EMPIRICAL ESSAYS ON MONETARY POLICY AND TRANSMISSION

Tuan Anh Phan

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DECLARATION

The material in Chapter 4 is based on work co-authored with Professor Ippei Fujiwara and Dr. Jouchi Nakajima. My contribution to the material in Chapter 4 is 80%. Otherwise, this thesis is my own work.

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Related to the materials of this thesis, a version of Chapter 3 is forthcoming in the *Economic Record* (Phan, 2014). Chapter 3 is also circulated as CAMA Working Paper 39/2014 and Crawford School Research Paper 14-3. Chapter 5 is available as Crawford School Research Paper 14-4. I acknowledge the contributions of Professor Ippei Fujiwara and Dr. Jouchi Nakajima to the materials in Chapter 4. My goal is to publish all four papers to ensure dissemination of the results.

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ABSTRACT

This thesis presents four self-contained empirical research papers on monetary policy and monetary transmission using vector autoregression (VAR), structural VAR (SVAR), and Bayesian time-varying parameter VAR (TVP-VAR) models. The first two papers compare aspects of monetary policy and transmission in selected developed countries: Australia, the US, and the Euro area (Chapter 3); and Australia, the US, UK, and Canada (Chapter 4). The last two papers (Chapters 5 and 6) explore monetary policy and effects of monetary policy on inflation in Vietnam – a transition developing country.

The empirical results indicate that the investment channel of monetary policy transmission plays a more important role than the consumption channel in Australia. Meanwhile the investment channel and the consumption channel make similar contributions to the overall transmission of monetary policy in the Euro area and the US. The difference between Australia and the Euro area appears to come from differences in housing investment responses, whereas Australia differs from the US mainly because it has a lower share of household consumption in total demand.

Results from TVP-VAR models suggest that there were comovements in the monetary policy reactions to unemployment across countries before the recent Global Financial Crisis (GFC). The policy rate seems to react more strongly to unemployment changes in more recent years, especially in the US and UK. Monetary policy responses to inflation/deflation are observed to be divided into two groups, with the responses in the US and UK showing a different pattern to the responses in Canada and Australia. Monetary policy seems to react most aggressively against inflation/deflation in the US.

The effects of monetary policy shocks on unemployment and inflation are similar across countries, and seem to have weakened over time.

Results also suggest that monetary policy transmission to inflation in a transition country like Vietnam appears to work in a similar way to as in developed countries. The impulse response functions of inflation to shocks in monetary policy are plausible and robust across the VAR and SVAR models. The policy interest rate plays an important role in affecting inflation. For the case of Vietnam as a small, open economy, shocks to output and prices in trading partners also appear to have strong effects on domestic inflation.

Allowing for the time-varying nature of the parameters and variance/covariance matrices, the results suggest that the State Bank of Vietnam (SBV) appears to have been steadily using monetary policy tools to contain inflation. TVP-VAR results also confirm that monetary policy in Vietnam appears to lead to reasonable inflation responses. The evidence therefore supports the argument that Vietnam's monetary policy might be more effective than expected.

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LIST OF ABBREVIATIONS

ABS	Australian Bureau of Statistics
ASEAN	Association of South East Asian Nations
AUD	Australian dollar
AWM	Area Wide Model
CPI	Consumer price index
DSGE	Dynamic stochastic general equilibrium
ECB	European Central Bank
EDO	Estimated dynamic optimisation
ERM	European Exchange Rate Mechanism
FED	US Federal Reserve
FOMC	Federal Open Market Committee
G-7	Group of 7 advanced countries (US, UK, Germany, France, Italy, Japan, and Canada)
GDP	Gross domestic product
GFC	Global Financial Crisis
GSO	General Statistics Office (Vietnam)
IMF	International Monetary Fund
KITT	Kiwi inflation targeting technology
M2	Broad money aggregate
MCMC	Markov chain Monte Carlo
MTM	Monetary transmission mechanism
NBER	US National Bureau of Economic Research
NEMO	Norwegian Economy Model
NPL	Non-performing loan
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary least squares
OMO	Open market operations
QE	Quantitative easing
RBA	Reserve Bank of Australia
RBNZ	Reserve Bank of New Zealand
SBV	State Bank of Vietnam

SC	Schwarz information criterion
SOE	State-owned enterprise
SVAR	Structural vector autoregression
ToTEM	Terms-of-Trade Economic Model
TVP-VAR	Time-varying parameter vector autoregression
UK	United Kingdom
US	United States
USD	United States dollar
VAR	Vector autoregression
VECM	Vector error correction model
VND	Vietnam dong
ZLB	Zero lower bound

CHAPTER 1

INTRODUCTION

Summary: This thesis presents four empirical research papers on monetary policy and monetary transmission using vector autoregression (VAR), structural VAR (SVAR), and time-varying parameter VAR (TVP-VAR) models. This chapter introduces the context, purpose, and contributions of the thesis. The chapter also lays out the organisation of this thesis.

1.1 Context and purpose

Two of the most important empirical questions about monetary policy are: *(i)* how does monetary policy react to macroeconomic variables?; and in the reverse direction, *(ii)* how does monetary policy affect macroeconomic variables? The first question deals with how a central bank reacts to developments in macroeconomic variables. The second question is about the transmission mechanisms through which monetary policy affects the macro economy.

In practice, central banks are informed by a huge set of variables when they decide their monetary policy (see, for instance, Board of Governors of the Federal Reserve System, various years; Reserve Bank of Australia, various years; State Bank of Vietnam, various years). Regardless of whether a central bank follows a monetary rule or a discretionary monetary policy, the key macroeconomic variables that the central bank needs to consider when deciding its monetary policy and also in checking the effectiveness of its policy are inflation/prices and output/the output gap/output growth/unemployment (see, for example, Taylor, 1993; Woodford, 2003).

This thesis does not aim to investigate the two introductory questions in their broadest terms. The thesis also does not try to estimate monetary reaction functions or measure all possible channels of monetary transmission. The purpose of this thesis is instead to explore specific aspects of monetary policy and monetary transmission that have not been well studied yet. The questions to be examined in this thesis are as follows.

First, is the investment or consumption channel of monetary policy transmission more important? In other words, is consumption or investment more affected by a tightening in monetary policy? Is the answer to this question similar for different countries? What are the main reasons behind any differences between countries? Chapter 3 aims to answer these questions for the cases of Australia, the United States (US), and the Euro area.

Second, are there similarities in monetary policy reactions to unemployment/inflation and in the effects of monetary policy shocks on unemployment/inflation across countries over time?[1] If so, has monetary policy become more aggressive to changes in unemployment and inflation? Have the effects of monetary policy shocks on unemployment and inflation become stronger or weaker? Chapter 4 addresses these questions for the cases of Australia, the US, the United Kingdom (UK), and Canada.

Third, how does monetary policy and monetary transmission operate in a small, open, transition economy? Are these comparable to how they operate in developed

[1] In this thesis, especially in Chapter 4, I will use the term 'comovement' which is 'similar movements (of reaction functions/response functions) over time'.

countries? These questions are the target of the analysis in Chapter 5, which investigates the macro determinants of inflation in Vietnam.

Finally, for the case of Vietnam, where its central bank (the State Bank of Vietnam – SBV) uses discretionary monetary policy rather than a monetary rule framework, have the monetary policy reactions and the monetary transmission to inflation been plausible and consistent over time? This question is examined in Chapter 6 where the dynamics of inflation management in Vietnam are investigated.

The methodology to be used in this thesis is the estimation of VAR, SVAR, and TVP-VAR models. VAR and SVAR models are implemented based on the assumption of constant parameters (constant coefficients and constant variance-covariance matrices), while TVP-VAR models allow for parameters to be time-variant. More details on the methodology are provided in Chapter 2.

1.2 Contribution

The primary contributions of this thesis are the empirical results. Chapter 3 is the first paper to compare the output composition of monetary policy transmission between Australia and the two major economies of the Euro area and the US. The results indicate that the investment channel of monetary policy transmission plays a more important role than the consumption channel in Australia, while the contributions of the two channels are similar in the Euro area and the US. Chapter 3 also explores the reasons behind these differences by further decomposing private investment and private consumption into more- and less-interest-rate-sensitive components, which has not been done in previous studies. The results suggest that the difference between Australia and the Euro area comes from differences in housing investment responses, whereas

Australia is different to the US mainly because it has a lower share of household consumption in total demand.

To my knowledge, Chapter 4 is the first paper to use TVP-VAR models similar to those used by Primiceri (2005) to investigate the changes of monetary policy and monetary transmission over time in different countries (Australia, the US, UK, and Canada). The results suggest that there were comovements in the monetary policy reactions to unemployment across countries before the recent Global Financial Crisis (GFC). The policy rate seems to react more strongly to unemployment in more recent years, especially in the US and UK. Monetary policy responses to inflation/deflation are observed to be divided into two groups, with the responses in the US and UK showing a different pattern to the responses in Canada and Australia. Monetary policy seems to react most aggressively against inflation/deflation in the US. The effects of monetary policy shocks on unemployment and inflation are similar across countries, and seem to have become weaker over time.

Chapter 5 is not the first study to estimate a VAR model for Vietnam's economy, but is the first to report that the impulse response function of domestic inflation in Vietnam is actually quite similar to the shapes for advanced economies. Chapter 5 is also the first to use impulse response functions from VAR and SVAR models to support the claims that the policy interest rate plays an important role in affecting inflation in Vietnam, and that Vietnam's inflation is strongly affected by trading partners' GDP and inflation.

Chapter 6 is the first study to estimate a TVP-VAR model to explore the dynamics of inflation management in Vietnam. The results in Chapter 6 support the argument of plausible impulse responses obtained for Vietnam in Chapter 5. Chapter 6 also finds

that monetary policy reactions to inflation and the effects of monetary policy shocks on inflation in Vietnam appear to have been consistent throughout the period 1996–2012.

1.3 Organisation

This thesis includes seven chapters. Chapter 2 provides a brief survey of the existing literature on monetary policy and monetary transmission mechanisms as well as the methodological approaches of VAR, SVAR, and TVP-VAR models. Chapters 3-6 present the four empirical research papers. Chapter 7 concludes.

CHAPTER 2

MONETARY POLICY AND MONETARY TRANSMISSION ANALYSIS USING VAR, SVAR, AND TVP-VAR MODELS

Summary: This chapter provides a short introduction to monetary policy and a survey of the channels of monetary policy transmission. The chapter also summarises the VAR, SVAR, and TVP-VAR methods for analysing monetary policy and monetary transmission.

2.1 Monetary policy

Monetary policy is the process by which the monetary authority of a country uses its instruments to achieve its objectives and targets. In most countries, the central bank is the authority to manage the money market of a country, dealing with the key variables in this market: money demand, money supply, and the price of money (interest rates).

Six basic objectives are commonly mentioned among central banks in conducting monetary policy, including high employment, economic growth, price stability, interest rate stability, financial market stability, and foreign exchange market stability. Different central banks explicitly pursue different sets of objectives. For instance, the US Federal Reserve's goals officially consist of high employment, price stability, and interest rate stability (see Mishkin, 2004, 2012; Labonte, 2014). Price stability is officially the primary goal for inflation-targeting central banks (see RBA, various years; King, 1997, 2002).

The goals of monetary policy are related to each other. The objectives of high employment and economic growth are closely correlated and one can often imply the other. However, there might be a trade-off between unemployment and inflation, as suggested by the Phillips curve, although evidence on this trade-off is less convincing recently than it was prior to the 1970s (see, for example, Mishkin, 2012). Meanwhile, interest rate stability and exchange rate stability might foster the stability of financial markets and vice versa.

In order to ultimately achieve the goals of monetary policy, central banks choose their operational, intermediate targets, which depend on actual macroeconomic circumstances. The targets might include a money growth target, short-run nominal interest rate target, real interest rate target, exchange rate target, or inflation target.

The set of instruments of monetary policy that central banks use to pursue their objectives and targets basically include the policy interest rate, open market operations (which affect the monetary base and reserves, and therefore money supply), and reserve requirements (which affect the money multiplier). From time to time in different central banks, the instrument set might also include exchange rate management, credit control measures, floors and ceilings of lending and borrowing interest rates, and unconventional monetary policy tools such as quantitative easing.

The policy interest rate is currently the most important tool used by the central banks of most developed countries. Central banks choose to target a short-term nominal interest rate (such as the FED funds rate in the US, the Bank rate in the UK, or the cash rate in Australia). Together with their transparency and credibility, central banks can influence expectations of future short-term interest rates, and therefore influence long-term real interest rates. These in turn affect decisions in the economy more broadly, for example decisions about consumption, saving, and investment (Mishkin, 2004, 2012).

During the 1970s and early 1980s, money supply (money aggregates) growth was the main operational target as well as the main tool used by the US Federal Reserve and many other central banks in developed countries (Mishkin, 2012). The money supply remains one of the major monetary policy tools in some developing countries such as Vietnam.

In using policy instruments and pursuing monetary policy objectives, central banks could be independent or not, both *de jure* and *de facto*. In general, most central banks nowadays have significantly higher legal and actual independence compared to about twenty five years ago (see Cukierman, 2008). Although reverse causality is difficult to exclude, Grilli *et al.* (1991), Cukierman *et al.* (1992, 2002), and Alesina and Summers (1993) suggest that there is a negative relation between central bank independence and inflation, especially in developed countries, and also in developing countries during more recent periods. Meanwhile there is no clear relationship between central bank independence and economic growth (Cukierman, 2008).

It is a consensus that monetary policy does not affect output in the long run when prices are fully flexible. Therefore, the main role of monetary policy is to achieve short-run stabilisation of the macro economy (see, for example, Romer, 2011; Dwyer, 1993). In conducting monetary policy, central banks generally take one of two approaches: a monetary rule or a discretionary policy.

Each of the two policy decision types has its own advantages and disadvantages. As pointed out by Dwyer (1993) and Greenspan (1997), a discretionary policy allows central bankers to respond quickly to any changes in the economy. However, discretionary policy might be subject to dynamic inconsistency. Meanwhile a rule-based approach can be more transparent and credible. Nevertheless, a rule-based policy might limit the flexibility and choices of the central banker in some circumstances.

The most well-known monetary rule is the 'Taylor rule' (see Taylor, 1993; Henderson and McKibbin, 1993), where the central bank decides the interest rate through the relationship between the interest rate and the output and inflation gaps:

$$i_t = \pi_t + r_t^* + a_\pi(\pi_t - \pi_t^*) + a_y(y_t - \bar{y}_t)$$

in which i_t is the target short-term nominal interest rate, π_t is the inflation rate, r_t^* is the assumed equilibrium real interest rate, π_t^* is the desired inflation rate, y_t is the logarithm of real gross domestic product (GDP), $\bar{y}_t$ is the logarithm of potential output, and a_π and a_y are parameters corresponding to the inflation gap and output gap respectively. Originally, Taylor proposed $a_\pi = a_y = 0.5$ for the US economy, which means a balanced weight between the output gap and the inflation gap. There have since been different variations of the Taylor rule where the output gap could be proxied by the unemployment rate (based on Okun's law; Okun, 1962) and different values for a_π and a_y. Recent developments include the 'meta' Taylor rule approach which uses model averaging techniques to take into account the difficulties in estimating the interest rate reaction function when regime uncertainty exists (for more details, see Lee *et al.*, 2011, 2013).

For a central bank which follows a discretionary policy, there is no such interest rate rule. The central bank would use combinations of its policy tools in response to developments of a set of macroeconomic variables in order to achieve its operational targets. Inflation and either unemployment/output/output gap/output growth are typically the key parts of any such macroeconomic variable set.

The question of how monetary policy reacts to changes in inflation and/or unemployment is explored in parts of Chapters 4 and 6 of this thesis. Meanwhile, Chapters 3 and 5 and the rest of Chapters 4 and 6 deal with the question of how

monetary policy shocks affect inflation and output/unemployment, i.e. the monetary transmission mechanisms.

2.2 Channels of monetary transmission

Monetary policy transmission mechanisms are the channels through which monetary policy affects the economy. As Mishkin (2004) and Boivin *et al.* (2010) have summarised, there are two main views on monetary transmission channels, namely the 'traditional view' (or 'neoclassical view') and the 'credit view'. The traditional view is comprised of direct interest rate effects, Tobin's q effects, wealth and inter-temporal substitution effects, and the exchange rate effects on net exports. The credit view includes bank lending effects, the balance sheet channel, cash flow channel, unanticipated price level channel, and household liquidity effects. Details of the channels are provided below.

2.2.1 Traditional view

According to the traditional view, there are five different channels through which monetary policy affects the economy. The first two channels relate to monetary policy effects on investment, while the next two relate to effects on consumption, and the last is about effects on net exports. Finally, all channels lead to effects on output (and subsequently unemployment and prices).

2.2.1.1 Direct interest rate channel

The direct interest rate channel is the most traditional, originating from a Keynesian view of the monetary transmission mechanism, and strongly supported by the work of Taylor (1995):

$$M \uparrow \Longrightarrow r \downarrow \Longrightarrow user\ cost\ of\ capital \downarrow \Longrightarrow I \uparrow \Longrightarrow Y \uparrow$$

where a monetary expansion ($M \uparrow$) will lead to a fall in real interest rates ($r \downarrow$), which in turn leads to a decline in the user cost of capital, causing an increase in investment (I) spending, and thereby a rise in aggregate demand and output (Y).

The channel is also a standard feature of earlier large scale macro-econometric models used for forecasting and policy analysis in many central banks, such as, in the US, the MPS model (Brayton and Mauskopf, 1985) and the FRB/US model (Reifschneider *et al.*, 1999). In the European area, examples include the ECB's Area Wide Model (Fagan *et al.*, 2005) and the Bank of England's Quarterly Model (Harrison *et al.*, 2005).

Notice that the key interest rate in the channel is the real interest rate, not the nominal interest rate. Theoretically even if the nominal interest rate is stuck at zero (the zero lower bound - ZLB), a monetary expansion can still lower the real interest rate through raising the expected price level:

$$M \uparrow \Longrightarrow P^e \uparrow \Longrightarrow \pi_e \uparrow \Longrightarrow r = (i - \pi_e) \downarrow$$

in which P^e is the expected price, π_e is inflation expectations, and r is the real interest rate.

However, in this circumstance, if the monetary expansion is not enough to lift expected inflation, it will also not be successful in lowering the real interest rate. This might help explain Japan's long period of being stuck in a zero lower bound since the 1990s.

2.2.1.2 Tobin's q theory

Tobin (1969) defines q as the market value of firms divided by the replacement cost of capital and explains the effects of a monetary expansion on q and therefore on investment spending and total output as follows:

$$M \uparrow \Longrightarrow P_s \uparrow \Longrightarrow q \uparrow \Longrightarrow I \uparrow \Longrightarrow Y \uparrow$$

where an expansionary monetary policy leads to excess money and therefore a rise in stock demand, henceforth a rise in stock prices (P_s), which in turn leads to higher q. A high q helps firms issue stocks with high prices relative to the replacement cost of capital, and therefore increase investment spending.

This Tobin's q channel is the baseline model of investment decisions in some dynamic stochastic general equilibrium (DSGE) models used at central banks. Examples include the Estimated Dynamic Optimisation (EDO) model of the Federal Reserve Board (Edge *et al.*, 2007, 2008, 2010; Kiley, 2010), the New Area Wide Model of the ECB (Christoffel *et al.*, 2008), and the Terms-of-Trade Economic Model (ToTEM) at the Bank of Canada (Murchison and Rennison, 2006).

2.2.1.3 Wealth effects

Modigliani and Brumberg (1954) then Ando and Modigliani (1963) are the first to propose this channel, which illustrates the link from an expansionary monetary policy to an increase in consumers' financial wealth through a rise in stock prices, and finally an increase in consumption (C) and GDP (Y):

$$M \uparrow \Longrightarrow P_s \uparrow \Longrightarrow wealth \uparrow \Longrightarrow C \uparrow \Longrightarrow Y \uparrow$$

This channel is investigated and estimated by some studies, including Fair (2004) and Catte *et al.* (2004), and is also embedded in some macro-econometric models used at central banks as mentioned above.

2.2.1.4 Inter-temporal substitution effects

Starting from the inter-temporal Euler equation in DSGE models, a decline in the interest rate will alter the consumption profile in a way that induces higher consumption today, and consequently higher output:

$$M \uparrow \Longrightarrow r \downarrow \Longrightarrow C \uparrow \Longrightarrow Y \uparrow$$

This inter-temporal substitution channel is incorporated in most of the New Keynesian DSGE models used in central banks, such as the Kiwi Inflation Targeting Technology (KITT) for the Reserve Bank of New Zealand (RBNZ) or Norwegian Economy Model (NEMO) for the Norges Bank.

2.2.1.5 Exchange rate effects on net exports

Bryant *et al.* (1993) and Taylor (1993) argue that the exchange rate channel plays an important role in monetary transmission.

$$M \uparrow \Longrightarrow r \downarrow \Longrightarrow E \downarrow \Longrightarrow NX \uparrow \Longrightarrow Y \uparrow$$

According to that channel, when domestic real interest rates fall as a result of an expansionary monetary policy, domestic currency deposits become less attractive relative to deposits denominated in foreign currencies. Consequently, the relative value of the domestic currency falls ($E \downarrow$), which in turn makes domestic goods cheaper than foreign goods, thereby leading to a rise in net exports (NX) and hence a rise in total output.

However, in Chapter 3 of this thesis, when using various VAR models, I find that net exports increase rather than decrease after a positive policy rate shock[2], though the increases are insignificant in most cases. This might come from a depreciation of the domestic currency in response to a contractionary monetary policy shock (rather than appreciation) that is also found in some VAR models for industrial economies (Sims, 1992; Grilli and Roubini, 1996; Racette and Raynauld, 1992).

Notice that a change in interest rates can affect prices without affecting GDP. A fall in domestic interest rates might lead to an increase in the inflow of foreign exchange, which in turn causes an appreciation of the domestic currency. As a result, prices of imported goods decline leading to a fall in the CPI. Goldberg and Knetter (1997) provide a review of this type of 'exchange rate pass-through'.

2.2.2 Credit view

The credit view of monetary transmission is an increasing strand which originated from attempts to address the shortcomings of the traditional view. Since the seminal paper by Bernanke and Gertler (1995), many other papers provide empirical evidence on the importance of credit channels – with the core of credit market imperfections – among the channels of monetary transmission mechanisms. Reviews of these credit channels (sometimes called 'non-neoclassical channels') can be found in the papers of Cecchetti (1995), Hubbard (1995), Mishkin (2004), and Boivin *et al.* (2010).

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[2] Within the scope of the thesis, a "positive policy rate shock" indicates a shock where the policy interest rate increases, and therefore is used in the same meaning as a "contractionary monetary policy shock". The two terms are used interchangeably throughout the thesis.

2.2.2.1 Bank lending channel

When bank reserves and bank deposits increase as a result of expansionary monetary policy, bank loans will also increase. This might cause investment spending, and possibly consumption spending, to rise.

$$M \uparrow \Longrightarrow bank\ deposits \uparrow \Longrightarrow bank\ loans \uparrow \Longrightarrow I(C) \uparrow \Longrightarrow Y \uparrow$$

As noticed by Mishkin (2004), this bank lending channel should have a greater effect on smaller firms, which are more dependent on bank loans compared to bigger firms. Supporting empirical evidence for this channel can be found, for example, in the work of Gertler and Gilchrist (1993, 1994), Kashyap and Stein (1995), and Peek and Rosengren (1995a, 1995b, 1997).

2.2.2.2 Balance sheet channel

An expansionary monetary policy leads to a rise in stock prices, or a higher net worth of business firms, which in turn lowers the potential of adverse selection and moral hazard problems in loans to these firms. Higher net worth means lenders effectively have more collateral for their loans to these firms, therefore potential losses from adverse selection are lower. Higher net worth also means higher value of firms owners' equities, providing less incentive for them to involve in riskier investment projects, therefore potential moral hazard (of not paying back the loans) decreases. As a result, the risk level of loans declines, causing lending to rise, which likely lifts up investment spending and thereby total GDP (see Mishkin, 2004, for more details).

$$M \uparrow \Longrightarrow P_s \uparrow \Longrightarrow adverse\ selection \downarrow, moral\ hazard \downarrow \Longrightarrow lending \uparrow \Longrightarrow I \uparrow \Longrightarrow Y \uparrow$$

Since the beginning of the recent Global Financial Crisis (GFC), there has been an increasing body of research focusing on this channel of monetary transmission.

Examples of these studies are Mishkin (2008), Wessel (2009), Angeloni and Faia (2009), Gerali *et al.* (2009), Gertler and Kiyotaki (2010), and Meh and Moran (2008).

2.2.2.3 Cash flow channel

An expansionary monetary policy that leads to a decline in the nominal interest rate might cause an improvement in firms' cash flow, and hence an improvement in firms' balance sheets. This once again reduces the risks of adverse selection and moral hazard problems in loans to these firms, thereby lifting lending and investment spending.

$$M \uparrow \Longrightarrow i \downarrow \Longrightarrow cash\ flow \uparrow \Longrightarrow adverse\ selection \downarrow,$$

$$moral\ hazard \downarrow \Longrightarrow lending \uparrow \Longrightarrow I \uparrow \Longrightarrow Y \uparrow$$

This channel is actually closely related to the balance sheet channel, with an interesting characteristic that it is the nominal interest rate that causes the effects, rather than the real interest rate. Curdia and Woodford (2009) and Carlstrom *et al.* (2009) are recent examples of research focusing on this channel of the monetary transmission mechanism.

2.2.2.4 Unanticipated price level channel

This channel is less well-known than the other channels. It also relates to the firms' balance sheet channel, where an eased monetary policy leads to an unanticipated rise in the price level, therefore lowering the value of firms' liabilities in real terms, since lending contracts are normally bound in fixed nominal terms. This in turn might raise firms' net worth and thereby raise credit quality and finally lending.

$$M \uparrow \Longrightarrow unanticipated\ P \uparrow \Longrightarrow adverse\ selection \downarrow,$$

$$moral\ hazard \downarrow \Longrightarrow lending \uparrow \Longrightarrow I \uparrow \Longrightarrow Y \uparrow$$

As Mishkin (2004) mentioned, unanticipated price movements have important effects on aggregate demand, which was the key feature of the debt-deflation view of the Great Depression of 1929–1933.

2.2.2.5 Household liquidity effects

This channel relates to households' rather than firms' balance sheets. When stock and other asset prices increase as a result of an expansionary monetary policy, households' financial wealth increases, which leads to a rise in durable consumption and housing expenditure. Finally, total output increases when private consumption increases.

$$M \uparrow \Longrightarrow P_s \uparrow \Longrightarrow financial\ assets \uparrow \Longrightarrow financial\ distress\ likelihood \downarrow$$

$$\Longrightarrow consumer\ durables \uparrow \Longrightarrow C \uparrow \Longrightarrow Y \uparrow$$

Examples of research related to this channel include Benito *et al.* (2006), Hatzius (2005), Iacoviello (2005), Iacoviello and Neri (2010), Calza, Monacelli, and Stracca (2007), and Iacoviello and Minetti (2008).

The channels of monetary transmission are summarised in Figure 2.1, which is a combination of the review by Mishkin (2004, 2012) and Boivin *et al.* (2010). In the subsequent chapters of this thesis, I will not examine each channel separately. Instead, I will concentrate on the final outcomes of how monetary policy affects components of output (in Chapter 3), and how effects of monetary policy shocks on unemployment and inflation have changed over time (in Chapter 4). The effects of monetary policy on inflation in a transitional economy (Vietnam) will be the focus of Chapters 5 and 6.

Figure 2.1 Channels of monetary transmission

Traditional view					Credit view				
Direct interest rate channel	**Tobin's q theory**	**Wealth effects**	**Inter-temporal substitution effects**	**Exchange rate effects**	**Bank lending channel**	**Balance sheet channel**	**Cash flow channel**	**Unanticipated price level channel**	**Household liquidity effects**
Monetary policy									
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Real interest rates	Stock prices	Stock prices	Real interest rates	Real interest rates	Bank deposits	Stock prices	Nominal interest rates	Unanticipated price level	Stock prices
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
User cost of capital	Tobin's q	Financial wealth	Slope of inter-temporal substitution	Exchange rate	Bank loans	↓	Cash flow	↓	Financial wealth
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
↓	↓	↓	↓	↓	↓	Adverse selection, Moral hazard	Adverse selection, Moral hazard	Adverse selection, Moral hazard	Probability of financial distress
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
↓	↓	↓	↓	↓	↓	Lending activity	Lending activity	Lending activity	↓
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Investment	Investment	Consumption	Consumption	Net exports	Investment; Consumption	Investment	Investment	Investment	Residential housing; Durable consumption
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
GDP (then prices, unemployment, etc.)									

Sources: Mishkin (2004) and Boivin *et al.* (2010).

2.3 VAR and SVAR models

As opposed to a theory-based approach which requires a clear understanding of all channels through which monetary policy affects the economy, the vector autoregression (VAR) approach provides a convenient method to assess the effects via a system of reduced-form equations where all macroeconomic variables are basically treated endogenously. Following Sims (1980), there has been a vast literature on using VAR models to empirically investigate monetary policy transmission mechanisms. Starting with VAR analysis for the US economy (Sims, 1980; Bernanke, 1986; Sims, 1986; Bernanke and Blinder, 1988, 1992; Leeper *et al.*, 1996; Christiano *et al.*, 1999, among many others), many VAR studies have also appeared for either individual industrialised countries, groups of industrialised countries, individual developing countries, or groups of developing countries.

The existing VAR papers focus on many different aspects of monetary policy transmission with some commonly-accepted findings, such as the hump shape of the impulse responses of output to a policy interest rate shock, or the delayed effects of policy rate shocks on inflation (see Christiano *et al.*, 2005). At the same time, VAR models could also be used to explore monetary reactions to changes in inflation and unemployment/output.

Variables included in VAR models appear in different forms. Classical time series econometrics normally transform series with unit roots into stationary form by taking first differences, and use vector error correction models (VECMs) to capture long-run relationships of series (as suggested by Box and Jenkins, 1970; Granger and Newbold, 1974; Dickey and Fuller, 1979). However, as Sims *et al.* (1990) argue, although VAR models with *I(1)* series might incur some loss in efficiency, estimators remain

consistent. In fact many well-known VARs have been estimated using levels or log levels, including by Sims (1980), Bernanke and Blinder (1992), Christiano *et al.* (1999, 2005), Peersman and Smets (2003), Erceg and Levin (2006), Boivin *et al.* (2010), and others. In this thesis, data in level and log level forms are used in Chapters 3, 4, and 5, while data in differenced form are employed in Chapter 6 (for a reason explained in that Chapter).

To date, three identification strategies have been employed in order to identify exogenous shocks that can be used to analyse the effects on macroeconomic variables in a VAR system. The first emerges directly from Sims (1980), which assumes that all macroeconomic variables are endogenous and applies a Cholesky recursive form in computing the impulse response functions. In a recursive Cholesky structure, a variable will depend contemporaneously on all variables that are placed before it in the VAR system. The only restriction used by this identification strategy is that a lower triangular matrix of structural shocks is assumed. Therefore, the ordering of variables in the VAR will decide whether its shocks have contemporaneous effects on other variables in the system. Examples of this traditional, 'unrestricted' VAR are found in the research of Sims (1992), Christiano and Eichenbaum (1992), Bernanke and Blinder (1992), and Christiano *et al.* (1999, 2005).

The second identification strategy lies somewhere between unrestricted VARs and systems of structural equations involving dynamics. In this 'restricted' VAR, some limits are imposed on either the contemporaneous structure or the lag structure of the system of variables. These restrictions are normally based on suggestions from structural models and therefore this type of VAR is called a 'structural VAR' (SVAR). Typical examples of restrictions are whether shocks have short-run or long-run effects.

Leeper *et al.* (1996), Cushman and Zha (1997), Clarida and Gertler (1997), and Dungey and Pagan (2000, 2009) are among authors using SVAR models.

The third identification strategy, emerging relatively recently, is based on 'sign restrictions'. The restrictions are imposed not for the parametric structure of the VAR, but for the expected signs of impulse response functions. These sign restrictions also originate from theoretical suggestions, such as the idea that (positive) demand shocks should lead to increases in both output and price, while (negative) supply shocks should end up with an increase in price, but a decline in output. The pioneers of sign-restricted VARs are Faust (1998), Canova and De Nicolo (2002), and Uhlig (2005). A review of sign-restricted VARs is provided by Fry and Pagan (2011).

A VAR(p) model, with the recursive identification assumption, can be written as:

$$Z_t = A_1 Z_{t-1} + \ldots + A_p Z_{t-p} + \alpha W_t + e_t \tag{2.1}$$

$$e_t = B\varepsilon_t \tag{2.2}$$

in which Z is a (k x 1) vector of endogenous variables; $A_1,\ldots A_p$ are (k x k) matrices of parameters; W_t is a (q x 1) vector of exogenous variables (if any) with parameter matrix α of the size (k x q); e is a (k x 1) vector of VAR error terms; ε is a (k x 1) vector of zero-mean, serially-, and cross-uncorrelated shocks; and B is a non-singular k x k matrix relating the VAR disturbances e with the shocks ε. Multiplying both sides of (2.1) by B^{-1} the equation becomes:

$$B^{-1}Z_t = D_1 Z_{t-1} + \ldots + D_p Z_{t-p} + B^{-1}\alpha W_t + \varepsilon_t \tag{2.3}$$

in which $D_j = B^{-1}A_j$ for all $j = 1, \ldots, p$. Add $(I_k - B^{-1})Z_t$ to both sides of (2.3) to have:

$$Z_t = (I_k - B^{-1})Z_t + D_1 Z_{t-1} + \ldots + D_p Z_{t-p} + B^{-1}\alpha W_t + \varepsilon_t \qquad (2.4)$$

in which I_k is the (k x k) identity matrix.

For a purely recursive, 'unrestricted' VAR, B is a lower triangular matrix with all diagonal components being unit. Therefore, the contemporaneous variables will appear in the form:

$$I_k - B^{-1} = \begin{bmatrix} 0 & 0 & \cdots & 0 \\ \beta_{21} & 0 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ \beta_{k1} & \beta_{k2} & \cdots & 0 \end{bmatrix} \qquad (2.5)$$

in which each equation contains the contemporaneous status of all endogenous variables that place before the dependent variable in the VAR. The lag structure includes all endogenous variables.

A limitation of unrestricted VARs is that we cannot examine the possible effects of shocks in an exogenous variable on endogenous variables. This mission, however, can be implemented through a restricted SVAR by endogenising the foreign variables in the VAR, but allowing only a one-way effect, where the foreign variables can affect domestic variables, but domestic variables cannot influence foreign variables.

An important drawback of using VAR models (in general terms, including SVAR and TVP-VAR models) to analyse monetary transmission is that VARs cannot fully address the issue of potential endogeneity. Without identifying truly exogenous shocks in monetary policy, it is difficult to accurately measure the effects of monetary policy on other macroeconomic variables, especially taking into account the role of expectations (though some VAR models might include direct measures of inflation and output expectations, as in the paper of Li et al., 2013). Modern central banking is about management of expectations (see, for example, Woodford 2003). Central banks can

affect nominal interest rates. However, economic participants make their decisions on investment, consumption, and other economic activities based on expected real interest rates. In turn, expected real interest rates depend not only on expected nominal interest rates but also expected developments in macroeconomic aggregates. The endogeneity bias tends to cause VAR models to underestimate the negative effects of a contractionary monetary policy shock on real economic variables (see Romer and Romer, 2004).

It might be argued that at any point of time, actual decisions are made taking into account all future expectations. Therefore, using actual data might have meaning as expectations may be embedded inside each decisional outcome (see, for example Sims, 1982; Sargent, 1984). Nevertheless, VAR models, which use only past and present data, are not able to perfectly identify the drivers of monetary policy, which is forward-looking, as well as monetary transmission mechanisms, which might change unexpectedly at any time if there is a change in future expectations.

Despite the difficulties of correctly measuring expectations, VAR models are still widely used in measuring monetary transmission and monetary policy reactions.[3] VAR models are also generally agreed to provide useful insights into how the economy operates (see, for example, Sims, 1992). Nevertheless, difficulties in identifying true macroeconomic cause-and-effect relationships should be borne in mind when reading the results both here and elsewhere.

As suggested by Orphanides (2001), Croushore and Evans (2006), and Lee *et al.* (2012), real-time data (the data that were available at the time policy decisions were

[3] As evidence, a search on ProQuest for published documents using VAR models within the past 12 months returns 5,726 publications. A similar search on Google Scholar returns about 17,300 results.

made) should ideally be used when estimating monetary policy reaction functions. Parts of the exercises in Chapters 4 and 6 could therefore be re-done when such real-time databases are available for the full set of countries of interest.

VAR models with the recursive identification assumption are used throughout this thesis. SVAR models with some structural contemporaneous and lag structures are used in Chapter 5 where I investigate the effects of trading partners' variables on Vietnam's domestic variables. The econometric models in this thesis are designed for examining monetary transmission and monetary policy reactions rather than dealing with other aspects such as the role of macroeconomic uncertainty as in the works of Friedman (1977), Cukierman and Meltzer (1986), and Shields *et al.* (2005). The specific details of the VAR and SVAR models to be used will be provided in each relevant Chapter.

2.4 TVP-VAR models

2.4.1 The model

A limitation of VAR and SVAR models is that they rely on an assumption of constant coefficients and constant variances throughout the period of interest. If structural changes have occurred over time, the VAR results might not be correct. To overcome this drawback, Cogley and Sargent (2001, 2003) propose a VAR model with time-varying coefficients. Primiceri (2005) follows with his seminal paper introducing a VAR model allowing all parameters (coefficients, variances and co-variances, and parameters relating structural shocks) to be time-variant.

After the introduction of the TVP-VAR by Primiceri (2005), several authors have used the model to investigate the time-varying structure of the macro-economy. Benati (2008) estimates a TVP-VAR model to examine possible sources of the 'Great

Moderation' in the United Kingdom (UK). Baumeister *et al.* (2008) estimate the model for assessing the effects of excess liquidity shocks on the macro-economy of the Euro area. Meanwhile Nakajima (2011) and Nakajima *et al.* (2011) use TVP-VAR models to explore the structural dynamics of the Japanese economy.

In this thesis, parsimonious TVP-VAR models of three and four variables will be used in Chapter 4 to explore the changes of monetary transmission over time in some developed countries. Chapter 6 will employ a TVP-VAR model to examine the dynamics of inflation management in Vietnam.

TVP-VAR models are built on basic structural VAR (SVAR) models as follows:

$$Ay_t = F_1 y_{t-1} + \cdots + F_s y_{t-s} + u_t \ , t = s+1, \ldots, n, \tag{2.6}$$

where y_t is a $k \times 1$ vector of variables, $A, F_1, \ldots, F_s$ are $k \times k$ matrices of coefficients, and u_t is a $k \times 1$ vector of structural shocks. Assume $u_t \sim N(0, \Sigma\Sigma')$, where

$$\Sigma = \begin{bmatrix} \sigma_1 & 0 & \cdots & 0 \\ 0 & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_k \end{bmatrix}.$$

The simultaneous relations of the structural shock are identified using a recursive assumption, therefore A is a lower-triangular matrix:

$$\mathrm{A} = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ a_{21} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ a_{k1} & \cdots & a_{k,k-1} & 1 \end{bmatrix}.$$

The reduced form of (2.6) is $y_t = B_1 y_{t-1} + \cdots + B_s y_{t-s} + A^{-1}\Sigma\varepsilon_t$, where $\varepsilon_t \sim N(0, I_k)$, $B_i = A^{-1}F_i$ for $i = 1, \ldots, s$. Stacking the elements in the rows of the B_is to

form β ($k^2 s \times 1$ vector), and defining $X_t = I_k \otimes (y'_{t-1}, \dots, y'_{t-s})$, in which $\otimes$ denotes the Kronecker product, the VAR model then can be written as

$$y_t = X_t \beta + A^{-1} \Sigma \varepsilon_t. \tag{2.7}$$

The time-invariant model (2.7) is extended to TVP-VAR by allowing the parameters to be time-varying. It means now the model becomes:

$$y_t = X_t \beta_t + A_t^{-1} \Sigma_t \varepsilon_t, \tag{2.8}$$

so that β_t, A_t, and Σ_t are time-varying parameters.

Following Primiceri (2005), let $a_t = (a_{21}, a_{31}, a_{32}, \dots, a_{k,k-1})'$ be a stacked vector of the lower-triangular elements in A_t; $h_t = (h_{1t}, \dots, h_{kt})'$ with $h_{jt} = \log \sigma_{jt}^2$ for $j = 1, \dots, k$ and $t = s+1, \dots, n$.

Assuming that the parameters in (2.8) follow a random walk process:

$$\beta_{t+1} = \beta_t + u_{\beta t}, a_{t+1} = a_t + u_{at}, h_{t+1} = h_t + u_{ht},$$

$$\begin{pmatrix} \varepsilon_t \\ u_{\beta t} \\ u_{at} \\ u_{ht} \end{pmatrix} \sim N\left(0, \begin{pmatrix} I & 0 & 0 & 0 \\ 0 & \Sigma_\beta & 0 & 0 \\ 0 & 0 & \Sigma_a & 0 \\ 0 & 0 & 0 & \Sigma_h \end{pmatrix}\right),$$

for $t = s+1, \dots, n$, where $\beta_{s+1} \sim N(\mu_{\beta_0}, \Sigma_{\beta_0})$, $a_{s+1} \sim N(\mu_{a_0}, \Sigma_{a_0})$, and $h_{s+1} \sim N(\mu_{h_0}, \Sigma_{h_0})$. As in Nakajima (2011), Σ_a and Σ_h are also assumed to be diagonal matrices.

2.4.2 Estimation

Let $y = \{y_t\}_{t=1}^{n}$, and $\omega = (\Sigma_\beta, \Sigma_a, \Sigma_h)$. The estimation of TVP-VAR models are based on Bayesian econometric principles. The prior probability density of ω is set as $\pi(\omega)$. Given data y, samples are drawn from the posterior distribution $\pi(\beta, a, h, \omega|y)$ using the following Markov chain Monte Carlo (MCMC) algorithm:

(1) Initialise $\beta, a, h,$ and ω,

(2) Sample $\beta|a, h, \Sigma_\beta, y$,

(3) Sample $\Sigma_\beta|\beta$,

(4) Sample $a|\beta, h, \Sigma_a, y$,

(5) Sample $\Sigma_a|a$,

(6) Sample $h|\beta, a, \Sigma_h, y$,

(7) Sample $\Sigma_h|h$,

(8) Go to (2).

The specific sampling process is illustrated as follows:

2.4.2.1 β sampling

In order to sample β from the conditional posterior distribution, the state space model is defined as:

$y_t = X_t\beta_t + A_t^{-1}\Sigma_t\varepsilon_t,$

$\beta_{t+1} = \beta_t + u_{\beta_t}$, where $t = s + 1, \ldots n$, $\beta_s = \mu\beta_0$, $u_{\beta_s} \sim N(0, \Sigma_0)$.

The simulation smoother requires a more general-form state space model as in de Jong and Shephard (1995):

$$y_t = X_t\beta + Z_t\alpha_t + G_t u_t,\ \ t = 1, \dots n,$$

$$\alpha_{t+1} = T_t\alpha_t + H_t u_t,\ \ t = 1, \dots n,$$

$$X_t\beta = 0_k, \qquad Z_t = X_t, \qquad G_t = (A_t^{-1}\Sigma_t, O_{k_\beta}),$$

$$T_t = I_{k_\beta}, \qquad H_t = (O_k, \Sigma_\beta^{1/2}), \qquad H_0 = (O_k, \Sigma_{\beta_0}^{1/2}),$$

where k_β is the number of rows of β_t.

2.4.2.2 a sampling

The state space model used to sample a is written as follows:

$$\hat{y}_t = \hat{X}_t a_t + \Sigma_t \varepsilon_t, \qquad t = 1, \dots n,$$

$$a_{t+1} = a_t + u_{a_t}, \qquad t = s, \dots n-1,$$

where $a_s = \mu a_0$, $u_{a_s} \sim N(0, \Sigma_{a_0})$, $\hat{y}_t = y_t - X_t\beta_t$, and

$$\hat{X}_t = \begin{bmatrix} 0 & \cdots & & & & & & 0 \\ -\hat{y}_{1t} & 0 & 0 & \cdots & & & & \vdots \\ 0 & -\hat{y}_{1t} & -\hat{y}_{2t} & & & & & \\ 0 & 0 & 0 & -\hat{y}_{1t} & \cdots & & & \\ \vdots & & & & \ddots & 0 & \cdots & 0 \\ 0 & \cdots & & & 0 & -\hat{y}_{1t} & \cdots & -\hat{y}_{k-1,t} \end{bmatrix}, \qquad t = s+1, \dots n.$$

The correspondences for the simulation smoother are defined as

$$X_t\beta = 0_k, \qquad Z_t = \hat{X}_t, \qquad G_t = (\Sigma_t, O_{k_a}),$$

$$T_t = I_{k_a}, \qquad H_t = (O_k, \Sigma_a^{1/2}), \qquad H_0 = (O_k, \Sigma_{a_0}^{1/2}),$$

where k_a is the number of rows of a_t.

2.4.2.3 h sampling

It is assumed that Σ_h and Σ_{h_0} are diagonal matrices. Therefore the inference for elements of the stochastic volatility h, $\{h_{jt}\}_{t=s+1}^{n}$, is made separately for $j\ (=1,\dots,k)$. Denote y_{it}^* as the i-th element of $A_t\hat{y}_t$, then:

$$y_{it}^* = \exp(h_{it}/2)\varepsilon_{it}, \quad t = s+1,\dots n,$$

$$h_{i,t+1} = h_{it} + \eta_{it}, \qquad t = s,\dots n-1,$$

$$\begin{pmatrix}\varepsilon_{it}\\ \eta_{it}\end{pmatrix} \sim N\left(0, \begin{pmatrix}1 & 0\\ 0 & v_i^2\end{pmatrix}\right),$$

where $\eta_{is} \sim N(0, v_{i_0}^2)$, v_i^2 and $v_{i_0}^2$ are the i-th diagonal elements of Σ_h and Σ_{h_0} respectively, and η_{it} is the i-th element of u_{ht}.

2.4.2.4 ω sampling

Components of ω (Σ_β, Σ_a, and Σ_h) are sampled separately as per their specified prior distributions.[4]

2.5 Conclusion

This chapter has briefly reviewed the concept of monetary policy as central banks' decisions to use their instruments to react to changes in macroeconomic variables, in

[4] Some other technical aspects of the TVP-VAR modelling such as degrees of freedom and the priors are discussed in more detail by Primiceri (2005). Chapters 4 and 6 of this thesis concentrate on empirically applying the TVP-VAR models used by Primiceri (2005) and Nakajima (2011) in examining monetary policy and transmission in specific countries. For a recent summary on specification searches for TVP-VARs, see Eisenstat *et al.* (2015).

which inflation and unemployment/output are the most important. A brief review of the channels of monetary transmission mechanisms has also been provided in Section 2.2. The basics of the VAR, SVAR, and TVP-VAR modelling approaches have been summarised.

Chapter 3 will use four VAR models to empirically explore and compare the 'consumption channel' and the 'investment channel' of the output composition of monetary transmission for the cases of Australia, the US, and the Euro area. Chapter 4 will use parsimonious TVP-VAR models to analyse the changes over time in monetary policy and monetary transmission in four developed countries (Australia, the US, the UK, and Canada). In Chapter 5, I will develop some VAR and SVAR models for Vietnam's economy to investigate the macro determinants of inflation in Vietnam from a monetary policy perspective. Chapter 6 will use a TVP-VAR model to examine the dynamics of inflation management in Vietnam, allowing for the parameters of the VAR systems to vary over time.

CHAPTER 3

OUTPUT COMPOSITION OF THE MONETARY POLICY TRANSMISSION MECHANISM: IS AUSTRALIA DIFFERENT?

Summary: This chapter compares the output composition of the monetary policy transmission mechanism in Australia to those for the Euro area and the United States. Four vector autoregression (VAR) models are used to estimate the contributions of private consumption and investment to output reactions resulting from nominal interest rate shocks for the period 1982Q3–2007Q4. The results suggest that the investment channel plays a more important role than the consumption channel in Australia, while the contributions of the two channels are indistinguishable in the Euro area and the US. The difference between Australia and the Euro area comes from differences in housing investment responses, whereas Australia is different to the US mainly because it has a lower share of household consumption in total demand.

3.1 Introduction

It is a consensus that an increase in the policy interest rate − the main tool of monetary policy for inflation-targeting central banks[5] − leads to a decline in output (Sims, 1980; Bernanke and Blinder, 1992; Eichenbaum, 1992; Leeper and Gordon,

[5] Because of the zero lower bound, some central banks are increasingly using 'quantitative easing' and other unconventional measures instead of interest rates in implementing monetary policy. This chapter focuses only on the effects of the interest rate as the main tool of monetary policy.

1992; and Christiano *et al.,* 1999).[6] On the demand side of the goods and services market, this process operates through two main channels: investment and consumption. As reviewed in Section 2.2, the investment channel traditionally comprises direct interest rate effects and Tobin's q effects. It might also contain other mechanisms through which monetary policy affects investment according to the credit view, including the bank lending, balance sheet, cash flow, and unanticipated price level effects. Similarly, the consumption channel traditionally includes wealth effects and inter-temporal substitution effects, as well as the bank lending and household liquidity effects according to the credit view.

Theories of consumption smoothing and investment volatility suggest that investment is more sensitive than consumption to changes in monetary policy (Modigliani and Brumberg, 1954; Friedman, 1956; Hall, 1978; Romer, 2011). In other words, investment is likely to react more strongly to a monetary policy shock than consumption, and therefore the investment channel may be stronger than the consumption channel.

Empirical evidence on the relative importance of the consumption and investment channels seems to vary by country. Angeloni *et al.* (2003) use vector autoregression (VAR) and dynamic stochastic general equilibrium (DSGE) models to conclude that whereas investment is the main transmission channel in the Euro area, the US data indicate that the consumption channel plays the major role. They refer to the US case as the '*output composition puzzle'*. Using similar VAR models, Fujiwara (2004) concludes that the situation of Japan (using data for 1980–1996) lies somewhere between the Euro area and the US cases, but the investment channel still makes the larger contribution.

[6] Uhlig (2005) finds a 'neutral effect' on output using a sign-restricted VAR.

According to Fujiwara (2004), the most compelling reason might be related to the housing market, where changes in mortgage rates do not have significant effects on private consumption in Japan, unlike the US.

The aim of this chapter is to analyse the output composition of the monetary transmission mechanism for the case of Australia and compare it to the Euro area and the US.[7] Australia is a small open economy that has a level of mortgage market development similar to the US and much higher than in most of the countries in the Euro area (IMF, 2008; Calza *et al.*, 2013). Therefore, it is expected that the output composition of the monetary policy transmission mechanism in Australia is likely to be similar to the US rather than the Euro area. Employing similar VAR models to those used by Angeloni *et al.* (2003) and Fujiwara (2004) with more recent data (1982Q3−2007Q4), the chapter answers two questions: *(i)* is the output composition of the monetary transmission mechanism in Australia different to those in the Euro area and the US?; and *(ii)* if so, why?

For the first question, the empirical results show that in Australia, the investment channel is stronger than the consumption channel. At the same time, consumption and investment contributions are basically equal in the Euro area[8] and the US (which also means that the evidence of the 'output composition puzzle' is unclear when recent data are used). Therefore, there is an unambiguous difference between Australia and the two comparators in terms of the output composition of monetary policy transmission.

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[7] I also ran VARs for Japan for the same period. However the zero lower bound of the interest rates which has been the circumstance in Japan since the 1990s leads all of the impulse responses in the VARs to be muted and inconsistent with theory. Some suggestions for an explanation can be found in Iwata and Wu (2006) and Fujiwara (2006).

[8] For convenience, the Euro area will be referred as a 'country' in this chapter.

This chapter then explores the second question, which has not been investigated explicitly in previous studies. In order to find the main reasons behind the difference between Australia and the comparators, investment is decomposed into housing investment (believed to be more sensitive to changes in the policy rate) and non-housing investment. Consumption is similarly decomposed into durable consumption and non-durable consumption. The results suggest that housing investment responses might be the main reason for the difference between Australia and the Euro area. Regarding the difference between Australia and the US, because of the similarities in the impulse response functions in the VARs, the larger share of consumption in total GDP in the US is likely the main reason for the difference.

Knowledge on the differences of the output composition can help shed light on the empirical differences of the monetary policy transmission mechanism between countries. Furthermore, identifying the output composition dissimilarities and the main reasons behind these might help us better understand the process of the effects from a monetary policy shock to the specific real sectors, such as housing and non-housing investment, and durable and non-durable consumption. This knowledge is informative for theories of monetary policy transmission mechanisms as well as for central banks.

The rest of this chapter is structured as follows. The four VAR models to be used are described in Section 3.2. Some explanations of available data will then be provided in Section 3.3. Section 3.4 presents the output composition results through impulse responses and contribution measures of consumption and investment, together with an exploration of the reasons behind the differences. Section 3.5 concludes.

3.2 VAR models

Following Sims (1980), many papers employ VAR models with different strategies of identification to investigate monetary policy transmission mechanisms. These include Bernanke and Blinder (1992), Eichenbaum (1992), Leeper and Gordon (1992), Gordon and Leeper (1994), Christiano and Eichenbaum (1992), and Leeper *et al.* (1996). Among those, Leeper *et al.* (1996) allow a non-recursive formation while Christiano *et al.* (1999) and others utilise recursive arrangements in the identification of monetary policy shocks. Summaries of the literature of using parametric restrictions in identifying shocks for VAR models can be found in papers by Canova (1995), Bagliano and Favero (1998), and Christiano *et al.* (1999). A recent non-parametric strategy to identify shocks uses sign restrictions, of which a review is provided by Fry and Pagan (2011). More details on VAR and SVAR models are presented in Section 2.3 of this thesis.

Regarding the Australia case, Brischetto and Voss (1999) use a structural VAR (SVAR) method similar to that of Kim and Roubini (1999) to examine the effects of monetary policy tools in Australia. Dungey and Pagan (2000, 2009) also estimate a SVAR model with restrictions emphasising some structural relations for the Australian economy. Some other authors such as Suzuki (2004) and Berkelmans (2005) examine the roles of each particular tool of monetary policy in Australia. Fry *et al.* (2008) use a SVAR model to examine the role of portfolio shocks in Australia while Fry *et al.* (2010) also use a SVAR model to investigate potential overvaluation in Australian housing and equity markets.

Output is specified as a single variable in almost all research on the transmission mechanism of monetary policy. Most frequently, output is measured by real GDP, the

output gap, or industrial production. The few papers that use VAR models to analyse the output composition of monetary policy transmission mechanisms do not cover Australia. The most relevant studies are by Angeloni *et al.* (2003), who analyse the output composition for the Euro area and the US, and Fujiwara (2004), who explores the case of Japan. Meanwhile, Erceg and Levin (2006) decompose US GDP into the durable sector (including durable consumption and residential investment) and other GDP components and find evidence in favour of strong responses of the durable sector to a contractionary monetary policy shock.

This chapter utilises the four VAR models of Angeloni *et al.* (2003) and Fujiwara (2004) to answer the first question of whether there is any difference in the output composition of the monetary transmission mechanism between Australia, the US, and the Euro area. In this chapter, GDP is decomposed into three variables: private consumption, private investment, and 'other GDP components' (which equals GDP minus private consumption and private investment, and therefore includes government expenditure, net exports, and small discrepancies).

Following Angeloni *et al.* (2003) and Fujiwara (2004), a recursive Cholesky identification assumption is used in all of the VARs in this chapter. As pointed out in Section 2.3, the recursive assumption justifies the estimation of monetary policy shocks by the fitted residuals in the OLS regression of the policy interest rate on the variables in the central banks' information set. This ordering assumes that all variables which are placed before the policy rate in the VARs are included in the central banks' contemporaneous information set. A policy rate shock can only instantly affect the variables placed after the policy rate in the VARs, while variables in the information set will respond with a lag.

As discussed in Chapter 2, identification challenges still exist in the VAR models, where in fact the policy rate might respond not only to contemporaneous and lagged variables but also to anticipated developments in variables such as inflation. For comparability purposes this chapter uses the simple recursive assumption employed by recent studies for other countries. The VAR results should be interpreted with the caveat of potential omitted (expected) variables in mind.

The VAR(p) models, with the recursive identification assumption, can be written as:

$$Y_t = A_0 + A_1 Y_{t-1} + \ldots + A_p Y_{t-p} + e_t \quad (3.1)$$

$$e_t = B\varepsilon_t \quad (3.2)$$

$$Y_t = \begin{bmatrix} Y_{1t} \\ i_t \\ Y_{2t} \end{bmatrix} \quad (3.3)$$

in which Y is the (k x 1) vector of endogenous variables; A_0 is the (k x 1) vector of constant terms; $A_1,\ldots A_p$ are (k x k) matrices of parameters; e is a (k x 1) vector of VAR error terms; ε is a (k x 1) vector of zero-mean, serially and cross-uncorrelated shocks; B is a k x k lower triangular matrix with all diagonal terms equal to 1; i is the policy rate; and Y_1 and Y_2 are vectors of variables that are placed before and after the policy rate respectively in the VARs.

The four models used in this chapter are versions of the well-known VAR models of Christiano *et al.* (2005), Erceg and Levin (2006), and Peersman and Smets (2003).

First, the VAR developed by Christiano *et al.* (2005) is estimated ('Christiano–Eichenbaum–Evans VAR'). In this VAR, Y_1 includes six variables in the order:

consumption, investment, other GDP components, CPI, real wages and labour productivity. Y_2 contains the profit-to-GDP ratio, money growth, and share price index.

Second, the VAR developed by Erceg and Levin (2006) is estimated ('Erceg–Levin VAR'). In this VAR, Y_1 includes consumption, investment, other GDP components, CPI, and commodity prices, while Y_2 is empty. In this VAR, commodity prices are included instead of real wages and labour productivity, but money growth and the share price index are not included. The Cholesky order of this VAR – with the policy rate placed last – assumes that a shock in the interest rate has no immediate effects on the other variables, while the central bank employs current information on all the other variables in targeting and implementing the interest rate.

Third, a 'generalised Erceg–Levin VAR' is used, in which Y_1 includes consumption, investment, other GDP components, CPI, commodity prices, and bond yields, while money growth is the only variable included in Y_2. This identification scheme is similar to an expansion of the VAR used by Gordon and Leeper (1994).

Lastly, the model based on Peersman and Smets (2003) is used to account for the effects of the real exchange rate and also some exogenous factors ('Peersman–Smets VAR'). In this model Y_1 includes five endogenous variables: consumption, investment, other GDP components, CPI, and money growth; Y_2 includes the real effective exchange rate. For this VAR, a shock of the policy rate affects the exchange rate contemporaneously, and the central bank uses information on money growth together with all GDP components and prices in determining the policy rate. For Australia and

the Euro area, three exogenous variables are used: the US FED funds rate, US GDP, and US prices.[9]

To take into account the fact that Australia is a small open economy while both the Euro area and the US are 'big economies', the three exogenous variables in the Peersman–Smets VAR are also used in the first three VAR models for Australia. That is, the four VAR models for Australia include exogenous variables, while exogenous variables appear only in the Peersman–Smets VAR for the two 'big' country comparators.[10]

3.3 Data

For Australia, data come from Australian Bureau of Statistics (ABS) and Reserve Bank of Australia (RBA). The same sources of data as in Angeloni *et al.* (2003) for the Euro area (AWM database from European Central Bank) and the US (from Moody's www.freelunch.com) are used. The data sources are listed together with data graphs in Appendix 3A.

To conduct an international comparison with data for the same time span, this chapter uses quarterly data for the period 1982Q3−2007Q4. The sample includes 102 observations. The sample begins in quarter 3 of 1982 as the RBA index of commodity

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[9] In this chapter, the international oil price is used as an exogenous variable in the Peersman–Smets VAR for the US. Exluding the oil price from this VAR makes no significant difference (results are not reported). This pattern is in line with the argument by Kilian (2008) that exogenous oil supply shocks made very little difference for the evolution of the U.S. economy since the 1970s.

[10] The four VAR models used in this chapter share the common drawback of all VAR models in analysing monetary transmission, where there are still possibilities of model misspecification, particularly endogeneity bias, as discussed in Chapter 2.

prices (G5 series from RBA) is available only from July 1982. Furthermore, as suggested by Angeloni *et al.* (2003), all impulse responses for the Euro area prior to 1980 are uncertain due to data problems. The end of the sample is chosen to avoid the Global Financial Crisis (GFC) which started in 2008 and had strong and prolonged effects for the countries of interest (although Australia did not technically experience two-consecutive quarters of negative growth during 2008–2009). Excluding the recent GFC also avoids the period of unconventional monetary policy in the US since the crisis period.

For Australia, the interbank rate is used for the policy rate. The short-term interest rate from the Area-Wide Model (AWM) database is used for the Euro area and the FED funds rate for the US. Money growth is measured as the annualised growth rate of broad money aggregate (M2) as in Angeloni *et al.* (2003) and Christiano *et al.* (2005). Except for money growth, the policy rate, and the profit-to-GDP ratio, all the other variables are natural logs of their levels. One or two lags are used for all VARs to conserve degrees of freedom. The Schwarz information criterion (SC) always points to 1 lag. In order to capture the dynamics of the variables with quarterly data, a 2-lag structure is used when the VAR can produce stable impulse response functions, as in Angeloni *et al.* (2003).[11]

[11] A list of lag lengths to be used as well as some additional tables and figures can be found in Appendix 3D.

3.4 Results

3.4.1 Output composition

The question of whether Australia is different to the Euro area and the US is examined in two aspects. First, the reactions of consumption and investment together with the other GDP components are assessed through the impulse response functions to a shock in the nominal policy rate in the VAR models, which can be named the 'proportional effect'. Second, the shares of each component in total GDP are taken into account to compute the 'size effect'.

3.4.1.1 Proportional effect

Figure 3.1 shows the impulse responses to a shock in the policy rate in each of the four VAR models for (a) Australia, (b) the Euro area, and (c) the US. The responses of consumption, investment, other GDP components, CPI, and the policy rate are shown. The thick lines demonstrate the impulse responses based on the point estimates, while the blurred lines illustrate the confidence intervals using the 10^{th} (lower) and 90^{th} (upper) percentile values of 1,000 bootstrap simulations.[12] The size of the positive shock in the nominal interest rate is computed according to Cholesky one-standard-deviation innovations, which are around 80 basis points for Australia, 30 basis points for the Euro area, and 35 basis points for the US.

[12] To obtain impulse responses and confidence intervals using bootstraps for all the VAR models in this chapter, I developed some MATLAB codes building on well-known Christiano VAR code (associated with Christiano *et al.*, 1999, available at the Python Macroeconomics Laboratory's codes). By design, bootstrapped confidence intervals are asymmetric and sometimes fluctuate wildly (see Davidson and MacKinnon, 2006).

In general, the responses are of similar shape across the different VARs for each country. After a contractionary monetary policy shock, both consumption and investment decrease with some lags and stay significantly below zero before gradually coming back to their steady state levels. In terms of comparing the proportional effect between consumption and investment, some observations can be made as follows.

A common observation across models and countries is that the peak investment reaction exceeds the peak consumption reaction. In response to a Cholesky innovation shock in the policy rate, the peak investment reaction is around double the peak consumption reaction in the Euro area, while in the US it is more than triple and in Australia the investment peaks are nearly five times bigger than the consumption ones.[13] For instance from Figure 3.1a, it can be seen that an 80 basis point increase in the interbank rate in Australia leads to a decline of about 1–1.5% in private investment at peak, but only about 0.2–0.35% in private consumption at its maximum responses.

The second common point is that consumption responses stay significantly negative for a longer period compared to investment responses. In other words, investment comes back to its steady state levels quicker than consumption although investment peaks are deeper. For example, Figure 3.1a shows that after becoming significantly negative around the 4th quarter, consumption responses in Australia stay significantly negative even after the 20th quarter, while investment responses basically come back to be insignificant at around the 16th quarter.

Some differences can be observed across countries. Investment reacts quicker and reaches its peak much sooner than consumption in Australia, while this is not

[13] The confidence intervals are overlapping most of the time, therefore the responses of consumption and investment are not 'significantly different' from each other.

necessarily the case for the Euro area and the US. Furthermore, both consumption and investment decline from the first lag in Australia's VARs while either consumption or investment, or even both, can be seen to increase in the first quarter before beginning to decline in the Euro area and the US.

The impulse responses of the other GDP components vary across models and countries. A suggested theoretical channel for the impulse response functions of the other GDP components (which are basically the sum of net exports and government expenditure) is that when interest rates are higher, the return on domestic assets increases relative to foreign assets. Then in a world with capital mobility, more foreign currencies tend to flow in to buy domestic assets, resulting in an appreciation of the domestic currency. As a result, domestic goods become more expensive relative to foreign goods, and net exports decline (see Boivin *et al.*, 2010 and subsection 2.2.1.5 of this thesis). I have also decomposed the 'other GDP components' into government expenditure and net exports to explore this hypothesis. However, the net exports responses indicate an increase in almost all VARs, though the increases are insignificant for Australia and the Euro area. This might come from a depreciation of the domestic currency in response to a contractionary monetary policy shock (rather than appreciation) that is also found in VAR models for industrial economies (Sims, 1992; Grilli and Roubini, 1996; Racette and Raynauld, 1992).[14]

[14] Different identifications with more restrictions and an inclusion of terms of trade might be needed to address this 'puzzle'. However, it is outside the scope of this chapter and might be a topic for future research. The impulse responses from VARs with net exports are included in Appendix 3B. I have also run VARs with government expenditure, exports and imports separated. The main observations on impulse responses of consumption and investment remain unchanged.

The impulse responses also demonstrate evidence of the '*price puzzle'* for all countries of interest, in which prices increase in response to a positive shock in the nominal interest rate. This result is similar to what Angeloni *et al.* (2003) and Fujiwara (2004) find using earlier data in the US and Japan with the same VAR identifications. On one hand, this '*price puzzle'* can be regarded as empirical evidence of the importance of the 'cost channel', or the 'supply-side effects' in the monetary policy transmission mechanism, as suggested by Barth and Ramey (2001), Ravenna and Walsh (2006), Chowdhury *et al.* (2006), Christiano *et al.* (2005), Gaiotti and Secchi (2006), Tillman (2008, 2009), and Ali and Anwar (2013).[15] Unfortunately there has not been any extensive research on the existence of the cost channel in Australia.

On the other hand, the 'price puzzle' could be a result of the identification challenge caused by omitted variables. The inclusion of commodity prices in Erceg–Levin and generalised Erceg–Levin VARs helps reduce the 'price puzzle' for the Euro area and the US, as suggested by Sims (1992), although this is not the case for Australia (see Figure 3.1a). Giordani (2004) and Hanson (2004) suggest using the output gap rather than output to resolve the 'price puzzle'. Li *et al.* (2013) suggest that the use of direct measures of expectations (such as survey measures of expected future inflation and output growth) as well as the GDP deflator for inflation might also help reduce the 'price puzzle'. Another possibly direct remedy to the 'price puzzle' is to use sign-restricted VARs as reviewed by Fry and Pagan (2011). However, given my emphasis on

[15] Since firms must borrow to finance their payment to their factors of production before they receive revenues from sales, an increase in the policy rate would raise firms' production costs and therefore affect aggregate supply (AS). This supply-side effect would bring the price level up rather than down as in the demand side in a classical AD-AS model.

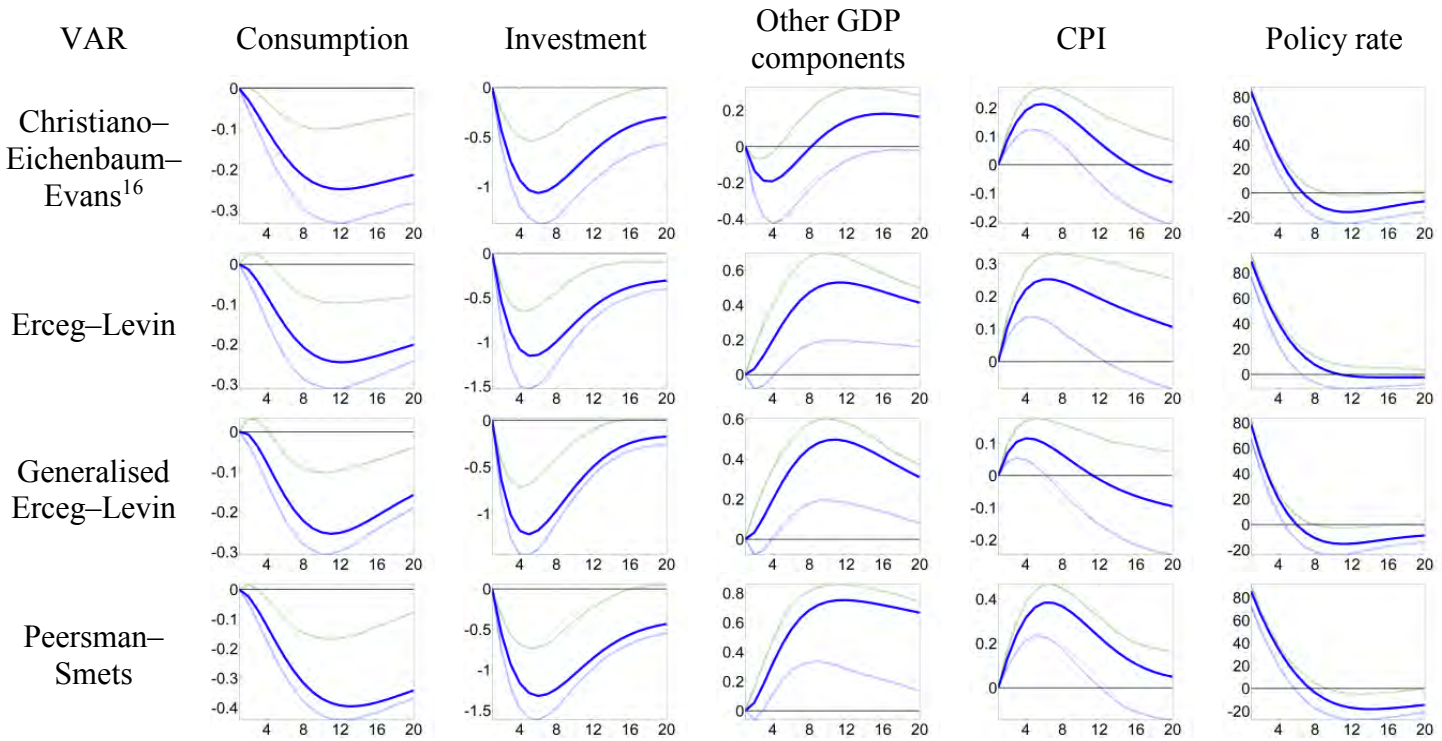
employing the recursive identification strategies used in previous work (Christiano *et al.,* 1999; Erceg and Levin, 2006; Peersman and Smets, 2003), this puzzle remains.

In summary, a positive shock in the nominal policy rate leads to declines in both consumption and investment, consistent with theory. The maximum responses of investment are larger, indicating that the proportional effect of an increase in the policy rate on investment is larger than on consumption, or the investment channel is dominant compared to the consumption channel in terms of proportional changes. However, the effects on consumption last longer than the effects on investment.

Figure 3.1 Impulse responses to a one standard deviation shock to the policy rate from VARs

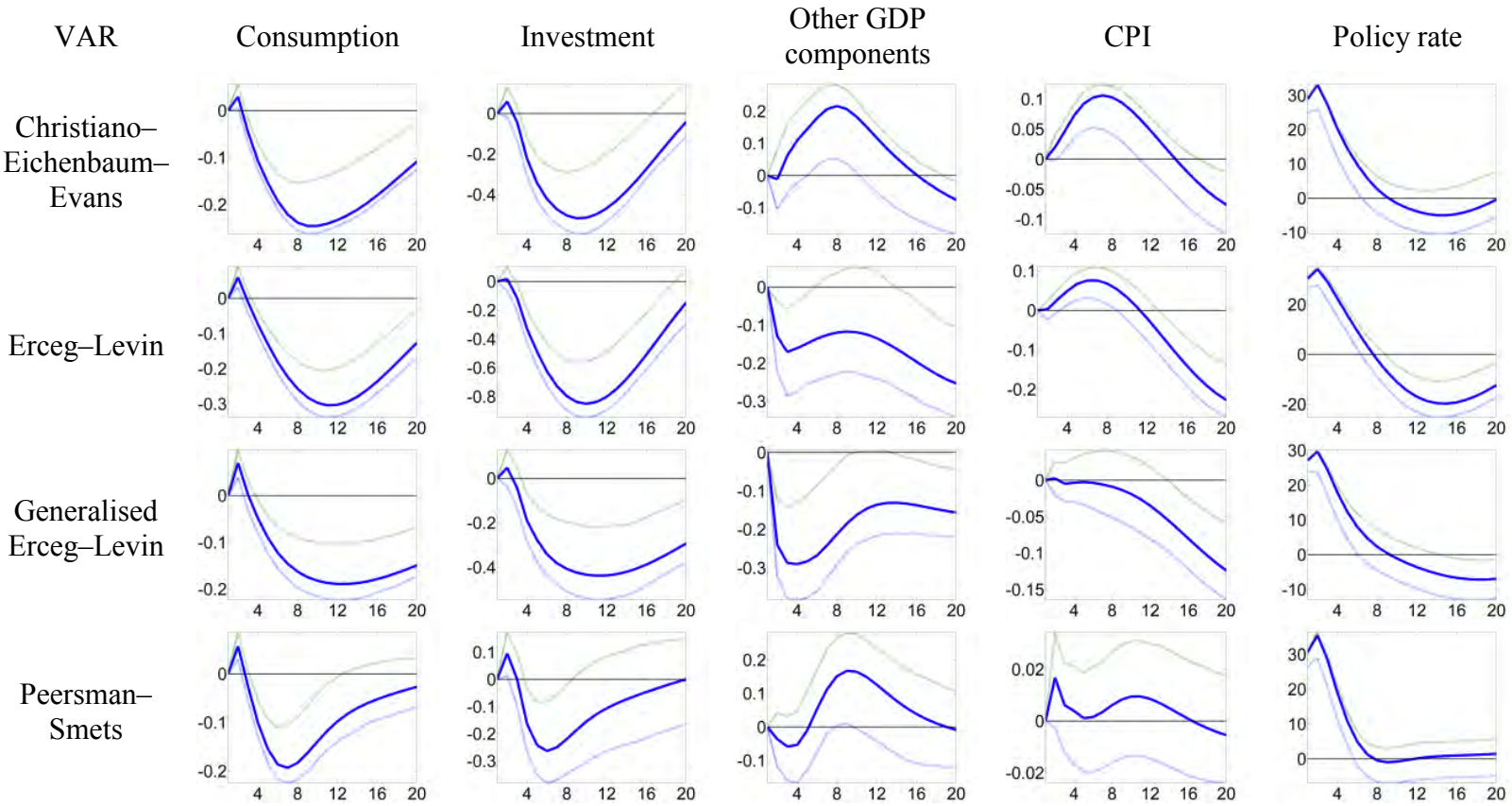
(1982Q3–2007Q4, 20-quarter horizon, confidence intervals drawn using the 10th (lower) and 90th (upper) percentile values of 1,000 bootstrap simulations; 'Policy rate' unit is basis point, all the rest are %)

a. **Australia**

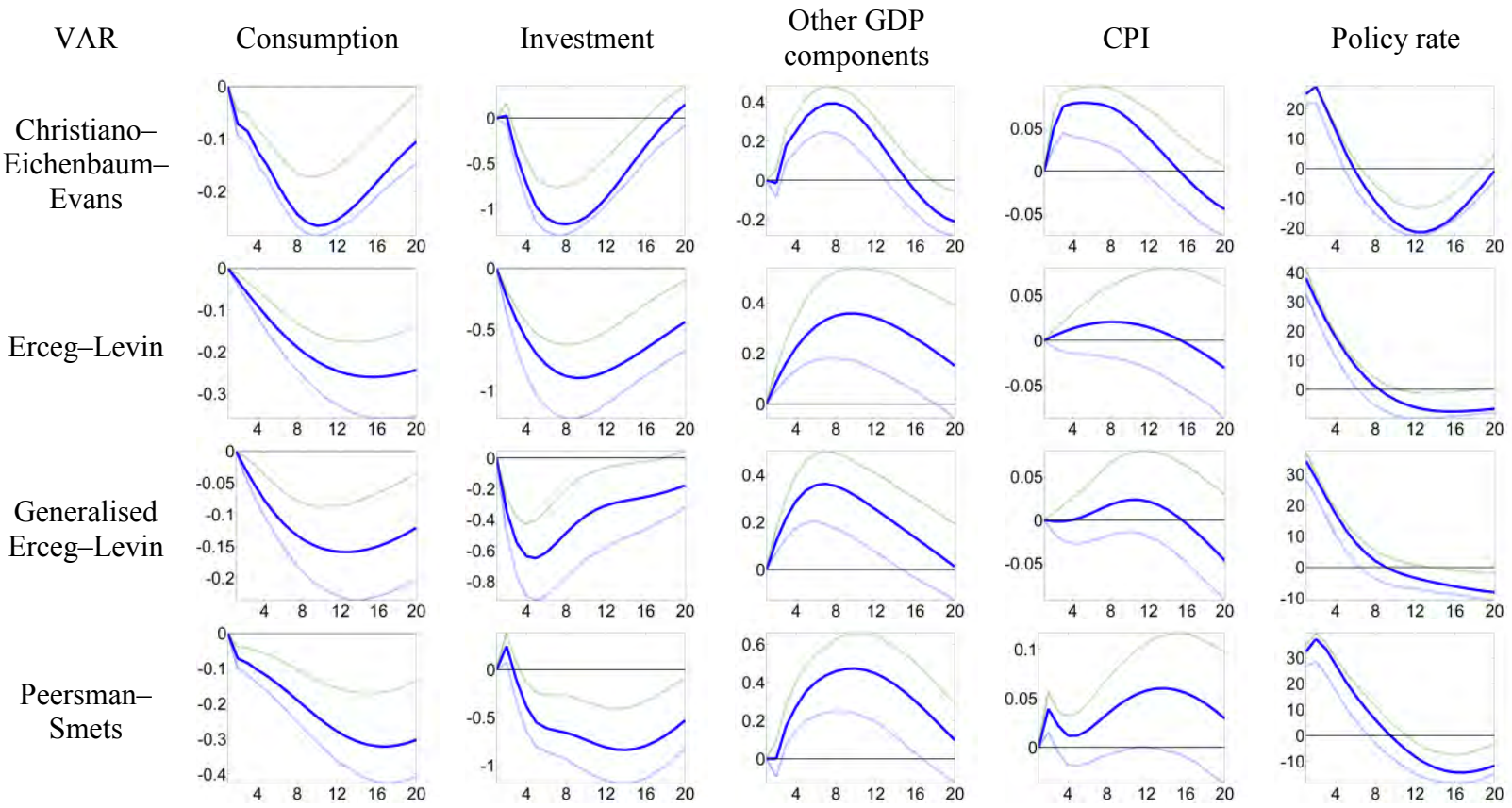


[16] For this specific VAR only, exogenous variables are opted out to produce stable impulse response functions.

b. **Euro area**


VAR
Consumption
Investment
Other GDP components
CPI
Policy rate
Christiano–Eichenbaum–Evans
Erceg–Levin
Generalised Erceg–Levin
Peersman–Smets

c. **US**


VAR
Consumption
Investment
Other GDP components
CPI
Policy rate
Christiano–Eichenbaum–Evans
Erceg–Levin
Generalised Erceg–Levin
Peersman–Smets

3.4.1.2 Size effect

In measuring the 'size effect', the impulse responses are weighted by contributions to the whole economy − for the consumption and investment channels. Similarly to Angeloni *et al.* (2003) and Fujiwara (2004), the size contributions of consumption and investment to the responses of private domestic demand, which is the sum of private consumption and private investment, are calculated via a 2-step process:

Step 1: The responses of consumption and investment are converted to ratios relative to the total GDP responses, in which consumption and investment movements are weighted by their shares in total GDP (see Table 3.1):

$$C_1 = \frac{C \times weight_C}{C \times weight_C + I \times weight_I + G \times weight_G} \tag{3.4}$$

$$I_1 = \frac{I \times weight_I}{C \times weight_C + I \times weight_I + G \times weight_G} \tag{3.5}$$

where *C, I, G* are responses of consumption, investment, and other GDP components respectively, which are estimated from each VAR and for each horizon.

Table 3.1 Shares of GDP components, 1982Q3–2007Q4

Country	Consumption	Investment	Other GDP components
Australia	0.54	0.17	0.29
Euro area	0.57	0.21	0.22
US	0.65	0.16	0.19

Step 2: C_1 and I_1 are then normalised so that they add to one. The contributions of consumption and investment in private domestic demand are correspondingly:

$$C_2 = \frac{C_1}{C_1 + I_1} \tag{3.6}$$

$$I_2 = \frac{I_1}{C_1 + I_1} \tag{3.7}$$

where C_2 and I_2 are the 'contributions', or 'size contributions' of consumption and investment. This procedure helps directly compare the size contributions between consumption and investment. A larger contribution means the more important channel in the output responses to the monetary policy shock.

Since $C_2 + I_2 = 1$, it is only necessary to look at either C_2 or I_2. Table 3.2 shows the measures of the contributions of consumption (C_2) based on the four VAR models at 4, 8, and 12 quarters. The calculations include the point estimates, together with the 10th, 50th, and 90th percentiles from 1,000 bootstrap simulations for each of the four VARs. Normally, $C_2, I_2 \in [0,1]$, however some numbers could be either negative or greater than 1 (outside the interval $[0,1]$), indicating that consumption and investment are responding in opposite directions at those periods (which are mostly early periods, at 1–4 quarters, for the 10th percentiles).

In addition to Table 3.2, Figure 3.2 shows the size contribution of consumption with confidence intervals where the median percentile is used as the main estimates (the thick lines) while the confidence intervals (the blurred lines) are drawn using the 10th (lower) and 90th (upper) percentiles of 1,000 bootstrap simulations. This figure can be used to formally test whether the consumption contribution (C_2) is higher or lower than 0.5 with 90% confidence.

Table 3.2 and Figure 3.2 indicate that in Australia, C_2 is significantly less than 0.5 from the 4th quarter in the four VARs, meaning that the investment channel dominates

the consumption channel. In the Euro area and US, C_2 is basically around 0.5 and sometimes can be significantly higher than 0.5, especially over a longer horizon (after 12 quarters). In Erceg–Levin and generalised Erceg–Levin VARs, C_2 in the Euro area and the US can be less than 0.5 for the period between 4 and 12 quarters, but still higher than the corresponding C_2 in Australia. This result means when the shares of GDP are taken into account, Australia's case is different to the Euro area and the US, where the two channels are generally equally important. The relative contributions in the Euro area and the US are similar.

Generally, it is concluded from the four VAR models that in terms of both the proportional effect (impulse responses) and the size effect, the investment channel plays a more important role than the consumption channel in monetary policy transmission in Australia. Meanwhile, although the investment responses are bigger at their peaks, when the sizes are accounted for, the two channels are similar in the Euro area and the US. These results indicate that the evidence of an 'output composition puzzle' as raised by Angeloni *et al.* (2003) reduces when the analysis is updated to use more recent data (to just prior to the GFC). To check for robustness, the order of the variables is changed so that the other GDP components are put before consumption and investment in the VARs (results are not reported). The main conclusions remain unchanged.

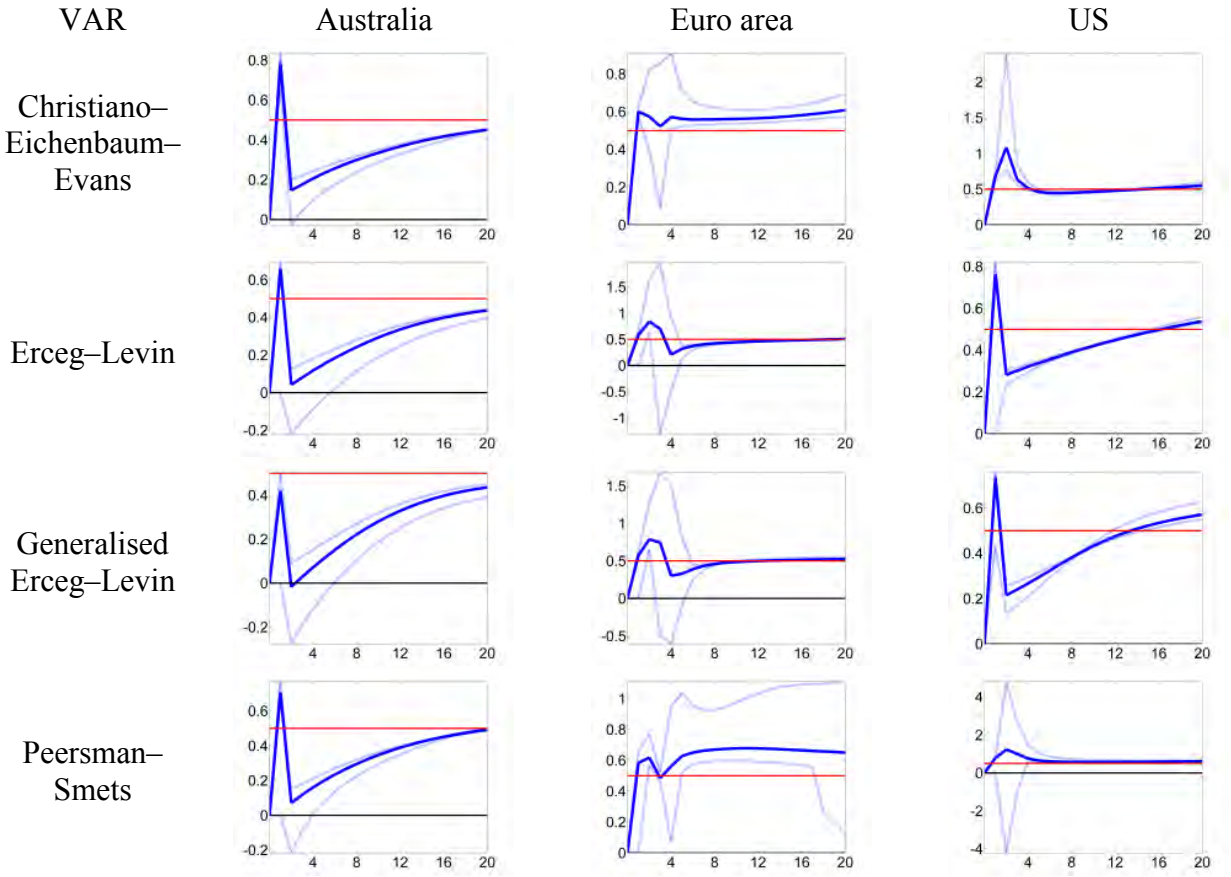
Table 3.2 Contribution of consumption in private domestic demand from VARs

(10^{th}, 50^{th}, and 90^{th} percentiles are calculated using 1,000 bootstrap simulations)

VAR	Quarter	Australia				Euro area				US			
		Point estimate	Percentile			Point estimate	Percentile			Point estimate	Percentile		
			10^{th}	50^{th}	90^{th}		10^{th}	50^{th}	90^{th}		10^{th}	50^{th}	90^{th}
Christiano–Eichenbaum–Evans	4^{th}	0.23	0.10	0.20	0.24	0.58	0.52	0.57	0.83	0.46	0.48	0.51	0.59
	8^{th}	0.31	0.24	0.29	0.31	0.56	0.54	0.56	0.61	0.45	0.44	0.45	0.47
	12^{th}	0.38	0.33	0.36	0.37	0.57	0.54	0.57	0.61	0.48	0.47	0.48	0.50
Erceg–Levin	4^{th}	0.16	-0.11	0.11	0.18	0.31	-0.51	0.21	0.98	0.38	0.30	0.32	0.34
	8^{th}	0.27	0.10	0.24	0.28	0.43	0.40	0.42	0.43	0.43	0.39	0.39	0.40
	12^{th}	0.35	0.24	0.33	0.35	0.47	0.46	0.46	0.46	0.48	0.45	0.45	0.46
Generalised Erceg–Levin	4^{th}	0.14	-0.11	0.08	0.16	0.28	-0.60	0.30	1.42	0.32	0.21	0.26	0.29
	8^{th}	0.27	0.11	0.23	0.28	0.47	0.44	0.46	0.47	0.43	0.37	0.38	0.39
	12^{th}	0.36	0.25	0.34	0.36	0.51	0.50	0.50	0.52	0.51	0.46	0.47	0.51
Peersman–Smets	4^{th}	0.22	0.03	0.16	0.21	0.66	0.10	0.57	0.90	0.66	0.59	0.76	1.41
	8^{th}	0.33	0.23	0.29	0.32	0.68	0.60	0.67	0.92	0.57	0.52	0.57	0.70
	12^{th}	0.41	0.36	0.39	0.39	0.69	0.60	0.67	0.98	0.57	0.54	0.57	0.65

Figure 3.2 Size contribution of consumption in private domestic demand from VARs

(20-quarter horizon, the thick lines are the 50th percentile values of C_2, the blurred lines are the confidence intervals drawn using the 10th (lower) and 90th (upper) percentile values of 1,000 bootstrap simulations)



3.4.2 Housing and non-housing investment responses

The task now is to find out the main reason behind the difference in the output composition of monetary policy transmission in Australia compared to the case in the Euro area and the US. From the definition of the contributions (C_2 and I_2) in equations (3.4) and (3.5), the reason might come from one of two sources: the proportional effect or the size effect.

In terms of proportional effect, as mentioned in subsection 3.4.1.1, at the peaks of the four VAR models, the consumption reaction in Australia is around five times smaller than that of investment, while it is around three times smaller in the US and only half as small in the Euro area. Therefore one can rank the Euro area the strongest in terms of relative responses of consumption compared to investment, then the US, and finally Australia.

In terms of size effect, Table 3.1 shows that the relative size ratio of consumption to investment is 3.2:1, 2.7:1, and 4.1:1 respectively for Australia, the Euro area, and the US. This means that in terms of the relative size of consumption to investment, the US is the biggest, then Australia, and then the Euro area.

By combining the size and proportional effects, it can be inferred that the consumption channel is weakest in Australia compared to the comparators. The next logical step therefore is to determine the factors behind the differences in the 'proportional effect', given the shares of consumption and investment in total GDP. As suggested by Angeloni *et al.* (2003) and Fujiwara (2004), it is supposed that housing (residential) investment, which is the more-interest-rate-sensitive component in the total private investment, might be the key candidate.

For this purpose, private investment is divided into housing (residential) investment and non-housing investment. The same four VAR models are estimated, with the same sets of exogenous variables for Australia (in all VARs), the Euro area, and the US (in the Peersman–Smets VAR) as implemented in Section 4.1.[17]

Figure 3.3 shows the impulse responses (proportional effect) of housing and non-housing investment to a shock in the policy rate for the three countries.[18] In Australia, housing investment responds more significantly and strongly at peaks compared to non-housing investment in all models. A similar pattern can be observed for the US. These results are similar to the ones found by Erceg and Levin (2006) who decompose US GDP into 'durable sector' output and 'other GDP components' and conclude that the durable sector reacts more strongly. However, the opposite is true of the Euro area, where housing investment reacts more weakly at peaks and less significantly to an interest rate shock compared to non-housing investment. Musso *et al.* (2011) also find that residential investment responds more strongly in the US compared to the Euro area after a contractionary monetary policy shock. This result might be explained by the fact that the levels of mortgage market development in the US and Australia are much higher than in most of the countries in the Euro area (IMF, 2008; Calza *et al.*, 2013), making housing investment more sensitive to interest rate changes.

[17] With the VAR models used in this chapter, only the direct effects from the interest rate to new housing supply (housing investment) are measured. A detailed survey on a set of other direct and indirect effects on housing markets (including user cost of capital, house price expectations, house-and-equity-price wealth effects, credit channel effects on consumer spending, and housing demand) was carried out by Mishkin (2007).

[18] The definition of the policy rate shocks are the same and the size of the shocks in the VARs are similar to the previous part.

Figure 3.3 Impulse responses of housing and non-housing investment to a policy rate shock from VARs

(1982Q3–2007Q4, 20-quarter horizon, confidence intervals drawn using the 10th (lower) and 90th (upper) percentile values of 1,000 bootstrap simulations)

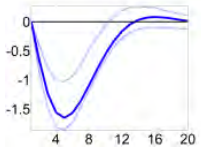
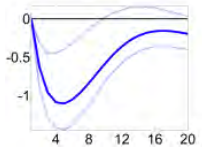
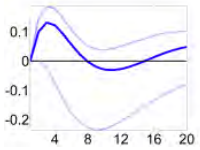
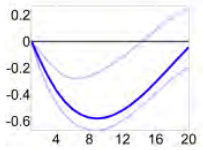
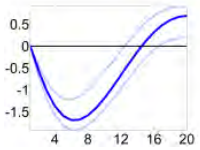
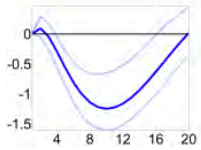
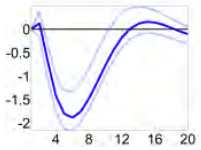
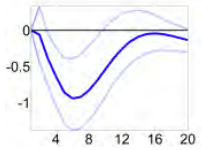
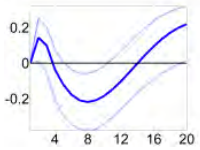
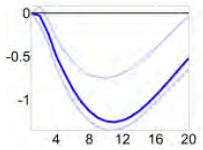
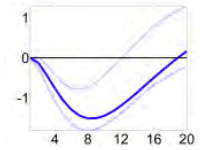
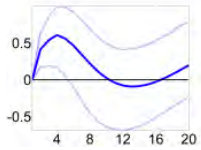
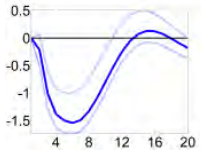
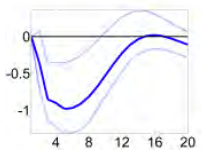
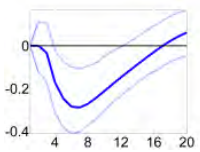
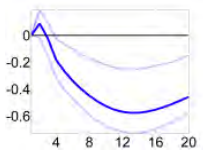
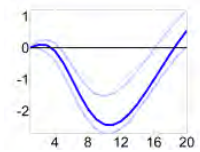
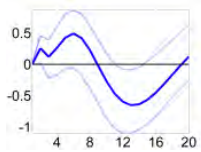
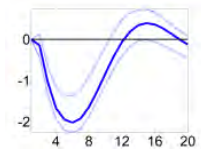
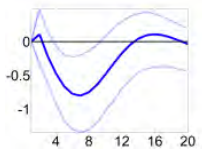
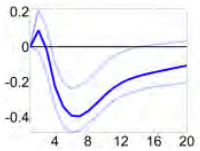
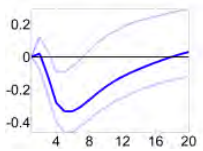
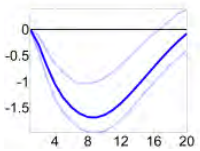
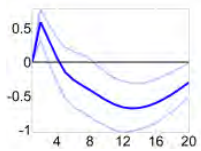
VAR models	Australia		Euro area		US	
	Housing investment	Non-housing investment	Housing investment	Non-housing investment	Housing investment	Non-housing investment
Christiano–Eichenbaum–Evans						
Erceg–Levin						
Generalised Erceg–Levin						
Peersman–Smets						

Table 3.3 Shares of housing and non-housing investment, 1982Q3–2007Q4

Country	Housing investment		Non-housing investment	
	In total GDP	In total private investment	In total GDP	In total private investment
Australia	0.06	0.35	0.11	0.65
Euro area	0.075	0.36	0.135	0.64
US	0.05	0.31	0.11	0.69

Combining the proportional effect with the measures of the size effect using shares of housing and non-housing in total private investment from Table 3.3, the relative contributions of housing investment in the three countries are shown in Table 3.4 and Figure 3.4.

Table 3.4 and Figure 3.4 show that housing investment's contribution in the Euro area is much weaker compared to in Australia and the US. In general, housing investment contributes more than its share in total private investment in Australia and the US (35% and 31% respectively, as shown in Table 3.3). Meanwhile housing investment's contribution is small in the Euro area, much smaller than its share in total private investment (36%), except for in the Peersman–Smets VAR.

Based on both the 'proportional effect' and the 'size effect', the difference in housing investment responses relative to non-housing investment responses might be the key reason behind the difference of private investment responses to a policy rate shock, therefore the key factor behind the output composition difference between Australia and the Euro area. These housing investment responses and contributions are similar between Australia and the US. A more detailed study on the effects of monetary policy on the housing market in Australia, which relates to research by Debelle (2004), Ellis (2006), Fry *et al.* (2010), is outside the scope of this chapter.

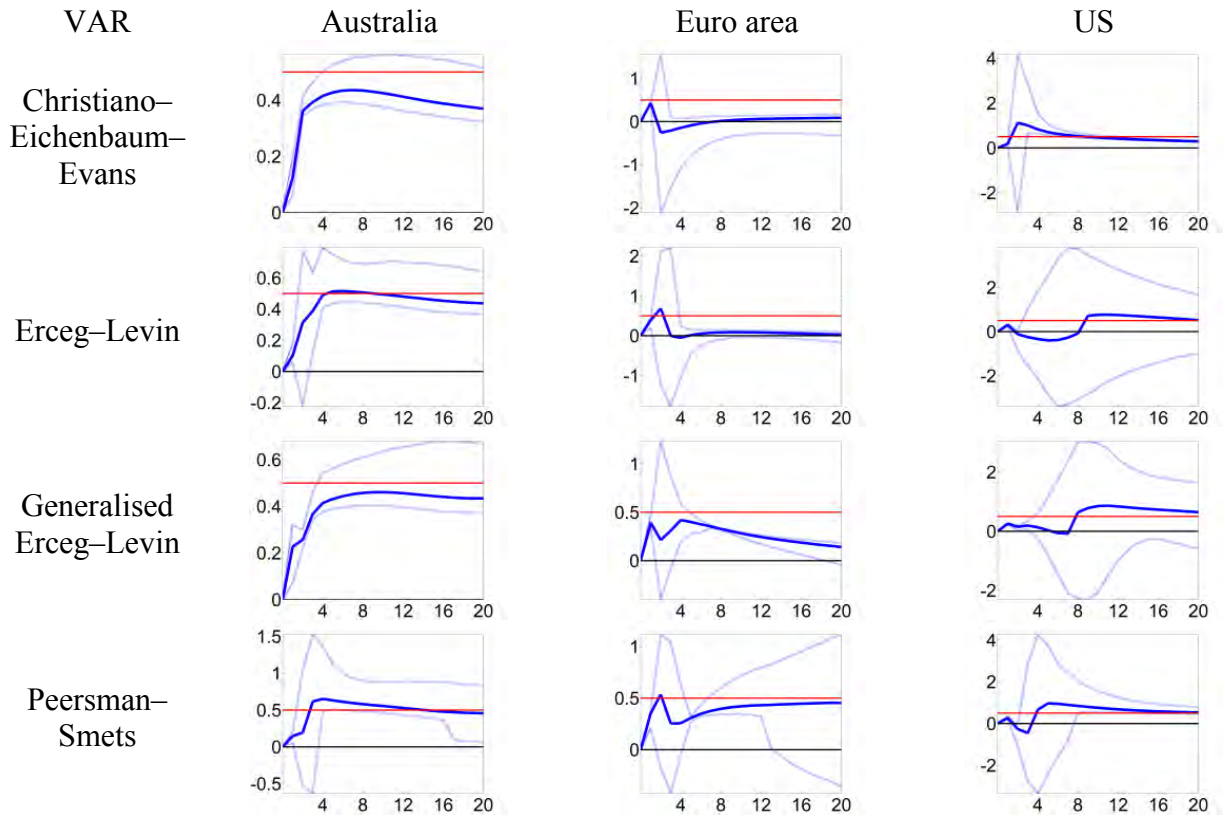
Table 3.4 Contribution of housing investment to the investment response to a monetary policy shock from VARs

(10^{th}, 50^{th}, and 90^{th} percentiles are calculated using 1,000 bootstrap simulations)

VAR	Quarter	Australia				Euro area				US			
		Point estimate	Percentile			Point estimate	Percentile			Point estimate	Percentile		
			10^{th}	50^{th}	90^{th}		10^{th}	50^{th}	90^{th}		10^{th}	50^{th}	90^{th}
Christiano–Eichenbaum–Evans	4^{th}	0.42	0.38	0.41	0.51	-0.25	-1.07	-0.16	0.08	0.72	0.64	0.83	1.52
	8^{th}	0.43	0.40	0.43	0.56	-0.09	-0.38	0.00	0.12	0.50	0.47	0.53	0.68
	12^{th}	0.40	0.37	0.41	0.56	-0.04	-0.25	0.05	0.14	0.40	0.38	0.41	0.51
Erceg–Levin	4^{th}	0.52	0.41	0.49	0.82	-0.03	-1.06	-0.03	0.74	-1.06	-2.14	-0.33	2.06
	8^{th}	0.51	0.44	0.51	0.74	0.07	-0.09	0.09	0.15	8.21	-2.98	-0.03	3.57
	12^{th}	0.48	0.41	0.49	0.76	0.06	-0.04	0.08	0.13	2.05	-1.86	0.76	2.74
Generalised Erceg–Levin	4^{th}	0.42	0.37	0.41	0.54	0.39	0.15	0.43	0.64	0.06	-0.04	0.17	0.36
	8^{th}	0.45	0.40	0.46	0.60	0.29	0.33	0.34	0.35	-0.70	-1.71	-0.15	1.94
	12^{th}	0.44	0.40	0.46	0.64	0.22	0.19	0.25	0.27	-8.66	-2.25	0.55	2.62
Peersman–Smets	4^{th}	0.68	0.48	0.66	1.45	0.28	0.02	0.27	0.58	2.21	-3.31	0.54	3.93
	8^{th}	0.60	0.48	0.59	0.96	0.37	0.35	0.40	0.59	0.87	0.55	0.85	2.15
	12^{th}	0.57	0.44	0.54	0.98	0.40	0.35	0.44	0.81	0.69	0.54	0.69	1.33

Figure 3.4 Size contribution of housing investment to investment responses from VARs

(20-quarter horizon, the thick lines are the 50th percentile values, the blurred lines are the confidence intervals drawn using the 10th (lower) and 90th (upper) percentile values of 1,000 bootstrap simulations)



3.4.3 Durable and non-durable consumption responses

What is left now is to find the main reason for the difference between Australia and the US. For this purpose, private consumption is decomposed into durable consumption, which includes private consumption of durable goods: vehicles, furnishings and household equipment (more-interest-rate-sensitive consumption), and non-durable consumption. It might be even clearer if the same could be done for the Euro area. However comparable data on durable and non-durable consumption are not available for the whole Euro area for the same period. Therefore this step is implemented for Australia and the US only. Total private investment is now kept as a single variable. Once again, the same process of examining the proportional effects through impulse responses from the same VAR models (in Figure 3.5), then measuring the size effect using shares of durable and non-durable consumption in Table 3.5, is used to compare the relative contributions of durable consumption to non-durable consumption.

Figure 3.5 Impulse responses of durable and non-durable consumption to a policy shock from VARs

(1982Q3–2007Q4, 20-quarter horizon, confidence intervals drawn using the 10th (lower) and 90th (upper) percentile values of 1,000 bootstrap simulations)

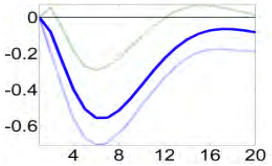
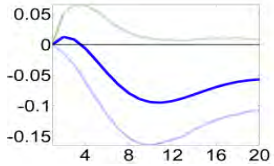
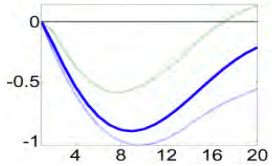
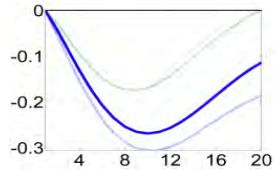
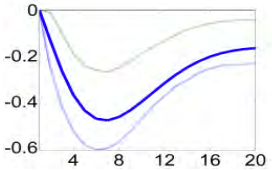
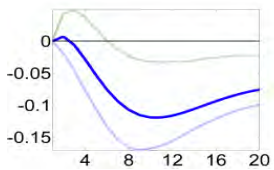
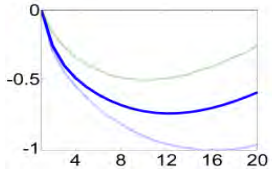
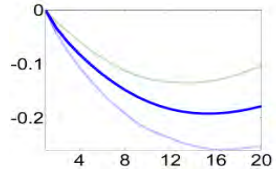
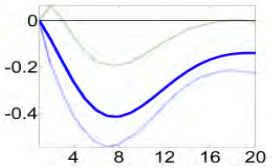
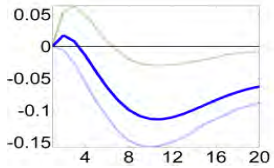
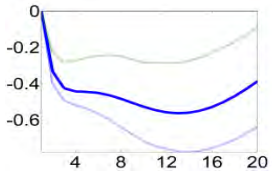
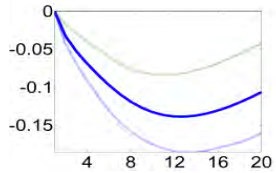
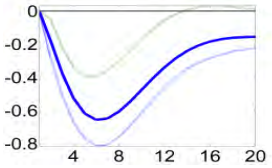
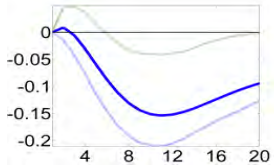
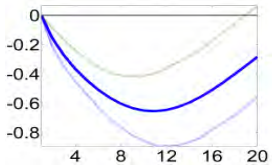
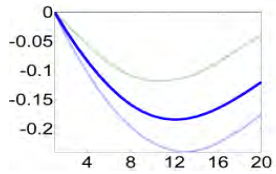
VAR models	Australia		US	
	Durable consumption	Non-durable consumption	Durable consumption	Durable consumption
Christiano–Eichenbaum–Evans				
Erceg–Levin				
Generalised Erceg–Levin				
Peersman–Smets				

Figure 3.5 shows a similar relative impulse response pattern between Australia and the US. After a nominal interest rate shock, durable consumption responds more strongly at peaks and more significantly compared to non-durable consumption. The responses of durable consumption are around four times bigger than the responses of non-durable consumption at the peaks for both countries.

Given similar small shares of durable consumption in total private consumption, Table 3.6 and Figure 3.6 show the contribution of durable consumption relative to non-durable consumption. Durable consumption contributions are observed to be around 0.3–0.4 for both Australia and the US in all VAR models (although the confidence intervals are wider in Australia).

The similarities between the two countries both in terms of the relative impulse responses and the size contributions of durable consumption henceforth lead to the conclusion that the shares of consumption and investment in total GDP (shown in Table 3.1) is likely the most important reason behind the difference of output composition in Australia and in the US.

Table 3.5 Shares of durable and non-durable consumption, 1982Q3–2007Q4

Country	Durable consumption		Non-durable consumption	
	In total GDP	In total private consumption	In total GDP	In total private consumption
Australia	0.04	0.075	0.50	0.925
US	0.055	0.085	0.595	0.915

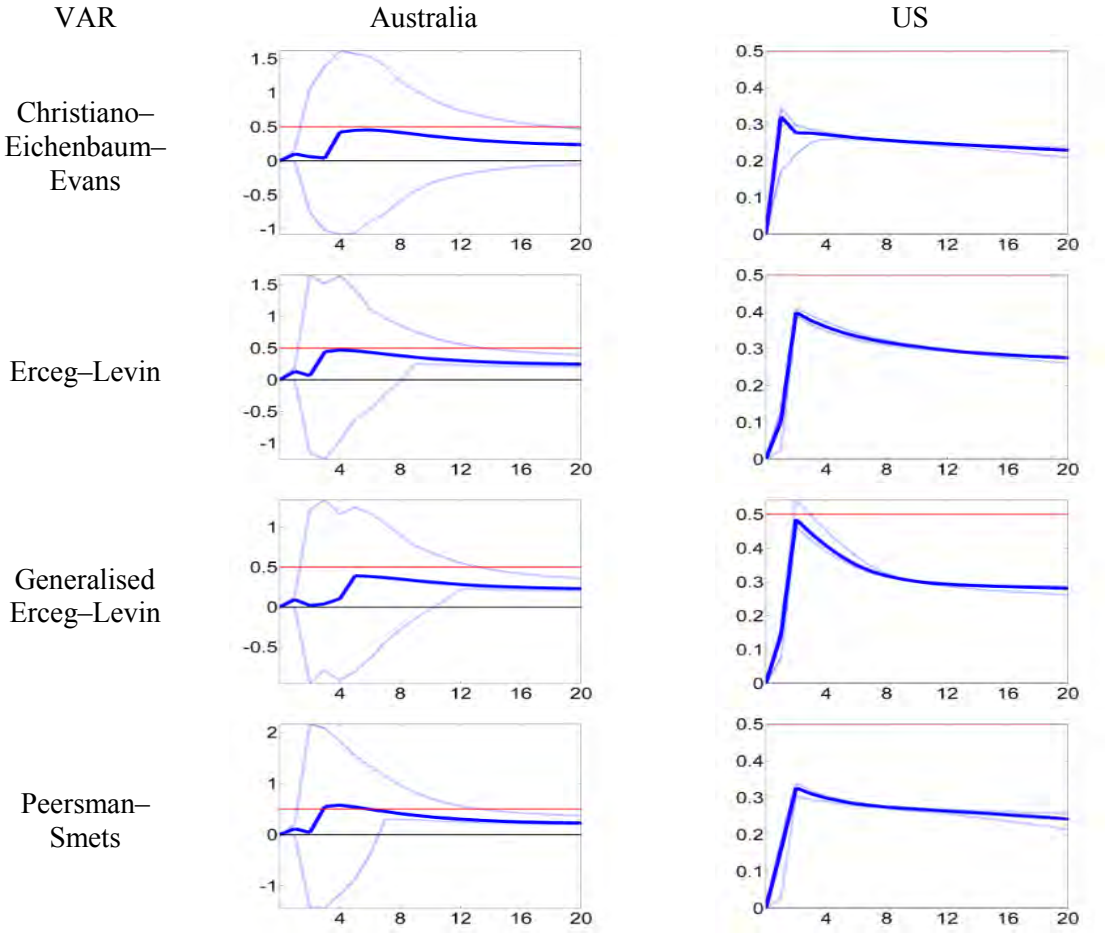
Table 3.6 Contribution of durable consumption to the responses to a monetary policy shock

(10^{th}, 50^{th}, and 90^{th} percentiles are calculated using 1,000 bootstrap simulations)

VAR	Quarter	Australia				US			
		Point estimate	Percentile			Point estimate	Percentile		
			10^{th}	50^{th}	90^{th}		10^{th}	50^{th}	90^{th}
Christiano–Eichenbaum–Evans	4^{th}	0.90	-1.08	0.42	1.61	0.28	0.26	0.27	0.28
	8^{th}	0.48	-0.57	0.42	1.17	0.26	0.25	0.26	0.26
	12^{th}	0.35	-0.21	0.32	0.74	0.25	0.24	0.25	0.25
Erceg–Levin	4^{th}	0.55	-0.96	0.47	1.64	0.36	0.35	0.36	0.37
	8^{th}	0.34	-0.02	0.38	0.85	0.33	0.31	0.32	0.32
	12^{th}	0.27	0.23	0.30	0.56	0.30	0.29	0.30	0.30
Generalised Erceg–Levin	4^{th}	0.71	-0.92	0.10	1.16	0.39	0.39	0.41	0.45
	8^{th}	0.34	-0.28	0.35	0.90	0.32	0.32	0.32	0.32
	12^{th}	0.26	0.22	0.28	0.55	0.30	0.29	0.29	0.30
Peersman–Smets	4^{th}	0.61	-1.17	0.58	1.82	0.29	0.29	0.30	0.30
	8^{th}	0.37	0.30	0.41	0.96	0.27	0.27	0.27	0.28
	12^{th}	0.28	0.25	0.30	0.56	0.26	0.26	0.26	0.27

Figure 3.6 Size contribution of durable consumption to consumption responses from VARs

(20-quarter horizon, the thick lines are the 50th percentile values, the blurred lines are the confidence intervals drawn using the 10th (lower) and 90th (upper) percentile values of 1,000 bootstrap simulations)



3.5 Conclusion

Using quarterly data for the period 1982Q3–2007Q4, four VAR models have been estimated to compare the output composition of the monetary policy transmission mechanism in Australia, the Euro area, and the US. Possible determinants of the differences across countries are also explored by decomposing investment and consumption so that more-interest-rate-sensitive components (housing investment and durable consumption) are introduced. The results indicate that:

i) In terms of the proportional effect, investment reacts more strongly than consumption at peaks for all countries. Consumption responses remain for a longer period. In Australia, investment responds more quickly compared to consumption after a monetary policy shock.

ii) When the shares in total GDP are accounted for, the investment channel is dominant in Australia, while the two channels are not significantly different to each other in the Euro area and the US.

iii) Housing investment might play the key role in explaining the difference between Australia and the Euro area, while the difference between Australia and the US likely comes from different shares of consumption in total GDP.

The results are informative for theories of monetary policy transmission mechanisms as well as for central banks. Noting the differences in the output composition of monetary transmission between Australia and other countries might help the Reserve Bank of Australia better understand monetary transmission in Australia itself. Knowing the responses of housing and non-housing investment, durable and non-durable consumption to monetary policy shocks could also help improve understandings on the way monetary policy shocks transmit to the real economy.

The recursive assumption was used for identifying monetary policy shocks in all the VAR models, as in previous studies (Angeloni *et al.*, 2003; Fujiwara, 2004). Some other identification strategies (see Dungey and Pagan, 2000, 2009; Fry *et al.*, 2008; Fry *et al.*, 2010) might arguably be more suitable for a SVAR model of Australia. Further issues, such as the responses of net exports to a shock in monetary policy; the existence of the 'cost channel' in Australia; and the detailed effects of monetary policy on the housing market in Australia – which need different identification schemes to be examined extensively – are left for future research.

CHAPTER 4

HOW MONETARY POLICY AND TRANSMISSION HAVE CHANGED OVER TIME ACROSS COUNTRIES: A TVP-VAR APPROACH

Summary: This chapter examines changes in monetary policy and monetary transmission over time in four developed countries (the United States, the United Kingdom, Canada, and Australia) using time-varying vector autoregression (TVP-VAR) models. The results suggest comovements in the monetary policy reactions to unemployment across countries before the recent Global Financial Crisis (GFC).[19] The policy rate seems to react more aggressively against unemployment in more recent years, especially in the US and UK. Monetary policy responses to inflation/deflation are observed to be divided into two groups, with the responses in the US and UK showing a different pattern to the responses in Canada and Australia. Monetary policy seems to react most aggressively against inflation/deflation in the US. There are comovements in the effects of monetary policy shocks on unemployment and inflation across countries, with these effects seeming to have weakened over time.

[19] In this chapter, the term 'comovement' is defined as 'similar movements (in reaction functions/impulse response functions) over time'.

4.1 Introduction

This chapter is motivated by the empirical topic of whether monetary policy and transmission have changed over time.[20] More precisely, the chapter addresses two questions: *(1) Have monetary policy reactions to unemployment and inflation changed over time?*; and *(2) Have the effects of monetary policy shocks on unemployment and inflation changed over time?*

On the first question, Primiceri (2005) uses a tri-variate time-varying parameter VAR (TVP-VAR) model to suggest that US monetary policy became more reactive to inflation and unemployment during the 1980s to 2001 compared to the 1960s and 1970s. Some earlier research including by Judd and Rudebusch (1998), Clarida *et al.* (2000), Cogley and Sargent (2001, 2003), and Lubik and Schorfheide (2004) also suggests that US monetary policy was more aggressive against inflation under the FED chairmanship of Paul Volcker (August 1979 to August 1987) and Alan Greenspan (August 1987 to January 2006) than under Arthur Burns (January 1970 to March 1978). Meanwhile others find little evidence of changes over time in the way US monetary policy reacts to inflation and unemployment (see, for example, Bernanke and Mihov, 1998; Leeper and Zha, 2002; Sims, 1999, 2001).

The second question is about the monetary transmission mechanism to unemployment and inflation. Primiceri (2005) finds that monetary transmission to unemployment and inflation did not change much across the different Federal Reserve

[20] Regarding monetary transmission, this chapter is not about the output composition of monetary transmission as in Chapter 3. Instead, this chapter focuses on monetary transmission to unemployment and inflation.

(FED) chairmanships of Burns, Volcker, and Greenspan. Boivin and Giannoni (2006) use a simple VAR model to argue that the effects of monetary policy on inflation and output declined in the post-Volcker period (after 1979Q4). Gali and Gambetti (2009) use TVP-VAR models to suggest that the effects of demand-type shocks (which might include the effect of the policy shocks) on output and inflation have declined over time. Meanwhile Canova and Gambetti (2009) use a sign restriction strategy with TVP-VAR models and find that output has become more responsive to monetary shocks in the US since the 1990s.

The literature of comparing monetary policy and monetary transmission between different countries comprises either studies among countries within the Euro area, or among G-7 countries. On monetary policy reaction functions, Romer (2005) argues that policy makers in different countries share some perceptions and form similar beliefs about the role of monetary policy, therefore monetary policy reactions could be similar in different countries. Nelson (2005a, 2005b) suggests a unified framework of beliefs prevailing among various developed countries. Recently, Chatterjee (2014) uses a Bayesian dynamic latent factor model to show that a common 'G-7 factor' plays an important role in the comovement of monetary reactions to inflation among G-7 countries during the period 1988-2003. Suda and Zervou (2014) argue that there might be a long-run relationship in the responses of monetary policy to inflation in G-7 countries.

Gerlach and Smets (1995) are among the first to compare the monetary transmission mechanisms of different countries. They use a structural vector autoregression (SVAR) model and report that the effects of monetary policy actions on inflation and output are similar across G-7 countries. Mojon and Peersman (2001) use SVAR models for individual countries of the Euro area before 1999 and conclude that

the effects of monetary policy on GDP and prices are broadly similar among the countries. Peersman (2004) also finds similar output responses to monetary policy shocks in seven Euro countries. Ciccarelli and Rebucci (2006) use a time-varying coefficient VAR to suggest that the long-run cumulative impact of monetary policy shocks on output has decreased since 1991 in four European countries (Germany, France, Italy, and Spain). Cecioni and Neri (2011) use SVAR and dynamic stochastic general equilibrium (DSGE) models to conclude that the effects of monetary policy shocks on output and prices in the Euro area have not changed much before and after the commencement of the Euro area in 1999.

This chapter uses TVP-VAR models similar to the ones used by Primiceri (2005) and Nakajima (2011) to examine the two above-mentioned questions for four developed countries: the United States (US), the United Kingdom (UK), Canada, and Australia. As pointed out by Suda and Zervou (2014), because of the operation of the European Central Bank (ECB) from 1999Q1, data for the three European G-7 members (Germany, France, Italy) are divisional and cannot be used smoothly pre- and post-ECB. Japan – the other G-7 member – has experienced a long period of zero interest rates since the late 1990s, which might lead to misleading and theoretically-inconsistent impulse responses (see, for example, Iwata and Wu, 2006; Fujiwara, 2006). Australia, meanwhile, is a non-G-7, developed economy with data available for the period of interest.

The results of this chapter suggest that *(i)* there were comovements in the monetary policy reactions against unemployment across countries before the recent GFC and the policy rate seems to have become more aggressive against unemployment since the 1990s; *(ii)* monetary policy reactions to inflation/deflation are observed to be divided into two groups, with the responses in the US and UK showing a different

pattern to the responses in Canada and Australia; and *(iii)* there are comovements in the effects of monetary policy on unemployment and inflation across countries, with these effects appearing to have become weaker over time.

The remainder of this chapter is structured as follows. Section 4.2 provides a background description of inflation, unemployment, and monetary policy in the four countries of interest. Section 4.3 describes the TVP-VAR models that are used in this chapter. Section 4.4 introduces the data. The empirical results are presented in Section 4.5. Section 4.6 concludes.

4.2 Background

In this section, a brief descriptive summary of macroeconomic developments and monetary policy in the four countries during the period 1971Q2–2011Q4 is provided. The key indicators used in this section are inflation, unemployment, and economic growth (real GDP growth).[21] The policy interest rate is employed to represent monetary policy (details on the data are provided in Section 4.4).

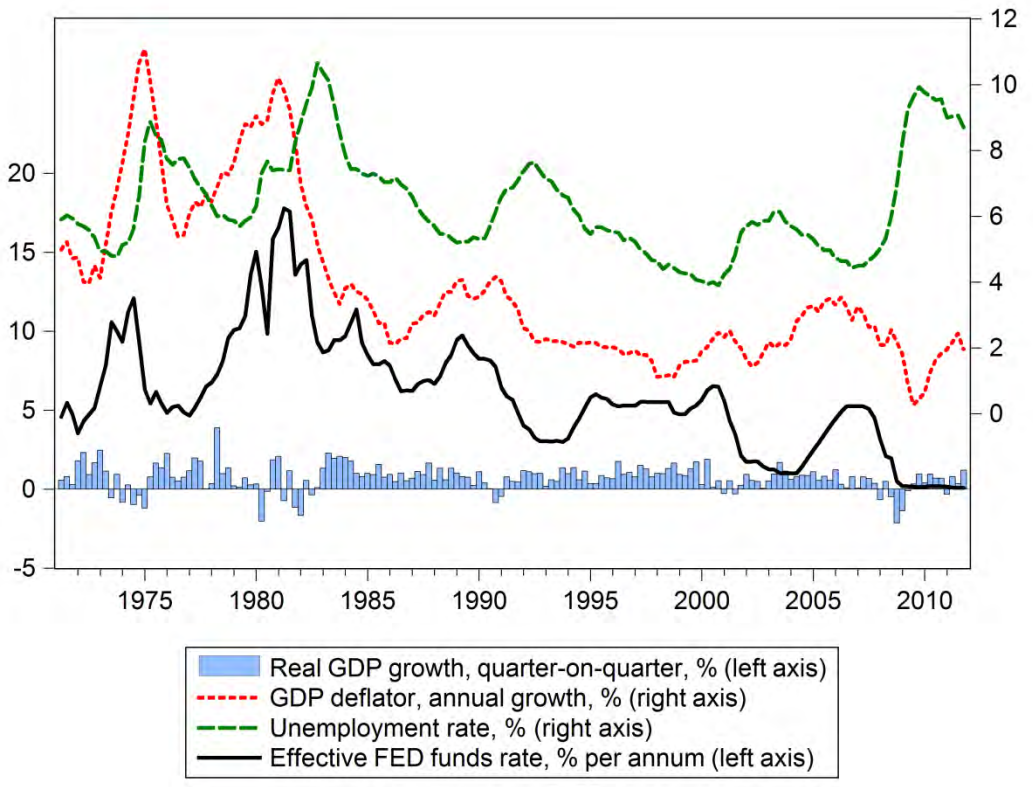
4.2.1 US

Figure 4.1 shows the key macroeconomic indicators for the whole period in the US. As observed in Figure 4.1, in the US, the 1970s and early 1980s (until around 1982Q4) was a period of macroeconomic instability, featuring high inflation and

[21] In this chapter, the annual growth rate of the GDP deflator (rather than CPI growth rate) is used for inflation, as in Primiceri (2005), Boivin and Giannoni (2006), and Baumeister and Benati (2013), among others.

fluctuating GDP growth. Inflation peaked at 11.1% in 1975Q1 and 10.2% in 1981Q1, with an average of 7.1% throughout this period. The peaks of inflation corresponded to the oil price shocks. During this period, three recessions were recorded (1974Q3–1975Q1, 1980Q2–1980Q3, and 1981Q4–1982Q1).[22] Unemployment also varied with high frequency and peaked at 10.7% in 1982Q4. In response, the policy rate was raised and lowered frequently, being 3.5% per annum in 1972Q1, increasing to 12.1% per annum in 1974Q3, decreasing again to 4.7% per annum in 1977Q1, and peaking at 17.8% per annum in 1981Q2.

Figure 4.1 Key economic indicators in the US, 1971Q2–2011Q4



Sources: see Appendix 4A.

[22] In this thesis, 'recession' is defined as two consecutive quarters of negative real GDP growth. The US National Bureau of Economic Research (NBER) has a different definition of recession (NBER, 2014).

For the next 24 years, from 1983Q1 to 2007Q2, the Federal Reserve (FED) was successful in keeping inflation below 4.5% per annum. The policy interest rate followed inflation developments closely. The unemployment rate peaked at 7.6% in 1992Q3 and 6.1% in 2003Q2 but usually was within a range of 4–6%.[23] During this period, the US economy experienced only one short recession (1990Q4–1991Q1) and two mild negative growth quarters in 2001 (not two consecutive quarters, but still classified as a recession by the NBER's Business Cycle Dating Committee – see NBER, 2014) at the time of the bursting of the 'dot-com' bubble. Following this short downturn, unemployment kept rising until 2003Q2. The FED then decided to keep the policy rate at a low level of 1–2% per annum, being fearful of a recession comeback. After the expansion measures gained momentum, unemployment declined and prices increased, the federal funds rate increased to 5.2% per annum in 2006Q3 and stayed there until 2007Q2 (for more details, see Labonte, 2014).

Some dramatic changes happened since the financial crisis starting in 2007Q3. Initiating in the subprime housing market, the crisis spread to the financial sector and then to the macro economy. In spite of a short pick up in 2008Q2, the US economy entered a severe recession until 2009Q2 and continued to have low growth. Although inflation was not an issue, unemployment rose to a peak of nearly 10% at 2009Q4. In response, the federal funds rate was pushed down to unprecedented levels. Starting in September 2007, in a series of ten moves, the FED decreased the target of its policy rate until it arrived at 'between 0 and 0.25% per annum' and kept it there until the end of

[23] This period of low and stable inflation, steady economic growth, and solid employment happened not only in the US but also in many developed countries. This period is normally referred to as the 'Great Moderation'. The start of the Great Moderation varies across countries. For instance, it was the mid-1980s for the US (see Bernanke, 2004), or after October 1992 for the UK (see Benati, 2008).

2011 (even until now in 2014). Because of this technical zero lower bound (ZLB), since then the FED has had to use unconventional expansion packages ('quantitative easing' – QE) as the main tool of monetary policy rather than the federal funds rate target.[24]

As argued by Stevens (1999) and Mishkin and Schmidt-Hebbel (2001), being able to gain credibility in achieving and maintaining low and stable inflation for an extended period since 1983 might be one of the reasons why the FED has not switched to an inflation targeting regime, despite its adoption in other countries such as New Zealand, Canada, the UK, Australia. At the end of 2011, the statutory role of the FED was still the dual mandate of maximum employment and stable prices.[25]

4.2.2 UK

Figure 4.2 presents a similar pattern of key indicators for the UK's economy. Inflation was high in the 1970s until 1982Q4, with peaks of 28.2% in 1975Q2 and 22.5% in 1980Q2 due to the oil price shocks, more than double the respective inflation levels in the US. Three recessions happened in the UK in this period, with the longest lasting for more than a year (from 1980Q1 to 1981Q1). Unemployment was low during the 1970s, but increased to 10.5% in 1982Q4. The policy interest rate also fluctuated frequently in response to the developments of inflation and unemployment/economic growth, with the peak as high as 17% per annum in 1980Q2.

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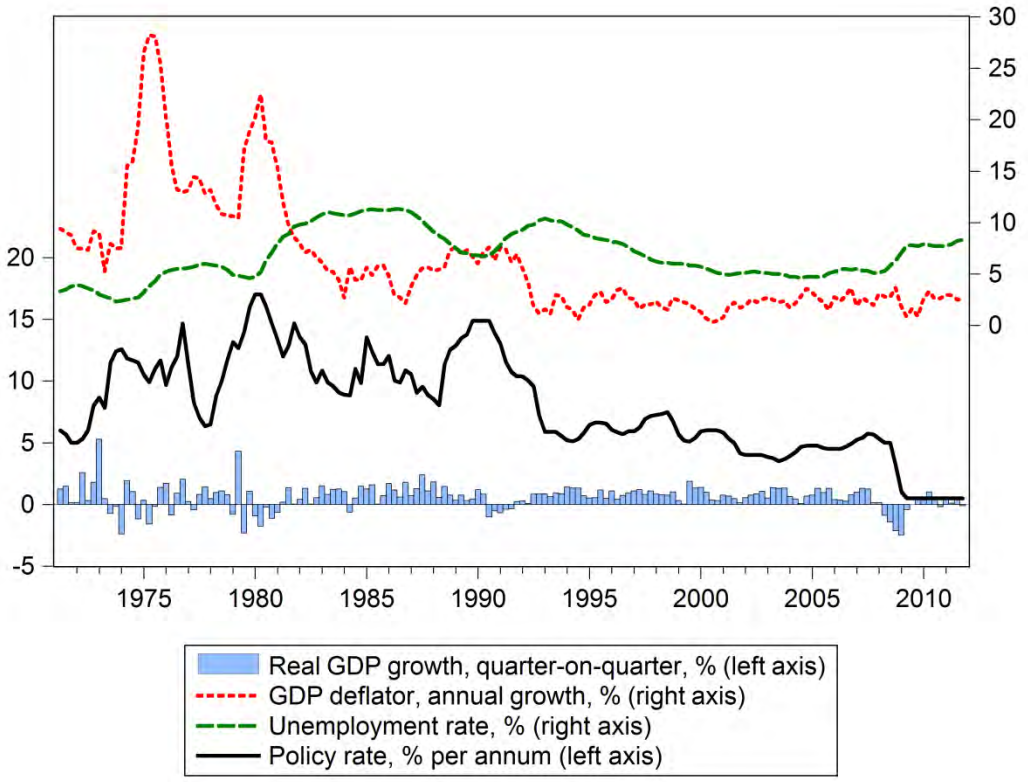
[24] Other unconventional methods include direct credit facilities to banks and non-bank institutions; central bank liquidity swaps with the ECB, Bank of Japan, and others; and forward guidance to affect expectations (see Labonte, 2014).

[25] The full statutory mandate of the FED includes 'maximum employment, stable prices, and moderate long-term interest rates'. Recently some economists have proposed to switch the FED's mandate to an inflation targeting regime (see Labonte, 2014).

Figure 4.2 Key economic indicators in the UK, 1971Q2–2011Q4



Sources: see Appendix 4A.

Unlike in the US, inflation in the UK did not maintain a decline throughout the 1980s. Inflation began to rise in 1986Q1 and stayed around 7–8% until the end of 1991. The policy rate was raised and kept as high as nearly 15% per annum. The UK then experienced a long recession from 1990Q3 to 1991Q3.[26]

After the British Sterling left the European Exchange Rate Mechanism (ERM), the Bank of England took up inflation targeting from October 1992. The UK then experienced a long period of low and stable inflation, steady economic growth, and solid employment (the Great Moderation). Inflation was kept within the band 1.5–3.5%,

[26] King (1994, 2002) argues that 'debt deflation' might have been the main cause of this recession in the UK.

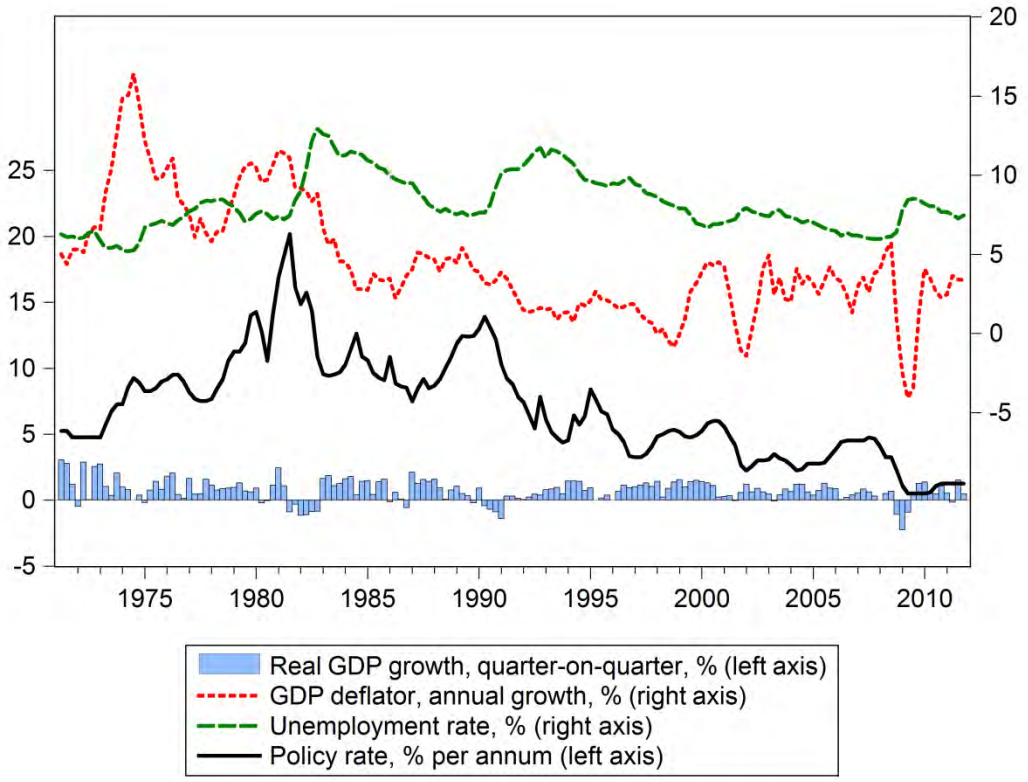
GDP growth remained continuously positive until 2008Q1, while the unemployment rate gradually decreased and stayed around 4.5–5.5%. The policy interest rate was kept within 3.5–7.3% per annum.

Among the four countries studied in this chapter, the UK was perhaps the second-most affected by the GFC after the US. The economy experienced five consecutive quarters of negative growth in 2008Q2–2009Q3, while unemployment increased from 5.1% in 2008Q1 to 8.3% in 2011Q4. The inflation rate fell below the target band of 1.5–3.5% to 0.9% in 2009Q2 and 2009Q4. As a result, the policy rate was pushed down sharply from 5% per annum in 2008Q3 to 0.5% per annum in 2009Q2, and stayed there until the end of 2011. Inflation did come back to the target band in 2009Q3, however unemployment kept increasing and GDP growth was low and unstable.

4.2.3 Canada

Figure 4.3 shows the macroeconomic indicators in Canada during the period 1971Q2–2011Q4. Similarly to the US and UK, the 1970s and early 1980s featured high and variable inflation, increasing unemployment, and unstable growth in Canada. The country experienced six consecutive quarters of negative growth in 1981Q3–1982Q4. Inflation peaked at 15.1% in 1974Q2, then 11.4% in 1981Q2, while unemployment climbed to 12.9% in 1982Q4. The policy rate (the bank rate) was raised to 20.2% per annum in 1981Q3 to fight inflation, then was pushed down sharply to 9.4% per annum in 1983Q2 to counteract high unemployment and low economic growth.

Figure 4.3 Key economic indicators in Canada, 1971Q2–2011Q4



Sources: see Appendix 4A.

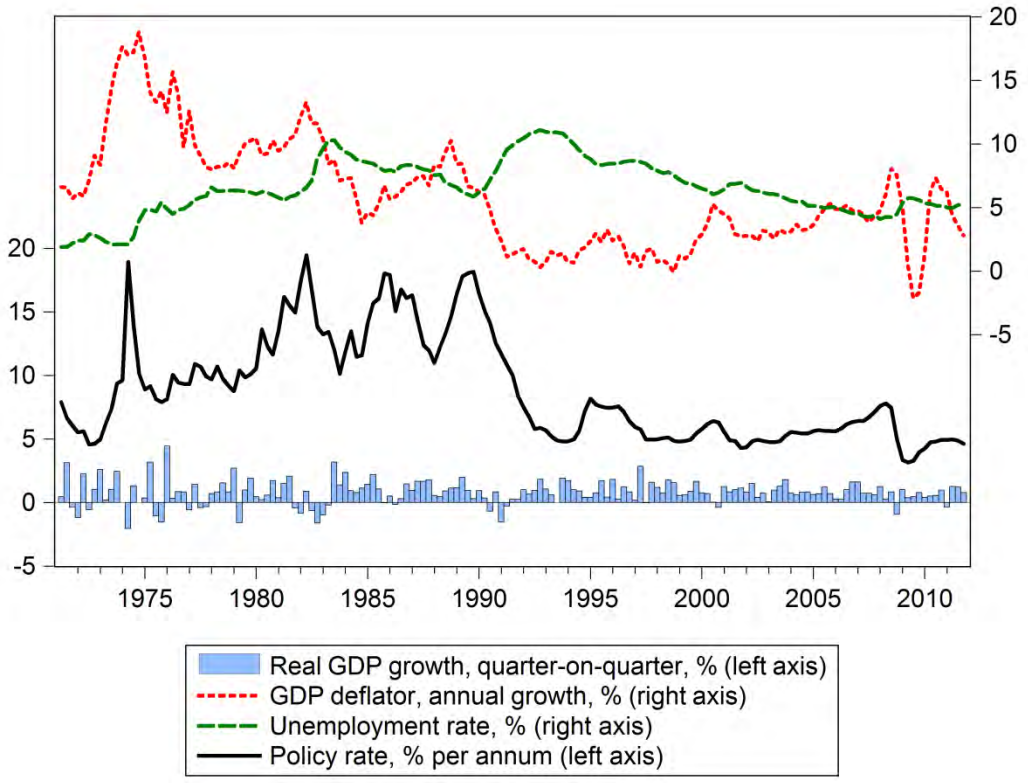
The Bank of Canada began to apply inflation targeting in February 1991, only second to New Zealand in the developed world. Just before that time, Canada suffered a recession from 1990Q2–1991Q1 and an increase in its unemployment rate since 1990Q2. During the Great Moderation, there were sub-periods when inflation fluctuated in Canada. Inflation fell to less than zero at some times (such as around 1998Q4 and 2001Q1), but also increased to 4.5–5% around 2001Q1 and 2003Q1. GDP growth was stable, and the unemployment rate kept declining right up until 2008Q2, when the GFC hit.

In 2008Q2 and 2008Q3, inflation climbed to 5.2% and 5.3% respectively, followed by a sharp fall to deep deflation of -4.1% in 2009Q2. Canada's economy went

into recession for 2008Q4–2009Q2, while unemployment peaked again at 8.5% in 2009Q3. The policy interest rate was pushed down remarkably to 0.5% per annum in 2009Q2 and remained unchanged before being lifted to more than 1% per annum in late 2010.

4.2.4 Australia

Figure 4.4 Key economic indicators in Australia, 1971Q2–2011Q4



Sources: see Appendix 4A.

In Australia (see Figure 4.4), the period 1971Q2–1993Q1 featured fluctuations in real GDP growth, inflation, and unemployment. Within 22 years, Australia experienced six periods of recession, the longest of which lasted four consecutive quarters from 1982Q3 to 1983Q2. Inflation ranged from 3.8% in 1984Q4 to a peak of 18.8% in 1974Q4, with many sub-periods of sharp rises or declines, before easing since 1991.

Unemployment also climbed to 10.2% in 1983Q2. In response, the policy rate in this period changed with high frequency and variance. It ranged from 4.6% per annum in 1972Q4 to peaks of 18–19.5% per annum (in 1974Q2, 1982Q2, 1985Q4, and 1989Q4). During the short period from 1991Q3 to 1993Q1, Australia's GDP growth rate was positive, and inflation was low (less than 2%). However, unemployment was high, with a peak of 11.1% in 1992Q4. The RBA therefore had to decrease its policy rate from 10% per annum to around 5%. This move appeared to help bring down unemployment. The unemployment rate continued its downward trend for a long period until the recent GFC.

The Reserve Bank of Australia (RBA) began an inflation targeting regime in the middle of 1993 (see Stevens, 1999)[27], with an inflation target of 2–3%. As suggested by Stevens (1999), the regime might have brought decent economic outcomes as well as enhanced the RBA's credibility, and therefore equipped the RBA with more flexibility in its policy to deal with exogenous shocks. Australia's macroeconomic performance has generally been good since, with a long period of stable economic growth and no recession.

During 1997–1998, in response to the Asian financial crisis with some signals of disinflation (the inflation rate fell to 0.3% in 1997Q2), the RBA decreased its policy rate (the cash rate) from 5.8% to 5% per annum, then kept it steady at around 4% per annum for more than 2 years. Australia managed to escape the Asian financial crisis without a quarter of negative growth. In 1999Q4 inflation came back to 2.5%. However,

[27] Mishkin and Schmidt-Hebbel (2001) marked September 1994 as the official commencement of inflation targeting in Australia.

inflation rose to 5.2% in 2000Q3, leading the RBA to raise its policy rate to 6.4% per annum, which once again helped bring inflation back to its target band.

During the recent GFC, the policy rate fell sharply from 7.4% per annum in 2008Q2 to 3.4% per annum in 2009Q1. Together with the fiscal stimulus packages in 2009 (see, for example, Leigh, 2012) as well as the effects of the 'mining boom' (Day, 2011), Australia avoided the recession that most other OECD countries (including the other three countries in this chapter) experienced. The unemployment rate was kept stable at around 4–5.5%, except for a short increase in 2009Q2.

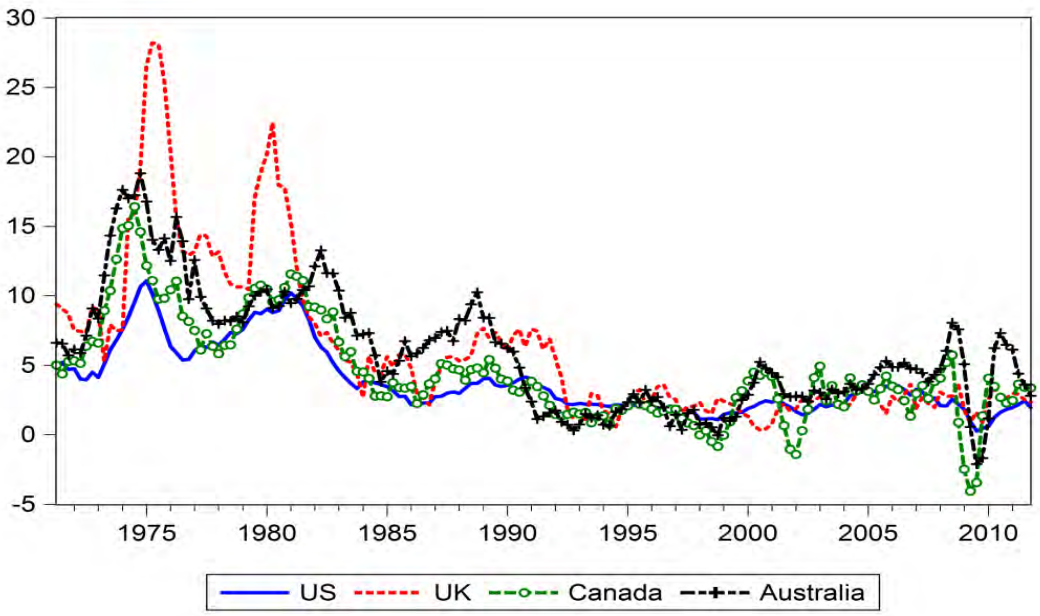
4.2.5 Similarities of key indicators across countries

Figures 4.5–4.7 show combined graphs of inflation, unemployment, and the policy rate respectively across the four countries. Tables 4.1–4.3 show pairwise correlation coefficients of inflation, unemployment, and the policy rate among the countries. All the correlation coefficients are significantly positive. The figures and tables indicate highly similar patterns for the movements of these variables across the four countries during the period of interest.

In the next section I will introduce the TVP-VAR model that I will use to gain insights into the policy rate reactions to changes of inflation and unemployment as well as the impulse response functions of inflation and unemployment to the policy rate shocks across the four countries, plus how these have changed over time.

Figure 4.5 Inflation rate in the four countries, 1971Q2–2011Q4

(Unit: %)



Sources: see Appendix 4A.

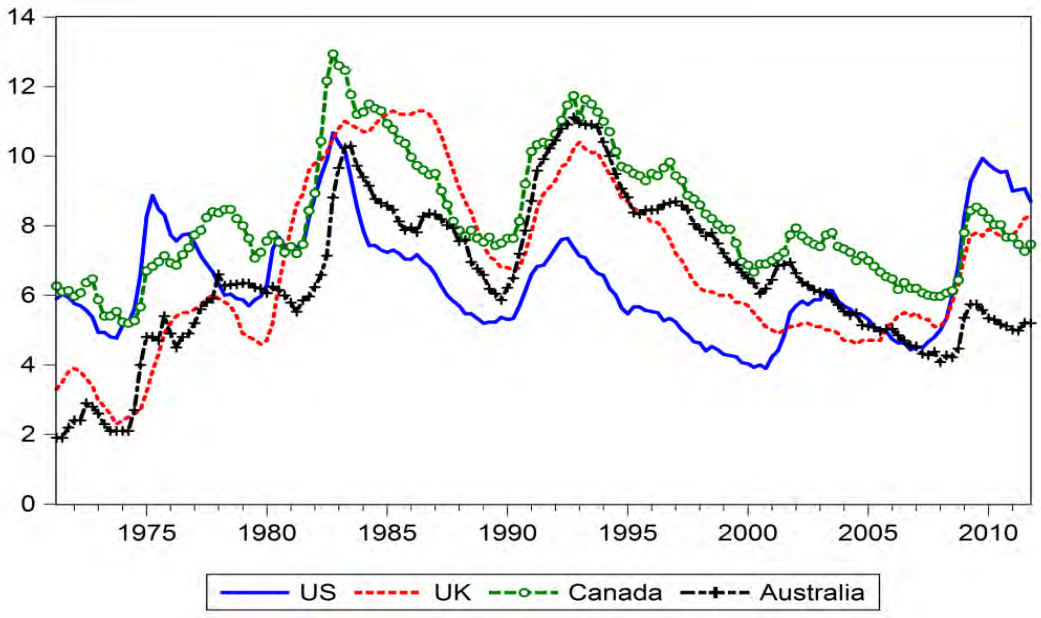
Table 4.1 Pairwise correlation of inflation in the four countries, 1971Q2–2011Q4

Country	US	UK	CAN	AUS
US	X			
UK	0.88***	X		
CAN	0.89***	0.77***	X	
AUS	0.82***	0.74***	0.90***	X

Notes: ***, **, * denote significance at 1%, 5%, and 10% respectively; 'X' = '1.00***'.

Figure 4.6 Unemployment rate in the four countries, 1971Q2–2011Q4

(Unit: %)



Sources: see Appendix 4A.

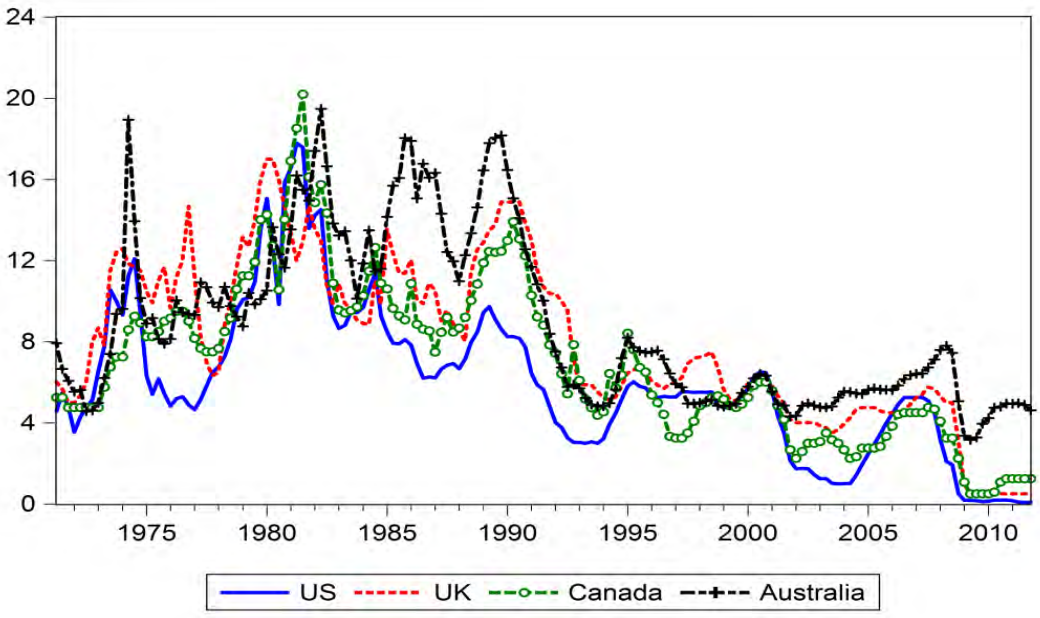
Table **4.2 Pairwise correlation of unemployment in the four countries, 1971Q2–2011Q4**

Country	US	UK	CAN	AUS
US	X			
UK	0.48***	X		
CAN	0.47***	0.86***	X	
AUS	0.18**	0.79***	0.89***	X

Notes: ***, **, * denote significance at 1%, 5%, and 10% respectively; 'X' = '1.00***'.

Figure 4.7 Policy interest rate in the four countries, 1971Q2–2011Q4

(Unit: % per annum)



Sources: see Appendix 4A.

Table 4.3 Pairwise correlation of the policy rate in the four countries, 1971Q2–2011Q4

Country	US	UK	CAN	AUS
US	X			
UK	0.83***	X		
CAN	0.91***	0.89***	X	
AUS	0.74***	0.78***	0.83***	X

Notes: ***, **, * denote significance at 1%, 5%, and 10% respectively; 'X' = '1.00***'.

4.3 TVP-VAR model

As discussed in Sections 2.3 and 2.4, a limitation of VAR models is that they assume constant coefficients and constant variances throughout the period of interest. If structural breaks happen during a period of examination, VAR estimates might not be correct. To overcome this drawback, Cogley and Sargent (2001, 2003) propose a VAR model with time-varying coefficients. Primiceri (2005) follows with his influential paper introducing a VAR model allowing all parameters (coefficients, variances, and co-variances) to be time-varying.

In this chapter, parsimonious TVP-VAR models of the kind used by Primiceri (2005) and Nakajima (2011) are used. The basic TVP-VAR model consists of three basic variables: inflation, unemployment, and the policy interest rate. This simple three-variable model is similar to the models used by Gerlach and Smets (1995), Cogley and Sargent (2001), Primiceri (2005), and Nakajima (2011). The exchange rate is added into the TVP-VAR for the UK, Canada, and Australia given the fact that they are 'small open economies' compared to the US. Due to significant increases in complexity relating to prior distributions of parameters, larger models with more variables are left for future research.

In the TVP-VARs, a recursive Cholesky identification is assumed, in which the order of variables is similar to as used by Primiceri (2005): inflation, unemployment, and the policy interest rate. This order implies the identification assumption that a shock in the nominal policy interest rate affects unemployment and inflation with a lag. At the same time, central banks use an information set that includes the current inflation and unemployment rates (together with lags of all three variables) in deciding the policy rate. The ordering of inflation and unemployment in the TVP-VAR turns out to be

unimportant in that the main results are qualitatively unchanged if unemployment is placed in front of inflation in the TVP-VAR models used in this chapter (results are not reported). With a commonly-used assumption that a shock in the policy rate will immediately affect the exchange rate (see, for example Peersman and Smets, 2003; Sims, 1992; Grilli and Roubini, 1996; Racette and Raynauld, 1992), the exchange rate is placed last (behind the policy rate) for the cases of the UK, Canada, and Australia in the TVP-VAR.[28]

As detailed in Section 2.4, TVP-VAR models are built on basic structural VAR (SVAR) models as follows:

$$Ay_t = F_1 y_{t-1} + \cdots + F_s y_{t-s} + u_t \ , t = s+1, \ldots, n, \tag{4.1}$$

where y_t is a $k \times 1$ vector of variables, $A, F_1, \ldots, F_s$ are $k \times k$ matrices of coefficients, and u_t is a $k \times 1$ vector of structural shocks. Assume $u_t \sim N(0, \Sigma\Sigma')$, where

$$\Sigma = \begin{bmatrix} \sigma_1 & 0 & \cdots & 0 \\ 0 & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_k \end{bmatrix}.$$

The simultaneous relations of the structural shock are identified using a recursive assumption, therefore A is a lower-triangular matrix:

$$\mathrm{A} = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ a_{21} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ a_{k1} & \cdots & a_{k,k-1} & 1 \end{bmatrix}.$$

[28] As discussed in Chapter 2 of this thesis, the simple three- or- four variable structure of the TVP-VAR models used in Chapter 4 might not completely solve the issue of endogeneity bias.

The reduced form of (4.1) is $y_t = B_1 y_{t-1} + \cdots + B_s y_{t-s} + A^{-1}\Sigma\varepsilon_t$, where $\varepsilon_t \sim N(0, I_k)$, $B_i = A^{-1}F_i$ for $i = 1, \ldots, s$. Stacking the elements in the rows of the B_is to form β ($k^2 s \times 1$ vector), and defining $X_t = I_k \otimes (y'_{t-1}, \ldots, y'_{t-s})$, in which $\otimes$ denotes the Kronecker product, the VAR model then can be written as

$$y_t = X_t \beta + A^{-1}\Sigma\varepsilon_t. \tag{4.2}$$

The time-invariant model (4.2) is extended to TVP-VAR by allowing the parameters to be time-varying. It means now the model becomes:

$$y_t = X_t \beta_t + A_t^{-1}\Sigma_t\varepsilon_t, \tag{4.3}$$

so that β_t, A_t, and Σ_t are time-varying parameters.

Let $a_t = (a_{21}, a_{31}, a_{32}, \ldots, a_{k,k-1})'$ be a stacked vector of the lower-triangular elements in A_t; $h_t = (h_{1t}, \ldots, h_{kt})'$ with $h_{jt} = \log \sigma_{jt}^2$ for $j = 1, \ldots, k$ and $t = s + 1, \ldots, n$.

Assuming that the parameters in (4.3) follow a random walk:

$$\beta_{t+1} = \beta_t + u_{\beta t}, a_{t+1} = a_t + u_{at}, h_{t+1} = h_t + u_{ht},$$

$$\begin{pmatrix} \varepsilon_t \\ u_{\beta t} \\ u_{at} \\ u_{ht} \end{pmatrix} \sim N\left(0, \begin{pmatrix} I & O & O & O \\ O & \Sigma_\beta & O & O \\ O & O & \Sigma_a & O \\ O & O & O & \Sigma_h \end{pmatrix}\right),$$

for $t = s + 1, \ldots, n$, where $\beta_{s+1} \sim N(\mu_{\beta_0}, \Sigma_{\beta_0})$, $a_{s+1} \sim N(\mu_{a_0}, \Sigma_{a_0})$, and $h_{s+1} \sim N(\mu_{h_0}, \Sigma_{h_0})$. As in the paper by Nakajima (2011), Σ_a and Σ_h are also assumed to be diagonal matrices. The model is then estimated using Bayesian econometric techniques. Given the data, the following priors are assumed for the i-th diagonals of the

covariance matrices: $(\Sigma_\beta)_i^{-2} \sim Gamma(20, 10^{-4})$, $(\Sigma_a)_i^{-2} \sim Gamma(4, 10^{-4})$, and $(\Sigma_h)_i^{-2} \sim Gamma(4, 10^{-4})$. More details on the estimation process of the TVP-VAR model are presented in Section 2.4 of this thesis.

4.4 Data

For the purpose of this chapter, 163 observations of quarterly data for the period 1971Q2–2011Q4 are used (notice that this period of data is longer than the one used in Chapter 3, as explained in Section 3.3).[29] Since the parameters are allowed to time-vary, the recent GFC since 2007Q3 is included in the analysis of this chapter. However, my emphasis will be on the pre-GFC sub-period (1971Q2–2007Q2) because the recent GFC features the problem of a zero lower bound in the policy interest rates and an increasing role of unconventional monetary policy, especially in the US and UK. For more details on the effects of unconventional monetary policy in the context of the recent GFC, see the work of Baumeister and Benati (2013).

The TVP-VAR models are estimated with a two-lag structure, as also done by Primiceri (2005), Baumeister and Benati (2013), and others. A detailed list of data sources is provided in Appendix 4A. Inflation is calculated by the annual growth rate of the GDP deflator. The unemployment rate is measured for the whole labour force in each country. The effective Federal Funds rate is used as the policy rate for the US, while the discount rate, the bank rate, and the 90-day bank accepted bill rate are used for

[29] Real-time data (the data that were available at the time policy decisions are made) might also be employed for monetary policy reaction analysis, as suggested by Orphanides (2001), Croushore and Evans (2006), and Lee *et al.* (2012).

the UK, Canada, and Australia respectively. For the UK, Canada, and Australia, the logs of the USD/local currency rates are added for the movement of the exchange rates. To estimate the 4-variable TVP-VARs, the matrix Σ_β is set to be diagonal. The simulations are based on 20,000 iterations of the Gibbs sampler using MATLAB codes developed by Nakajima (2011). The convergence of the Markov chain Monte Carlo algorithm for all estimations is provided in Appendix 4B.

4.5 Results

4.5.1 How monetary policy has changed over time across countries

As reviewed in Section 2.1, monetary policy reactions might provide insights into how aggressive monetary policy has been against unemployment and inflation/deflation over time. This section explores monetary policy reactions to unemployment and inflation respectively. Unlike Primiceri (2005), in this chapter the changes of inflation/unemployment are assumed to be temporary rather than permanent. The policy reactions are therefore short-run reactions rather than being close to long-run parameters in the Taylor rule. The size of a temporary shock in unemployment/inflation is assumed to be a one percentage point increase.

The policy reaction functions here are estimated simply from the parsimonious TVP-VARs rather than a formal Taylor rule estimation. Suggestions for more comprehensive estimation of 'meta' Taylor rules for the cases of the US, UK, and Australia can be found in the works of Lee *et al.* (2011, 2013).

4.5.1.1 Monetary policy reactions to unemployment

The posterior means of the monetary policy reaction to a one percentage point increase in unemployment in the four countries are presented in Figure 4.8 (for a 30-quarter horizon) and Figure 4.9 (at the 4th, 8th, and 12th quarter). Table 4.4 provides the pairwise correlation of the policy responses to unemployment among the countries for two sub-periods: 1971Q2–2007Q2 (pre-GFC) and 2007Q3–2011Q4 (since GFC) at the 4th, 8th, and 12th quarters. Three main patterns can be observed from Figures 4.8 and 4.9 and Table 4.4, as follows.

First, comovements in the monetary policy reactions to unemployment across the countries are observed for the pre-GFC period, especially over short-run horizons. Most of the pairwise correlation coefficients at the 4th quarter are significantly positive.

Second, it is observable that the policy rate responds immediately and expectedly to unemployment in all four countries. The policy rate falls in response to a one percentage point increase in unemployment and remains under its steady state level at the 4th, 8th, and 12th quarters.

Third, the policy rate appears to react slightly more aggressively against unemployment over time. This pattern is evidenced by the downward trend of the policy responses at the 4th quarter.

In addition to the graphs of responses for the whole period, I also selected several time points to illustrate the changes of the monetary policy reactions over time in the four countries. Six time points are chosen: the second quarters of 1975, 1985, 1993, 1998, 2003, and 2008. 1975Q2 is in the centre of the oil price shock period of the 1970s, 2008Q2 is at the early days of the current GFC, while the other four points are picked somewhat arbitrarily so that there is a distance of at least 5 years between them,

with priority given to more recent years. These six time points are used throughout the chapter.

The posterior means of the policy responses to unemployment at the six chosen time points shown in Figure 4.10 and Figure 4.11 support the three main patterns observed from Figures 4.8 and 4.9 and Table 4.4. In response to a one percentage point increase in unemployment, the policy rate declines immediately by around one percentage point per annum in all of the four countries. The policy rate keeps decreasing by a peak of around 2–5 percentage points per annum after about 4–8 quarters.

A more aggressive trend in recent years is most notable in the US and UK. The US and UK also seem to demonstrate higher levels of reaction against unemployment compared to the other two countries. This result for the US is similar to the more aggressive trend of monetary policy against unemployment in the US found by Primiceri (2005), Judd and Rudebusch (1998), Clarida *et al.* (2000), Cogley and Sargent (2001, 2003), and Lubik and Schorfheide (2004).

Figure 4.8 Posterior means of the policy responses to a one percentage point increase in unemployment, 1971Q2–2011Q4 (30-quarter horizon)

(Unit: percentage point)

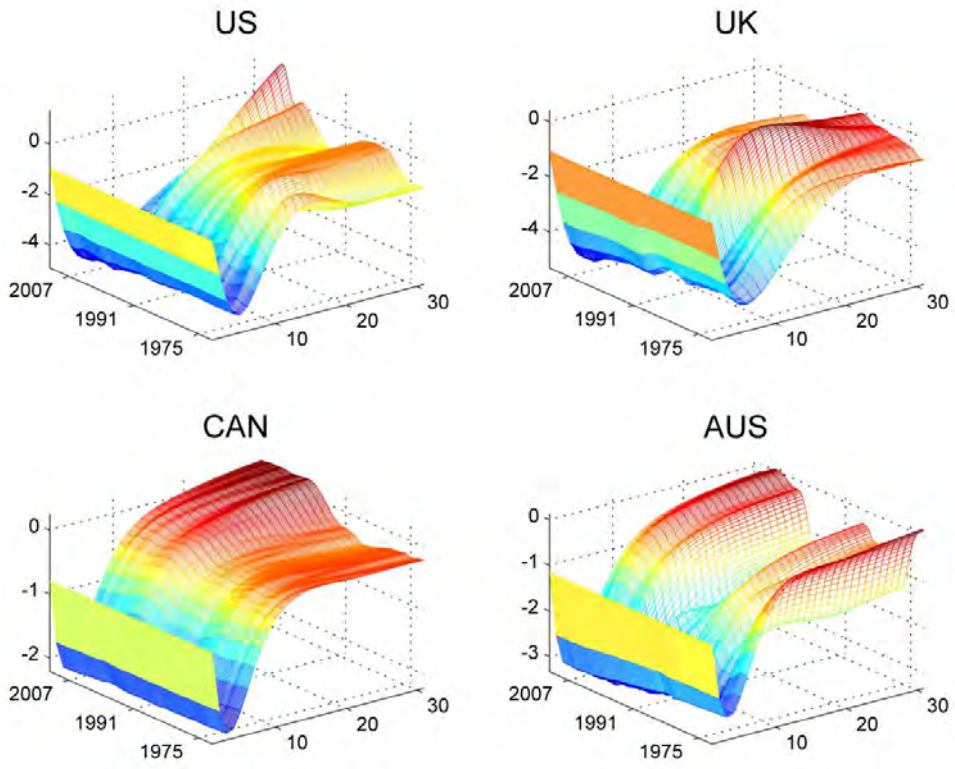
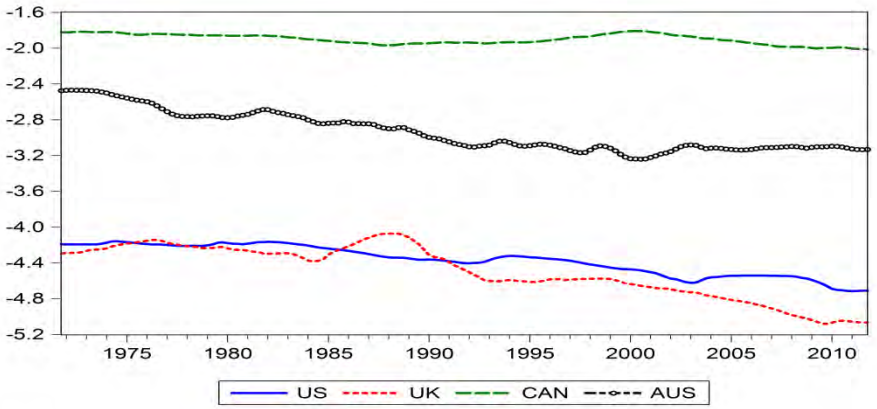


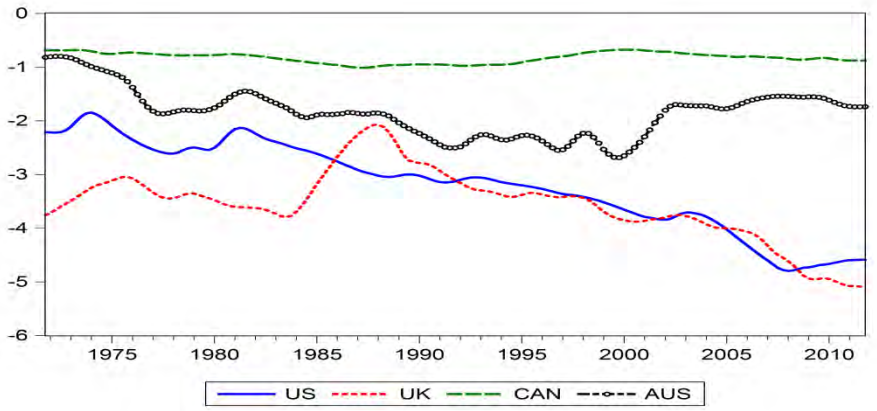
Figure 4.9 Posterior means of the policy responses to a one percentage point increase in unemployment, 1971Q2–2011Q4 (at 4th, 8th, 12th quarters)

(Unit: percentage point)

4th quarter



8th quarter



12th quarter

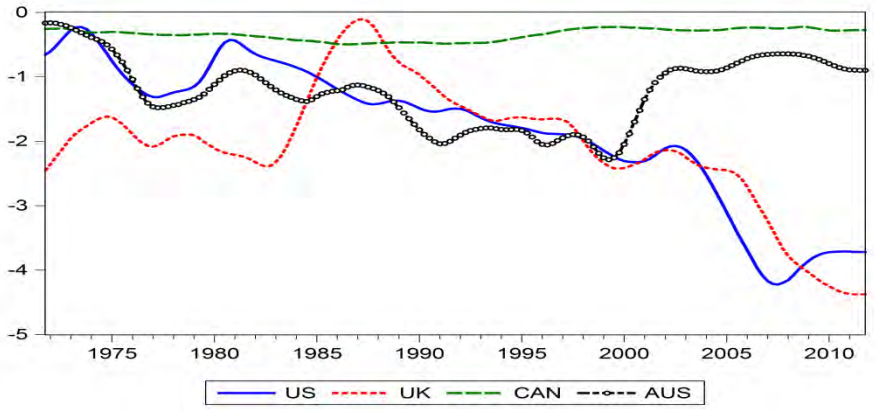


Table 4.4 Pairwise correlation of the policy rate responses to a one percentage point increase in unemployment, 1971Q2–2011Q4

Time	Country	1971Q2–2007Q2			2007Q3–2011Q4		
		US	**UK**	**CAN**	**US**	**UK**	**CAN**
4th quarter	**US**	X			X		
	UK	***0.83*****	X		***0.79*****	X	
	CAN	***0.26*****	0.12	X	***0.73*****	***0.77*****	X
	AUS	***0.86*****	***0.78*****	***0.37*****	***0.49*****	0.29	***0.73*****
8th quarter	**US**	X			X		
	UK	***0.39*****	X		0.***79*****	X	
	CAN	0.02	-0.65***	X	0.*77***	0.***64*****	X
	AUS	***0.50*****	-0.10	***0.38*****	-0.94***	-0.61***	-0.87***
12th quarter	**US**	X			X		
	UK	***0.39*****	X		***0.86*****	X	
	CAN	-0.39***	-0.80***	X	***0.91*****	***0.72*****	X
	AUS	***0.17*****	-0.24***	***0.30*****	-0.83***	-0.66***	-0.97***

Notes: ***, **, * denote significance at 1%, 5%, and 10% respectively; significantly positive correlations are in bold italics; 'X' = '1.00***'.

Figure 4.10 Posterior means of the policy responses to a one percentage point increase in unemployment across six specific time points

(Unit: percentage point; 30-quarter horizon)

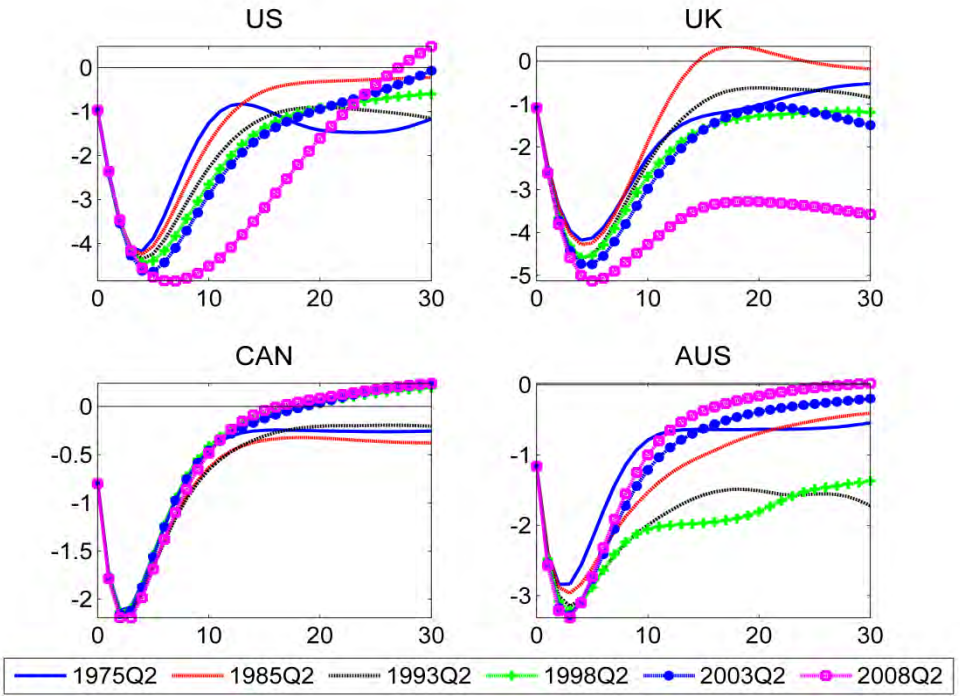
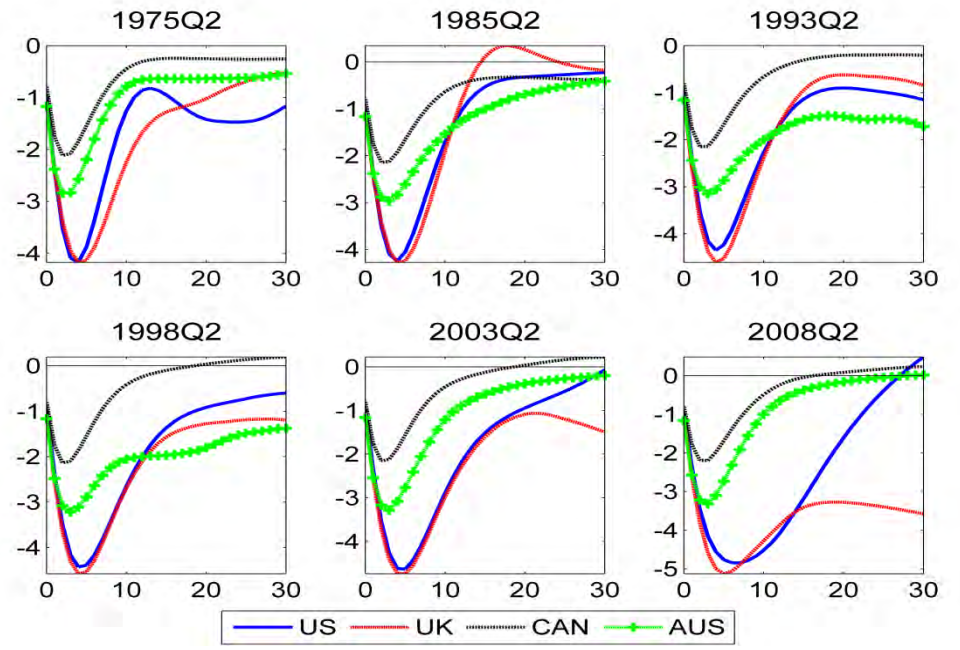


Figure 4.11 Posterior means of the policy responses to a one percentage point increase in unemployment at six specific time points across countries

(Unit: percentage point; 30-quarter horizon)



4.5.1.2 Monetary policy reactions to inflation

Figures 4.12 and 4.13 show the posterior means of the policy rate reactions to a one percentage point increase in inflation in the four countries for the whole 30-quarter horizon and at the 4^{th}, 8^{th}, and 12^{th} quarters. Table 4.5 provides pairwise correlations of these policy rate responses across countries. From Figures 4.12 and 4.13 and Table 4.5, some key patterns can be observed.

First, the movements of the policy rate reactions to inflation seem not to be similar across the countries. Before the GFC, the policy rate responses in the US and UK are different compared to the ones in Canada and Australia. The pairwise correlation coefficients between the US and UK are significantly positive at the 4^{th}, 8^{th}, and 12^{th} quarters, as are the correlations between Canada and Australia. However, the policy rate reactions of the two groups negatively correlate.

Second, although the changes in the monetary policy reactions are not similar across countries, it seems that the policy rate responds to inflation shocks in an expected way in all countries. An increase in inflation is followed by an increase in the policy rate. The policy rate remains below its steady level at all 4^{th}, 8^{th}, and 12^{th} quarters.

Third, the US might show the most aggressive monetary policy reactions to inflation. For the whole period, the policy rate in the US appears to react most strongly to inflation, at all of the three specific horizons (4^{th}, 8^{th}, and 12^{th} quarters). This pattern might relate to the fact that the US is the only country in this analysis that has not moved to an inflation-targeting regime. However, this hypothesis requires further study to be formally confirmed.

Notice that the assumption of a one percentage point increase in inflation is being imposed. During the recent GFC, inflation was not an issue in developed countries

(unlike in some Asian developing countries; see, for example Tang, 2014). Therefore the term 'inflation' here should be understood as 'inflation or deflation'. Becoming more aggressive against deflation means the policy rate declines by a higher margin when price levels drop. As King (1994, 2002) suggests, deflation is as bad as inflation in certain circumstances, therefore central banks should also be as aggressive against severe deflation as they should be against high inflation.

Figure 4.14 illustrates the posterior means of the monetary policy reactions to inflation at the (combined) six time points in each of the four countries, while Figure 4.15 shows the posterior means of the monetary policy reactions (combined) across the countries at each of the six time points. Figures 4.14 and 4.15 support the main features of Figures 4.12 and 4.13 and Table 4.5. In response to a one percentage point increase in inflation, the policy rate increases immediately and remains higher than its steady level over long horizons. Figures 4.14 and 4.15 also seem to emphasise the high level of aggressiveness of the monetary policy reactions in the US, which appears to stand out compared to the other countries.

The more aggressive monetary policy against inflation over time in the US is similar to what has been found by Judd and Rudebusch (1998), Clarida *et al.* (2000), Cogley and Sargent (2001, 2003), Lubik and Schorfheide (2004), and Primiceri (2005).

In general, there are comovements in the monetary policy reactions to unemployment across countries at the short horizons. However, the movements of the monetary policy reactions to inflation are not so similar and seem to be divided into two groups. The policy rate seems to react expectedly to changes in inflation and unemployment. The policy rate appears to respond more aggressively over time to

changes in unemployment, and the US demonstrates the more aggressive policy reactions to inflation than the three inflation-targeting countries.

The more aggressive trend of monetary policy might reflect the fact that central banks have become more independent over time. Furthermore, it might also be because central banks switched from money and credit growth targets to using interest rates as their primary policy instrument after the oil price shocks in the 1970s (Labonte, 2014).

Figure 4.12 Posterior means of the policy rate responses to a one percentage point increase in inflation, 1971Q2–2011Q4 (30-quarter horizon)

(Unit: percentage point)

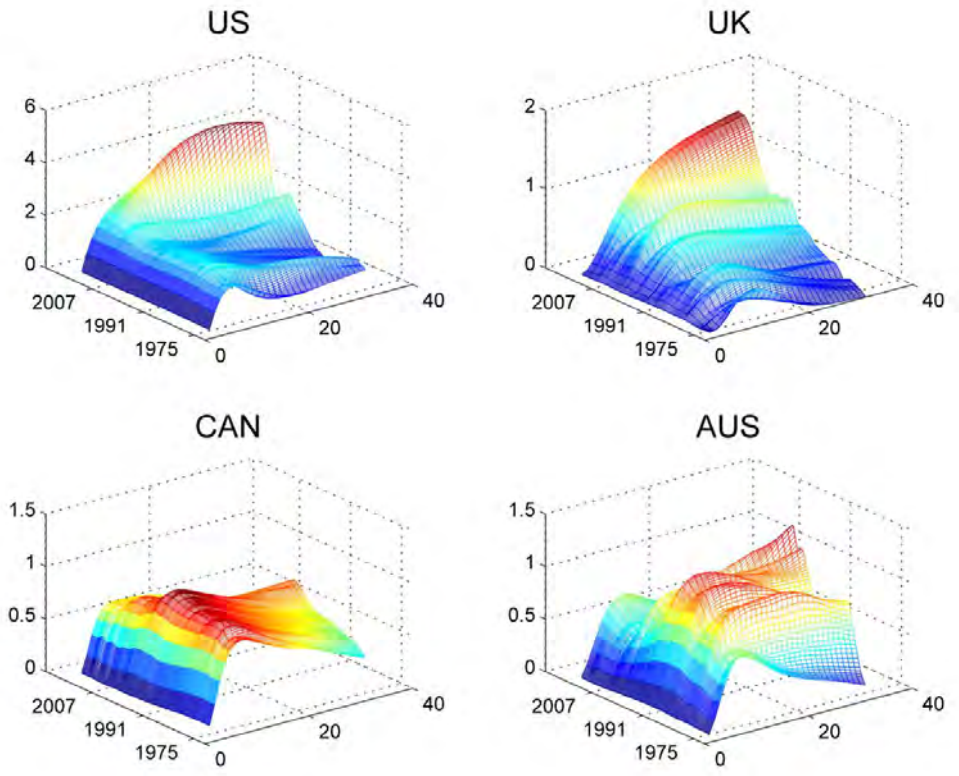
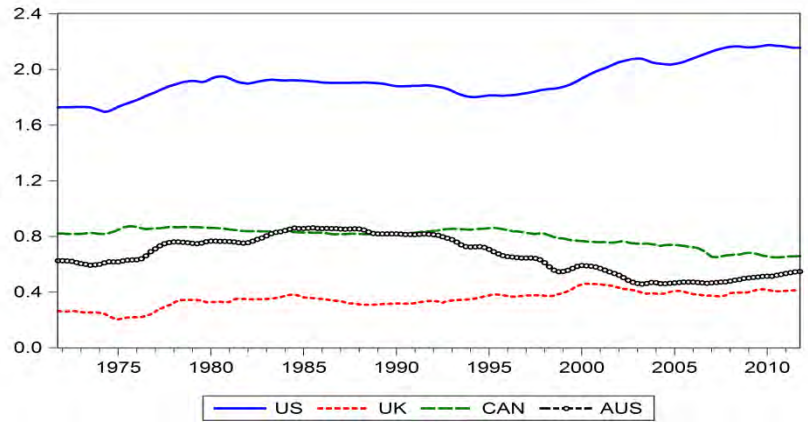


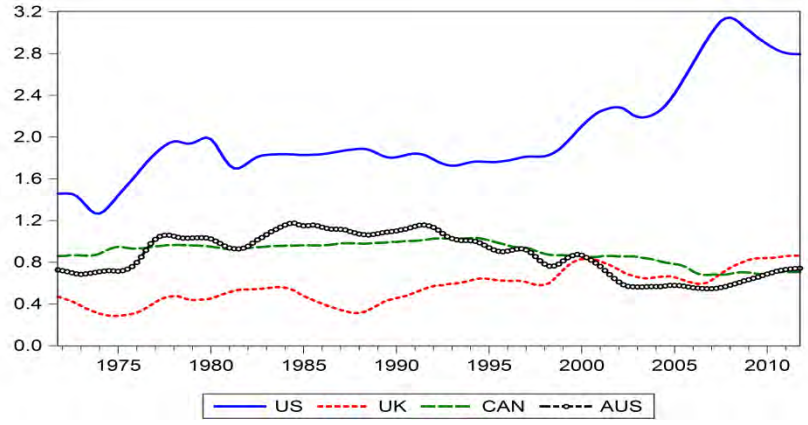
Figure 4.13 Posterior means of the policy rate responses to a one percentage point increase in inflation, 1971Q2–2011Q4 (at 4th, 8th, 12th quarters)

(Unit: percentage point)

4th quarter



8th quarter



12th quarter

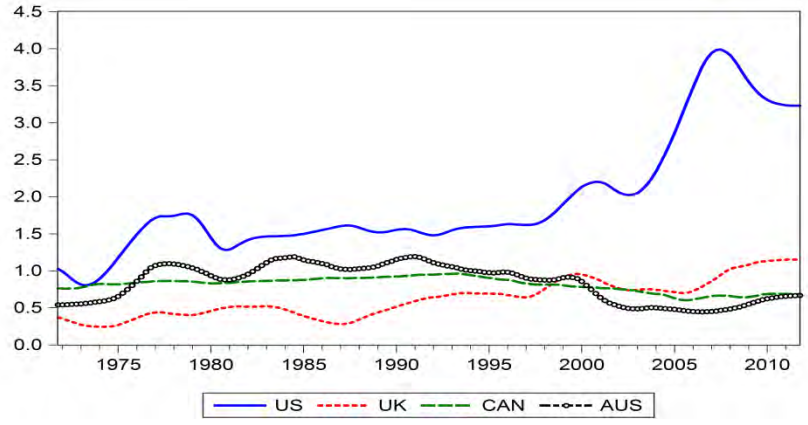


Table 4.5 Pairwise correlation of the policy rate responses to a one percentage point increase in inflation, 1971Q2–2011Q4

Time	Country	1971Q2–2007Q2			2007Q3–2011Q4		
		US	**UK**	**CAN**	**US**	**UK**	**CAN**
4th quarter	**US**	X			X		
	UK	***0.71*****	X		-0.41*	X	
	CAN	-0.72***	-0.55***	X	***0.77*****	-0.10	X
	AUS	-0.34***	-0.30***	***0.71*****	0.11	-0.28	***0.47*****
8th quarter	**US**	X			X		
	UK	***0.56*****	X		***0.63*****	X	
	CAN	-0.65***	-0.36***	X	***0.92*****	***0.65*****	X
	AUS	-0.40***	-0.32***	***0.85*****	-0.99***	-0.54**	-0.88***
12th quarter	**US**	X			X		
	UK	***0.63*****	X		***0.80*****	X	
	CAN	-0.67***	-0.37***	X	***0.96*****	***0.66*****	X
	AUS	-0.45***	-0.27***	***0.88*****	-0.99***	-0.74***	-0.98***

Notes: ***, **, * denote significance at 1%, 5%, and 10% respectively; significantly positive correlations are in bold italics; 'X' = '1.00***'.

Figure 4.14 Posterior means of the policy rate responses to a one percentage point increase in inflation across six specific time points

(Unit: percentage point; 30-quarter horizon)

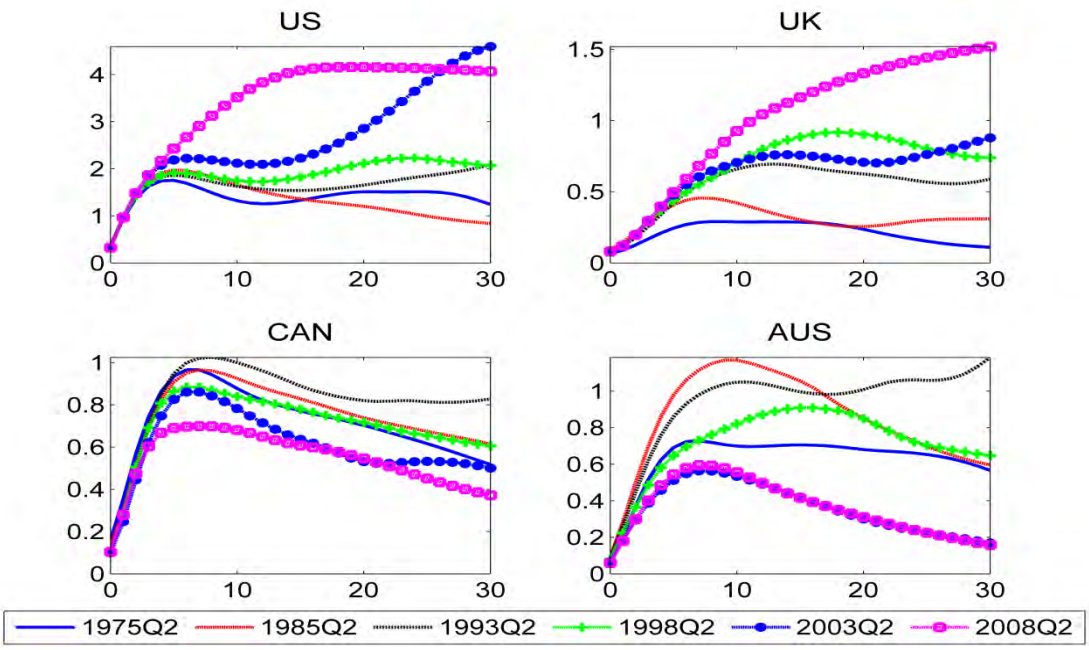
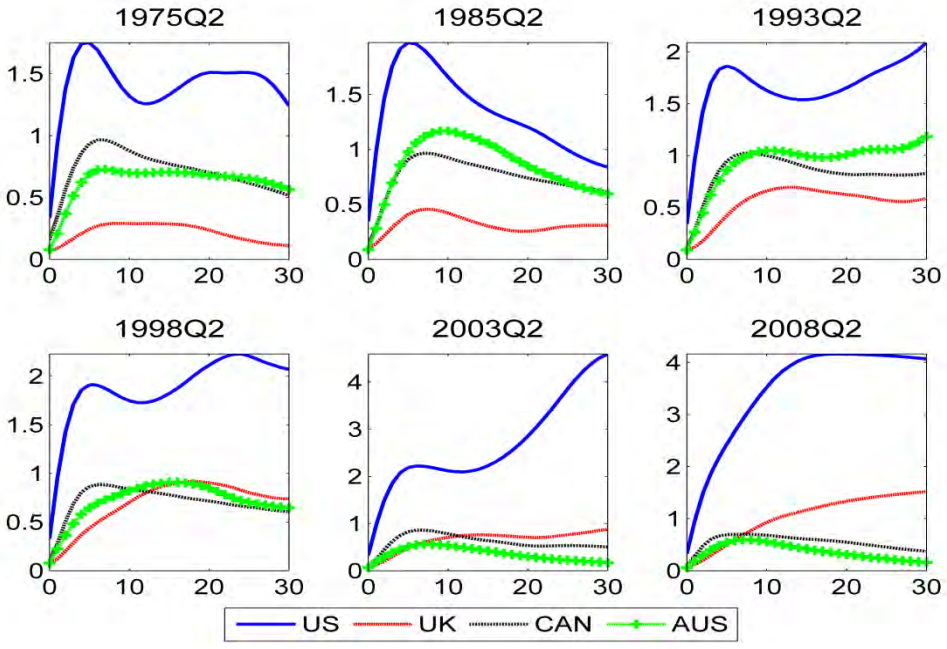


Figure 4.15 Posterior means of the policy rate responses to a one percentage point increase in inflation at six specific time points across countries

(Unit: percentage point; 30-quarter horizon)



4.5.2 How monetary transmission has changed over time across countries

I now turn to answering the question of how the effects of monetary policy shocks on inflation and unemployment have changed over time in the four developed countries. The first step is to observe the monetary policy shocks in the countries obtained from the TVP-VARs. The next step is to examine the impulse responses of unemployment and inflation to monetary policy shocks, assuming the same-size policy rate shocks across countries.

4.5.2.1 Monetary policy shocks

As argued by Primiceri (2005), in the setup of the parsimonious TVP-VAR models, it seems natural to measure the relative importance and changes of monetary policy shocks by the time varying standard deviations of the residuals of the policy rate equation. Figure 4.16 shows the posterior means together with 95% confidence intervals of this policy shocks measure in the four countries.

It is observable from Figure 4.16 that the variance of the policy rate shocks was high during the times of oil price shocks (middle 1970s and early 1980s), but has remained small since the mid-1980s in the US, the early 1990s in the UK and Australia, and the late 1990s in Canada, only picking up slightly during the recent GFC (specifically 2008Q4 or 2009Q1). The generally-decreasing standard deviation of the policy rate shocks might reflect the fact that central banks have become more independent over time, reacting more sensitively to changes in unemployment and inflation, therefore there are not many chances for 'monetary policy mistakes' or 'unpredicted policy shocks' over time in the TVP-VAR system that already includes unemployment and inflation. In other words, Taylor-type rules might closely

approximate monetary policy reactions in the four countries during the Great Moderation (see, for example, Primiceri, 2005).

Particularly in the US, the standard deviations of the policy rate residuals exhibit a substantially high variance of monetary policy shocks for the period 1979–1983 (under the Volcker chairmanship of the Federal Reserve). This pattern is consistent with what is found by Bernanke and Mihov (1998), Sims (1999, 2001), Sims and Zha (2006), Primiceri (2005), and Canova and Gambetti (2009).

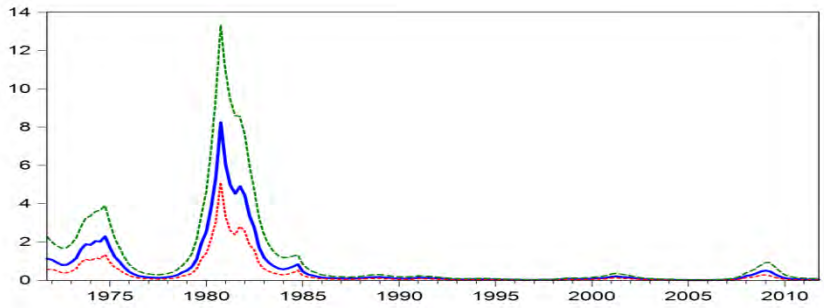
Table 4.6 shows the pairwise correlations of the standard deviations of the policy rate residuals. All the correlation coefficients are significantly positive, ranging from 0.24 to 0.71. The correlations suggest that there are comovements in the policy rate shocks across countries over time. However, as Figure 4.16 suggests, the size of the policy rate shocks seem to become smaller in the later part of the period.

Next I turn to comparing the effects of the policy rate on unemployment and inflation across the countries. In order for the impulse responses to be comparable across countries, same-size policy rate shocks are imposed. The policy shocks are assumed to be a 25 basis point temporary increase in the policy interest rate for all countries.

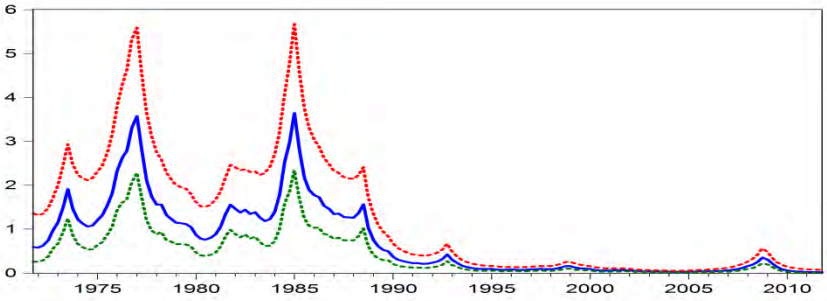
Figure 4.16 Posterior standard deviations of residuals of the policy rate equations, 1971Q2–2011Q4

(Unit: percentage point)

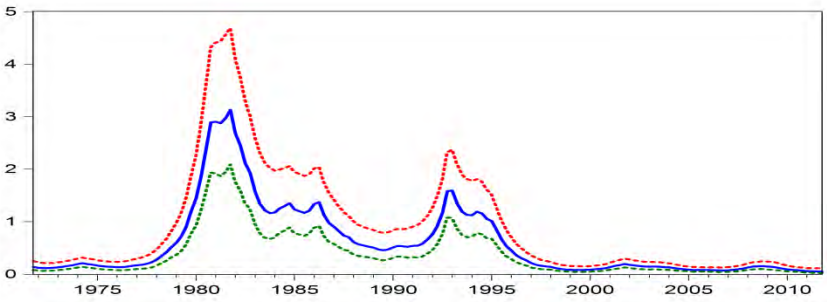
US



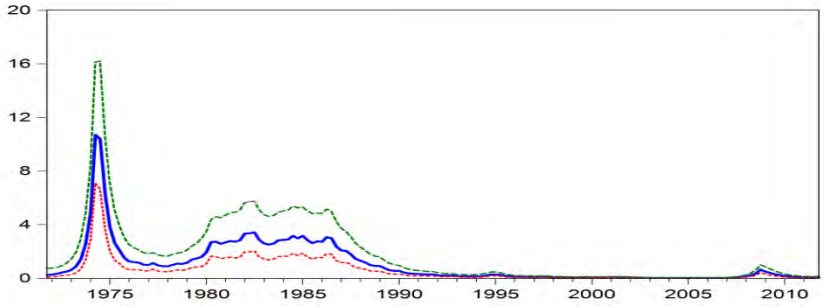
UK



Canada



Australia



Notes: Solid lines: posterior means; dashed lines: 95% confidence intervals.

Table 4.6 Pairwise correlation of the standard deviations of residuals of the policy rate equations, 1971Q2–2011Q4

Country	US	UK	CAN	AUS
US	X			
UK	0.24***	X		
CAN	0.71***	0.30***	X	
AUS	0.52***	0.54***	0.39***	X

Notes: ***, **, * denote significance at 1%, 5%, and 10% respectively; 'X' = '1.00***'.

4.5.2.2 Unemployment responses

The posterior means of the unemployment impulse responses to a 25 basis point increase in the policy rate are shown in Figure 4.17 (for the whole 30-quarter horizon) and Figure 4.18 (at the 4th, 8th, and 12th quarters). Table 4.7 shows the pairwise correlations of the unemployment responses at the 4th, 8th, and 12th quarters. Some features can be observed from Figures 4.17 and 4.18 and Table 4.7.

First, comovements in the unemployment responses to the policy shocks across countries exist for the pre-GFC period, especially over short horizons. All of the correlation coefficients at the 4th and 8th quarters are significantly positive, ranging from 0.26 to 0.95. Most of the correlations at the 12th quarter are also significantly positive. The correlation coefficients have not been so high since the GFC.

Second, in general, unemployment seems to respond expectedly to the policy shocks. Unemployment increases in response to a 25 basis point shock in the policy rate. However, the responses are observed to be slightly declining over time. This pattern is reflected in the downward trend of the unemployment responses.

When the six chosen time points are considered in Figures 4.19 and 4.20, the key features seen in Figures 4.17 and 4.18 can also be observed. There were comovements in the unemployment impulse response functions across the countries at the five earlier time points (pre-GFC). The responses at the last time point of 2008Q2 show dissimilarities. In response to a 25 basis point increase in the policy rate, unemployment increases by 0.15–0.2 percentage points at peak. However, the responses seem to decline for the more recent time points.

Primiceri (2005) reports a similar finding of a declining trend in the monetary policy effects on unemployment in the US. Using output rather than unemployment, Boivin and Giannoni (2006) and Gali and Gambetti (2009) also find decreasing output responses to policy rate shocks for the case of the US.

Figure 4.17 Posterior means of unemployment responses to a 25 basis point increase in the policy rate, 1971Q2–2011Q4 (30-quarter horizon)

(Unit: percentage point)

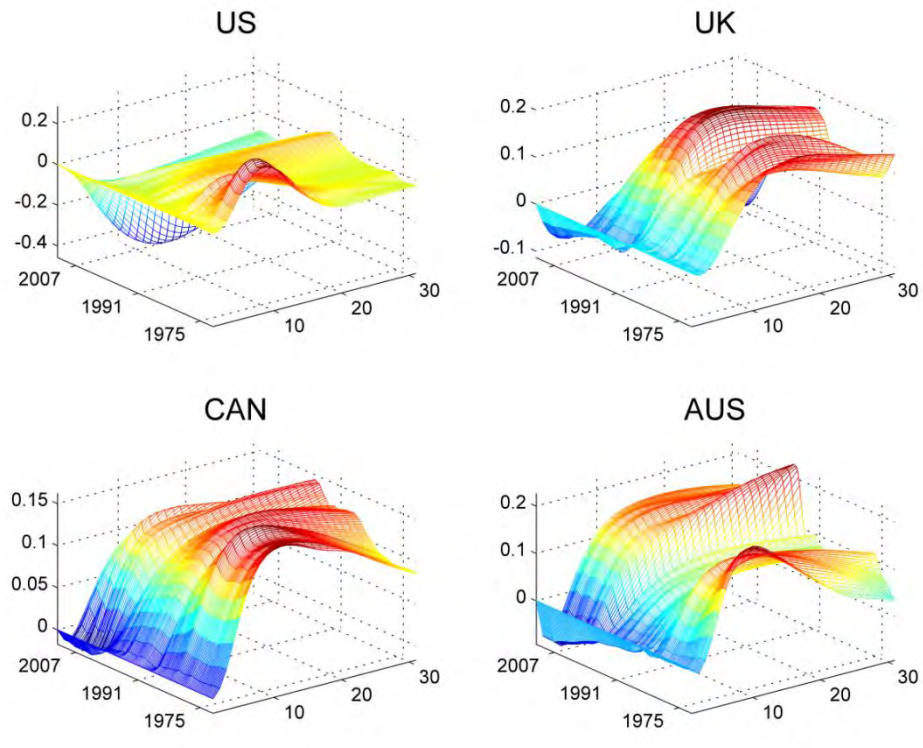
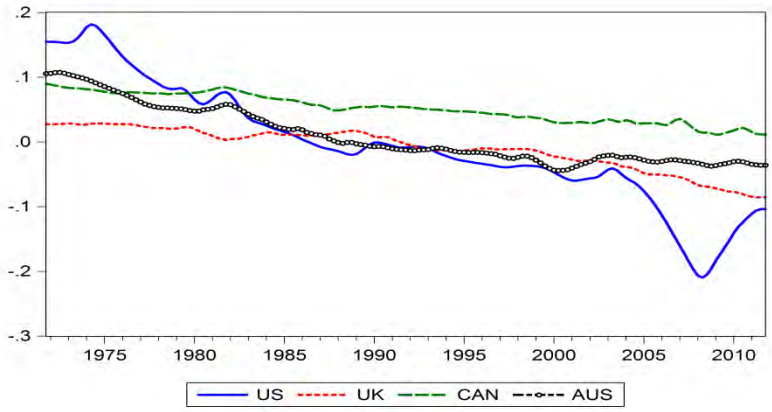


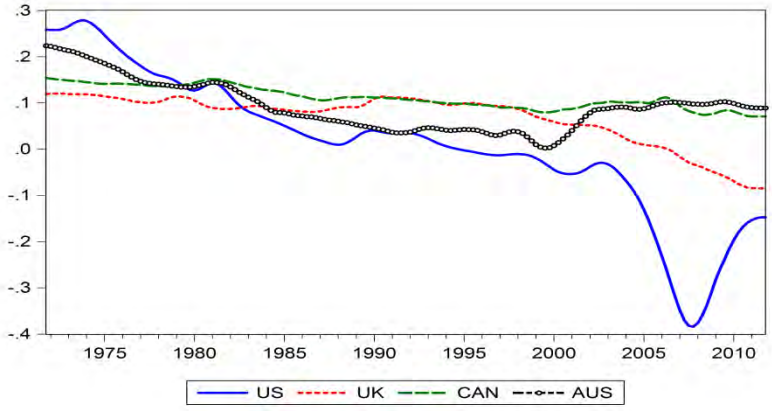
Figure 4.18 Posterior means of unemployment responses to a 25 basis point increase in the policy rate, 1971Q2–2011Q4 (at 4th, 8th, 12th quarters)

(Unit: percentage point)

4th quarter



8th quarter



12th quarter

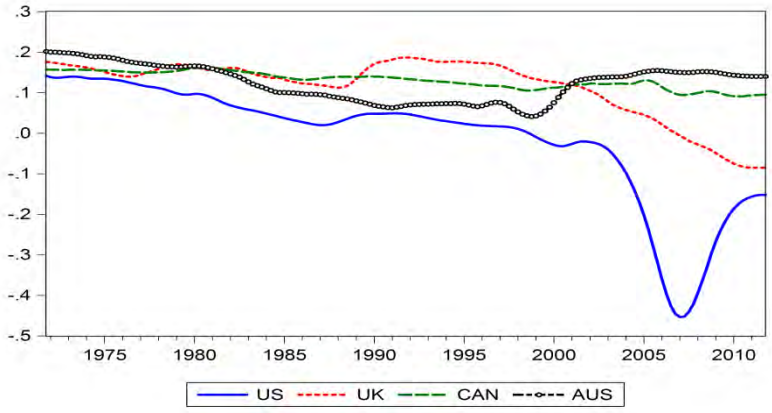


Table 4.7 Pairwise correlation of unemployment responses to a 25 basis point increase in the policy rate, 1971Q2–2011Q4

Time	Country	1971Q2–2007Q2			2007Q3–2011Q4		
		US	**UK**	**CAN**	**US**	**UK**	**CAN**
4th quarter	**US**	X			X		
	UK	***0.88******	X		***0.84******	X	
	CAN	***0.91******	***0.88******	X	0.17	0.40	X
	AUS	***0.95******	***0.82******	***0.95******	0.08	-0.09	-0.92
8th quarter	**US**	X			X		
	UK	***0.84******	X		***0.90******	X	
	CAN	***0.78******	***0.51******	X	***0.68******	***0.50*****	X
	AUS	***0.66******	***0.26******	***0.88******	-0.59***	-0.39	-0.99***
12th quarter	**US**	X			X		
	UK	***0.86******	X		***0.85******	X	
	CAN	***0.71******	***0.49******	X	***0.94******	***0.71******	X
	AUS	0.11	-0.19**	***0.59******	-0.89***	-0.63***	-0.99***

Notes: ***, **, * denote significance at 1%, 5%, and 10% respectively; significantly positive correlations are in bold italics; 'X' = '1.00***'.

Figure 4.19 Posterior means of unemployment responses to a 25 basis point increase in the policy rate across six specific time points

(Unit: percentage point; 30-quarter horizon)

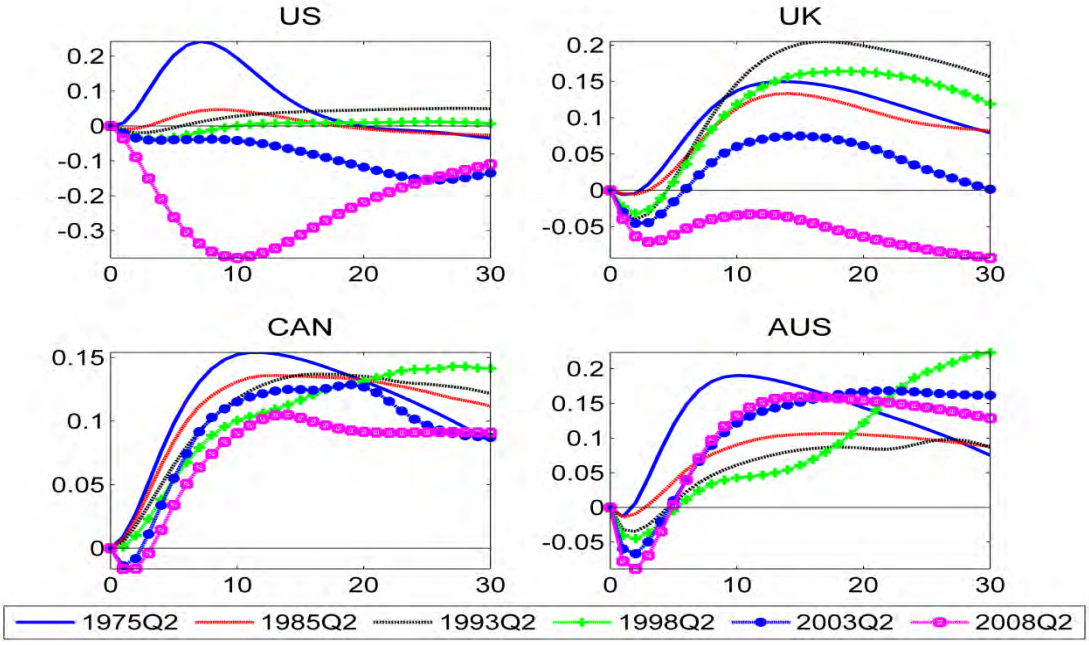
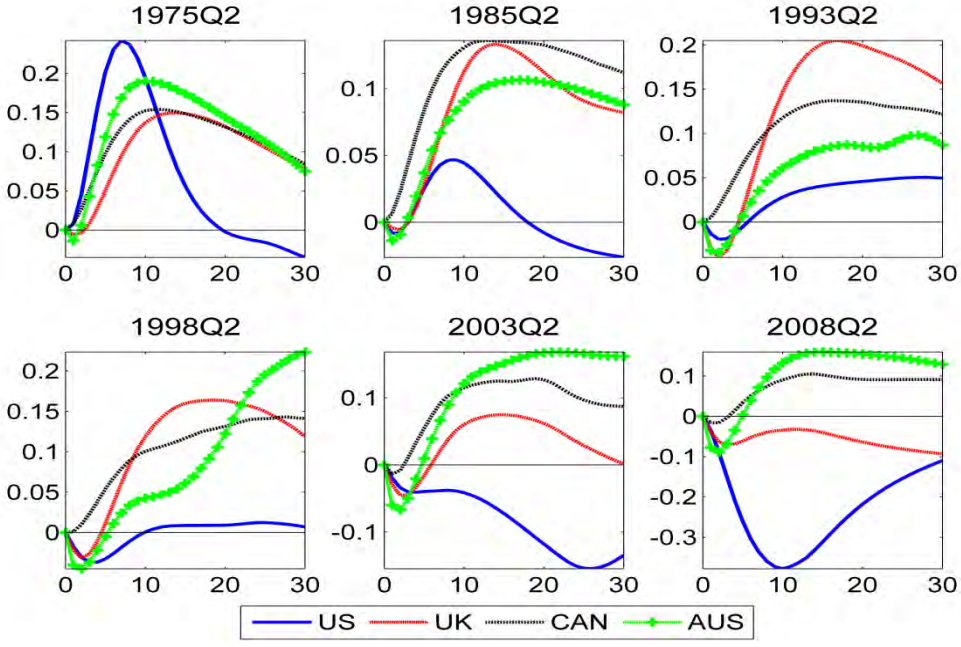


Figure 4.20 Posterior means of unemployment responses to a 25 basis point increase in the policy rate at six specific time points across countries

(Unit: percentage point; 30-quarter horizon)



4.5.2.3 Inflation responses

Figures 4.21 and 4.22 show the posterior means of the inflation impulse responses to a 25 basis point increase in the policy rate for the whole 30-quarter horizon and at the 4^{th}, 8^{th}, and 12^{th} quarters. Table 4.8 provides the pairwise correlations of these responses for the pre-GFC period and since the GFC. Two key features are observed.

First, there were comovements in the inflation responses across countries for the pre-GFC period, especially at the 8^{th} and 12^{th} quarters. All the correlation coefficients are significantly positive at the 8^{th} and 12^{th} quarters, ranging from 0.71 to 0.91. The correlation coefficients are much lower since the GFC.

Second, it seems that the effects of the policy rate shocks on inflation were faster and stronger during the 1970s and 1980s and became slower and weaker during recent periods. This is evidenced by the upward trend in the inflation responses shown in Figures 4.21 and 4.22.

In addition, the 'price puzzle' is observed for all countries, which might relate to the possible misspecification of the parsimonious 3- or 4-variable TVP-VAR models in this chapter.[30] Baumeister *et al.* (2013) find little evidence of the 'price puzzle' for US data using a time-varying factor-augmented VAR model. Li *et al.* (2013) suggest that the 'price puzzle' might be reduced with inclusions of the output gap and direct measures of expectations (such as survey measures of expected future inflation and output growth), which are outside the scope of this chapter. However, the 'price puzzle'

[30] Adding the oil price or commodity price helps decrease the price puzzle only for the US, while the number of parameters increases exponentially, requiring tighter priors for the estimation to be efficiently runnable. Therefore, I decided to accept the price puzzle in order for the estimations to be comparable across the countries. Further explorations are needed to solve this issue completely.

might reaffirm the existence of a 'cost channel', or 'supply-side effects' in the monetary transmission mechanism as suggested by Barth and Ramey (2001), Ravenna and Walsh (2006), Chowdhury *et al.* (2006), Christiano *et al.* (2005), Gaiotti and Secchi (2006), Tillman (2008, 2009), and Ali and Anwar (2013). For the case of the US, Primiceri (2005) also finds the price puzzle using earlier data.

The posterior means of the inflation responses to policy shocks at the six chosen time points are shown in Figures 4.23 and 4.24. These figures are supportive of the above key observations. The responses indicate stronger effects of policy rate shocks on inflation at earlier time points, while the effects seem to decline at more recent time points in the four countries. The result of a weakening effect of monetary policy shocks on inflation in the US is similar to the findings of Primiceri (2005), Boivin and Giannoni (2006), and Gali and Gambetti (2009).

Compared to Primiceri's (2005) results, the time-point unemployment and inflation responses estimated in this chapter seem to be more time-variant. This difference might be explained by the fact that this chapter uses more time points, spread out over the whole period, while Primiceri (2005) uses only three time points corresponding to the three different chairmanships of the Federal Reserve.

Figure 4.21 Posterior means of the inflation responses to a 25 basis point increase in the policy rate, 1971Q2–2011Q4 (30-quarter horizon)

(Unit: percentage point)

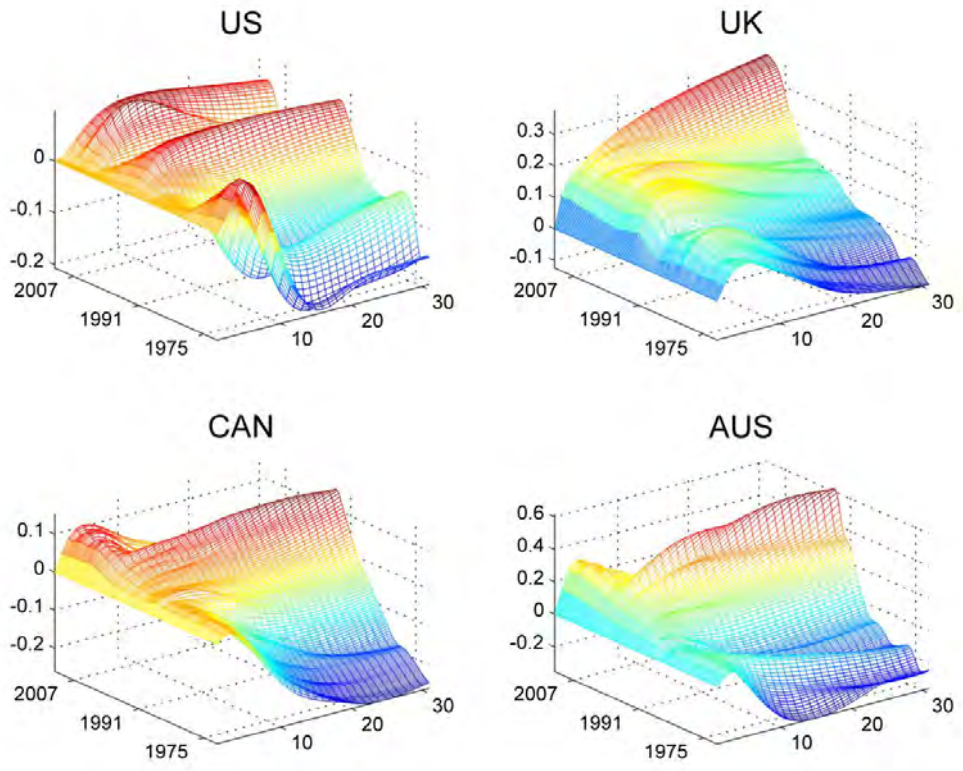
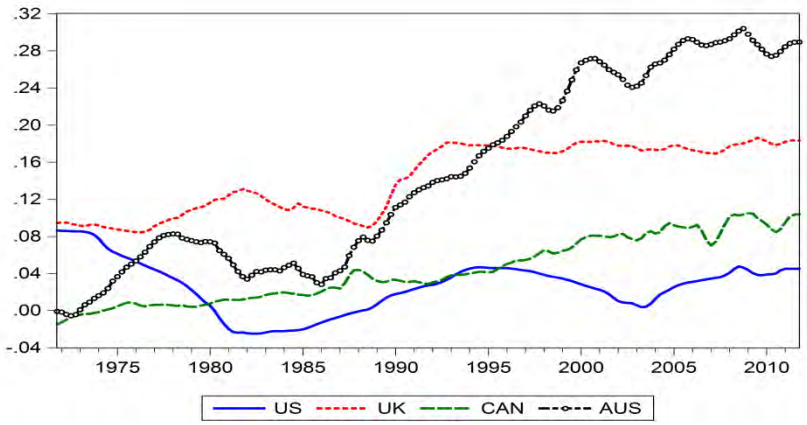


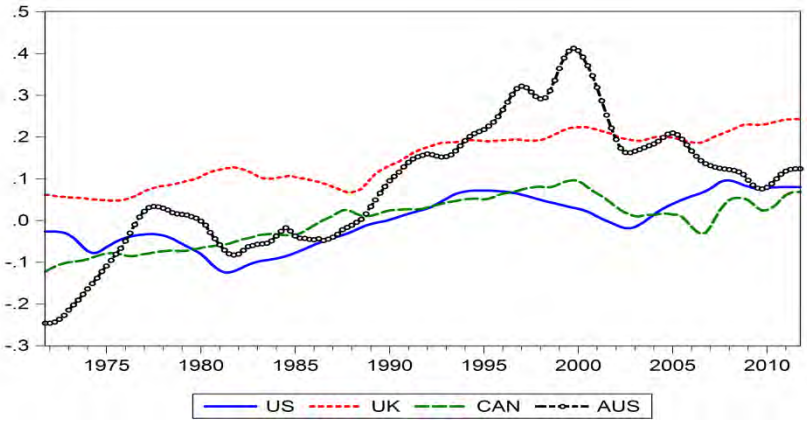
Figure 4.22 Posterior means of the inflation responses to a 25 basis point increase in the policy rate, 1971Q2–2011Q4 (at 4th, 8th, 12th quarters)

(Unit: percentage point)

4th quarter



8th quarter



12th quarter

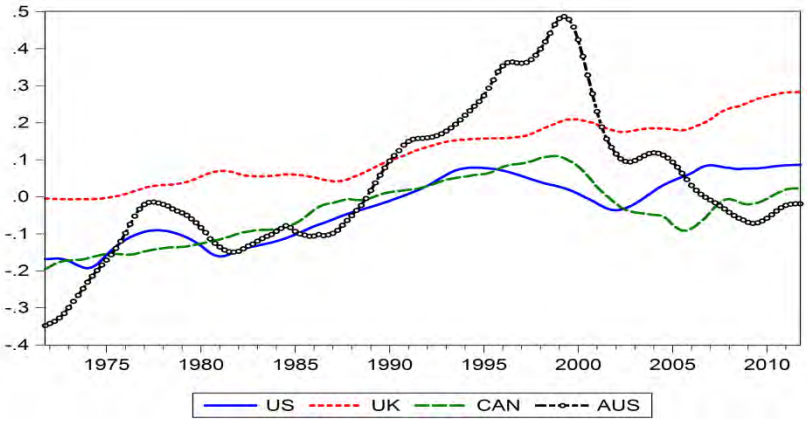


Table 4.8 Pairwise correlation of inflation responses to a 25 basis point increase in the policy rate, 1971Q2–2011Q4

Time	Country	1971Q2–2007Q2			2007Q3–2011Q4		
		US	**UK**	**CAN**	**US**	**UK**	**CAN**
4th quarter	**US**	X			X		
	UK	0.01	X		***0.70******	X	
	CAN	-0.11	***0.82*****	X	-0.13	***0.54****	X
	AUS	0.06	***0.88*****	***0.95*****	***0.53****	***0.61*****	0.30
8th quarter	**US**	X			X		
	UK	***0.72*****	X		***0.68*****	X	
	CAN	***0.71*****	***0.83*****	X	-0.14	***0.50****	X
	AUS	***0.76*****	***0.91*****	***0.89*****	***0.63*****	0.06	-0.79***
12th quarter	**US**	X			X		
	UK	***0.90*****	X		***0.82*****	X	
	CAN	***0.83*****	***0.76*****	X	0.28	***0.75*****	X
	AUS	***0.82*****	***0.81*****	***0.86*****	***0.88*****	***0.93*****	***0.66*****

Notes: ***, **, * denote significance at 1%, 5%, and 10% respectively; significantly positive correlations are in bold italics; 'X' = '1.00***'.

Figure 4.23 Posterior means of the inflation responses to a 25 basis point increase in the policy rate across six specific time points

(Unit: percentage point; 30-quarter horizon)

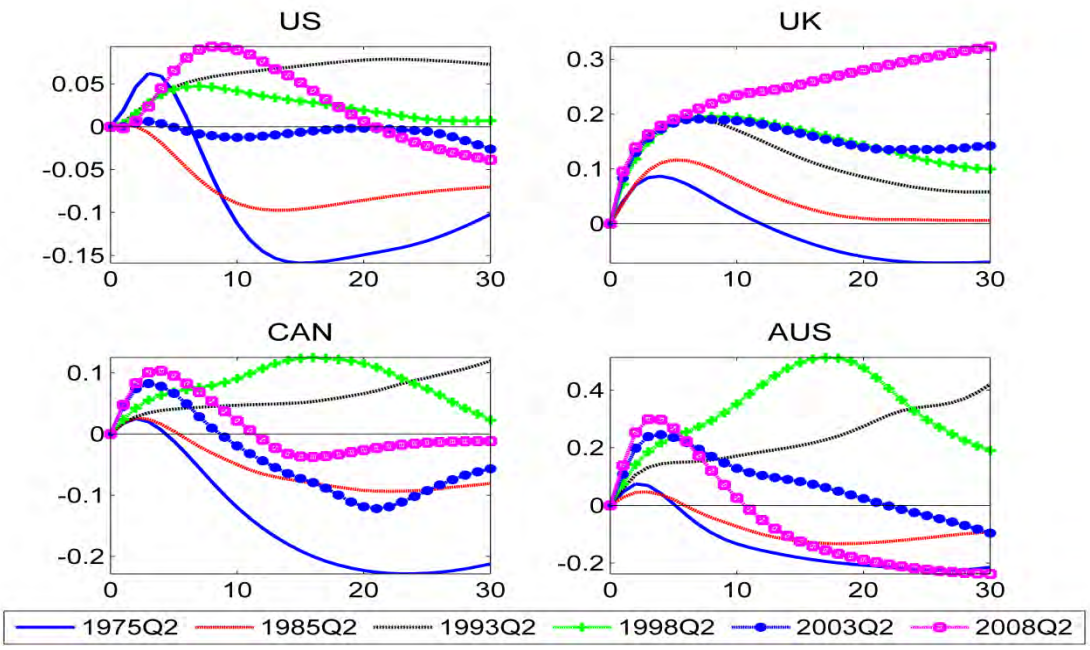
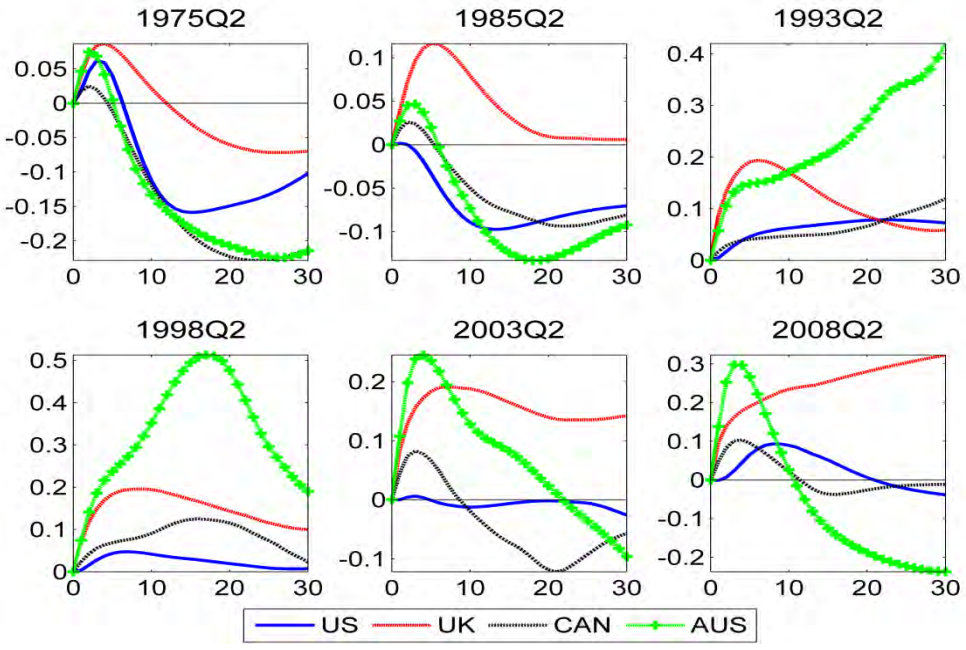


Figure 4.24 Posterior means of the inflation responses to a 25 basis point increase in the policy rate at six specific time points across countries

(Unit: percentage point; 30-quarter horizon)



In general, there were comovements in the effects of the policy rate shocks on unemployment and inflation across the countries for the pre-GFC period. Since the GFC, the responses are less similar. The movements of unemployment responses are more similar at short-run horizons, while the movements of inflation responses are similar over longer horizons. This pattern might be consistent with the consensus of slower responses of sticky prices compared to output/unemployment for VARs with monetary policy emphasis (see, for example, Christiano *et al.*, 1999).

The policy shock effects on both unemployment and inflation seem to decline over time. This pattern is consistent with the finding by Primiceri (2005), Boivin and Giannoni (2006), and Gali and Gambetti (2009) for the US.

4.6 Conclusion

This chapter examines the changes of monetary policy and monetary transmission over time in four developed countries (the United States, the United Kingdom, Canada, and Australia) using time-varying vector autoregression (TVP-VAR) models. The results suggest that:

i) There were comovements in the monetary policy reactions against unemployment before the GFC. The policy interest rate seems to have become more aggressive against unemployment over time in the four countries, especially in the US and UK.

ii) Monetary policy reactions to inflation/deflation are observed to be divided into two groups, with the responses in the US and UK showing a different pattern to the responses in Canada and Australia. Monetary policy seems to be most

aggressive against inflation/deflation in the US – the only non-inflation-targeting country among the four.

iii) There are comovements in the effects of monetary policy on unemployment and inflation across countries, with these effects appearing to have become weaker over time.

The results of this chapter might help shed light on the practice of monetary policy transmission. Knowing the similarities and dissimilarities of monetary transmission across countries might help central banks better understand the extent to which monetary policy has contributed to the dynamics of important macroeconomic variables such as unemployment and inflation.

The limitations of the parsimonious TVP-VARs suggest the possibility of expanding the models to bigger ones with more variables and structural relations to provide a further analysis on the reasons behind the comovements and differences between the countries. However, doing so might raise some technical issues, since the number of parameters to be estimated would increase exponentially, which in turns require tighter priors for the TVP-VAR to be estimated correctly. Another possible direction is to impose theory-consistent sign restrictions into the TVP-VARs to avoid the price puzzle and other unexpected responses. The investigation in this chapter might also be expanded to cover other countries, especially for the European area when time series of data under the European Central Bank regime become long enough for a TVP-VAR analysis.

It could also be useful to know whether there are micro-level explanations for the comovements in monetary policy transmission across countries. However, a detailed

analysis of this type might require a highly structural model as well as micro-level data rather than a small TVP-VAR system like the one used in this chapter.

Furthermore, as Orphanides (2001), Croushore and Evans (2006), and Lee *et al.* (2012) suggest, real-time data (the data that were available at the time the policy decisions were made) should ideally be used when estimating monetary policy reaction functions. The exercises in this chapter could be re-done when such real-time databases are available for all countries of interest.

CHAPTER 5

THE DETERMINANTS OF INFLATION IN VIETNAM: VAR AND SVAR APPROACHES

Summary: This chapter employs vector autoregression (VAR) and structural VAR (SVAR) models to analyse Vietnam's inflation determinants using quarterly data from 1996 to 2012. The results suggest that: (*i*) inflation responses to monetary policy shocks are plausible and similar to standard monetary transmission in advanced economies; (*ii*) the policy interest rate plays an important role in affecting inflation, which differs with what has been found in previous studies for Vietnam; and (*iii*) shocks to output and prices in trading partners have strong effects on inflation in Vietnam, while international oil and rice prices seem not to systematically affect Vietnam's inflation. The State Bank of Vietnam does appear to use monetary policy tools to ease inflationary pressure caused by foreign factors.

5.1 Introduction

Vietnam is a developing transitional economy that has experienced some periods of high inflation. Understanding the macroeconomic determinants of inflation is important to better control of inflation in Vietnam. This chapter aims to analyse the macroeconomic determinants of inflation in Vietnam using vector autoregression (VAR) and structural VAR (SVAR) models, emphasising the role of monetary policy.

There are three key results. First, inflation responds expectedly to monetary policy shocks. Second, the policy interest rate plays an important role in explaining inflation

variation. Third, trading partners' GDP and prices have strong effects on Vietnam's inflation.

The first two findings contrast with results from previous studies on inflation determinants for the case of Vietnam. Previous research (Le and Pfau, 2009; Nguyen and Nguyen, 2010; Bhattacharya, 2014) shows either insignificant or unexpected inflation response functions that are nowhere near the standard impulse response function shapes found for developed countries (see, for instance, Christiano *et al.*, 1999, 2005 for the US; Dungey and Pagan, 2000, 2009 for Australia) or other developing countries (see, for example, Disyatat and Vongsinsirikul, 2003 for Thailand, Tang, 2006a, 2006b for Malaysia, Aleem, 2010 for India). Meanwhile, this chapter employs a longer period of data and provides expected impulse response functions of inflation to monetary policy shocks.

Previous studies provide different results regarding macroeconomic determinants of inflation in Vietnam. Using single-equation methods, Goujon (2006) argues that rice prices, exchange rates, and excess money play the most important roles in determining inflation. Nguyen *et al.* (2012) use the same type of single equation methods to argue that inflation persistence, 2-lagged level of money price, and oil and rice price index are the main determinants of Vietnam's inflation. Employing either VAR or vector error correction models (VECMs), Camen (2006), IMF (2006), Le and Pfau (2009), Nguyen and Nguyen (2010), and Bhattacharya (2014) conclude differently about the main determinants of inflation in Vietnam (see the details in Appendix 5A). Nevertheless, the policy interest rate plays no role in determining inflation according to those studies. In contrast, this chapter finds that the policy interest rate is an important factor in explaining inflation variation in Vietnam.

Results from the SVAR models used in this chapter also indicate that trading partners' prices strongly affect Vietnam's inflation, as also found by Bhattacharya (2014). Furthermore, this chapter presents empirical evidence of the importance of trading partners' GDP on Vietnam's inflation. Nevertheless, international oil prices and rice prices seem not to affect domestic inflation systematically, which contrasts with the results found by Goujon (2006) and Nguyen *et al.* (2012). Moreover, the State Bank of Vietnam (SBV) does appear to use monetary policy tools to ease inflationary pressures caused by foreign GDP and price shocks.

The remainder of this chapter is structured as follows. Section 5.2 provides a background of Vietnam's inflation dynamics and monetary policy. Section 5.3 introduces the VAR and SVAR models, together with the data to be used. Section 5.4 provides the empirical results, and Section 5.5 concludes.

5.2 Vietnam's inflation and monetary policy

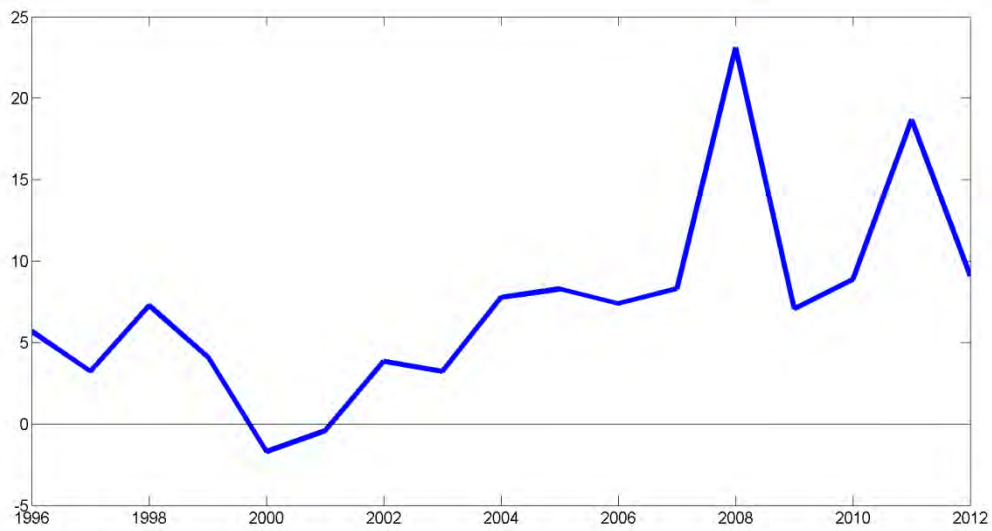
This section provides a brief background on inflation dynamics as well as the relationships between inflation and monetary policy in Vietnam.

Consumer price index (CPI) inflation is officially used for measuring the inflation rate in Vietnam.[31] Figure 5.1 shows year-on-year CPI inflation in Vietnam for the period 1996–2012. After a period of high inflation during and after '*doi moi*' (renovation) in the 1980s and early 1990s, the annual inflation rate in Vietnam remained moderate (less than 10%) during 1996–2007. Recently, however, inflation displayed strong spikes in 2008 (more than 23% per annum) and 2011 (nearly 19% per annum).

[31] Food (nearly 40%) and housing (together with housing-related items, 10%) are the biggest groups in measuring CPI. A list of current weights in the CPI basket is provided in Appendix 5B.

Figure 5.1 CPI inflation in Vietnam, 1996–2012

(*%, year-on-year*)



Sources: see Appendix 5F

Vietnam's central bank is a body of Vietnam's government. The Governor of the State Bank of Vietnam (SBV) is a member of the cabinet. Before 2011, the SBV was governed by the old Law ('Law on the State Bank of Vietnam') of 1997, which defined national monetary policy as "a component of the State's economic and financial policies aiming at stabilising the currency's value, containing inflation, contributing to improving social-economic development, ensuring state security and defence, and improving people's lives" (Vietnam National Assembly, 1997).

In 2010, a new Law was issued to replace the old Law of 1997, with a greater focus on inflation as the primary objective. According to the Law of 2010 (which is in effect from 2011), national monetary policy consists of "national-level decisions on monetary affairs made by competent state agencies, including decisions on the objective of currency value stability which is denoted by the inflation rate, and decisions on the use of tools and measures to obtain the set objective" (Vietnam National Assembly, 2010).

Although changes in the legal framework have signalled a move toward a more independent SBV – both *de jure* and *de facto* (and also toward an 'inflation targeting' central bank) – Vietnam continues to face some serious macroeconomic challenges (see, for instance, Bingham, 2010; Cargill and Nguyen, 2013). For example, credit misallocation and non-performing loans (NPLs) problems have originated from the prolonged dominance of state-owned enterprises (SOEs), most of which have been performing poorly for a long time. The undeveloped banking and credit system is under a restructuring process (see Vietnam Prime Minister, 2012), while the financial system remains highly volatile, uncertain, and vulnerable to exogenous shocks, as evidenced since 2008. Meanwhile, the SBV itself is still bound by political constraints and a lack of transparency (Bingham, 2010).

This chapter focuses on the effects of monetary policy tools on inflation rather than those recent challenges. To some extent, this chapter reviews the SBV performance in a narrow aspect: how monetary policy has transmitted to inflation during the period 1996–2012.

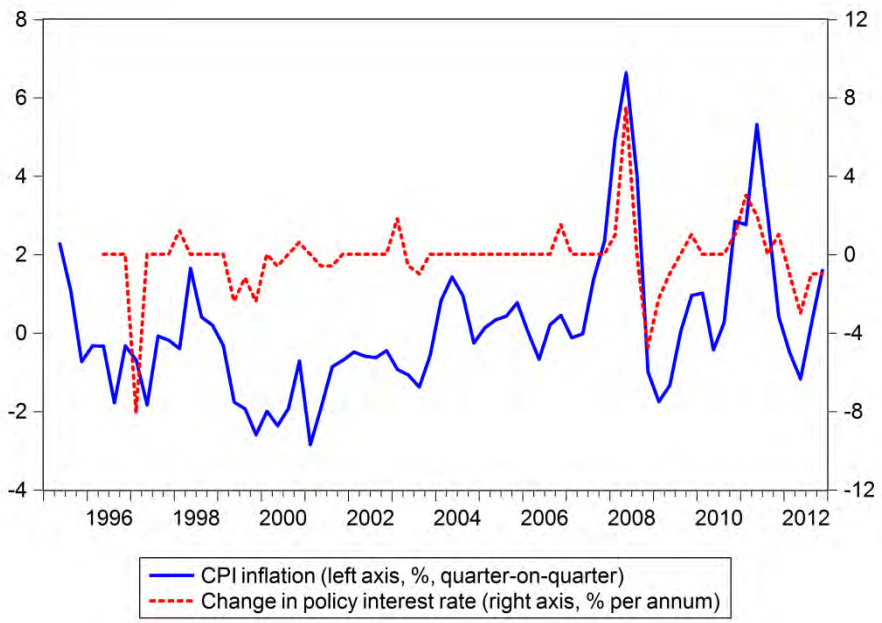
In developed countries, the policy interest rate is used as the main policy tool of central banks (as in Chapters 3 and 4 of this thesis). Meanwhile central banks in countries with underdeveloped financial systems seem to use a broader array of policy instruments than just the policy interest rate (Bingham, 2010). That is also the case for Vietnam. The SBV claims to use interest rates, the money supply target, credit growth targets, exchange rates, compulsory reserve requirements, refinancing, and open market operations (OMO) as the instruments of monetary policy (Vietnam National Assembly, 2010; SBV, 2011, 2012). Some other tools – including deposit and lending rate ceilings or floors, moral suasion, and prudential regulations – are also used.

This chapter examines the policy rate, the money supply, and aggregate credit as the main tools of monetary policy in Vietnam. This set of policy instruments is similar to the sets used in previous studies on inflation determinants in Vietnam (see, for example, Camen, 2006; Le and Pfau, 2009; Nguyen and Nguyen, 2010; Bhattacharya, 2014). The graphical relationships between these policy instruments and inflation are illustrated as follows.

Figure 5.2 shows the relationship between CPI inflation and changes in the policy interest rate in Vietnam during the period 1996–2012. It is observable that the policy interest rate and the inflation rate tend to move together, especially during recent bouts of high inflation in 2008 and 2011. This pattern suggests that the SBV does actually use the interest rate as a main policy tool to contain inflation, as the SBV argues (see SBV, 2011).

Money and credit growth (3- and 2-quarter lagged respectively) are graphed together with the inflation rate in Figure 5.3. Abnormally high peaks of more than 22% for both money and credit growth are recorded around 1999Q4 to fight against the deflation that commenced in 1999Q2. Some hikes of both money and credit growth in 2007, 2009, and 2010 suggest that money and credit growth might be the triggers of the inflation peaks in 2008 and 2011. The data also suggest that the SBV used aggressive monetary policy to curb high inflation in 2008, but then eased monetary policy just as ‘aggressively’ when the SBV observed the signals that the tightened policy might affect GDP growth. Quick loosening of monetary policy once again might be the main cause of the new hike in inflation in 2011 (see, for example, Cargill and Nguyen, 2013).

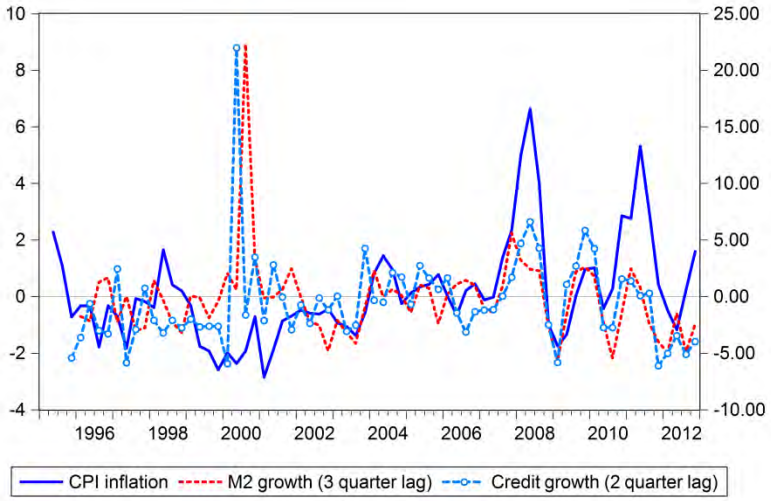
Figure 5.2 CPI inflation and changes in the policy interest rate, 1996–2012



Sources: see Appendix 5F

Figure 5.3 CPI inflation and growth in M2 and credit, 1996–2012

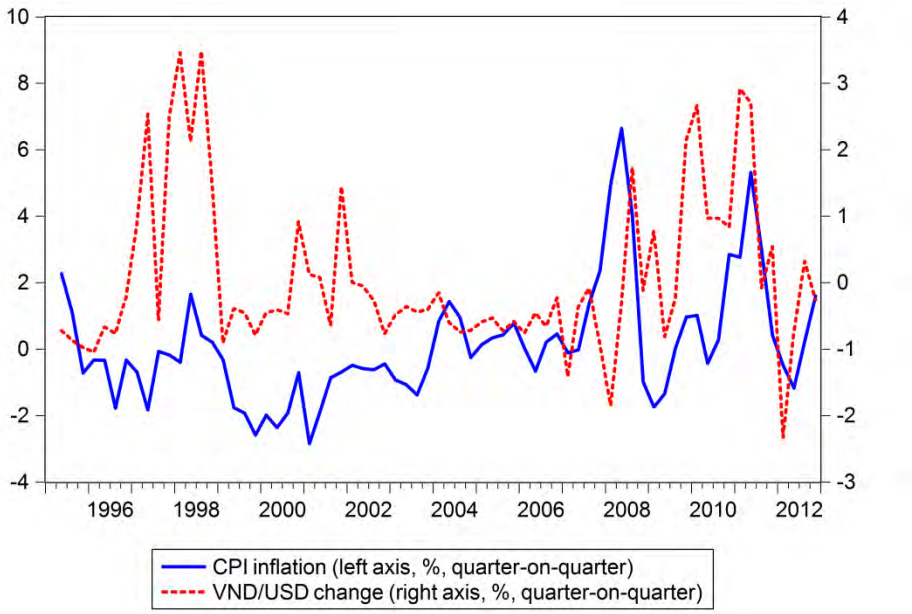
(*%, quarter-on-quarter*)



Sources: see Appendix 5F

The current exchange rate regime in Vietnam is described as a managed float. Since 1999, the SBV has not set an official rate anymore, and the daily exchange rate has been determined by the foreign exchange market. However, the SBV sets a stipulated band, and remains the major force in the market. Moreover, various forms of administrative control over the foreign exchange market are retained. For more details about Vietnam's exchange rate policy, see Nguyen and Nguyen (2009), and Takagi and Pham (2011).

Figure 5.4 CPI inflation and changes in nominal exchange rate, 1996–2012



Sources: see Appendix 5F

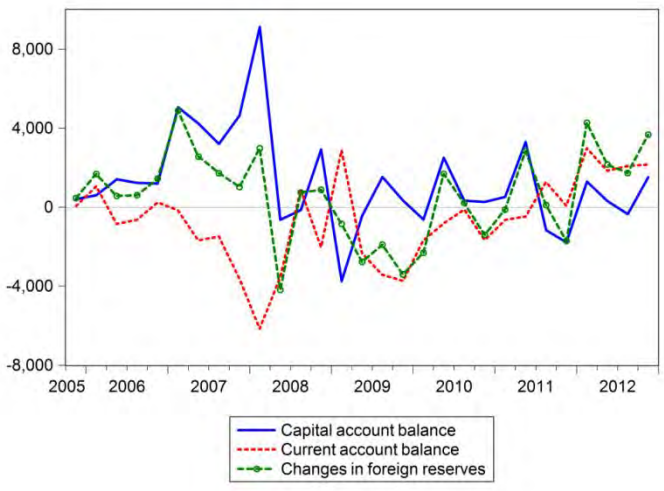
The nominal exchange rate is graphed together with CPI inflation in Figure 5.4. This figure suggests that the inflation rate and the nominal exchange rate are positively correlated. A depreciation of the Vietnam dong (VND) seems to accompany rises in inflation, although the band of variation for the VND/USD rate has been kept below 4% (quarter on quarter). Given this managed float, the exchange rate is included not as an

independent monetary policy tool, but only to cover a possible channel through which monetary policy tools (especially the policy interest rate) might affect CPI.

Regarding the recent peaks in Vietnam's inflation in 2008 and 2011, Pham and Riedel (2012, 2013) provide some evidence of the contribution of monetary policy. Since 2007, Vietnam's capital account balance has been volatile. Because of the managed exchange rate regime, the SBV is obliged to intervene in the foreign exchange market using its foreign reserves (see Figure 5.5). At the same time, the SBV must sterilise its market intervention to keep money growth within its target. Pham and Riedel (2012) argue that failures in these sterilisation efforts by the SBV have let the money supply grow unexpectedly, causing an acceleration in inflation. Within the scope of this chapter where VAR and SVAR models are used to examine the effects of monetary policy for a long period rather than just recent years, this potential channel of sterilisation affecting inflation is not investigated. This could be picked up in future research.

Figure 5.5 Balance of payments and changes in foreign reserves, 2005Q4–2012Q4

(*USD millions*)



Sources: see Appendix 5F

Apart from domestic monetary policy instruments, this chapter also analyses the effects of foreign variables on Vietnam's inflation through SVAR models. The foreign factors are explained in detail in the next section. The relationships between Vietnam's inflation and exogenous foreign factors are graphed in Appendix 5C. The correlation coefficients between Vietnam's inflation rate and changes in the domestic and foreign factors are provided in Appendix 5D.

It is observable that there are significant correlations between CPI inflation and some of the foreign and domestic variables. Nevertheless, in order to analyse the determinants of inflation for the case of Vietnam, it is necessary to explore the transmissions from shocks in foreign and domestic macro variables to domestic inflation. Using VAR and SVAR models, this chapter aims to do so.

5.3 VAR, SVAR models, data, and specification tests

5.3.1 VAR model

The vector of endogenous variables included in the VAR in this chapter is:

$$Z = (y, p, i, m, cr, e)' \tag{5.1}$$

in which $y, p, i, m, cr,$ and e are output, price level, policy interest rate, money, credit, and exchange rate in that order. The recursive assumption implies that a shock in the policy interest rate will affect money, credit, and the exchange rate instantly, but can only affect output and prices with a lag. These endogenous variables are typical for a VAR regarding monetary policy (see, for example, Sims, 1992; Peersman and Smets, 2003), except for the inclusion of aggregate credit, which is argued to be important for both inflation management and economic growth in Vietnam (Camen, 2006; Le and

Pfau, 2009; Nguyen and Nguyen, 2010; Bhattacharya, 2014). Also, as pointed out by the SBV (2011), a combination of monetary policy tools (interest rate, money supply, and credit growth control) is typically used to combat inflation in Vietnam. As discussed in Section 5.2, given the managed float regime, the exchange rate is included in the VAR not as an independent monetary policy tool, but as a possible channel through which the monetary policy tools (especially the policy interest rate) might affect output and CPI.

Industrial output is used as a proxy for output. The price level is measured by the CPI, while the refinancing rate is used as the policy interest rate. M2 is used for the money supply, and total domestic claims are used to measure aggregate credit. The nominal VND/USD is employed for the exchange rate, similar to the existing studies of VAR models for Vietnam.

A missing channel in this VAR is the asset price (Tobin's q) channel. Vietnam's stock exchange market opened in December 2000 (in Ho Chi Minh City), but remained in its infancy until 2004 (see NUS, 2013). The share price index therefore can hardly reflect the confidence and expectations of investors about the major fundamentals of the macro economy. For this reason, asset prices are not included in the model. Among the existing studies, the only VAR and VECM research for the case of Vietnam that includes a stock trading volume index is by Nguyen and Nguyen (2010), who find no significant effects of this channel on either output or inflation. Another related research by Siregar and Nguyen (2013) assesses the inflationary implication of gold prices in Vietnam using a monetarist framework which is outside the scope of this chapter.

To account for the fact that Vietnam is a small, open economy, a set of exogenous foreign variables are included in the VAR:

$$W = (y^w, oil, rice, p^w, i^w)' \quad (5.2)$$

in which $y^w, oil, rice, p^w, i^w$ are foreign GDP, the international oil price, international rice price, foreign price level, and foreign interest rate respectively.

Foreign GDP is proxied by the real GDP of Vietnam's eleven biggest trading partners, weighted by the shares of each partner in Vietnam's total trade (including both exports and imports, for the period 2007–2012 when detailed data are available). The foreign price level is calculated by the CPI of twelve countries from which more than 80% of Vietnam's imported goods originate, weighted by the shares of those partners in Vietnam's total imports for the period 2007–2012. The details of the foreign GDP and foreign price level, with the list of the biggest trading partners, are provided in Appendix 5E. The US Federal Funds rate is used as a proxy for the foreign interest rate. Because of a lack of data, the terms of trade or a direct measure of either export prices or import prices are not included in the VAR.

Due to the important role of the oil price (see, for example, Hamilton, 1983; Abeysinghe, 2001), the inclusion of the international oil price as an exogenous variable is common in studies for any small, open economy. Meanwhile the international rice price is included as it might play an important role for the case of Vietnam, one of the three world's largest rice exporters (together with Thailand and India). The rice price is also used in most existing studies for Vietnam (Camen, 2006; Goujon, 2006; Le and Pfau, 2009; Nguyen and Nguyen, 2010; Nguyen *et al.*, 2012).

As reviewed in Chapter 2 of this thesis, a limitation of the simple unrestricted VAR is that the possible effects of shocks in an exogenous variable on endogenous variables cannot be examined. However, SVAR models can help implement this mission.

5.3.2 SVAR models

The first SVAR model to be developed in this chapter (which is called SVAR1) applies a 'block-recursive' structure where foreign variables are now treated as endogenous as well, but they stay 'exogenous' in the sense that all domestic variables will not have any effect on foreign variables. Therefore the transmission is one-way only, from the foreign block to the domestic block, not the other way round. This 'block-recursive' approach was first employed by Dungey and Pagan (2000, 2009), from which the SVAR1 in this chapter borrows some key aspects. An alternative to the 'block-recursive' could be found in a SVAR model developed by Abeysinghe and Forbes (2005) through trade linkages and output-multiplier effects.

Inside each block of the 'block-recursive' structure, the recursive assumption is also applied so that the contemporaneous level of any variable does not appear in the equations of the variables that place before it in the SVAR1. For the foreign block, the equations are constructed with the main aim of identifying the shocks for each of the foreign variables. Since the foreign series are not from an actual single foreign country, the shock identification for the foreign block in the SVAR1 is far from perfect. The sets of foreign and domestic variables are exactly the same as in the VAR. The contemporaneous and lag structures of the SVAR1 are presented in Tables 5.1 and 5.2.

For the foreign sector, foreign GDP is assumed to depend on lags of foreign price, the oil price, foreign interest rate, and foreign GDP itself. The oil price depends on the current level and lags of foreign GDP, and lags of the oil price itself. Similarly, the rice price is assumed to be dependent upon the contemporaneous and lagged foreign GDP, and lags of the rice price itself.

The foreign price level equation includes the current levels and lags of foreign GDP and the oil price, and also lags of the foreign price level and foreign interest rate. Meanwhile, the foreign interest rate depends on current and lagged levels of foreign GDP and the foreign price level, and also lags of the foreign interest rate itself.

The domestic block is ordered after the foreign block in the SVAR1 and no domestic variable appears in any of the foreign variable equations. Though Vietnam is a big rice exporter, there is no reason to believe that Vietnam's domestic variables in this SVAR1 can affect the international rice price.

Inside the domestic block, the structure of the variables is almost purely recursive, except for the assumption that the exchange rate does not depend directly on aggregate credit, both contemporaneously and dynamically. However, a shock in the credit equation can still transmit to the exchange rate indirectly through other variables.

Transmission from the foreign block to the domestic variables is presented in three equations. Both domestic output and domestic price are assumed to depend on foreign GDP, the oil price, rice price, and the foreign price level contemporaneously and dynamically. Meanwhile, the exchange rate depends on current levels and lags of foreign GDP, foreign price level, and the foreign interest rate.

Table 5.1 Contemporaneous structure of SVAR1

Dependent variable		Independent variable										
		y^w	*oil*	*rice*	p^w	i^w	*y*	*p*	*i*	*m*	*cr*	*e*
Foreign block	y^w	-										
	oil	*	-									
	rice	*		-								
	p^w	*	*		-							
	i^w	*			*	-						
Domestic block	*y*	*	*	*	*		-					
	p	*	*	*	*		*	-				
	i						*	*	-			
	m						*	*	*	-		
	cr						*	*	*	*	-	
	e	*			*	*	*	*	*	*		-

Table 5.2 Lag structure of SVAR1

Dependent variable		Independent variable										
		y^w	*oil*	*rice*	p^w	i^w	*y*	*p*	*i*	*m*	*cr*	*e*
Foreign block	y^w	*	*		*	*						
	oil	*	*									
	rice	*		*								
	p^w	*	*		*	*						
	i^w	*			*	*						
Domestic block	*y*	*	*	*	*		*	*	*	*	*	*
	p	*	*	*	*		*	*	*	*	*	*
	i						*	*	*	*	*	*
	m						*	*	*	*	*	*
	cr						*	*	*	*	*	*
	e	*			*	*	*	*	*	*		*

Besides the SVAR1 that might capture reasonable structural relations between the variables, another SVAR is developed, which is called SVAR2. The contemporaneous and lag structures of the SVAR2 are presented in Tables 5.3 and 5.4. In SVAR2, the contemporaneous structure is the same as in a VAR of 11 endogenous variables. Any equation will include the current level of all variables placed before the dependent variable in the SVAR2 ordering. Each variable in the foreign block (foreign GDP, the oil price, rice price, foreign prices, and foreign interest rate) will affect the contemporaneous levels of all domestic variables. However, in terms of lag structure,

there is no connection between the foreign and domestic blocks. This SVAR2 therefore can be regarded as similar to the VAR above, except that the SVAR2 allows the presence of foreign variable shocks that will transmit to the domestic variables, and not vice versa.

Table 5.3 Contemporaneous structure of SVAR2

Dependent variable		Independent variable										
		y^w	oil	rice	p^w	i^w	y	p	i	m	cr	e
Foreign block	y^w	-										
	oil	*	-									
	rice	*	*	-								
	p^w	*	*	*	-							
	i^w	*	*	*	*	-						
Domestic block	y	*	*	*	*	*	-					
	p	*	*	*	*	*	*	-				
	i	*	*	*	*	*	*	*	-			
	m	*	*	*	*	*	*	*	*	-		
	cr	*	*	*	*	*	*	*	*	*	-	
	e	*	*	*	*	*	*	*	*	*	*	-

Table 5.4 Lag structure of SVAR2

Dependent variable		Independent variable										
		y^w	oil	rice	p^w	i^w	y	p	i	m	cr	e
Foreign block	y^w	*	*	*	*	*						
	oil	*	*	*	*	*						
	rice	*	*	*	*	*						
	p^w	*	*	*	*	*						
	i^w	*	*	*	*	*						
Domestic block	y						*	*	*	*	*	*
	p						*	*	*	*	*	*
	i						*	*	*	*	*	*
	m						*	*	*	*	*	*
	cr						*	*	*	*	*	*
	e						*	*	*	*	*	*

To some extent, SVAR1 and SVAR2 can also be regarded as a check on the robustness of the impulse responses obtained from the VAR. From the construction of the VAR and the SVARs, it can be seen that the SVAR2 is closer to the VAR compared

to the SVAR1. Therefore, it can be predicted that the impulse responses from SVAR2 will lie somewhere in between the ones from the VAR and SVAR1. The VAR is the least restricted model. SVAR1 is the most restricted.

5.3.3 Data and specification tests

Data on Vietnam's industrial output and the policy interest rate are available since 1996. Therefore quarterly data from 1996Q1–2012Q4 are used for the VAR and SVAR models. Almost all domestic series are from either the International Monetary Fund (IMF) or the Vietnam General Statistics Office (GSO). A detailed list of data sources together with data graphs are presented in Appendix 5F. All data are in log seasonally-adjusted levels, except for the interest rates. Also, all the series are de-meaned and de-trended before the estimations, as suggested by Dungey and Pagan (2000). Shocks or changes therefore should be referred to as shocks or changes from the long-run trends of the variables. With a small sample of 68 observations, a 2-lag structure is used for the VAR and SVAR models to conserve degrees of freedom. The SVAR models are estimated using a GAUSS code developed by Dungey and Pagan (2000).

With the data employed and a 2-lag structure, the VAR and both SVARs provide stable impulse responses. For SVAR1 and SVAR2, each of the equations for the domestic variables is also tested using a test for serial correlation, a test for heteroskedasticity, the RESET test for regression specification error, and the Jarque–Bera test for normality.

In general, the equations pass the tests, except for some exceptions. First, the policy interest rate equation in SVAR1 fails the serial correlation test while in SVAR2 it faces the problem of heteroskedasticity. However, the issues are solved when three dummies are included for 1997Q1, 2008Q2, and 2011Q1. The policy rate declined by a

record amount in 1997Q1, while in 2008Q2 and 2011Q1 it increased dramatically in the periods of fighting against high inflation in Vietnam.

Second, the money equation in SVAR2 fails the serial correlation test. A Quandt–Andrews test indicates a possible break point of 1999Q4. The inclusion of the dummy for this point solves the problem. Therefore, this dummy is presented in the money equation in both SVAR1 and SVAR2. In fact, there was a sharp increase in the money growth at 1999Q4.

Lastly, some equations fail normality tests. However, as pointed out by Dungey and Pagan (2000), the small sample size is likely the main reason for non-normality. Therefore, there is little that can be done about it.

5.4 Results

The sizes of the shocks from the models are measured by one standard deviation and presented in Table 5.5. It is observed that the sizes of the shocks are similar across the models.

Table 5.5 Size of shocks

(Units: i and i^w: % per annum; the rest are %)

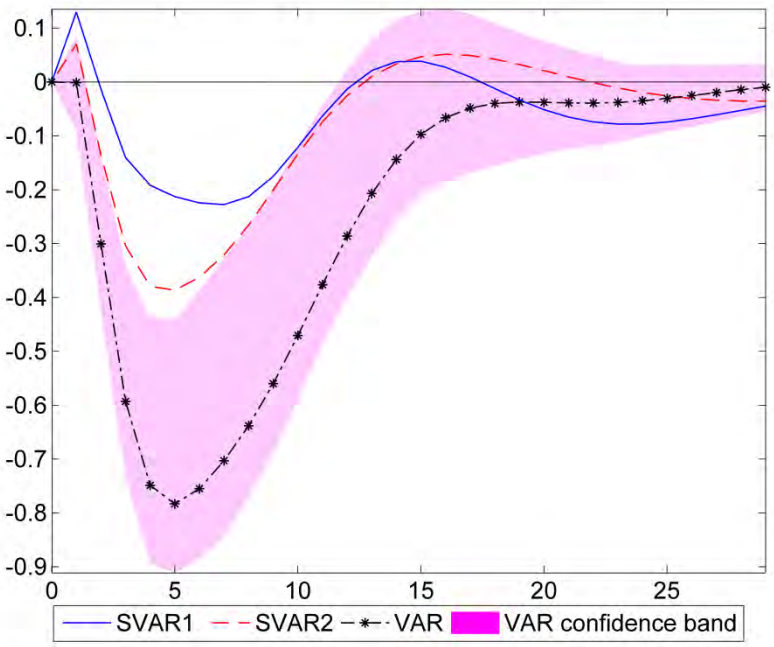
Model \ Shock	Monetary policy tools and exchange rate				Foreign variables				
	i	m	cr	e	y^w	oil	$rice$	p^w	i^w
VAR	1.07	2.41	1.99	0.73					
SVAR1	1.15	1.57	2.15	0.83	1.07	11.04	9.89	0.23	0.29
SVAR2	1.07	1.46	2.00	0.74	1.03	9.38	8.78	0.21	0.25

5.4.1 Effects of monetary policy shocks on the CPI

Figure 5.6 shows the impulse responses of the CPI to a shock in the policy rate from the VAR and SVARs. The impulse response function from the VAR is presented together with a confidence interval band. The lower band is constructed at the 10th percentile, while the upper band is for the 90th percentile of 1,000 bootstrap simulations for the VAR. A 30-quarter horizon is shown in this figure as well as throughout the other figures in this chapter.[32]

Figure 5.6 Impulse responses of the CPI to a shock in the policy rate

(Unit: %; 30-quarter horizon)



According to Figure 5.6, it can be observed that a positive shock in the policy rate leads the CPI to fall after 1–2 quarters. The effect reaches its peak at around the 5th–6th

[32] Although only the confidence intervals of the VAR model are shown (for simplicity), the confidence intervals are similar between the three models. Therefore the results are mainly drawn from the point estimates.

quarter before the CPI comes back gradually to its steady state level at around the 12th quarter. The CPI reacts most strongly in the VAR, and most weakly in the SVAR1. As expected, the responses of the CPI in the SVAR2 are close to the ones in the VAR and almost lie within the confidence band from the VAR for the whole 30 quarters. A small 'price puzzle' appears at the 1st quarter, but the puzzle is insignificant in the VAR.

The presence of the structural restrictions and the introduction of the foreign variables could be the main reasons why the CPI reacts weakly in the SVARs compared to the VAR. However, the patterns of the impulse response functions are plausible and similar across the models. It therefore can be stated that the CPI does respond expectedly to a shock in the policy rate as a main instrument of monetary policy.

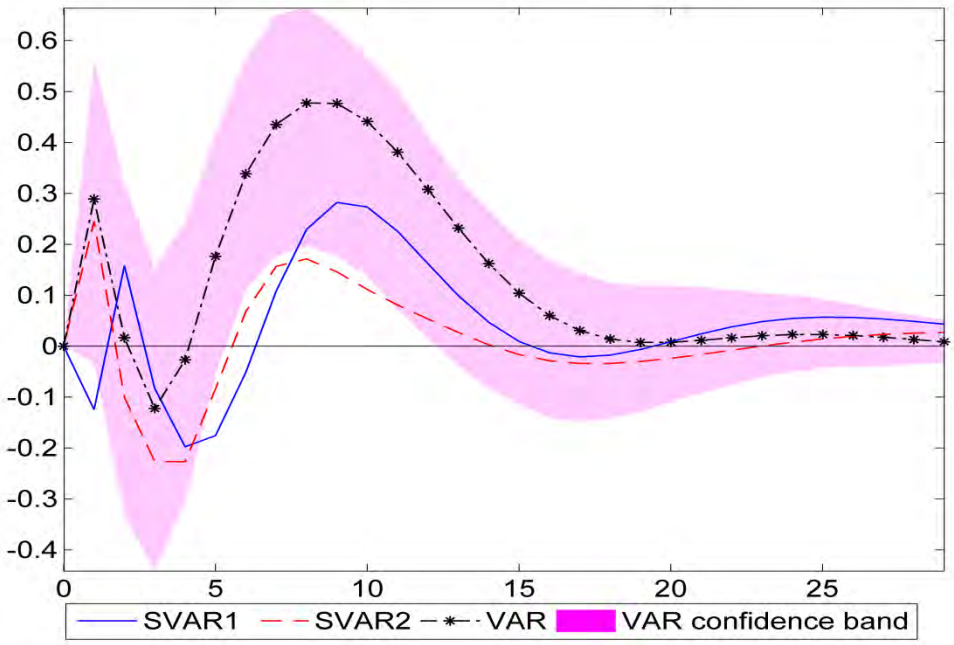
This impulse response function is similar to the functions obtained from VAR models for developed countries (see, for example, Christiano *et al.*, 1999 and 2005; Peersman and Smets, 2003; Erceg and Levin, 2006; Dungey and Pagan, 2000, 2009). The impulse response is also similar to the ones for some other developing countries in which monetary policy regimes are 'more advanced' compared to Vietnam (see Disyatat and Vongsinsirikul, 2003 for Thailand; Tang, 2006a, 2006b for Malaysia, Aleem, 2010 for India).

As reviewed in Section 2.2, the policy interest rate can affect the CPI through affecting the aggregate demand (output). However, the impulse responses of output to a positive policy rate shock in Figure 5.7 show that output seems not to be affected systematically by the policy rate shocks. One possible explanation to these unexpected impulse responses could be found as suggested by IMF (2013). In response to a tightening monetary policy, some part of the aggregate demand is negatively affected. However, some other components might be unaffected, such as the export sector,

especially foreign invested enterprises. This pattern of 'two-speed economy' responses might be explored more clearly when enough data of all components of GDP are available for Vietnam.

Figure 5.7 Impulse response functions of output to the policy rate shocks from VAR and SVARs

(Unit: %; 30-quarter horizon)

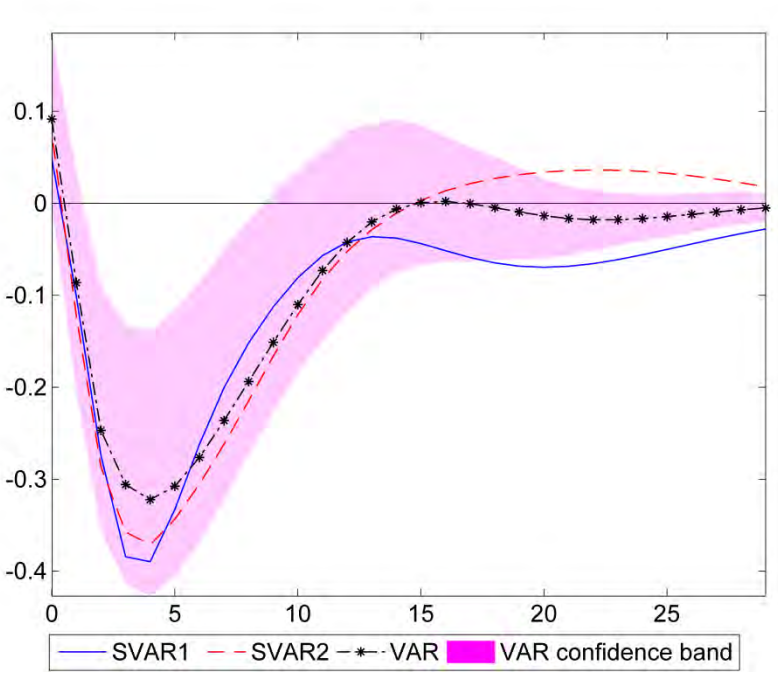


Another possible path through which a policy rate shock might affect CPI without significantly affecting output is as follows. An increase in domestic interest rates might lead to an increase in the inflow of foreign exchange, which in turn causes an appreciation of the domestic currency. As a result, prices of imported goods decline leading to a fall in the CPI (a review of this type of 'exchange rate pass-through' is provided by Goldberg and Knetter, 1997). This pattern might be observed in Figure 5.8 where impulse responses of the VND/USD exchange rate to the policy rate shocks are shown. In response to an increase of around one percentage point of the policy rate, the

VND appreciates by around 0.3–0.4% at peak, which might lead to a decline in prices of imported goods, and therefore a decline in the CPI.

Figure 5.8 Impulse response functions of the nominal exchange rate to the policy rate shocks from VAR and SVARs

(Unit: %; 30-quarter horizon)



Figures 5.9 and 5.10 present the impulse response functions of the CPI and output to a shock in M2. In general, the impulse responses show similar patterns across the models. A positive shock to the money supply leads output to increase significantly. The rise of output reaches its peak at around the 1st–2nd quarter, and falls back to its steady level quickly. The CPI also responds expectedly and significantly to a money supply shock, but more slowly. The CPI responses stay positive and reach a peak at around the 5th–6th quarter before starting to decline back to the long-run time trend level at around the 7th–8th quarter.

Figure 5.9 Impulse responses of the CPI to a shock in M2

(Unit: %; 30-quarter horizon)

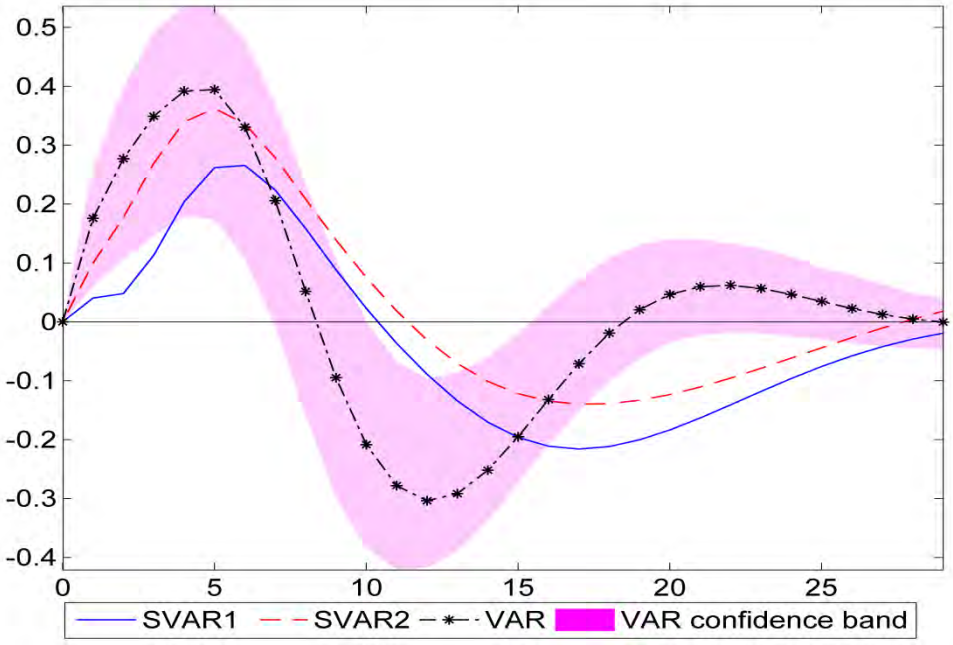
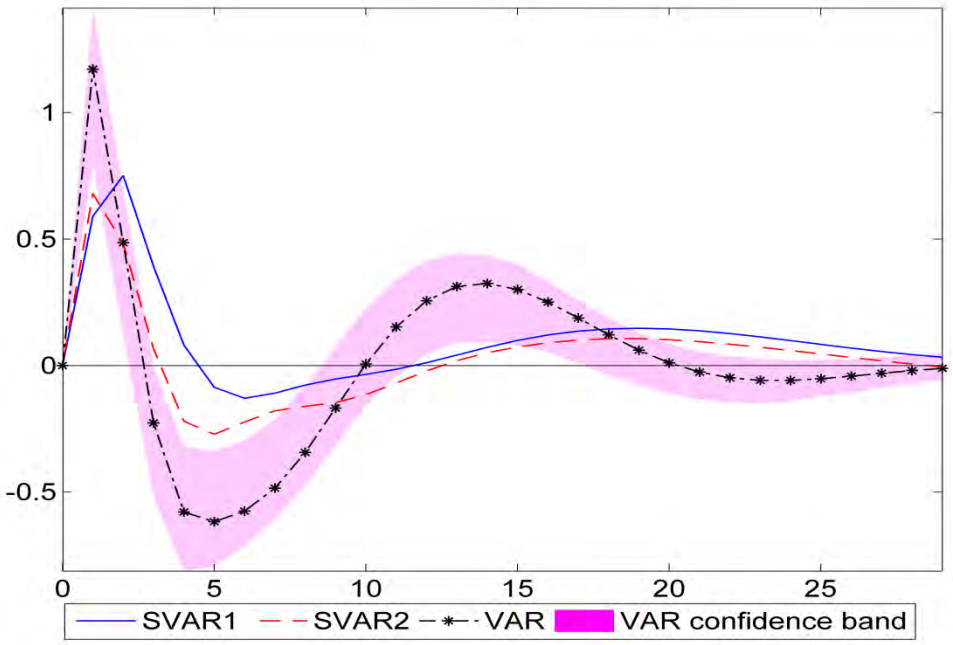


Figure 5.10 Impulse response functions of output to a shock in M2

(Unit: %; 30-quarter horizon)



The impulse response functions of the CPI to a shock in the aggregate credit equation are presented in Figure 5.11. The CPI responds to aggregate credit shocks in a similar way to its responses to a money supply shock shown in Figure 5.9. A positive shock to the residuals of the credit equation leads the CPI to increase significantly. CPI responses reach their peak at around the 2nd quarter before starting to fall back to their steady state level at around the 4th–5th quarter. Compared to Figure 5.9, Figure 5.11 suggests that the CPI responds to aggregate credit shocks more quickly than to money shocks, but remains affected for a shorter period.

Figure 5.12 shows the output responses to a shock in aggregate credit. Output unexpectedly declines at the 1st–2nd quarter before eventually increasing around the 8th–10th quarter in response to an expansion of credit. The initial fall of output might be a product of credit misallocation originating from the easy and favourable credit to state-owned enterprises (SOEs), most of which have been operating inefficiently for a long time. These SOEs then contribute to the CPI increase by their easy purchases, rather than contribute to GDP (see WB, 2012, for a review of Vietnam's SOEs). A further decomposition of aggregate credit into 'credit to SOEs' and 'credit to others' might provide a clearer observation when data are available.

Figure 5.11 Impulse responses of the CPI to a shock in aggregate credit

(Unit: %; 30-quarter horizon)

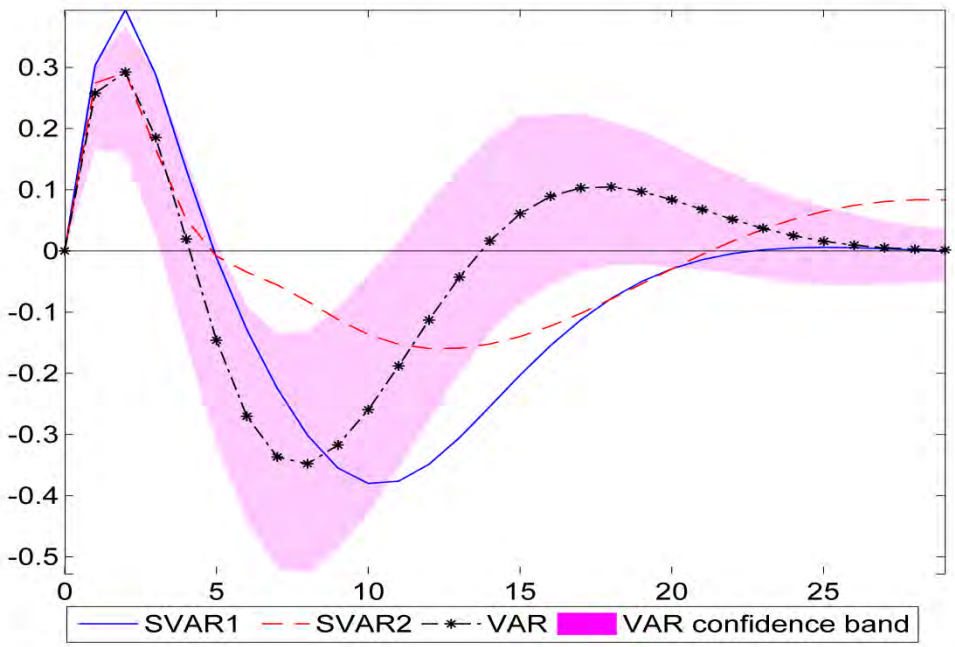
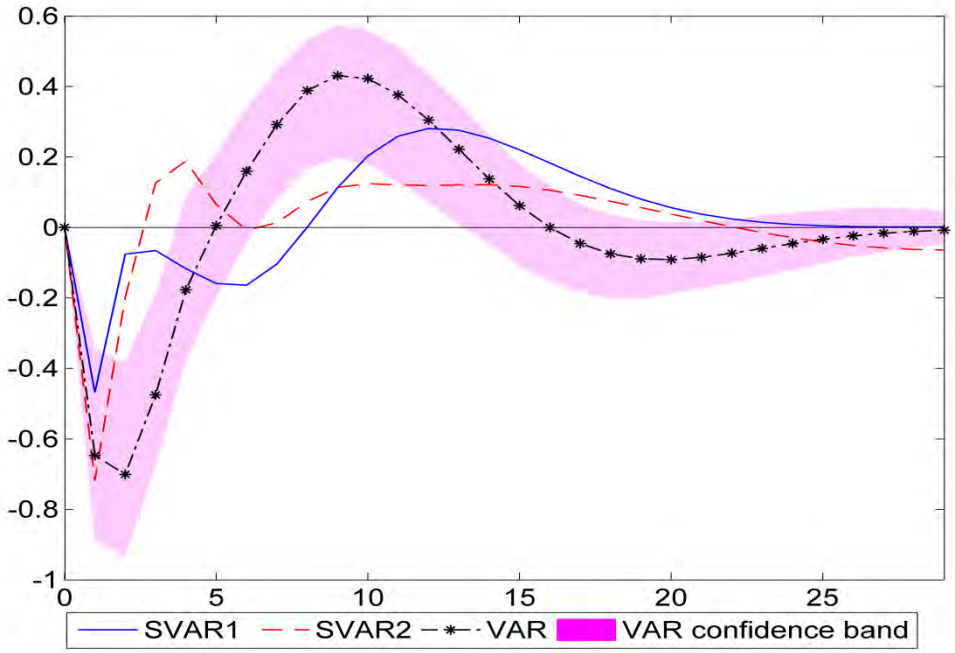


Figure 5.12 Impulse response functions of output to a shock in aggregate credit

(Unit: %; 30-quarter horizon)



Both money supply and aggregate credit seem not to affect the exchange rate systematically. The impulse responses of the exchange rate to shocks in M2 and credits are provided in Appendix 5G.

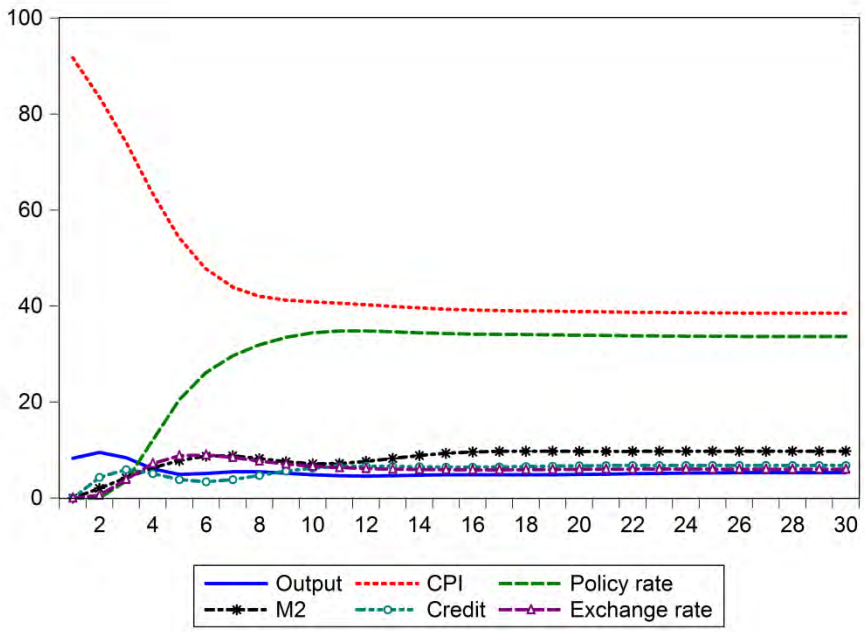
Besides the impulse responses, Figure 5.13 presents the variance decomposition of the CPI obtained from the VAR.[33] This figure suggests the importance of the policy rate shocks in explaining variation of the CPI. Apart from the inflation persistence which accounts for roughly 40% of the CPI variance from the 10th quarter onward, the policy rate explains around 35% of the CPI's volatility. The next most important factor is the money supply, which contributes more than 10% of the variation of the CPI. Aggregate credit, the exchange rate, and output are less important factors in determining CPI changes.

Strong inflation persistence is similar to what is found by previous studies (IMF, 2006; Nguyen and Nguyen, 2010; Nguyen *et al.*, 2012; Bhattacharya, 2014) and might reflect the sluggish adjustment of inflationary expectations. Once the inflation rate is already high, it is difficult to bring it down. It might also relate to the public's memory of high inflation periods for the case of Vietnam. However, this hypothesis requires further investigation.

[33] The codes for SVAR models do not include variance decomposition computation. Furthermore, the inclusion of novel foreign variable shocks in together with identified domestic variable shocks in variance decomposition might be confusing. Therefore I decided to use the variance decomposition from the VAR only.

Figure 5.13 Variance decomposition of the CPI from the VAR

(Unit: %)



Figures 5.14 and 5.15 show the variance decompositions of output and the exchange rate from the VAR. It is observable that the policy rate contributes around 18% of the exchange rate variance while it contributes little of the output variance. The money supply and aggregate credit play more important roles in explaining output than in the exchange rate variance.

Figure 5.14 Variance decomposition of output from the VAR

(Unit: %)

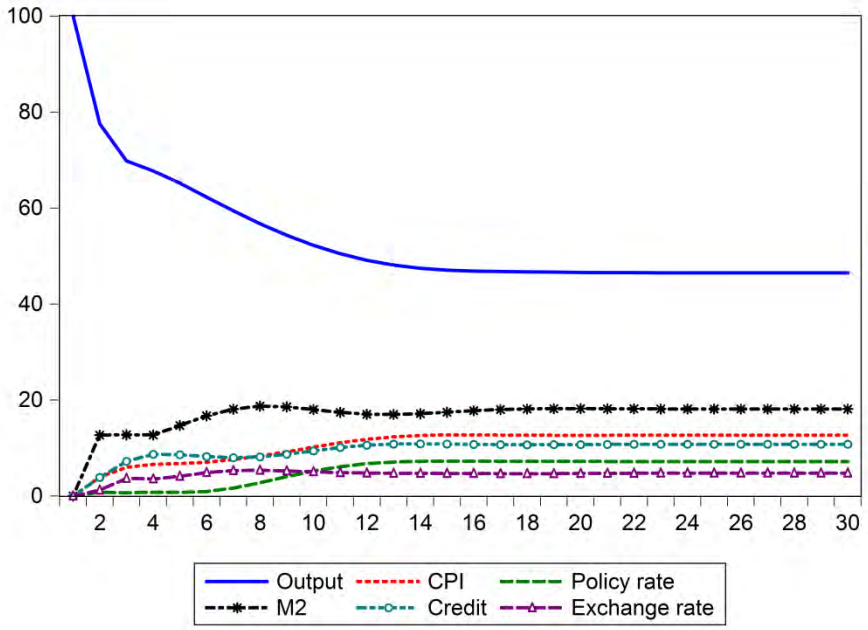
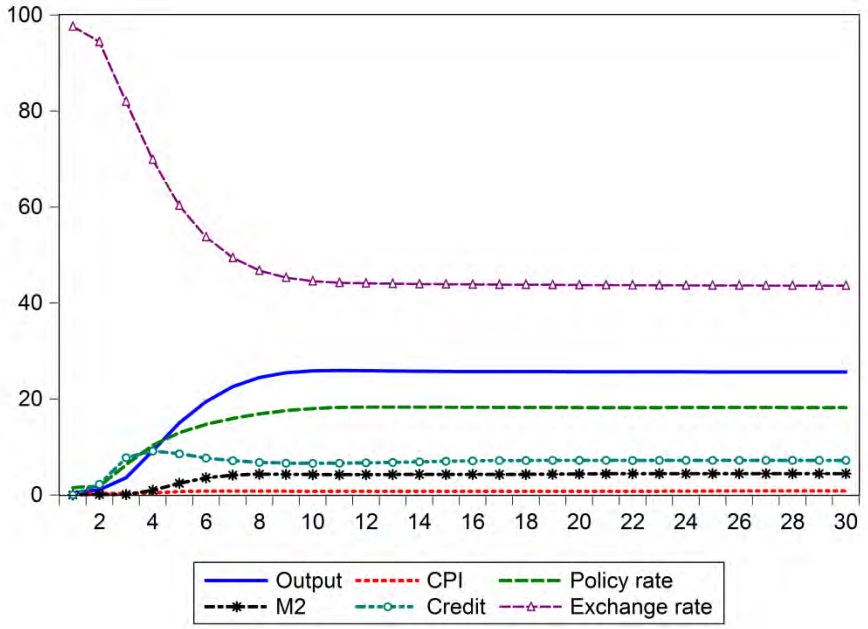


Figure 5.15 Variance decomposition of the exchange rate from the VAR

(Unit: %)



In summary, two main points can be observed about the effects of monetary policy instruments' shocks in the VAR and SVARs. First, the CPI responds expectedly after a shock in monetary policy (especially a shock in the policy rate). Second, the impulse response functions from SVAR1 and SVAR2 show patterns similar to the ones from the VAR. These observations suggest a conclusion that the impulse responses obtained by the VAR are plausible and robust across the models.

The differences between the results of the VAR in this chapter and previous studies might mainly come from data. This chapter uses the longest possible quarterly data in logs forms, as in many well-known VARs for developed countries (see, among others, Sims, 1980; Bernanke and Blinder, 1992; Christiano *et al.*, 1999, 2005; Peersman and Smets, 2003; Erceg and Levin, 2006; Boivin *et al.*, 2010). For the case of Vietnam, IMF (2006), Le and Pfau (2009), Nguyen and Nguyen (2010), Nguyen *et al.* (2012), and Bhattacharya (2014) use either differenced or 'percentage change' data, while Camen (2006) and Goujon (2006) use logs of monthly data. Moreover, the periods of data seem to be quite short for a VAR analysis in the studies of the IMF (2006), Le and Pfau (2009), and Bhattacharya (2014).

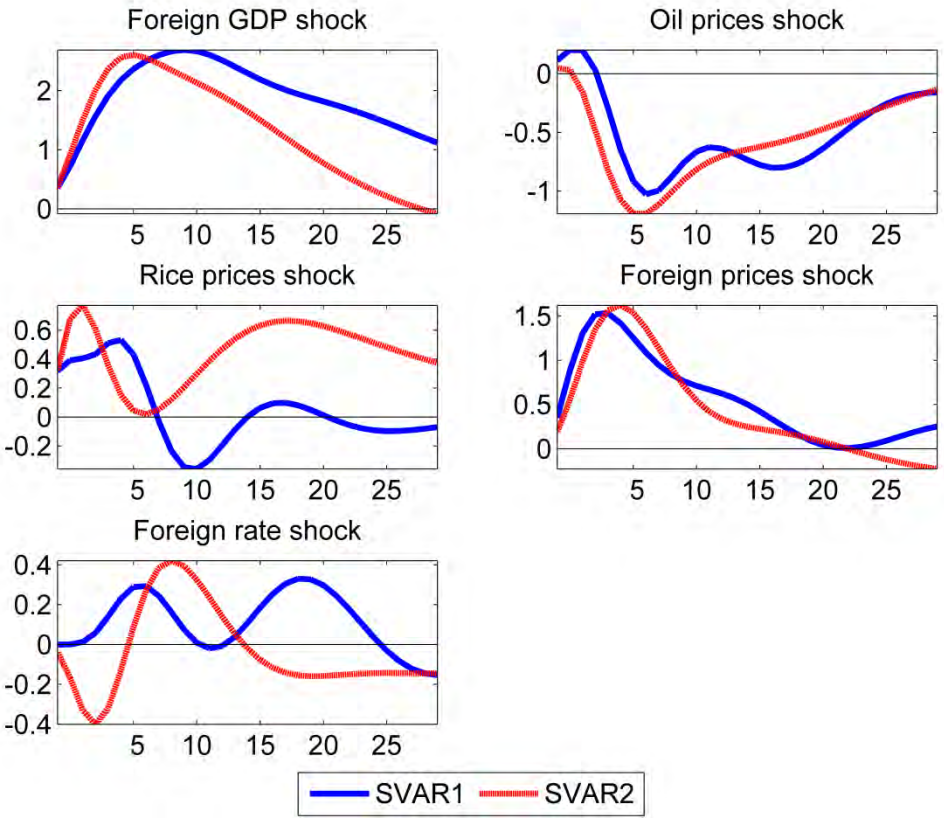
5.4.2 Effects of foreign shocks on the CPI and domestic monetary policy variables

The advantage of introducing SVARs in this chapter is to enable an assessment of the responses of domestic variables to shocks in foreign variables. Figure 5.16 presents the CPI impulse responses to shocks in the five foreign variables. Among those, the foreign GDP and foreign price shocks show the strongest, expected effects on the domestic CPI. The international rice price and foreign interest rate shocks show mixed patterns, while the oil price shock leads to unexpected CPI responses. This muted oil price shock is similar to that found by Nguyen and Nguyen (2010) and could be

explained by the fact that Vietnam's government has long imposed a strict control on retail fuel and gas prices, therefore, the international crude oil price shocks hardly transmit to domestic retail fuel prices.

Figure 5.16 Impulse responses of the CPI to foreign shocks

(Unit: %; 30-quarter horizon)

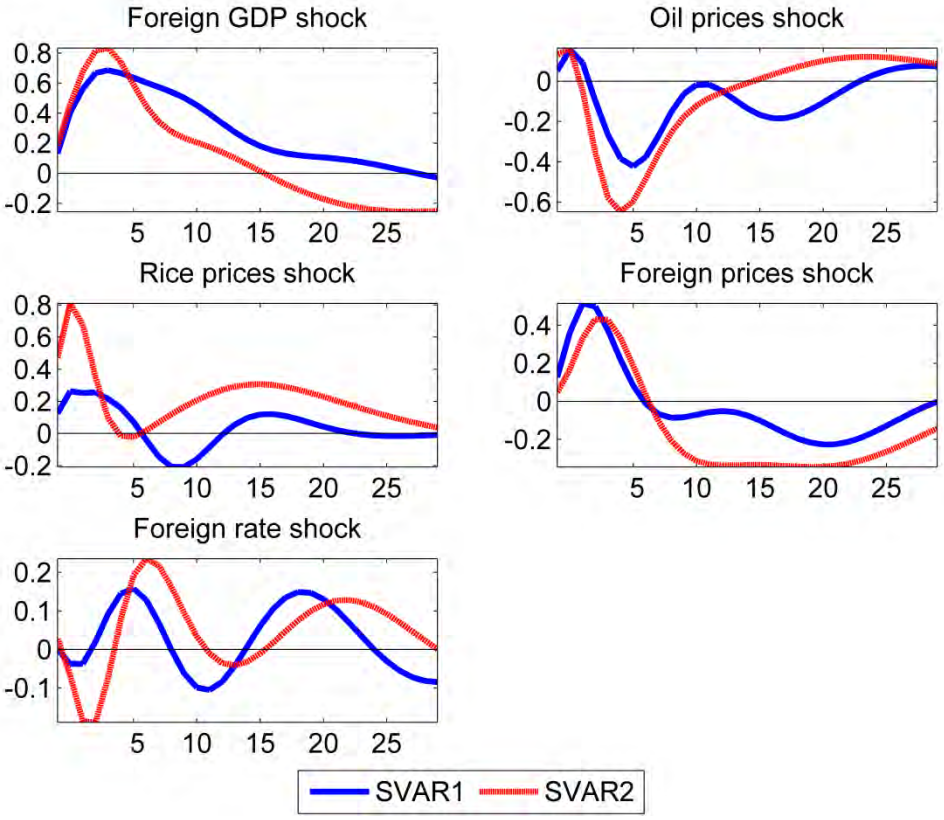


Besides the impulse responses of the CPI, the responses of the domestic monetary policy instruments are also provided in Figures 5.17–5.19 to examine how the SBV reacts to the foreign shocks that affect the domestic inflation. An interesting observation could be drawn from the impulse responses of the domestic policy interest rate shown in Figure 5.17. It seems that while the domestic policy rate does not react systematically to shocks in foreign interest rate, the domestic policy rate is likely to respond to positive shocks in foreign GDP and foreign price level. This might suggest that the domestic

policy rate is raised by the SBV to fight against inflation in response to shocks in foreign GDP and the foreign price level shown in Figure 5.16.

Figure 5.17 Impulse responses of the policy rate to foreign shocks

(Unit: percentage point; 30-quarter horizon)



A similar explanation could be applied to the patterns of the impulse response functions of the domestic money supply and the domestic aggregate credit to the shocks in the foreign variables, which are presented in Figures 5.18 and 5.19. Both the money supply and aggregate credit seem to decrease in response to shocks in foreign GDP and foreign price. This pattern suggests that the SBV might have tried to reduce the money supply and bank lending as an effort to ease the inflationary pressure that the foreign GDP and prices put on domestic prices.

Figure 5.18 Impulse responses of M2 to foreign shocks

(Unit: %; 30-quarter horizon)

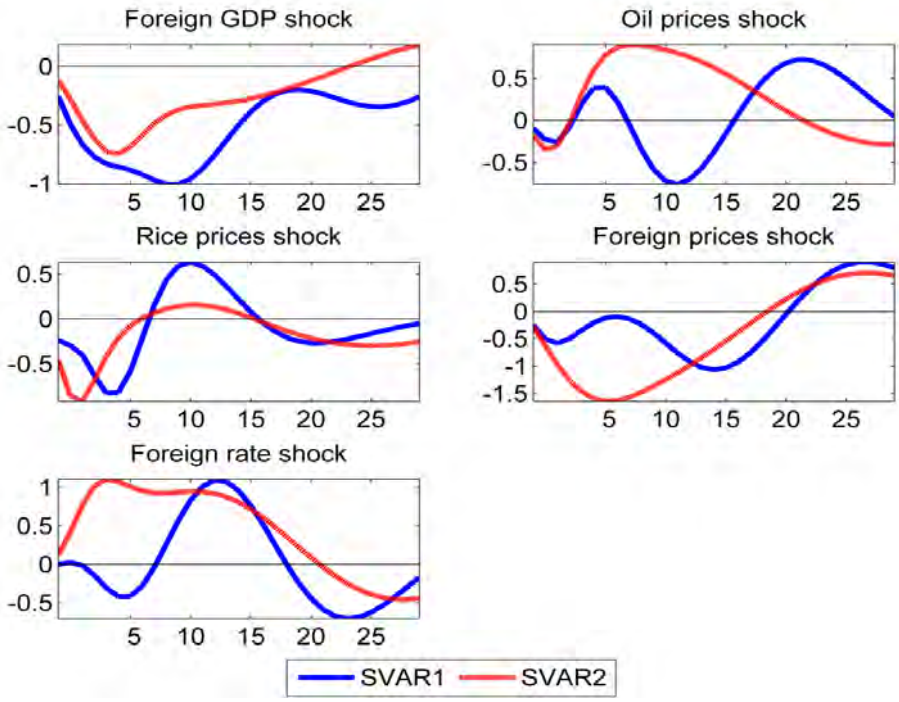
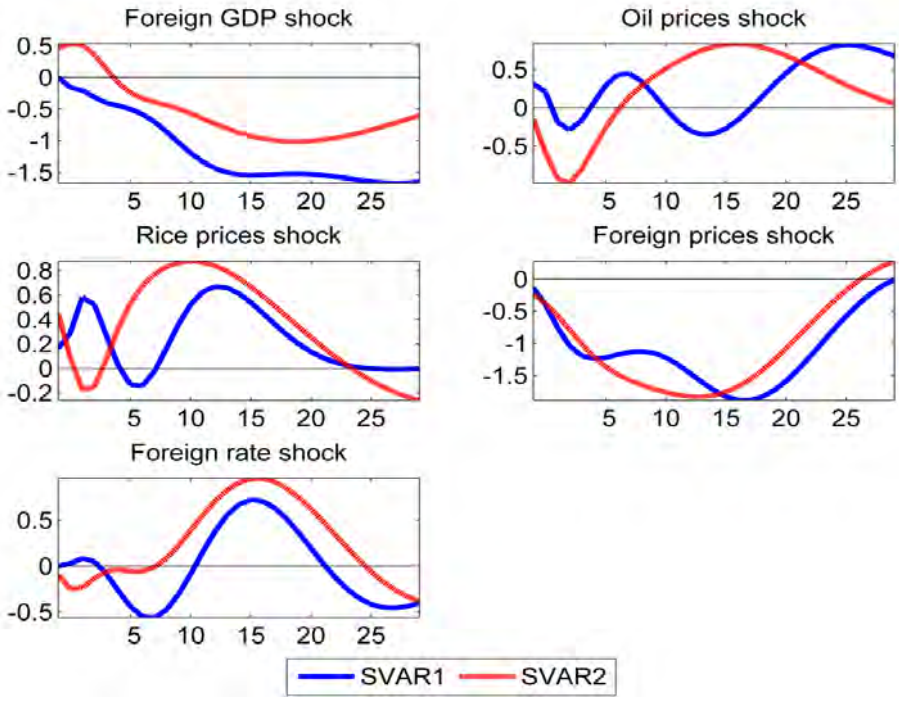


Figure 5.19 Impulse responses of domestic credit to foreign shocks

(Unit: %; 30-quarter horizon)



In summary, two main observations could be drawn from the effects of the foreign shocks to the domestic variables. First, foreign GDP and foreign price level shocks lead to increases in the domestic CPI in Vietnam. Second, the SBV appears to use monetary policy instruments, including the policy interest rate, the money supply, and aggregate credit controlling measures to soften inflation pressures from foreign GDP and foreign price shocks.

5.5 Conclusion

This chapter uses a VAR and two SVAR models to assess the determinants of inflation in Vietnam. Using quarterly data for the period 1996Q1–2012Q4, the results suggest some main points. First, Vietnam's CPI responds expectedly after a shock in monetary policy, especially the policy interest rate. The CPI impulse responses obtained by the VAR and the SVARs are plausible and robust across the models. Second, the policy rate is an important factor in explaining the variation of Vietnam's CPI. Third, among the foreign variables, foreign GDP and foreign price level play prominent roles, while foreign interest rates and the international oil and rice prices seem not to systematically affect domestic CPI. The policy interest rate, the money supply, and aggregate credit controlling measures appear to be used by the SBV as policy tools in fighting against inflation that foreign GDP and foreign price shocks force on domestic prices.

Based on the first two points above, Vietnam's monetary policy might be actually more effective and more advanced than expected, especially in terms of inflation control. Recent changes in the Law on the SBV now identify inflation as the primary target of monetary policy, rather than the multiple goals of the previous Law (Vietnam National Assembly, 1997 and 2010). With the changes being in favour of a toward-

inflation-targeting type and a more important role of the policy interest rate, it seems that Vietnam is on the quest toward a standard monetary policy. The plausibility of the monetary transmission to inflation found in this chapter, as in some of Vietnam's neighbouring countries such as Indonesia and Thailand (see, for example, Siregar and Goo, 2010), might provide the SBV with more confidence in pursuing the quest.

A possible direction to further check the conclusions of this chapter is to allow for possible changes over time in the VAR parameters and variance/covariance matrix during the period of interest. This task will be partly implemented in Chapter 6, where the dynamics of inflation management in Vietnam are investigated using a TVP-VAR model.

CHAPTER 6

DYNAMICS OF INFLATION MANAGEMENT IN VIETNAM: A TVP-VAR APPROACH

Summary: This chapter examines the dynamics of inflation management in Vietnam during the period 1996–2012. Using a TVP-VAR model of six variables, the chapter concludes that the SBV appears to use monetary policy tools, including the policy interest rate, the money supply, and domestic credit control measures, to contain inflation in a similar way throughout the period. On the other hand, shocks in the monetary policy tools lead to expected inflation responses. The evidence therefore supports the conclusion of Chapter 5. Vietnam's monetary policy appears to be more effective than expected.

6.1 Introduction

As argued in Chapter 5, Vietnam's monetary policy might be surprisingly effective in terms of affecting inflation. The VAR and SVAR models used in Chapter 5 require an assumption that there are no significant changes during the period of interest in terms of the variables employed, and therefore all parameters and variance/covariance matrices are constant.

A useful way to check that argument is to use TVP-VAR where parameters and variance/covariance matrices are allowed to change over time. This chapter employs a TVP-VAR model which consists of six variables for Vietnam and aims to answer two questions. First, how have monetary policy tools been used by the SBV in order to

control inflation in the country? Second, how have the effects of the shocks in monetary policy tools to inflation changed in the process of fighting inflation in Vietnam?

To my knowledge, this chapter is the first study applying TVP-VAR models to analyse inflation management and monetary policy for the case of Vietnam.[34] The method could be readily applied to explore similar questions in other developing countries (such as other ASEAN countries), with necessary adjustments to suit the specific features of these countries.

The remainder of the chapter is as follows. Section 6.2 provides a summary of the model and data. Section 6.3 presents the results. Section 6.4 concludes.

6.2 Model and data

The TVP-VAR model to be used in this chapter is based on the general TVP-VAR model with stochastic volatility of the type employed by Primiceri (2005) and Nakajima (2011) as detailed in Section 2.4. The data sources are the same as in Chapter 5, in which the series are output, CPI, the policy interest rate, the money supply, aggregate credit, and the nominal exchange rate.

Quarterly data from 1996Q1–2012Q4 are used for the TVP-VAR model in this chapter. The policy interest rate is in differenced form, while all other series are in

[34] Some examples of authors employing TVP-VAR models for developing countries include Tang *et al.* (2013), who measure the impacts of fiscal policy in five ASEAN countries (Indonesia, Malaysia, Philippines, Singapore, and Thailand), and Gupta *et al.* (2013), who analyse fiscal policy and asset prices in South Africa.

differenced log form.[35] Therefore, the changes in the variables (other than the policy rate) could be interpreted as the growth rates of these variables. Similar to Chapter 5 (but in terms of changes or growth rates rather than levels and log levels), the changes in the policy rate, the money growth, and the growth of domestic credit are considered as the policy tools of the SBV. The growth rate of nominal exchange rate is included to cover a possible channel through which the monetary policy shocks might affect output growth and inflation.

As in Chapter 5, a 2-lag structure is used. The TVP-VAR model is estimated using the same MATLAB code as in Chapter 4 of this thesis. The code is developed based on the codes used by Nakajima (2011) and Primiceri (2005). Similarly to in Chapter 4, I assume that the priors for the i-th diagonals of the covariance matrices follow the Gamma distribution: $(\Sigma_\beta)_i^{-2} \sim Gamma(20, 10^{-4})$, $(\Sigma_a)_i^{-2} \sim Gamma(4, 10^{-4})$, and $(\Sigma_h)_i^{-2} \sim Gamma(4, 10^{-4})$. The matrix Σ_β is also set to be diagonal to allow the model to be estimated.

6.3 Results

The two main questions are now examined using the posterior means of the impulse response functions obtained from the TVP-VAR model. First, the reactions of each of the monetary policy tools to an increase in inflation are examined. Then the impulse response functions of inflation to shocks of each of the policy tools are investigated.

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[35] The data transformation used in this chapter is different to the one used in Chapter 5 for a technical reason: for the six-variable TVP-VAR in this chapter, the MATLAB code can only be estimated correctly with differenced data.

I first use the time-varying impulse response functions for the whole time span to see the changes of these responses during the period of interest. I then analyse the impulse response functions at five specific time points: 1998Q2, 2001Q1, 2004Q2, 2008Q2, and 2011Q2. 1998Q2 is the peak inflation point during the period 1996–1999, meanwhile 2001Q1 is the height of the deflation period 2000–2001. 2004Q2 is when quarterly inflation was highest during the period 2002–2007. The last two points correspond to the recent spikes in Vietnam's inflation, when it reached 23% and 19%, respectively (see Section 5.2 for more details on inflation in Vietnam).

The convergence rates of the results are much higher than the ones obtained in Chapter 4 for developed countries. The inefficiency coefficients are low, likely because of the use of the differenced and differenced log data for the series employed in this chapter. The table of the convergence rate and inefficiency could be found in Appendix 6A.

Similarly to Chapter 5 and previous studies using VARs for Vietnam (see Camen, 2006; Nguyen and Nguyen, 2010; Bhattacharya, 2014), this chapter focuses on inflation management. Impulse response functions related to output obtained from the TVP-VAR are shown in Appendix 6B.

6.3.1 How monetary policy reacts to inflation

Figure 6.1 shows the posterior means of the change of the policy rate responses to a one percentage point increase in the CPI inflation rate for the whole 30-quarter horizon (panel a) and at the 4^{th}, 8^{th}, 12^{th}, 16^{th}, and 20^{th} quarters (panel b). In general, the policy rate responds expectedly and consistently to an increase in inflation throughout the period. Four quarters after an increase of one percentage point in inflation, the SBV raises the policy rate by around 2 percentage points. At the 8^{th} quarter, the policy rate

remains around 1.5 percentage points higher than its steady level. The increase of the policy rate in response to inflation provides evidence for the argument that the SBV does in fact use the policy rate as an important tool in fighting inflation throughout the period.

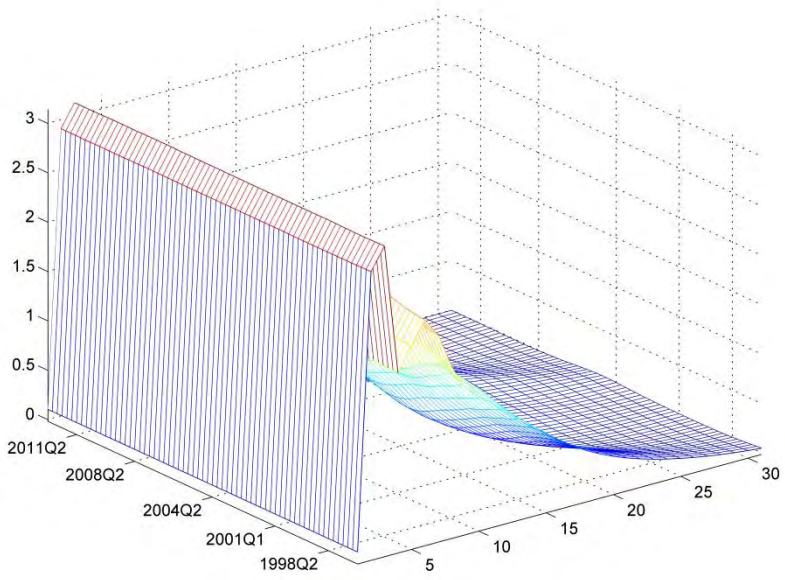
Figure 6.1 also demonstrates that there were some periods when the SBV reacted more aggressively to inflation: 1996–1999 and especially 2008–2011. The former was followed by two years of deflation (2000–2001) and the latter appears to be in response to the recent peaks of inflation in 2008 and 2011 (for more details, see Figure 5.1, Section 5.2, as well as SBV, 2009, and Siregar and Lim, 2010). The reaction by the SBV was less aggressive during the period of low and moderate inflation from 2000 to 2007.

Figure 6.2 shows the posterior means of the change of the policy rate reaction to a one percentage point increase in inflation at the five specific time points. It is observable that the responses follow a surprisingly consistent pattern where the SBV raises the policy interest rate by more than 3 percentage points 2–3 quarters after the rise of inflation. The difference of the policy rate reactions between the five time points can only be observed within the horizon of 10–20 quarters after the inflation shock happens. Among these time points, 1998Q2 and 2008Q2 are observed to be a little more aggressive while 2011Q2 seems to demonstrate a less aggressive reaction.

Figure 6.1 Posterior means of the change of the policy rate responses to a one percentage point increase in inflation, 1996Q2–2012Q4

(Unit: percentage point)

(a) 30-quarter horizon



(b) At specific horizons

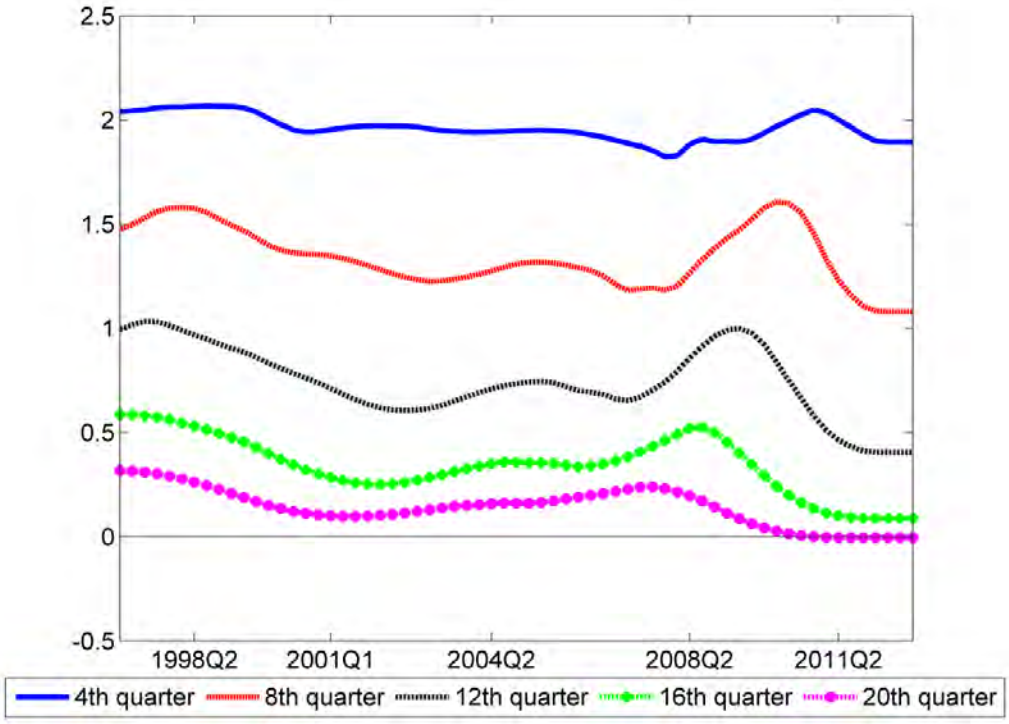
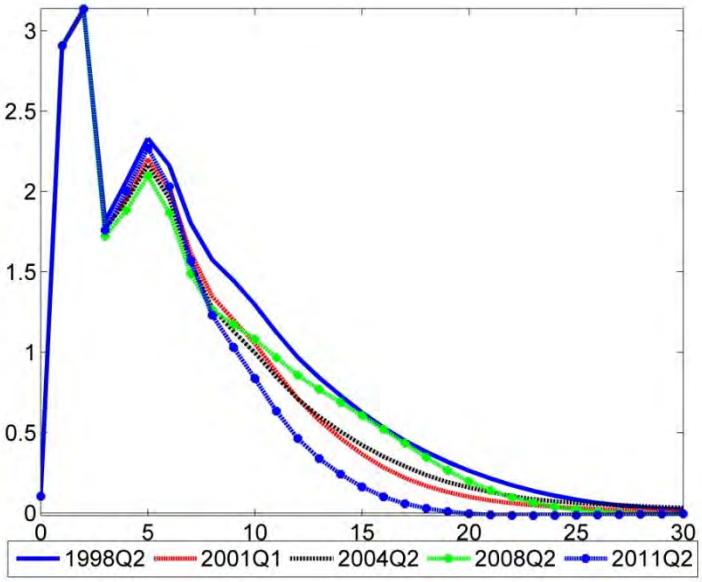


Figure 6.2 Posterior means of the change of the policy rate responses to a one percentage point increase in inflation at five specific time points

(Unit: percentage point; 30-quarter horizon)



In addition to the policy interest rate, as mentioned in Section 5.2, the SBV appears to use the money supply as another main tool for containing inflation. Figure 6.3 shows the posterior means of the money growth responses to a one percentage point increase in inflation. It is observed once again that the money growth reactions are expected and consistent throughout the period. Four quarters after the rise in inflation, money growth drops by 0.6–0.7 percentage points. However, the fall of the money growth seems not to remain for a long time. It comes back towards the steady level dramatically after reaching its peak around the 4th quarter. Unlike the policy interest rate reactions, the money growth responses seem to be less aggressive in 2008–2010 and then increasingly aggressive since.

It is however noticeable that sometimes the SBV seems to fail to keep the actual money growth within its target. Pham and Riedel (2012) argue that failures in

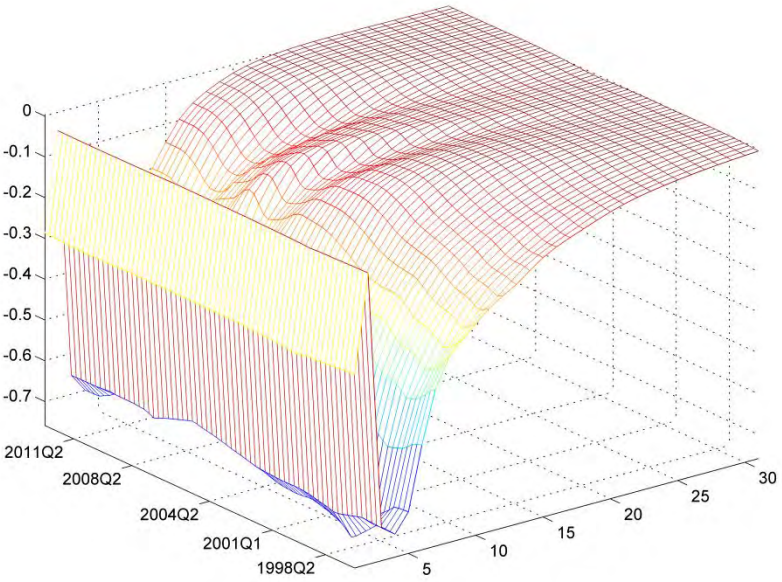
sterilisation efforts by the SBV might have let the money supply grow unexpectedly, causing an acceleration in inflation, especially in 2008.

The posterior means of the money growth responses to a one percentage point increase in inflation at the five specific time points shown in Figure 6.4 support the patterns observed in Figure 6.3. For all five time points, money growth immediately falls by 0.3 percentage points, and reaches a peaked decline of around 0.7 percentage points 3–4 quarters after the rise of inflation. Nevertheless, money growth quickly returns towards its stable level afterwards.

Figure 6.3 Posterior means of money growth responses to a one percentage point increase in inflation, 1996Q2–2012Q4

(*Unit: percentage point*)

(a) 30-quarter horizon



(b) At specific horizons

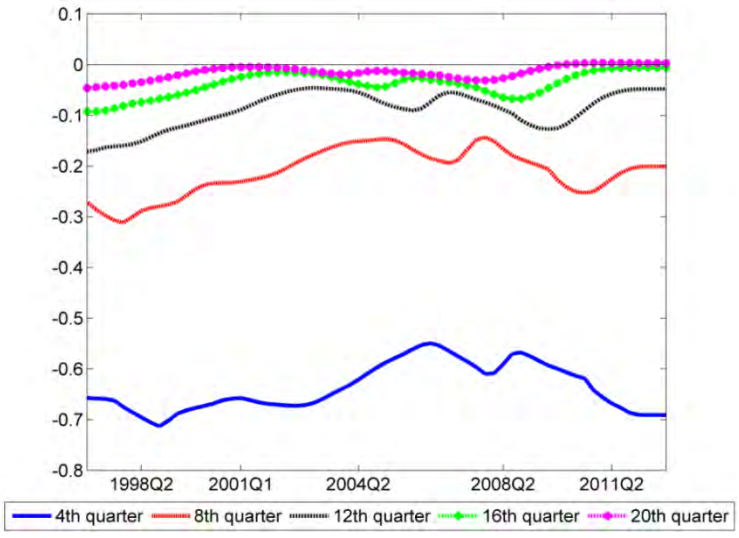


Figure 6.4 Posterior means of the money supply growth responses to a one percentage point increase in inflation at five specific time points

(*Unit: percentage point; 30-quarter horizon*)

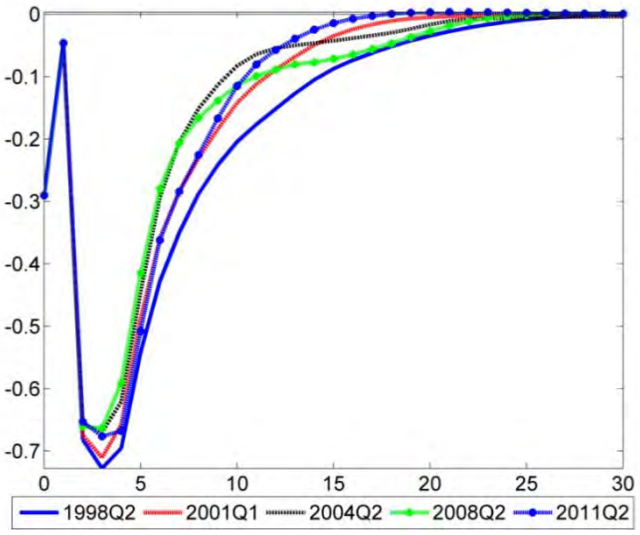


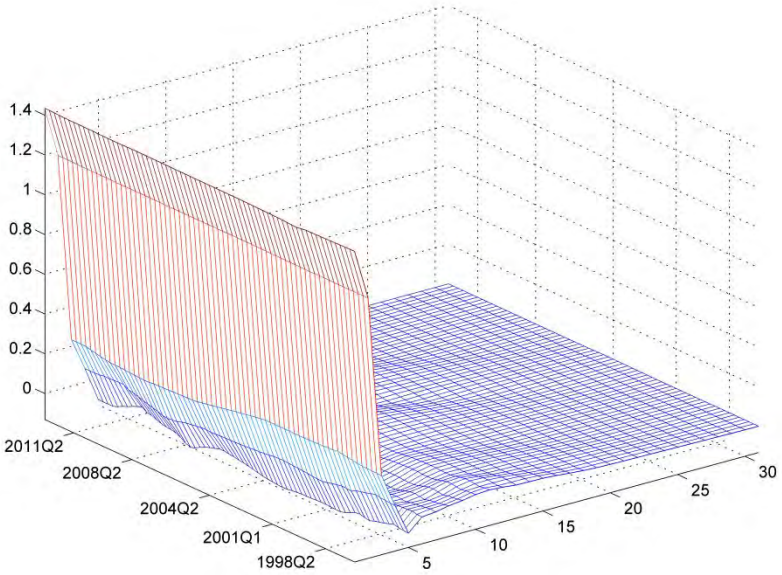
Figure 6.5 shows the posterior means of the aggregate credit growth responses to a one percentage point increase in inflation for the whole 30-quarter horizon (panel a) and at the 4th, 8th, 12th, 16th, and 20th quarters (panel b). The patterns of Figure 6.5 should be examined together with Figure 6.6 where the aggregate credit growth response functions at the five specific time points are drawn. According to these figures, aggregate credit growth rises immediately by 1.4 percentage points after an increase of one percentage point in inflation. Nevertheless, aggregate credit growth drops dramatically afterwards and seems to come back to its steady level after only 3–5 quarters. This feature is observed consistently and the differences between the time points are minor.

Once again, it might be argued from Figures 6.5 and 6.6 that the SBV might have been using credit control measures to push down aggregate credit growth in order to at least soften the inflation pressure on the economy. And the SBV might have been employing these measures in a similar way throughout the period.

Figure 6.5 Posterior means of the aggregate credit growth responses to a one percentage point increase in inflation, 1996Q2–2012Q4

(*Unit: percentage point*)

(a) 30-quarter horizon



(b) At specific horizons

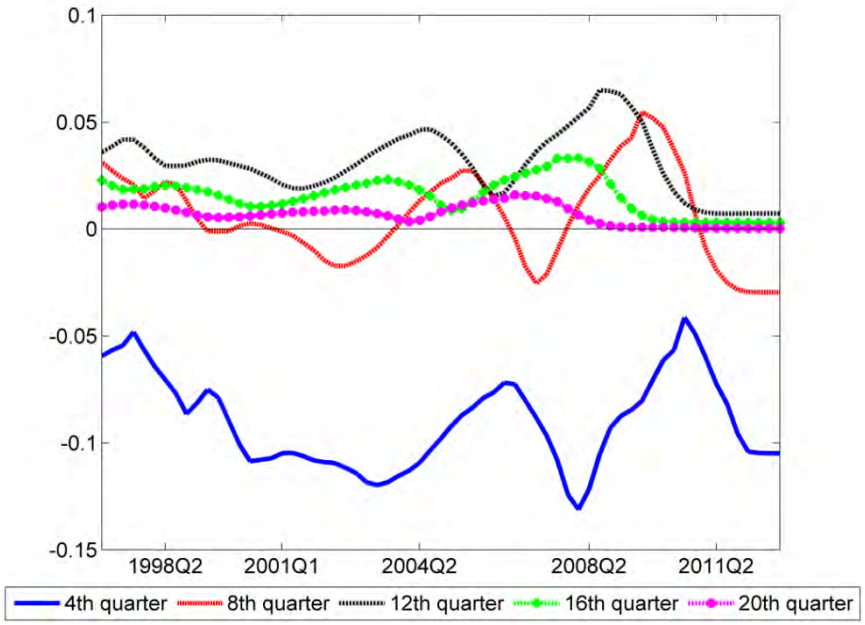
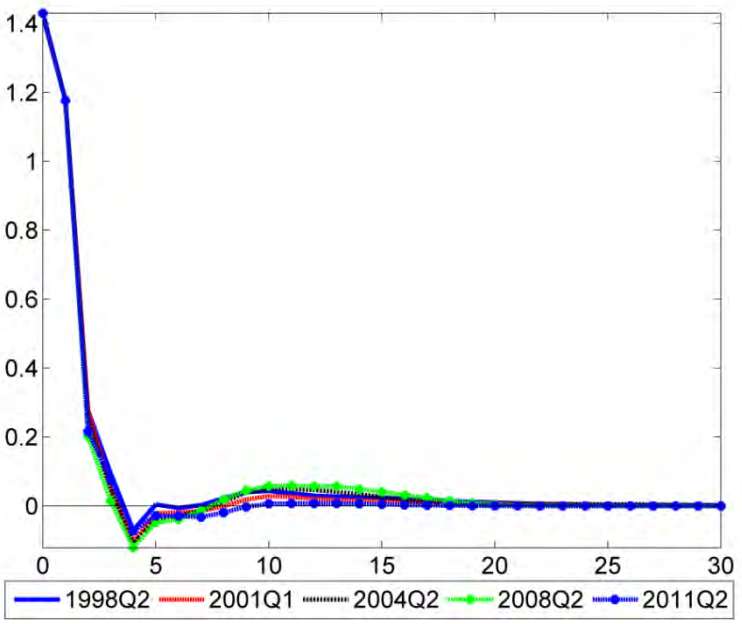


Figure 6.6 Posterior means of the aggregate credit growth responses to a one percentage point increase in inflation at five specific time points

(*Unit: percentage point; 30-quarter horizon*)



In sum, an observation could be made that throughout the period, the SBV has consistently used its policy tools in fighting inflation. For all of the three policy tools examined within the scope of this chapter, there is evidence that these policy tools react in expected directions against the inflation pressure.

Among the policy tools, the policy interest rate seems to react most strongly. An increase of one percentage point in inflation could lead the SBV to raise the policy rate by around three percentage points at peak, and this increase remains over a long horizon. The other two policy tools seem to respond with small magnitudes (aggregate credit growth) or the responses decline quickly after the peaks (money supply growth). This observation could be explained by the fact that the SBV is likely to have more inclusive control over the policy rate than over money supply growth and aggregate credit growth, therefore the interest rate instrument could be used more freely by the SBV.

As observed from the reactions of the policy rate and the aggregate credit to an increase in inflation, it suggests that the SBV might have become more aggressive against inflation during 2008–2011. However, the money growth responses seem not to be as aggressive as the other policy tool responses until 2011. The responses also are evidence that the SBV might not have been so aggressive during 2000–2007, when the inflation rate was low or moderate.

6.3.2 Impulse responses of inflation to monetary policy shocks

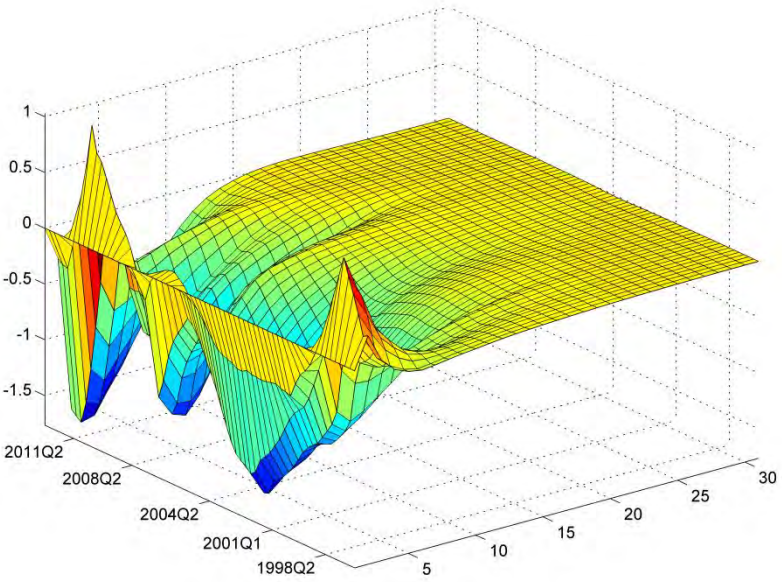
I now turn to the second question of how inflation responds to monetary policy shocks during the period of interest. The size of the shocks is assumed to be unity, which means a shock of one percentage point for each of the variables investigated (the policy rate, money growth, and aggregate credit growth). The inflation impulse response functions will help clarify the transmission mechanism from monetary policy shocks to inflation, therefore will also clarify the effectiveness of monetary policy in terms of managing inflation in Vietnam.

Figure 6.7 shows the posterior means of inflation responses to a one percentage point increase in the policy interest rate for the whole time span (panel a) and at the 4^{th}, 8^{th}, 12^{th}, 16^{th}, and 20^{th} quarters (panel b). Combining with Figure 6.8 where the inflation responses at the five chosen time points are shown, it is observed that a shock to the policy rate has expected effects on inflation. A shock of a one percentage point increase in the policy rate leads to a decline of around 1.6 percentage points in inflation at peak (around 4 quarters after the shock). It is also observable that inflation responds most strongly around 2003Q2, 2008Q2, and 2011Q4 during the period examined. A short 'price puzzle' appears at the 1^{st} quarter for two time points: 1998Q2 and 2011Q2.

Figure 6.7 Posterior means of inflation responses to a one percentage point increase in the policy rate, 1996Q2–2012Q4

(*Unit: percentage point*)

(a) 30-quarter horizon



(b) At specific horizons

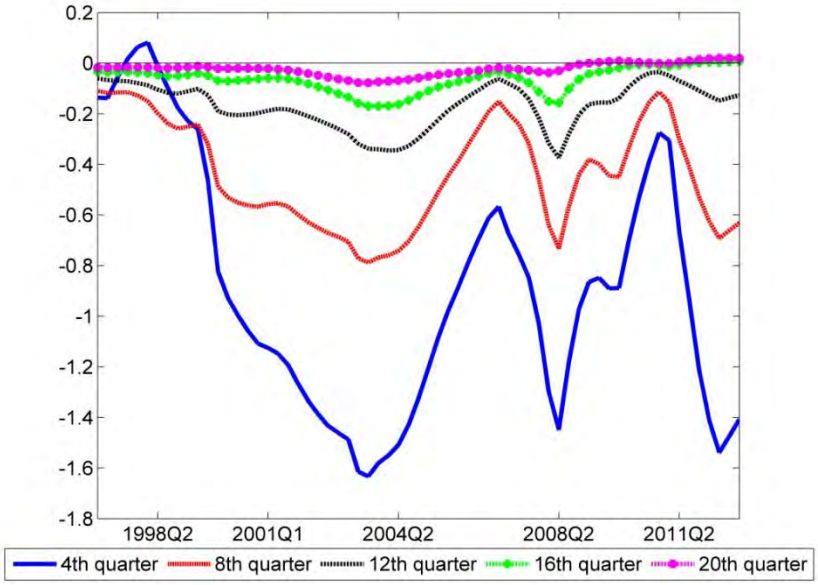
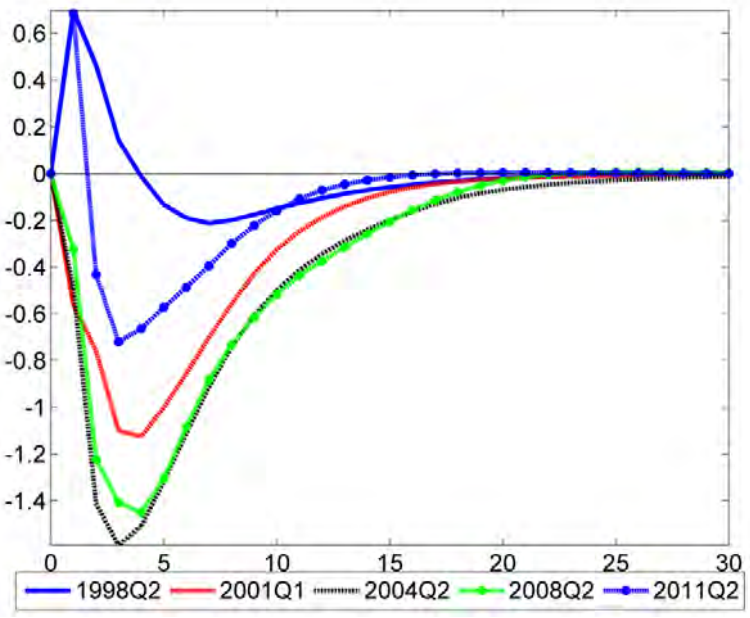


Figure 6.8 Posterior means of inflation responses to a one percentage point increase in the policy rate at five specific time points

(*Unit: percentage point; 30-quarter horizon*)

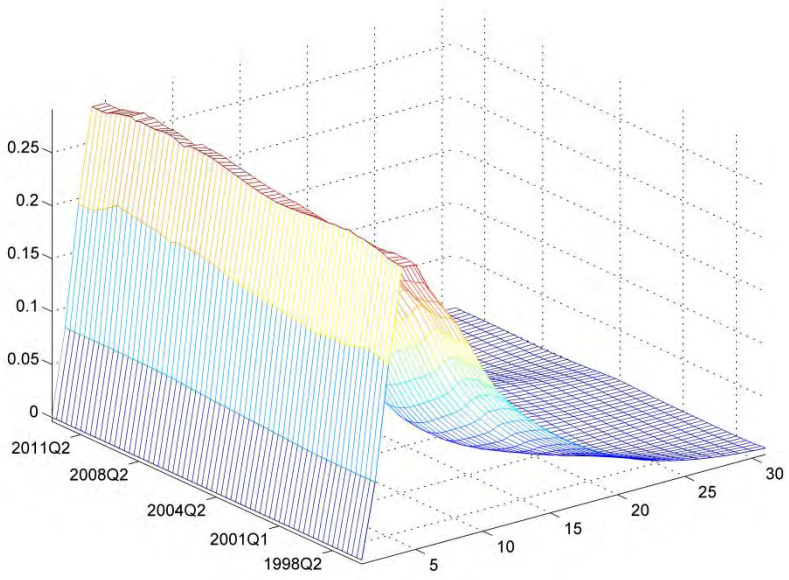


The posterior means of inflation responses to a one percentage point increase in money growth are illustrated in Figure 6.9. Figure 6.10 shows the responses at the five chosen time points across a 30-quarter horizon. The two figures once again demonstrate expected and consistent impulse response functions of inflation to the shocks in money growth. In response to an increase of one percentage point in money growth, the inflation rate rises by nearly 0.3 percentage points at peak, which is around the 4th quarter after the money growth shock. The effects of money growth on the inflation rate seem to be higher during the sub-periods 1996–1998, 2004–2006, and 2008–2010, especially for longer horizons.

Figure 6.9 Posterior means of inflation responses to a one percentage point increase in money growth, 1996Q2–2012Q4

(*Unit: percentage point*)

(a) 30-quarter horizon



(b) At specific horizons

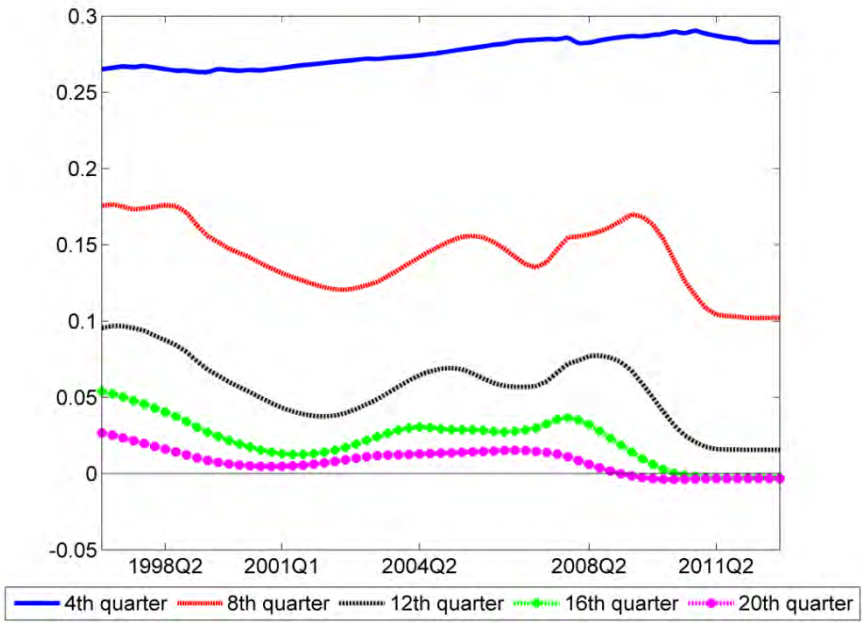
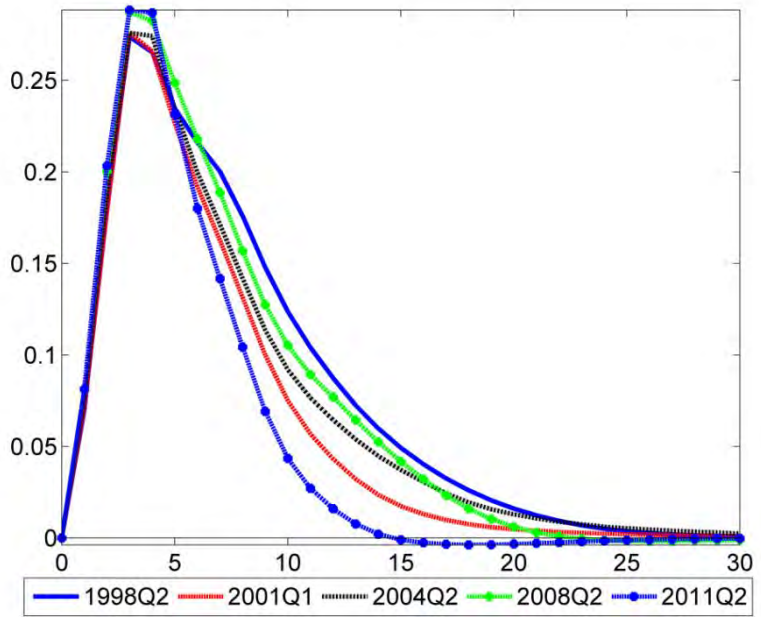


Figure 6.10 Posterior means of inflation responses to a one percentage point increase in money growth at five specific time points

(*Unit: percentage point; 30-quarter horizon*)

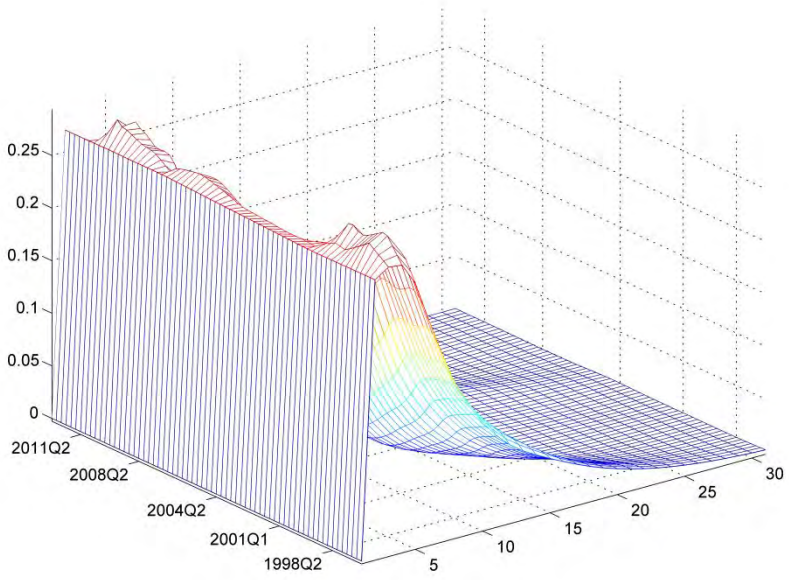


Figures 6.11 and 6.12 demonstrate the posterior means of the inflation rate responses to a one percentage point increase in aggregate credit growth. These figures are noticeably similar to the figures for the money growth shocks (Figures 6.9 and 6.10). In response to an increase of one percentage point in credit growth, the inflation rate rises by about 0.3 percentage points at peak, which is around the 4th quarter. The effects of credit growth on the inflation rate are also observed to be higher during the sub-periods 1996–1998, 2004–2006, and 2008–2010. This pattern suggests a similarity in the effects on inflation when the SBV uses its instruments to target money growth and credit growth. This suggestion is also similar to what was found in Chapter 5.

Figure 6.11 Posterior means of inflation responses to a one percentage point increase in aggregate credit growth, 1996Q2–2012Q4

(*Unit: percentage point*)

(a) 30-quarter horizon



(b) At specific horizons

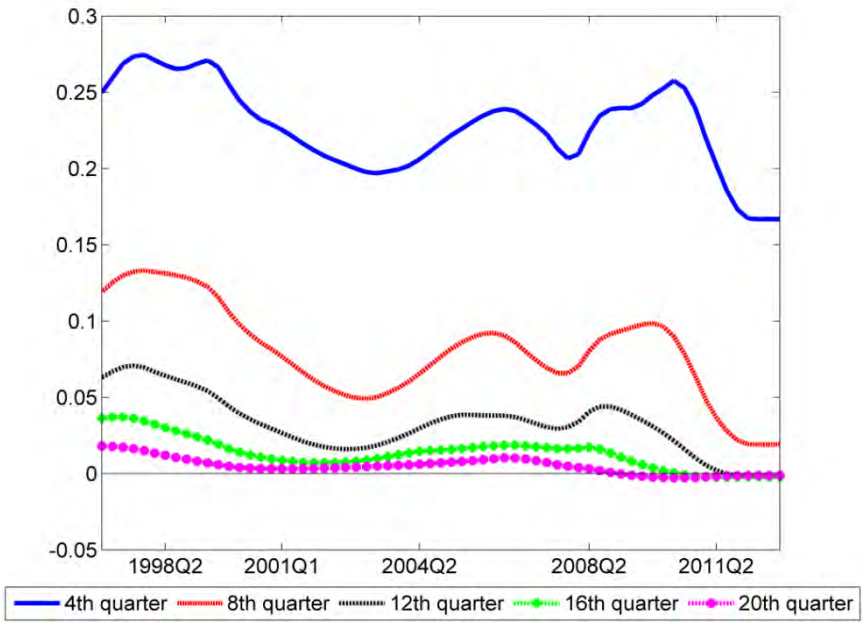
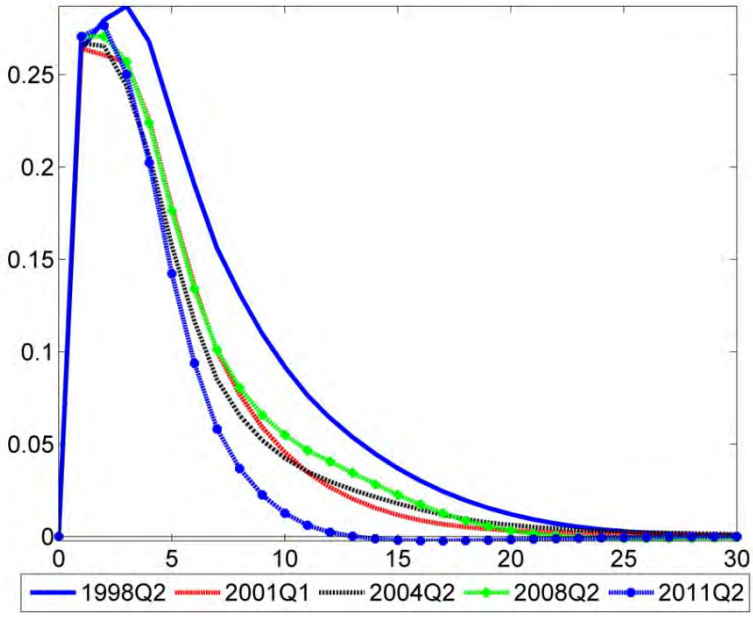


Figure 6.12 Posterior means of inflation responses to a one percentage point increase in aggregate credit growth at five specific time points

(Unit: percentage point; 30-quarter horizon)



In summary, inflation in Vietnam responds expectedly to monetary policy tools, including the policy interest rate, money growth, and credit growth. During the period 1996–2012, shocks in these policy variables lead to the expected changes in the inflation rate. Money growth and credit growth show extremely similar effects on inflation.

6.4 Conclusion

This chapter analyses the dynamics of inflation management in Vietnam for the period 1996Q2–2012Q4. Using a TVP-VAR model of six variables, including three monetary policy instruments, the empirical results suggest some key points.

First, the SBV appears to use the policy interest rate, money supply growth, and aggregate credit controls to contain inflation. The monetary policy reactions seem to be more aggressive during the sub-periods of high inflation.

Second, inflation responds expectedly to shocks in the monetary policy tools. There is a noticeable similarity between money growth and credit growth in terms of their effects on the inflation rate.

These observations support the suggestion obtained from Chapter 5 that Vietnam's monetary policy might be more effective and more advanced than expected, at least in terms of using monetary policy tools to contain inflation. Similarly to Chapter 5, the results from this chapter also support an argument that the plausible impulse response functions obtained from the TVP-VAR model might provide the SBV with more confidence in its quest to become a modern, inflation-targeting type of central bank, as in some of Vietnam's neighbouring countries such as Indonesia and Thailand (see Disyatat and Vongsinsirikul, 2003; Siregar and Goo, 2010).

Combining the results from this chapter to the ones obtained in Chapter 5, a small additional finding could be suggested. That is although there are some significant changes in the macroeconomic variables during the period 1996–2012, this period seems not to have seen any structural breaks in terms of both monetary policy reactions to inflation and inflation responses to policy shocks. The impulse response at the chosen specific time points show no noticeable difference. Therefore, in general the VAR and SVAR models in Chapter 5 where parameters are assumed to be time-invariant provide reasonable results.

Similarly to Camen (2006), Le and Pfau (2009), and Nguyen and Nguyen (2010), the scope of this chapter is limited to inflation management dynamics. Furthermore, the

analysis concentrates on the reactions and effects of some key monetary policy tools only, leaving aside any potential effects of fiscal policy as well as other possible channels of the transmission mechanisms such as the asset price channel.

Finally, similar to Chapter 4, parts of the analysis in this chapter might be re-done when real-time data are available, as suggested by Orphanides (2001), Croushore and Evans (2006), and Lee *et al.* (2012). However, this seems to be a long-run prospect for the case of Vietnam.

CHAPTER 7

CONCLUSION

Summary: This chapter summarises the key findings and policy implications of the thesis. This chapter also sketches some suggestions for future research.

7.1 Key findings

This thesis consists of four key findings based on the four empirical research papers on monetary transmission mechanisms (Chapters 3–6). Each of the findings is new. The first is that the investment channel plays a more important role than the consumption channel in the monetary transmission mechanism in Australia, while the contributions of the two channels are indistinguishable in the Euro area and the US. The difference between Australia and the Euro area comes from differences in housing investment responses, whereas Australia is different to the US mainly because it has a lower share of household consumption in total demand.

The second finding is that monetary policy reactions to unemployment comoved over time before the recent Global Financial Crisis (GFC). The policy rate seems to react more strongly to unemployment in recent years, especially in the US and UK. Monetary policy responses to inflation/deflation are observed to be divided into two groups, with the responses in the US and UK showing a different pattern to the responses in Canada and Australia. The US seems to show the most aggressive monetary policy reactions to inflation/deflation. There are comovements in the effects of monetary policy on unemployment and inflation across countries, and these effects seem to have weakened over time.

The third finding is that the inflation responses to monetary policy shocks in Vietnam are similar to standard monetary transmission mechanisms. The plausible and robust monetary transmission for the case of Vietnam suggests that Vietnam's monetary policy shares similarities to monetary policy in advanced countries. Moreover, evidence from SVAR models confirms that shocks to output and prices in trading partners also have strong effects on inflation in Vietnam.

The fourth finding is that the SBV has reacted consistently to inflation developments during the period 1996-2012, including with its use of the policy interest rate, the money supply, and the aggregate credit control measures. The monetary policy reactions were more aggressive during the sub-periods of higher inflation, and less aggressive during the sub-periods of low and moderate inflation.

7.2 Policy implications

The results in Chapter 3 could be informative to theories on monetary transmission, as well as to central banks such as the Reserve Bank of Australia. Noting the differences in the responses of housing and non-housing investment, durable and non-durable consumption to monetary policy shocks between Australia and the two big comparators (the Euro area and the US) might help the Reserve Bank of Australia better understand monetary transmission in Australia itself.

Results from Chapter 4 help shed light on the practice of monetary policy transmission. Knowing the similarities and dissimilarities of monetary transmission across countries might help central banks understand better the extent to which monetary policy has contributed to the dynamics of important macroeconomic variables such as unemployment and inflation.

The plausibility of the monetary transmission to inflation found in Chapters 5 and 6 suggest that the SBV has capacity to use its policy tools to contain inflation. It therefore might provide the SBV with more confidence in pursuing the quest toward a standard, modern monetary policy as aimed for by the new Law on SBV in 2010.

7.3 Suggestions for future research

Although the simple recursive VAR models, the SVAR models, and the TVP-VAR models used in this thesis are widely used in research on monetary policy and transmission, there are still some drawbacks. Among those, the endogeneity issue seems to be the most significant one. Because of the role of expectations in monetary policy decisions, it is difficult to correctly identify the truly exogenous shocks in monetary policy. As a result, it is also difficult to accurately measure the effects of monetary policy on other macroeconomic variables.

Using the type of real-time data provided by Orphanides (2001), Croushore and Evans (2006), and Lee *et al.* (2012) could only solve the timing aspect of the identification issue. A potential direction for future research might involve using an instrumental variable approach based on exogenous shocks to interest rates. Such shocks are difficult to find, however.[36]

[36] Romer and Romer (2004) develop a new measure of monetary policy shocks through a two-step process. First, they use the Federal Open Market Committee (FOMC) meetings' records to deduce the Federal Reserve's intentions to change the FED funds rate. They then regress their measure of these intentions on the Federal Reserve's forecasts of inflation, real output growth, and the unemployment rate. They use the error term from this regression to form a monetary policy shock measure that is relatively independent from expectations.

From the research in this thesis, several potential topics emerge for further study. From the analysis in Chapter 3, some issues, such as the responses of net exports to a shock in monetary policy; the existence of the 'cost channel' in Australia; and the detailed effects of monetary policy on the housing market in Australia – which need different identification schemes to be examined extensively – are potential topics for future research.

From Chapter 4, the limitations of the parsimonious TVP-VAR models suggest possibly adopting a model with more variables and structural relations. Another possible direction is to impose theory-consistent sign restrictions into the TVP-VAR to avoid the price puzzle. The analysis could also be done for the Euro area when the time series of data under the European Central Bank regime become long enough for a consistent TVP-VAR analysis. Moreover, it could be also useful to know whether there are micro-level explanations for the similarities in monetary policy transmission across countries.

For the case of Vietnam in Chapter 5 and Chapter 6, the VAR, SVAR, and TVP-VAR models implemented in Chapters 5 and 6 could be expanded to provide more insights into the monetary transmission mechanism to specific components of the real macro activities if the quarterly data of GDP components (e.g. consumption, investment, etc.) for Vietnam are available. The method of TVP-VAR in Chapter 6 could also be applied to the cases of other developing countries, such as other ASEAN countries, with suitable adjustments.

APPENDICES

Appendices to Chapter 3

Appendix 3A Data sources and data graphs for Chapter 3

Series	Sources
Australia	
Consumption	RBA, G11 Gross Domestic Product – expenditure components, private spending, consumption, seasonal adjusted
Investment	RBA, G11 Gross Domestic Product – expenditure components, private spending, investment, seasonal adjusted
GDP	RBA, G10 Gross Domestic Product – GDP, 2009/10 chained volume measures, seasonal adjusted
Other GDP components	RBA, GDP minus consumption and investment, seasonal adjusted
Government expenditure	RBA, Other GDP components minus net exports, seasonal adjusted
Net exports	RBA, G11 Gross Domestic Product – expenditure components, exports minus imports
CPI	RBA, G2 CPI, all groups, 1989/90 = 100, seasonal adjusted
Real wages	RBA, G6 Labour costs – average weekly earnings, seasonal adjusted
Labour productivity	GDP/hours worked from ABS, 6202.0 Labour Force, aggregate monthly hours worked, persons, seasonal adjusted
Policy rate	RBA, F1 Interest rates and yields – money market, interbank rate
Profit to GDP ratio	Profits/GDP, profits from ABS, 5206.0 Table 7. Income from GDP, Gross operating surplus
M3	RBA, D3 Monetary aggregates, M3, seasonal adjusted
Share price index	ASX All Ordinaries price index, Wren Research, http://www.wrenresearch.com.au/downloads/
Commodity prices	RBA, G5 Index of Commodity prices, 2008/09 = 100, all items
Bond yields	RBA, F2 Capital market yields, Government bonds, 10 years
REER	RBA, F15 Real exchange rate measures, real trade-weighted index, 1995 = 100
Housing investment	ABS, 13500DO013_201204 Table 8– Table 3.4 – Private gross fixed capital formation and inventories, Private gross fixed capital formation, Dwellings, chain volume measures, seasonal adjusted
Durable consumption	ABS, 13500DO013_201204 Table 2–Table 3.1 – Household final consumption expenditure, Purchases of vehicles plus furnishings and household equipment, chain volume measures, seasonal adjusted

Series	Sources
Euro area	All from Area-Wide Model (AWM17UP12)[37], except:
Housing investment	Datastream, EKXIPRD.C, Oxford Economics, EK investment, private dwellings, real conn
US	
GDP	RBA, I1 International GDP, seasonal adjusted; and US Bureau of Economic Analysis (BEA), Gross Domestic Product, (Bil. Ch. 2009 USD, SAAR), http://www.economy.com/freelunch
Consumption	US Bureau of Economic Analysis (BEA), Personal Consumption Expenditures, (Bil. Ch. 2009 USD, SAAR), http://www.economy.com/freelunch
Investment	US Bureau of Economic Analysis (BEA), Gross Private Domestic Investment, (Bil. Ch. 2009 USD, SAAR), http://www.economy.com/freelunch
Other GDP components	GDP minus Consumption and Investment
CPI	RBA, I2 International CPI, 1996 = 100; and US Bureau of Labor Statistics, CPI: Urban Consumer – All items, (Index 1982–84 = 100, seasonal adjusted), http://www.economy.com/freelunch
Real wages	Datastream, USWAGESPD, US Bureau of Labor Statistics BLS, US AVG HOURLY REAL EARN.OF PRODN. EMPLOYEES, 1982–84 prices, seasonal adjusted
Labour productivity	US Bureau of Labor Statistics (BLS), Business: All Persons – Output Per Hour, (Index 2005=100, seasonal adjusted), http://www.economy.com/freelunch
Policy rate	US Board of Governors of the Federal Reserve System (FRB), Federal Funds Effective Rate, http://www.economy.com/freelunch
Profit to GDP ratio	Profits/GDP; Profits: US Bureau of Economic Analysis (BEA), US profits after tax – corporate business
M2	US Board of Governors of the Federal Reserve System (FRB): H.6 Money Stock Measures, Money Stock: M2, (Bil. USD, seasonal adjusted), http://www.economy.com/freelunch
Share price index	Standard and Poor's, S&P 500 Stock Price Index, http://research.stlouisfed.org/fred2/
Commodity prices	Bridge/CRB, KR-CRB Futures Price Index, (1967=100), http://www.economy.com/freelunch
Bond yields	US Board of Governors of the Federal Reserve System (FRB): H.15 Selected Interest Rates, Treasury Constant Maturities Nominal – 10 year, http://www.economy.com/freelunch
REER	Board of Governors of the Federal Reserve System, Real Trade Weighted US Dollar Index: Broad, March 1973=100,

[37] I thank José Emilio Gumiel from DG – Research/ Monetary Policy Research Division, ECB for providing me with the latest AWM data.

Series	Sources
	http://research.stlouisfed.org/fred2/
Housing investment	US Bureau of Economic Analysis (BEA), Private Fixed Investment: Residential, (Bil. Ch. 2009 USD, SAAR), http://www.economy.com/freelunch
Durable consumption	US Bureau of Economic Analysis (BEA), Personal Consumption Expenditures: Durable Goods, (Bil. Ch. 2009 USD, SAAR), http://www.economy.com/freelunch
Oil price	Dow Jones & Company, Spot Oil Price: West Texas Intermediate, http://research.stlouisfed.org/fred2/

Figure 3A1 Data graphs for Australia

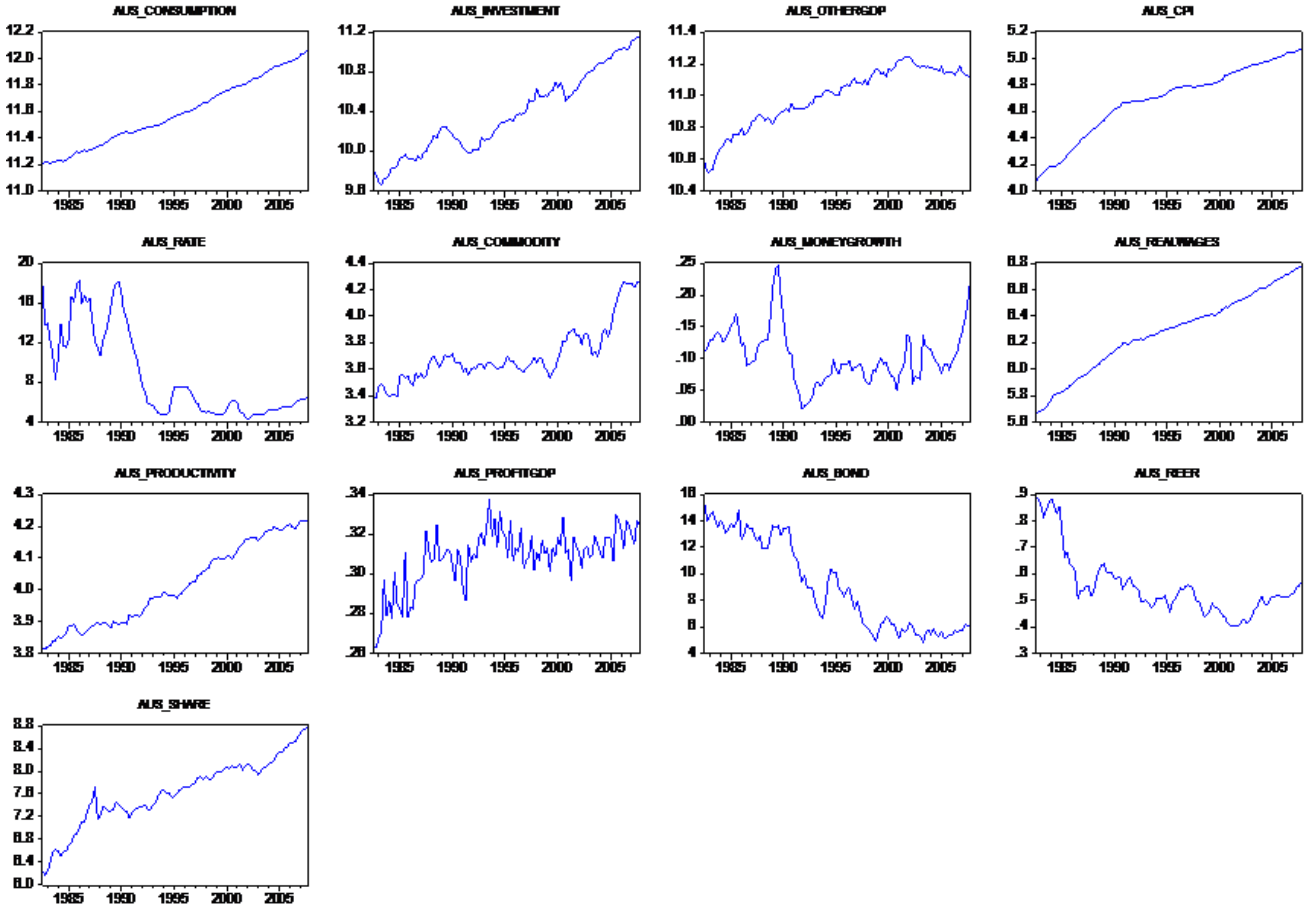


Figure 3A2 Data graphs for Euro area

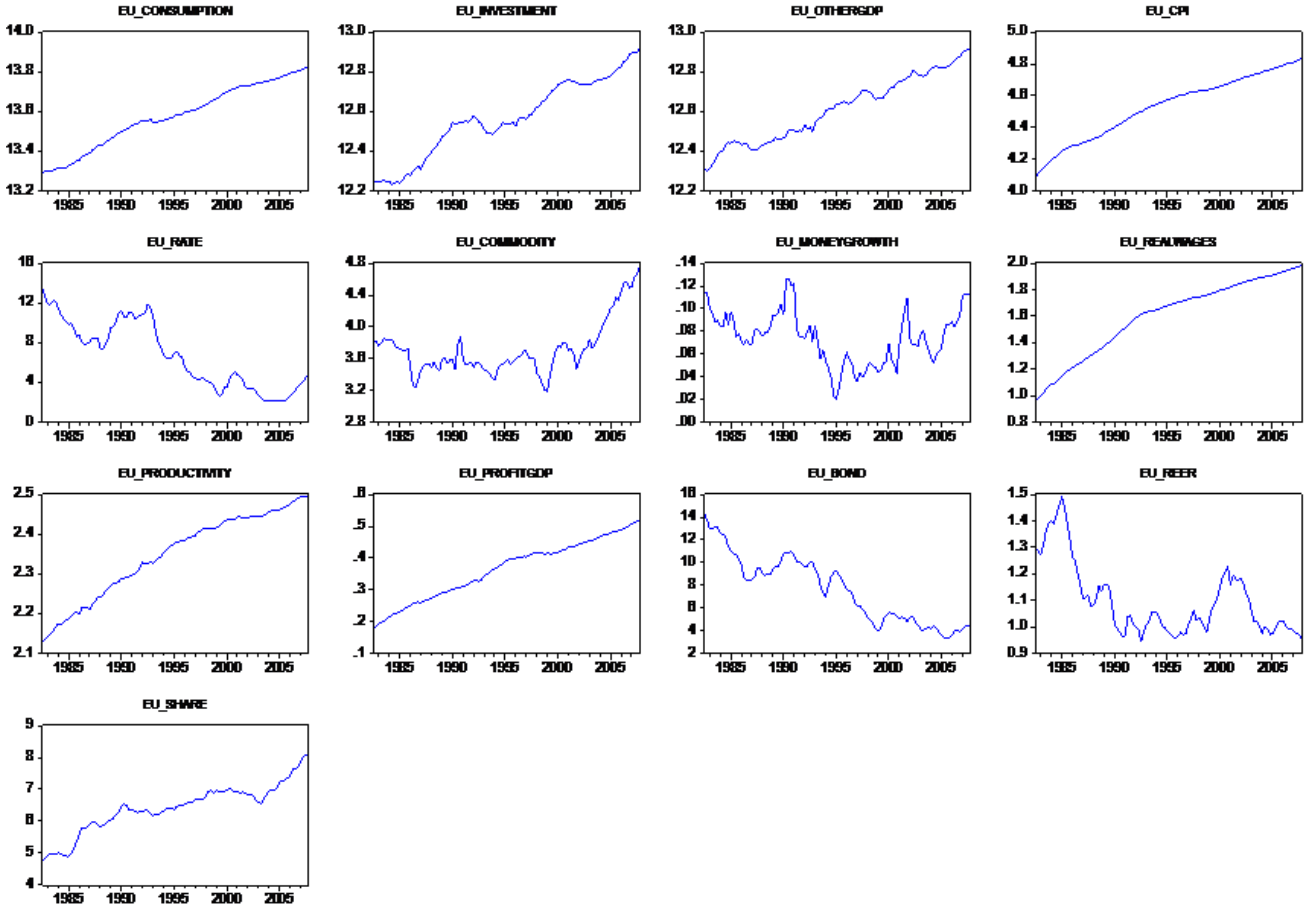
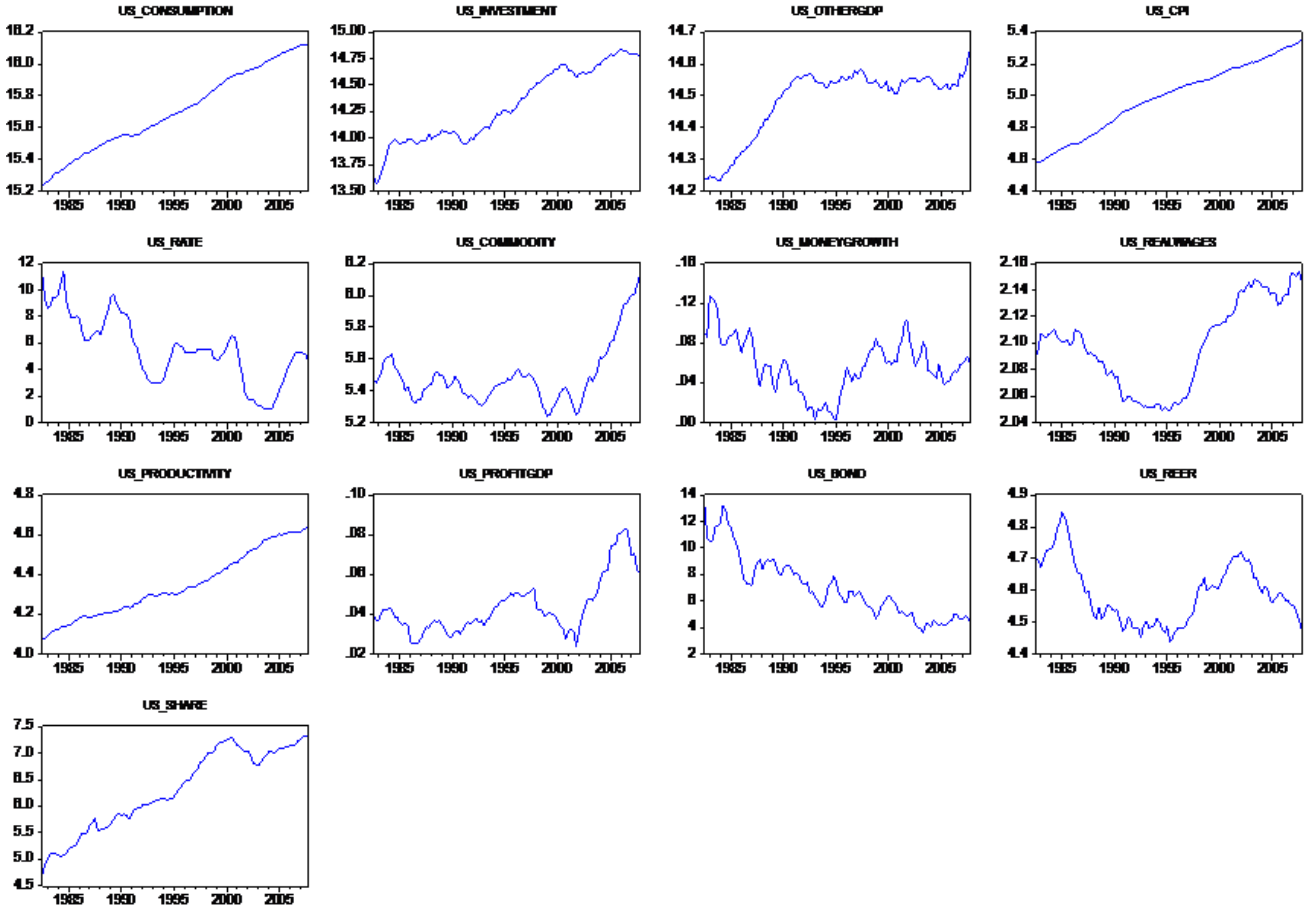


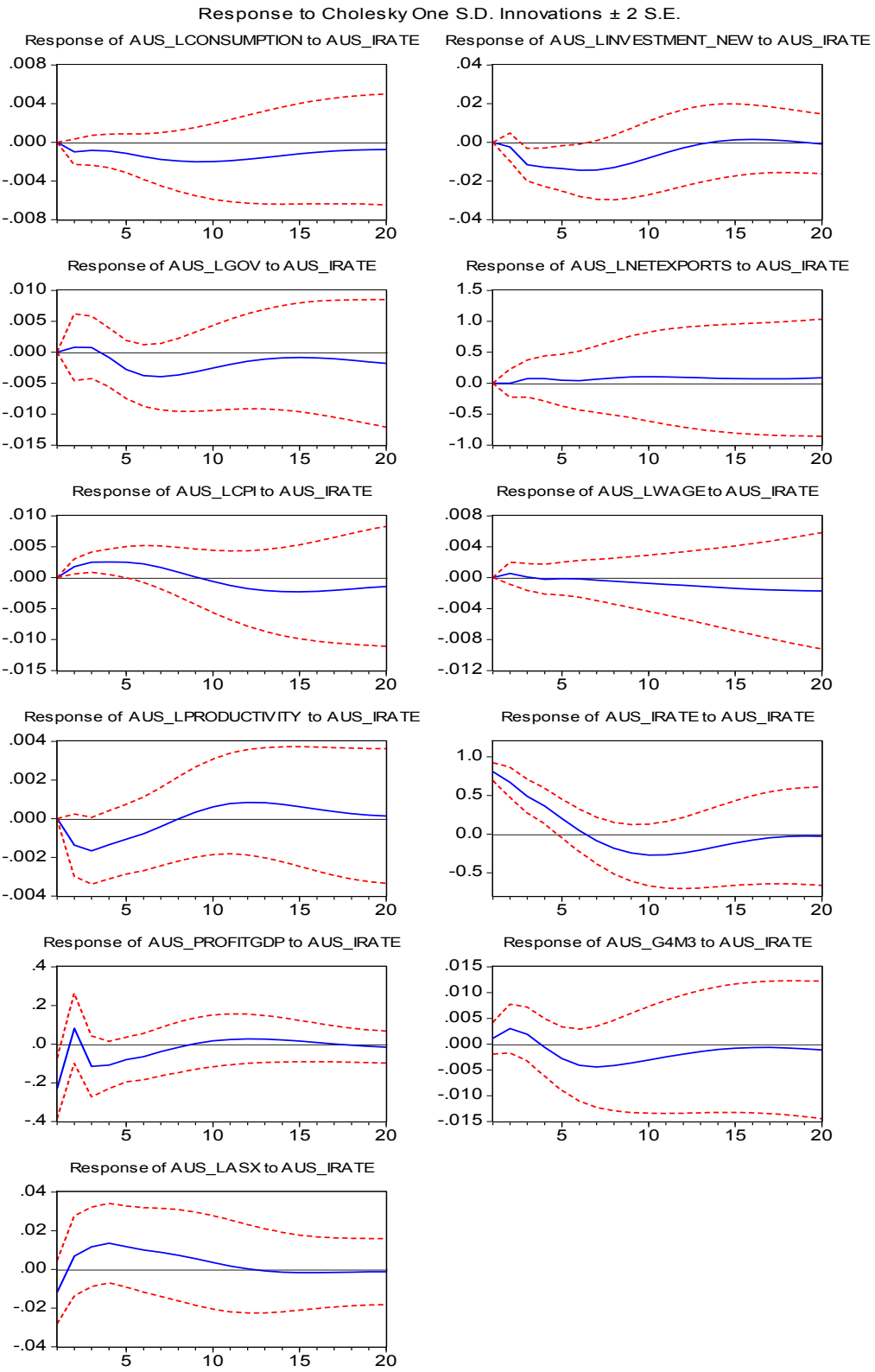
Figure 3A3 Data graphs for the US

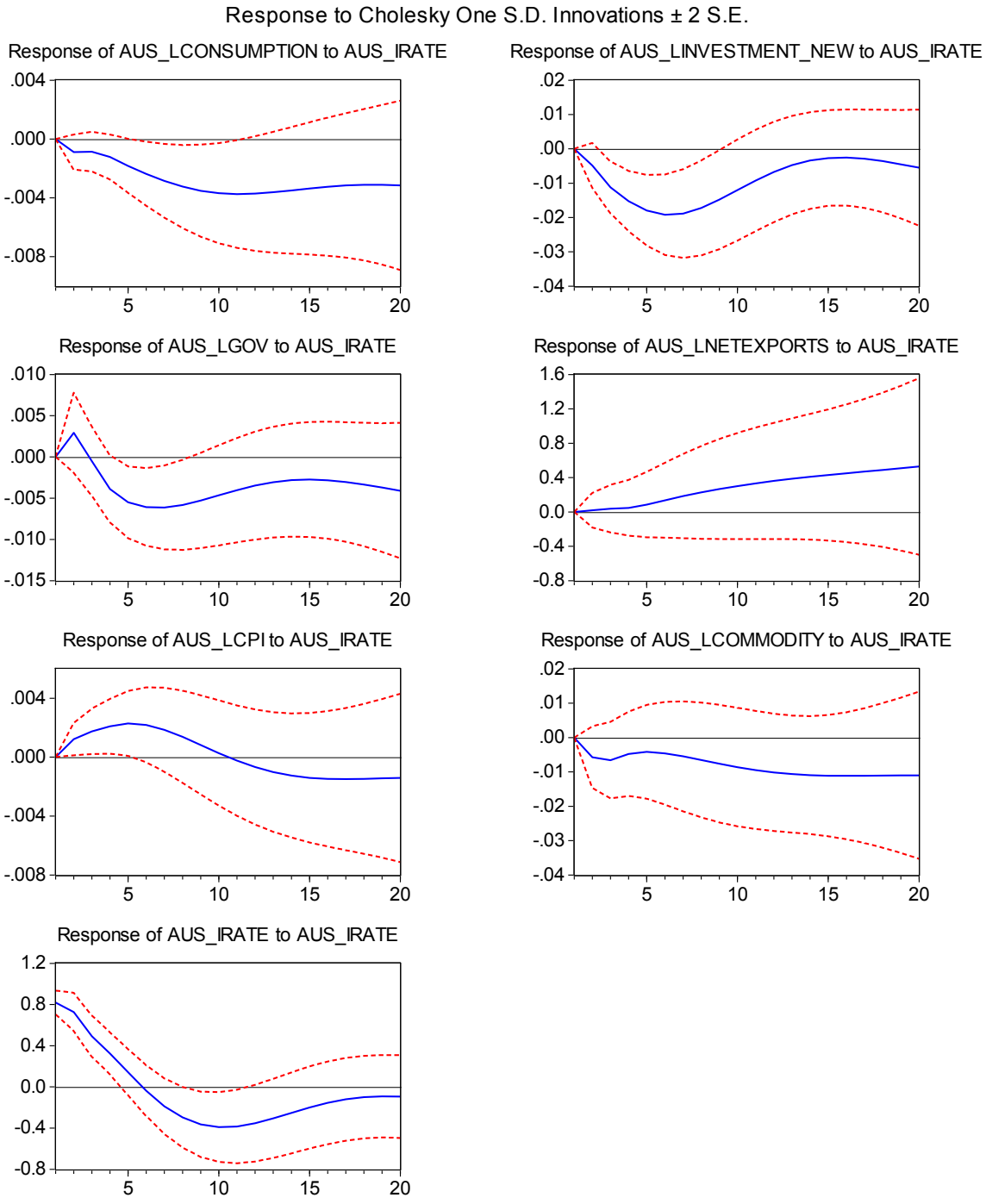


Appendix 3B Impulse responses from VARs with net exports

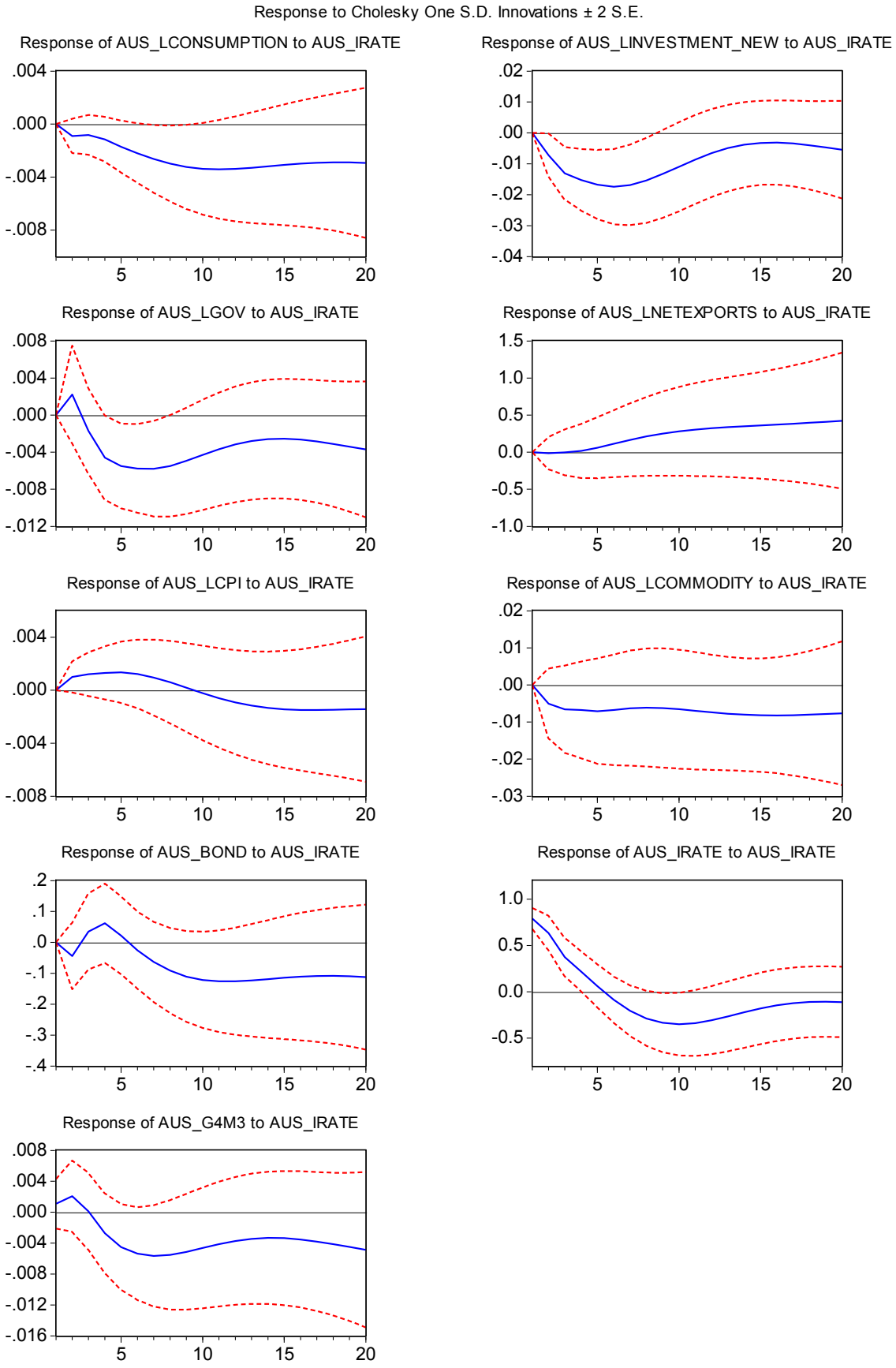
Australia

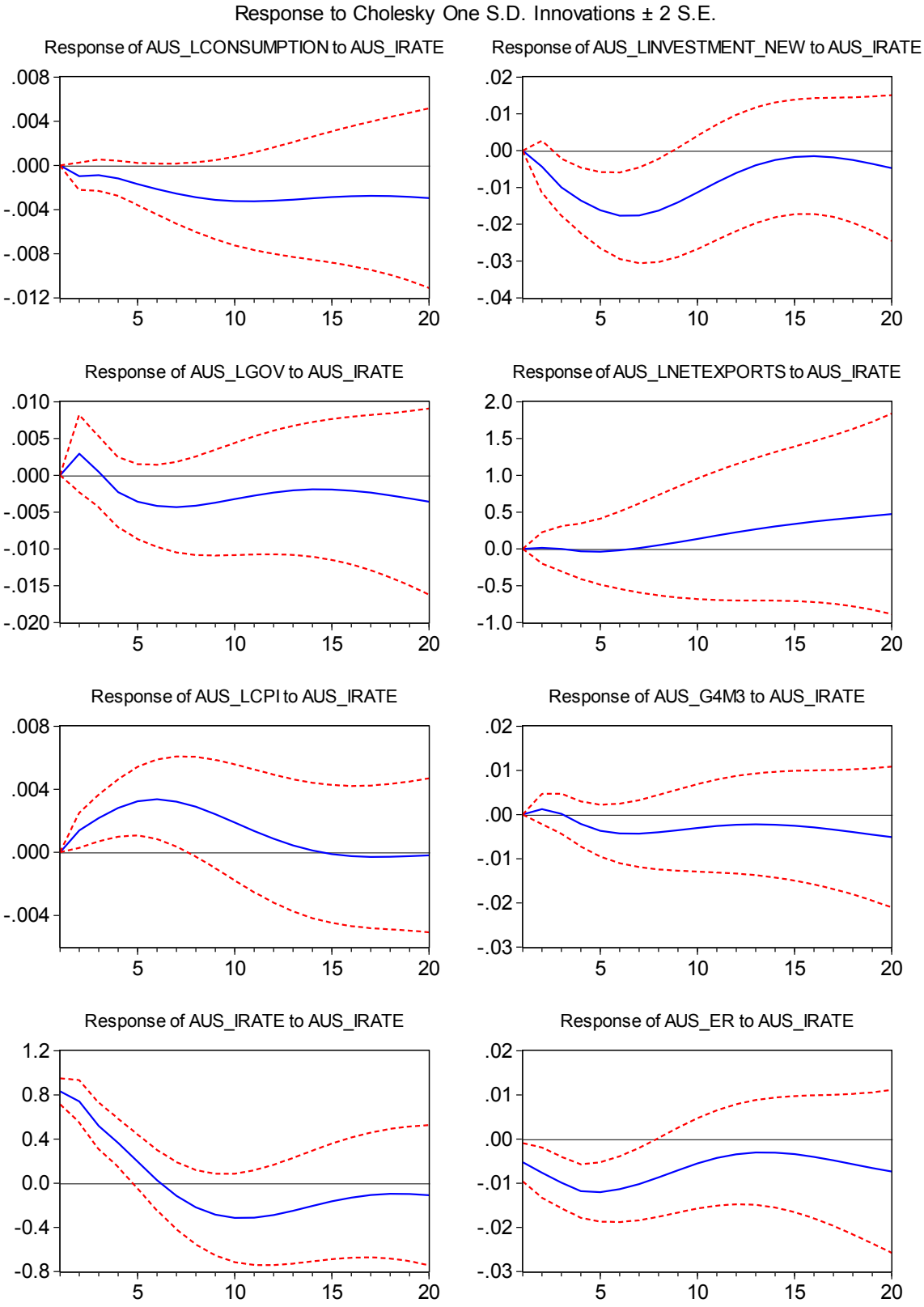
Christiano–Eichenbaum–Evans VAR




Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of AUS_LCONSUMPTION to AUS_IRATE
Response of AUS_LINVESTMENT_NEW to AUS_IRATE
Response of AUS_LGOV to AUS_IRATE
Response of AUS_LNETEXPORTS to AUS_IRATE
Response of AUS_LCPI to AUS_IRATE
Response of AUS_LCOMMODITY to AUS_IRATE
Response of AUS_IRATE to AUS_IRATE

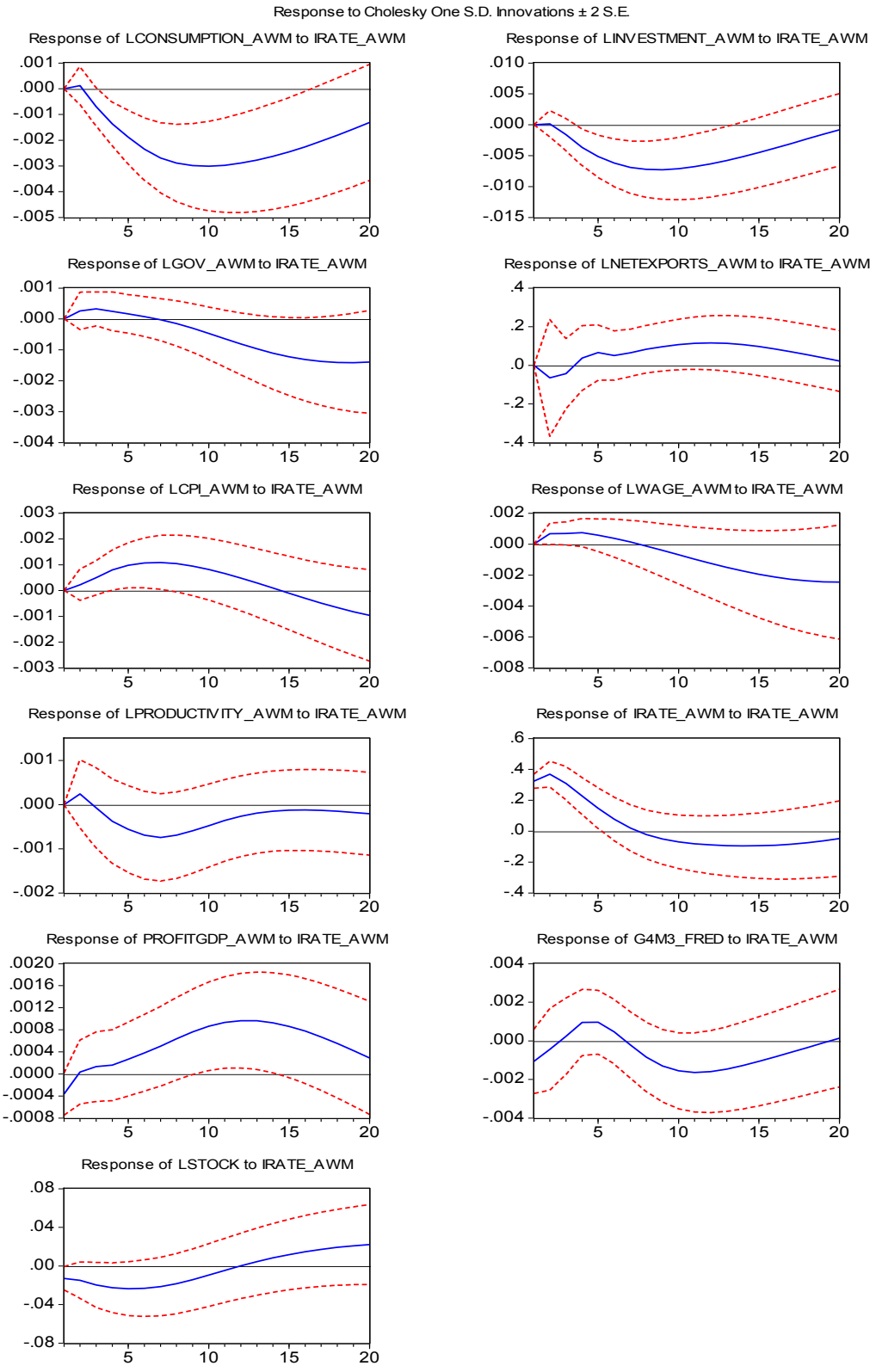
Generalised Erceg–Levin VAR

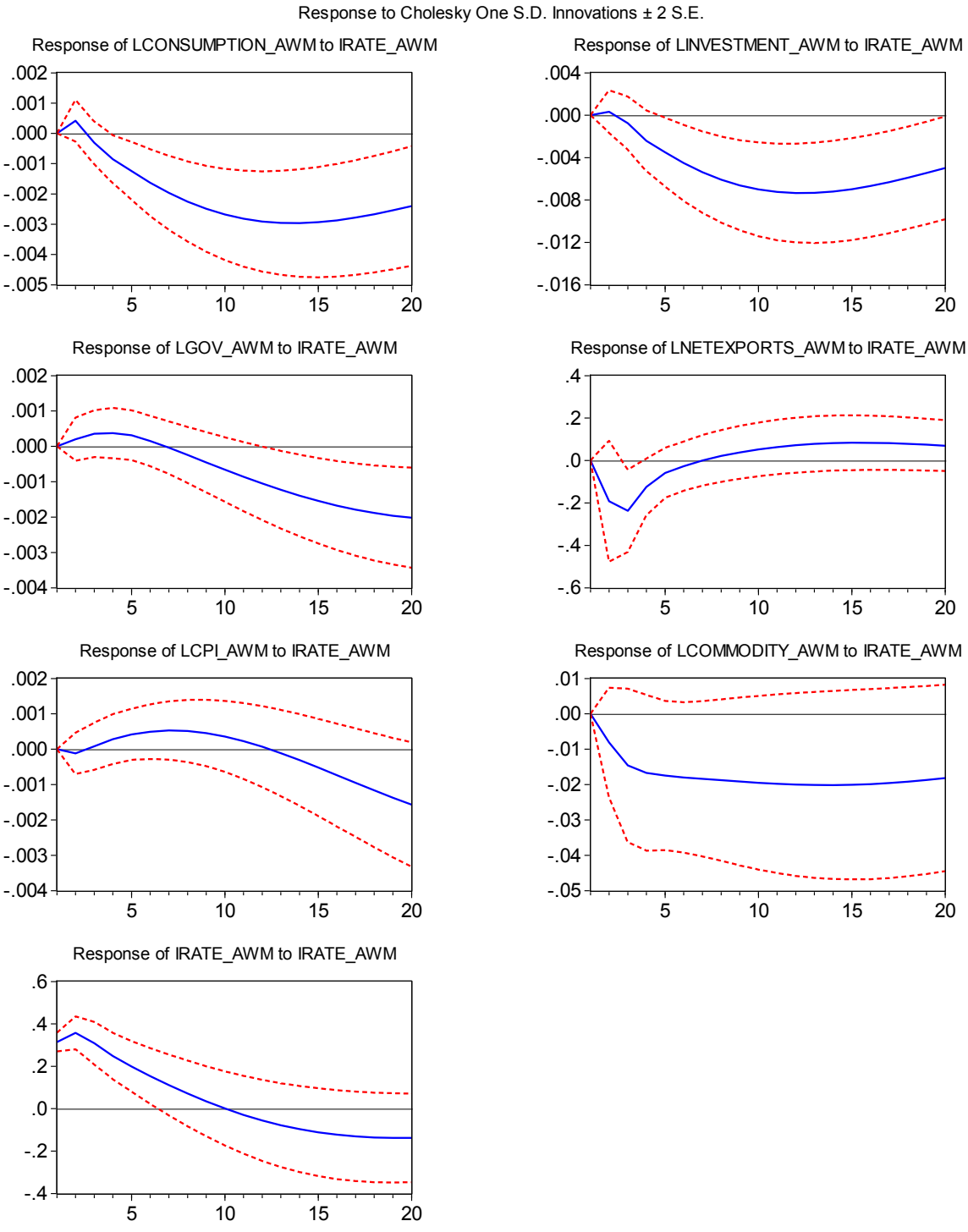



Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of AUS_LCONSUMPTION to AUS_IRATE
Response of AUS_LINVESTMENT_NEW to AUS_IRATE
Response of AUS_LGOV to AUS_IRATE
Response of AUS_LNETEXPORTS to AUS_IRATE
Response of AUS_LCPI to AUS_IRATE
Response of AUS_G4M3 to AUS_IRATE
Response of AUS_IRATE to AUS_IRATE
Response of AUS_ER to AUS_IRATE

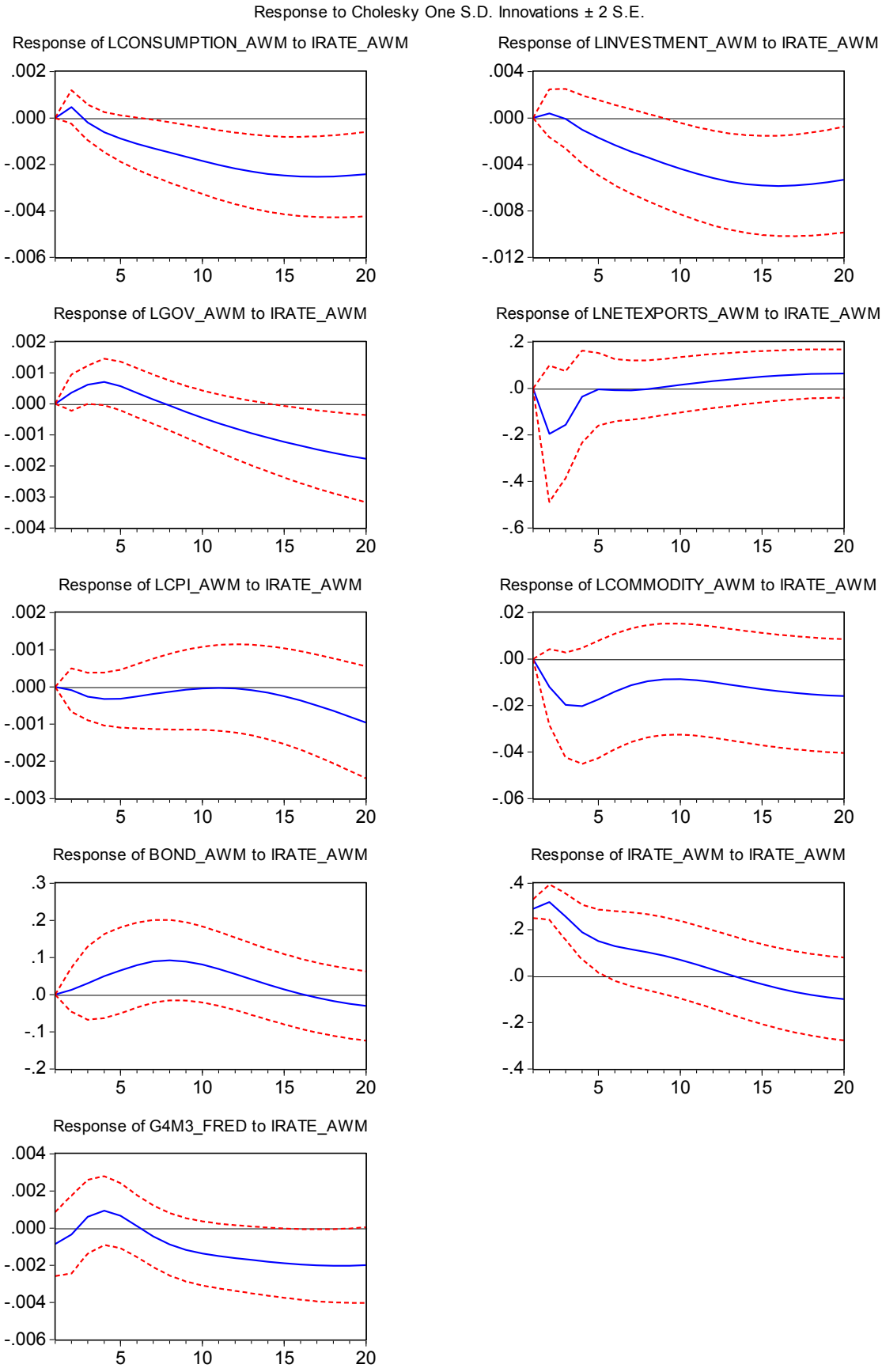
Euro area

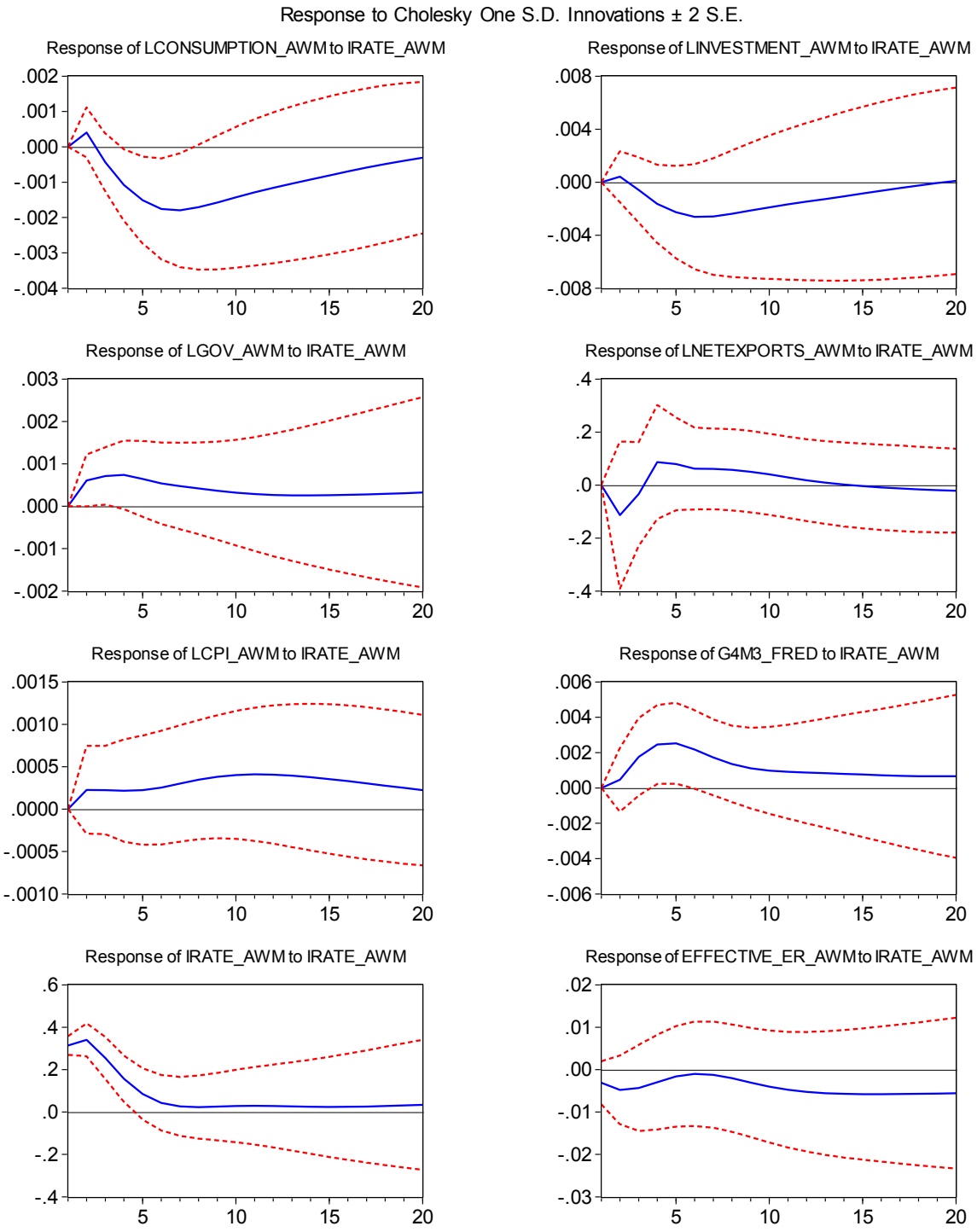
Christiano–Eichenbaum–Evans VAR




Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of LCONSUMPTION_AWM to IRATE_AWM
Response of LINVESTMENT_AWM to IRATE_AWM
Response of LGOV_AWM to IRATE_AWM
Response of LNETEXPORTS_AWM to IRATE_AWM
Response of LCPI_AWM to IRATE_AWM
Response of LCOMMODITY_AWM to IRATE_AWM
Response of IRATE_AWM to IRATE_AWM

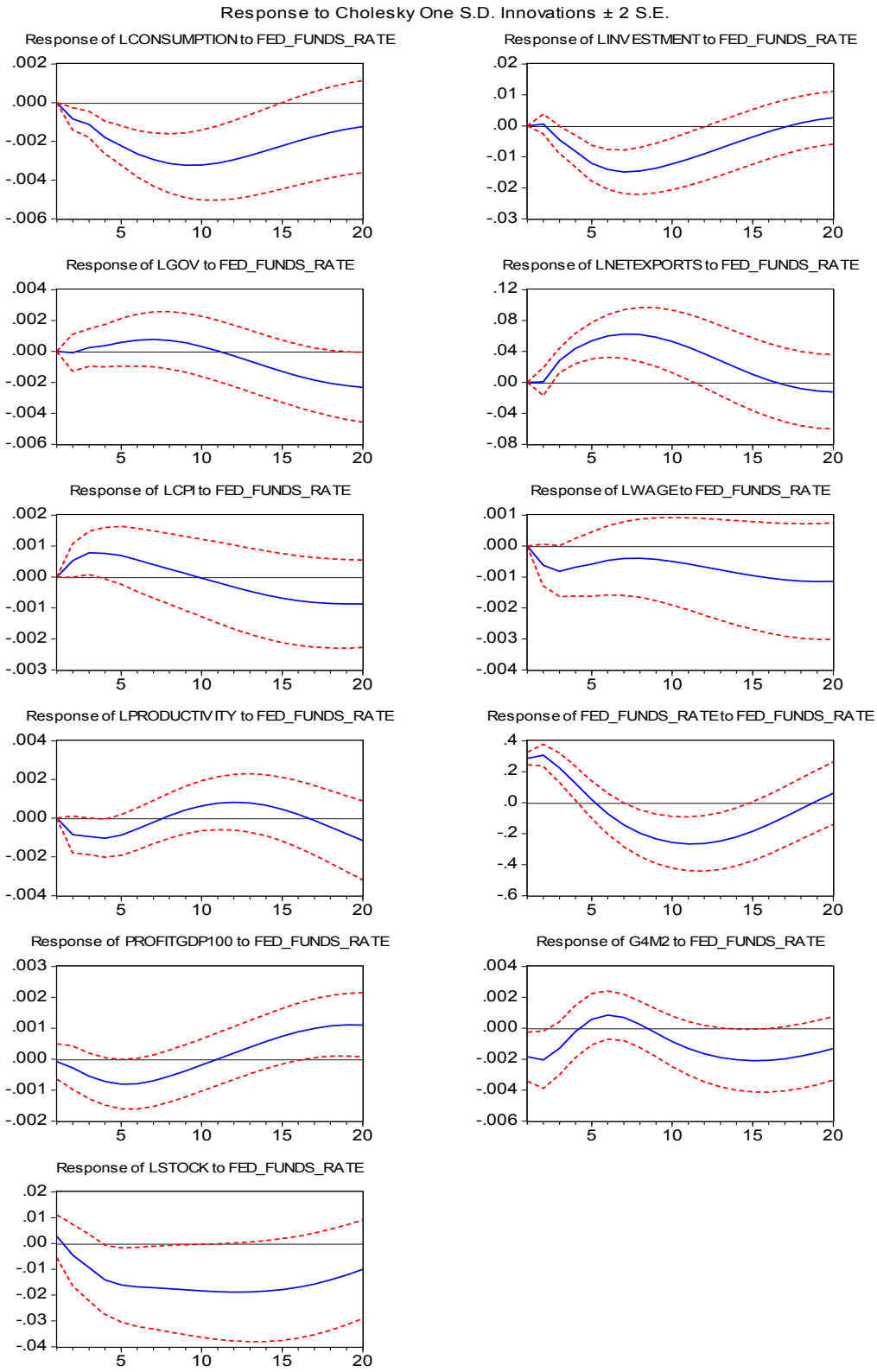
Generalised Erceg–Levin VAR



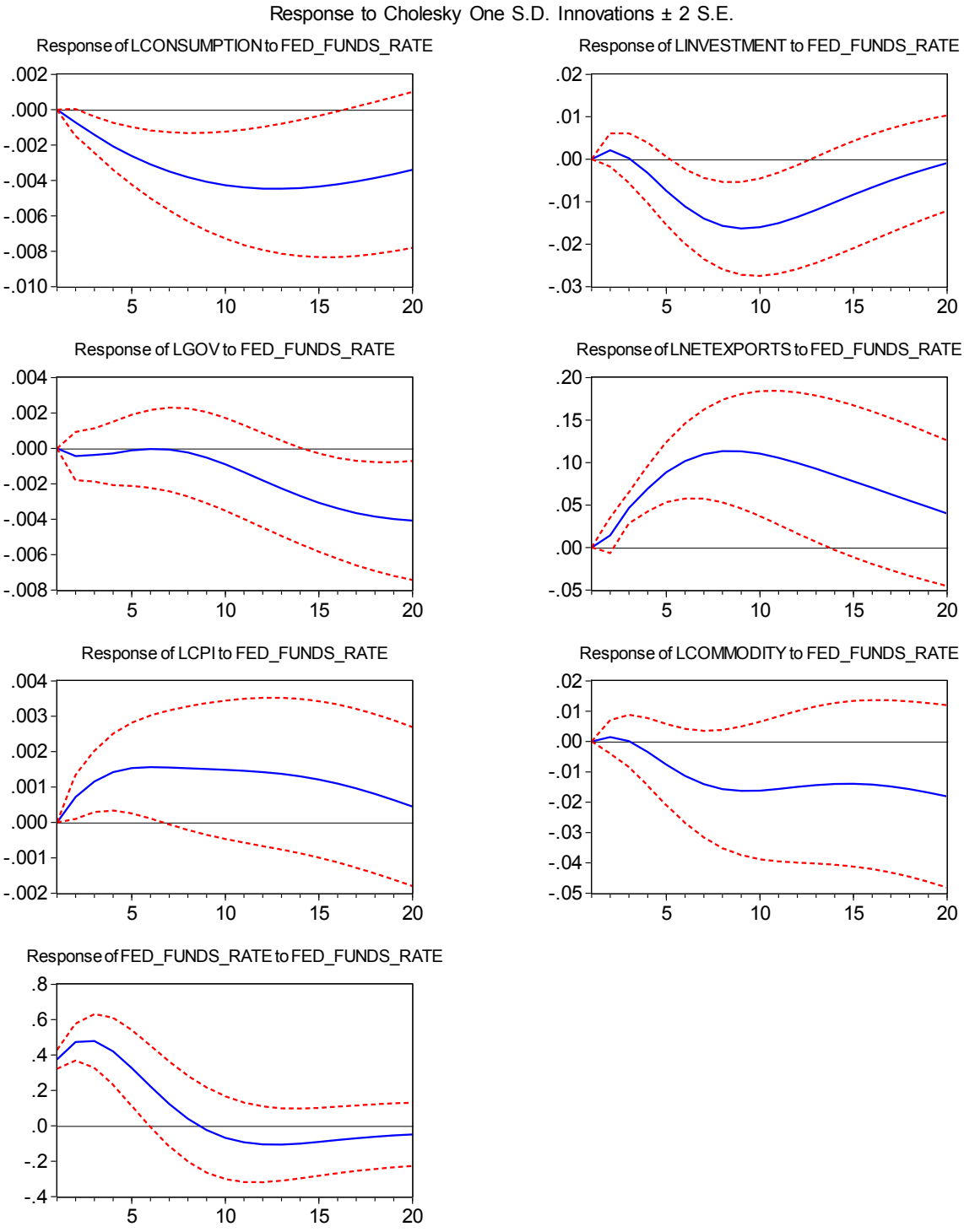

Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of LCONSUMPTION_AWM to IRATE_AWM
Response of LINVESTMENT_AWM to IRATE_AWM
Response of LGOV_AWM to IRATE_AWM
Response of LNETEXPORTS_AWM to IRATE_AWM
Response of LCPI_AWM to IRATE_AWM
Response of G4M3_FRED to IRATE_AWM
Response of IRATE_AWM to IRATE_AWM
Response of EFFECTIVE_ER_AWM to IRATE_AWM

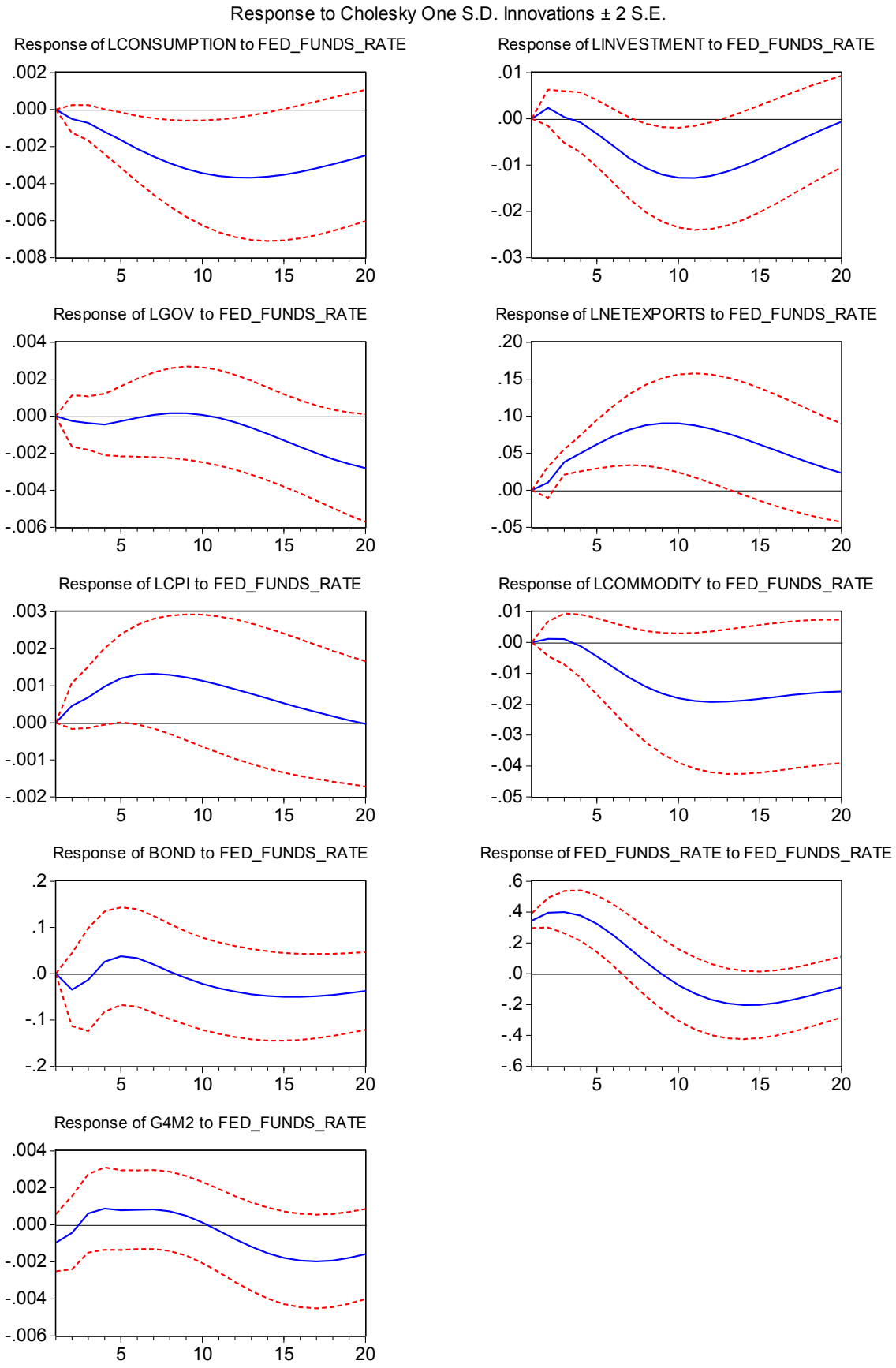
US

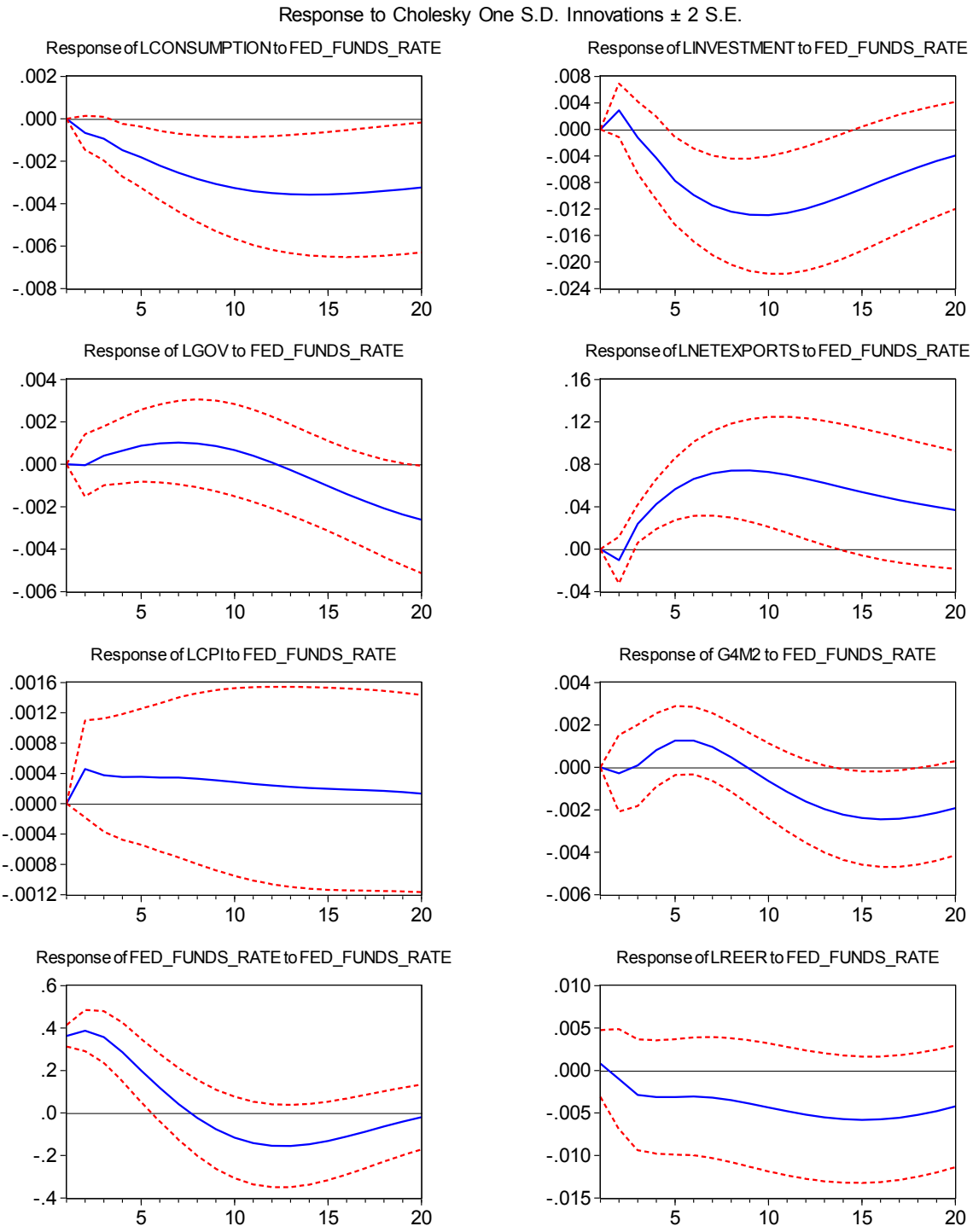
Christiano–Eichenbaum–Evans VAR



Erceg–Levin VAR




Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of LCONSUMPTION to FED_FUNDS_RATE
Response of LINVESTMENT to FED_FUNDS_RATE
Response of LGOV to FED_FUNDS_RATE
Response of LNETEXPORTS to FED_FUNDS_RATE
Response of LCPI to FED_FUNDS_RATE
Response of LCOMMODITY to FED_FUNDS_RATE
Response of BOND to FED_FUNDS_RATE
Response of FED_FUNDS_RATE to FED_FUNDS_RATE
Response of G4M2 to FED_FUNDS_RATE


Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of LCONSUMPTION to FED_FUNDS_RATE
Response of LINVESTMENT to FED_FUNDS_RATE
Response of LGOV to FED_FUNDS_RATE
Response of LNETEXPORTS to FED_FUNDS_RATE
Response of LCPI to FED_FUNDS_RATE
Response of G4M2 to FED_FUNDS_RATE
Response of FED_FUNDS_RATE to FED_FUNDS_RATE
Response of LREER to FED_FUNDS_RATE

Appendix 3C Quandt-Andrews unknown break point test results

The equation to be tested:

$$consumption_t = \beta_{0t} + \beta_{1t}\, consumption_{t-1} + \beta_{2t}\, consumption_{t-2} + \beta_{3t}\, investment_{t-1} + \beta_{4t}\, investment_{t-2} + \beta_{5t}\, othergdp_{t-1} + \beta_{6t}\, othergdp_{t-2} + \beta_{7t}\, cpi_{t-1} + \beta_{8t}\, cpi_{t-2} + \beta_{9t}\, policyrate_{t-1} + \beta_{10t}\, policyrate_{t-2}$$

Variables to be varied across break points: $policyrate_{t-1}$ and $policyrate_{t-2}$

Australia

Quandt-Andrews unknown breakpoint test
Null Hypothesis: No breakpoints within 15% trimmed data
Varying regressors: AUS_IRATE(-1) AUS_IRATE(-2)
Equation Sample: 1983Q1 2007Q4
Test Sample: 1986Q4 2004Q2
Number of breaks compared: 71

Statistic	Value	Prob.
Maximum LR F-statistic (2003Q2)	3.549464	0.2842
Maximum Wald F-statistic (2003Q2)	7.098929	0.2842

Note: probabilities calculated using Hansen's (1997) method

Euro area

Quandt-Andrews unknown breakpoint test
Null Hypothesis: No breakpoints within 15% trimmed data
Varying regressors: IRATE_AWM(-1) IRATE_AWM(-2)
Equation Sample: 1982Q3 2007Q4
Test Sample: 1986Q3 2004Q1
Number of breaks compared: 71

Statistic	Value	Prob.
Maximum LR F-statistic (1992Q2)	4.775078	0.1132
Maximum Wald F-statistic (1992Q2)	9.550156	0.1132

Note: probabilities calculated using Hansen's (1997) method

US

Quandt-Andrews unknown breakpoint test
Null Hypothesis: No breakpoints within 15% trimmed data
Varying regressors: FED_FUNDS_RATE(-1)
FED_FUNDS_RATE(-2)
Equation Sample: 1982Q3 2007Q4
Test Sample: 1986Q3 2004Q1
Number of breaks compared: 71

Statistic	Value	Prob.
Maximum LR F-statistic (1997Q3)	5.690366	0.0539
Maximum Wald F-statistic (1997Q3)	11.38073	0.0539

Note: probabilities calculated using Hansen's (1997) method

Appendix 3D List of lag lengths used for the VARs in the chapter

VAR	Australia	Euro area	US
Christiano–Eichenbaum–Evans	1	2	2
Erceg–Levin	1	2	1
Generalised Erceg–Levin	1	2	1
Peersman–Smets	1	2	2
With housing investment			
Christiano–Eichenbaum–Evans	1	1	1
Erceg–Levin	2	2	2
Generalised Erceg–Levin	2	2	2
Peersman–Smets	2	2	2
With durable consumption			
Christiano–Eichenbaum–Evans	1	NA	1
Erceg–Levin	1	NA	1
Generalised Erceg–Levin	1	NA	1
Peersman–Smets	1	NA	1

Appendices to Chapter 4

Appendix 4A Data sources for Chapter 4

Series	Sources
US	
Inflation	Annual growth rate of GDP deflator, GDPDEF, Federal Reserve Bank of St Louis, http://research.stlouisfed.org/fred2/
Unemployment	Unemployment rate, 16 years or over, LNS14000000, US Bureau of Labour Statistics
Policy rate	Effective Federal Funds rate, H15, Board of Governors of the Federal Reserve System
Real GDP growth rate	Gross Domestic Product by Expenditure in Constant Prices: Total Gross Domestic Product, Growth rate previous period, Federal Reserve Bank of St Louis, http://research.stlouisfed.org/fred2/
UK	
Inflation	Annual growth rate of GDP deflator, GBRGDPDEFQISMEI, Federal Reserve Bank of St Louis, http://research.stlouisfed.org/fred2/
Unemployment	Harmonised Unemployment Rate: All Persons for United Kingdom, GBRURHARMQDSMEI, Federal Reserve Bank of St Louis, http://research.stlouisfed.org/fred2/
Policy rate	Discount rate, INTDSRGBM193N, Federal Reserve Bank of St Louis, http://research.stlouisfed.org/fred2/
Real GDP growth rate	Gross Domestic Product by Expenditure in Constant Prices: Total Gross Domestic Product, Growth rate previous period, Federal Reserve Bank of St Louis, http://research.stlouisfed.org/fred2/
Canada	
Inflation	Annual growth rate of GDP deflator, CANGDPDEFQISMEI, Federal Reserve Bank of St Louis, http://research.stlouisfed.org/fred2/
Unemployment	Unemployment Rate: Aged 15 and Over: All Persons for Canada, LRUNTTTTCAQ156S, Federal Reserve Bank of St Louis, http://research.stlouisfed.org/fred2/
Policy rate	Bank rate, Data and Statistics Office, Bank of Canada
Real GDP growth rate	Gross Domestic Product by Expenditure in Constant Prices: Total Gross Domestic Product, Growth rate previous period, Federal Reserve Bank of St Louis, http://research.stlouisfed.org/fred2/
Australia	
Inflation	Annual growth rate of GDP Implicit Price Deflator, AUSGDPDEFQISMEI, Federal Reserve Bank of St Louis, http://research.stlouisfed.org/fred2/
Unemployment	Unemployment rate, 6202.0 Labour Force, Australian Bureau of Statistics
Policy rate	90 days bank accepted bills, F1, Reserve Bank of Australia
Exchange rate	Growth rate of US/Australia Foreign Exchange Rate, DEXUSAL, Federal Reserve Bank of St Louis, http://research.stlouisfed.org/fred2/
Real GDP growth rate	Gross Domestic Product by Expenditure in Constant Prices: Total Gross Domestic Product, Growth rate previous period, Federal Reserve Bank of St Louis, http://research.stlouisfed.org/fred2/

Appendix 4B Convergence of the Markov chain Monte Carlo algorithm

For the US

Parameter	Mean	Stdev	95%U	95%L	Geweke	Inefficiency
sb1	0.0046	0.0018	0.0025	0.0093	0.113	119.91
sb2	0.0047	0.0018	0.0026	0.0092	0.142	84.07
sa1	0.0056	0.0016	0.0034	0.0097	0.479	51.31
sa2	0.0055	0.0015	0.0034	0.0092	0.054	44.17
sh1	0.0961	0.0316	0.0503	0.1747	0.002	95.21
sh2	0.0071	0.0039	0.0036	0.0180	0.597	191.06

For the UK

Parameter	Mean	Stdev	95%U	95%L	Geweke	Inefficiency
sb1	0.0023	0.0003	0.0018	0.0029	0.412	9.78
sb2	0.0023	0.0003	0.0018	0.0029	0.331	9.2
sa1	0.005	0.0013	0.0032	0.0079	0.629	28.42
sa2	0.0054	0.0015	0.0033	0.0092	0.391	46.95
sh1	0.18	0.0645	0.0876	0.335	0.082	137.8
sh2	0.0057	0.0018	0.0034	0.0102	0.383	70.47

For Canada

Parameter	Mean	Stdev	95%U	95%L	Geweke	Inefficiency
sb1	0.0023	0.0003	0.0018	0.0029	0.294	10.18
sb2	0.0023	0.0003	0.0018	0.0029	0.104	11.05
sa1	0.0052	0.0013	0.0033	0.0082	0.259	40.27
sa2	0.0055	0.0016	0.0034	0.0096	0.289	49.96
sh1	0.1203	0.0387	0.0619	0.2115	0.49	98.96
sh2	0.0069	0.0038	0.0036	0.0148	0.81	160.06

For Australia

Parameter	Mean	Stdev	95%U	95%L	Geweke	Inefficiency
sb1	0.0023	0.0003	0.0018	0.0029	0.196	7.23
sb2	0.0023	0.0003	0.0018	0.0029	0.416	8.03
sa1	0.0055	0.0016	0.0034	0.0094	0.997	39.40
sa2	0.0056	0.0016	0.0034	0.0098	0.348	50.28
sh1	0.2017	0.0496	0.1134	0.3069	0.337	68.76
sh2	0.0427	0.0169	0.0155	0.0814	0.139	123.04

Notes: Some of the inefficiency parameters are quite high, but arguably acceptable for 20,000 iterations.

Appendices to Chapter 5

Appendix 5A Previous studies

Studies	Data period	Methods and variables	Results of inflation determinants
Camen (2006)	Monthly 1996M2-2005M4	VAR, (logs): VND/USD, CPI, M2, credit, lending rate, commodity prices (oil and rice), exogenous: US M3	Important factors: Credit, Petrol and rice prices, ER M2 and lending rate are not important
Goujon (2006)	Monthly 1991M1-1999M6	Single equation, (logs): M2 (also with dollar-denominated bank deposits), CPI, industrial output, actual inflation as proxy for expected inflation, rice price, weighted CPI of 10 main trading partners (all with some lags)	Important factors: rice price, ER, excess money
IMF (2006)	Quarterly 2001Q1– 2006Q2	Single dynamic panel equation (difference of): CPI, M2, NEER, output gap	Important factors: past inflation, output gap, M2, NEER
Le and Pfau (2009)	Quarterly 1996Q2-2005Q4	VAR, (percentage changes): industrial output, CPI, M2, real lending rate, credit, REER index. Exogenous: world oil price, rice price, US FED funds rate	Important factors: ER, credit M2 and lending rate are not important
Nguyen and Nguyen (2010)	Monthly 2000M1-2010M12	VAR, VECM (difference of): CPI, industrial production output, M2, credit, interest rate, ER, PPI, cumulative budget deficits, stock market trading value, import price index, world oil price, rice price	Important factors: Past inflation, ER, world oil and rice prices Interest rate and budget deficit are unimportant
Nguyen, Cavoli and Wilson (2012)	Monthly 2001M1-2009M2; output from 2004M1	Goujon type (difference of) refinancing rate, broad M2 (together with USD-denominated bank deposits), industrial output, oil and rice price combined index, foreign inflation of 10 main trading partners	Important factors: Past inflation, M2(t-2), oil and rice index Interest rate and ER are not important
Bhattacharya (2014)	Quarterly 2000Q1-2012Q2 (for inflation equation); 2004Q1-2012Q2 (for VAR)	Goujon type (compared to some other Asian countries) and VAR (yearly percentage changes) CPI inflation, real GDP growth, credit growth, refinancing rate, changes in nominal ER, changes in import price deflator	Important factors: Past inflation, GDP and import price are important. ER is the key in short term, GDP and credit are the keys in medium term.

Appendix 5B Weights in the CPI basket

Group	Goods	Weights
01	Food and food services	39.93
02	Drinks and cigarettes	4.03
03	Clothes and shoes	7.28
04	Housing and related items (electricity, water, gas, building materials)	10.01
05	Furniture	8.65
06	Chemists and medical services	5.61
07	Transportation	8.87
08	Posts and telecommunication	2.73
09	Education	5.72
10	Culture, entertainment and tourism	3.83
11	Other goods and services	3.34
	Total	**100.00**

Source: Vietnam GSO

Appendix 5C Relationship between Vietnam inflation and exogenous factors

Figure 5C1 Vietnam's CPI inflation and changes in foreign GDP and prices, 1996–2012

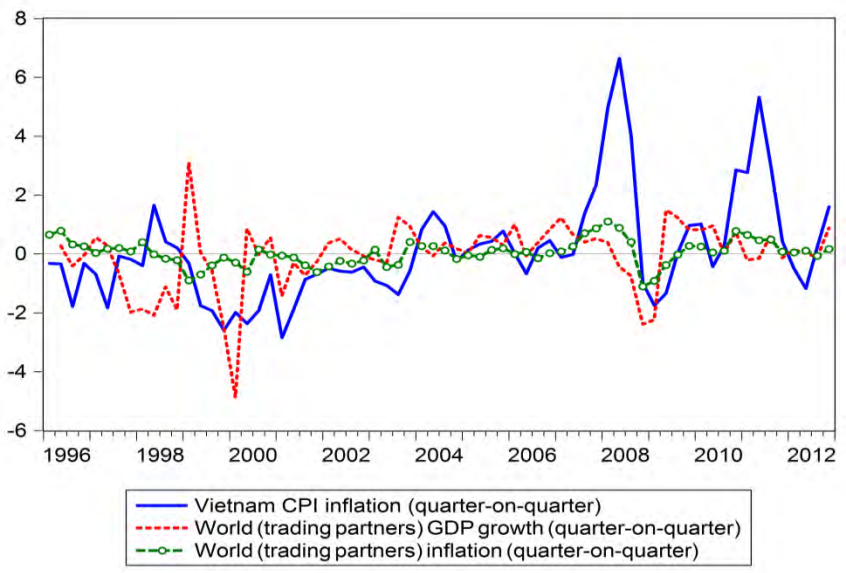


Figure 5C2 Vietnam's CPI inflation and changes in oil and rice prices, 1996–2012

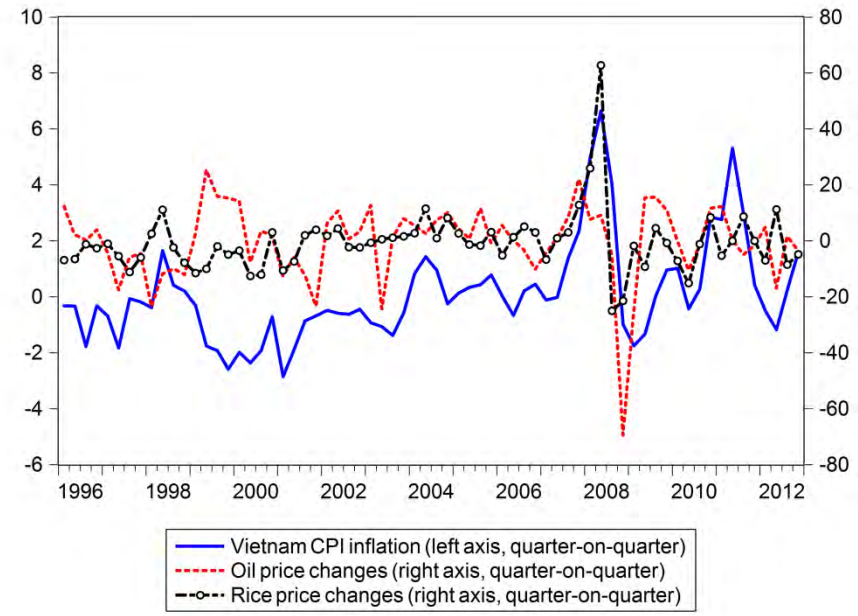
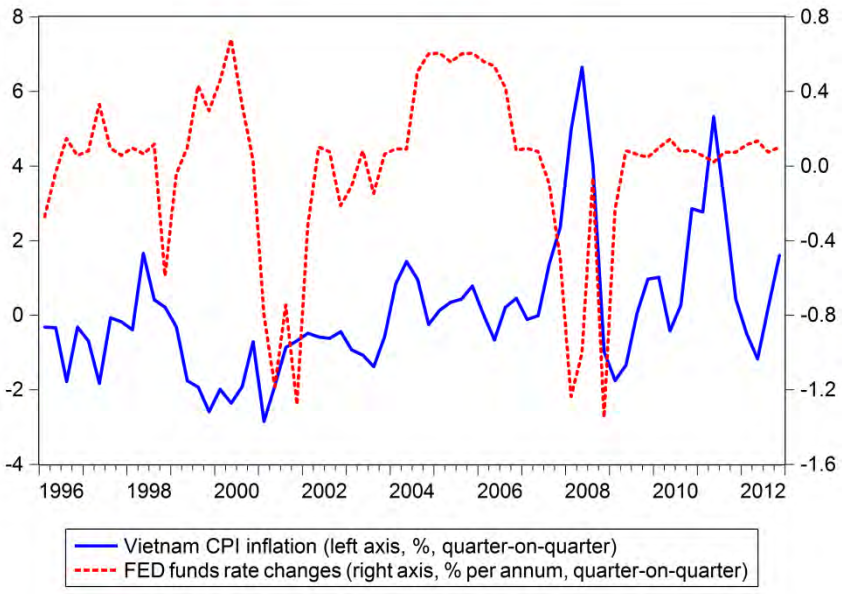


Figure 5C3 Vietnam's CPI inflation and changes in FED funds rate, 1996–2012



Appendix 5D Correlation of Vietnam inflation and changes in factors

Factor	Correlation coefficient
Domestic policy interest rate	0.54
M2	-0.40
M2 (3-quarter lagged)	0.09
Credit	-0.20
Credit (2-quarter lagged)	0.24
Nominal exchange rate	0.19
Foreign GDP	0.16
Foreign CPI	0.65
International oil price	0.17
International rice price	0.54
FED funds rate	-0.19

Appendix 5E List of trading partners with weights to compute foreign GDP and foreign price level

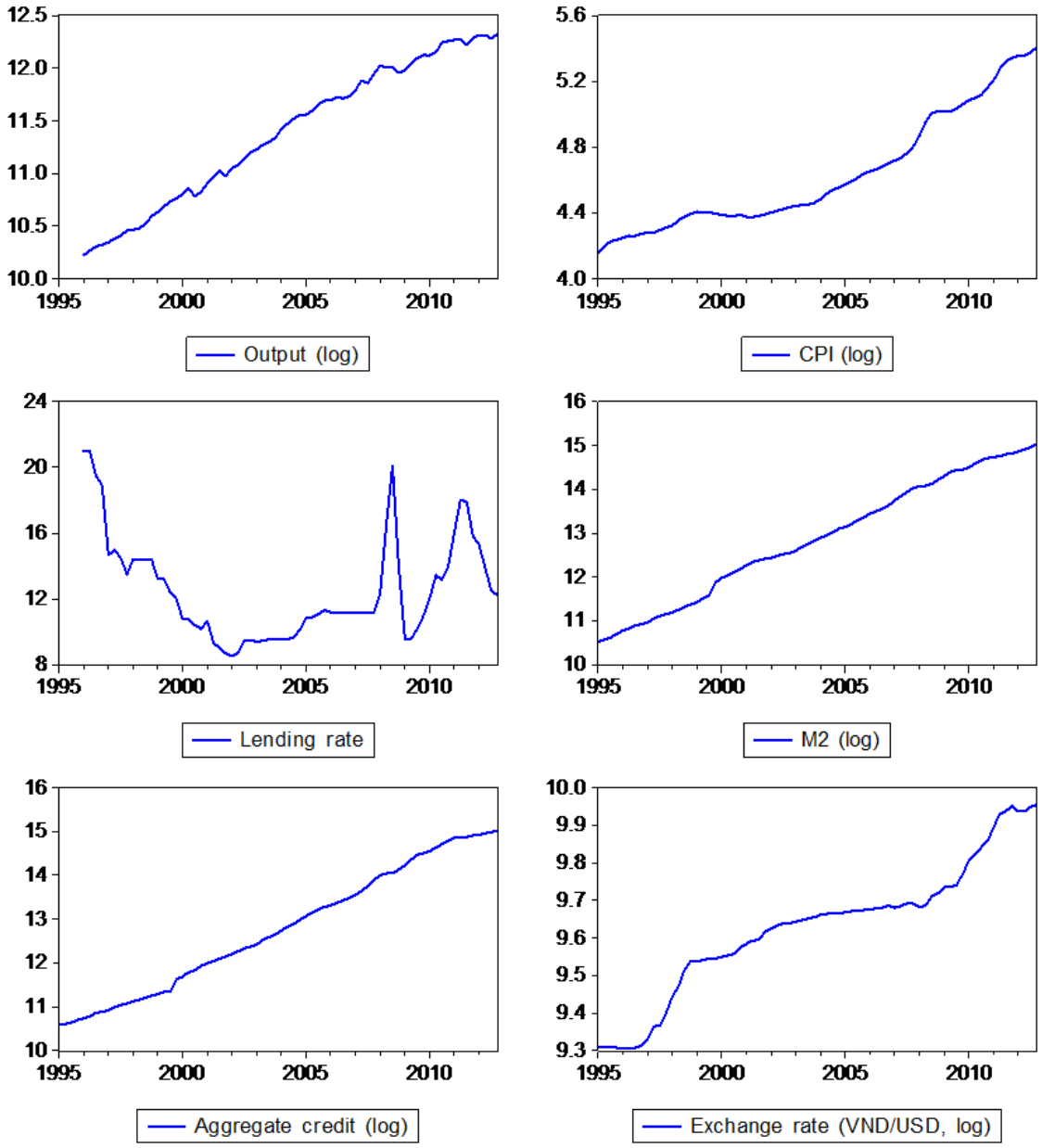
Trading partners	For computing foreign GDP		For computing foreign price	
	Shares in the total trade (2007–2012) (%)	Weights	Shares in the total imports (2007–2012) (%)	Weights
China (with Hong Kong)	19.07	0.25	26.26	0.32
Japan	11.17	0.14	10.91	0.13
US	11.27	0.15	4.05	0.05
South Korea	8.02	0.10	11.99	0.15
Taiwan	5.94	0.08		
Singapore	5.78	0.07	8.13	0.10
Thailand	4.26	0.06	6.27	0.08
Malaysia	3.53	0.05	3.79	0.05
Germany	2.85	0.04	2.22	0.03
Australia	3.10	0.04	1.76	0.02
Indonesia	2.19	0.03	2.27	0.03
India			2.18	0.03
France			1.56	0.02
Total	**77.17**	**1.00**	**81.40**	**1.00**

Source: calculated from Vietnam GSO

Appendix 5F Data sources and data graphs for Chapter 5

Series	Sources
Industrial output	1996 – 2005: extracted from Le and Pfau (2009); 2006 – 2012: calculated from GSO monthly reports, http://www.gso.gov.vn, access date: 15 October 2013
CPI	Consumer Prices, All items, 2005=100, from IMF
Policy rate	Refinancing rate,% per annum, from IMF
M2	Money plus Quasi-Money, billion VND, from IMF
Aggregate credit	Domestic claims, billion VND, from IMF
Nominal VND/USD rate	National Currency per US Dollar, period average, from IMF
Capital account balance	Capital account balance, billion VND, from IMF
Current account balance	Current account balance, billion VND, from IMF
Foreign reserve	Foreign reserve, billion VND, from IMF
Foreign GDP	Calculated basing on real GDP, from IMF, weighted by shares of total trade value for 2007–2012 from GSO exports–imports statistics, http://www.gso.gov.vn, access date: 15 October 2013
Foreign price	Calculated basing on CPI, from IMF, weighted by shares of imports value for 2007–2012 from GSO exports–imports statistics, http://www.gso.gov.vn, access date: 15 October 2013
FED Funds rate	US Board of Governors of the Federal Reserve System (FRB), Federal Funds Effective Rate, http://www.economy.com/freelunch
International oil price	Crude oil price, USD per barrel, from Indexmundi, www.indexmundi.com, access date: 15 October 2013
International rice price	Rice price, USD per tonne, from Indexmundi, www.indexmundi.com, access date: 15 October 2013

Figure 5F1 Graphs of endogenous variables



Appendix 5G Additional impulse response functions

Figure 5G1 Impulse response functions of output to shocks in foreign variables from SVARs

(Unit: %; 30-quarter horizon)

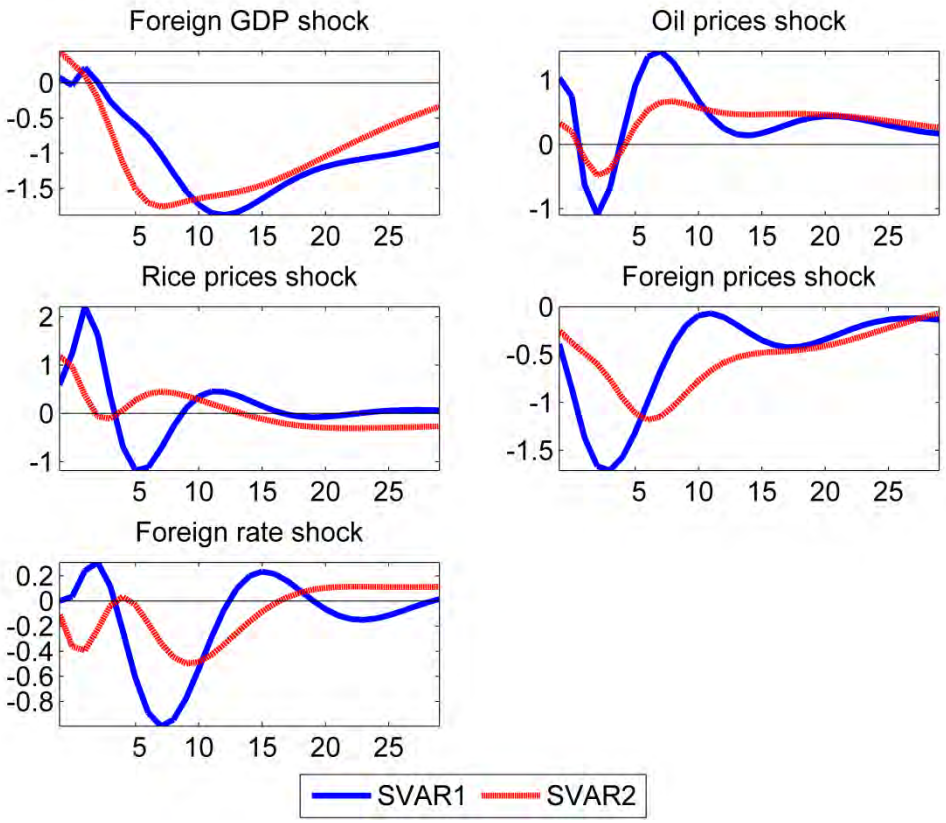


Figure 5G2 Impulse response functions of the exchange rate to a shock in M2

(Unit: %; 30-quarter horizon)

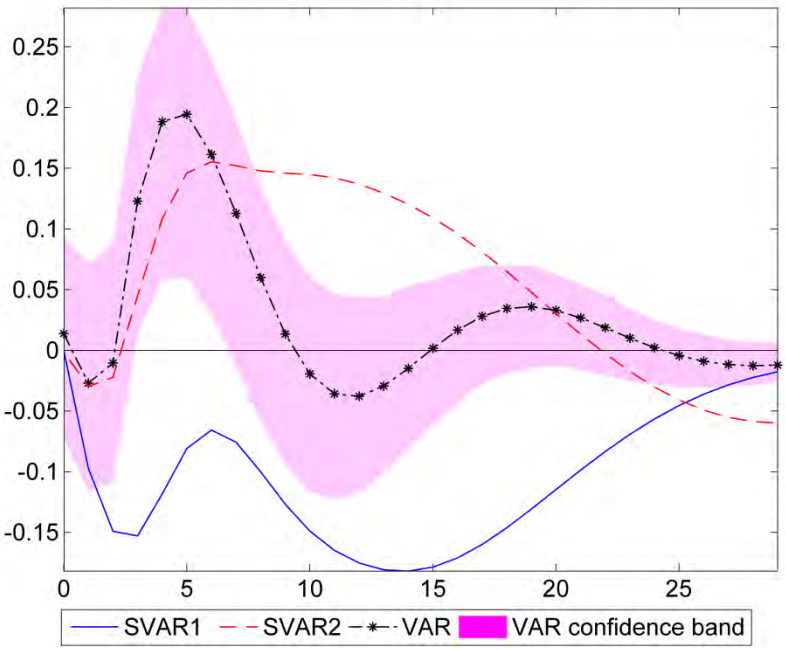


Figure 5G3 Impulse response functions of the exchange rate to a shock in aggregate credit

(Unit: %; 30-quarter horizon)

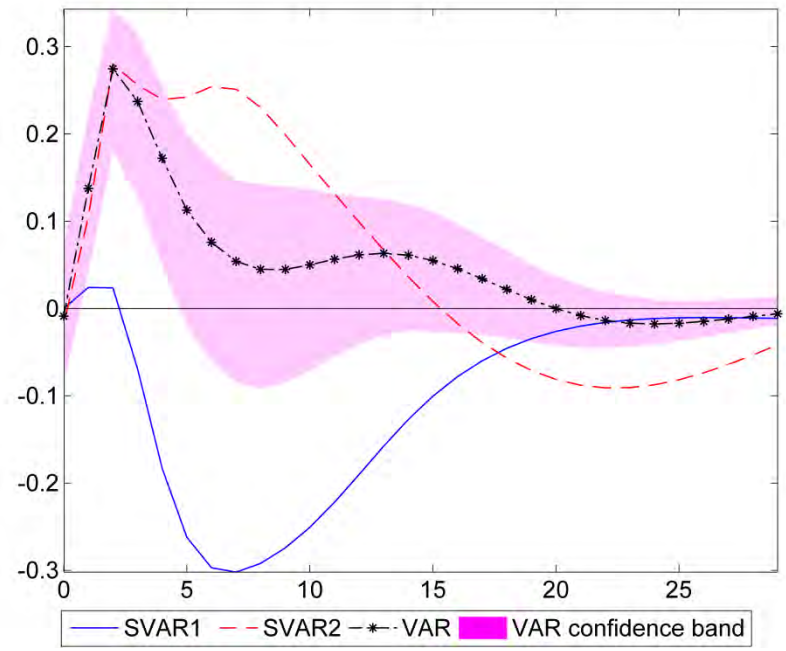
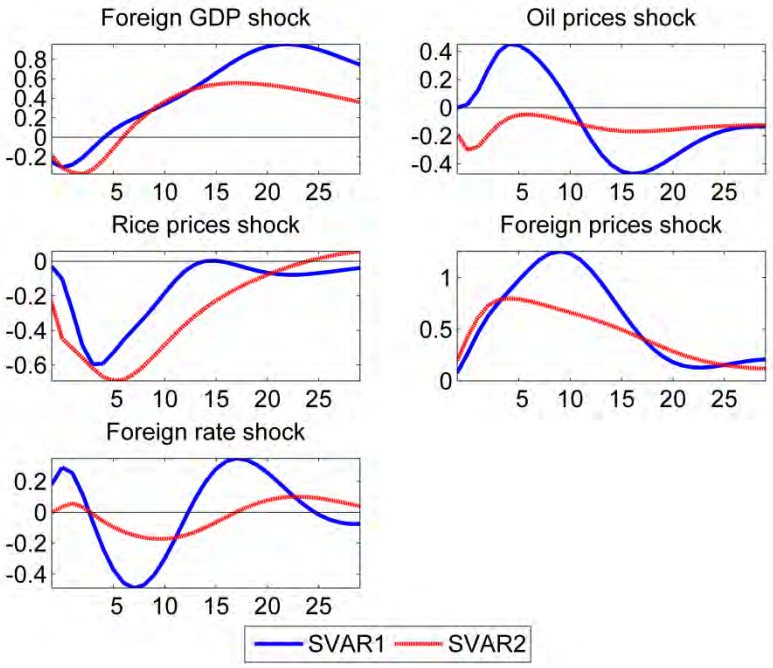


Figure 5G4 Impulse responses of the nominal exchange rate to foreign shocks

(Unit: %; 30-quarter horizon)



Appendices to Chapter 6

Appendix 6A Convergence of the Markov chain Monte Carlo algorithm

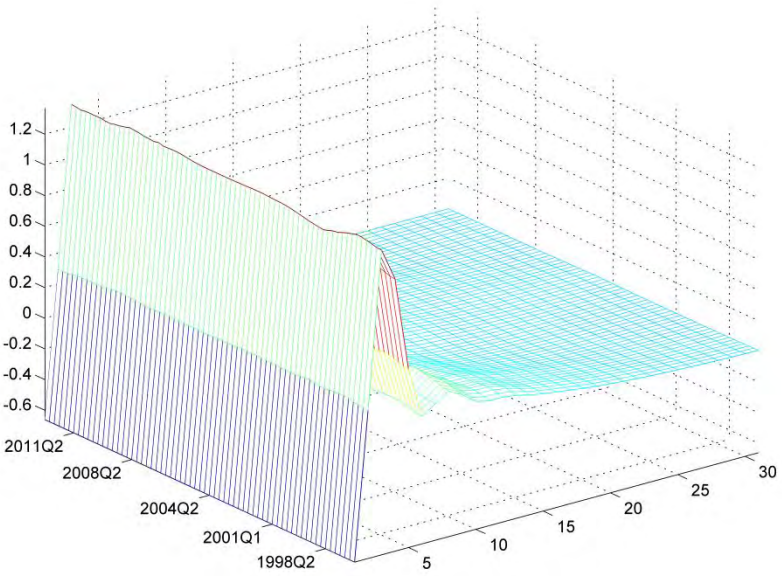
Parameter	Mean	Stdev	95%U	95%L	Geweke	Inefficiency
sb1	0.0023	0.0003	0.0018	0.0029	0.630	3.76
sb2	0.0023	0.0003	0.0018	0.0028	0.125	4.23
sa1	0.0055	0.0015	0.0034	0.0093	0.873	17.70
sa2	0.0056	0.0016	0.0033	0.0097	0.836	17.94
sh1	0.0056	0.0017	0.0034	0.0099	0.608	28.30
sh2	0.0056	0.0017	0.0034	0.0099	0.626	21.32

Appendix 6B Impulse response functions related to output from the TVP-VAR

Figure 6B1 Posterior means of the change of the policy rate responses to a one percentage point increase in output growth, 1996Q2–2012Q4

(Unit: percentage point)

(a) 30-quarter horizon



(b) At specific horizons

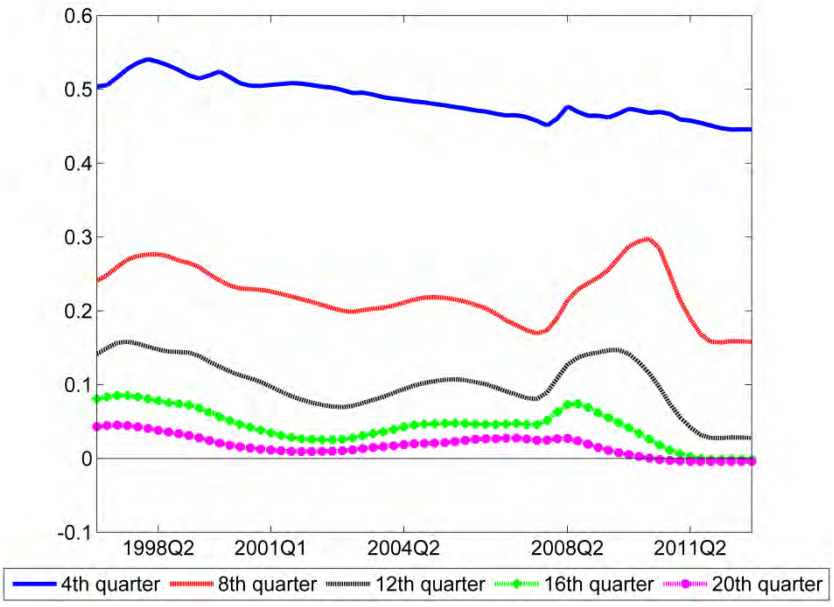


Figure 6B2 Posterior means of the change of the policy rate responses to a one percentage point increase in output growth at five specific time points

(Unit: percentage point; 30-quarter horizon)

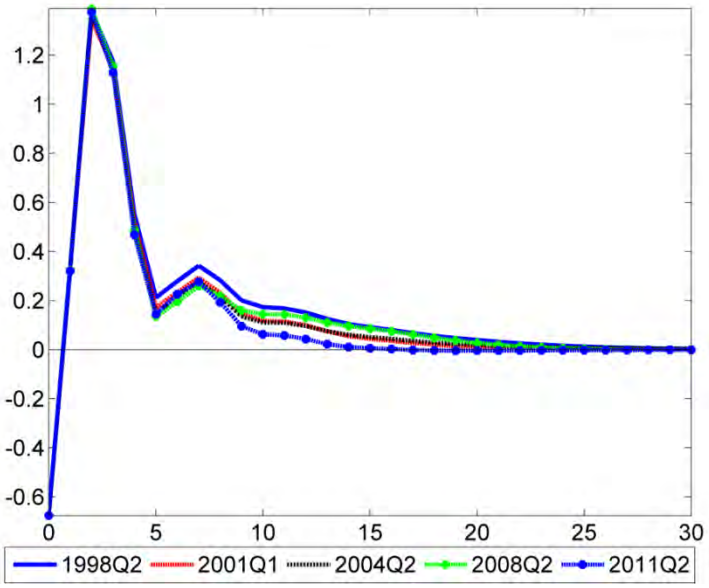
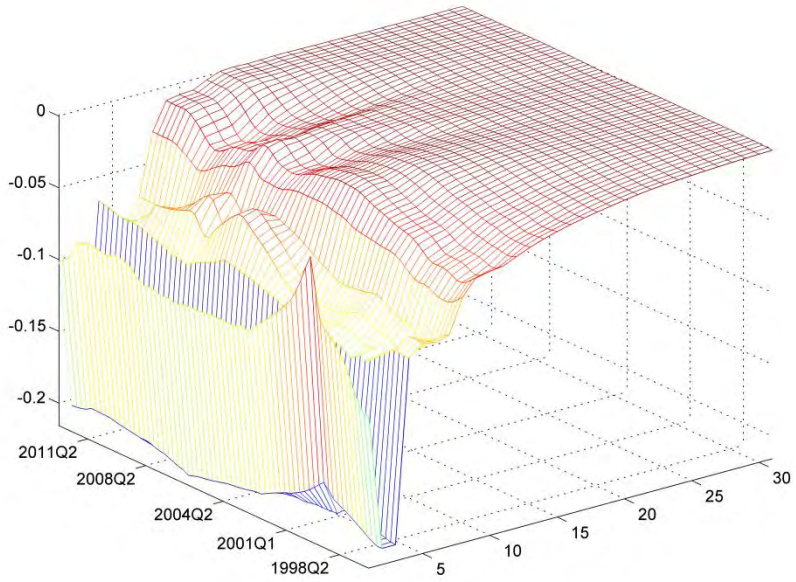


Figure 6B3 Posterior means of the money growth responses to a one percentage point increase in output growth, 1996Q2–2012Q4

(*Unit: percentage point*)

(a) 30-quarter horizon



(b) At specific horizons

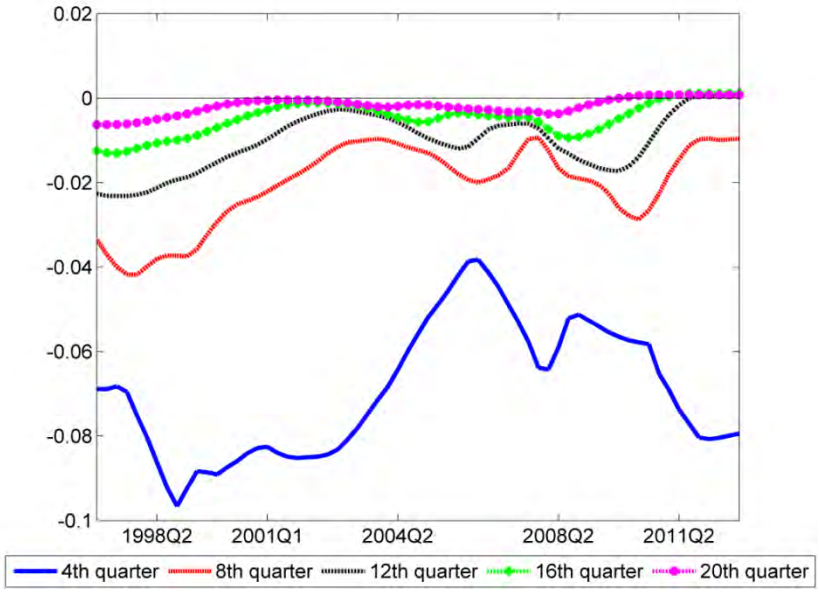


Figure 6B4 Posterior means of the money growth responses to a one percentage point increase in output growth at five specific time points

(*Unit: percentage point; 30-quarter horizon*)

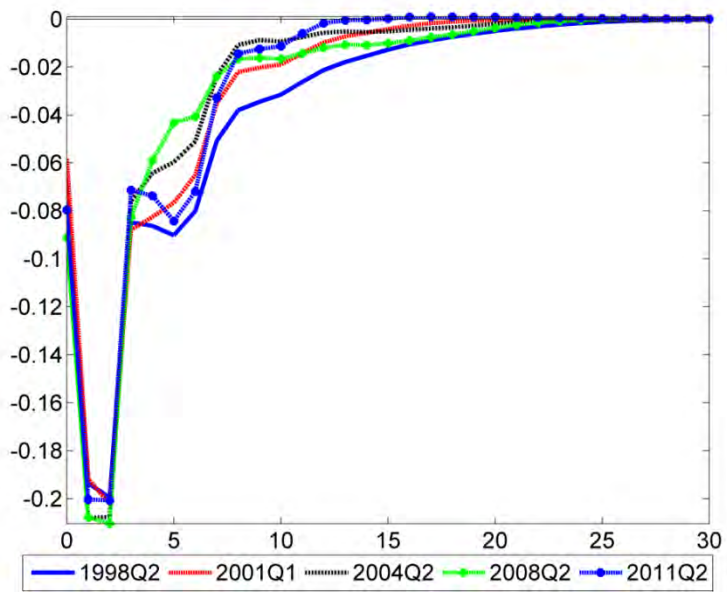
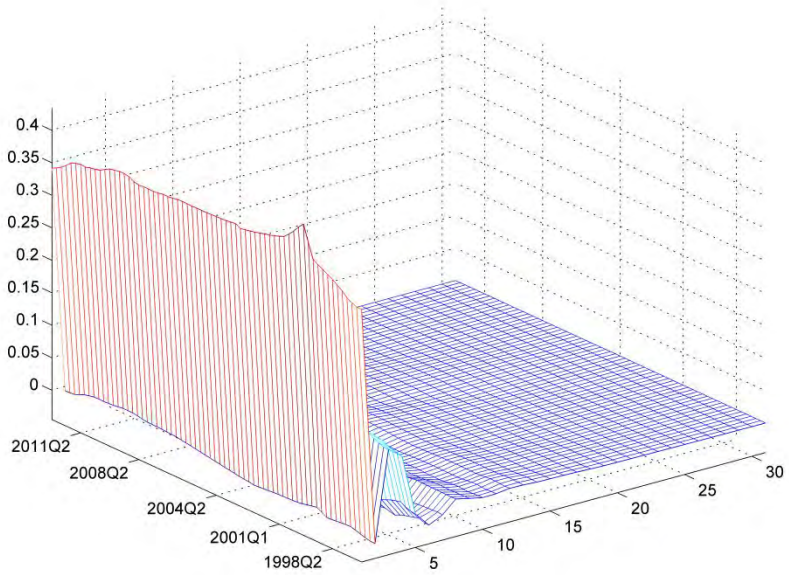


Figure 6B5 Posterior means of the aggregate credit growth responses to a one percentage point increase in output growth, 1996Q2–2012Q4

(*Unit: percentage point*)

(a) 30-quarter horizon



(b) At specific horizons

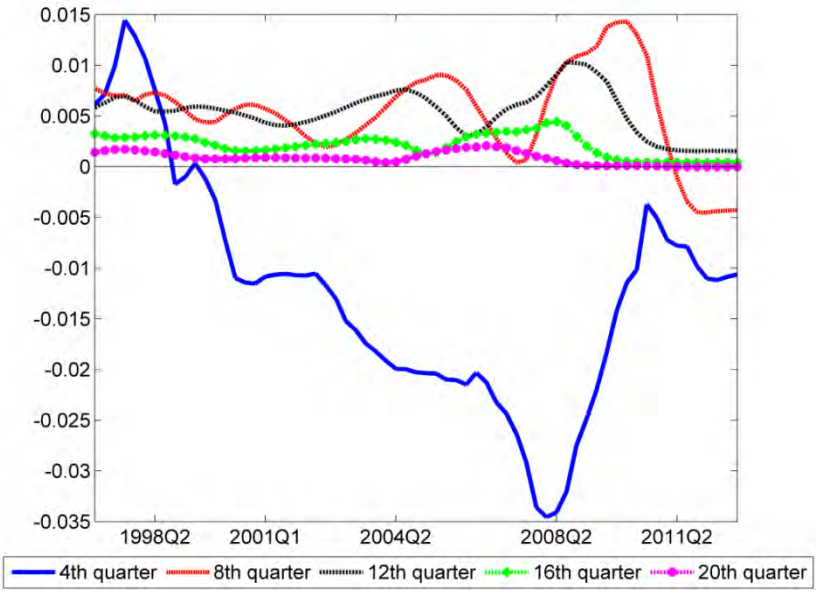


Figure 6B6 Posterior means of the aggregate credit growth responses to a one percentage point increase in output growth at five specific time points

(*Unit: percentage point; 30-quarter horizon*)

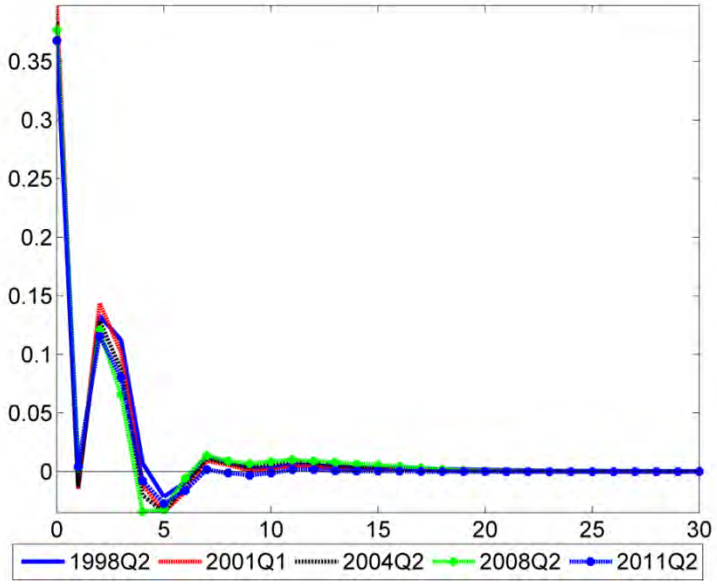
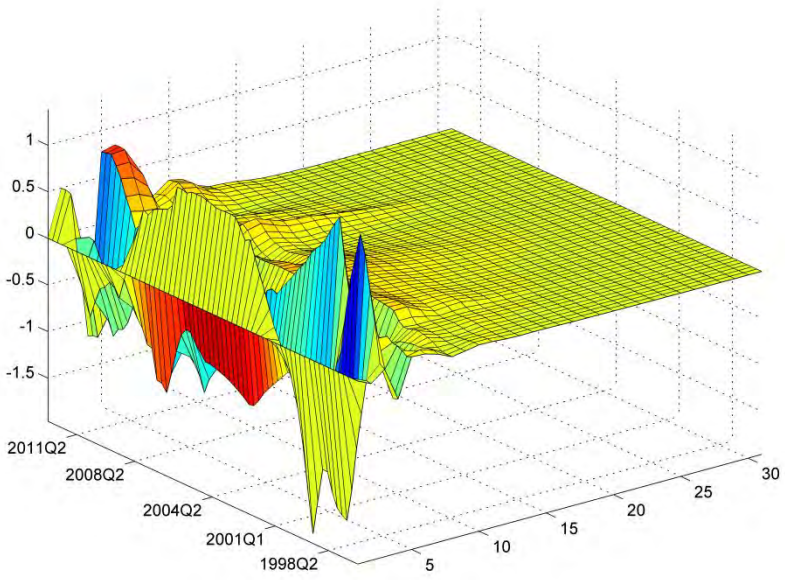


Figure 6B7 Posterior means of the output growth responses to a one percentage point increase in the policy rate, 1996Q2–2012Q4

(*Unit: percentage point*)

(a) 30-quarter horizon



(b) At specific horizons

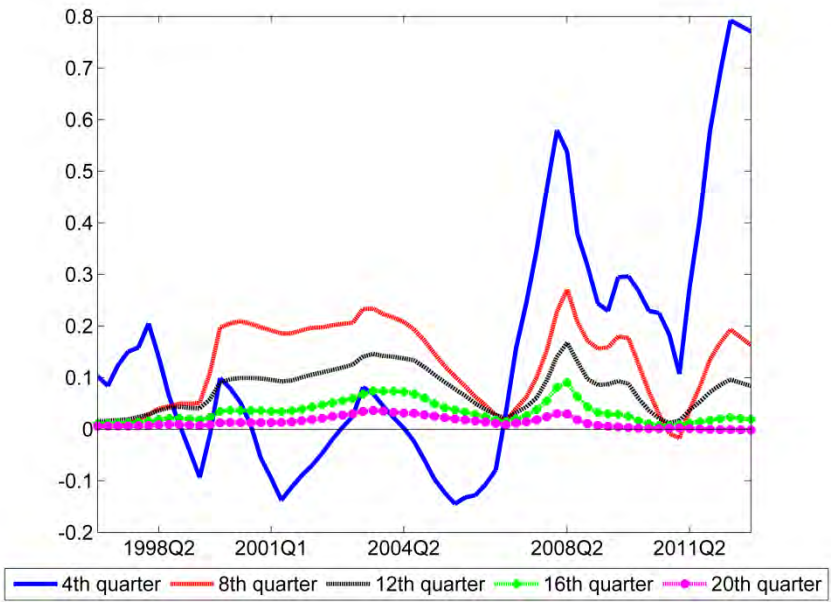


Figure 6B8 Posterior means of the output growth responses to a one percentage point increase in the policy rate at five specific time points

(*Unit: percentage point; 30-quarter horizon*)

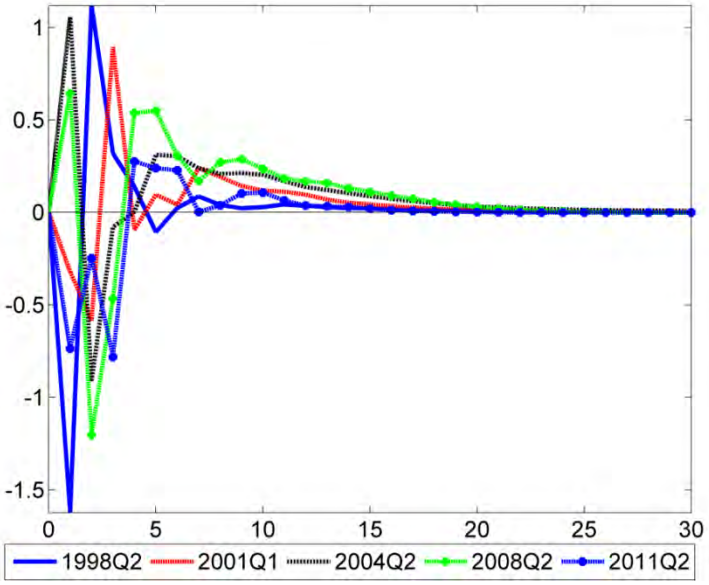
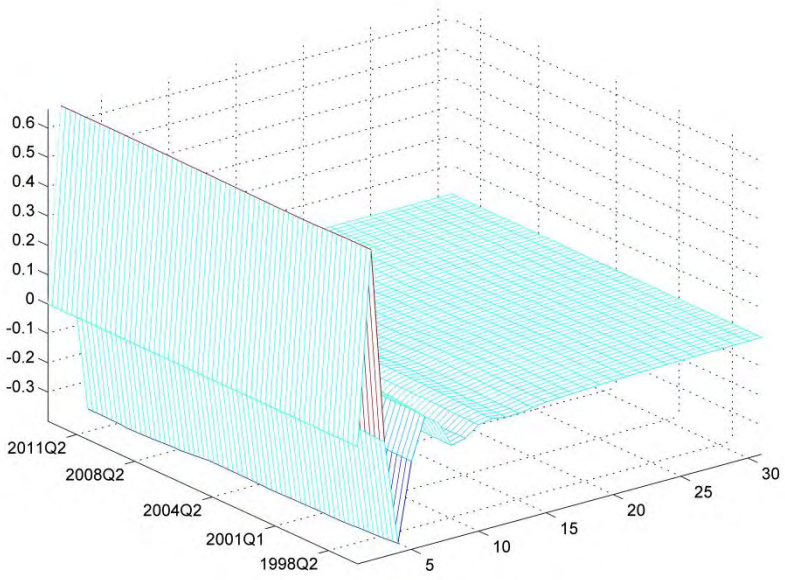


Figure 6B9 Posterior means of the output growth responses to a one percentage point increase in money growth, 1996Q2–2012Q4

(*Unit: percentage point*)

(a) 30-quarter horizon



(b) At specific horizons

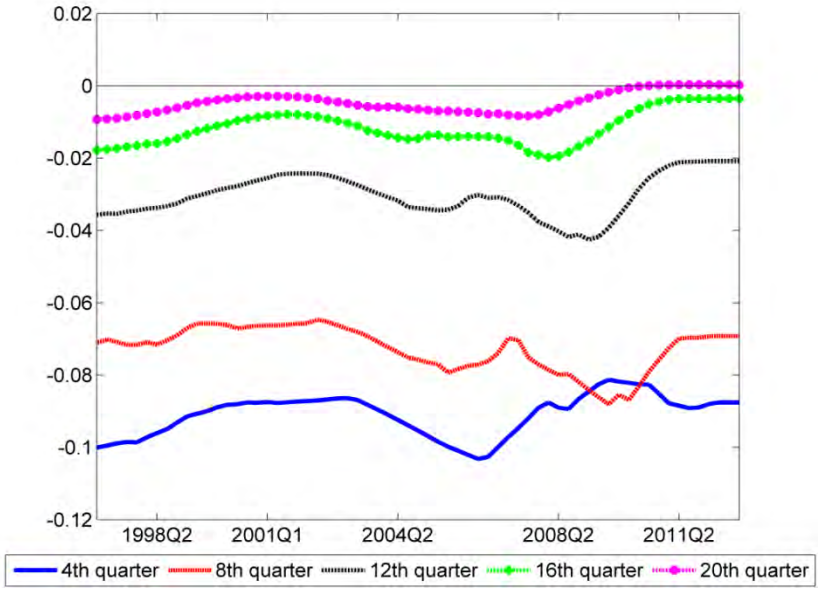


Figure 6B10 Posterior means of the output growth responses to a one percentage point increase in money growth at five specific time points

(*Unit: percentage point; 30-quarter horizon*)

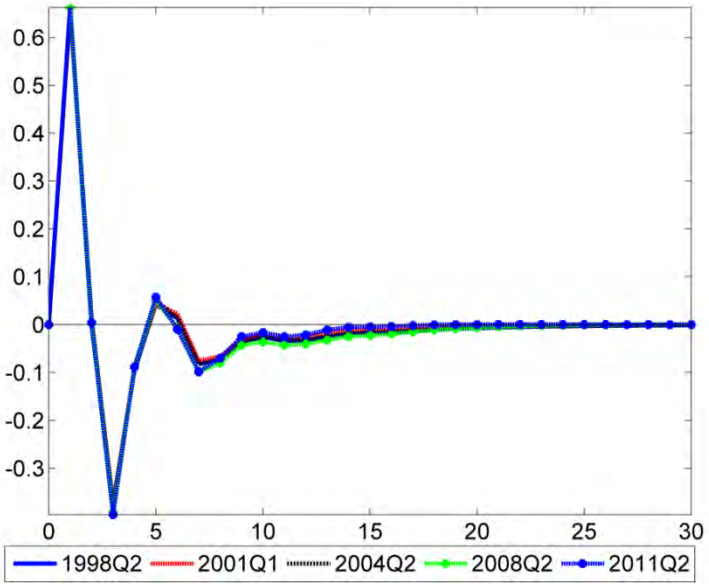
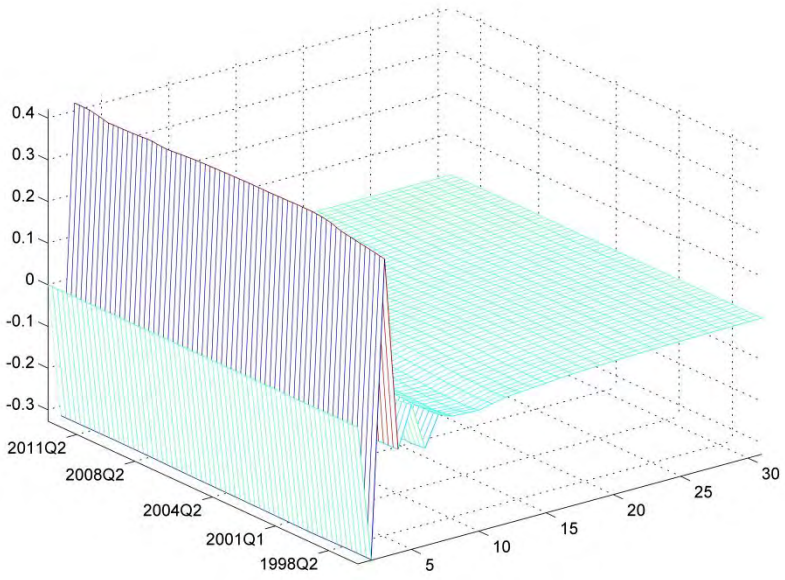


Figure 6B11 Posterior means of the output growth responses to a one percentage point increase in aggregate credit growth, 1996Q2–2012Q4

(*Unit: percentage point*)

(a) 30-quarter horizon



(b) At specific horizons

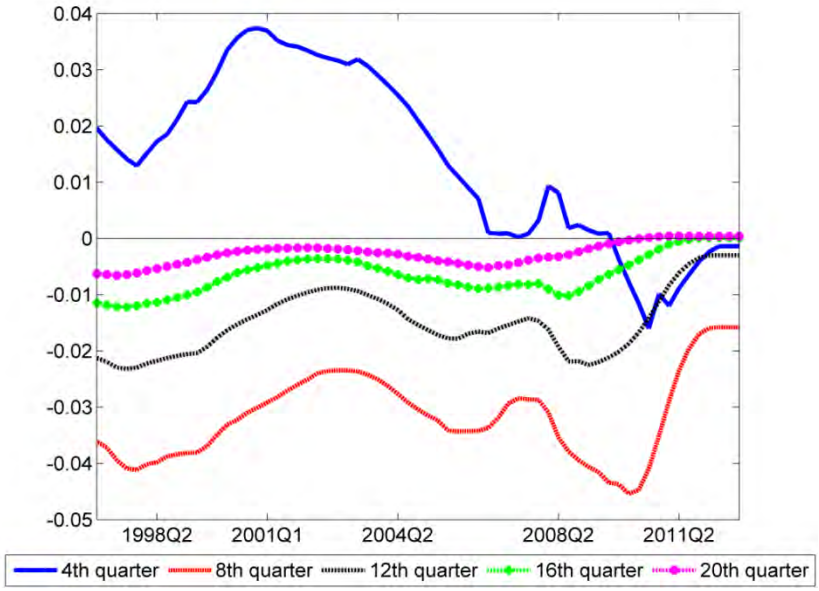
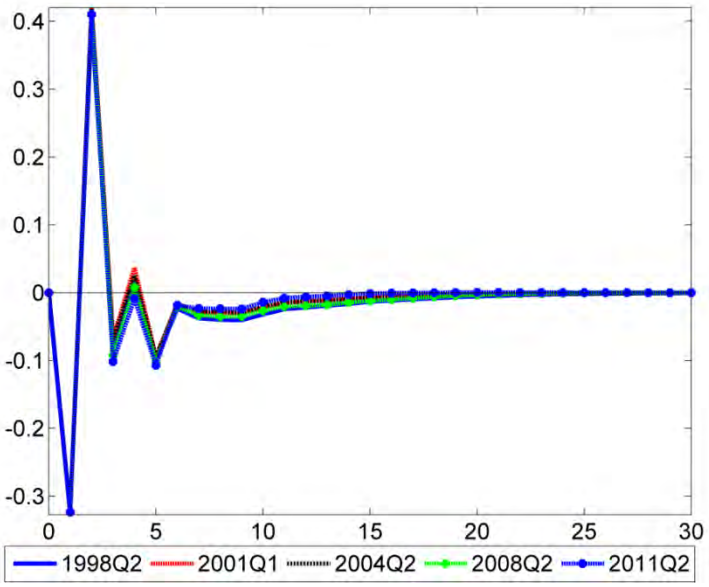


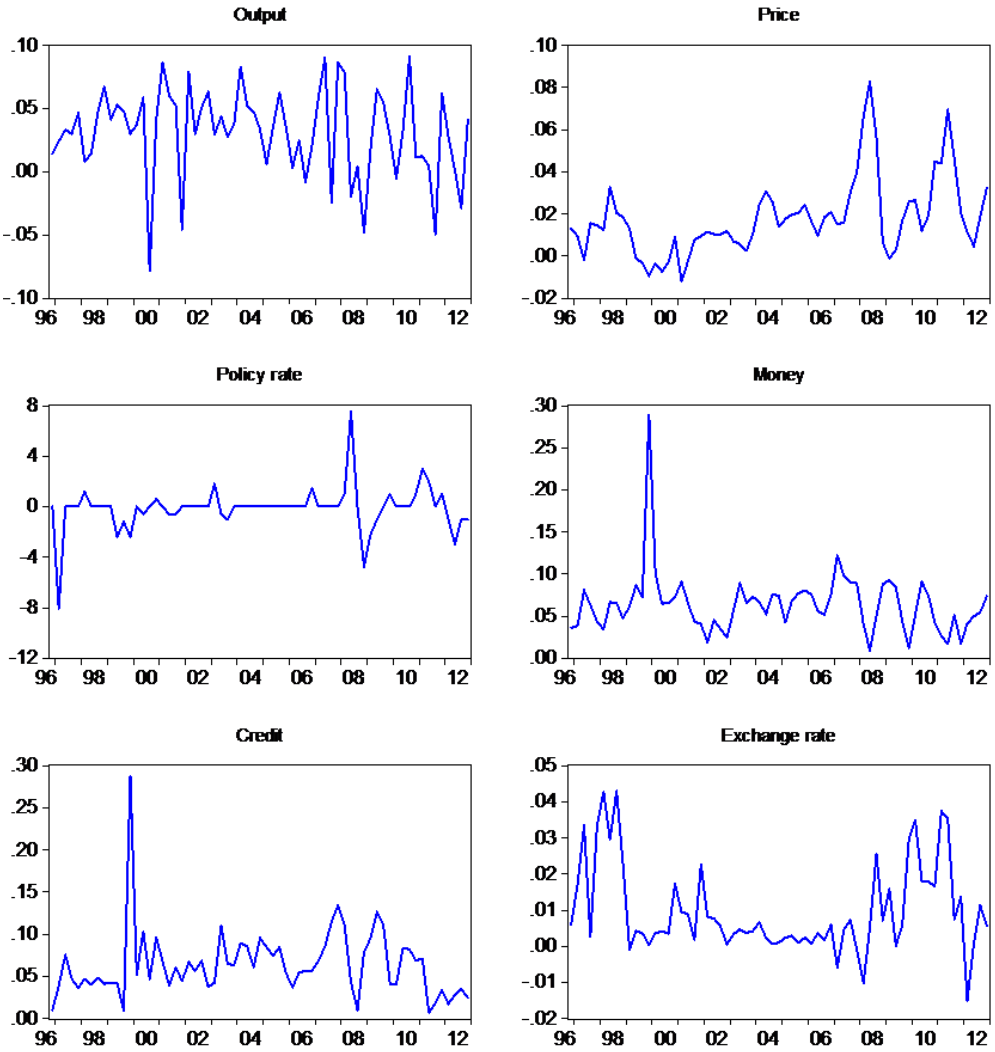
Figure 6B12 Posterior means of the output growth responses to a one percentage point increase in aggregate credit growth at five specific time points

(Unit: percentage point; 30-quarter horizon)



Appendix 6C Data graphs

(the policy rate is in differenced form, all other variables are in differenced log form)



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