spending shock of one dollar using net debt, 1993Q2-2015Q3 sample

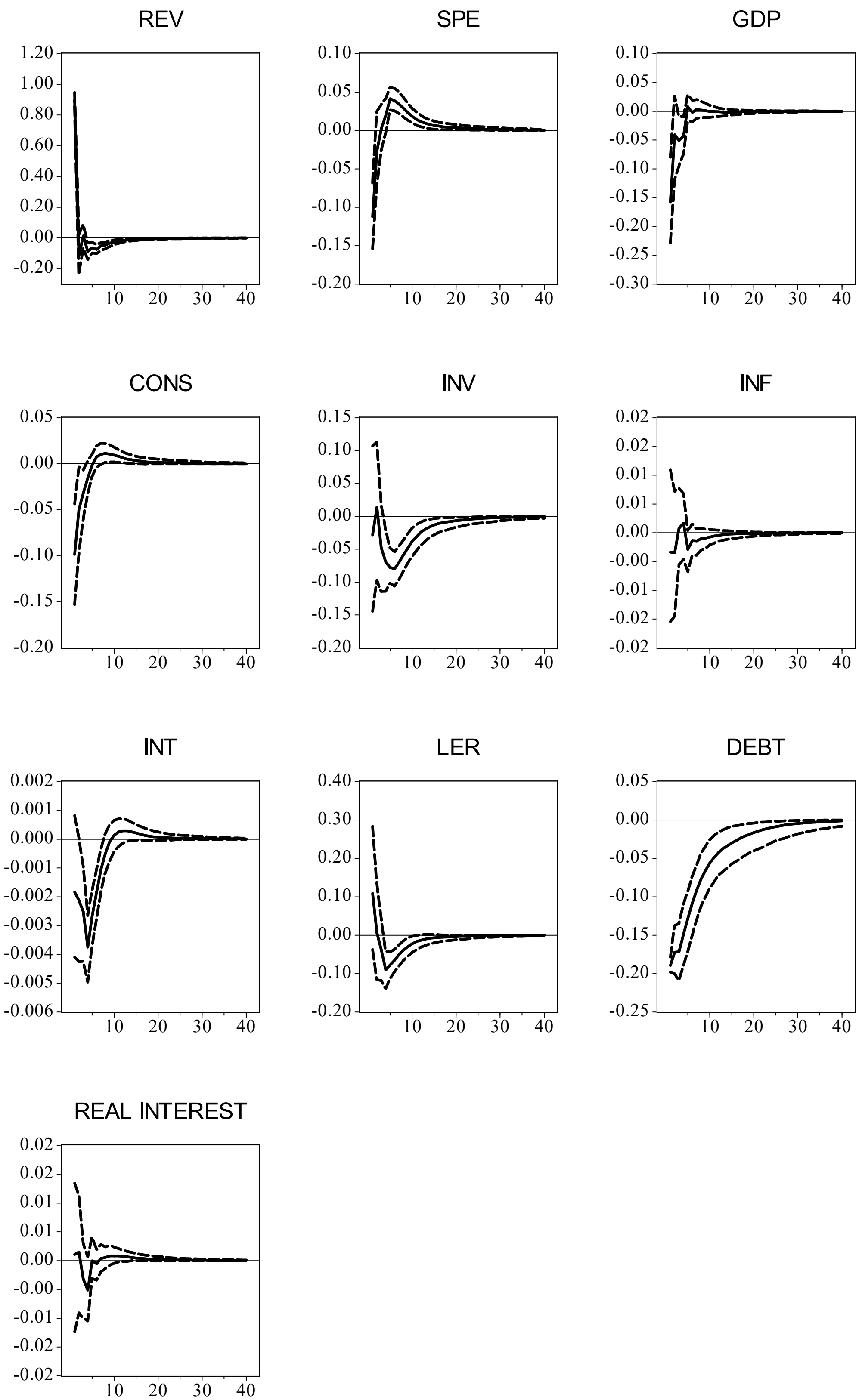


Figure 2.11 Response to a revenue shock of one dollar using net debt, 1993Q2-2015Q3 sample

Interaction between monetary policy, credit and asset prices

ABSTRACT

This study assesses the relationship between monetary policy, credit and asset prices in Australia from 1993Q2 to 2017Q4, using a FAVAR approach. Two asset prices are considered: share and housing prices. The shock for monetary policy and credit are the changes to the cash interest rate and the growth rate of credit to the private sector, respectively. The results indicate that a contractionary monetary policy reduces share and housing prices and that this effect is statistically significant. The effect of an increase in credit on asset prices is not statistically significant and is negative for share prices and positive for house prices. This study also finds a statistically significant positive credit response to an increase in share and housing prices, providing evidence supporting the financial accelerator hypothesis.

3.1 Introduction

The global financial crisis is a reminder that a financial crisis due to large falls in asset prices and high leverage can occur in the context of price stability. This experience has reignited the debate on the appropriate policy response to achieve financial stability and contain financial imbalances. After the Global Financial Crisis, there has been an increasing consensus that monetary authorities should respond to emerging signals of financial imbalances (Bloxham et al., 2010). However, in order to implement a response, central banks should take into account the effect of monetary policy and credit on asset prices and other relevant macroeconomic variables and the feedback effect of asset prices on financial and real variables. Changes in asset prices affect the valuation of assets that are used as collateral to access bank loans. This feedback effect has been emphasized by Kiyotaki and Moore (1997) and Bernanke et al. (1994), who study the role of the value of assets in the availability of loans and the transmission mechanism of monetary policy. The current study assesses the effect of monetary policy and credit on share and housing prices in Australia and the effects of asset prices on the interest rate and credit using a FAVAR approach. This study also quantifies the collateral effects of these policies on other macroeconomic variables, such as output and prices.

There is a debate concerning how central banks should react to movements in asset prices. According to Greenspan (2002, 2004, 2010), it is not possible to identify an asset price bubble with certainty and hence a pre-emptive policy response could be destabilising. According to his view, central banks should respond to the burst of an asset bubble but not respond to asset price booms. Bernanke and Gertler (1999) consider that focusing on targeting inflation would implicitly address the problems generated by asset booms and bubbles without having to decide whether the asset price movements respond to fundamentals or not. This approach was the prevalent view of central banks in most developed economies, where the emphasis was on inflation targeting using interest rates as the instrument of monetary policy rather than money aggregates. White (2006), in his study comparing bubbles and busts in the 1990s and the 1920s, concludes that the methods of apportioning bubbles and fundamentals in a boom are fragile and that central banks have a role in responding to market crashes as providers of liquidity for a brief period of time and without shifting its intermediate or long-term goals. According to Borio (2011), central banks did not lose interest in financial stability, but financial stability hardly ever influenced the stance of monetary policy.

An alternative view is presented by Cecchetti et al. (2000 and 2002), Kent and Lowe (1997) and Woodford (2012). Cecchetti et al. (2000 and 2002) argue that central banks should react to asset price misalignments without necessarily having to target asset prices. Even a modest increase in interest rates during asset price bubbles can affect economic agents' expectations about the willingness of the central bank to lean against the wind. Concerning the uncertainties in estimating a price bubble, they argue that central banks already face similar uncertainty in estimating the output gap. Kent and Lowe (1997) propose that central banks should raise the probability of the bust through an increase in interest rates. In relation to the argument that bubbles are not predictable and are difficult to identify until they burst, Woodford (2012) considers that central banks do not need to predict exactly when the crisis will occur, it suffices that central banks identify circumstances (e.g. extreme levels of leverage in the financial sector) under which the risk of a crisis increases and identify policies that can affect these risks. He claims that these risks can be reduced with small changes in the short term interest rate. He proposes a "flexible inflation targeting" that aims to control the inflation rate in the long-run but responds to financial imbalances (or output gaps as currently happens) in the short-run.

In addition to the direct effect of the interest rate on asset prices, credit has also been associated with the evolution of asset prices. Many studies consider the surge of asset price and credit as leading indicators of the risk of financial crisis: IMF (2009b), Claessens et al. (2013), Babecký et al. (2012), Borio and Lowe (2002), Borio and Drehmann (2009), Reinhart and Rogoff (2008) and Altunbas et al. (2010). However, the quantification of the effects of credit on asset prices and the feedback effect has not been extensively studied, and this is one of the objectives of this study.

Although the emphasis of this chapter is on the quantification of the interaction between monetary policy, credit and asset prices, it also quantifies the collateral effects of the shocks to these variables on other macroeconomic variables. A change in policy levers to affect asset prices can also have significant negative effects on other macroeconomic variables. For example, in a study that includes 17 OECD countries, Assenmacher-Wesche and Gerlach (2008a) find that using monetary policy to offset asset price movements can have sizable effects on economic activity. Dokko et al. (2009) find that tight monetary policy in the US sufficient to reduce housing prices would have resulted in an unemployment rate far higher than the realised rate. Svensson (2014) also finds evidence for Sweden that the monetary policy effect on household indebtedness is very small compared to the large costs of too-high unemployment and too-low inflation. The approach followed in this chapter allows not only the study of the interaction between the interest rate, credit and asset prices but also shows the effect of the shocks to these variables on other variables such as GDP, employment, GNE and inflation rate. The FAVAR model can evaluate the effects of the shocks on any of the variables included in the database, which includes 236 variables, allowing a thorough analysis of the collateral effects of the shocks.

The results indicate that an increase in the policy interest rate reduces share and housing prices and that this effect is statistically significant. The effect of an increase in credit on asset prices is not statistically significant and is negative for share prices and positive for house prices. This study also finds a statistically significant positive response of credit to an increase in share and housing prices, providing evidence that supports the financial accelerator hypothesis.

This chapter is organised as follows. Section 3.2 surveys studies that quantify the interaction between monetary policy, credit and asset prices. Section 3.3 discusses the FAVAR methodology. Section 3.4 describes the data. Section 3.5 discusses the results. Section 3.6 concludes and summarises the effects of the cash rate, credit and asset prices shocks on the macroeconomic variables included in the base model.

3.2 Literature on the interaction between monetary policy, credit and asset prices

This section reviews the literature on the interaction between the policy interest rate, credit, share prices and housing prices. This review emphasizes the literature that presents the quantification of the relationship between these variables and the interaction mechanisms. This information is useful to compare with the results of this study in Section 3.5.

Monetary policy and asset prices

Goodhart and Hofmann (2008) analyse the interaction between money, credit, house prices, and economic activity in industrialized countries. The analysis is based on a fixed-effects panel VAR, estimated using quarterly data for the period 1970–2006. The vector of endogenous variables includes the log difference of real GDP, the log difference of the consumer price index, the level of the short-term nominal interest rate, the log difference of nominal residential house prices, the log difference of nominal broad money, and the log difference of nominal private credit. They find evidence of a significant multidirectional link between house prices, monetary variables, and the macroeconomy and that the link between house prices and monetary variables is stronger over a more recent sub-sample from 1985 to 2006. They found that a 25 basis point expansionary interest rate shock leads to a statistically significant 0.8 per cent increase in house prices.

Similar research is conducted by Assenmacher-Wesche and Gerlach (2008b) using the following variables in a panel VAR with Cholesky identification: consumer prices, GDP, credit, three-month interest rate, residential property prices and equity prices. Unlike the Goodhart and Hofmann study, Assenmacher-Wesche and Gerlach estimate the panel VAR in levels, with all variables except for the interest rate expressed in logarithms. They estimate that a positive interest rate shock of 0.75 basis points decreases nominal asset prices, consumer price and real GDP in 1.8 per cent, 0.1 per cent and 0.45 per cent, respectively.

Del Negro and Otrok (2007) estimate a VAR with six variables: a house factor, total reserves, CPI inflation rate, GDP growth, the 30-year mortgage rate and the Federal Funds rate. The first four variables are in growth rates and the interest rate variables are in first differences. The treatment of the interest rate is similar to the one used in the present chapter. After a shock to the policy interest rate of approximately 17 basis points, house prices immediately fall by of 0.6 per cent but this fall dissipates rapidly, with lower housing prices of 0.1 per cent after 2 years. Sharp falls in GDP and prices also occur immediately by 0.11 per cent and 0.035 per cent, respectively. After two years, the GDP response is zero, and the prices response is still negative by 0.01 per cent. Kuttner (2012) finds that studies based on VAR models show that the impact of a 25 basis points reduction to the policy interest rate on house prices is significantly smaller (0.3 to 0.8 per cent) than the estimates from models based on user cost theory (1.3 to 1.6 per cent). Other studies include Otrok and Terrones (2005), Jarocinski and Smets (2008) and Sá et al. (2011), which estimate VAR models where a monetary policy shock is identified using sign restrictions.

The studies presented in this subsection document statistically significant effects of monetary policy on house prices. Even though there is a negative effect of contractionary monetary policy on house prices, the cost of implementing this policy can be onerous in terms of the effects on output and inflation. As documented by Williams (2015) based on different empirical studies, the estimated ratios of the effect on house prices relative to the effect on real GDP after two years are clustered between 3 and 6 with a median estimate of 4. This means that to offset an increase in house prices of 20 per cent, a monetary policy intervention would require a decline in GDP of 5 per cent.

On the other hand, asset prices can affect interest rates. An increase in asset prices can increase wealth, which raises aggregate demand and the demand for credit, generating pressure for a rise in interest rates. Furthermore, higher asset prices allow credit-constrained households that use their assets as collateral for loans to improve their borrowing capacity and hence increase the demand for loans and interest rates. Assenmacher-Wesche and Gerlach (2008b) report a shock of approximately 2.1 per cent in housing prices increases the interest rate with a peak increase of 25 basis points. Additionally, a shock of 0.9 per cent to equity prices generates a response in the interest rate of 7.5 basis points in four quarters, which remains around that value for the next 10 quarters. Goodhart and Hofmann (2008) document positive responses of the interest rate (approximately a peak of 12 basis points in two years) to a positive shock to house prices of 1 per cent. For Australia, Fry et al. (2010) show positive responses of the interest rate to shocks to supply and demand for houses while Fry et al. (2008) and Dungey and Pagan (2009) find a positive response of the interest rate to an equity price shock.

Monetary policy and credit

Credit conditions can be influenced by changes in the policy interest rate. An increase in the policy rate is expected to reduce credit. Credit can also change due to other factors besides the changes in monetary policy, such as innovations that facilitate securitisation processes, overseas funding conditions for the banks, and prudential regulation. Credit shocks independent of monetary policy action can also affect the interest rate. Hence the relationship between credit and the interest rate is a two-way interaction.

Peersman (2011) estimates the impact of different types of bank lending shocks in the Euro area using an SVAR model with sign restrictions to identify loan demand. His model allows the evaluation of the two-way interaction of the interest rate and credit. Peersman's model includes industrial production, prices, the volume of bank loans, the monetary base, the interest rate on bank loans, and the monetary policy rate. Peersman (2011) shows that a reduction of the policy interest rate increases the volume of bank loans. He also observes that after a positive lending demand shock, the interest rate for loans and the policy interest rate increase during the first 12 quarters and decrease afterwards. A positive credit shock not related to monetary policy generates a decrease in the lending rate but an increase in the policy rate.

Nocera and Roma (2017) find that an increase in 25 basis points in the monetary policy rate reduces real banking loans in 7 European countries, with a maximum average decrease of 0.6 per cent occurring contemporaneously. On the reverse relationship, Gambetti and Musso

(2012), in their study of the effects of credit supply shocks on the business cycle for the Euro Area, the UK and the United States, identify loan supply using sign restrictions. They find a statistically significant negative response of lending and short-term interest rates to a loan supply shock during the initial quarters (as expected by the restriction) and a positive response afterwards. However, the latter periods are statistically insignificant. Bijsterbosch and Falagiarda (2014) also identify the credit supply shock using sign restrictions and use a time-varying parameter vector autoregressive model that includes the real GDP growth rate, the inflation rate, the credit growth rate, a composite lending rate and the short-term market rate. They find that credit supply shocks are an important driver of the business cycles in the Euro area. Their study also shows that a credit supply shock reduces the lending rate in the first quarters following the shock but increases later as the short-term interest rate increases. In the last two studies mentioned above, Gambetti and Musso (2012) and Bijsterbosch and Falagiarda (2014), the shock to credit growth is persistent in most countries included, resulting in significant increases in the level of credit over time. A similar result is found for Australia in the present study.

In relation to models for the Australian economy, Suzuki (2004) estimates VAR models to assess whether the lending channel is dominant in Australia. Suzuki (2004) includes prices, GDP, the cash rate, monetary base, loan price, loan quantity, the real exchange rate, commodity prices, US prices, US GDP and the US interest rate. The US variables are treated as block exogenous. He claims that the lending channel is dominant if three conditions are met after a contractionary monetary policy: the quantity of bank loans does not increase, the price of loans rises, and the real output decreases. His estimates show that credit and loan prices increase after a positive interest rate shock. These results contradict the hypothesis that the lending channel of monetary policy is dominant and imply that banks accommodate a temporary increase in demand for loans. Another relevant study for Australia is that conducted by Berkelmans (2005). He estimates two models using a 7-variable SVAR that include real commodity prices, real US GDP, real Australian GDP, the inflation rate, real credit, the cash rate, and the real weighted exchange rate index. In the first model, the monetary response is endogenous, and in the second model, there is no monetary response. In the endogenous monetary policy response model, after a shock to the cash rate in 0.25 basis points, the cash rate reduces rapidly, and credit diminishes by around 0.5 per cent in 6 years. A shock to credit of 0.5 per cent increases the cash rate by 80 basis points on impact, which gradually reduces to almost zero after the next 6 years. In the model with no monetary response, a shock to the cash rate of 0.25 basis points decreases credit significantly over the following 6 years (3.5 per cent) as the cash rate after the shock is not allowed to fall (the cash rate remains constant at 0.25 basis points over the base scenario). Similarly, a shock to credit of 1 per cent produces persistent growth in this variable (around 6 per cent in 6 years) as the cash rate is not allowed to increase.

Credit and asset prices

In relation to the role of credit and asset prices, many studies consider the importance of monitoring asset price increases and credit expansion as the surge of these variables is identified as a leading indicator of financial crises: IMF (2009b), Claessens et al. (2013), Babecký et al. (2012), Borio and Lowe (2002), Borio and Drehmann (2009), Reinhart and Rogoff (2008) and Altunbas et al. (2010). Although the correlation between credit and asset prices is observed, the causal relationship could be both ways.

Credit expansion is expected to increase the price of assets. An increase in credit may affect asset prices in different ways. Property prices are determined by the discounted future stream of property returns. An increase in credit availability may lower interest rates and improve current and future expected economic activity. Both effects stimulate asset price growth. Another way a credit expansion affects asset prices is that more credit increases the demand for assets, and with a temporarily fixed supply of houses and shares, their prices increase.

On the other hand, an increase in asset prices has a positive effect on credit through different mechanisms. The first mechanism is related to the financial accelerator as described by Kiyotaki and Moore (1997) and Bernanke et al. (1994). Lenders are likely to have little information about the reliability of any given borrower. Due to this asymmetric information, borrowers facing high agency costs (e.g., consumers and small businesses) are required to maintain assets as collateral to have access to credit. An increase in asset prices raises the value of collateral required by banks, increasing credit. Conversely, a fall in asset prices deteriorates the value of collateral and, hence, the ability of investors to borrow, which negatively impacts investment and output and reduces asset prices. This process repeats in a loop called the financial accelerator. Small adverse shocks to the economy can be amplified to cause large fluctuations in economic activity. Other mechanisms that explain the effect of asset prices on credit are outlined by Segoviano, Goodhart and Hofmann (2006). An increase in asset prices generates an increase in wealth, which induces consumers to increase spending and hence their demand for credit to smooth consumption. They also affirm that an increase in asset prices increases credit through the improvement of the capacity of banks to provide more loans, not only because of the higher value of the collateral of loans but also because of the higher value of their own portfolio.

3.3 The FAVAR approach

Most of the empirical studies mentioned above are based on VAR models. One problem of VAR models is that only a limited number of variables can be included in the models that can lead to results not supported by economic theory. For example, a common puzzle found in VAR models is the price puzzle, where a reduction of interest rates reduces prices as reported by Sims (1992) and Eichenbaum (1992).

According to Bernanke et al. (2005), these puzzles are the result of the limited information in the VAR models that are usually constructed using a relatively small number of variables. A related problem motivated by the limited information in VAR models is the problem of measurement errors in economic statistics such as GDP and CPI that do not necessarily capture the economic concepts of economic activity and inflation. Additionally, low-dimensional VARs only allow the analysis of responses of the small number of variables included in the model. One way to overcome these limitations is to increase the number of variables in the models; however, this generates a statistical problem reducing the degrees of freedom of the model by increasing the number of unrestricted VAR coefficients.

An alternative is the use of factors that summarise the information of a large number of economic variables and apply the VAR model on these factors and observable variables. This is the Factor Augmented Vector Autoregressive (FAVAR) approach developed by Stock and Watson (2002) and Bernanke et al. (2005). This study uses this framework to assess the interaction between the policy interest rate (cash rate), credit and asset prices and the effects on other relevant macroeconomic variables in Australia.

Following Bernanke et al. (2005), the dynamics of a time series can be explained by observed variables and by unobserved factors. Let Y_t be an Mx1 vector of observable economic variables. This vector could contain a policy indicator and observable measures of real activity. The conventional approach is to estimate a VAR using only the M variables in Y_t. However, it is possible that not all information needed to explain the effects of the policy variable are contained in Y_t. Some additional information may be relevant, although not directly observable. This additional information on a large number of variables can be found in an Nx1 vector X_t (informational time series), where N is large. This information can be summarised in a Kx1 vector of unobserved factors, F_t where K is small. The dynamics of F_t and Y_t are given by the following equation.

$$\begin{bmatrix} F_t' & Y_t' \end{bmatrix}' = B(L)\begin{bmatrix} F_{t-1}' & Y_{t-1}' \end{bmatrix}' + v_t, \qquad (1)$$

where $B(L)$ is a conformable polynomial of order d and v_t is an error term with mean zero and covariance Q.

Economic concepts such as 'potential output' or 'credit conditions' that are reflected in a large number of economic variables can be difficult to include in a VAR. This wide range of variables can be summarised in a factor or in a small number of factors, F_t, that can easily be incorporated into a VAR model.

In order to estimate equation (1), there should be a large set of information that can be used to extract the factors. This data set X_t is related to the unobservable factors F_t and the observed variables Y_t by the following equation:

$$X_t = A^f F_t + A^y Y_t + e_t. \qquad (2)$$

Another advantage of the FAVAR approach is that the impulse response functions can be constructed for any variable in X_t.

Bernanke et al. (2005) work with 120 monthly US macroeconomic time series from 1951:1 to 2001:08, which are initially transformed to induce stationarity. Some variables are classified as slow-moving (non-contemporaneous response to monetary policy) and fast-moving (contemporaneous response to monetary policy). In the preferred model of Bernanke et al. (2005), the Federal interest rate is the only observable variable.

Bernanke et al. (2005) used two approaches to estimate equations (1) and (2). The first is the two-step principal component approach. The second approach estimates equations (1) and (2) jointly by maximum likelihood, assuming independent normal errors. This approach is computationally more complex than the first approach. Bernanke et al. (2005) show that both procedures produce very similar results. This study follows the first approach.

In the first step of the two-step principal component approach F_t is estimated, taking the first K+M principal components of X_t denoted $C(F_t, Y_t)$ and determining the part of $C(F_t, Y_t)$ that is not spanned by Y_t. If the interest rate R_t is the only element of Y_t, in order to use these factors in a VAR estimation such as equation (1), the effect of the correlation of the estimated factors with R_t must be removed from $C(F_t, Y_t)$. Bernanke et al. (2005) propose the regression $C(F_t, Y_t) = aC^*(F_t) + bR_t + e$, where $C^*(F_t)$ can be estimated as factors of the slow-moving variables, which by definition, are not contemporaneously correlated with R_t. The estimated F_t can be obtained as $C(F_t, Y_t) - bR_t$. In the second step, equation (1) is estimated using a VAR model.

Bernanke et al. (2005) consider two sets of identification restrictions. The first is the usual normalization of the principal components: $C'C / T = I$ in order to generate a unique set of loadings and scores. The second is related to the identification of structural shocks. The authors assume a recursive structure where R_t is ordered last in Y_t, and all the factors in equation (1) will respond with a lag to changes in R_t. This means that there is no need to identify the factors in equation (1) separately, but only the space spanned by them. Consequently, no further restrictions are required on equation (2).

One of the relevant results in Bernanke et al. (2005) is that, in their FAVAR models, the price puzzle is reduced significantly compared to standard VAR models. Additionally, the response of industrial production is persistent in the VAR model while it returns to zero in the FAVAR models, which is more consistent with long-run money neutrality.

There are several applications of the FAVAR model to different countries. For example, Mumtaz and Surico (2009) extend the Bernake et al. (2005) model to the open economy (UK), including international factors. Boivin et al. (2010) apply the FAVAR approach to analyse the transmission effects of the monetary policy in a small open economy (Canada) and argue that relevant international variables are contained in the domestic variables. Hence they do not include any foreign series in their model. This last approach is followed in this chapter.

3.4 Data and model specification

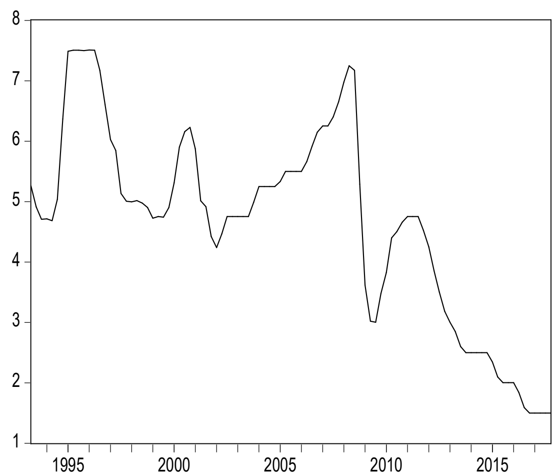
The data include 236 Australian economic variables. The variables are listed in Appendix 3.3 and include indicators of output, aggregate demand, price, interest rate, credit, leverage, as well as other indicators related to Australia's international trade. The sample period is quarterly data from 1993Q2 to 2017Q4. Appendix 3.3 also shows the data mnemonics, the variables assumed as slow-moving, the types of data transformations to ensure stationarity and data sources. The data are seasonally adjusted.

This study considers the following types of shocks in the following variables: the RBA cash interest rate (monetary policy shock), bank credit, share prices, and housing prices under three model specifications shown in Table 3.1. This chapter presents a base model (Model 1), and two additional models (Model 2 and Model 3) to discuss the robustness of the base model. The responses in the FAVAR models include the responses of the Observed Variables and Other Variables listed in the second and fifth columns of Table 3.1. Model 1 consists of 4 lags according to the LR criteria. The same number of lags is used in Model 3 and only one lag is used in Model 2 because of the reduction of degrees of freedom due to the additional variables included.

Table 3.1 List of models

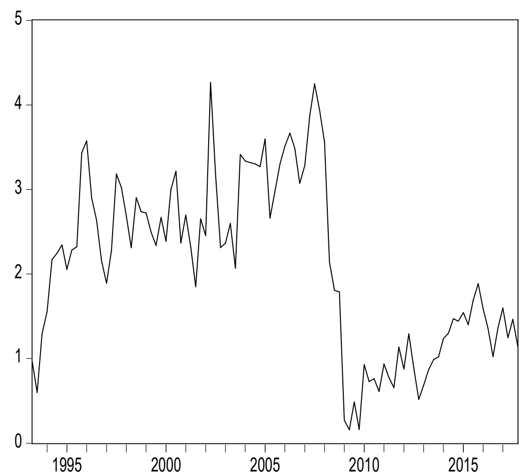
Models	Observable Variables	Type of model	Lags	Other Variables
Model 1	ICASH, CR, SP, HP (one at the time)	FAVAR (7 factors)	4	GDP, GNE, CPI, EMPT
Model 2	GDP, CPI, ICASH, CR, SP, HP	FAVAR (7 factors)	1	GNE, EMPT
Model 3	GDP, CPI, ICASH, CR, SP, HP	VAR	4	

The base model (Model 1) is a FAVAR model with one observable variable, which is also the shock variable. The policy interest rate (*ICASH*), credit (*CR*), share price (*SP*) and house price (*HP*) are included in the model as the observable variable one at the time in a FAVAR model with 7 factors and 4 lags. The interest rate is the cash rate of monetary policy interest rate set by the Reserve Bank of Australia. Credit includes loans and advances of banks and non-banking financial institutions. Share prices are constructed from the MSCI index taken from the GVAR database for the period 1993Q2 to 2016Q4 extended to 2017Q4 using the quarterly per cent change of the ASX 200 index published by the RBA. House price is the price index for single-family houses taken from the Bank for International Settlements database (Code Q:AU:4:3:0:1:6:0). In addition to the responses of these four variables to different shocks, the responses of other variables such as the real Gross Domestic Product (*GDP*), the real Gross National Expenditure (*GNE*), the Consumer Price Index (*CPI*) and employment (*EMPT*) are also presented in Section 3.5 in order to assess the macroeconomic effect of the shocks. These variables are sourced from the Australian Bureau of Statistics. All variables are non-stationary. In order to achieve stationarity, the cash rate is included in simple differences, as in Del Negro and Otrok (2007) that points out the need of stationarity of the variables in a factor model. The other variables are included in log difference forms. The number of factors is chosen to reduce the possibility of the existence of a price puzzle. A set of charts with 3 factors is included in Annex 3, where the main effects of the shocks are similar to the case of 7 factors; however, the price puzzle is still present. The evolution of the cash interest rate, credit growth, share prices, and house prices are shown in the figures below. Figure 3.1 shows the evolution of the cash rate, which is calculated as a quarterly average of the monthly rates published by the Reserve Bank of Australia. There is a clear declining trend after the global financial crisis. Figure 3.2 shows the evolution of the credit growth rate, which corresponds to the credit growth rate, sourced from the RBA Statistics. Figure 3.3 shows the growth rate of share prices, sourced from the GVAR database until 2014, and complemented by data published in the RBA statistics. Figure 3.4 shows the growth rate of house prices, sourced from the Australian Bureau of Statistics.



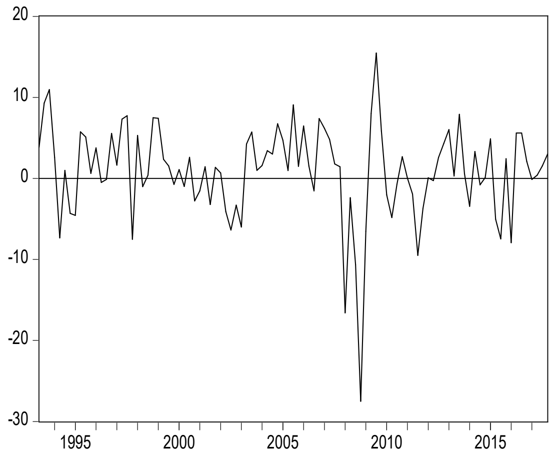
Source: Reserve Bank of Australia Statistics

Figure 3.1 Cash interest rate 1993Q3-2017Q4 (per cent)



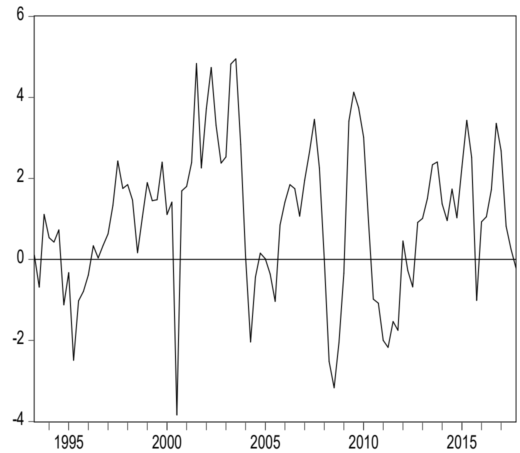
Source: Reserve Bank of Australia Statistics

Figure 3.2 Credit growth rate 1993Q3-2017Q4 (per cent)



Source: GVAR database and RBA statistics

Figure 3.3 Share prices growth rate 1993Q3 2017Q4 (per cent)



Source: Australian Bureau of Statistics

Figure 3.4 House prices growth rate 1993Q3 2017Q4 (per cent)

The second model (Model 2) is a FAVAR model with 6 observed variables, 7 factors and 1 lag. The observed variables are *GDP*, *CPI*, *ICASH*, *CR*, *SP* and *HP*. The last four variables are chosen to address the aim of this chapter, which is the study of the interaction of monetary policy, credit and asset prices. *GDP* and *CPI* are also included in the model as Observed Variables, while *GNE* and *EMPT* are included as unobserved variables in order to assess collateral effects to the macroeconomy. The third model (Model 3) is a VAR model with a recursive identification, with 6 endogenous variables and 4 lags. The variables considered in this model are the observed variables from Model 2: *GDP, CPI*, *ICASH*, *CR*, *SP* and *HP*. The order of the variables in Model 2 and Model 3 is similar to the order adopted by Goodhart and Hofmann (2008), except that they include the asset price (only housing price in their model) between the interest rate and credit. These authors also work with the difference of logarithms except for the interest rate. The orthogonalised shocks are recovered based on a Cholesky decomposition with the ordering mentioned above. In relation to the ordering of the first three variables, GDP and the inflation rate are ordered before the interest rate as the interest rate can respond contemporaneously to changes in the inflation rate and GDP in an inflation targeting regime. The ordering of credit, share prices and house prices, assumes that credit affects asset prices contemporaneously, but asset prices affects credit in the following period. As found in Goodhart and Hofmann (2008), the orthogonalised shocks should not be interpreted as structural shocks, but rather as orthogonalised reduced form shocks. For example, the credit shock should be interpreted as an increase in credit unrelated to changes in GDP, prices, interest rates, share prices and house prices. Under this identification assumption, it is not possible to distinguish whether the underlying structural shocks are a demand or supply shock in different markets, requiring a different identification in SVAR models such as a combination of long-run and short-run restrictions or sign restrictions.

3.5 Results

The following subsections show the impulse responses of economic variables under different model specifications. The impulse response figures show the impulse response point estimates and the corresponding confidence intervals. The top and bottom lines are the 68% confidence intervals, and the point estimate response is in between. The confidence intervals are constructed taking one standard deviation bands, computed by Monte Carlo simulations (assuming normality) based on 1000 replications. The responses are presented in differences and levels. The responses in differences show the periods where the responses are statistically significant. These responses converge to stable levels. Although the responses in differences of Model 1 are volatile, they are robust as discussed in Section 3.5.2. The differences are that Model 2 and Model 3 have lower volatility or longer periods of statistical significance. The impulse response figures of Model 2 and Model 3 are presented in Appendix 3.1 and Appendix 3.2, respectively.

3.5.1 FAVAR model with 1 observable variable and 7 factors (4 lags)

Under this modelling scenario, there is one observable variable, which is also the shock variable. In this subsection, the interest rate, credit, share price and housing price are included in the model as the observable variable one at the time in a FAVAR model with 7 factors. As mentioned in the FAVAR methodology, it is possible to derive the impulse responses of any variable in the complete data set using the factors estimated. In this scenario, the shock variable and the additional variables are GDP, GNE, prices, the cash interest rate, credit, share prices, housing prices and employment. Table 3.2 summarises the cumulative responses of these variables after 2 and 5 years to shocks to the cash rate, credit, share price and house price . The columns in Table 3.2 represent the shocks variable and the rows show the responses of different variables. The rest of this section describes the responses to each shock.

Table 3.2 Cumulative response to cash rate, credit, share price and house price shocks (per cent)

	2 years				5 years			
	Cash rate	Credit	Share price	House price	Cash rate	Credit	Share price	House price
GDP	-0.21	0.36	0.02	-0.02	-0.23	0.49	0.04	0.05
GNE	-0.64	0.54	0.07	0.27	-0.75	1.15	0.09	0.47
CPI	-0.11	0.00	0.02	0.31	-0.16	0.16	0.02	0.34
Cash rate	-0.03	-0.09	0.03	0.23	0.03	0.08	0.02	0.26
Credit	-0.57	4.15	0.22	0.93	-0.90	6.85	0.38	1.93
Share Price	-1.92	-1.70	1.43	1.14	-2.11	-2.42	1.51	0.98
House price	-0.51	1.46	0.02	2.86	-0.57	1.90	0.00	3.61
Employment	-0.27	0.03	0.03	0.22	-0.28	0.20	0.03	0.23

Note: The shocks are 25 basis points for the cash rate and 1 per cent for credit, share price and house price.

Interest rate shock

Figure 3.5 shows the impulse response in first differences to a shock in the cash interest rate. All variables converge to zero, and all variables have periods with statistically significant impulse responses. Figure 3.6 shows the impulse responses in levels. The interest rate goes back to its original level. GDP and GNE decrease by 0.23 and 0.75 per cent, respectively, in 5 years with respect to levels without the shock. In the same period, share prices decline by 2.11 per cent, which is higher than the decrease in housing prices (0.57 per cent). The increase in the interest rate induces a reduction in credit of 0.9 per cent after 5 years. The estimated ratio of the effect on house prices relative to real GDP after two years is around 2.4, lower than the median ratio of 3.9 in the studies analysed by William (2015). Credit responds more slowly to the shock than GDP does, a result which is also found in Berkelmans (2005). The response of the inflation rate and price levels can be observed in Figures 3.5 and 3.6, respectively. The price puzzle is still present in the first 3 periods, where the inflation rate response is positive (Figure 3.5). However, the inflation rate response becomes negative after the third quarter resulting in a level of prices of 0.16 per cent below the counterfactual levels after 5 years. Bernanke et al. (2005) also find that the inclusion of factors reduces the price puzzle, but a positive response of prices is still present during the first quarter. Employment is also 0.28 per cent lower after 5 years.

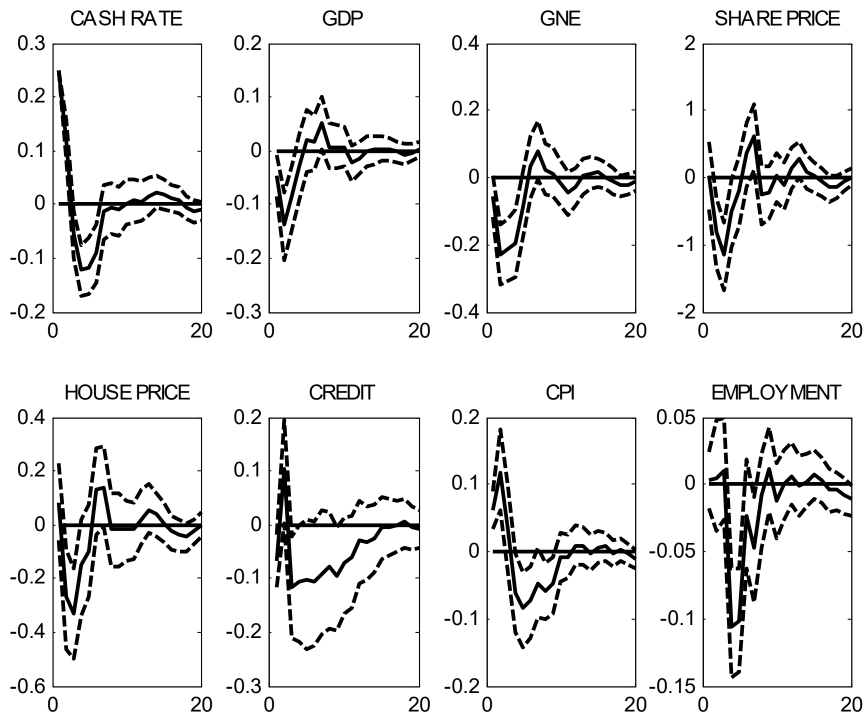


Figure 3.5 FAVAR model, 1 observable variable. Response to an interest rate shock of 0.25 per cent points for the model in differences

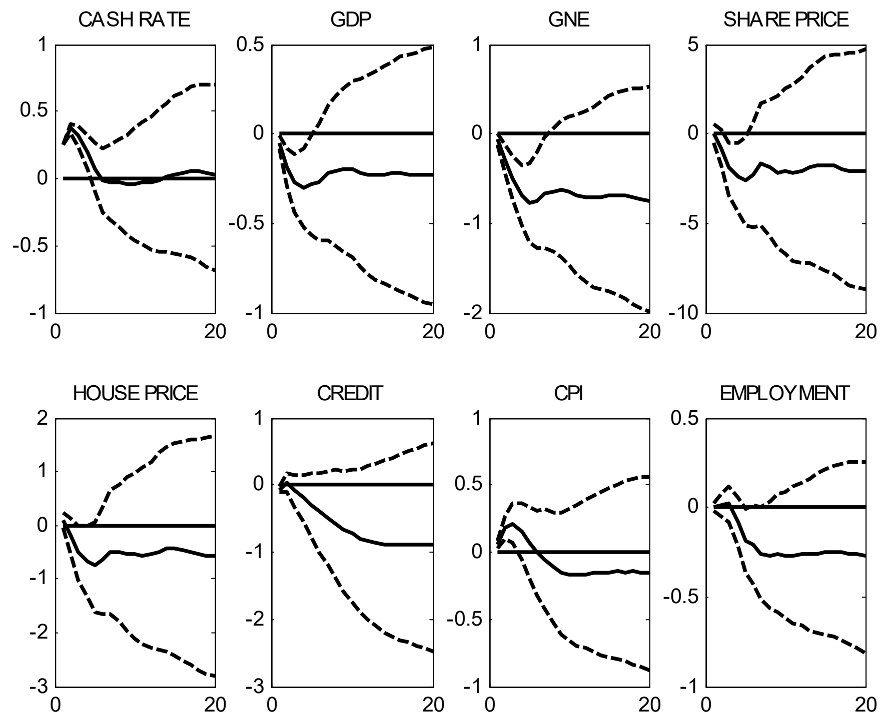


Figure 3.6 FAVAR model, 1 observable variable. Cumulative response to an interest rate shock of 0.25 per cent points.

Credit shock

Figure 3.7 shows the impulse response functions in first differences to a 1 per cent positive credit shock. The responses converge to zero showing the stationarity of the variables in first differences. However, most of the responses are not statistically significant. Credit growth reduces slowly, generating a big cumulative response, as shown in Figure 3.8. This figure also shows that the interest rate generated by the model is approximately zero. A similar credit effect is found in Berkelmans (2005) under the assumption of no monetary response where the impulse response of the interest rate is constrained to be zero. The shock in credit has a positive effect on activity as GDP increases by 0.49 per cent in 5 years, employment by 0.2 per cent and GNE by 1.15 per cent in the same period. The higher growth in GNE with respect to the growth in GDP suggests a negative effect on the current account of the balance of payment. The effect on asset prices is not as expected. More credit in the economy means that more resources are available to purchase assets and increase their prices. However, although this is verified for house prices, the effect on share prices is negative. The CPI index is higher in 0.16 per cent after 5 years.

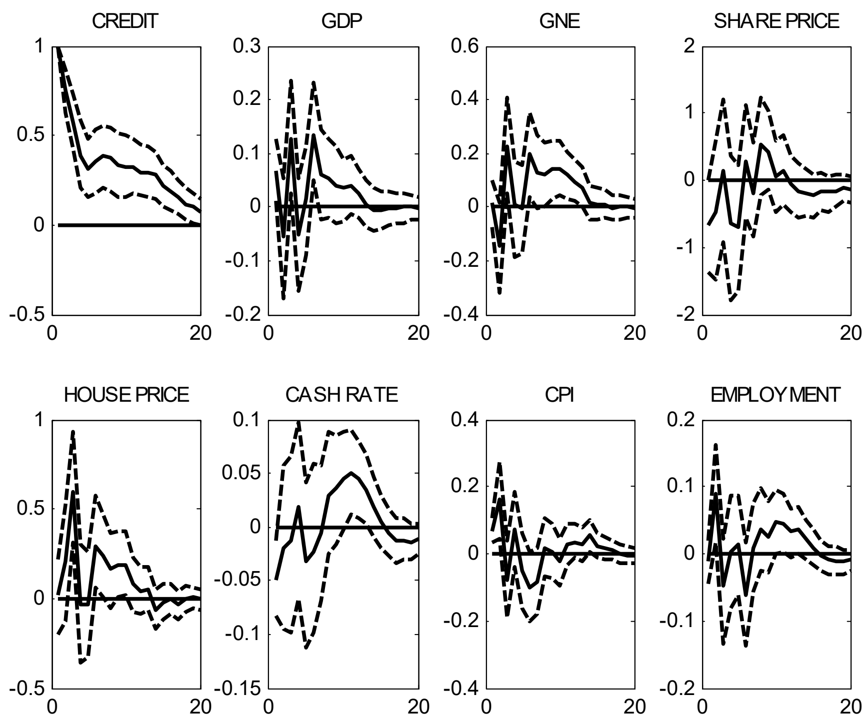


Figure 3.7 FAVAR model – 1 observable variable. Response to a credit shock of 1 per cent for the model in differences

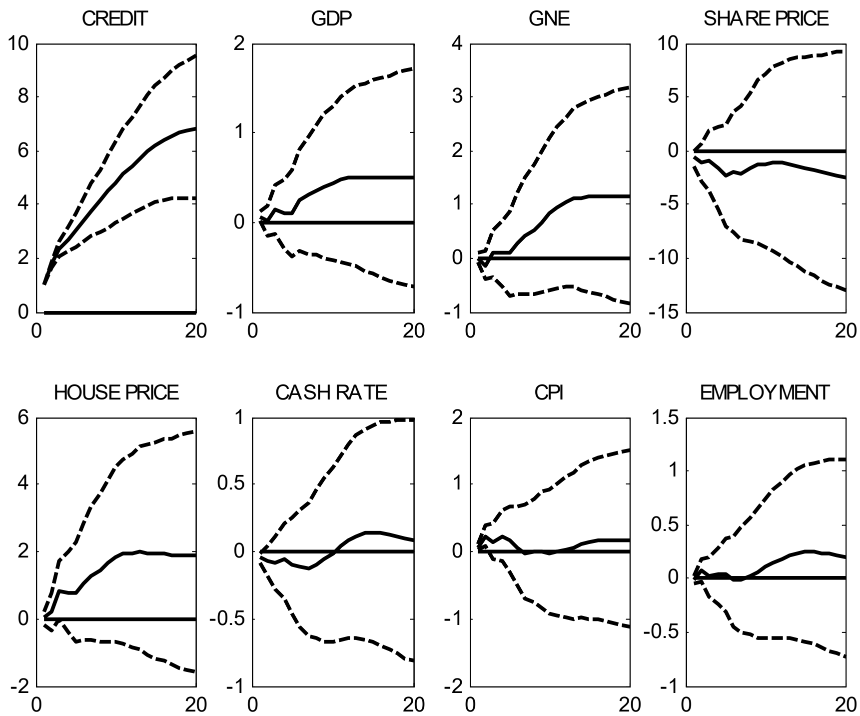


Figure 3.8 FAVAR model – 1 observable variable. Cumulative response to a credit shock of 1 per cent

Share prices shock

Figure 3.9 shows the impulse response functions in first differences for a 1 per cent positive shock to share prices. The responses converge to zero. The credit response is statistically significant for most of the projection period. Other variables such as GNE, CPI, the cash rate and employment have brief periods where the responses are statistically significant. The effects on levels are shown in Figure 3.10. The response of share prices is persistent as the share prices are 1.51 per cent higher than the share prices under a no shock scenario in 5 years. After the same period, the effect on housing prices is negligible. The effect on activity is very small as the responses of GDP, employment and GNE are 0.04, 0.03 and 0.09 per cent, respectively. Prices are higher by 0.02 per cent, and the interest rate shows practically no response (2 basis points). The credit response is statistically significant and higher by 0.38 per cent after five years. A possible explanation of this effect could be the fact that more valuable assets can be used as collateral for credit, as proposed by Kiyotaki and Moore (1997) and Bernanke et al. (1994).

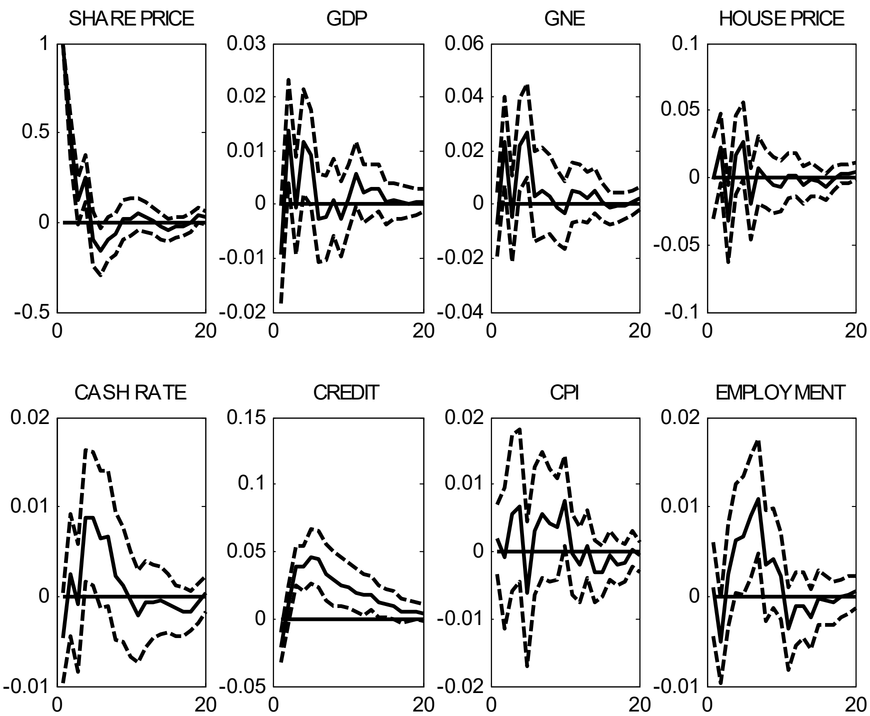


Figure 3.9 FAVAR model, 1 observable variable. Response to a share price shock of 1 per cent for the model in differences

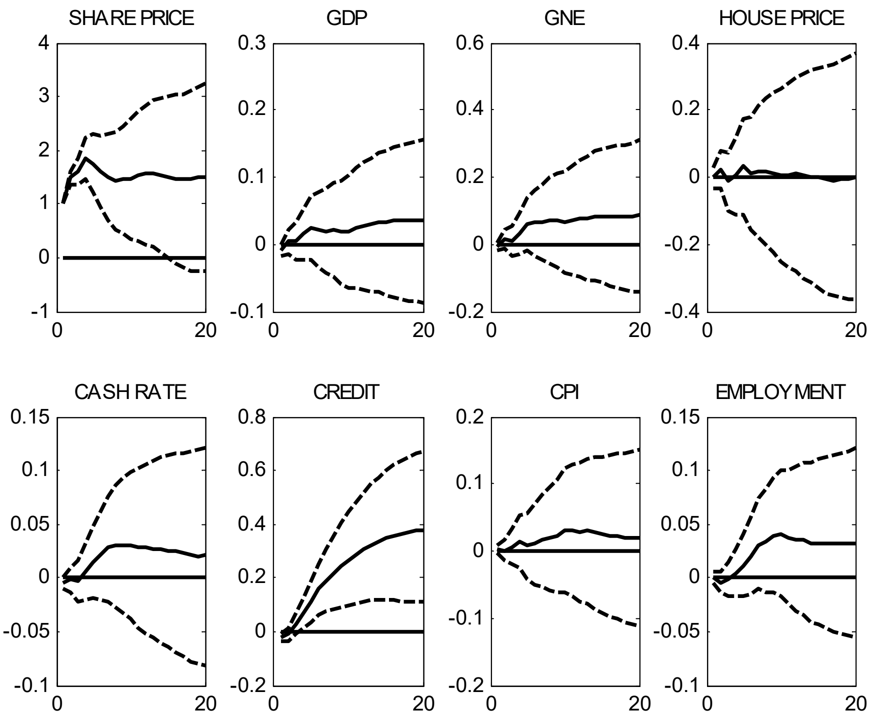


Figure 3.10 FAVAR model, 1 observable variable. Cumulative response to a share price shock of 1 per cent

House price shock

Figure 3.11 shows the impulse response functions in first differences for a 1 per cent positive shock to housing prices. As in the case of the share price shock, the credit response is statistically significant. However, in this case, the responses of the other variables (except GDP) are also statistically significant at various segments of the horizon analysed. The evolution of the data in levels in Figure 3.12 shows that the housing prices continue to increase after the shock, and after 5 years, housing prices are 3.61 per cent above price houses under the non-shock scenario. The highest effect on other variables is on credit that is higher by 1.93 per cent than its counterfactual value after 5 years. This effect on credit is consistent with the impact of the share prices shock on credit discussed above.

Regarding the effect on economic activity, GDP increases by 0.05 per cent after 5 years, GNE increases by 0.47 per cent, which means that the wealth effect due to the higher values of assets increases domestic and foreign spending, and employment increases by 0.23 per cent. Unlike the negligible response of house prices to a share price shock, the shock to house prices increases share prices by 0.98 per cent. The interest rate increases by 26 basis points and prices by 0.34 per cent. In general, the scale of the responses of the variables considered (except share prices) is higher than the responses to a shock to share prices.

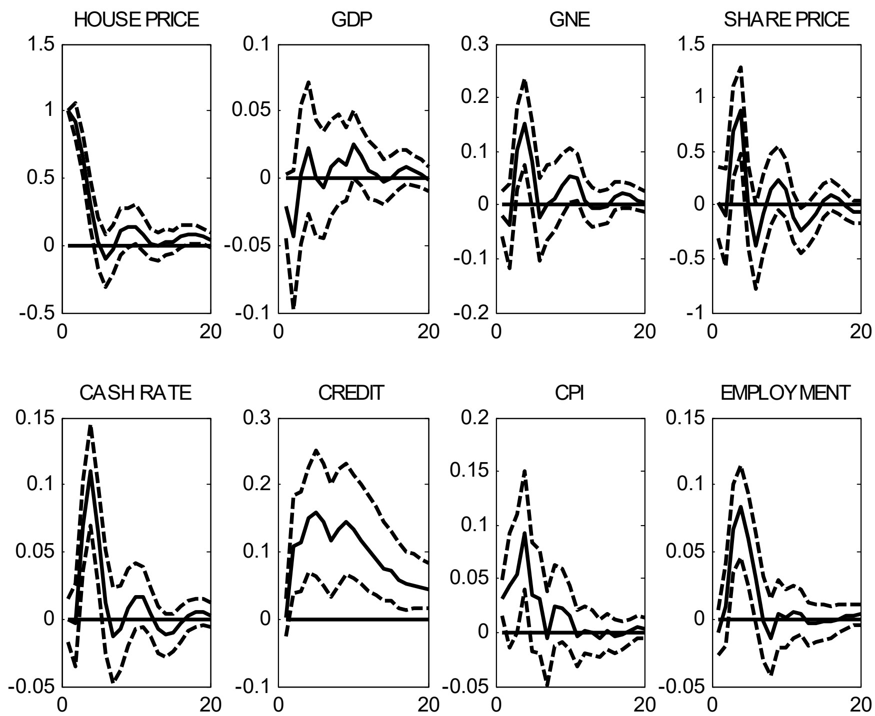


Figure 3.11 FAVAR model, 1 observable variable. Response to a housing price shock of 1 per cent for the model in first differences

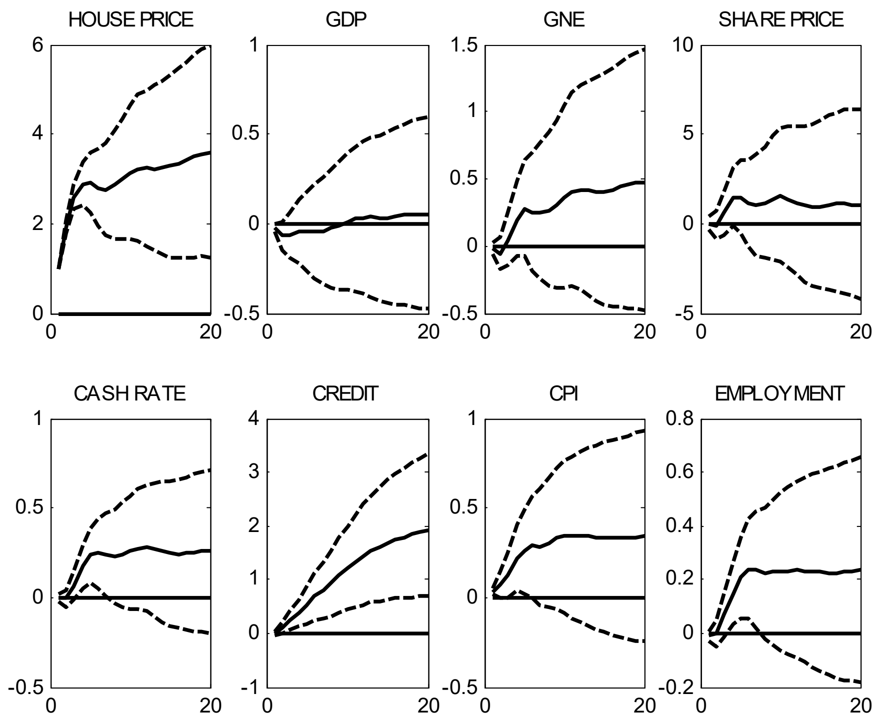


Figure 3.12 FAVAR model, 1 observable variable. Cumulative response to a housing price shock of 1 per cent.

3.5.2 Robustness

This section compares the cumulative responses of the base model with the cumulative responses in other models with the alternative specifications described in Section 3.4. The comparative responses are shown in Tables 3.3 to 3.6, for shocks to interest rate, credit, share prices and house prices. Each of these Tables includes the cumulative responses for 2 and 5 years for Models 1, 2 and 3. The responses corresponding to Model 1 in these tables are the same as the responses in Table 3.2. The alternative FAVAR specification in Model 2 confirm the direction of most of the responses of Model 1, except the responses of CPI and share prices to a cash rate shock and the responses of GDP, GNE and share prices to a house price shock. The comparison of the responses between the three models shows that in Model 1 the price puzzle is reduced. This result is more in line with economic theory than the result from Model 2 and Model 3. As the responses in Model 1 are consistent with economic theory, this is the preferred model. Another difference between the results of the models is the cost of using interest rate to reduce house prices (lean against the wind). In Models 1 and 2, this cost in terms of GDP loss is higher than in Model 3 and also higher than the cost reported by Williams (2015) for other developed economies.

Interest rate shock

As shown in Table 3.3, the responses of GDP, GNE and employment in Model 2 and Model 3 are negative as in the case of Model 1, consistent with a contraction of economic activity generated by a contractionary monetary policy. The response of prices is positive in Model 2 and Model 3, which represents a price puzzle. Incorporating factors in Model 1 eliminates the price puzzle after the third quarter, while Model 2 does not eliminate the price puzzle even though this model also incorporates factors. These results suggest the importance of model specification besides the incorporation of factors in the model. The response of the cash rate is close to zero in Model 1, while it is positively persistent in the alternative models. The ratios of the effect of the interest rate shock on house prices relative to the effect on real GDP after two years are approximately 2.4, 1.9 and 12.0 for Model 1, Model 2 and Model 3, respectively. As mentioned in Section 3.5.1, the median ratio is 3.9 for the countries reported by Williams (2015). This means that a shock to the interest rate aiming to reduce housing prices by 1 per cent would generate a reduction in GDP after 2 years by approximately 0.4, 0.5 and 0.1 per cent in Model 1 and Model 2 and Model 3, respectively. For the countries reported by Williams (2015) the reduction in GDP was 0.25 per cent. Considering the results from the models with data-rich specifications, the cost of the use of monetary policy to reduce house prices is higher in Australia than in other countries surveyed in Williams (2015). This suggests that pre-emptive action against house price bubbles could lead to a relatively significant contractionary effect on the Australian economy.

The responses of credit and house prices are negative in all models and statistically significant in Model 1 during the first 2 years. Unlike the negative and statistically significant response of share prices in Model 1, the responses of share prices in Model 2 and Model 3 are small, positive (0.15 and 0.09 per cent, respectively after 5 years) and statistically non-significant.

Table 3.3 Cumulative response to an interest rate shock of 25 basis points (per cent)

	2 yrs			5 yrs		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
GDP	-0.21	-0.23	-0.16	-0.23	-0.24	-0.17
GNE	-0.64	-0.65		-0.75	-0.66	
CPI	-0.11	0.26	0.15	-0.16	0.29	0.11
Cash rate	-0.03	0.25	0.38	0.03	0.28	0.36
Credit	-0.57	-0.25	-0.57	-0.90	-0.32	-0.92
Share Price	-1.92	0.23	-0.33	-2.11	0.15	0.09
House price	-0.51	-0.43	-1.92	-0.57	-0.32	-1.84
Employment	-0.27	-0.13		-0.28	-0.12	

Credit shock

Table 3.4 shows that in general, the responses to a credit shock have similar signs in all models. A positive shock to credit increases GDP, GNE and employment. After 5 years, prices are higher in all models but close to zero in Model 2. The cash rate increase is close to zero in Model 1, while it is positively persistent in the other models. House prices increase after 5 years in all models, although the response in Model 2 is smaller (0.31 per cent) than the responses in Model 1 and Model 3 (1.90 and 1.01 per cent, respectively). The large response of credit found in Model 1 is confirmed by the similar response of this variable in the other models. The statistically non-significant negative response of share prices found in Model 1 is also found in the other models.

Table 3.4 Cumulative response to a credit shock of one per cent (per cent)

	2 yrs			5 yrs		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
GDP	0.36	0.12	0.29	0.49	0.20	0.40
GNE	0.54	0.37		1.15	0.71	
CPI	0.00	0.06	0.21	0.16	0.04	0.29
Cash rate	-0.09	0.30	0.13	0.08	0.22	0.15
Credit	4.15	4.27	5.10	6.85	5.62	6.78
Share Price	-1.70	-0.22	-1.47	-2.42	-1.25	-2.25
House price	1.46	-0.02	0.88	1.90	0.31	1.01
Employment	0.03	0.27		0.20	0.32	

Share prices

As shown in Table 3.5, Model 2 and Model 3 confirm that the main effects of a shock to share prices are the positive effects on the same variable and credit. As in Model 1, the wealth effect generated by higher share prices has a small positive effect on GDP, GNE and employment. The responses of prices and the cash rate are close to zero in all models. The main difference between the responses in the three models is the response of house price. While the response of house prices is zero in Model 1, this response is positive and statistically significant in Model 2 and Model 3.

Table 3.5 Cumulative response to a share price shock of one per cent (per cent)

	2 yrs			5 yrs		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
GDP	0.02	0.01	0.01	0.04	0.02	0.02
GNE	0.07	0.03		0.09	0.05	
CPI	0.02	0.02	0.04	0.02	0.02	0.04
Cash rate	0.03	0.02	0.07	0.02	0.01	0.06
Credit	0.22	0.17	0.22	0.38	0.24	0.30
Share Price	1.43	1.21	1.29	1.51	1.14	1.26
House price	0.02	0.09	0.17	0.00	0.11	0.16
Employment	0.03	0.01		0.03	0.02	

House prices

Model 2 and Model 3 confirm the persistence of the housing price shock and the positive effect of the housing shock on credit. However, the effect on credit in Model 2 is weaker than the response in the other models. As in Model 1, the response of GDP is also statistically non-significant in Models 2 and 3. Unlike Model 1, the response of GNE in Model 2 is negative, although it is statistically non-significant. The responses of prices and the cash rate have the same sign in the three models. After 5 years, the responses of share prices in Model 2 and Model 3 are negative, the opposite sign of the response in Model 1.

Table 3.6 Cumulative response to house price shock of one per cent (per cent)

	2 yrs			5 yrs		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
GDP	-0.02	-0.10	-0.05	0.05	-0.12	-0.04
GNE	0.27	-0.07		0.47	-0.10	
CPI	0.31	0.16	0.24	0.34	0.14	0.23
Cash rate	0.23	0.24	0.27	0.26	0.20	0.25
Credit	0.93	0.22	0.41	1.93	0.09	0.50
Share Price	1.14	-1.76	-1.08	0.98	-1.82	-1.13
House price	2.86	2.11	2.38	3.61	2.24	2.29
Employment	0.22	0.13		0.23	0.11	

3.6 Conclusions

After the Global Financial Crisis, there has been an increasing consensus that it is desirable to respond to emerging signals of financial imbalances. However, to implement a response, it is necessary to assess the effect of potential policies on asset prices and other relevant macroeconomic variables and the feedback effect of asset prices on financial variables. This feedback effect has been emphasised by Kiyotaki and Moore (1997) and Bernanke et al. (1994), who show that asset prices play an important role in the availability of loans and the transmission mechanism of monetary policy.

This study assesses the relationship between monetary policy, credit and asset prices in Australia from 1993Q2 to 2017Q4, using a FAVAR approach. Two asset prices are considered: share and housing prices. The shock variables for monetary policy and credit are the changes to the cash interest rate and the growth rate of credit, respectively.

The results of the preferred model (Model 1) indicate that a positive shock of 25 basis points to the cash rate reduces credit and asset prices in relation to a non-shock scenario. Credit reduces by 0.9 per cent after 5 years. During the same period, the reduction of share prices and house prices are 2.11 per cent and 0.57 per cent, respectively. An interest rate shock reduces GDP, GNE and employment. These variables are reduced by 0.23 per cent, 0.75 per cent and 0.28 per cent, respectively, after five years. The results suggest that pre-emptive action against house price bubbles could lead to a significant contractionary effect on the

Australian economy, higher than the effect on other countries surveyed by Williams (2015). . An increase of the interest rate aiming to reduce housing prices by 1 per cent would generate a reduction in GDP after 2 years by approximately 0.4 per cent in the preferred model. For the countries reported by Williams (2015) the reduction in GDP would be 0.25 per cent. This information should be taken into account by monetary authorities when considering the use of monetary policy to lean against the wind.

Regarding the price response to the shock to the cash rate, the price puzzle is still present in the first 3 periods, where the inflation rate response is positive. However, the inflation rate response becomes negative after the third quarter resulting in a level of prices of 0.16 per cent below the counterfactual levels after 5 years. Bernanke et al. (2005) also find that the inclusion of factors reduces the price puzzle, but a positive response of prices is still present during the first quarter. The effect of an increase in credit on asset prices is not statistically significant and is negative for share prices and positive for house prices. The response of interest rate is almost zero for the whole projection period, which could be explained by an elastic supply of loans in Australia, as the international funds market is an essential source of financing for bank loans. This study also finds a statistically significant positive response of credit to an increase in share and housing prices, providing evidence that supports the financial accelerator hypothesis. Credit increases by 0.38 per cent and 1.93 per cent after five years due to a shock in share and housing prices, respectively. The results also report that a positive asset price shock, especially a house price shock, increase expenditure. GNE increases by 0.09 per cent and 0.47 per cent after five years in response to a share and house price, respectively.

Appendix 3.1 Impulse response functions of Model 2. FAVAR with 6 observable variables and 7 factors (1 lag)

Figures 3.13 to 3.20 show the impulse-response functions for Model 2 described in Section 3.4. The figures show the responses in first differences and in levels (cumulative) for shocks to the cash rate, credit, share price and house price.

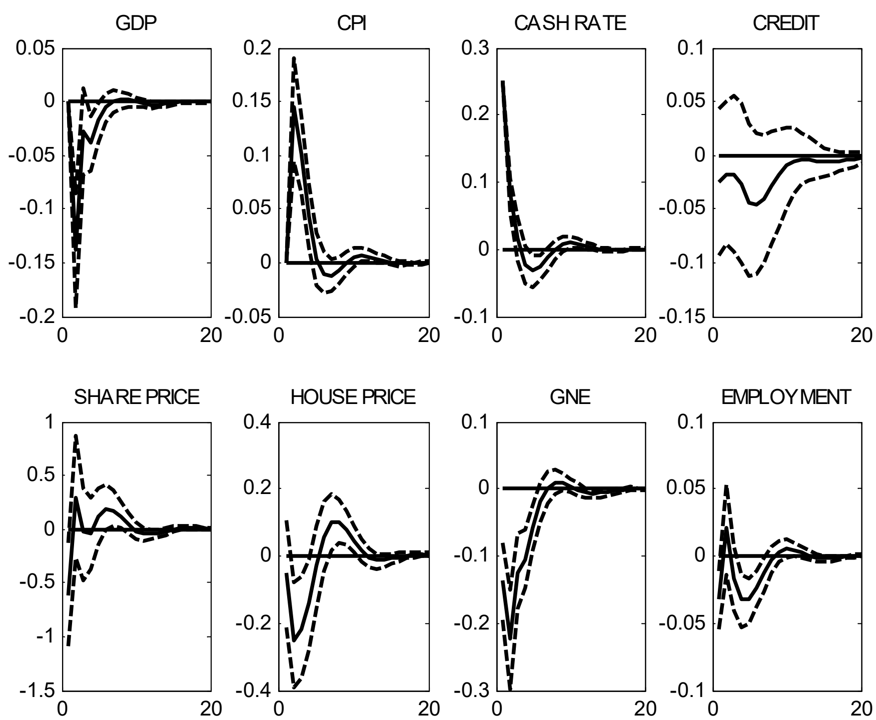


Figure 3.13 FAVAR model, 6 observable variables. Response to an interest rate shock of 0.25 per cent points for the model in differences

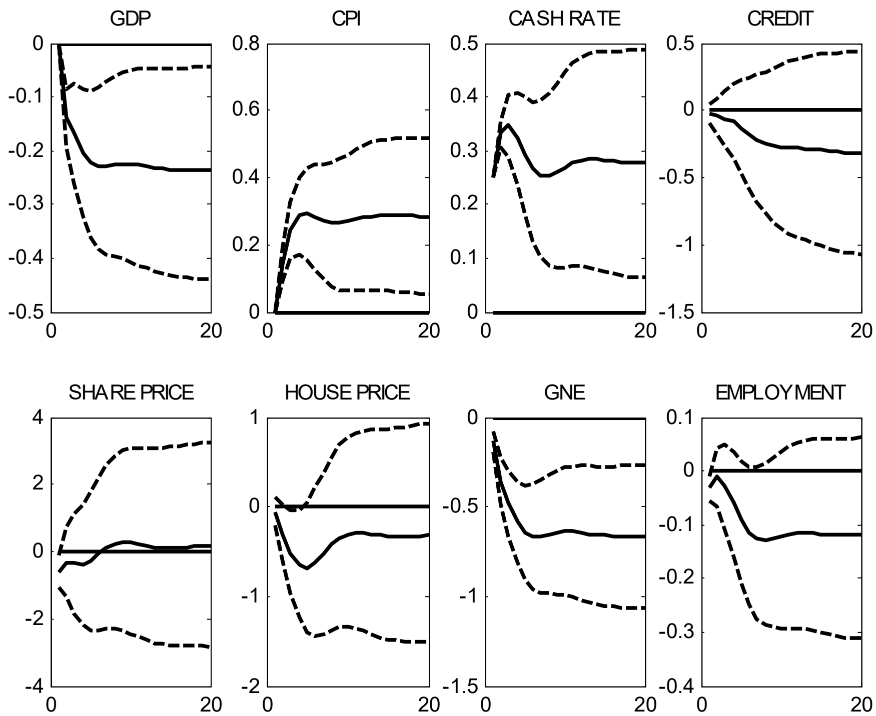


Figure 3.14 FAVAR model, 6 observable variables. Cumulative response to an interest rate shock 25 per cent points

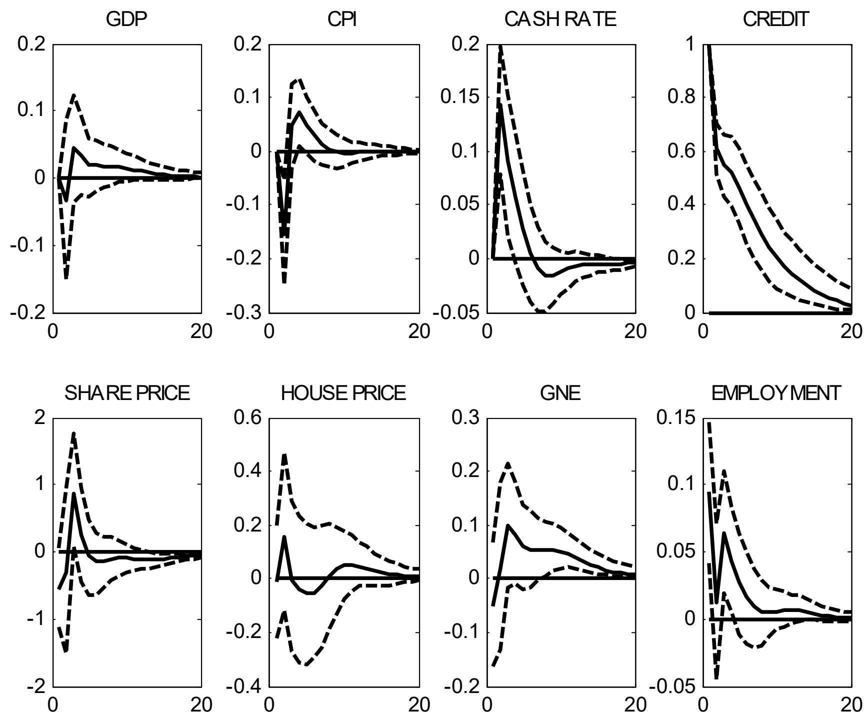


Figure 3.15 FAVAR model, 6 observable variables. Response to a credit shock of 1 per cent for the model in differences

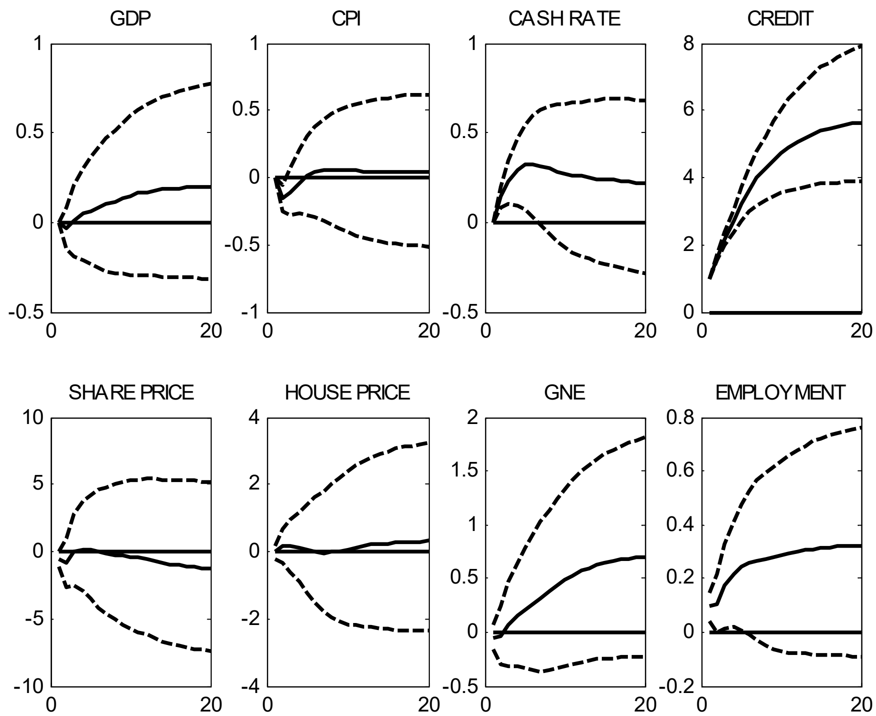


Figure 3.16. FAVAR model, 6 observable variables. Cumulative response to a credit shock of 1 per cent

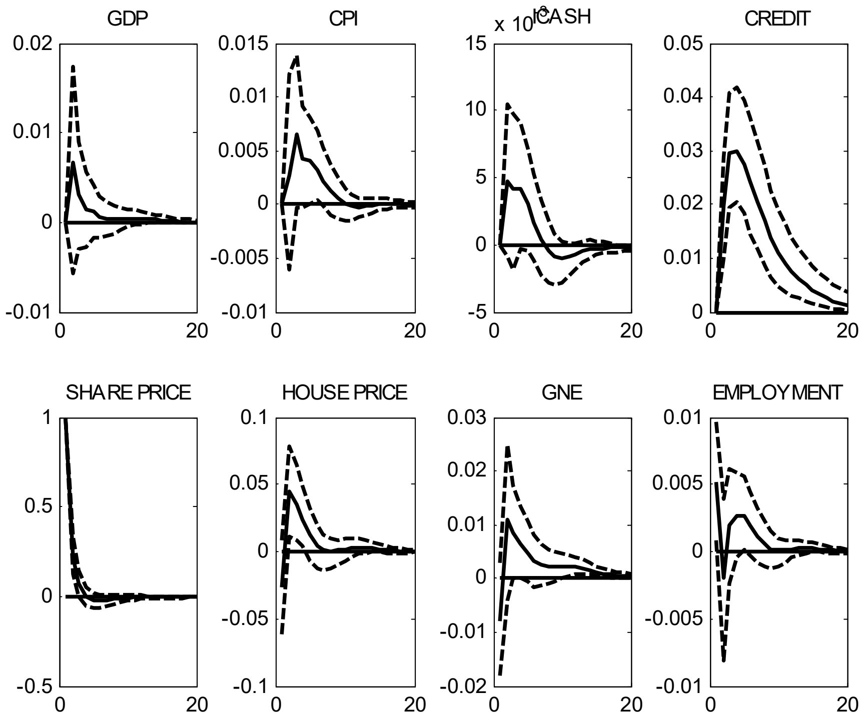


Figure 3.17 FAVAR model, 6 observable variables. Response to a share price shock of 1 per cent for the model in differences

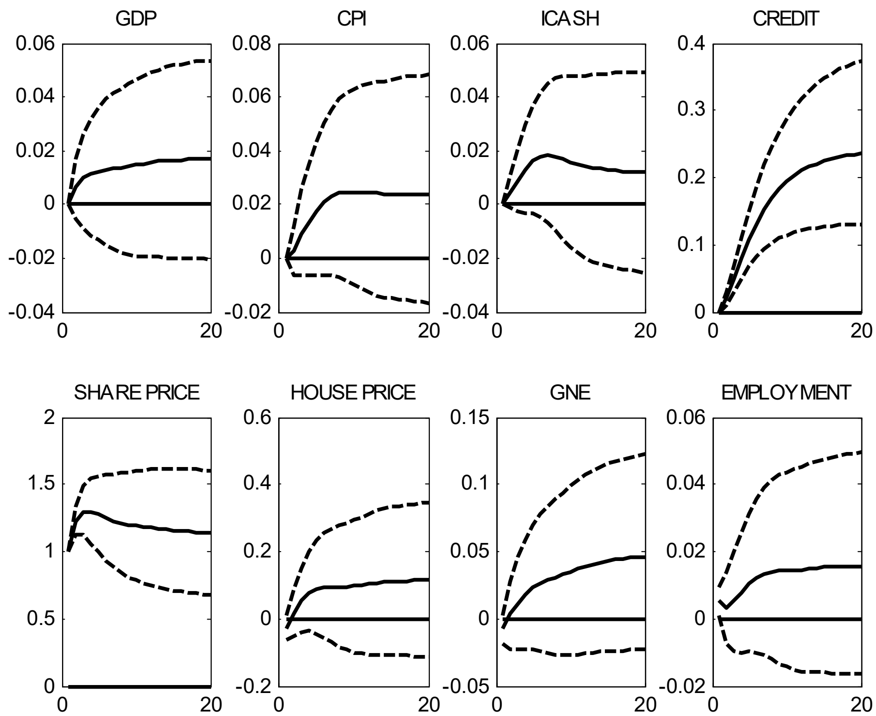


Figure 3.18 FAVAR model, 6 observable variables. Cumulative response to a share price shock of 1 per cent

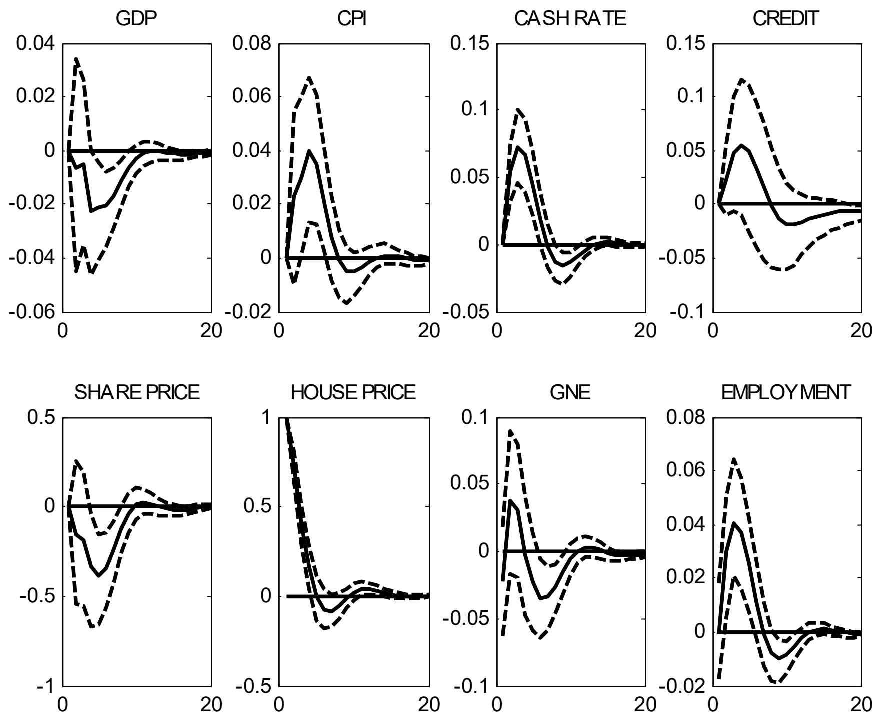


Figure 3.19. FAVAR model, 6 observable variables. Response to a housing price shock of 1 per cent for the model in differences

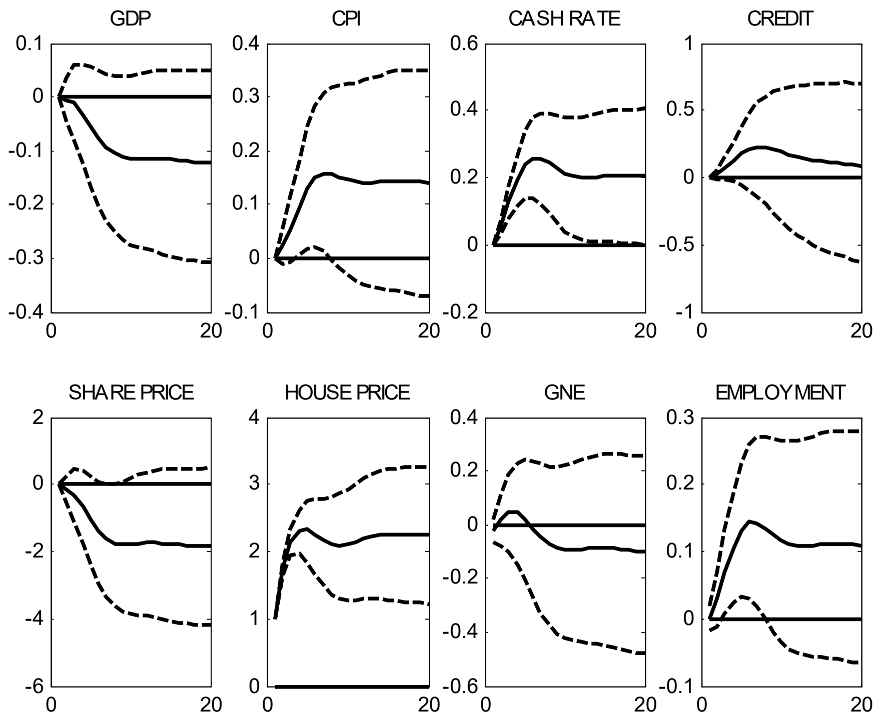


Figure 3.20 FAVAR model, 6 observable variables. Cumulative response to a house price shock of 1 per cent

Appendix 3.2 Impulse response functions of Model 3. A recursive VAR

Figures 3.21 to 3.28 show the impulse-response functions for Model 3 described in Section 3.4. The figures show the responses in first differences and in levels (cumulative) for shocks to the cash rate, credit, share price and house price.

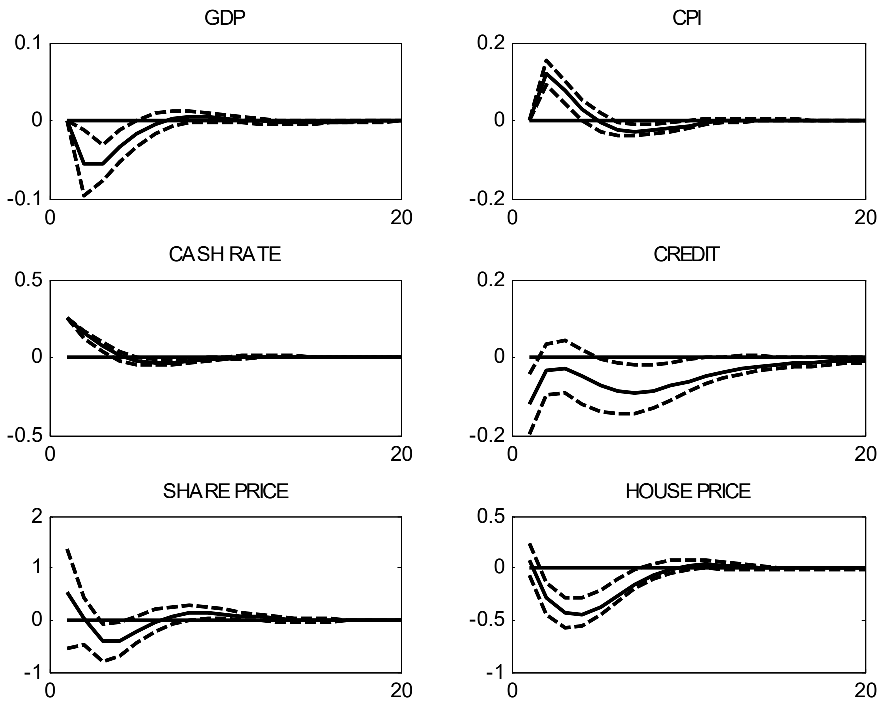


Figure 3.21 VAR recursive model. Response to an interest rate shock of 0.25 per cent points for the model in differences

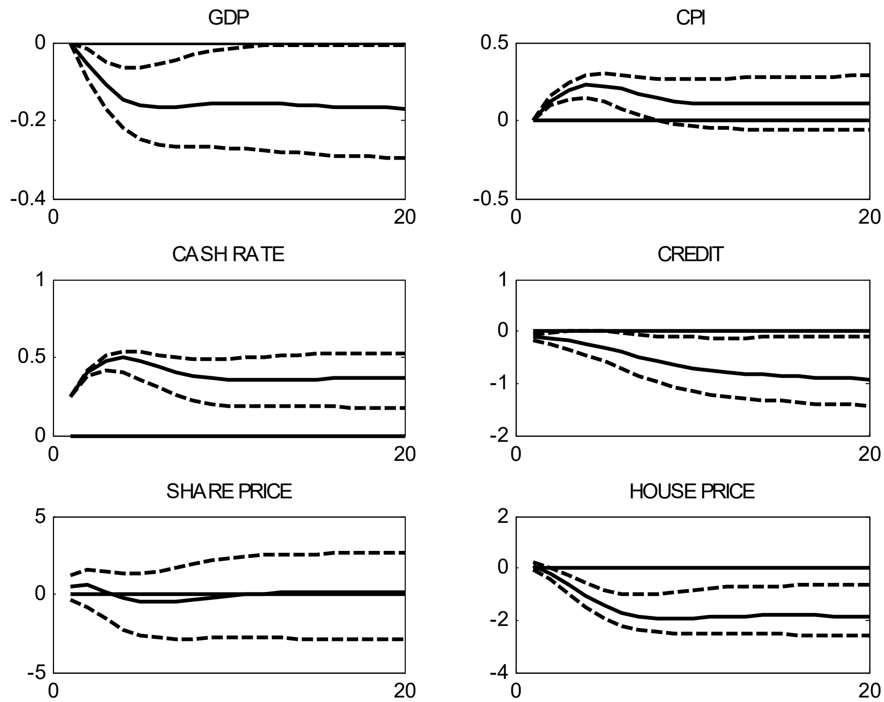


Figure 3.22 VAR recursive model. Cumulative responses to an interest rate shock of 0.25 per cent points

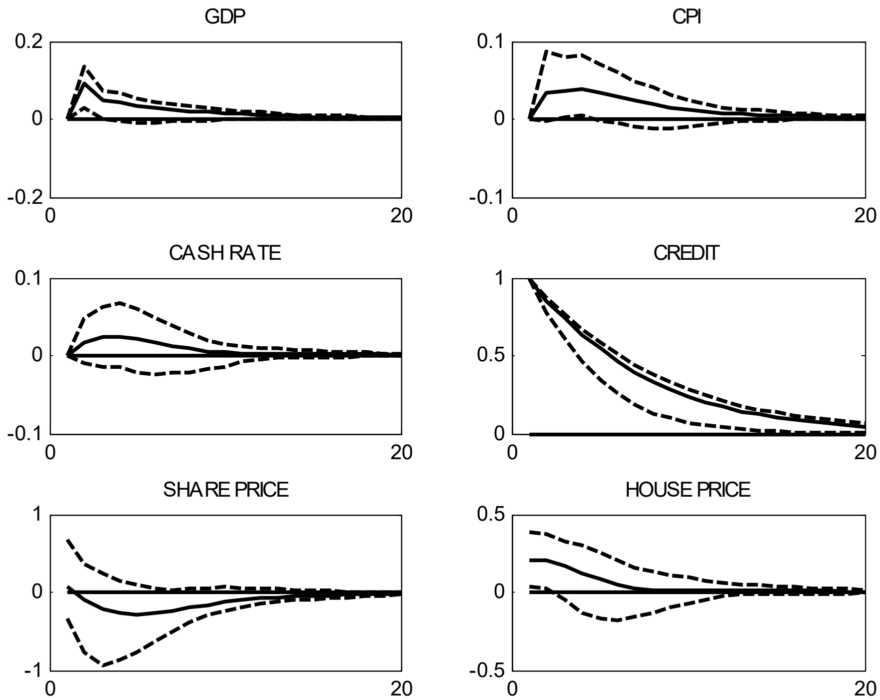


Figure 3.23 VAR recursive model. Response to a credit shock of 1 per cent for the model in differences

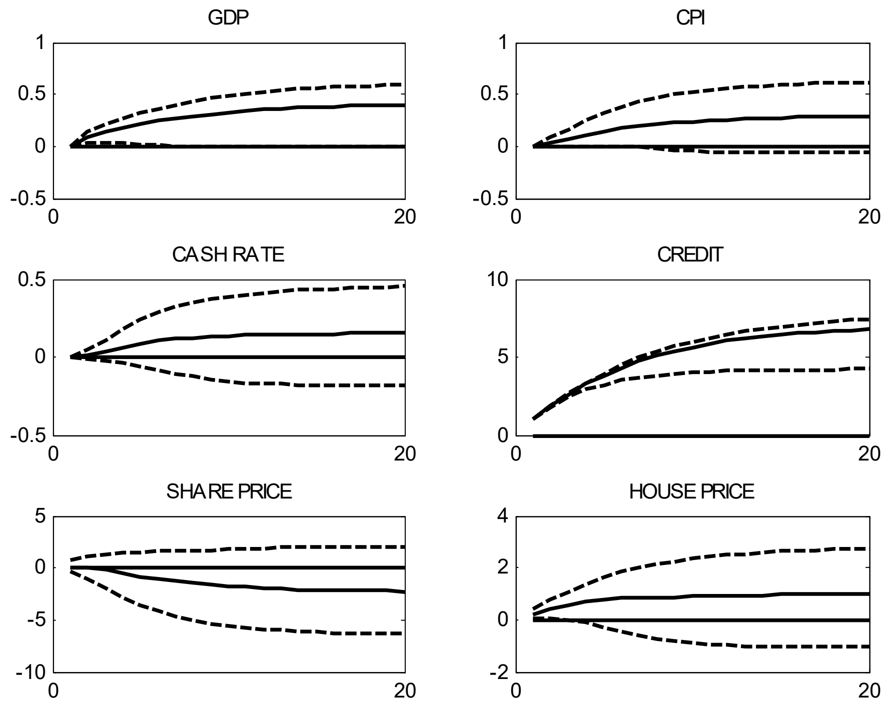


Figure 3.24 VAR recursive model. Cumulative responses to a credit shock of 1 per cent

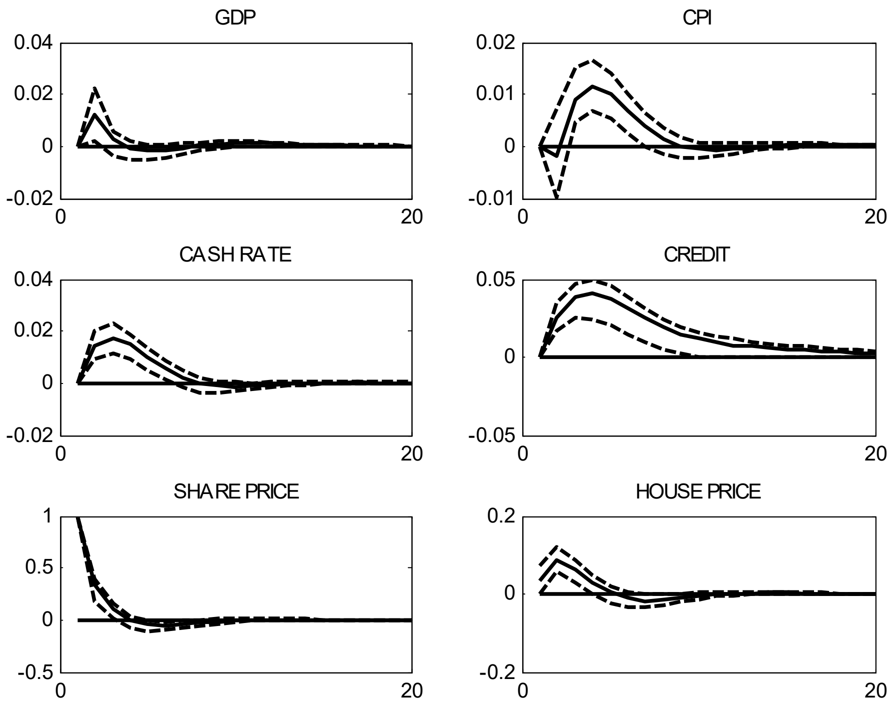


Figure 3.25 VAR recursive model. Response to a stock price shock of 1 per cent for the model in differences

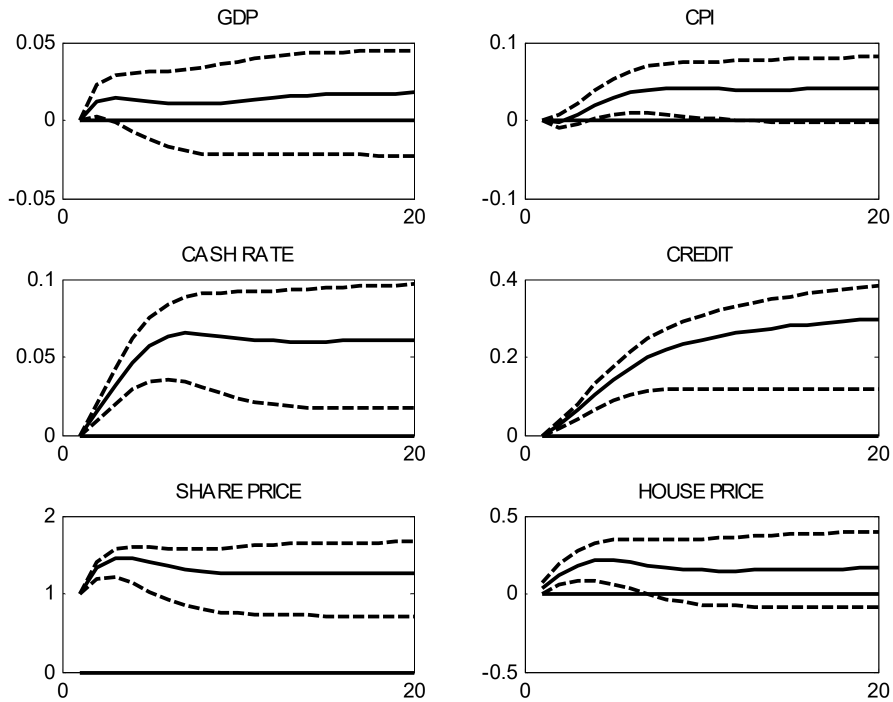


Figure 3.26 VAR recursive model. Cumulative responses to a stock price shock of 1 per cent

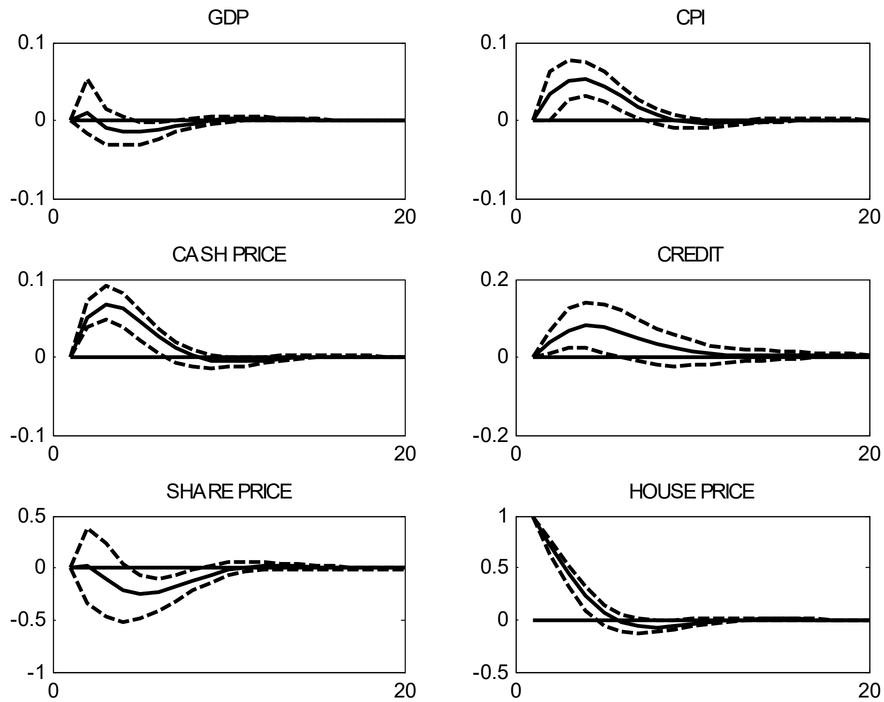


Figure 3.27 VAR recursive model. Response to a housing price shock of 1 per cent for the model in differences

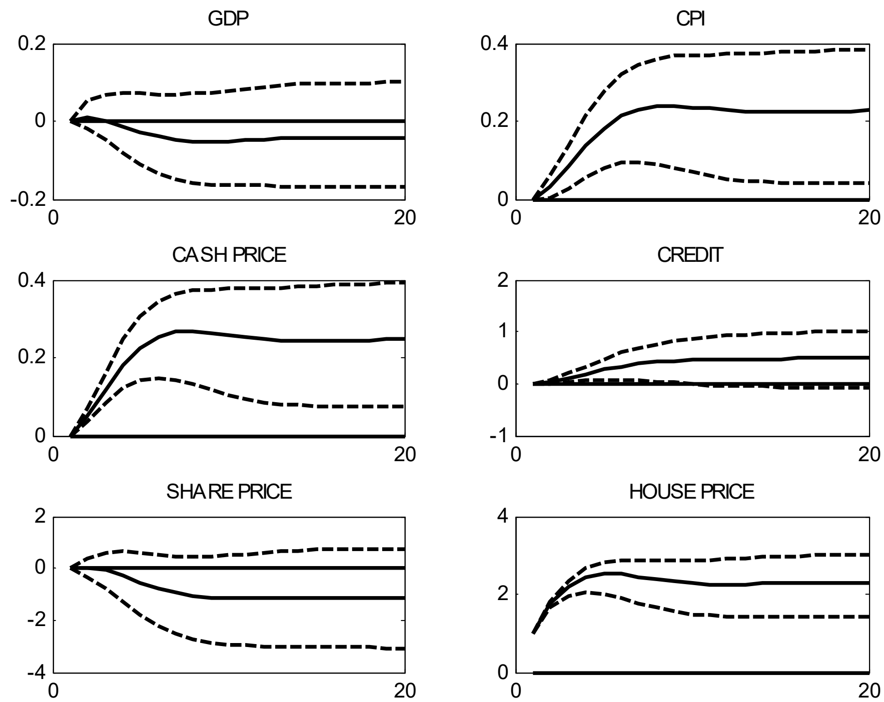


Figure 3.28 VAR recursive model. Cumulative responses to a housing price shock of 1 per cent

Appendix 3.3 Impulse response functions of a FAVAR model with 1 observable variable and 3 factors (4 lags)

Figures 3.29 to 3.36 show the impulse-response functions for a FAVAR model similar to Model 1 (1 observable variable and 4 lags) but with 3 factors rather than 7 factors. The figures show the responses in first differences and in levels (cumulative) for shocks to the cash rate, credit, share price and house price.

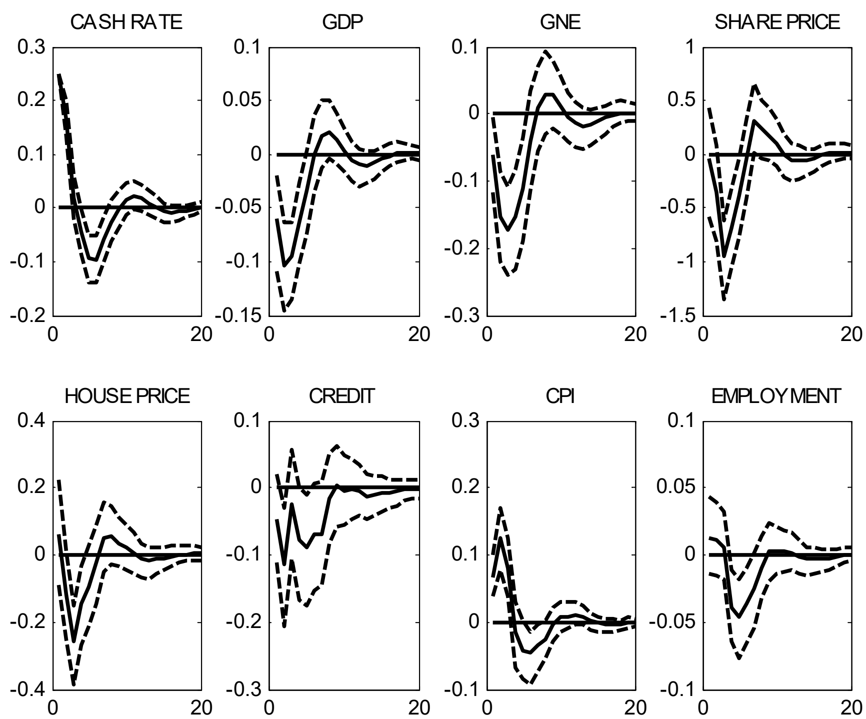


Figure 3.29 FAVAR model with 1 observable variable and 3 factors. Response to an interest rate shock of 0.25 per cent points for the model in differences

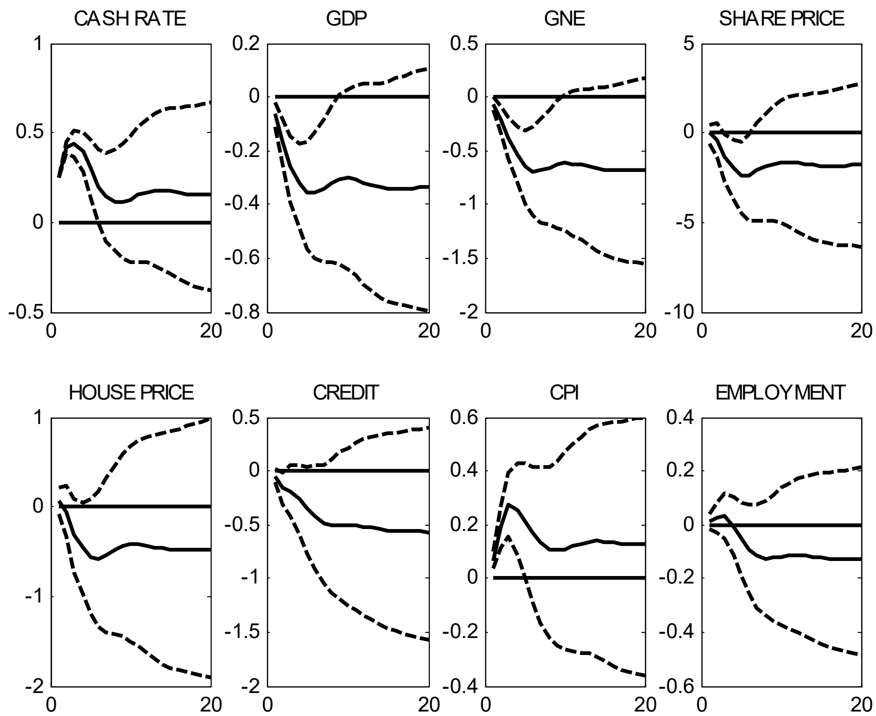


Figure 3.30 FAVAR model with 1 observable variable and 3 factors. Cumulative response to an interest rate shock 25 per cent points

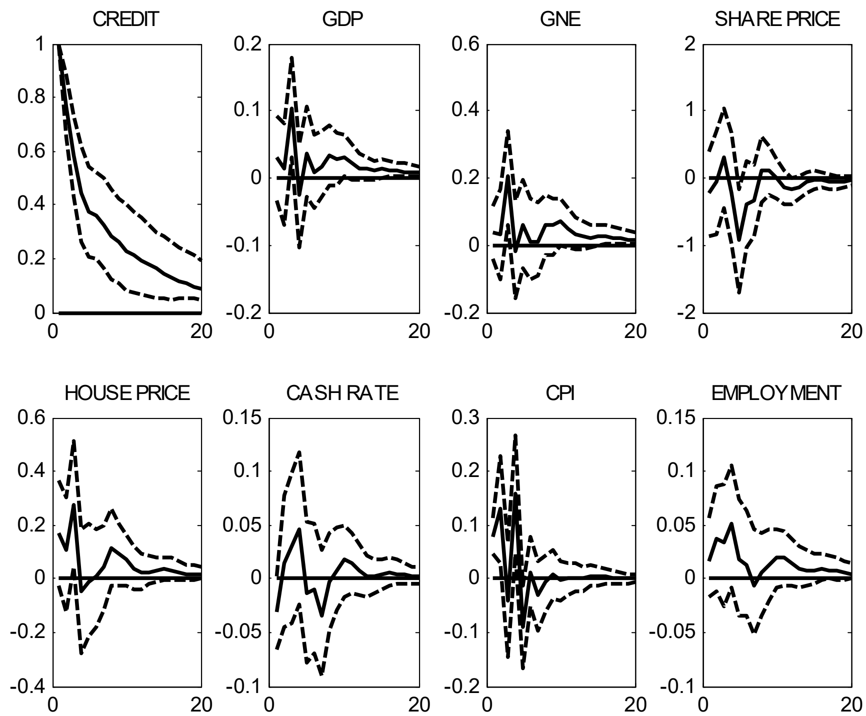


Figure 3.31 FAVAR model with 1 observable variable and 3 factors. Response to a credit shock of 1 per cent for the model in differences

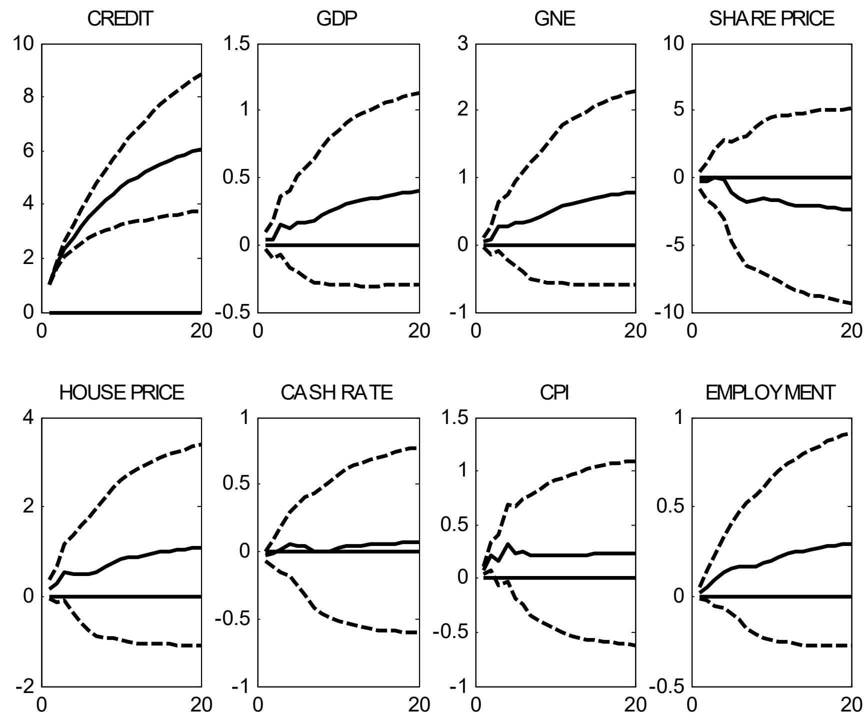


Figure 3.32. FAVAR model with 1 observable variable and 3 factors. Cumulative response to a credit shock of 1 per cent

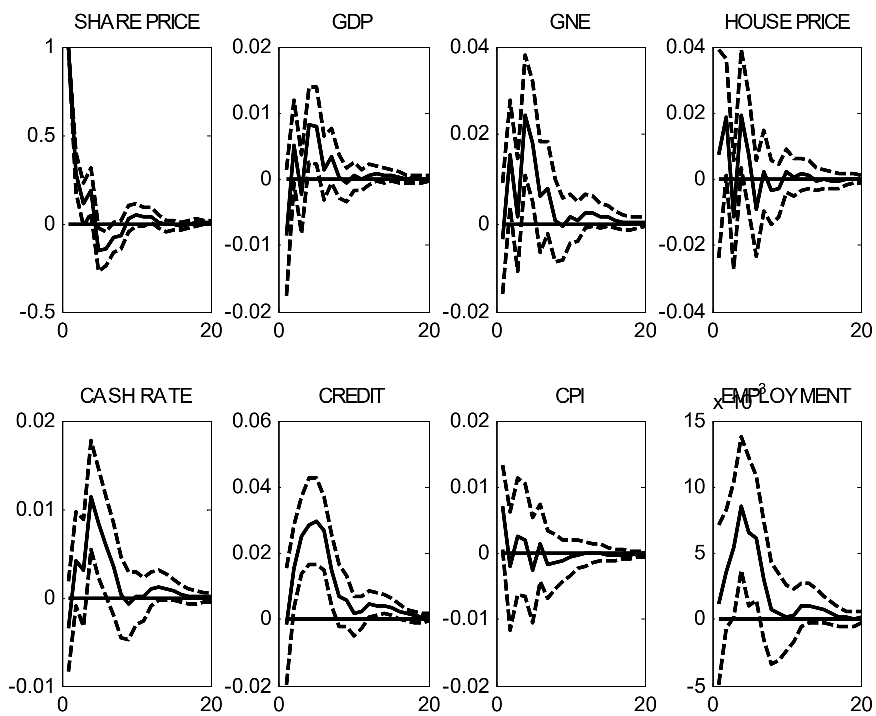


Figure 3.33 FAVAR model with 1 observable variable and 3 factors. Response to a share price shock of 1 per cent for the model in differences

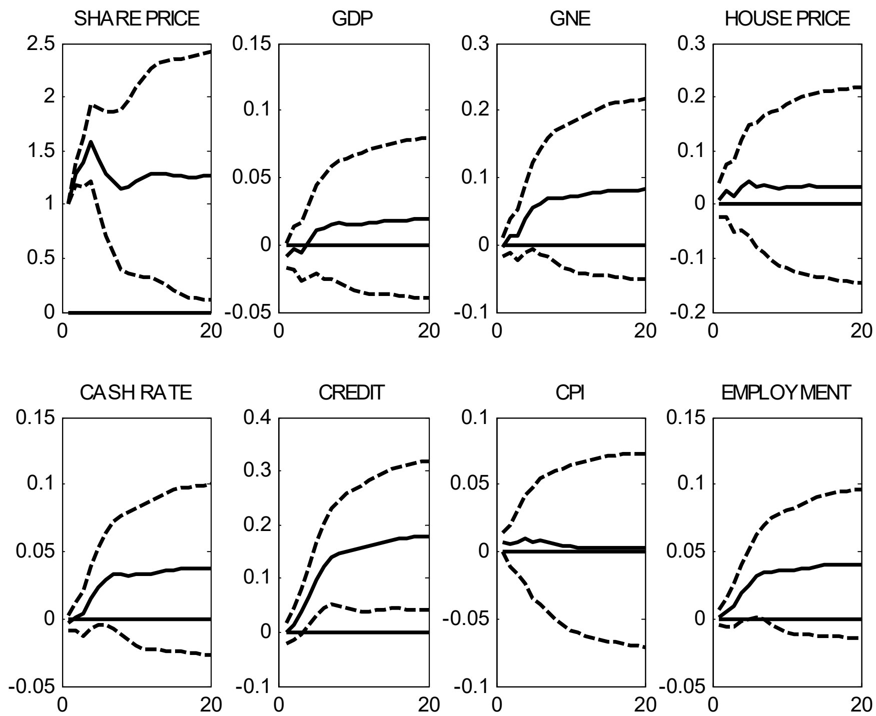


Figure 3.34 FAVAR model with 1 observable variable and 3 factors. Cumulative response to a share price shock of 1 per cent

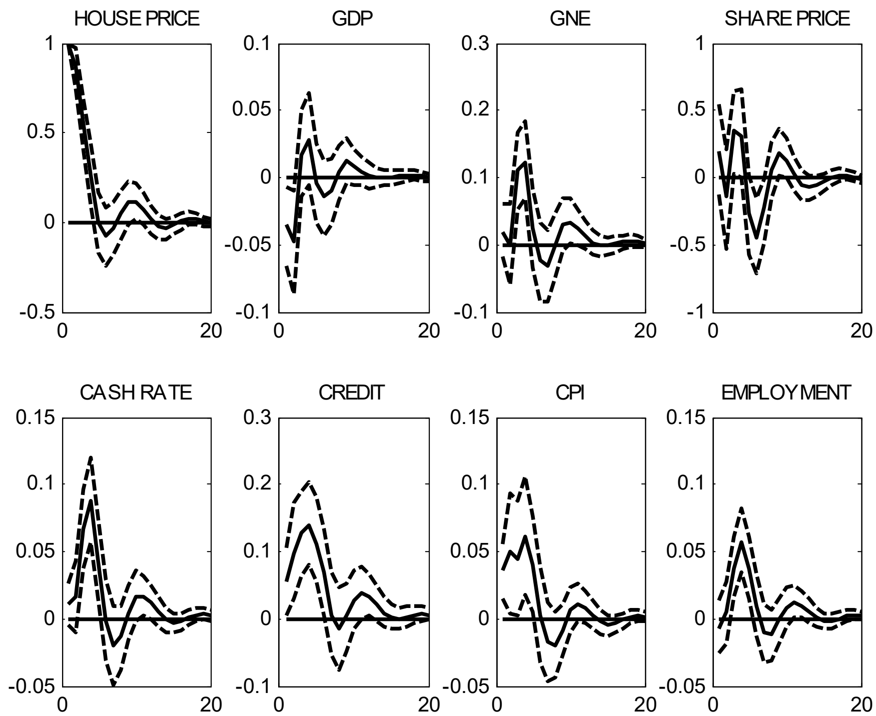


Figure 3.35 FAVAR model with 1 observable variable and 3 factors. Response to a housing price shock of 1 per cent for the model in differences

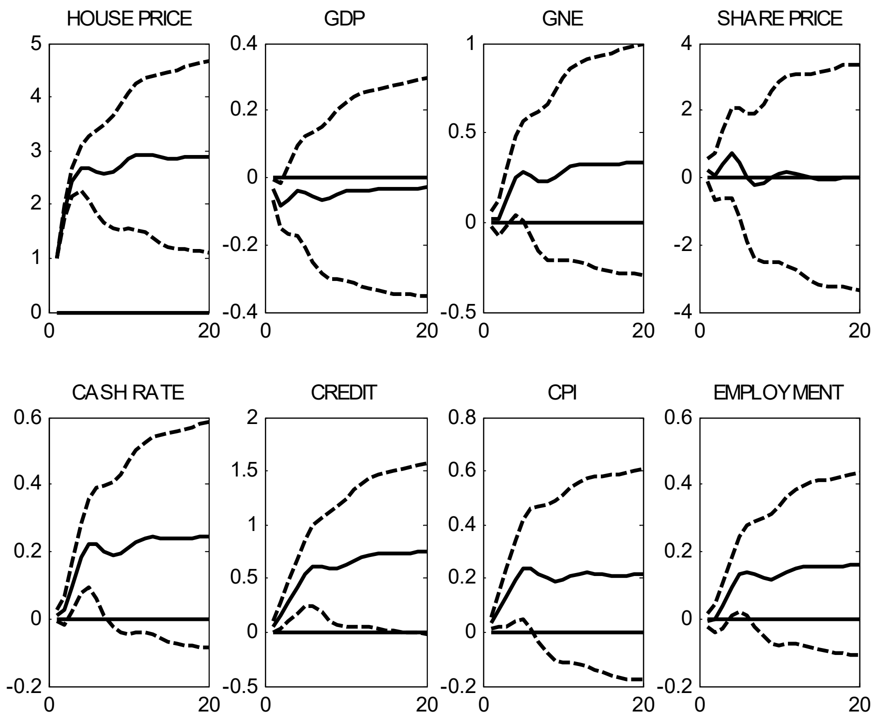


Figure 3.36 FAVAR model with 1 observable variable and 3 factors. Cumulative response to a house price shock of 1 per cent

Appendix 3.4 Data Description

The data used in this study are below. The period covered is 1993Q2 to 2017Q4. The asterisk (*) in the third column indicates a variable assumed to be slow moving in the estimation. The fourth column indicates the type of transformation of the data: (1) no transformation, (2) difference, (3) log difference.

1	GVAAG	*	3	Real gross value added: Agriculture, forestry and fishing	ABS
2	GVAMIN	*	3	Real gross value added: Mining	ABS
3	GVAFOOD	*	3	Real gross value added: Manufacturing ; Food, beverage and tobacco	ABS
4	GVAPET	*	3	Real gross value added: Manufacturing ; Pet., coal, chem. and rubber	ABS
5	GVAMP	*	3	Real gross value added: Manufacturing ; Metal products	ABS
6	GVAMACH	*	3	Real gross value added: Manufacturing ; Machinery and equipment	ABS
7	GVAOTH	*	3	Real gross value added: Manufacturing ; Other manufacturing	ABS
8	GVAMAN	*	3	Real gross value added: Manufacturing	ABS
9	GVAELEC	*	3	Real gross value added: Electricity, gas, water and waste services	ABS
10	GVACON	*	3	Real gross value added: Construction	ABS
11	GVAWT	*	3	Real gross value added: Wholesale trade	ABS
12	GVART	*	3	Real gross value added: Retail trade	ABS
13	GVAACC	*	3	Real gross value added: Accommodation and food services	ABS
14	GVATR	*	3	Real gross value added: Transport, postal and warehousing	ABS
15	GVAIT	*	3	Real gross value added: Information media and telecommunications	ABS
16	GVAFIN	*	3	Real gross value added: Financial and insurance services	ABS
17	GVARENT	*	3	Real gross value added: Rental, hiring and real estate services	ABS
18	GVAPSS	*	3	Real gross value added: Professional, scientific and technical services	ABS
19	GVAASS	*	3	Real gross value added: Administrative and support services	ABS
20	GVAPUB	*	3	Real gross value added: Public administration and safety	ABS
21	GVAEDU	*	3	Real gross value added: Education and training	ABS
22	GVAHEA	*	3	Real gross value added: Health care and social assistance	ABS
23	GVAART	*	3	Real gross value added: Arts and recreation services	ABS
24	GVAOTH	*	3	Real gross value added: Other services	ABS
25	OD	*	3	Ownership of dwellings Ownership of dwellings	ABS
26	GDP	*	3	Real gross domestic product	ABS
27	GNE	*	3	Real gross national expenditure	ABS
28	NATINC	*	3	Real gross national income	ABS
29	DISPINC	*	3	Real net national disposable income	ABS
30	PCDI	*	3	Percapita disposable income	ABS
31	PCW	*	3	Percapita wealth	ABS
32	LP	*	3	Labour productivity	ABS
33	EAG	*	3	Employment, Agriculture, Forestry and Fishing	ABS
34	EMIN	*	3	Employment, Mining	ABS
35	EMAN	*	3	Employment, Manufacturing	ABS
36	EELEC	*	3	Employment, Electricity, Gas, Water and Waste Services	ABS
37	ECON	*	3	Employment, Construction	ABS
38	EWHO	*	3	Employment, Wholesale Trade	ABS
39	ERET	*	3	Employment, Retail Trade	ABS

40	EACC	*	3	Employment, Accommodation and Food Services	ABS
41	ETRAN	*	3	Employment, Transport, Postal and Warehousing	ABS
42	EINF	*	3	Employment, Information Media and Telecommunications	ABS
43	EFIN	*	3	Employment, Financial and Insurance Services	ABS
44	ERENT	*	3	Employment, Rental, Hiring and Real Estate Services	ABS
45	EPROF	*	3	Employment, Professional, Scientific and Technical Services	ABS
46	EADM	*	3	Employment, Administrative and Support Services	ABS
47	EPUB	*	3	Employment, Public Administration and Safety	ABS
48	EEDUC	*	3	Employment, Education and Training	ABS
49	EHEALTH	*	3	Employment, Health Care and Social Assistance	ABS
50	EART	*	3	Employment, Arts and Recreation Services	ABS
51	EOTHSS	*	3	Employment, Other Services	ABS
52	EMPFT	*	3	Employment - full-time ; Persons	ABS
53	EMPPT	*	3	Employment - part-time ; Persons	ABS
54	EMPT	*	3	Employment - total; Persons	ABS
55	UNEMP	*	3	Unemployment - total; Persons	ABS
56	LFORCE	*	3	Labour Force; Persons	ABS
57	URATE	*	1	Unemployment rate	ABS
58	PRMALE	*	2	Participation rate males	ABS
59	PRFEM	*	2	Participation rate females	ABS
60	HWAVER	*	2	Average weekly hours worked	ABS
61	HWALL	*	3	Hours worked all	ABS
62	HWMKT	*	3	Hours worked market	ABS
63	HWAGR	*	3	Hours worked agriculture	ABS
64	HWRESTMK	*	3	Hours worked rest of market	ABS
65	HWNONMK	*	3	Hours worked non market	ABS
66	HWEDU	*	3	Hours worked education	ABS
67	HWRESTNMK	*	3	Hours worked rest of non-market	ABS
68	CONFOOD	*	3	Real consumption expenditure:Food	ABS
69	CONCIG	*	3	Real consumption expenditure:Cigarettes and tobacco	ABS
70	CONALC	*	3	Real consumption expenditure:Alcoholic beverages	ABS
71	CONCLO	*	3	Real consumption expenditure:Clothing and footwear	ABS
72	CONRENT	*	3	Real consumption expenditure:Rent and other dwelling services	ABS
73	CONELEC	*	3	Real consumption expenditure:Electricity, gas and other fuel	ABS
74	CONFURN	*	3	Real consumption expenditure:Furnishings and household equipment	ABS
75	CONHEA	*	3	Real consumption expenditure:Health	ABS
76	CONVEH	*	3	Real consumption expenditure:Purchase of vehicles	ABS
77	CONOV	*	3	Real consumption expenditure:Operation of vehicles	ABS
78	CONTR	*	3	Real consumption expenditure:Transport services	ABS
79	CONCOM	*	3	Real consumption expenditure:Communications	ABS
80	CONREC	*	3	Real consumption expenditure:Recreation and culture	ABS
81	CONEDU	*	3	Real consumption expenditure:Education services	ABS
82	CONHOT	*	3	Real consumption expenditure:Hotels, cafes and restaurants	ABS
83	CONFIN	*	3	Real consumption expenditure:Insurance and other financial services	ABS
84	CONOTH	*	3	Real consumption expenditure:Other goods and services	ABS

85	CONTOT	*	3	Real consumption expenditure:Total	ABS
86	CONPC	*	3	Real consumption per capita	ABS
87	IDW		3	Private investment Dwellings - Total	ABS
88	ITDW		3	Private investment Ownership transfer costs	ABS
89	INDW		3	Private investment Non-dwelling construction - Total	ABS
90	IMACH		3	Private investment Machinery and equipment - Total	ABS
91	IPRIV		3	Private investment Total	ABS
92	DWH		3	Dwelling units completed Private Sector ; Houses ; New	ABS
93	DWOR		3	Dwelling units completedPrivate Sector ; Total Other Residential ; New	ABS
94	VRES		3	Real value of work done Total Sectors ; Total Residential	ABS
95	VNRES		3	Real value of work done Total Sectors ; Total Non-residential	ABS
96	VPRT		3	Real value of work done Private Sector ; Total (Type of Building)	ABS
97	VPUT		3	Real value of work done Public Sector ; Total (Type of Building)	ABS
98	RETFOOD		3	Retail trade food	ABS
99	RETHH		3	Retail trade household goods	ABS
100	RETCLO		3	Retail trade clothing	ABS
101	RETDS		3	Retail tradedepartment stores	ABS
102	RETOTHER		3	Retail trade other retailing	ABS
103	RETSS		3	Retail trade café and other services	ABS
104	RTRADE		3	Retail trade	ABS
105	SP		3	Share prices index	GVAR, RBA
106	HP		3	House prices index	ABS
107	ERW		3	Exhange rate:Real trade-weighted index	RBA
108	ERJPN		3	Exhange rate:Japanese Yen	RBA
109	ERUSA		3	Exhange rate:United States dollar	RBA
110	ERKOR		3	Exhange rate:South Korean Won	RBA
111	ERNZ		3	Exhange rate:New Zealand dollar	RBA
112	ERCHN		3	Exhange rate:Chinese renminbi	RBA
113	ERUK		3	Exhange rate:UK poud sterling	RBA
114	TOT		3	Terms of trade: Index	RBA
115	ICASH		2	Interest rate:Cash rate	RBA
116	IBA90		2	Interest rate:Bank accepted bills (90 days)	RBA
117	ISMLL		2	Interest rate:Small business overdraft	RBA
118	ILRG		2	Interest rate:Large business variable rate	RBA
119	IHOU		2	Interest rate:Home loans standard variable rate	RBA
120	IGOV5		2	Interest rate:Government bonds 5 year	RBA
121	IGOV10		2	Interest rate:Government bond 10 years	RBA
122	SIBA90		1	Spread: Bank accepted bills - cash rate	RBA
123	SISMLL		1	Spread: Small business overdraft - cash rate	RBA
124	SILRG		1	Spread: Large business variable rate - cash rate	RBA
125	SIHOU		1	Spread: Home loans standard variable rate - cash rate	RBA
126	SIGOV5		1	Spread: Government bonds 5 year - cash rate	RBA
127	SIGOV10		1	Spread: Government bond 10 years - cash rate	RBA
128	M1		3	M1 nominal	RBA
129	M3		3	M3 nominal	RBA
130	MBROA		3	Broad money supply	RBA

131	MBASE		3	Monetary base	RBA
132	M3R		3	Real M3	RBA
133	MBASER		3	Real monetary base	RBA
134	M3Y		2	M3/GDP	RBA
135	MBASEY		2	Monetary base / GDP	RBA
136	CRHO		3	Credit households for housing- nominal	RBA
137	CRHI		3	Credit households investment housing - nominal	RBA
138	CROP		3	Credit households other - nominal	RBA
139	CRBS		3	Credit to businesses - nominal	RBA
140	CR		3	Credit - nominal	RBA
141	CRHOR		3	Real credit households for housing	RBA
142	CRHIR		3	Real credit households investment housing	RBA
143	CROPR		3	Real credit households other	RBA
144	CRBSR		3	Real credit to businesses	RBA
145	CRREAL		3	Real credit	RBA
146	CRHOY		2	Credit households for housing / GDP	ABS, RBA
147	CRHIY		2	Credit households investment housing / GDP	ABS, RBA
148	CROPY		2	Credit households other / GDP	ABS, RBA
149	CRBSY		2	Credit to businesses / GDP	ABS, RBA
150	CRY		2	Credit / GDP	ABS, RBA
151	HHDW		3	Household dwellings	ABS
152	HHLAND		3	Household land	ABS
153	HHFA		3	Household financial assets	ABS
154	HHLIAB		3	Household liabilities	ABS
155	TIER1CAP		3	Tier 1 capital	RBA, APRA
156	CAPITAL		3	Total banking capital	RBA, APRA
157	RWA		3	Total risk weighted assets	RBA, APRA
158	TIER1		2	Tier 1 Capital ratioper cent	RBA, APRA
159	CRR		2	Capital/risk weighted asset ratioper cent	ABS
160	LIQ		1	Liquidity ratio	ABS
161	CPIFOOD	*	3	Consumer price index:Food and non-alcoholic beverages	ABS
162	CPIALC	*	3	Consumer price index:Alcohol and tobacco	ABS
163	CPICLOTH	*	3	Consumer price index:Clothing and footwear	ABS
164	CPIHOUS	*	3	Consumer price index:Housing	ABS
165	CPIFURN	*	3	Consumer price index:Furnishings, household equipment and ss	ABS
166	CPITR	*	3	Consumer price index:Transport	ABS
167	CPICOMM	*	3	Consumer price index:Communication	ABS
168	CPI	*	3	Consumer price index:All consumption groups	ABS
169	CPIEXP1	*	3	Consumer expectations index	ABS
170	CPIEXP2	*	3	Consumer expectations index	ABS
171	PGOVCON	*	3	Price index General government ; consumption	ABS
172	PCONS	*	3	Price index - Households ; consumption	ABS
173	PIDW	*	3	Price index - Private; Investment: Dwellings	ABS
174	PITDW	*	3	Price index - Private ; Investment: Ownership transfer costs	ABS
175	PINDW	*	3	Price index - Private ; Investment: Non-dwelling construction	ABS
176	PIMACH	*	3	Price index - Private ; Investment: Machinery and equipment	ABS

177	PIPRIV	*	3	Price index - Private ; Investment	ABS
178	PGOVINV	*	3	Price index - Public ; Investment	ABS
179	PGNE	*	3	Price index - Investment	ABS
180	PEXP	*	3	Price index - Exports of goods and services	ABS
181	PIMP	*	3	Price index - Imports of goods and services	ABS
182	PGDP	*	3	GDP deflator;	ABS
183	WAGE	*	3	Average weekly earnings	ABS
184	GOVREV	*	1	Real federal government revenue	ABS, TREASURY
185	GOVEXP	*	1	Real federal government expenditure	ABS, TREASURY
186	SURPLUS	*	1	Real federal government surplus	ABS, TREASURY
187	DEBTGDP	*	1	Federal government debt/GDP	ABS, TREASURY
188	GOVCON	*	3	All general government consumption	ABS
189	GOVINV	*	3	Public sector investment	ABS
190	EXPORT	*	3	Total real exports of goods and services	ABS
191	EXFOOD	*	3	Real exports of merchandise: Food and live animals	ABS
192	EXBEV	*	3	Real exports of merchandise: Beverages and tobacco	ABS
193	EXMAT	*	3	Real exports of merchandise: Crude materials, inedible, except fuels	ABS
194	EXMIN	*	3	Real exports of merchandise: Mineral fuels, lubricants	ABS
195	EXANI	*	3	Real exports of merchandise: Animal and vegetable oils, fats and waxes	ABS
196	EXCHEM	*	3	Real exports of merchandise: Chemicals and related products, nes	ABS
197	EXMAN	*	3	Real exports of merchandise: Manufactured goods	ABS
198	EXMACH	*	3	Real exports of merchandise: Machinery and transport equipment	ABS
199	EXMISC	*	3	Real exports of merchandise: Miscellaneous manufactured articles	ABS
200	EXCOMM	*	3	Real exports of merchandise: Commodities and transactions not classified	ABS
201	EXTOT	*	3	Total real exports of merchandise	ABS
202	EXCHINA	*	3	Real exports of merchandise - China	ABS
203	EXHK	*	3	Real exports of merchandise - Honk Kong	ABS
204	EXINDIA	*	3	Real exports of merchandise - India	ABS
205	EXJPN	*	3	Real exports of merchandise - Japon	ABS
206	EXKOR	*	3	Real exports of merchandise - Korea	ABS
207	EXNZ	*	3	Real exports of merchandise - New Zealand	ABS
208	EXUSA	*	3	Real exports of merchandise - USA	ABS
209	IMPORT	*	3	Real imports of goods and services	ABS
210	IMFOOD	*	3	Real imports of merchandise: Food and live animals	ABS
211	IMBEV	*	3	Real imports of merchandise: Beverages and tobacco	ABS
212	IMMAT	*	3	Real imports of merchandise: Crude materials, inedible, except fuels	ABS
213	IMMIN	*	3	Real imports of merchandise: Mineral fuels, lubricants	ABS
214	IMANI	*	3	Real imports of merchandise: Animal and vegetable oils, fats and waxes	ABS
215	IMCHEM	*	3	Real imports of merchandise: Chemicals and related products, nes	ABS
216	IMMAN	*	3	Real imports of merchandise: Manufactured goods	ABS
217	IMMACH	*	3	Real imports of merchandise: Machinery and transport equipment	ABS
218	IMMISC	*	3	Real imports of merchandise: Miscellaneous manufactured articles	ABS
219	IMCOMM	*	3	Real imports of merchandise: Commodities and transactions not classified	ABS
220	IMTOT	*	3	Total real imports of merchandise	ABS
221	IMCH	*	3	Real imports of merchandise - China	ABS
222	INGER	*	3	Real imports of merchandise - Germany	ABS

223	IMJPN	*	3	Real imports of merchandise - Japon	ABS
224	IMKOR	*	3	Real imports of merchandise - Korea	ABS
225	IMNZ	*	3	Real imports of merchandise - New Zealand	ABS
226	IMUS	*	3	Real imports of merchandise - USA	ABS
227	CAGDP	*	1	Current account / GDP	ABS
228	DINV	*	1	Direct investment / GDP	ABS
229	PORTINV	*	1	Portfolio investment / GDP	ABS
230	FINDER	*	1	Financial derivatives / GDP	ABS
231	OINV	*	1	Other investments / GDP	ABS
232	RFA	*	1	Reserves / GDP	ABS
233	COMMP1	*	3	Rural commodity prices	ABS
234	COMMP2	*	3	Non-rural commodity prices	ABS
235	COMMP3	*	3	Base metals prices	ABS
236	COMMP4	*	3	Bulk commodities prices	ABS

Chapter 4

The dynamics of hours worked and technology

ABSTRACT

This chapter analyses the responses of output and hours worked to shocks that have permanent and transitory effects on output. This chapter uses an SVAR model with long-run restrictions and Australian data from 1978Q4 to 2017Q4. In line with the approach followed by Blanchard and Quah (1989), this chapter interprets the first type of shock as a supply disturbance and the second type of shock as a demand disturbance. The supply disturbance takes the form of a neutral technology shock and is later extended to include an investment-specific technology shock. Hours worked is decomposed into average hours worked and employment. This decomposition allows the analysis of different types of temporary demand shocks associated with average hours and employment shocks. The results show a negative response of total hours to a positive, neutral technology shock, and total hours adjust mainly through employment. When the price of investment is included in the model, a positive investment-specific technology shock produces a positive response of total hours worked, with average hours having a more relevant role in the adjustment of total hours than in the case of the responses to a neutral technology shock. Labour productivity decreases temporarily after an average hours shock and increases after an employment shock. The shock to average hours is interpreted as an unexpected temporary demand shock, where firms are uncertain about the permanence of the shock. The shock to employment is interpreted as a shock to demand generated by the expectation of consumers and investors of a permanent increase in productivity that finally does not occur. Analysis of the variance decomposition in the base model shows that labour inputs explain 86 and 57 per cent of the GDP variance on impact in the samples 1978Q4 -1999Q4 and 2000Q1-2017Q4, respectively, while productivity explains around 83 and 95 per cent of the variance in the long-run in the same sample periods. The extended model with investment-specific technology shock confirms that most of the variance of output in the long-run is explained by neutral technology shock.

4.1 Introduction

One controversial issue in the study of business cycles is the effect of technology on total hours worked. The positive response of hours worked to a positive shock in productivity is associated with a validation of the Real Business Cycle theory, while a negative response is associated with price rigidities found in New Keynesian models (Galí, 1999). More broadly, this issue is related to the estimation of the relative importance of permanent and temporary shocks to explain changes in output and hours worked (e.g., Blanchard and Quah, 1989 and Fischer, 2006).

This chapter analyses the responses of output and hours worked to shocks that have permanent and transitory effects on output. In line with the approach adopted by Blanchard and Quah (1989), this chapter interprets the first type of shock as a supply disturbance and the second type of shock as a demand disturbance. This chapter presents an SVAR model with long-run restrictions using Australian quarterly data from 1978Q4 to 2017Q4. The base model includes labour productivity, average hours worked and employment. The shock to labour productivity is a supply disturbance and corresponds to a neutral technology shock (Galí, 1999), and the model is later extended to include an investment-specific technology shock as an additional supply shock (Fischer, 2006). The shock to average hours is interpreted as an unexpected temporary demand shock, where firms are uncertain about the permanence of the shock as described by Hamermesh (1996). The shock to employment is interpreted as a shock to demand generated by the expectation of consumers and investors of a permanent increase in productivity that finally does not occur, as described by Lorenzoni (2006).

One of the features of the models presented in this chapter is the decomposition of total hours worked into average hours worked (i.e., intensive margin) and employment (i.e., extensive margin). These two components are not necessarily perfect substitutes as they make different contributions to the production process and the costs attached to them are also different (Cahuch et al., 2014). Due to these differences, average hours worked and employment do not respond similarly to shocks, and the responses to shocks to average hours worked and employment are also different.

The importance of both margins is documented in several countries. Ohanian and Raffo (2012) construct a database with hours worked for 14 OECD countries and find that a large portion of labour adjustment takes place along the intensive margin and that the volatility of hours has increased over time. Other studies such as those conducted by Taskin (2013), Wesselbaum (2011), Herzog-Stein and Nüβ (2016) and Cacciatore et al. (2016) find that the extensive margin is predominant, but the intensive margin is still important.

For Australia, Bishop et al. (2016) estimate that average hours explain 25 per cent of the cyclical variation of total hours between 1978 and 2016. However, by splitting the sample between a period of high output volatility (1978-1998) and a period of low output volatility (1999-2016), they find that the contribution of average hours worked increased from 20 per cent in the first sample to 58 per cent in the second sample. They explain that the increase in the importance of the adjustment through hours is associated with the reforms to industrial relations in the late 1980s and 1990s that facilitated a direct bargain between employees and employers, which may have helped employers reduce working hours and retain workers[1].

To assess the robustness of the results, the base model is estimated for the full period 1978Q4 to 2017Q4 and for two additional periods: 1978Q4 to 1999Q4 and 2000Q1 to 2017Q4. Additionally, the base model is expanded in two ways. In addition to the variables considered in the base model, the first extension incorporates the investment price, the inflation rate and the interest rate. The investment price allows for the inclusion of an investment-specific technology shock as an additional supply shock (Fischer, 2006). Additionally, the second extension includes the terms of trade growth rate, the US GDP growth rate and the US real interest rate as exogenous variables.

This analysis will answer the following questions: How do output, employment and average hours worked respond to a change in technical progress and demand? How important are productivity shocks in explaining the variance of economic activity? And, have these interactions changed over time?

The results in the base model show a negative response of total hours to a positive, neutral technology shock and that total hours adjust mainly through employment. This result is verified for the whole sample period and the two subsamples. Additionally, when the base

[1] Borland (2011) analyses a series of reforms in the labour market legislation during the late 1980s and the 1990s, including the *Industrial Relations Amendment Act 1992 and 1994*, the *Industrial Relations Reform Act 1993* and the *Workplace Relations and Other Legislation Amendment Act 1996.* This legislative framework allowed agreements with individual workers; introduces restrictions on the role of unions; outlaws the union preference clauses, and discrimination in favour of union members; and limits the right to strike. According to Borland these measures have significant importance in the structure of the labour market especially from year 2000.

model is extended to include the price of investment, a positive investment-specific technology shock produces a positive response of total hours worked, with average hours having a more relevant role in the adjustment of total hours than in the case of the responses to a neutral technology shock. Analysis of the variance decomposition shows that labour inputs explain 86 and 57 per cent of the variance of GDP on impact in the samples 1978Q4 - 1999Q4 and 2000Q1-2017Q4, respectively. In comparison, productivity explains around 83 and 95 per cent of the variance in the long-run, in the same sample periods. The extended model with investment-specific technology shock confirms that most of the variance of output in the long-run is explained by neutral technology shock.

There are several issues discussed in the literature in relation to the econometric estimation of the response of output and hours worked to permanent and transitory shocks. These issues include the sign of the response of hours to a positive shock to technology, the stationarity of hours worked, the types of technology change considered and the reliability of estimates based on long-run restrictions.

Blanchard and Quah (1989) provide one of the early studies that use an SVAR model with a long-run restriction approach with similar variables to those of this study. Their model includes output and the unemployment rate, while the base model in this chapter, as mentioned above, includes labour productivity and the two components of total hours worked: average hours worked and employment. Blanchard and Quah (1989) propose that output can be affected by more than one type of disturbance. They assume that there are two kinds of uncorrelated disturbances. The first shock, called a demand disturbance, does not affect output or unemployment permanently. The other shock, called a supply disturbance, has a temporary effect on unemployment but a permanent effect on output. They find that a demand shock has hump-shaped effects on output and unemployment, with opposite signs. The effects of demand vanish in three to five years. A positive supply shock generates a positive response of output over time, reaching a plateau after five years. It also produces a temporary positive response of the unemployment rate during the first four quarters and a negative response after five quarters but returns to the original value in the long run.

Galí (1999) and Christiano et al. (2003) estimate models relevant for this study that include variables similar to those of this chapter. Galí (1999) estimates bivariate SVAR models with labour productivity and hours worked. Both variables are included in the model in log difference form. Galí’s basic identifying assumption is that only technology shocks can have a permanent effect on the level of labour productivity. Galí reports a negative response of hours worked to a positive technology shock. Under a similar identification scheme, Francis and Ramey (2002) and Galí and Rabanal (2004) also find a negative response of hours worked. However, Christiano et al. (2003) find that Galí's conclusion depends on the treatment of hours worked. They claim that hours worked is stationary and should be included in the model in levels. Under this specification, the response of hours worked is positive. Francis and Ramey (2002) also find a positive response when hours worked is stationary. In relation to the types of technology shocks, Fischer (2006) and Canova et al. (2010) consider two types: a neutral technology shock (called an N-shock) and an investment-specific technology shock (called an I-shock). The extended models in this chapter include these two types of technology shocks.

Regarding the use of long-run restrictions, Faust and Leeper (1997) discuss three reasons why this identification method may not be reliable. The first reason, which is specific to SVARs with long-run restrictions, is that the long-run effect of shocks would be imprecisely estimated in finite samples, leading to imprecise estimates of other parameters in the model. The two additional reasons concern the identification problems of most empirical studies using time series in models that aggregate across variables (e.g. a supply shock must combine oil shocks, labour-supply shocks, and productivity shocks) and across time (e.g. orthogonality assumption may be inappropriate in time-aggregated or infrequently sampled data). In relation to the first reason that is specific to the identification approach used in this chapter, Faust and Leeper (1997) suggest that some ways to resolve this issue are to impose *apriori* restrictions on the lag length of the underlying model or on the horizon at which the effect of the shock goes to zero. An alternative is to impose short-run restrictions and use the long-horizon responses as an informal diagnostic. Faust and Leeper conclude that the results of their article do not suggest that the long-run schemes should be abandoned, but provide approaches to evaluate and improve the robustness of inferences under this approach. Söderlin and Vredin (1996) find that this approach does well when used with data generated from standard macroeconomic models. St-Amant and Tessier (1998) suggest that a reasonable approach is to present robustness checks to assist in the evaluation of what the effects of possible approximation errors might be. This chapter provides robustness analysis comparing the base model with the same model estimated for two subsamples and with extended models that include additional variables.

The base model in this chapter assumes that only technology affects labour productivity in the long run, in line with the approach followed by Galí (1999). The I-shock is introduced in the two extended models when the real investment price is included. In these extended models, it is assumed that only the investment-specific shock has a long term effect on the real price of investment, following Fischer (2006). Additionally, as discussed in Section 4.2, average hours worked and employment (as a share of working-age population) are included in the models in levels with a trend. This is consistent with the stationarity of the ratio of total hours worked to the working-age population.

The chapter is organised as follows: Section 4.2 describes the data used in the SVAR model. Section 4.3 describes the methodology used. Section 4.4 presents the empirical results described by impulse response functions. Section 4.5 explores robustness comparing the full sample responses to responses in the two subsamples of 1978Q4 to 1999Q4 and 2000Q1 to 2017Q4. This section also presents estimates of the variance decomposition for the subsamples and presents two extensions of the base model. Section 4.6 concludes.

4.2 Data

Several models are estimated in this chapter. Table 4.1 summarizes the variables and sample periods of each model. The models are all estimated using seasonally adjusted quarterly data. The first two models are bivariate models that include labour productivity and the ratio of total hours worked to the working-age population. In both models, labour productivity is in log difference form (*dlx*), while the total hours worked ratio is in log difference (*dlhw*) in the first model and in the log of the level of the ratio (*lhw*) in the second model. These models do not decompose hours worked but are useful to compare results with other bivariate models found in the literature, such as those developed by Blanchard and Quah (1989), Galí (1999) and Christiano et al. (2003). The second row of Table 4.1 summarizes the specification of the base model. This model includes three variables: the log difference of labour productivity, the log of average hours worked (*lh*) and the log of the employment-to-working age population ratio (*ln*). This model includes the minimum number of variables needed to analyse the effect of technology on the two components of total hours worked. The base model is estimated for three sample periods. This model includes a deterministic time trend (*t*). The data for the bivariate models and the base model are analysed below in this section.

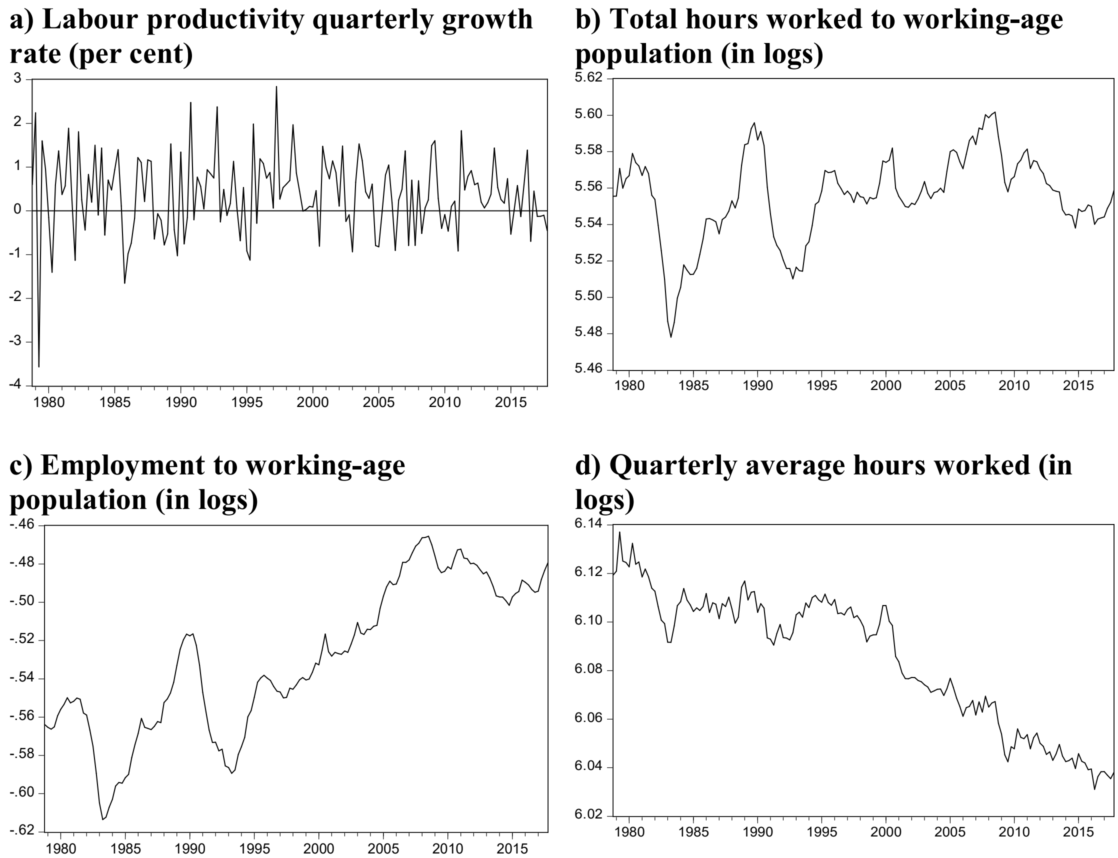
Table 4.1 List of models

Models	Sample period	Endogenous variables	Exogenous variables
Bivariate models	1978Q4-2017Q4	*dlx, dlhw*	
	1978Q4-2017Q4	*dlx, lhw*	
Base model	1978Q4-2017Q4	*dlx, lh, ln*	*T*
	1978Q4-1999Q4	*dlx, lh, ln*	*T*
	2000Q1-2017Q4	*dlx, lh, ln*	*T*
Extended models	1978Q4-2017Q4	*dlpinv, dlx,lh, ln, inf, r*	*T*
	1978Q4-2017Q4	*dlpinv, dlx,lh, ln, inf, r*	*dltot, dly_us, r_us, t*

The third panel of Table 4.1 summarizes the extensions to the base model analysed in Section 4.5.3. In addition to the variables in the base models, the first extension includes the log difference of the ratio of the price of investment-to-price of consumption (*dlpinv*), the Australian inflation rate (*inf*) and the Australian real interest rate (*r*) in the model specification. The second extension includes the same variables of the first extension plus the contemporaneous log difference of the terms of trade (*dltot*), the log difference of the per-capita US GDP (*dly_us*) and the US real interest rate (*r_us*). These models include a deterministic time trend.

The domestic variables in the models are included with two lags according to the AIC lag selection criteria. The treatment of the data used in the bivariate models and the base models is discussed in this section. The treatment of the variables in the extended models is discussed in Section 4.5. Henceforth, the log of the ratio of total hours worked to working-age population, the log of the ratio of employment to working-age population and the log of average hours worked can also be referred as total hours worked, employment and average hours worked, respectively.

Labour productivity is measured as the ratio of GDP to total hours worked. Both series are published by the Australian Bureau of Statistics. Panel a) of Figure 4.1 shows the evolution of the growth rate of labour productivity. The augmented Dickey-Fuller (ADF) and KPSS unit root tests for the log of labour productivity (*lx*) indicate the presence of unit root for the whole sample 1978Q4 to 2017Q4 (see Table 4.2). Labour productivity is included in the model in log differences in line with the approach followed by Galí (1999), Christiano et al. (2003) and Fischer (2006).



Source: Australian Bureau of Statistics

Figure 4.1 Variables included in the bivariate and base models, 1978Q4-2017Q4

As shown in panel d) of Figure 4.1, the average hours worked shows a declining trend for the period 1978Q4 to 2017Q4. After a sharp decline from 1980 to 1982, the average hours worked do not show a clear trend from 1983 to 1999. However, after that period, the average hours worked shows a declining trend. The negative trend in average hours worked is accompanied by a positive trend of the employment to working-age population ratio. This is explained by the increase in part-time employment shares, especially after the year 2000. The beginning of the declining trend of average hours worked coincides with lower volatility in real GDP and lower duration of downturns.

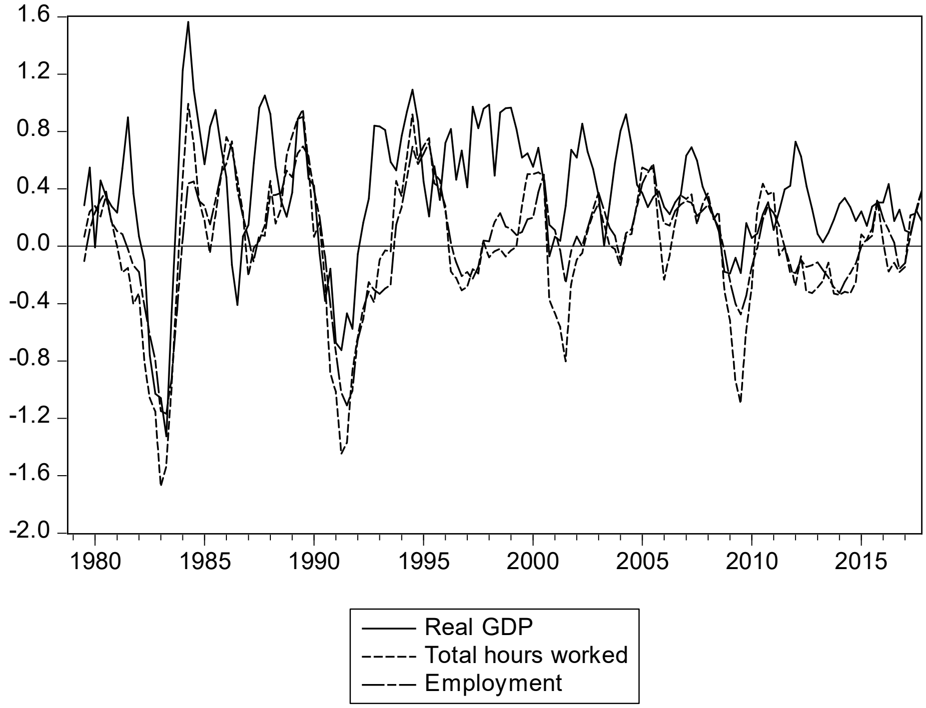
The Augmented Dickey-Fuller and KPSS tests are used to test for stationarity of the data over the full sample 1978Q2 to 2017Q4. Both tests support the stationarity of total hours worked. According to the Augmented Dickey-Fuller test, the null hypothesis of a unit root for average hours worked and employment cannot be rejected at a five per cent significance level. However, according to the KPSS test, the null hypothesis of stationarity can be rejected at a five per cent significance level for the average hours worked and cannot be rejected for employment. It is not clear whether employment follows a random walk or not, and hence it is not clear from these tests whether the labour variables should be included as differences or as levels in the SVAR. Given that total hours worked is stationary, the models in this chapter include the average hours worked and employment in levels with a time trend. This approach will generate responses of the average hours worked and employment consistent with the stationarity of total hours worked. This treatment of labour variables is consistent with Christiano et al. (2003), who recommend that total hours worked be included in levels.

Table 4.2 Augmented Dickey-Fuller and KPSS unit root tests statistics (1978Q4 to 2017Q4)

Variable	ADF	KPSS
lx	-2.38	0.14 **
lhw	-4.27 *	0.08
ln	-3.05	0.1
lh	-3.06	0.28 *

ADF null hypothesis: The variable has a unit root.
KPSS null hypothesis: The variable is stationary.
(*) Reject the null hypothesis at a 5 per cent significance level.
(**) Reject the null hypothesis at a 10 per cent significance level.
The ADF and KPSS statistics for all variables are based on regressions that include constants and linear trends.

Although total hours worked and the ratio of GDP to the working-age population (henceforth GDP or output) are not included as variables in the SVAR, their responses to different shocks are estimated for all models. These responses are estimated from the included variables. GDP is estimated by the sum of labour productivity, average hours worked and employment. Total hours worked is estimated by the sum of average hours worked and employment. Figure 4.2 shows the four-quarter moving average of the growth rate of real GDP, total hours worked and employment. The figure shows big downturns during the first years of the 1980s and the 1990s. After the year 2000, the GDP is less volatile.



Note: The variables are ratios over the working-age population.
Source: Australian Bureau of Statistics

F2igure 4.2. Real GDP, total hours worked and employment growth rates. Four quarter-moving average, 1978Q4-2017Q4 (per cent)

4.3 Methodology and identification

This section describes the methodology used to estimate the base model, where total hours worked is split between average hours worked and employment. A similar methodology is used for the bivariate models and the extended models. The effect of a permanent technology shock and other transitory shocks on employment and average hours are estimated using an SVAR(2) model with long-run restrictions. The restriction is that labour productivity growth is only determined by a neutral technology change in the long-run as in Galí (1999). The dynamic effects of technology are estimated using the method of Shapiro and Watson (1988) described in Ouliaris, Pagan and Restrepo (2016). This procedure is also followed by Christiano et al. (2003).

In the SVAR the labour productivity (x_t) is included in log difference (dlx_t), while average hours (h_t) and employment (n_t) are in log levels (lh_t and ln_t, respectively). A deterministic time trend is also included. The base model has three equations that correspond to labour productivity growth, average hours worked and employment.

The first equation in the SVAR(2) is the structural equation for labour productivity growth that has the form:

$$dlx_t = \alpha_{12}^0 lh_t + \alpha_{13}^0 ln_t + \alpha_{11}^1 dlx_{t-1} + \alpha_{12}^1 lh_{t-1} + \alpha_{13}^1 ln_{t-1} + \alpha_{11}^2 dlx_{t-2} + \alpha_{12}^2 lh_{t-2} + \alpha_{13}^2 ln_{t-2} + u_{xt}, \qquad (1)$$

so that there are no long-run effects of the average hours worked and employment on labour productivity growth, the coefficients of the model are restricted so that $\alpha_{12}^0 = -(\alpha_{12}^1 + \alpha_{12}^2)$ and $\alpha_{13}^0 = -(\alpha_{13}^1 + \alpha_{13}^2)$. After imposing these restrictions, equation (1) becomes equation (2),

$$dlx_t = \beta_{12}^0 dlh_t + \beta_{13}^0 dln_t + \alpha_{11}^1 dlx_{t-1} + \beta_{12}^1 dlh_{t-1} + \beta_{13}^1 dln_{t-1} + \alpha_{11}^2 dlx_{t-2} + u_{xt}, \qquad (2)$$

where $\beta_{12}^0 = -(\alpha_{12}^1 + \alpha_{12}^2)$; $\beta_{12}^1 = -\alpha_{12}^2$; $\beta_{13}^0 = -(\alpha_{13}^1 + \alpha_{13}^2)$; $\beta_{13}^1 = -\alpha_{13}^2$.

If one of the shocks driving lh_t and ln_t is u_{xt} then the labour input variables and u_{xt} will be correlated, and the parameters have to be estimated using instrumental variables. The instruments are chosen to be the second lag of average hours worked and employment (lh_{t-2} and ln_{t-2}) for the contemporaneous difference of these variables. The estimated residual vector of this equation ($\hat{u}_{xt}$) is used as an instrument in the equations for average hours worked and employment.

The second equation of the SVAR for average hours worked is

$$lh_t = \alpha_{21}^0 dlx_t + \alpha_{21}^1 dlx_{t-1} + \alpha_{22}^1 lh_{t-1} + \alpha_{23}^1 ln_{t-1} + \alpha_{21}^2 dlx_{t-2} + \alpha_{22}^2 lh_{t-2} + \alpha_{23}^2 ln_{t-2} + u_{ht}. \qquad (3)$$

This equation can be estimated by instrumental variables using the residual of the labour productivity equation as the instrument ($\hat{u}_{xt}$) for the contemporaneous growth rate of labour productivity (dlx_t).

The third equation of the SVAR corresponds to employment and is specified as:

$$ln_t = \alpha_{31}^0 dlx_t + \alpha_{32}^0 lh_t + \alpha_{31}^1 dlx_{t-1} + \alpha_{32}^1 lh_{t-1} + \alpha_{33}^1 ln_{t-1} + \alpha_{31}^2 dlx_{t-2} + \alpha_{32}^2 lh_{t-2} + \alpha_{33}^2 ln_{t-2} + u_{nt}. \qquad (4)$$

This equation can be estimated by instrumental variables using the residual from the labour productivity equation ($\hat{u}_{xt}$) and the residual from the average worked equation ($\hat{u}_{ht}$) as instruments for the contemporaneous growth rate of labour productivity (dlx_t) and average hours worked (lh_t).

A recursive identification structure is assumed between average hours worked and employment. Average hours worked affects employment contemporaneously, but employment does not have a direct effect on average hours worked contemporaneously. It does have an effect indirectly through labour productivity.

Given estimates of the shocks in equations (2) to (4), the dynamic response of dlx_t, lh_t, and ln_t to labour productivity, average hours worked and employment shocks can be obtained using the parameters of the SVAR. First, a VAR(2) is estimated.

$$
\begin{aligned}
& Y_t = \lambda + B(L)Y_{t-1} + e_t \ , \\
& Y_t = [dlx \quad lh \quad ln]' \ , \\
& e_t = [e_{xt} \quad e_{ht} \quad e_{nt}]' ,
\end{aligned} \tag{5}
$$

where Y_t is the vector of endogenous variables, λ is the constant term of the VAR, $B(L)$ is a conformable lag polynomial matrix, and e_t is the vector of residuals from the VAR. The fundamental economic shocks of the SVAR, u_t and the residual from the VAR, e_t, are related as in the set of equations in (6), where c_x, c_h and c_n are estimated by ordinary least squares

$$
\begin{aligned}
e_{xt} &= \beta_{12}^0 e_{ht} + \beta_{13}^0 e_{et} + c_x u_{xt} , \\
e_{ht} &= \alpha_{21}^0 e_{xt} + c_h u_{ht} , \\
e_{nt} &= \alpha_{31}^0 e_{xt} + \alpha_{32}^0 e_{ht} + c_n u_{nt} .
\end{aligned} \tag{6}
$$

4.4 Results

This section presents the results for the bivariate and base models for the sample period 1978Q4 to 2017Q4, as described in Table 4.1. The shock to a variable corresponds to a one per cent positive shock. The top and bottom lines of the impulse response figures are the one standard deviation confidence intervals (68 per cent confidence interval). The responses in the bivariate models are shown in Figures 4.3 and 4.4. These figures show only the responses of hours worked to shocks in technology, which are the responses most frequently reported in the literature. The responses to shocks to technology, average hours worked and employment are shown for the base model in Figures 4.5 to 4.7. As mentioned before, labour productivity is included in the model in log difference form; however, in the impulse response figures of labour productivity is presented in levels (cumulative response) as the other variables included in the figures.

4.4.1 The bivariate models: the response of hours worked to a technology shock.

Before analysing the responses to shocks to the base model, this subsection looks at the bivariate models to compare them with similar bivariate models in the literature, such as Galí (1999) and Christiano et al. (2003). The responses to technology in two bivariate models are shown in Figures 4.3 and 4.4. In the first bivariate, model total hours worked is in differences. This specification is similar to Galí (1999), except that he does not standardise total hours worked by the working-age population. In the second model, total hours worked is in levels (as in Christiano et al., 2003). In both models, the labour productivity variable is in log difference form.

In both models, the response of hours is negative. This contrasts with Christiano et al. (2003) that reports conflicting responses of the sign of hours worked under the two specifications of hours worked. The bivariate models also illustrate the difference in the permanence of the response of total hours worked to a technology shock. In the model where hours worked is in difference form, hours worked permanently changes as in Galí (1999), while in the model where hours worked is in levels form, the response of total hours worked is transitory and returns to their trend after a period of time. This response of hours worked in the model, where hours is in levels, is consistent with the stationarity of total hours worked in Australia. The specification of hours worked will be in levels with a time trend in the models that follow.

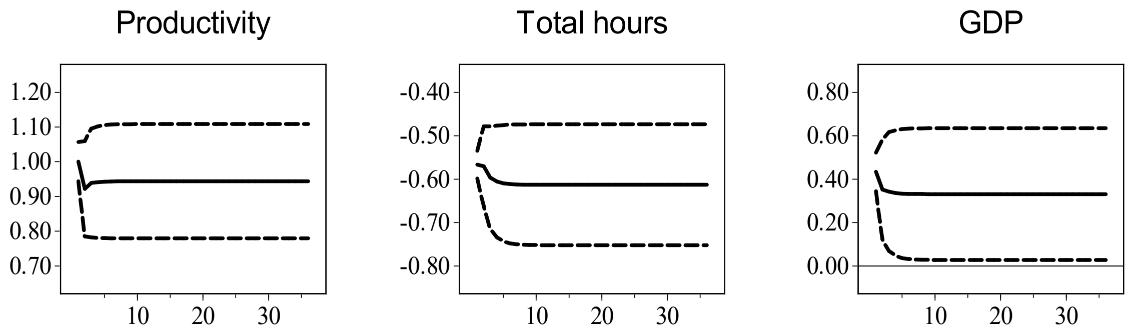


Figure 4.3 Bivariate model, hours in differences. Response to a neutral technology shock of 1 per cent

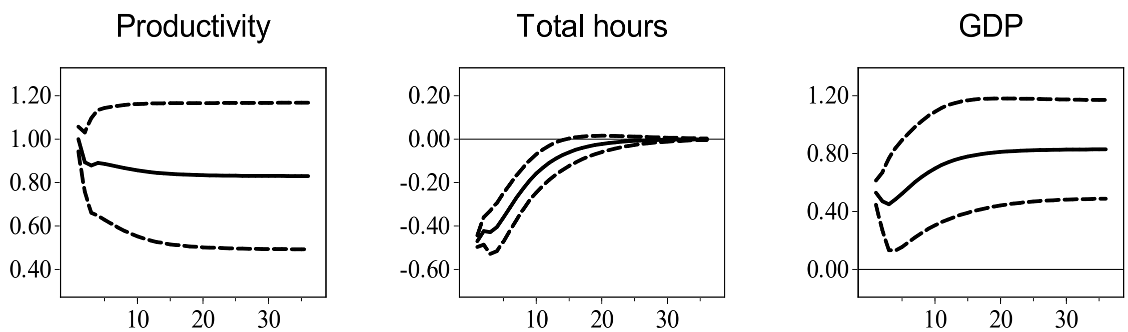


Figure 4.4 Bivariate model, hours in levels. Response to a neutral technology shock of 1 per cent

4.4.2 The base model

This section presents the results of the base model described above for the sample 1978Q4 to 2017Q4. Figures 4.5 to 4.7 show the response in levels of labour productivity, average hours worked and employment to a one per cent shock to labour productivity, average hours worked and employment. Additionally, the response of GDP and total hours worked are also presented. The GDP response is calculated as the sum of the responses of labour productivity, average hours worked and employment. The response of total hours worked is calculated as the sum of the responses of average hours worked and employment.

A neutral technology shock

The responses to a neutral technology shock are shown in Figure 4.5. A shock to labour productivity (neutral technology shock) generates a permanent increase in labour productivity and GDP. The shock also generates a temporary negative response of total hours worked.

Most of the adjustment in hours worked is through a reduction in employment, while the average hours worked shows a slight increase. The GDP increase during the initial periods is lower than the increase in productivity due to the total hours worked contraction; however, GDP converges to the level of productivity as the responses of the average hours worked and the employment ratio goes to zero. The result is consistent with results for the US shown by Galí (1999) and others that include hours worked in differences. The results in this chapter are based on a model in levels as in Christiano et al. (2003), but the response of hours worked has the opposite sign for the Australian case.

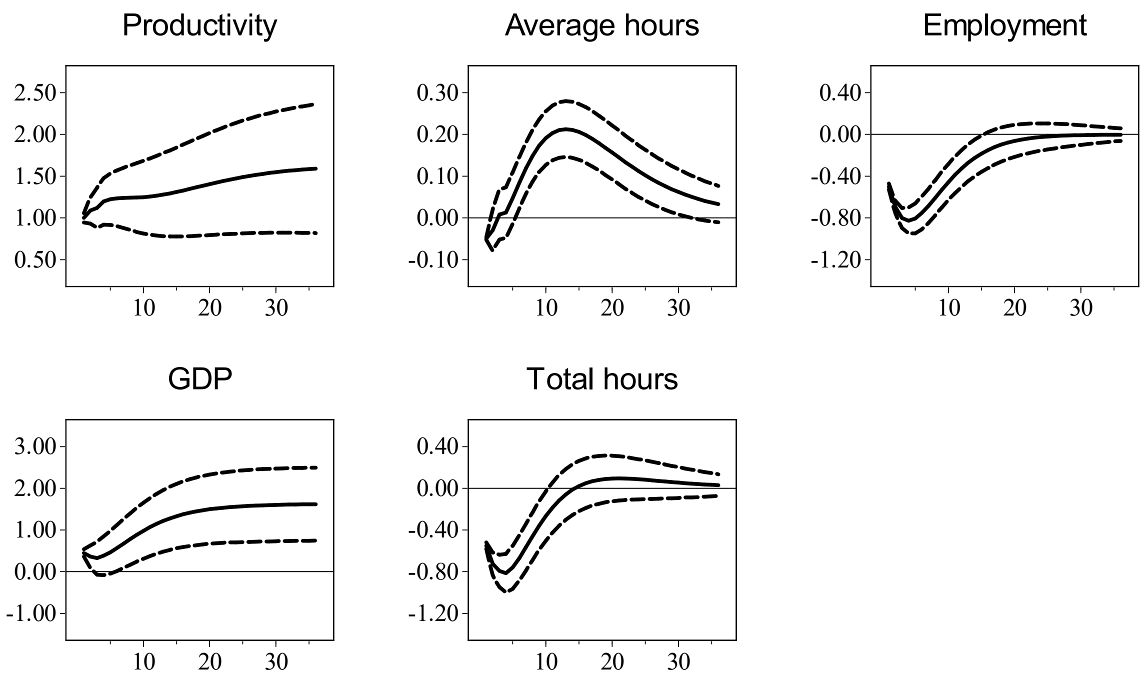


Figure 4.5 Base model, 1978Q4-2017Q4. Responses to a technology shock of 1 per cent

There are several explanations for the negative response of hours worked to a technology shock in the literature. Galí (1999) explains the reduction in total hours worked by the existence of price rigidity. He illustrates the mechanism in a model with sticky prices and with an aggregate demand that depends on the real money stock. He assumes that prices are set at the beginning of the day and that the productivity shock takes place during the day, but firms do not adjust their prices immediately. As prices do not change, and the central bank does not increase nominal money, the real money balances and the aggregate demand do not change either. In order to meet the same demand, the supply does not change. In order to produce the same with higher productive workers, firms have to reduce labour input. Under this explanation, an inefficient response of monetary policy in the context of sticky prices produces a fall in hours.

Erceg, et al. (2005) assess the reliability of the Galí methodology by using Monte Carlo simulations of a DSGE model with rigidities and in an RBC model. They find that the DSGE model that includes habit persistence in consumption, costs of changing investment, variable capacity utilisation, and nominal price and wage rigidity can replicate Galí's results better than the RBC model. Francis and Ramey (2002) estimate two models that can explain the reduction of total hours in response to a technology shock, even assuming flexible prices. The first model assumes Leontief technology with variable utilisation and the second model assumes habit formation in consumption and adjustment costs of investment. They conclude that these models capture the empirical facts described by Galí (1999) without relying on sticky price assumptions. However, the models do not support the technology-driven RBC hypothesis that positive technology shocks lead to positive output, hours, and productivity co-movements. According to Canova et al. (2007), the employment reduction after a technology shock occurs due to the presence of search frictions in the labour market. They consider that the evidence is consistent with the Schumpeterian process of the introduction of new technology, where the technologically obsolete productive units are destroyed and new technological advanced units are created, causing a temporary rise in unemployment. Cantore et al. (2017) point out the importance of the elasticity of substitution between capital and labour to explain the response of hours to a neutral technology shock. They use an RBC model with a Constant Elasticity of Substitution production function. They find that the increase in the elasticity of substitution between capital and labour over time explains the change in response of hours from a negative response in early samples to a positive response in more recent samples. This is a less extreme case than the model with a Leontief technology with zero elasticity of substitution developed by Francis and Ramey (2002).

Based on this literature, from the policy perspective, to reduce the temporary effect of technology on hours worked, central banks should be ready to efficiently respond to a technology shock in a context of sticky prices. Also, policies aiming to reduce search frictions in the labour market and adjustment costs of investment can attenuate the negative effect of technology shocks on hours worked.

Average hours shock

The responses to an average hours shock are shown in Figure 4.6. The shock to average hours has transitory effects on all three variables. The dynamics of average hours worked and employment are similar to the responses to an unexpected temporary demand shock where firms are uncertain about the permanence of the shock, described by Hamermesh (1996). According to Hamermesh, when the demand shock occurs, firms do not know whether the shock is permanent or not. Initially, the firms treat the shock as a temporary shock and adjust hours worked because the rate at which the firm expects to amortise the fixed cost of hiring and firing workers over the worker's tenure (δ) is perceived to be high. As the shock persists, firms believe that the shock will take longer than initially expected, the perceived δ decreases, and firms increase employment. When firms realise that the shock will finally disappear, they reduce average hours faster than employment as the reduction of hours does not generate adjustment costs. The responses of hours worked and employment in Figure 4.6 follow Hamermesh's description. The demand shock generates an immediate reaction of firms to increase average hours worked. Over time average hours decreases while employment increase for four quarters and decline afterwards when firms realise that the shock is temporary. The reduction of employment is slower than the reduction of average hours worked due to higher costs (e.g. firing costs), and employment takes longer to return to trend, as predicted by Hamermesh (1996). Average hours worked returns to trend in approximately 4 years while employment takes around 6 years. The response of output on impact is lower than 1 per cent resulting in a reduction of labour productivity. The effect on labour productivity and output are temporary. Over time, as average hours worked and employment converge to trend, labour productivity and output also converge to trend.

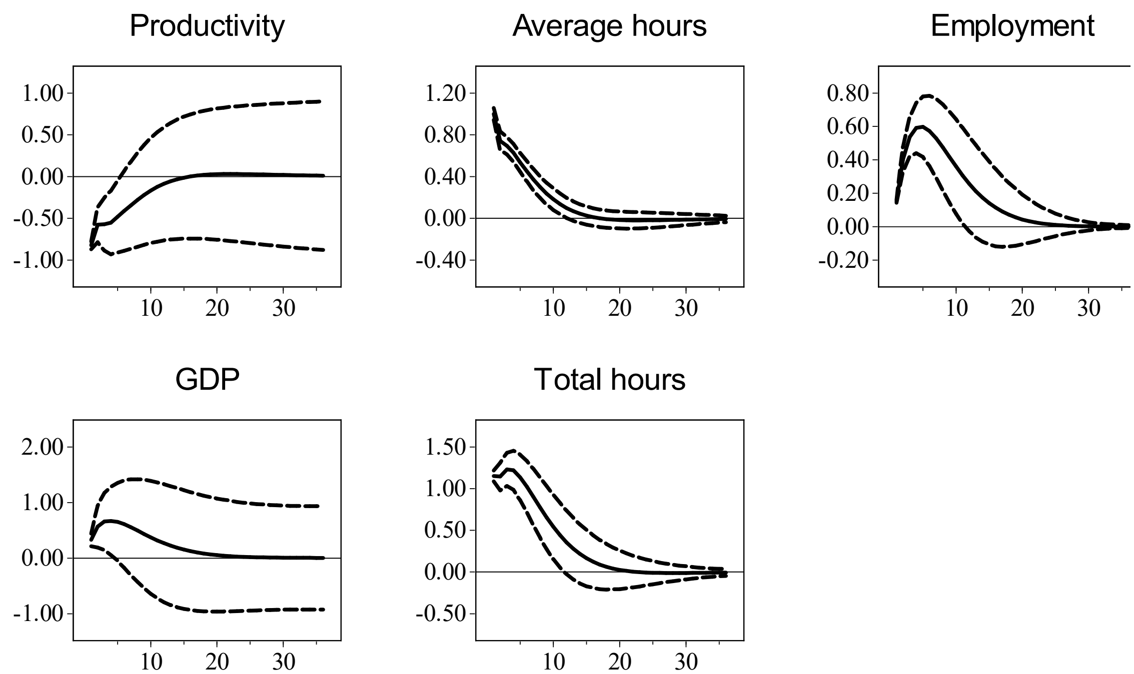


Figure 4.6 Base model, 1978Q4-2017Q4. Response to an average hours worked shock of 1 per cent

Employment shock

The responses to a shock to employment are shown in Figure 4.7. The shock to employment can be interpreted as a shock to demand generated by the expectation of consumers and investors of a permanent increase in productivity that finally does not occur. This demand shock caused by aggregate mistakes about productivity is described by Lorenzoni (2006). He assumes that productivity follows a random walk with a shift component μ_t; however, consumers and firms do not directly observe this process. They form their expectations based on public sources of information, summarised in a public signal. This signal does not fully predict productivity and has a noise component or news shock, which is the source of private agents' mistakes. Hence, his model includes two shocks: one is the productivity shock and the other is the news shock. The productivity shock has features of an aggregate supply shock. A positive shock to productivity increases output, and decreases prices and employment. The qualitative responses of output and employment are similar to other studies mentioned above (e.g., Galí,1999).

On the other hand, a news shock generates a temporary deviation of output from its natural level, similar to a demand shock, leading to positive comovement between output, inflation and employment. From this explanation, a shock to employment can be interpreted as a shock to demand generated by the expectation of consumers and investors of a permanent increase in productivity that finally does not occur. The responses of average hours worked in Figure 4.7 can be explained using Lorenzoni's model. As firms believe that there is an increase in productivity that will generate a permanent increase in demand, they are willing to increase employment early because the fixed costs of hiring will be amortised over a long period. The expected increase in demand produces a positive and increasing employment response during the first 4 periods. After this learning period, firms realise that the permanent change will not occur and they have to reduce total hours worked. As employment reduction is costly, firms reduce average hours worked faster even to a level lower its trend for a period of time, while employment is still in its adjustment process. The final adjustment of employment to trend takes approximately 6 years.

According to this framework, news in the form of announcements or projections generated by public entities can affect real variables as economic agents rely on them to make economic decisions. For example, Rodriguez Mora and Schulstald (2007) show that aggregate consumption responds more to public announcements than to actual changes in GNP. Also, Oh and Waldman (1990, 2005) study the importance of government announcements. In their 1990 paper, they find that predictions of future growth influence its actual realization. In their 2005 paper, they use forecasters' data to show that false announcements on the index of leading indicators have a direct effect on the forecasters' predictions.

Output and total hours worked responses are stronger than in the case of the average worked shock. After a shock to employment, the output response is stronger than the response of total hours worked, resulting in a positive response of labour productivity. Similar to the case of an average hours shock, the effects on output and labour productivity are temporary. Over time, as average hours worked and employment converge, labour productivity and output also converge to trend.

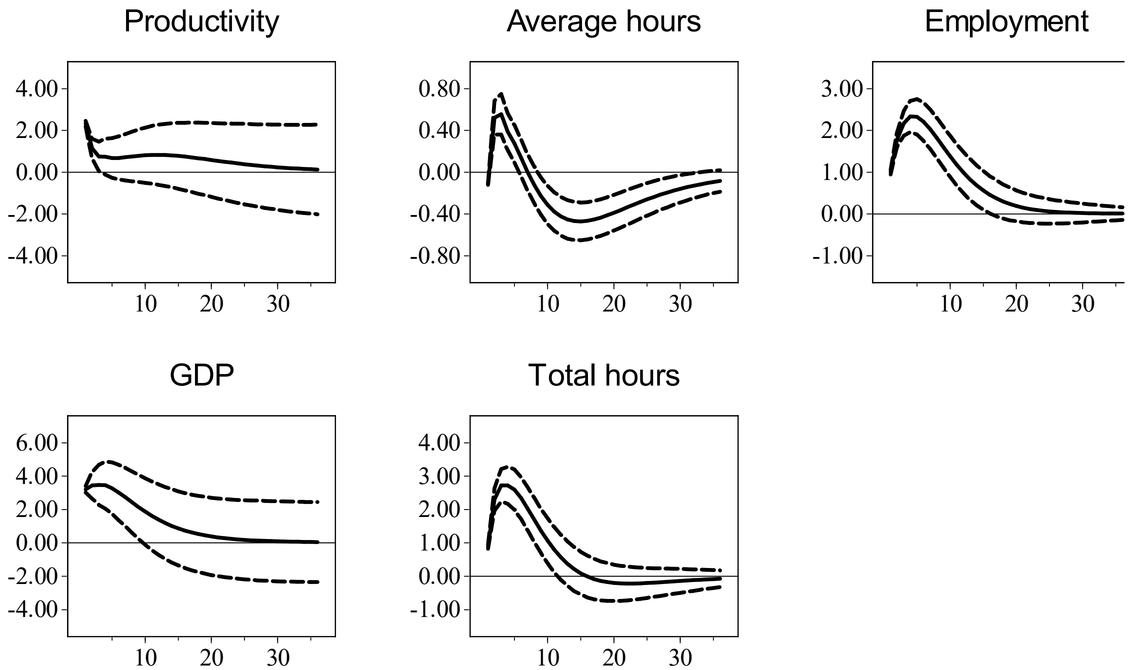


Figure 4.7 Base model, 1978Q4-2017Q4. Response to an employment shock of 1 per cent

4.5 Robustness

In this section, the results of the previous section for the base model are compared to the results from the same model estimated for two subsamples: 1978Q2 to 1999Q4 and 2000Q1 to 2017Q4. The samples correspond to periods of relatively high and low volatility of GDP, respectively. The variance decomposition of output for these two subsamples is also presented in this section. The results of the base model is also compared to the results of two extended models.

4.5.1 Comparing samples

Figures 4.8 to 4.13 show the comparative responses of labour productivity, average hours worked, employment, GDP and total hours worked to shocks in productivity, average hours worked and employment. The figures are ordered by type of shock for the two sample periods 1978Q4 to 1999Q4 and 2000Q1 to 2017Q4. It is important to assess the two subsamples because the volatility of GDP and employment is significantly different in these two periods. In most cases, the shape of the responses are similar in both samples. The main differences between the results of the two subsamples are related to the difference in volatility between the sample periods, as discussed below.

A neutral technology shock

Similar to the response in the full sample, in both subsamples, a positive technology shock produces a temporary decline in average hours worked and employment and a permanent effect on labour productivity and GDP. However, the responses in the subsamples are weaker. Employment decreases in both sub-samples; however, the employment response for the period 2000Q1 to 2017Q4 takes longer to return to zero. In general, the sign of the responses to a technology shock does not change when the full sample is split, although the size of the responses are significantly different, especially in the cases of the labour productivity and GDP responses. The labour productivity and GDP responses of the two subsamples are lower than the responses in the full sample.

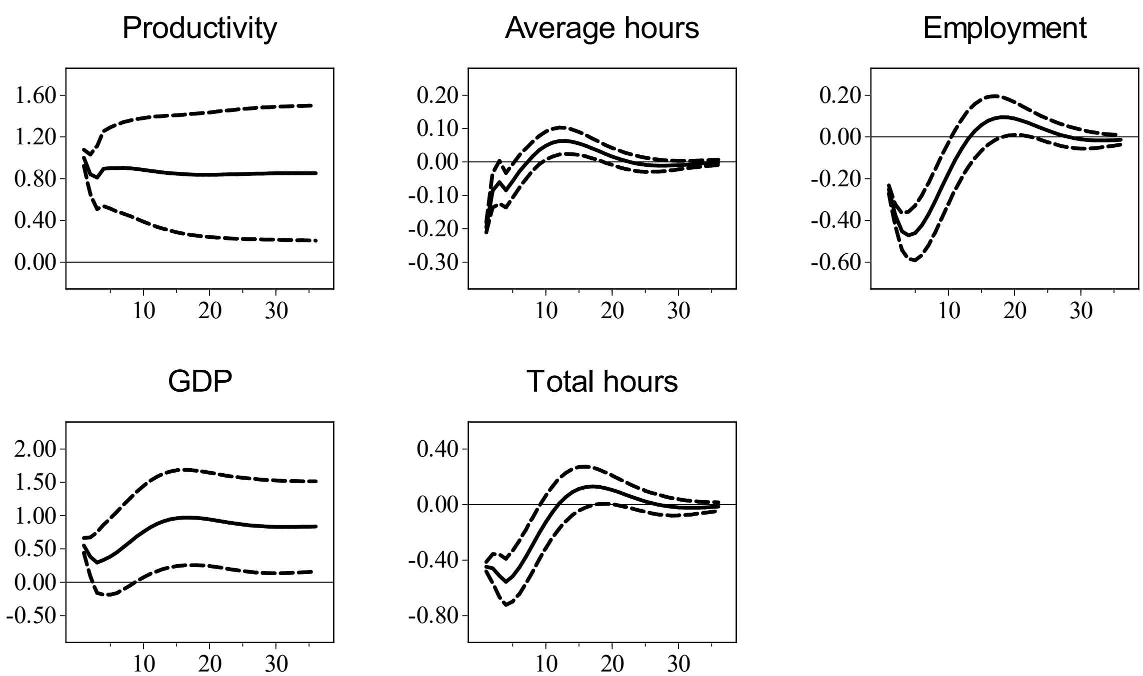


Figure 4.8 Base model, 1978Q4-1999Q4. Response to a technology shock of 1 per cent

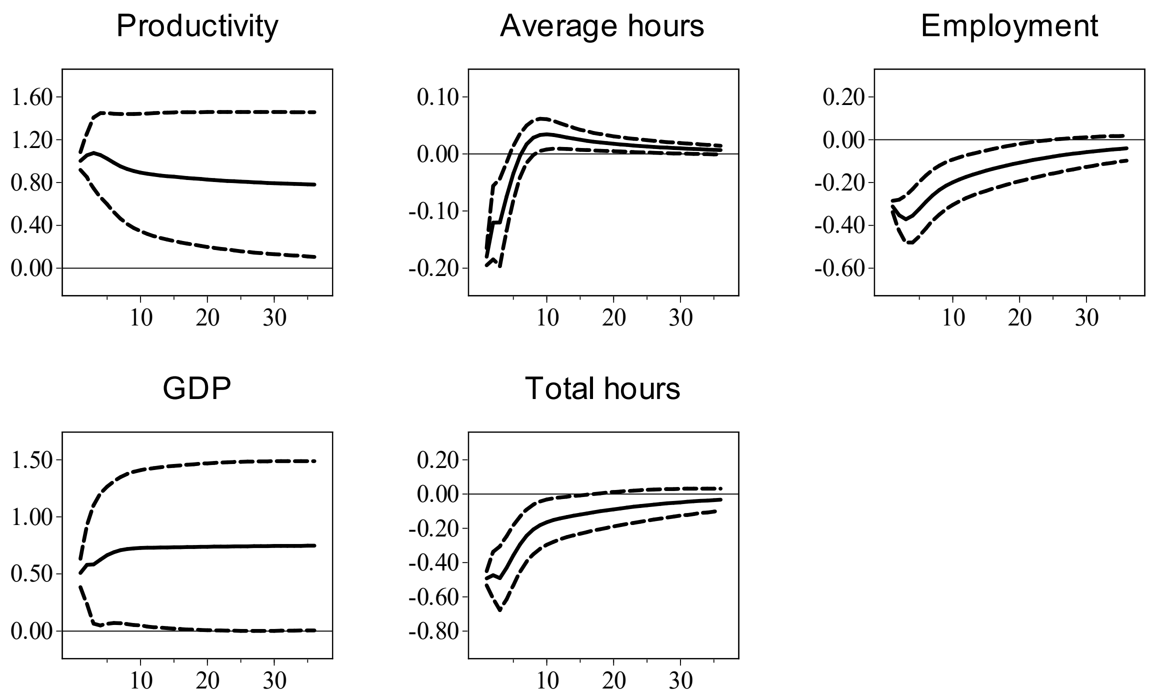


Figure 4.9 Base model, 2000Q1-2017Q4. Response to a technology shock of 1 per cent

Average hours worked shock

Similar to the full sample case, a shock to average hours worked generates a temporary effect on all variables under analysis. The directions of the responses are similar to the responses in the full sample case. Although the initial labour productivity response is negative in the models with full sample and both subsamples, the response is close to zero in the model with the first subsample, which is associated to a higher response of GDP than the corresponding responses in the full sample and second subsample. Employment increases in both samples; however, the response of employment in the first sample period is much higher than the response in the second sample. This is consistent with the historical data during the 1980 and 1990 GDP cycles, where large movements in GDP were accompanied by large changes in employment.

Employment shock

Following a shock to employment, as in the case of the responses with the full sample, the response of the variables analysed are transitory. Employment in the second subsample is more persistent, which is also reflected in the persistence of total hours worked. Average hours worked has a similar behaviour as in the full sample, although the negative response after the initial quarters is less pronounced in both subsamples. The main difference between the different scenarios is the response of GDP and labour productivity to the shock in employment. The response of GDP on impact in the first sample is almost double the response in the second sample. The response of GDP is higher than the employment shock in the period of higher volatility and lower in the period of lower volatility resulting in a positive response of labour productivity in the first sample and in a negative response in the second sample.

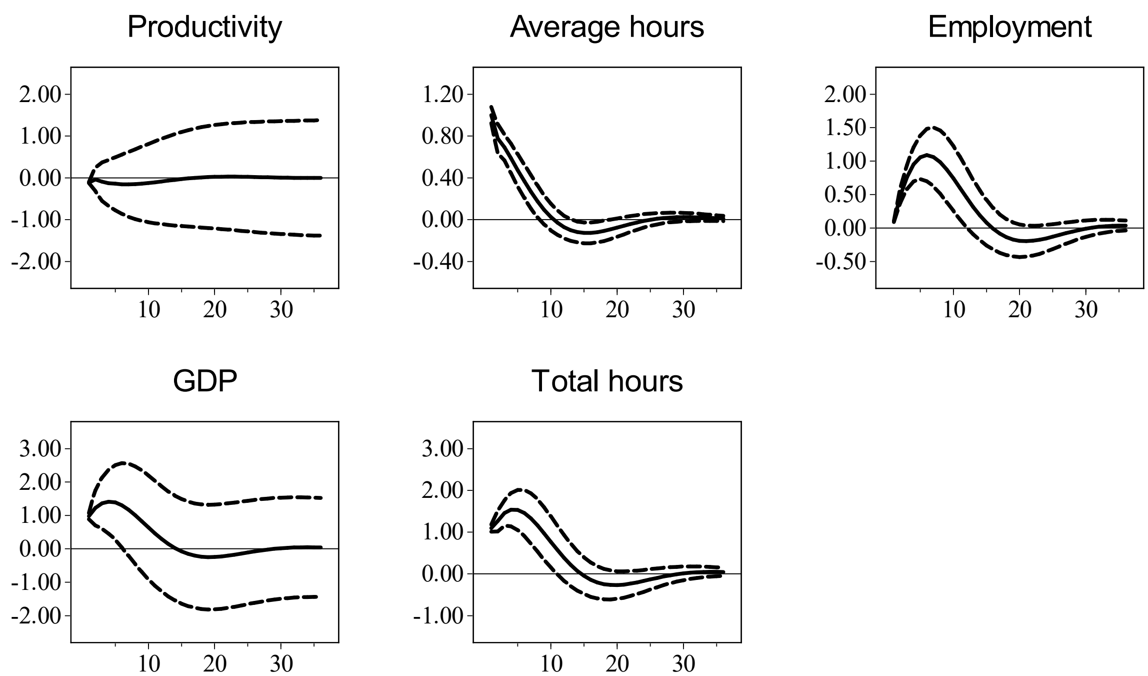


Figure 4.10 Base model, 1978Q4-1999Q4. Response to an average hours worked shock of 1 per cent

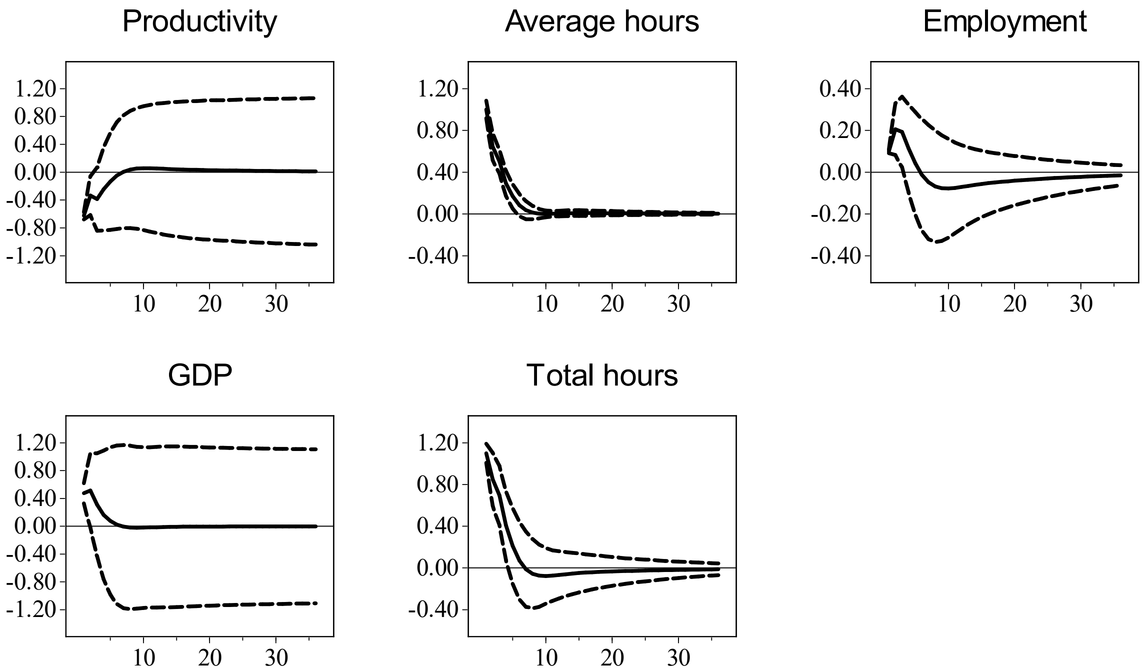


Figure 4.11 Base model, 2000Q1-2017Q4. Response to an average hours worked shock of 1 per cent

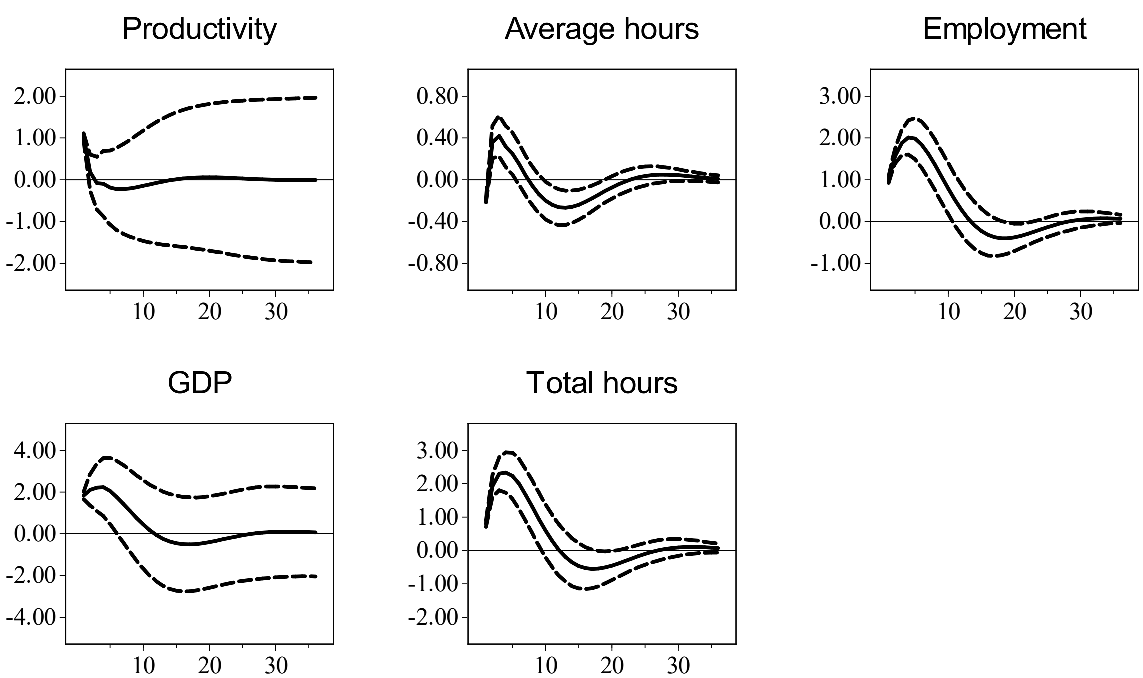


Figure 4.12 Base model, 1978Q4-1999Q4. Response to an employment shock of 1 per cent

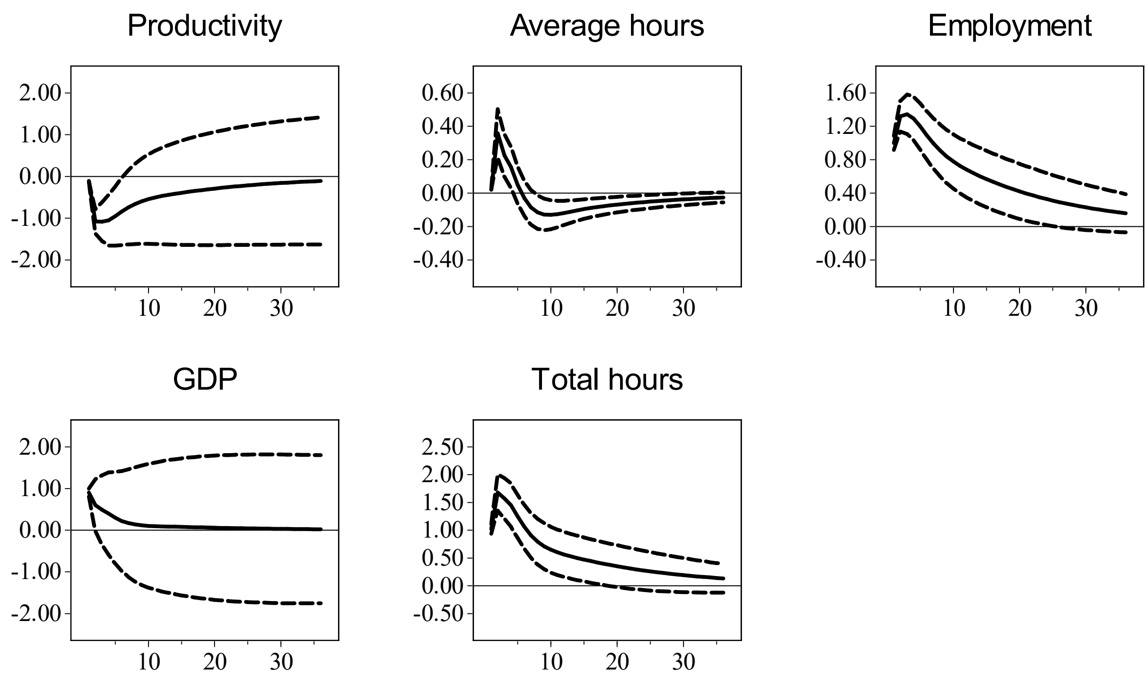


Figure 4.13 Base model, 2000Q1-2017Q4. Response to an employment shock of 1 per cent

4.5.2 Variance decomposition

Table 4.3 shows the variance decomposition of output for the two subsamples. In the first quarter, the contributions of employment are 29 per cent and 24 per cent in the first and second samples, respectively. The contributions of average hours worked are 57 per cent and 33 per cent in the first and second samples, respectively. In the first subsample, the contribution of labour inputs after 10 quarters explains 47 per cent of the variance. This is a period of large comovements of output and laour inputs. During the same period, in the second subsample, the contributions of labour inputs rapidly fall to 14 per cent. In the long-run, the contribution of labour inputs to output variance is small, especially in the second sample, and output variance is explained mainly by the technology shock. After 30 quarters, a technology shock explains most of the output variance: 83 per cent in the first sample and 95 per cent in the second sample.

Table 4.3 Variance decomposition of output (Per cent)

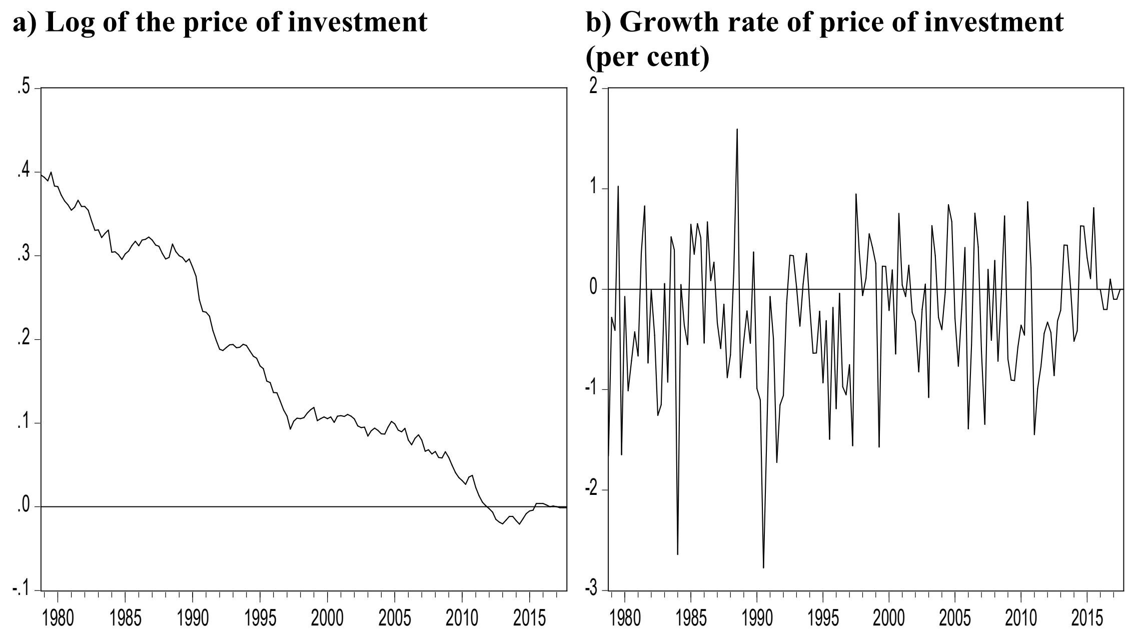
	Quarters				
	1	2	5	10	30
Labour productivity					
1978Q4-1999Q4	13	25	35	53	83
	(1, 46)	(5, 58)	(10, 67)	(31, 77)	(73, 91)
2000Q1-2017Q4	43	65	79	86	95
	(6, 79)	(23, 86)	(43, 93)	(58, 95)	(82, 98)
Average hours worked					
1978Q4-1999Q4	57	46	44	34	13
	(35, 70)	(25, 65)	(22, 65)	(17, 53)	(7, 20)
2000Q1-2017Q4	33	18	9	5	2
	(17, 47)	(9, 31)	(5, 18)	(3, 10)	(1, 4)
Employment					
1978Q4-1999Q4	29	29	20	13	5
	(16, 39)	(15, 41)	(10, 30)	(6, 21)	(2, 8)
2000Q1-2017Q4	24	17	12	9	4
	(2, 52)	(4, 51)	(3, 44)	(2, 34)	(1, 15)

Note: Median obtained by bootstrapping with 1000 repetitions. The 16th and 84th percentiles are reported in parenthesis.

4.5.3 Extended models

In this section, two new models are considered. These models extend the three-variable model from the previous section. The first extended model (EM1) adds three variables: the price of investment growth rate, the inflation rate and the real interest rate. The second extended model (EM2) additionally includes exogenous variables relevant to a small open economy such as the US real interest rate and the growth rates of the terms of trade and US output per capita.

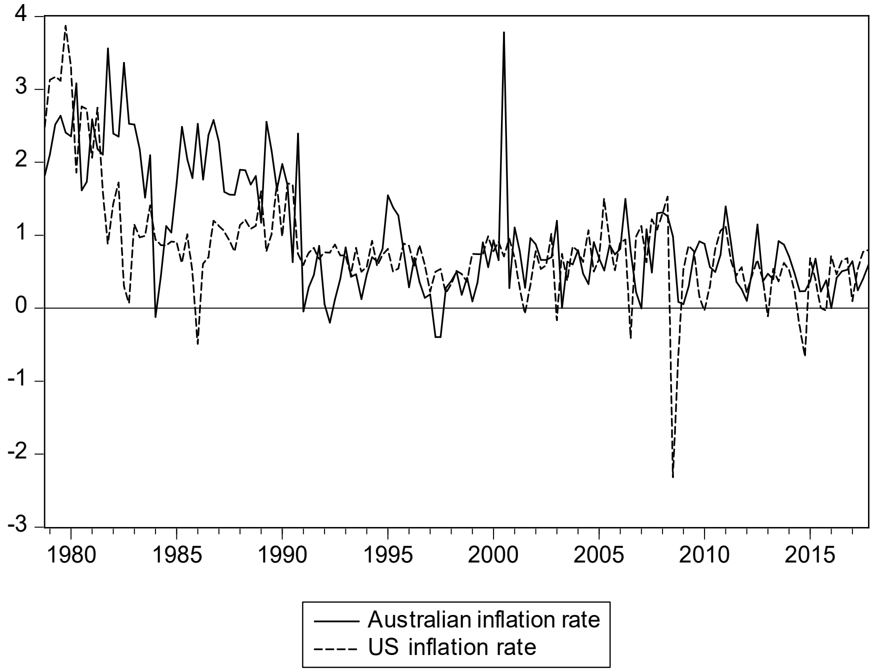
Fischer (2006) includes an investment-specific technology shock (I-shock) in addition to the neutral technology shock considered by Galí (1999). He assumes that only I-shocks affects the price of investment in the long run and that only neutral and investment-specific shocks affect labour productivity in the long run. Figure 4.14 shows the price of investment in logs and log differences. The price of investment is calculated as the ratio of gross fixed capital formation index divided by the household final consumption index. These indexes are published by the Australian Bureau of Statistics. The unit root tests (see Table 4.4) are not conclusive in relation to the presence of unit root in the log of the price of investment (*lpinv*). The price of investment is included in the extended SVAR models in log differences following Fischer (2006) and Canova et al. (2007) models where a shock to the price of investment has permanent effects on output.



Source: Australian Bureau of Statistics

Figure 4.14 The price of investment, 1978Q4-2017Q4

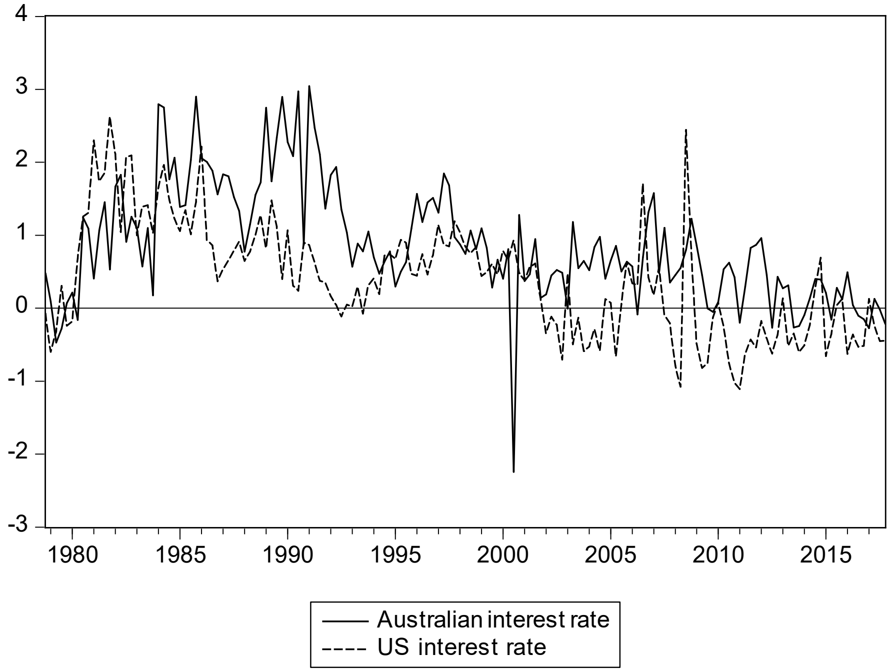
In Figure 4.15, the inflation rate in Australia is the growth rate of the GDP deflator sourced from the Australian Bureau of Statistics and the US inflation rate is the growth rate of the consumer price index published by the Federal Reserve Economic Data.



Note: The Australian inflation rate is the growth rate of the GDP deflator sourced from the Australian Bureau of Statistics. The US inflation rate is the growth rate of the US consumer price index taken from the US Federal Reserve Economic Data.

Figure 4.15 Inflation rate, 1978Q4-2017Q4 (per cent)

The Australian and US real interest rates are shown in Figure 4.16. The nominal rates are the cash rate and the Effective Federal Funds Rate, respectively, published by the Reserve Bank of Australia and Federal Reserve Economic Data. The corresponding inflation rates have been subtracted from the nominal interest rates to calculate the real interest rates. The Australian inflation rate, and the Australian and US real interest rates do not show a unit root during 1978Q4 to 2017Q4 according to the ADF unit root test (See Table 4.4). These variables are included in levels in the extended models.



Note: The Australian real interest rate is the cash rate adjusted by the growth of the GDP deflator. The cash rate is sourced from the Reserve Bank of Australia Statistics. The US real interest rate is the Effective Federal Funds Rate adjusted by the growth rate of the US consumer price index. The interest rate is sourced from the US Federal Reserve Economic Data.

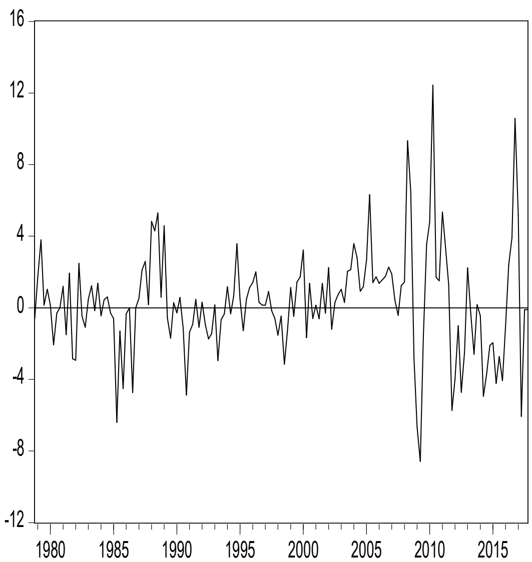
Figure 4.16 Real interest rate, 1978Q4-2017Q4. (per cent)

The terms of trade and the US per-capita GDP are also considered in the second extended model as indicators of foreign economic conditions. The source for the terms of trade is the Australian Bureau of Statistics, and the source of US GDP per capita is the US Federal Reserve Economic Data. The log of the terms of trade (*ltot*) and the log of per-capita US GDP (*ly_us*) are included in differences in the second extended model as the unit root tests show the presence of unit root. (See Table 4.4).

Table 4.4 Augmented Dickey-Fuller and KPSS unit root tests statistics. Extended models. (1978Q4 to 2017Q4)

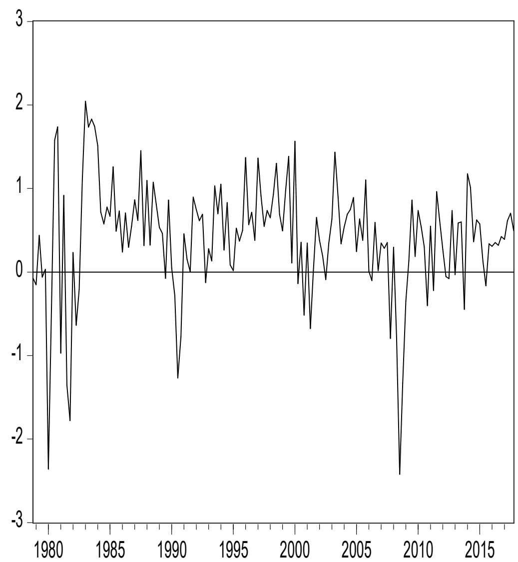
Variable	ADF	KPSS
lpinv	-4.06 *	0.27 *
inf	-4.61 *	0.25 *
r	-4.66 *	0.14
ltot	-2.29	0.24 *
ly_us	-1.75	0.27 *
r_us	-6.96 *	0.05

ADF null hypothesis: The variable has a unit root.
KPSS null hypothesis: The variable is stationary.
(*) Reject the null hypothesis at the 5 per cent significance level.
The statistics are based on regressions that include a constant and a linear trend.



Source: Australian Bureau of Statistics

Figure 4.17 Terms of trade growth rate, 1978Q4-2017Q4 (per cent)



Source: US Federal Reserve Economic Data

Figure 4.18 US GDP per-capita growth rate, 1978Q4-2017Q4 (per cent)

The addition of the I-shock is based on Fischer (2006). He identifies the long-run effects of a technology shock from a competitive equilibrium growth model, where the social planner chooses consumption (C_t), investment (X_t) and hours worked (H_t) and the next period capital stock (K_{t+1}) to maximise the expected intertemporal utility function:

$$\text{Max } E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, H_t), \tag{7}$$

subject to

$$C_t + X_t \le A_t K_t^{\alpha} H_t^{1-\alpha}, \tag{8}$$

$$K_{t+1} \le (1-\delta) K_t + V_t X_t \ , \tag{9}$$

$$A_t = \exp(\gamma + \varepsilon_{at}) A_{t-1} \ , \tag{10}$$

$$V = \exp(\nu + \varepsilon_{vt}) V_{t-1} \ , \tag{11}$$

where β is the discount factor, δ is the depreciation rate, A_t is the level of neutral technology and V_t is the level of investment-specific technology. The innovations to neutral (ε_{at}) and investment-specific technology (ε_{vt}) are jointly normal distributed with zero mean and a diagonal variance-covariance matrix. The stochastic characteristic of these innovations drives permanent effects.

Fischer shows in the competitive equilibrium of this economy the real price of an investment good is $P_t = 1/V_t$. The implication of this is that only investment-specific technology shocks have long term effect on the real price of an investment good, which implies that a neutral technology shock has no long-run effect on the price of investment, or equivalently:

$$\lim_{j\to\infty} \frac{\partial \ln P_{t+j}}{\partial \varepsilon_{vt}} = -1 \qquad \lim_{j\to\infty} \frac{\partial \ln P_{t+j}}{\partial \varepsilon_{at}} = 0 . \tag{12}$$

Fischer also shows in his model that positive innovations to both types of technology increase labour productivity in the long run. Another implication of the model is that other exogenous shocks can be included. The balanced growth path is achieved as long as these shocks are transitory and do not affect labour productivity and investment prices in the long run.

These findings are used to identify the dynamic responses to exogenous technology shocks. In his econometric implementation, Fischer assumes that in the long-run, only investment-specific shocks affect the investment price, and only neutral technology shocks and investment-specific shocks affect labour productivity.

Two SVAR(2) models (EM1 and EM2) are implemented by taking these assumptions as long-run restrictions. The estimation of the model uses the full sample from 1978Q4 to 2017Q4. The variables included in the models are outlined in Table 4.1. EM2 is the preferred model because it includes international exogenous variables that are relevant to account for the external sector in an small open economy such as Australia. The impulse responses are shown in Figures 4.19 to 4.26.

Figures 4.19 and 4.20 show the responses to an investment-specific shock. A positive investment-specific technology shock is implemented as a negative shock to the investment price (one per cent drop). In both models EM1 and EM2, there is a positive transitory response of hours worked to a positive investment-specific technology shock. According to Fischer (2006), total hours worked increases due to a strong intertemporal substitution of current leisure and consumption for future consumption, motivated by higher returns to working and saving. In the adjustment process of total hours worked, under this shock, average hours worked has a more relevant role compared to the role in the adjustment following a neutral technology shock. In EM2 the intensive margin is even stronger than the extensive margin. The importance of the intensive margin response to an investment-specific technical shock is also found in Canova et al., (2007) and Furlanetto and Sveen. (2009) using US data. Labour productivity initially falls in both extended models before gradually rises to its positive long-run level. In EM2, the initial negative response of labour productivity is stronger, with an initial negative response of output that gradually increases to its positive long-run level. The initial decrease in labour productivity after a positive investment-specific shock can be explained by the time that it takes for new capital to be fully productive. The behaviour of these variables is also found in the theoretical models developed by Fischer (2006, Fig. 1), who explains this behaviour of labour productivity as the result of the immediate positive response of hours and the slow response of capital.

Figures 4.21 to 4.26 show the responses to a neutral technology shock, average hours and employment. As in the base model, a positive, neutral technology shock in the two extended models generates a positive, permanent effect on output and a negative, temporary effect on total hours worked, which is the result of the predominance of a negative effect on employment over a positive effect of average hours worked. Also, shocks to average hours worked and employment (demand shocks) produce transitory effects on labour productivity, output, average hours and employment. The responses to neutral technology, average hours worked and employment shocks are similar to the responses in the base model, although in the model with US variables (EM2), the responses to an average hours worked shock take longer to go to zero.

The responses for the EM1 and EM2 models are qualitatively similar. The main differences are for the responses of employment and GDP after an investment price reduction. These responses have opposite signs in EM1 and EM2 during the first quarters after the shock. This difference is explained by the presence of variables in EM2 that better captures the dynamics of an open economy. The lower investment price in an open economy increases the demand for capital that can be imported immediately and partially substitute employment in the short run and increase employment and activity only after some time. In contrast, in a closed economy, capital can only be produced domestically, increasing employment and activity right after the shock.

Table 4.5 shows the variance decomposition for model EM2. The investment-specific technology shock explains 24 per cent of variance of output in the first quarter and declines over time to 6 per cent after 30 quarters. Labour inputs also are important during the first quarter but decline over time. The neutral technology shock explains most of the variation of output in the long-run, with 79 per cent after 30 quarters.

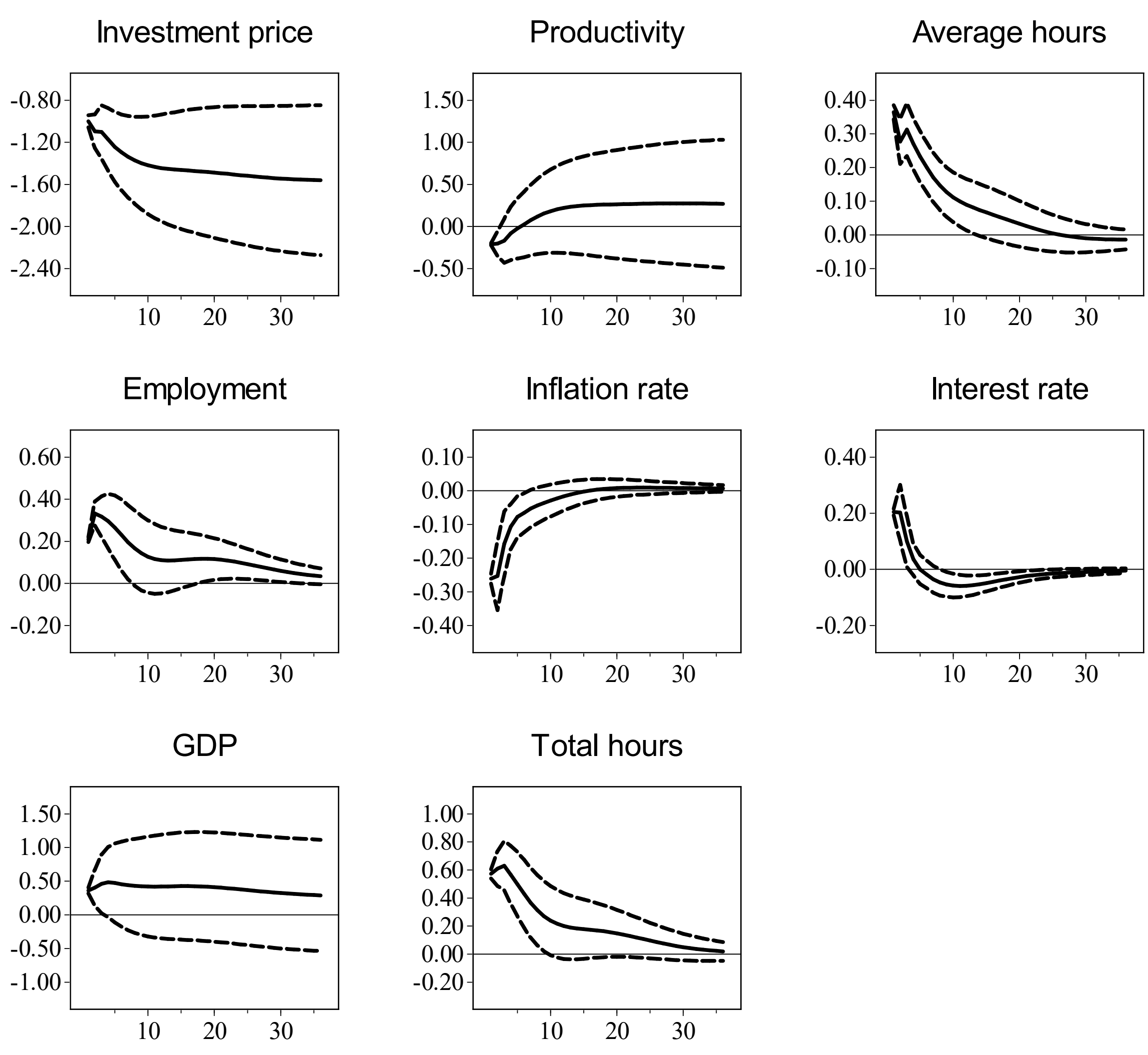


Figure 4.19 EM1. Response to a price of investment shock of 1 per cent

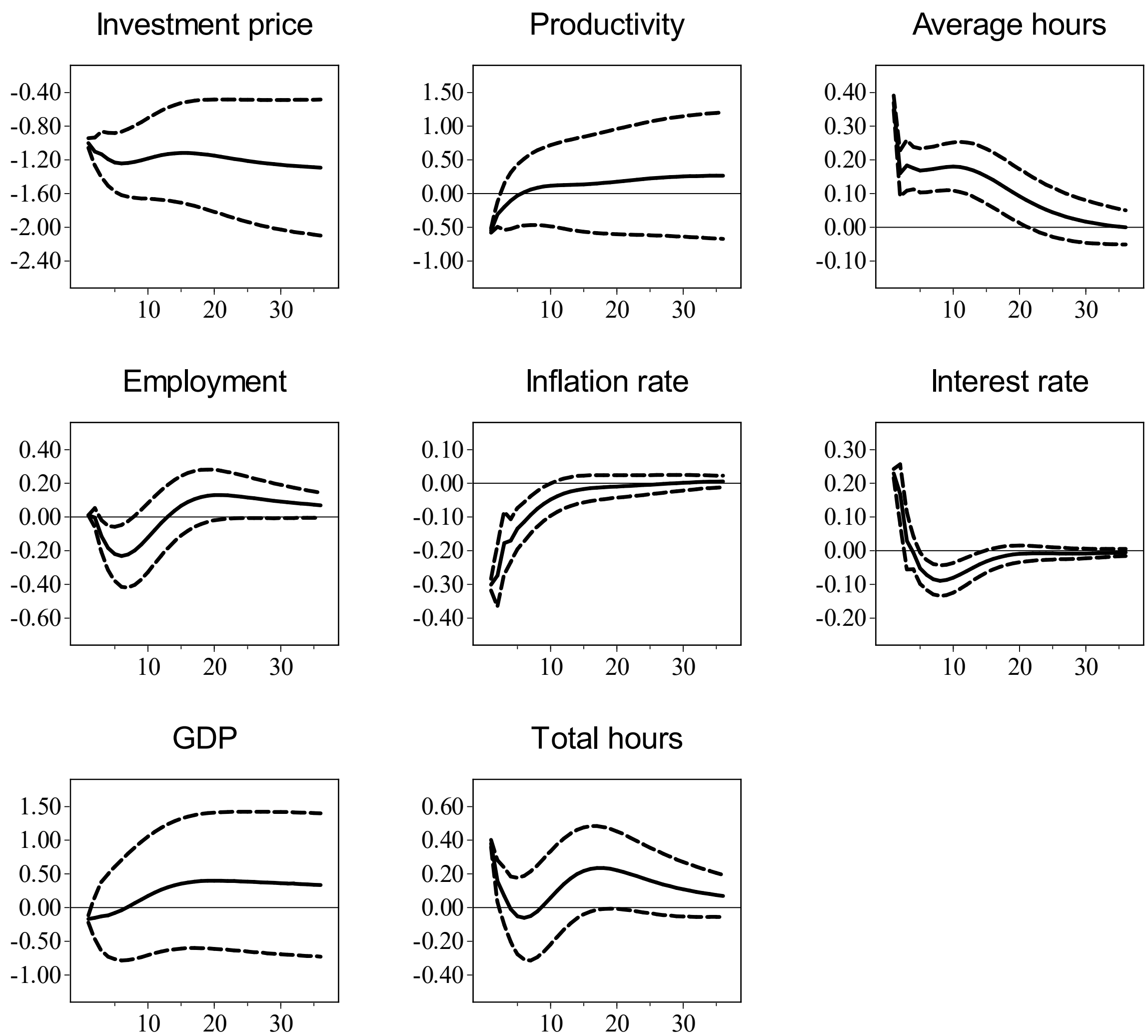


Figure 4.20 EM2. Response to a price of investment shock of 1 per cent

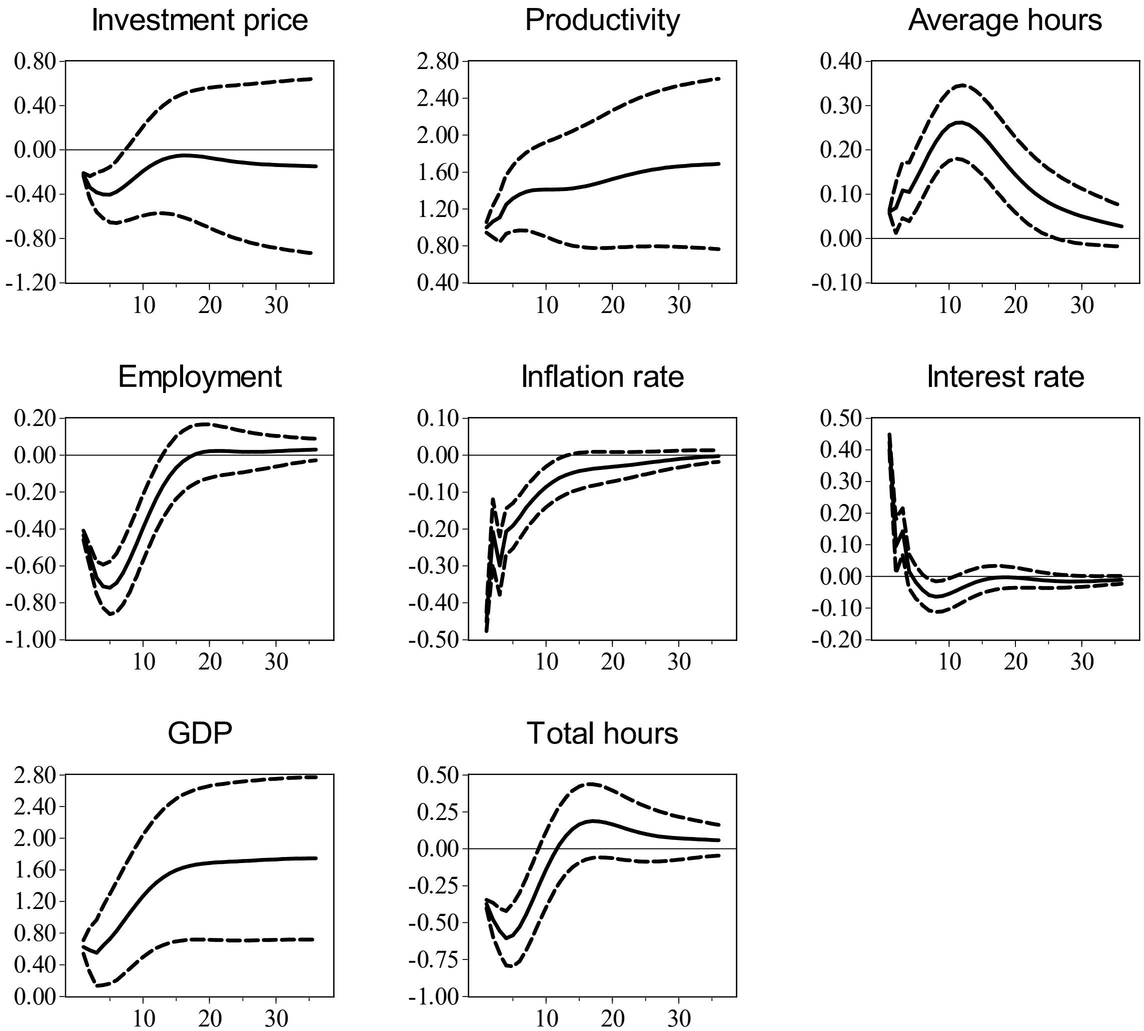


Figure 4.21 EM1. Response to a labour productivity shock of 1 per cent

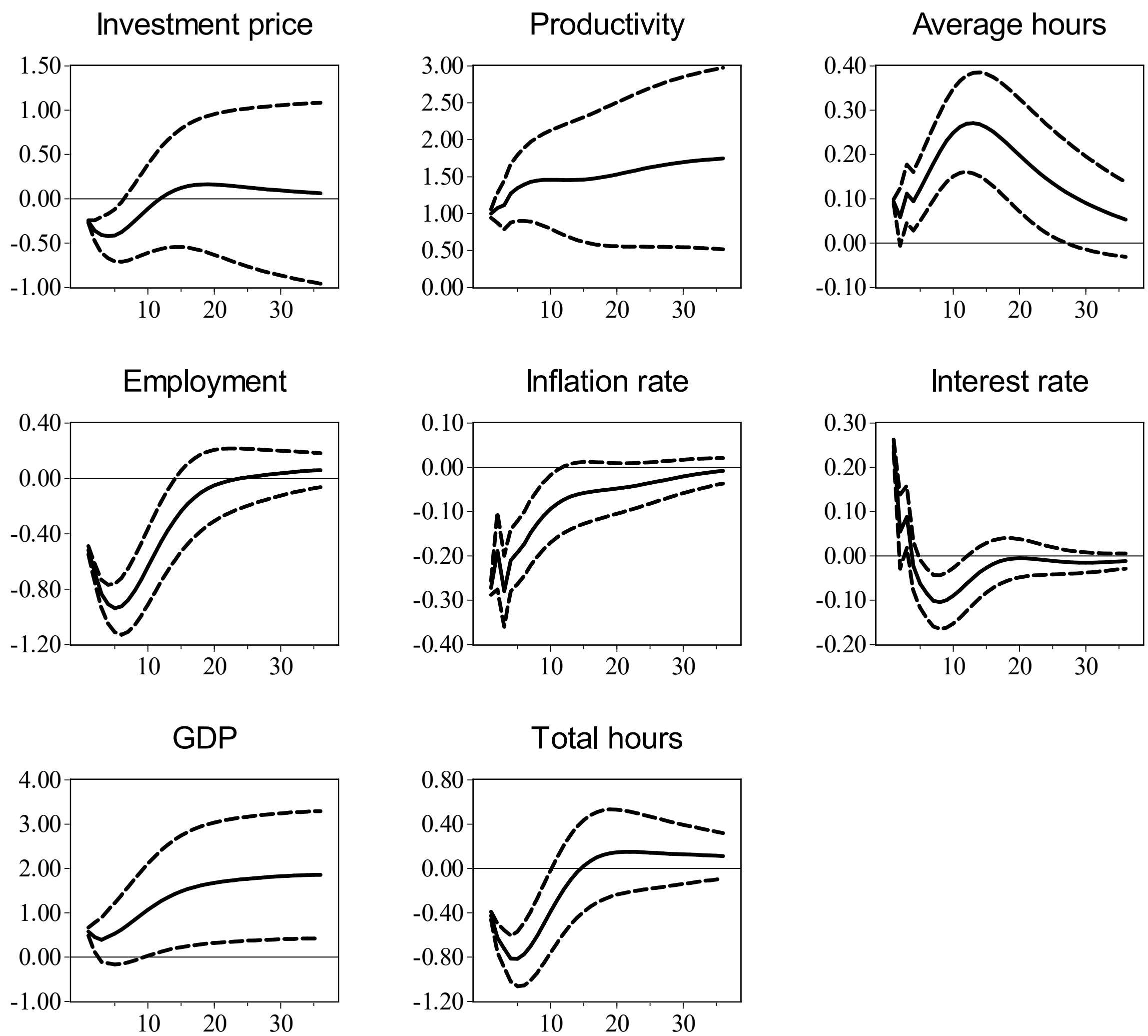


Figure 4.22 EM2. Response to a labour productivity shock of 1 per cent

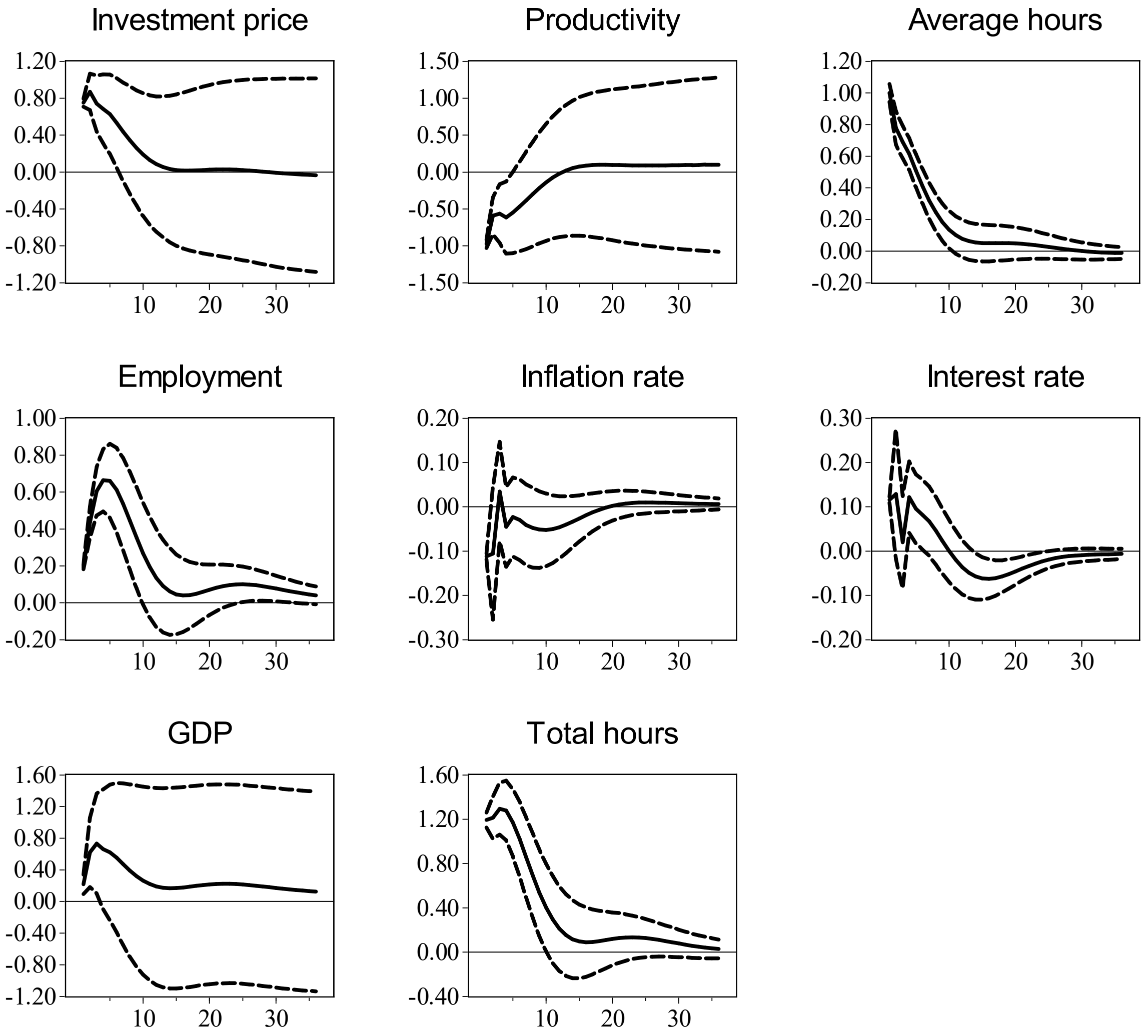


Figure 4.23 EM1. Response to an average hours worked shock o 1 per cent

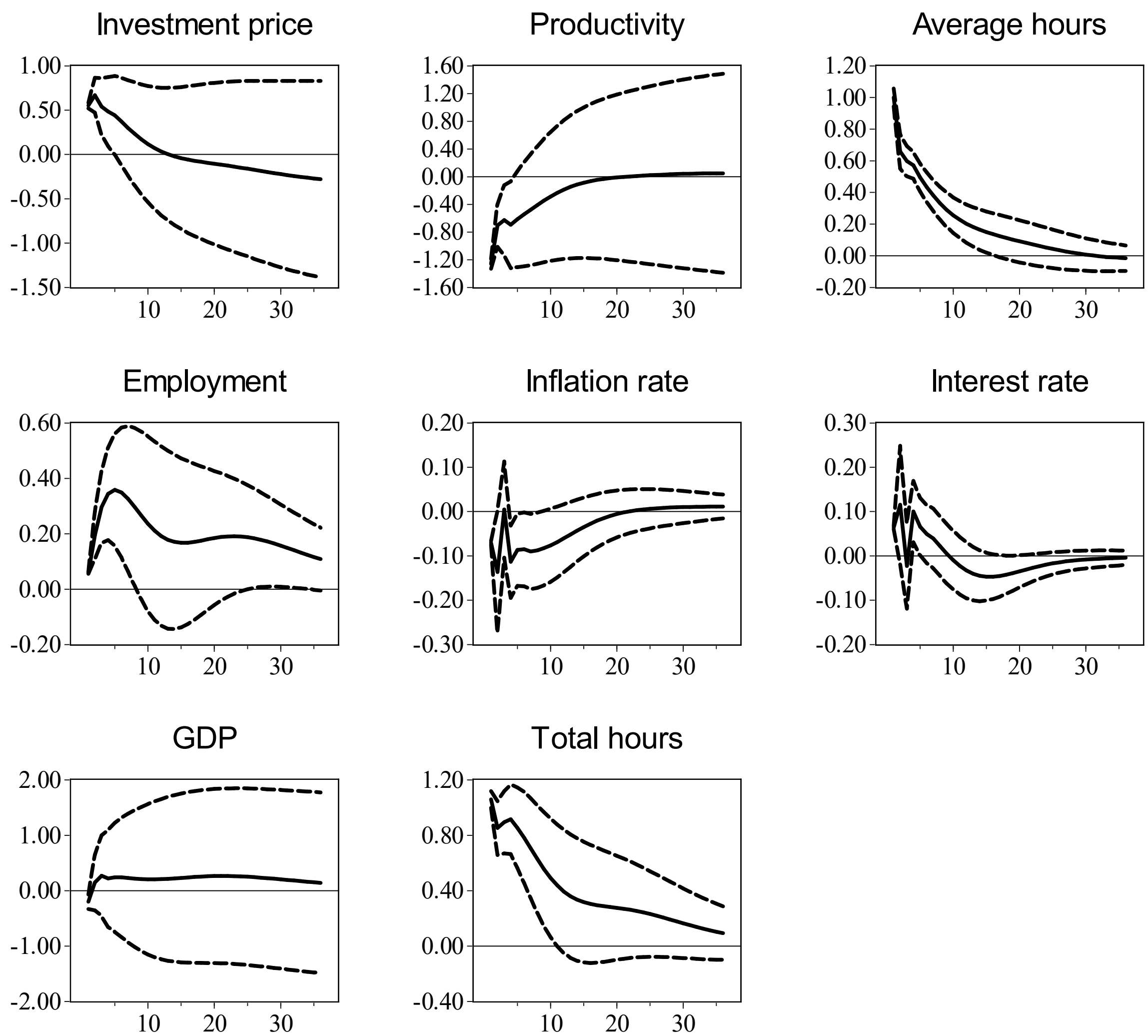


Figure 4.24 EM2. Response to an average hours worked shock of 1 per cent

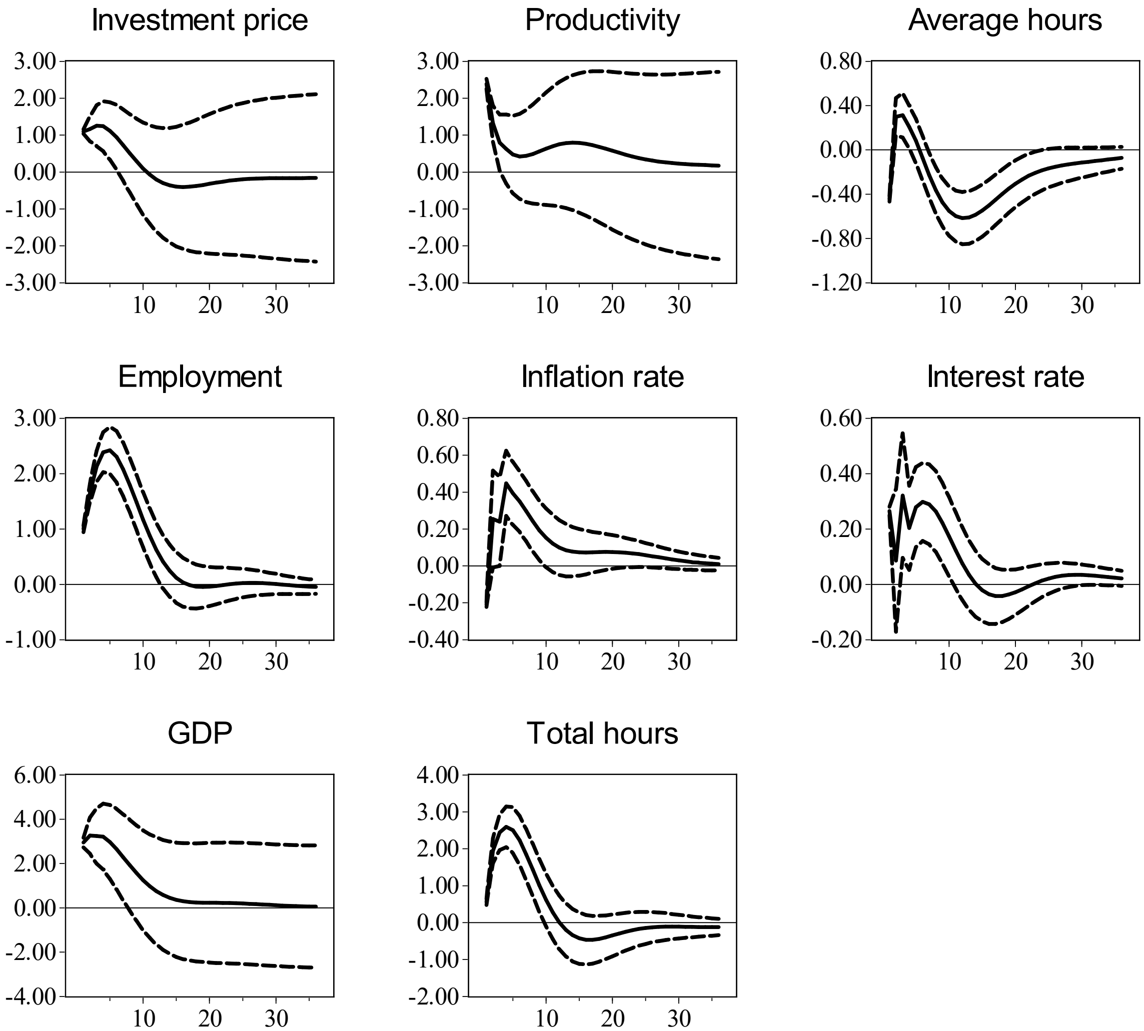


Figure 4.25 EM1. Response to an employment shock of 1 per cent

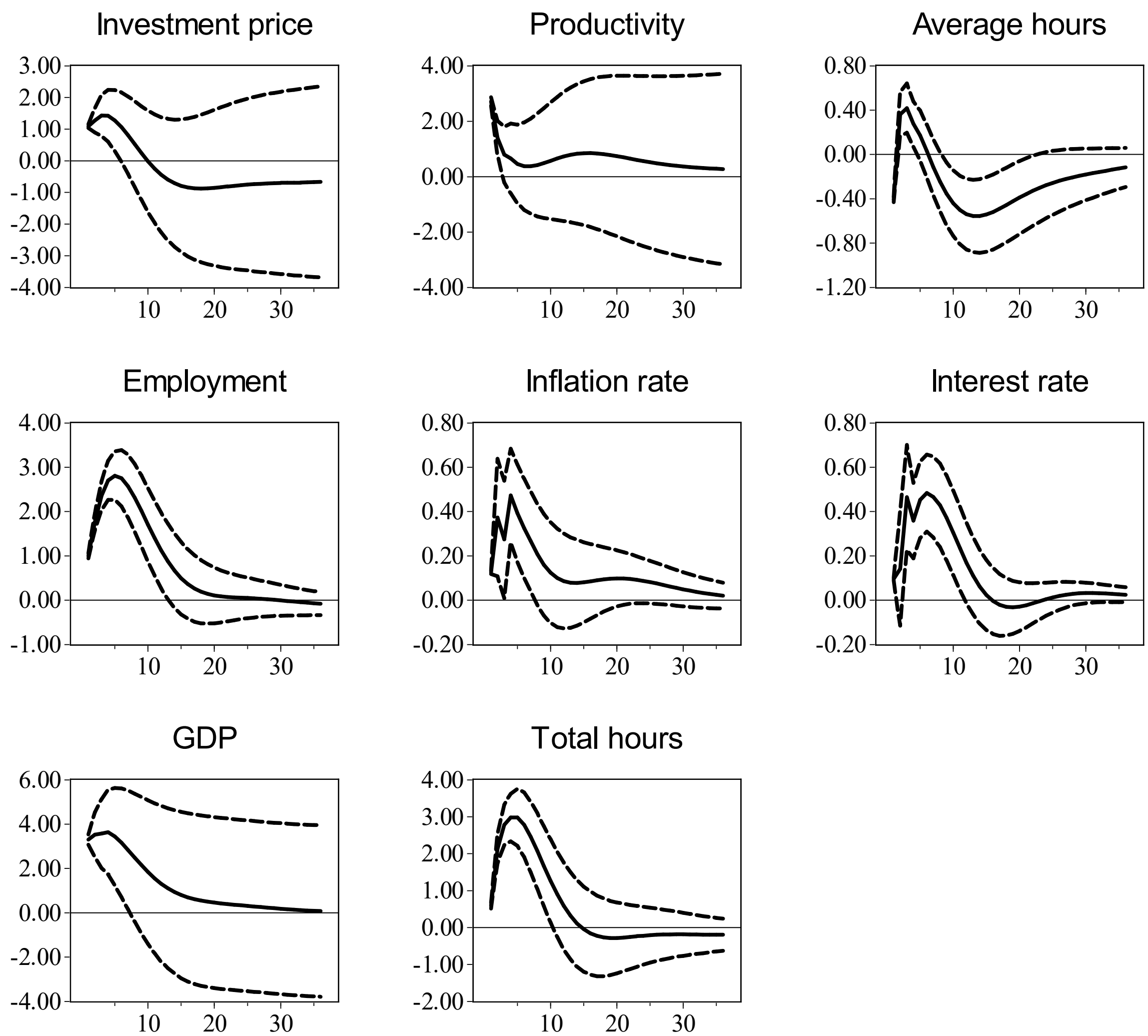


Figure 4.26 EM2. Response to an employment shock

Table 4.5 Variance decomposition of output - EM2 model (Per cent)

	Quarters				
	1	2	5	10	30
Price of investment	24	17	14	10	6
	(8, 42)	(6, 33)	(4, 29)	(3, 21)	(2, 14)
Labour productivity	14	24	37	54	79
	(3, 33)	(9, 44)	(19, 58)	(37, 71)	(69, 87)
Average hours worked	27	21	18	14	6
	(16, 41)	(10, 33)	(8, 30)	(6, 24)	(3, 10)
Employment	34	37	30	20	7
	(15, 56)	(17, 56)	(13, 47)	(9, 32)	(3, 11)

Note: Median obtained by bootstrapping with 1000 repetitions. The 16th and 84th percentiles are reported in parenthesis.

4.6. Conclusions

This chapter analyses the responses of output and hours worked to shocks that have permanent and transitory effects on output. This study has used an SVAR model with long-run restrictions and Australian data from 1978 to 2017. In line with the approach adopted by Blanchard and Quah (1989), this study has interpreted the first type of shocks as supply disturbances and the second type of shocks as demand disturbances. The supply disturbance takes the form of a neutral technology shock in the initial models, which is extended to include an investment-specific technology shock. Hours worked is decomposed into average hours worked and employment. This decomposition allows the analysis of different types of temporary demand shocks associated with average hours and employment shocks.

The results show a negative and transitory response of total hours worked to a positive, neutral technology shock. This result is verified for the whole sample period, for the two subsamples and extended models with additional domestic variables and foreign variables. Average hours worked and employment respond differently to a technology shock. Employment has a stronger reaction to a technology shock and lasts longer than the average hours worked response. When the price of investment is included in the model, a positive investment-specific technology shock produces a positive response of average hours worked and employment, with average hours having a more relevant role in the adjustment of total hours than in the case of a neutral technology shock.

The response to a shock to average hours has been interpreted as an unexpected temporary demand shock, where firms are uncertain about the permanence of the shock. In this case, after the shock, the immediate reaction of firms is to increase average hours worked. Over time, average hours decreases while employment increases for four quarters and declines afterwards when firms realise that the shock is temporary. The reduction of employment is slower than the reduction of average hours worked due to firing costs, and employment takes longer to return to trend. Average hours worked returns to trend in approximately 4 years while employment takes around 6 years. The temporary response of total hours worked is stronger than the positive response of output, resulting in a negative response of labour productivity. The response of labour productivity is temporarily negative as workers are working more intensively and new workers require a period of training.

The response to a shock to the employment ratio can be interpreted as a shock to demand generated by the expectation of consumers and investors of a permanent increase in productivity that finally does not occur. The expected increase in demand produces a positive and increasing employment response during the first 4 quarters. After this learning period, firms realise that the permanent change will not occur and that they have to reduce total hours worked. As employment reduction is costly, firms reduce average hours worked faster even to a level lower than its trend for a period of time, while employment is still in their adjustment process. The final adjustment of employment to trend takes approximately 6 years.

The analysis of variance in the base model shows that a neutral technology shock explains most of the variation of output in the long run: 83 and 95 per cent in the first and second subsamples. Labour inputs during the first quarter explain 86 and 57 per cent for the first and second subsamples, respectively, while only explain 18 and 6 per cent in 30 quarters. The extended model with investment-specific technology shock confirms that most of the variance of output in the long-run is explained by neutral technology shock.

To attenuate the negative effect of technology shocks on hours worked, policymakers can affect demand temporarily in a context of sticky prices or promote policies to reduce search frictions in the labour market and adjustment costs of investment. Policymakers should also be aware that the news they generate in the form of announcements or forecasts that can affect the decisions of economic agents and the business cycle.

Conclusions

This thesis has explored the effects of fiscal and monetary policies and credit, asset prices and demand and supply shocks on the Australian economy. This chapter summarises the main findings and suggests areas for further research.

This thesis makes three main contributions. First, the thesis has presented the estimation of fiscal expenditure and net revenue multipliers, taking into account the external sector and the government budget constraint. Second, this thesis contributes to the understanding of the interaction of monetary policy, asset prices and credit. For example, the thesis presents the results of the estimation of the effect a monetary policy shocks on asset prices and the collateral effects of this policy on GDP and employment. Finally, the thesis estimates the effects of neutral and investment-specific technology shocks on output and hours worked. Hours worked is decomposed into employment and average hours worked, which have different responses depending on the types of technology shocks.

Chapter 2 assesses the effect of fiscal policy on real activity and debt dynamics. The estimated government expenditure multipliers are 0.45 and 0.75 on impact, for the 1993Q2-2015Q3 and the 1993Q2-2007Q4 samples, respectively. The impact of a revenue shock on output is -0.20 and -0.26 for the 1993Q2-2015Q3 and the 1993Q2-2007Q4 samples, respectively. These results are statistically significant. The model shows that the effect of fiscal policy is of short duration and takes place basically during the first quarter. When debt feedback is included in the model, the shock to government spending generates a higher GDP on impact and over time and higher government revenue and exchange rate than the corresponding responses in the model without debt feedback. The GDP and net revenue responses in the model with debt feedback contribute to the gradual reduction of the debt-to-GDP ratio. The composition of the change of GDP is also affected with more investment and less net exports over time. The results also support the Keynesian view that a positive shock to government spending increases private consumption.

Further work could be done on the effects of fiscal policy on output. One line of research would be to examine the effect of fiscal policy under periods of expansion and contraction of economic activity or during specific periods of extraordinary fiscal policy measures (i.e. GFC or pandemics). Another area of additional research could be the effect of anticipated tax measures in Australia using a narrative approach or a VAR approach (Mertens and Ravn, 2012), which requires the identification of the timing of announcement and implementation of tax changes. Another potential area of research would be the analysis of the effect of different components of government expenditure (e.g. government consumption and government investment) and government revenue (e.g. company taxes, personal income taxes and taxes on products). Also, DSGE models such as May Li and Spencer (2016) could be expanded to include greater detail of government revenue and expenses and the effect of anticipated fiscal policy.

Chapter 3 assesses the relationship between monetary policy, credit and asset prices. The results indicate that a positive shock of 0.25 per cent points to the cash rate reduces asset prices in relation to a non-shock scenario. The reduction of share prices is 1.9 per cent and 2.11 per cent after two years and five years, respectively. The reduction of housing prices is 0.51 per cent and 0.57 per cent after two years and after five years, respectively. The use of monetary policy to lean against the wind should consider that this shock reduces GDP, GNE and employment. These variables are reduced by 0.23 per cent, 0.75 per cent and 0.28 per cent, respectively, after five years. The results suggest that pre-emptive action against house price bubbles could lead to a significant contractionary effect on the Australian economy, higher than the effect on other countries surveyed by Williams (2017). The effect of an increase in credit on asset prices is not statistically significant and is negative for share prices and positive for house prices. The response of interest rate is almost zero for the whole projection period, which could be explained by an elastic supply of loans in Australia, as international funds market is an important source of financing for bank loans. This study also finds a statistically significant positive response of credit to an increase in share and housing prices, providing evidence that supports the financial accelerator hypothesis. Credit increases in 0.38 per cent and 1.93 per cent after five years due to a shock in share and housing prices, respectively.

Potential research using the FAVAR approach would be to use another FAVAR methodology such as the procedure proposed by Ouliaris, Pagan and Restrepo (2016), the inclusion of external factors to analyse the effects of international shocks (Mumtaz and Surico, 2009) and the estimation of a time-varying FAVAR (Mumtaz et al., 2011). If detailed banking data are available, the FAVAR approach could be used to assess the role of banks' financial conditions on macroeconomic variables (Jimborean et al., 2010). Additionally, a DSGE model calibrated for Australia that captures the relationship between macroeconomic variables and financial markets could provide a theoretical framework for the explanation of the transmission mechanisms of changes in monetary policy, asset prices and credit. This framework could also assist in explaining the effects of credit on asset prices that were found statistically non-significant in Chapter 3.

Chapter 4 analyses the responses of output and hours worked to shocks that have permanent and transitory effects on output for the period 1978Q4 to 2017Q4. The permanent and transitory shocks are identified using an SVAR with long term restrictions, assuming that only technological shocks can have a permanent effect on labour productivity and that hours worked per working-age population follows a stationary process. Hours worked is decomposed into average hours and employment. The results show a negative response of total hours to a positive neutral technology shock and that total hours adjust mainly through employment. Additionally, when the model is extended to include the price of investment, a positive investment-specific technology shock produces a positive response of average hours worked and employment, with average hours having a more relevant role in the adjustment of total hours than in the case of the responses to a neutral technology shock. The shock to average hours is interpreted as an unexpected temporary demand shock, where firms are uncertain about the permanence of the shock. The shock to employment is interpreted as a shock to demand generated by the expectation of consumers and investors of a permanent increase in productivity that finally does not occur. The analysis of the variance decomposition of output shows that after the year 2000, employment and average hours worked explain around half of the output volatility on impact, while productivity explains most of the output variance in the long-run. To attenuate the negative effect of technology shocks on hours worked, policymakers can affect demand temporarily in the context of sticky prices or promote policies to reduce search frictions in the labour market and adjustment costs of investment. Policymakers should also be aware that the news they generate in the form of announcements or forecasts can affect the decisions of economic agents and the business cycle.

A potential area of study would be assessing the relative importance of the different factors that explain the negative response of hours worked to a positive, neutral technology change. The factors identified in the literature include habit formation in consumption, capital-labour elasticity of substitution, adjustment costs of investment and the presence of price rigidities.

The model could also separate hours worked into average hours worked and employment (Canova et al., 2010), including the possibility of news shock described by Lorenzoni (2006) and investment-specific and labour-augmenting technical changes as additional sources of supply shocks.

Overall, this thesis shows that the fiscal multipliers are smaller than previous studies and that a government expenditure and net revenue changes affect output mainly in the first quarter. Regarding monetary policy, the chapter on the effect of monetary policy on asset prices provides evidence on the effect of this policy on asset prices as well as the collateral effects on employment, GDP and GNE, which should be taken into account in the decision to use this policy to influence asset prices. Concerning long term effects on output, positive neutral and investment-specific technology shocks have a permanent positive effect on output. However, the effect on hours worked is temporary, and the sign of the response depends on the type of technology shock. The response is negative to a neutral technology shock with the adjustment of total hours worked mainly through employment; and positive to an investment-specific technology shock, with average hours worked having a significant role in the adjustment of total hours worked.

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