The Australian Residential Property Market and Monetary Policy: A SVAR Approach

Shayla Khan

ID: 43141870

Thesis submitted in partial fulfilment of the requirements for the Masters of Research (MRes), Department of Economics

Macquarie University,

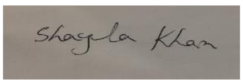
October, 2015

Supervised by Dr. Wylie Bradford and Dr. Natalia Ponomareva

Statement of Candidate

I certify that the work in this thesis entitled 'The Australian Residential Property Market and Monetary Policy: A SVAR Approach' has not been submitted previously for a degree and is independently submitted to Macquarie University as a requirement for a degree.

I also certify that this thesis is an original piece of research written by me. Any help and support that I have received throughout my research work of the thesis has been properly acknowledged including all the information, sources and literature.



Shayla Khan

9th October 2015

Acknowledgements

First of all, I want to say thanks to both of my supervisors, Dr. Wylie Bradford and Dr. Natalia Ponomareva for their supervision and their valuable comments and suggestions throughout the MRes thesis project.

I am very grateful to MRes Co-ordinator and MRes course teacher, Associate Professor Tony Bryant for his wonderful teaching and support during the whole MRes program. He always encouraged me and was a great motivation for me to complete this program.

I would like to thank the Australian Government for financial support. If the MRes program did not offer support from the Government fund, it would have been impossible for me to complete this program.

I want to say thanks to staff at the Australian Bureau of Statistics (ABS) (especially to Brodie Johnson) for their help. Whenever I contacted them via electronic mail, they replied very quickly with the information that I wanted. I would also like to express my very great appreciation to Phanh Oudomlith and Sean Bullock, Research Librarians at Macquarie University, for their enormous support in data collection.

My very special thanks go to my MRes friends, Vidhi Nandini, Andrew Evans and Samir Sultani. I often discussed my project with them, especially with Vidhi Nandini, she always listened to me very carefully and gave her suggestions, which was very important to me. I received a great deal of support and feedback from Andrew Evans on the empirical analysis part of my thesis. I am very grateful to him.

Last, but not least, I would like to thank my family, especially to my sweetheart, adorable 3-year-old daughter, Wafiya for her sacrificing play time with me. I give very special thanks to my husband for his support and understanding during the study. I am always grateful to my parents, sisters and brothers, and to my mother-in-law for their encouragement that always mentally support me to go further.

ABSTRACT

Using 1992Q1–2014Q4 housing market, monetary policy and macroeconomic data for the Australian economy, this study investigates the dynamic impact of monetary policy on the Australian housing market. Considering number of purchased residential properties, dwelling investment and real estate prices as housing sector variables, the main objective of this study is to identify how households' or investors' purchasing decisions for residential properties and dwelling investment on new constructions and renovation of residential properties are influenced by the monetary policy shock, exchange rate and real estate prices shocks. To achieve the research goal, a seven-variable SVAR model is developed for the Australian housing market and the empirical findings of this study suggest that purchasing residential properties and dwelling investment are significantly and consistently influenced by the monetary policy shock but dynamic effect of exchange rate shocks on the number of purchased residential properties is insignificant. The interrelationship between monetary policy rate and purchasing residential properties is also acknowledged in this study.

Keywords: The Australian Housing Market, Purchasing Residential Properties, Monetary Policy, SVAR, Dwelling Investment,

TABLE OF CONTENTS

TABLES AND FIGURES

TABLES:

FIGURES

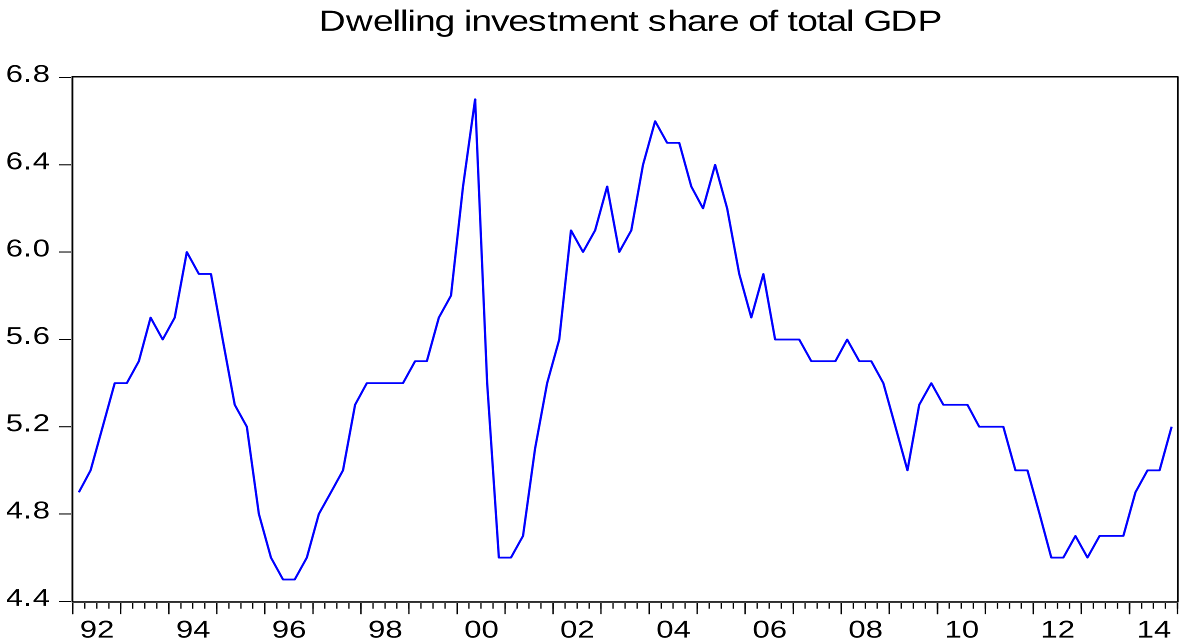
CHAPTER 1

Introduction:

The Australian housing sector has great importance in the Australian economy. During the last three years, continuous negative growth in the mining sector has had significant adverse effects on economic growth in Australia. But strong growth in the housing sector along with export and consumption growth is reducing the gap between target and actual economic growth. Figure 1.1 explains that dwelling investment as a share of total GDP is fluctuated, but it makes a significant contribution to total GDP. The strength of the housing market in Australia is evidenced by the existence of a high proportion of dwelling turnover and auction clearance rates since the middle of 2013. According to the Australian Bureau of Statistics (ABS), dwelling approvals increased by 13.4% in 2015, and loan approvals for new constructions are at high levels, pointing to strong growth in housing market. The current housing prices in Australia, especially in two large capital cities, Sydney and Melbourne, are comparatively higher than at any period of the previous decade, and interest rates are at the lowest level in the last six decades. According to ABS data, residential property prices increased by 6.9% from last year's prices, whereas, RBA data reports that the current monetary policy rate is 2%, which is the lowest rate in the last fifty years. While it is felt that the continuous reduction in the monetary policy rate since the end of 2011, especially the two interest rate cuts at the beginning of 2015, is the main factor for the strong growth in housing prices, the findings in the existing literature of Fry et al. (2010)[1] and Wadud et al. (2012)[2] create confusion about this issue.

[1] Fry et al. (2010) explain that monetary policy is not important determinant of overvaluation of housing prices.
[2] Wadud et al. (2012) suggest that contractionary monetary policy does not have negative impact on housing prices

Figure 1.1. Dwelling investment share of total GDP (1992Q1-2014Q4), Sources: ABS



Monetary policy plays a fundamental role in the macroeconomic management of an economy. As a central bank, the Reserve Bank of Australia (RBA) is responsible for implementing monetary policy in Australia. Monetary policy is conducted by setting the short-term interest rate (cash rate) on overnight loans in the money market. The changes in the cash rate stimulate other interest rates in the economy and affect the borrowing and lending behaviour in financial markets. Figure 3.2 on page 15 shows that lending rates for housing loans in Australia move in same direction of the cash rate. To maintain price stability, and encourage economic growth and employment are the main objectives of monetary policy. To achieve these goals, the RBA sets inflation targets, and over the medium term wants to keep the inflation rate at 2–3 percent on average. Although house prices are not among the specific assigned objectives of the RBA, house price swings can have serious implications for economic growth and inflation. Therefore, it is important for the RBA and other regulatory organizations that regulate financial institutions to consider movement in housing prices as an important part of financial steadiness. It is evident after the global financial crisis (GFC) that the Australian housing sector and the greater economy were comparatively less affected by the GFC than were other developed economies. Costello et al. (2015), Yates and Berry (2011) and Burke and Hulse (2010) mention the importance and uniqueness of the Australian housing market kept the Australian economy from the adverse impact of the global financial crisis. Burke and Hulse (2010) suggest that the differentiated aspects of the Australian housing market in housing production, landownership and development acts to protect the Australian economy from any spare unsold construction. They contrast this with negatively affected global housing markets and argue that it is not possible to regenerate a speculative 'surplus of unsold' construction in Australia.

The relationship between the housing market and monetary policy is evident in the existing literature (Aoki et al., 2004; Elbourne, 2008; Ellis, 2011; Fry et al., 2010; Vargas-Silva, 2008; Wadud et al., 2012). The importance of the housing sector in monetary policy transmission processes can be explained in two different ways. Firstly, the cost to the user of housing loans, expected future house prices, and dwelling supply are measured as the direct transmission mechanism of these channels (Mishkin, 1996 and Boibin Kiley and Mishkin, 2010). Secondly, the wealth and credit effect are considered as the subsidiary transmission mechanism (Mishkin, 2007). The user costs of housing capital are affected by monetary policy. When the short-term interest rate is reduced, long-term interest rates also tend to reduce driven by the prediction of future low interest rates; and hence, the average mortgage rate also reduces leading to lower user costs of dwelling capital. Lower user costs lead to increases in residential property demand that influence a rise in residential property prices and residential output (Wadud et al., 2012).

It is generally observed that after a reduction in interest rates, housing demand increases, which leads to increase housing prices. However, several studies on the Australian housing market and monetary policy (for example, Fry et al. 2010 and Wadud et al. 2012) suggest that Australian residential prices are not significantly influenced by monetary policy shocks. This raises the question; if housing prices are not influenced, how then is the housing sector affected by monetary policy? According to Wadud et al. (2012), growth in the housing sector is influenced by monetary policy, but it is a long-run issue. Therefore, questions remain on the issue of how the housing sector reacts initially to monetary policy shocks. Considering these questions, the objective of the present study is to examine the dynamic impact of monetary policy on the housing sector in Australia based on several housing sector indicators.

It is expected that in the property market, households' or investors' purchasing or selling decisions fluctuate immediately after the interest rate decision is taken by the central bank. It can be explained by expansionary monetary policy that if the central bank cuts interest rates, first home buyers may then be able to afford mortgage repayments, and the demand for owning a home increases, which in turn leads to an increase in the total number of purchased residential properties. Similarly, demand for buying investment properties also increases, because user costs of investment capital also reduce with low interest rates. In addition to the response of dwelling investment and housing prices, to find out the response by households and investors to monetary policy shocks in the purchasing of residential properties is one of the main aims of the present study. Moreover, it is expected that if the Australian dollar depreciates, along with foreign investment on new property, domestic demand for housing property (new and established) also increases. This expectation is developed based on the assumption that Australian migrant citizens can bring money from their home countries when the Australian currency becomes less expensive and they can then afford to buy housing property in Australia. Therefore, housing prices and number of residential properties purchased will be influenced by the exchange rate along with dwelling investment. Justifying this assumption with empirical investigation is another motive of this study.

To estimate the dynamic impact of monetary policy on the housing sector, the present study uses the structural vector autoregression (SVAR) model, which is originally developed by Sims (1980) and later it has been largely used to identify the impact of monetary policy on the economy (Sims 1986; Gordon and Leeper, 1994; Bernanke and Mihov, 1995). To measure the significance of monetary policy in a small and open economy such as Australia, several SVAR models have been developed that consider monetary policy and other macroeconomic variables (Berkelmans, 2005; Brischetto and Voss, 1999; Dungey and Pagan, 2000; Kim and Roubini, 2000). In the housing market and monetary policy literature, SVAR models are also commonly used to capture the short-run dynamics across housing sector and monetary policy variables (Costello et al., 2015; Elbourne, 2008; Fry et al., 2010; Lee et al., 2002; Musso et al., 2011; Vargas-Silva, 2008; Wadud et al., 2012). The present study develops a seven-variable SVAR model for Australia based on Amisano and Giannini (1997) for investigating the dynamic response of the housing market to structural innovations in monetary policy.

This study makes four contributions to the literature. Firstly, this research acknowledges the impact of monetary policy shocks on the housing market by considering three key variables: dwelling investment, the real estate price index, and total number of residential properties purchased. These variables are important in explaining housing market scenarios such as growth or supply of residential properties, housing property prices and market demand for residential properties respectively. Secondly, the present study investigates how the purchasing of residential properties is influenced by the variation in housing prices from a steady state level. Thirdly, it identifies the housing sector response to exchange rate and other macroeconomic shocks. Fourthly, how the housing sector influences the monetary policy rate is also analysed in this study.

The rest of the paper is organised as follows. Section 2 represents a brief review of the literature on the housing market and monetary policy. Section 3 gives a description of the variables and data sources, while the econometric model is explained in Section 4. Section 5 describes the methodology and estimation, and some empirical findings from this research, and Section 6 consists of the impulse response analysis followed by an examination of the robustness of the econometric model. Section 7 presents the conclusion.

CHAPTER 2

Literature review:

The housing market has attracted a lot of research interest in different areas, such as determinants of housing prices, housing price volatility and the impact of monetary policy on the housing market. The Australian housing market literature has also been developed on these areas. The main focus of the present study is the impact of monetary policy on the housing market in Australia. However, for a better understanding of the housing market and monetary policy (i.e. variables, structure of the variables, and the methodology used in the housing market literature), Australian housing sector literature on other issues, and the global literature on the present issue are also included in the review of the Australian housing market and monetary policy literature.

Abelson et al. (2005) develop and estimate a long-run equilibrium model that shows the real economic determinants of house prices. Using 1970 to 2003 data, their findings suggest that the real income and inflation rate positively impacts on Australian house prices, and is significantly and negatively related with the unemployment rate, mortgage rates, equity prices and housing stock. Their findings are in line with results of the study by Holly and Jones (1997), who work with long-period data for the housing sector in the UK. They find that the real income is the single most important determinant of real house prices. Whereas, Tsatsaronis and Zhu (2004), investigate 17 developed countries (including Australia) to identify the factors that determine the housing prices dynamic, and their results relate to the importance of the inflation rate as a driving force behind housing prices. Across countries, inflation accounts for more than 50 percent of the deviation in house prices at the five-year horizon, and in the short run, the impact of inflation on housing prices is high at around 90 percent. Their results also suggest that the inflation rate has more influence on real house prices than on nominal house prices. Tumbarello and Wang (2010), investigate the factors responsible for higher housing prices in Australia, New Zealand and Canada, and their findings explain that increases in the proportion of the working aged population, the terms of trade and the real mortgage rate are the main factors that influence the housing prices in these countries.

Like other asset prices, there is a volatility pattern in real estate prices. In the housing sector literature, fluctuation of housing prices is a well-known phenomenon, and it is generally accepted that housing consumption and housing investment are considerably affected by the large price movements in the housing market. Xiao (2010) explains that housing consumption and investment increases substantially during a boom period[3] in the housing market, but a sharp fall in consumption and investment spending is observed during a recession period. These determinants of housing price volatility are found in several examples in the housing market literature. Miller and Peng (2006) examine house price appreciation rates and Gross Metropolitan Product growth rates as the main factors of US housing price volatility, whereas Hossain and Latif (2007) find that GDP growth rate, house price appreciation rate, and inflation rate are the main determinants of housing price volatility. In the standard theoretical framework, housing markets are treated as an asset market, with house prices considered forward-looking and dependent entirely on current and future net capital gain. However, according to Lee and Ong (2005), the traditional property price model may not explain housing price volatility adequately. They explain that changes in demand for housing credit, and credit-constrained households are more responsible to large swing in housing prices. The credit constraint argument of housing price volatility is also supported by Ortalo-Magne and Rady (2005) and Leung et al. (2002), who explain that credit constraints play an effective role in housing demand and housing prices. However, Stein (1995), argues that 'down payment'[4] constraints are the main sources of fluctuation in housing prices. For the Australian housing market and house price volatility, Lee (2009) and Lee and Reed (2014) investigate the determinants of Australian housing price volatility and the volatility decomposition of Australian housing prices. The findings of the first study explain that inflation is the main determining factor of Australian housing price volatility, whereas results from the other research demonstrate that the impact from transitory volatility is much larger than that from permanent volatility, but the persistence of transitory or short-term volatility is much less than that of permanent or long-term volatility.

There are several studies that explore the impact of monetary policy on housing sectors for different countries. Using different housing sectors and macroeconomic variables, and using different identification procedures in VAR or SVAR models, the existing literature provides various findings of the impact of monetary policy on housing markets. Vargas-Silva (2008) examines the significance of monetary policy on the US housing market by using a sign restriction VAR model. This study uses an agnostic identification procedure to identify the

[3] When house price rises very quickly.
[4] An initial amount paid at the time of purchase.

impact of monetary policy on the housing market. In this identification procedure, sign restrictions are imposed on some variables for certain periods, but leave the response of the main variable of interest open. Using housing starts[5] and residential investment as two alternative measures of housing market activity, and taking housing prices into consideration, the findings of this study suggest that housing starts and residential investment are inversely related with the monetary policy rate. This result suggests that residential investment reduced by 0.5 percent in response to contractionary monetary policy shocks. Since residential investment is 4-5 percent of total US GDP, this reduction in residential investment has important economic consequences. The same result is reached in some other studies. Erceg and Levin (2006) find that there is a negative relationship between residential investment and contractionary monetary policy. According to Iacoviello and Neri (2007), residential investment reduced by more than 3 percent due to the change in monetary policy shock.

However, other identification methods described in the housing literature impose casual restrictions in order to identify the influence of monetary policy shocks and money supply shocks on the housing market. Using two identification procedures in the VAR model, Lastrapes (2002) examines the effect of money supply shocks on the housing market. In this study, it is assumed that money supply shocks are neutral in the long run, and a block-recursive structure such as housing variables do not affect monetary policy contemporaneously. The results suggest that money supply shocks have a positive impact on different measures of house sales. Aoki et al. (2002) also use a recursive VAR model to estimate the impact of monetary policy shocks on the United Kingdom housing market and find that after five quarters of a 50 basis-point interest rate shock, UK housing prices are 0.8 percent lower than they were after the previous shock. Iacoviello (2002) also estimates the impact of monetary policy on the UK housing market by using a VAR model. By using nine macroeconomic variables, this study finds that UK house prices fall by 1.5 percent following a 50 basis-points increase in the short term interest rate. To explore the impact of macroeconomic variables on the housing market, Wheeler and Chowdhury (1993), as well as Hasan and Taghavi (2002), use a recursive structure of VAR with the monetary policy variable preceding residential investment in the ordering. Their results based on variance decompositions and historical decompositions suggest that monetary policy does have important effects on residential investment.

[5] The number of new privately-owned housing units.

Musso et al. (2011) provide a systematic empirical analysis of the role of the housing market in the macro economy in the US and European areas by focusing on the effects of monetary policy. They use the Cholesky identification scheme as the baseline in their SVAR model to identify the three shocks: monetary policy shock, housing demand shock and credit supply shock on the housing market as well as on the overall macro economy. Their research findings explain that monetary policy shock has impact on the US housing market-related variables, in particular on dwelling investment and real house prices. This research finds that a rise in the nominal interest rate leads to a rise in mortgage lending rates, but by a lesser amount, because in the short run, a drop in the mortgage spread suggests that mortgage-lending rates are sticky in the short run.

There are several studies that explore the relationship between monetary policy and the housing market in Australia. In particular, they are interested in whether housing prices are significantly affected by the monetary policy shock. Using construction costs and real house prices as housing sector indicators, Fry et al. (2010) investigate whether it is monetary policy or wealth effects from equity markets that are responsible for the overvaluation of housing prices in Australia. To identify the factors responsible for this overvaluation, they develop a long-run SVAR model and find that, during the period of 2002 to 2008, the real house prices in Australia were overvalued. The study suggests that the wealth effects from the equity markets are the main factors in housing market overvaluation, while monetary policy is not an important factor. The study also finds that housing demand shock and real sectors' shock (goods market) are the important determinants that drive the overvaluation of Australian housing prices. However, by estimating a SVAR model of three primary variables: interest rate, money supply and house prices, Liu and Liu (2012) find that monetary policy does have a significant impact on the housing market in Australia. According to their study, monetary policy may have an impact through adjustments in interest rates and money supply. Using Australian housing market and macroeconomic data for the period 1974 to 2008, Wadud et al. (2012) examine the dynamic effects of monetary policy shock and other macroeconomic shocks on the housing market in Australia. Their study also analyses the reaction of monetary policy to housing market shocks. In this study, the authors use house prices, material costs and number of dwelling approvals as housing sector variables and the findings of the study suggest that a contractionary monetary policy has a significantly negative impact on housing activities, but it does not exert any significant negative effect on real house prices. Housing output and real house prices are also affected by housing demand and supply shocks and other macroeconomic shocks. Therefore, their findings indicate that changes in house prices along with the usual targets of inflation and output gaps need to be considered in monetary policy formation in Australia.

Considering the supply-side of the Australian housing market, Liu and London (2013) explore the interrelationship between monetary policy and the housing market in the environment of global economic turbulence. In their research, the terrorist attack in the US in 2001 and the global financial crisis in 2007–08 are considered as two instances of global economic turbulence. Using a vector error correction model (VECM) with house price, construction cost of residential properties, and new housings as housing sector indicators, Liu and London's (2013) study assesses the impact of monetary policy on housing supply in Australia. It finds that in the Australian housing sector, monetary policy is a significant driving force of housing supply.

The impact of monetary policy on house prices in the capital cities of six different states are not identical, because the prevailing economic conditions and housing demand at the time of the monetary policy shock may not be the same across these cities. This issue is explained in the most recent study of the Australian housing market and monetary policy conducted by Costello et al. (2015). By adapting Lastrapes' (2005) two-part SVAR model, the study focuses on the impact of the same monetary policy structural innovation on house prices at national and capital city levels of aggregation. Using 1982–2012 data for the Australian economy, and considering house prices as a housing sector variable, the authors find that while the impact of shocks to monetary policy on national aggregate house prices is almost neutral, the responses of the six states to this shock reveal substantial asymmetries, which may be the result of wealth and leverage differentials. Among all cities, only Sydney house prices follow most closely the Australian national response, whereas the house price response in Adelaide is opposite to that of the other cities with house prices seeming to rise after a positive shock in interest rates. All other cities show different patterns of response, which vary from the national aggregate pattern. The study findings also suggest that approximately three years of single-interest rate shocks may have a similar impact on all capital cities. Vargas-Silva (2008) and Carlino and DeFina (1998) demonstrate similar findings for US housing starts. They explain that sensitivity to monetary policy shocks differs across US regions.

Table 2.1: Summary of the Australian housing market and monetary policy literature.

Authors	Objective	Variables	Model & sample period	Findings
Costello et al. (2015)	Investigate the impact of monetary policy on house price at national and state levels.	Household consumption, GDP, 90-day BAB rate, Trade Weighted Index (TWI), house prices	The Lastrapes (2005) two-part SVAR 1982–2012	Impact of monetary policy on aggregate house prices is neutral but asymmetric responses are found in state level.
Liu & London (2013)	Identify the relationship between housing supply and monetary policy	Interest rate, money supply, house prices, vacancy rate and construction cost, new housing, Exchange rate	VECM 1997Q1–2009Q4	Supply side of housing sector is significantly affected by the monetary policy
Wadud et al. (2012)	Impact of monetary policy on Australian housing market	Material cost, real house prices, private sector housing approval, real GDP, short-term nominal interest rate, inflation rate, foreign interest rate, real net government spending on housing and nominal exchange rate	SVAR 1974Q2–2008Q4	Housing sectoral activities are negatively affected by the tight monetary policy through material costs but it does not have any significant negative effect on real house prices.
Fry et al. (2010)	Find out the overvaluation of house prices and driving forces of overvaluation house prices from 2002-2008	Real GDP, nominal interest rate, inflation rate, real price of Australian equity, real value of foreign equity, ratio of construction cost to land cost, house price relative to the cost	Long- Run SVAR 1980Q1–2008Q2	House prices were overvalued during the 2002-2008, but monetary policy is not responsible for overvalued housing prices. Housing demand shocks and real sectors shock (good market) are the main determinant of overvaluation.
Liu & Liu (2010)	Investigate monetary policy and housing affordability	Interbank rates, money supply, house prices	SVAR 1996–2009	Interbank rate negatively effect on house prices, where, money supply positively effect on house prices.

The summary of literature on the Australian housing market and monetary policy (Table 2.1) suggests that to demonstrate the impact of monetary policy on the housing market, housing price is used as one of the key indicators in most of the previous studies. There are two studies, Wadud et al. (2012) and Liu and London (2013), in which some supply-side variables of the housing market are included. Besides housing prices and house supply, auction clearance rates or number of sold or purchased residential properties may be affected by the monetary policy rate. However, these variables were not considered in the existing Australian housing market literature. In addition, new housing and new housing approvals are included as supply of housing or housing sector growth variables, renovation of established dwellings may change the housing supply qualitatively. Considering the number of purchased residential properties and dwelling investments on new construction and renovation along with housing prices, this study aims to extend the current literature by examining the impact of monetary policy on the housing market in Australia.

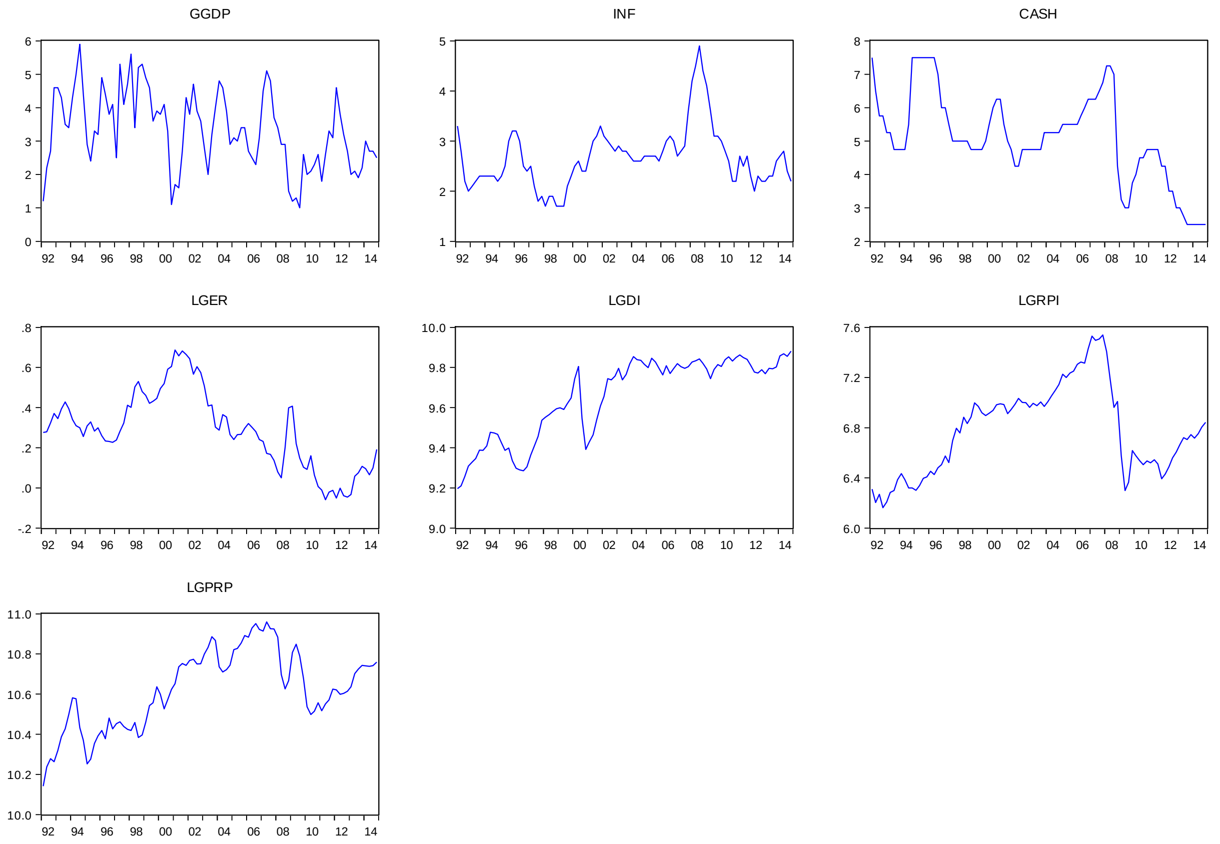
CHAPTER 3

Data and Variables:

3.1: Selection and description of variables

The seven variables housing sector model is estimated in this study. The variables are the growth rate of real GDP (GGDP), trimmed mean inflation rate (INF), cash rate (CASH), nominal exchange rate (LGER) against the US dollar, total dwelling investment(LGDI) on construction of new residential properties and renovation of established residential properties, real estate property price index (LGRPI) and total number of purchased new and established residential properties (LGPRP).

Figure 3.1: Sequences of Australian macroeconomic, monetary policy and housing market variables.



The real GDP[6] growth rate is included to represent the macroeconomic performance of the Australian economy, and any structural innovation in GDP growth rate is considered as a macroeconomic shock in this study. The present series of real GDP is the chain volume measure of year-ended GDP growth rate. GDP or real GDP are commonly used in monetary policy and housing market literature (e.g. in Aoki et al., 2002; Abelson et al., 2005; Costello, et al., 2015; Fry et al., 2010; Wadud et al., 2012; Giuliodori, 2005; Iacoviello, 2002; Lee et al., 2013; Luciani, 2015 and Vargas-Silva, 2008).

The inflation rate and CPI are generally used in the monetary policy and housing market literature as a macroeconomic indicator of price level (Aoki et al., 2002; Fry et al., 2010; Giuliodori, 2005; Iacoviello, 2002; Lee et al., 2013; Luciani, 2015 and Wadud et al., 2012). However, the present study uses trimmed mean inflation as a macroeconomic indicator of price level. Trimmed mean inflation is an alternative approach of underlying inflation, which is used in a number of central banks. The trimmed-mean rate of inflation is defined as the average rate of inflation after trimming away a certain proportion of distribution of price changes at both ends of the distribution. The Reserve Bank of Australia (RBA) also has trimmed mean inflation series from 1983Q1. To calculate the trimmed mean inflation, the RBA follows three steps: ordering the seasonally adjusted price changes for all CPI components from lowest to highest for any particular period; trimming away 15 percent of those items that lie at the two outer edges of the distribution of price changes for that period; and calculating an average inflation rate from the remaining set of price changes (Richards and Rosewall, 2010).

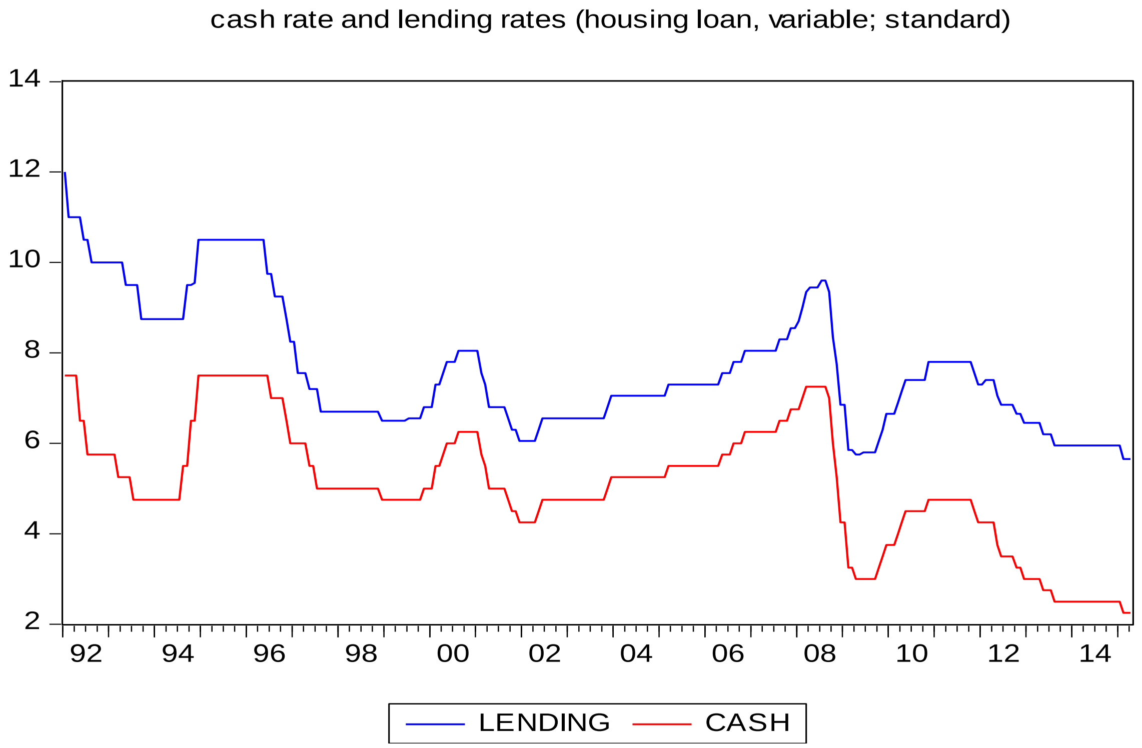
The present study uses trimmed mean inflation instead of headline inflation because sometimes there is a very large movement in prices for particular items that has a significant effect on the conventional average of all price changes, but which are relatively unrepresentative of the price changes of other goods and services. While exclusion methods remove some pre-specified items in every period regardless of whether or not their price changes are extreme, trimmed-mean measures down-weight the impact of items in a given period if their price changes are unrepresentative. As a result, these series provide an estimate for the central tendency of the distribution of price changes that is less affected by large fluctuation in prices for individual items (Richards and Rosewall, 2010). Therefore, in the trimmed mean inflation rate, there is no extreme value or outlier. Because of the noise in short-horizon movements in the CPI, the

[6] Gross Domestic Product (GDP) is defined as the total market value of all final goods and services that are produced within a country in a given period of time (in one year). When GDP is calculated by fixed-year or base-year prices instead of current market prices, it is called real GDP.

RBA often looks to measures of underlying inflation or core inflation in making monetary policy decisions (Richards, 2006). Therefore, as an alternative approach to underlying inflation, trimmed mean inflation may provide a more appropriate contemporaneous relationship between the policy rate and inflation rate.

This study uses the official overnight cash rate as a measure of monetary policy because it is often argued that the overnight cash rate is the most appropriate indicator of changes in the stance of monetary policy and since the floating of the dollar in 1983 is the main instrument of monetary policy (Grenville, 1997). In Australia, movement of mortgage or lending rates is determined by the cash rate. Figure 3.2 shows the co-movement of the cash rate and the lending rates for housing loans. To measure the impact of monetary policy on the Australian economy, Brischetto and Voss (1999), Dungey and Pagan (2000) and Suzuki (2004) also use the cash rate as the monetary policy indicator in their VAR and SVAR models.

Figure 3.2: Co-movement of cash rate and lending rates of housing loan in Australia, source: RBA



Alternative measures of monetary policy indicators are also used in earlier housing market studies. Costello et al. (2015) use a 90-day Bank Acceptance Bill (BAB) instead of the target cash rate. Luciani (2015) uses both monetary aggregates and the interest rate as the Federal Reserve's policy instruments. Aoki et al. (2002) also use both real broad money and the short-term interest rate as monetary policy variables. Elbourne (2008) uses money supply and the short-term interest rate in a housing market and monetary policy study for the same economy. The present research is also consistent with Vargas-Silva (2008), who uses the federal funds rate as a monetary policy variable.

To examine the impact of monetary policy on the housing market and to identify the interrelationship between the housing sector and monetary policy, several studies are conducted considering the nominal exchange rate as an influential endogenous variable with other monetary policy and macroeconomic variables (Elbourne, 2008 and Fry et al., 2010). In the present study, the nominal exchange rate against the US dollar (AUD to USD) is included in order to identify the response of the Australian housing market to the structural innovation of the exchange rate.

Dwelling investment on construction of new dwellings and renovation of established residential properties is used as a measure of housing sector's growth both qualitatively and quantitatively; since renovation of established dwellings improves the value of residential properties. The aim of using dwelling investment as a housing sector's growth indicator is not only to find out the impact of monetary policy shocks on the housing sector's growth, it is also an imperative objective in identifying how other housing sector variables such as housing prices and purchasing residential properties and exchange rate influence dwelling investment more generally. In the housing market literature, very few studies use dwelling investment or residential investment to measure the influence of monetary policy rate on housing sectoral growth (Aoki et al., 2002; Luciani, 2015; Vargas- Silva, 2008)

The Real estate price index is used in this study instead of the house price index. In Australia, the availability of house price data for conducting empirical studies is quite challenging (Fry et al., 2010). The Australian Bureau of Statistics (ABS) has two series of house price index (HPI) data for established houses. The first or historical series of the HPI, covers the time period 1986Q2 to 2005Q2 and the data are constructed on the index reference period of 1989–90=100. The second or current series of the HPI begins in March 2002, and is based on the index reference period 2011–12=100. According to the ABS, there are significant changes in methodology from the historical series to the current, which has led to a series break. Since two series of the HPI follow different methodologies, connecting these series by re-referencing may be inconsistent in economic analysis. According to Fry et al. (2010), changes in the methodology for constructing a house price index causes problems in analyses, especially when the change in methodology overlaps with a period that is considered by some analysts as a bubble in the real estate market. The ABS also has another two series of indexes: the Attached Dwelling Price Index (ADPI) and an aggregate Residential Property Price Index (RPPI), but both series commence in the September quarter 2003. Since this study considers 1992 to 2014 as a sample period, it is not possible to use any one from the last two series. Therefore, to avoid the series break, this study uses a continuous series real estate price index (RPI) from RP data. This index is calculated using a hedonic methodology. In this approach, to construct the real estate price index, number of bedrooms and bathrooms, location, size and other attributes are considered as a contributing factors of residential property prices. The daily RPI data are available from the period of 1973 to the present, and are collected from DataStream and other information of this data are provided in the Appendix A.

This is the first study that uses the total number of purchased residential properties as a housing sector variable, and this is one of the main variables of interest. The total number of purchased residential properties is calculated by a summation of the total number of purchased new residential properties and total number of purchased established residential properties. There are two specific reasons for using this variable in the current study. Firstly, purchased residential properties represent the number of sold properties as well, and it is expected that residential property purchasing or selling decisions are sensitive to the monetary policy rate. Therefore, using this variable to find out how policy rates influence households' or investors' purchasing or selling decisions is one of the main aims of this study. And secondly, the variable is used to find out how purchasing or selling decisions fluctuate due to residential property prices.

3.2: Data Sources and Estimation Period

All variables except the growth rate in real GDP, inflation and the cash rate are expressed in log-terms. Fig. 3.1 demonstrates the plots of the variables in this study. Data for the real GDP growth rate and trimmed mean inflation rate are collected from the RBA, the total number of purchased residential properties are taken from the ABS, and the exchange rate, cash rate, dwelling investment and real estate price index data are obtained from DataStream. Sources of data are explained in detail in the Appendix A. The data used to estimate the SVAR model are quarterly – beginning in March 1992 and ending December 2014 – resulting in a total of 92 observations.

CHAPTER 4

Econometric Model:

4.1: A SVAR Framework

Sims (1980) first introduced the vector autoregression (VAR) model as an alternative to traditional large-scale macroeconomic models. The structural VAR is used to capture the dynamics and interaction between multiple time series, where all variables are treated symmetrically and endogenous in a structural sense. In the present study, the structural vector autoregression (SVAR) model is used to capture the dynamics and interaction between monetary policy and housing market time series, where all variables are considered as symmetrically and endogenous variables. Following previous studies, this research considers the following structural vector autoregression form for the simultaneous equations of the Australian housing market, macroeconomic and monetary policy variables.

$$AZ_t = \gamma_0 + \Phi_1 Z_{t-1} + \Phi_2 Z_{t-2} + \cdots + \Phi_p Z_{t-p} + B\varepsilon_t \qquad (1)$$

Where Z_t is an $(n \times 1)$ vector of endogenous variables, γ_0 is the vector of constant term, Z_t-i is a vector of the lagged values of endogenous variables. $\mathcal{E}_t$ are uncorrelated or orthogonal white-noise structural innovations with the covariance matrix being an identity matrix $E(\varepsilon_t, \varepsilon_t')$= I. A is $(n \times n)$ matrix of structural parameters that explain the contemporaneous relationship among endogenous variables, Φi is a $(n \times n)$ matrix of coefficients of lagged endogenous variables (∀ i= 1, 2, 3, … , p). B is the $(n \times n)$ square matrix whose non-zero off-diagonal elements allow for direct effects of some shocks on more than one endogenous variable in the system, and it explains the contemporaneous response of the variables to the innovations. We can write (1)

$$AZ_t = \gamma_0 + \Phi(L) Z_{t-i} + B\varepsilon_t \qquad (2)$$

Where, $\Phi(L)$ is a $(\boldsymbol{n} \times \boldsymbol{n})$ matrix polynomial in the lag operator L of length p**.** To estimate the structural vector autoregression (SVAR) model, the reduced form, VAR has to be estimated first. As the coefficients of matrix (2) are unknown, and there are contemporary interrelationships among the variables, the model in this form cannot be completely identified. However, it is possible to transform (2) into a reduced form model by multiplying both sides of the equation by the inverse matrix of A, which represents the standard form of VAR (Tashrifov, 2005).

$$Z_t = \beta_0 + c(L)Z_{t-1} + e_t \qquad (3)$$

Where,

$$\beta_0 = A^{-1}\,\gamma_0,\ C(L) = A^{-1}\,\Phi(L),\ \text{and}$$

$$e_t = A^{-1}B\varepsilon_t \qquad (4)$$

There are two structural breaks that are observed in the Australian economy during the sample period 1992Q1–2014Q4 of this study; the introduction of the Goods and Service Tax (GST) in 2000, and the Global Financial Crisis (GFC) of 2007–08. Considering these two structural breaks, two dummy variables are included for the period 2000Q3[7] and for the period 2008Q2 to 2009Q3 in the reduced form VAR model (3).

$$Z_t = \beta_0 + D_1 + D_2 + c(L)Z_{t-1} + e_t \qquad (5)$$

Where, dummy1, $D_1 = 1$ for 2000Q3 and 0 for other periods, and dummy2, $D_2 = 1$ for 2008Q2–2009Q3 and 0 for other periods.

The AB model is estimated on the basis of Amisano and Giannini (1997), and can be written in the following way, from (4)

$$Ae_t = B\varepsilon_t \qquad (6)$$

A and B are invertible matrices of order n and the error terms e_t are linear combinations of the orthogonalised shocks (ε_t), such that each individual error term is serially uncorrelated with a zero mean and a constant variance. The vector of white noise random disturbances e_t, which is known as the vector of innovations is the main source of fluctuation in the endogenous variables in the reduced form VAR model (Amisano and Giannini, 1997). The variance-covariance matrix of the reduced form residuals is defined as $\Sigma = E\,(e_{t,}\ e_t')$.

[7] The introduction of the GST became effective from September 2000.

The main problem with this approach is identification, because the number of parameters that have to be estimated in the structural model is larger than that of the estimated reduced form model. In order to solve the identification problem, restrictions on matrices A and B have to be imposed

4.2 Identification

The orthogonality assumption of identity variance-covariance matrix of structural innovation and constant variance-covariance matrix of reduced form residuals impose identification restrictions on the A and B matrix as

$$A\Sigma A' = BB' \qquad (7)$$

A total number of $2n^2$ unknown elements can be identified upon which n(n+1)/2 restrictions are imposed by equation (7), as A and B are $(\boldsymbol{n} \times \boldsymbol{n})$ dimensional matrices. To identify the A and B matrices, it is essential to impose at least $2n^2 - n(n+1)/2$ additional restrictions. These restrictions can be imposed in three different ways. The first is by using Sims's (1980) recursive factorisation, which depends on a Cholesky decomposition of matrix A. In this approach, it is assumed that elements of matrix A are recursively related and that matrix A is lower triangular. This recursive relationship implies that the identification of the structural innovation depends on the ordering of variables, and the order of the variables is subject to the contemporaneous relationship among endogenous variables. In this case, the most endogenous variable is ordered in the last, and first variable implies that there are no contemporaneous relationships with all other variables in the model, indicating that its reduced form shock is identical to its structural shocks (Favero, 2001). The second variable in recursive ordering has contemporaneous relationship only with its own and with the structural shocks of the first variable and, similarly, the third variable is contemporaneously related with its own and with the first two variables, and so on. In the recursive identification scheme, the models are just or exactly identified. Secondly, structural factorisation is an alternative approach of identification, where restrictions are imposed on matrix A and B on the basis of economic theory (Sims and Zha, 1998; Bernanke and Mithov, 1995 and Sims, 1986). Thirdly, the long-run SVAR is an alternative approach to imposing restrictions. The long-run restriction model, introduced by Shapiro and Watson (1988) and Blanchard and Quah (1989), is based on the hypothesis that the long-run impact of particular shocks on particular variables is restricted. In the long-run model, restrictions are imposed on long run parameters (lag-coefficient matric C) for the structural disturbances. Besides these three identification procedures, Uhlig (2005) proposes an 'agnostic'[8] methodology of identification. Vargas-Silva (2008) uses this sign restriction identification scheme to find the impact of monetary policy on the US housing market.

The present study uses the structural factorisation of identification in the housing market model, where restrictions are made on the basis of economic theory.

4.3. Specification of Model and Restrictions

Given that Australia is a small open economy, the present study uses a seven-variable SVAR model to analyse the dynamic effect of monetary policy shocks on the Australian housing market. This SVAR model is composed of a system of seven equations, representing the relationship between the main housing sector variables, monetary policy, and macroeconomic variables of Australia. The vector of endogenous variables is

$$Z_t' = [ggdp_t, inf_t, cash_t, lger_t, lgdi_t,, lgrpi, lgprp_t]' \qquad (8)$$

In this study, log of dwelling investment on construction of new housing and renovation of existing housing (lgdi), real estate price index (lgrpi), and total number of purchased residential properties (lgprp) are considered as housing sector variables; growth rate of real gross domestic product (ggdp), trimmed mean inflation rate (inf), and exchange rate (lger) are considered as macroeconomic variables; and the cash rate (cash) is used as a monetary policy indicator. Considering the same level of population growth rate, it is expected that; if the growth rate of real GDP increases, then the per-capita income of households also increases, then this will lead to an increase in housing demand. Therefore, house prices and housing sector growth will increase. Moreover, if economic growth continues, it will influence an increase in dwelling investment on construction for new residential properties and renovation for established residential properties. However, a negative relationship is expected between real estate prices and the inflation rate, since high inflation reduces the purchasing power of households, therefore the housing demand decreases in an inflationary situation. The cash rate is used as a monetary policy rate.

[8] In this identification scheme, sign restrictions are imposed on the response of some of the variables for a certain period and the response of the main variable of interest is kept open.

This research uses contemporaneous relations in the Australian housing market, the monetary policy reaction function, and the economic growth and inflation of the Australian economy in general to impose restrictions. Since in this study seven variables are included in the model specification, at least $2x7^2 – 7(8)/2=70$ restrictions are needed to be imposed in matrices A and B for an exact identified model. The B matrix is assumed diagonal with seven free parameters, which provides 42 restrictions, and 28 zero and one restrictions in matrix A. Following the previous studies, such as Shapiro and Watson (1988), and Wadud et al. (2012), and taking into account the Australian housing market and macroeconomic conditions, several assumptions are made and a number of restrictions are imposed on the structural models of this study. Therefore, the SVAR is

$$A\,Zt=\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 & 0 \\ a_{51} & 0 & a_{53} & a_{54} & 1 & 0 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & 0 & 1 & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{bmatrix}\begin{bmatrix} ggdp \\ inf \\ cash \\ lger \\ lgdi \\ lgrpi \\ lgprp \end{bmatrix} \qquad (9)$$

Depending on the economic explanations of the contemporaneous relationship among the variables, the restrictions are imposed in coefficient matrix A in (9). Growth rate of real GDP is considered the prominent variable in this procedure, in the sense that structural shocks in the GDP growth rate immediately impact on all other variables, while the converse is not true. The first equation suggests that the growth rate of real GDP is not contemporaneously affected by other macroeconomic variables, the policy variable and housing market variables. It is consistent with the economic theory in that growth may respond to the other shocks with a considerable lag. Karame and Olmedo (2002) explain that most types of real economic activities may respond only with a lag to monetary variables because of intrinsic sluggishness and planning delays. Costello et al. (2015), assume that real GDP is not affected by other variables in the short run. This is based on the assumption that while shocks to other variables will eventually have an effect on GDP, the unwillingness to reduce the factors of production in the short run will result in such shocks having no immediate impact on domestic output, although they will have long-run impact on GDP. To investigate the impact of monetary policy on the Australian housing market, Wadud et al. (2012) also assume that real GDP is not affected by other macroeconomic and housing sector variables contemporaneously.

In the second equation, it is assumed that the inflation rate is contemporaneously affected by the real GDP, but it is not contemporaneously affected by the monetary policy rate and housing market variables. Lee et al. (2013) explain the interrelationship between house prices, stock prices and monetary policy, assuming that only the fluctuation of real GDP can influence the inflation rate in the short run. This argument is also supported by Bjømland and Jacobson (2010) who argue that macroeconomic variables such as output and inflation do not simultaneously react to policy variables.

The third equation demonstrates that the monetary policy rate is contemporaneously affected by the real GDP and inflation rate. In Australia, the main objective of monetary policy is to keep the inflation rate at the target level and improve economic growth and employment. Therefore, the cash rate is influenced by the inflation rate contemporaneously. The cash rate is also influenced by the growth rate of real GDP. Housing sector variables such as dwelling investment and total number of purchased residential properties can influence the monetary policy rate, since these variables are associated with demand for loans. However, it is observed that the cash rate responds to housing sector shocks with some lags, not contemporaneously.

The fourth column explains that the exchange rate is contemporaneously affected by the domestic GDP growth rate, the inflation rate and by the cash rate. The exchange rate has a contemporaneous effect on the housing sector variables, but these variables do not have a feedback effect on the exchange rate. This assumption is made based on the idea that when the Australian dollar value changes, it may affect the net cash inflow or capital inflow which can in turn influence housing investment and consumption demand. Tumbarello and Wang (2010) argue that positive terms-of-trade shocks are associated with larger increases in house prices in Australia. Wadud et al. (2012) make similar restrictions in their Australian housing market model. They argue that Australian house prices can be contemporaneously affected by the nominal exchange rate, but that house prices do not influence the nominal exchange rate.

The last three equations explain the housing sector variables that are contemporaneously affected by the macroeconomic and policy variables. It is assumed that if the real GDP growth rate increases, then the per-capita income of households also increases, and it is evident that households' income is an important determinant of housing demand (Abelson et al., 2005 and Wadud et al., 2012). The monetary policy variable, the cash rate, has contemporaneous impact on housing investment, residential property prices and total number of purchased or sold residential properties. Elbourne (2008) assumes that the interest rate does influence housing prices in the short run to explain the impact of monetary policy on the UK housing market. Moreover, in this SVAR model, it is assumed that housing sector variables except dwelling investment can be affected by the inflation rate in the short run. Since, it takes time to adjust inflation rate with ongoing construction, dwelling investment is not affected by the structural innovation of inflation rate contemporaneously. This restriction is also used by Wadud et al. (2012), who argue that inflation does have contemporaneous effects on housing prices, but not on housing supply. In addition, the sixth equation explains that real estate prices are influenced by all macroeconomic, policy, and housing sector variables except for dwelling investment, since dwelling investment on new construction can change the housing supply, but with lags.

To investigate the effects of monetary policy shocks, housing price shocks and exchange rate shocks on the Australian housing market, this research employs the models used in the applied SVAR studies: reduced form of VAR; the short-term SVAR models; the impulse-response function (IRF); and the forecast error variance decomposition (FEVD).

CHAPTER 5

Methodology and Estimation

5.1. Unit Root Test:

The first step in using time-series data is to check whether a series is stationary or non-stationary by using a unit root test. The unit root test is applied in the present study to detect the pattern of the housing market, monetary policy and macroeconomic data. There are many tests for determining whether a series is stationary or non-stationary; the Augmented Dickey–Fuller test is the most popular one. There are three variations of the Dickey–Fuller test designed to take account of the role of the constant term and the trend

$$\Delta x_t = \alpha + \lambda t + \theta x_{t-1} + \delta \sum_{i=1}^{k} \Delta x_{t-i} + v_t \quad (a)$$

$$\Delta x_t = \alpha + \theta x_{t-1} + \delta \sum_{i=1}^{k} \Delta x_{t-i} + v_t \quad (b)$$

$$\Delta x_t = \theta x_{t-1} + \delta \sum_{i=1}^{k} \Delta x_{t-i} + v_t \quad (c)$$

Where, Δx_t is the time series of a particular variable of interest. The first equation includes a constant term α and a trend term λt, the number of lagged terms and a white noise error term v_t. The lag term is included to capture the full dynamic nature of the process, with the number of lagged terms determined by examining the autocorrelation function (ACF) of the residual v_t, or the significance of the estimated lag coefficient δ, (Hill et al., 2008). The second model considers only the constant term and no trend term, and the third model includes neither the intercept not the trend term. The hypothesis for the Augmented Dickey–Fuller (ADF) test are as follows:

H_0: $\theta = 0$, there is a unit root in the series (the series is non-stationary)

H_1: $\theta < 0$, there is not any unit root in the series (the series is stationary)

If the null hypothesis is rejected at a conventional significance level, then the series is stationary.

5.2. Cointegration test:

Since this study deals with the multivariate VAR model, to test the cointegration relationship among variables, the Johansen cointegration approach (Johansen and Juselius, 1990) is used. For this test, the following model in vector-error correction form is used:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \cdots \ldots \ldots + \Gamma_{p-1} \Delta Z_{t-p+1} + \Pi Z_{t-p} + u_t \qquad \text{(d)}$$

Where $u_t \sim$ NID $(0, \Sigma)$ and the estimate of Γ_i measures the short-run adjustment to change in Z_t, while Π contains information on the long-run adjustment to changes in Z_t. Assuming that Z_t is a vector of I (1) variables, while r (cointegration rank) linear combinations of Z_t are stationary. Testing for cointegration involves testing the rank of Π. If Π has a full rank, the variables are stationary and if rank of Π is zero, there is no cointegration relationship among the variables. The Π is defined as

$$\Pi = \varphi \beta', \qquad \text{(e)}$$

Where φ represents the speed of adjustment and β is a matrix of long-run coefficients. To determine the existence of cointegration relationships, the cointegration rank (r) must be determined. Johansen (1992) proposes two methods; trace test and maximum eigenvalue test to determine the cointegration rank. Trace statistics are defined as

$$\lambda_{trace}(r_0) = -T \sum_{j=r_0+1}^{k} \log(1 - \lambda_j), \qquad \text{(f)}$$

Where, T is the sample size. If there are r cointegration relationships, it must be the case that $\log(1 - \lambda_j) = 0$ for the smallest k-r eigenvalues for j = r+1, r+2,……., k. The null and alternative hypothesis are H_0: $r \leq r_0$ and H1: $r_0 < r \leq k$.

The alternative test is called the maximum eigenvalue test, it is based on the estimated (r_0+1)th largest eigenvalue

$$\lambda_{max}(r_0) = -T \log(1 - \lambda_{r0+1}) \qquad \text{(g)}$$

Null hypothesis, H_0: $r \leq r_0$ and alternative hypothesis, H_1: $r = r_0 + 1$.

5.3. Estimation

To check the stationarity of data, this study applies an Augmented Dickey–Fuller (ADF) unit root test for three cases (intercept; intercept and trend; and none of intercept and trend). The test results suggest that all series are non-stationary without trend, and only the growth rate of real GDP and dwelling investment are stationary with trend and intercept. Therefore, all data are not stationary at level. The unit root test results[9] for trend are given in Table 5.1. Along with the ADF test, this study applies the Kwiatkowski- Phillips- Schmidt- Shin (KPSS) test as well (Appendix B) and test results also show that all variables are not stationary at level. This raises the issue of accurate estimation methodology. Following standard practice, this paper estimates the vector autoregression model in levels, even though most of the variables are non-stationary. If the structural shocks are properly specified, then estimating SVAR at levels with non-stationary variables will provide consistent estimated coefficients

Table 5.1: Augmented Dickey–Fuller unit root test

Variables	ADF test Statistic with c & t (p- value)	ADF test statistic at I (1)	Critical value at 5% level	Stationarity
GGDP	-3.71 (0.026)	-9.72 (0.00)	-3.46	Stationary with trend only
INF	-2.86 (0.180)	-3.70 (0.005)	-3.46	Stationary at first difference I (1)
CASH	-3.31 (0.07)	-6.45 (0.00)	-3.46	Stationary at first difference, I (1)
LGER	-2.43 (0.36)	-7.17 (0.00)	-3.46	Stationary at first difference I (1)
LGDI	-3.46 (0.05)	-7.013 (0.00)	-3.46	Stationary with trend only
LGRPI	-1.81 (0.69)	-7.46 (0.00)	-3.46	Stationary at first difference.
LGPRP	-2.64 (0.26)	-6.77 (0.00)	-3.46	Stationary at first difference, I(1)

[9] Unit root tests results for 'intercept' and 'none of intercept and trend' are available from author upon request.

Moreover, the cointegration test (Tables 5.2.a and 5.2.b) findings show that both the Trace and the Maximum Eigenvalue tests indicate that variables are cointegrated, having two cointegrating vectors. The finding of cointegration allows the estimation of the SVAR at levels rather than first difference. This is consistent with the argument of Sims et al. (1990). Their research on inference in linear time-series models with some unit roots explains that transforming data from non-stationary to stationary is unnecessary because statistic of interest often have distributions that are unaffected by non-stationarity. According to their study, hypotheses can be tested without first transforming to stationary regressors. In SVAR literature, the findings of Sims et al. (1990) are commonly accepted. In order to explain the impact of monetary policy and credit shocks, Berkelmans (2005) estimates SVAR model for the Australian economy with non-stationary data and suggests that, when considering the appropriate number of lags for the variables, residuals will be stationary, even with cointegrated variables. Costello et al. (2015), Musso et al. (2011), Vargas-Silva (2008), and Wadud et al. (2012) estimate SVAR at level with non-stationary variables to investigate the impact of monetary policy shocks on housing markets.

Table 5.2.a: Johansen Cointegration test (Trace test):

Hypothesis H0 H1	Eigenvalue	Trace statistic	5% critical value	Prob.**	Hypothesized number of cointegrating equations
r=0, r>1	0.515820	162.2880	125.6154	0.0000	None*
r≤ 1 r ≥2	0.372053	97.73642	95.75366	0.0363	At most 1*
r≤ 3 r ≥3	0.231186	56.32481	69.81889	0.3650	At most 2
r≤ 4 r ≥4	0.167663	32.92620	47.85613	0.5609	At most 3
r≤ 5 r ≥5	0.118506	16.59315	29.79707	0.6699	At most 4
r ≤6 r ≥6	0.046220	5.366970	15.49471	0.7687	At most 5
r≤ 7 r ≥7	0.012897	1.155294	3.841466	0.2824	At most 6

Note: Trace test indicates 2 cointegrating equations at the 5% level, * indicates reject H_0 at 5% level

Table 5.2.b: Johansen Cointegration test (Maximum eigenvalue test):

Hypothesis H0 H1	Eigenvalue	Max-Eigen statistic	5% critical value	Prob.**	Hypothesized number of cointegrating equations
r= 0 r =1	0.515820	64.55157	46.23142	0.0002	None*
r≤ 1 r= 2	0.372053	41.41161	40.07757	0.0352	At most 1*
r≤ 2 r = 3	0.231186	23.39861	33.87687	0.5002	At most 2
r≤ 3 r= 4	0.167663	16.33304	27.58434	0.6374	At most 3
r≤ 4 r = 5	0.118506	11.22618	21.13162	0.6247	At most 4
r≤ 5 r = 6	0.046220	4.211676	14.26460	0.8364	At most 5
r≤ 6 r = 7	0.012897	1.155294	3.841466	0.2824	At most 6

Note: Max- eigenvalue test indicates 2 cointegrating equations at the 5% level, * indicates reject H_0 at the 5% level, model: deterministic trends

5.4. Optimal Lag selection:

For choosing the optimal lag order of the VAR system, this study checked different optimal lag length criteria, setting the maximum lag order to 8. According to the Akaike information criterion (AIC) and final prediction error (FPE), choosing 8 lags is optimal for this SVAR model. However, the Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ) suggest that lag order one is optimal for this model and sequential modified LR test statistics (each test at 5% level) shows lag order six is optimal. The optimal lag length criteria results are presented in Table 5.3. The problem with choosing AIC or FPE and LR criteria is that the VAR model becomes unstable with 8 or 6 lags, because some inverse roots of the characteristic autoregressive (AR) polynomial lie outside the unit circle. Choosing one lag on the basis of SC and HQ criteria provides a stable VAR model, since all inverse roots of the characteristic autoregressive (AR) polynomial have a modulus less than one and lie inside the unit circle. However, residuals in the VAR or SVAR models are autocorrelated in lag order one. Besides the autocorrelation problem, choosing one lag order is too short to capture the dynamic of the system. Since the number of observations (87 after adjustment) is not large enough, the lag order of four or less is more suitable. However, lag order three and four also provide serial autocorrelation and instability problems. To avoid the instability and autocorrelation problems and to capture the dynamic effect of monetary policy on the housing market, five lags are considered in estimating the VAR and SVAR models in this research.

Table 5.3: Optimal lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-126.4460	NA	7.90e-08	3.510620	4.118324	3.754912
1	448.2175	1012.502	2.92e-13	-9.005178	-6.979497*	-8.190871*
2	514.9481	106.4513	1.98e-13	-9.427336	-5.983679	-8.043015
3	552.1873	53.19883	2.82e-13	-9.147317	-4.285683	-7.192981
4	601.1433	61.77784	3.25e-13	-9.146270	-2.866660	-6.621920
5	670.3059	75.74950	2.55e-13	-9.626332	-1.928745	-6.531967
6	747.6373	71.80768*	1.90e-13	-10.30089	-1.185325	-6.636508
7	820.0365	55.16129	1.96e-13	-10.85801	-0.324472	-6.623617
8	928.6580	64.65570	1.18e-13*	-12.27757*	-0.326057	-7.473164

Notes: LR Sequential modified LR test, FPE final prediction error, AIC Akaike information criterion, SC Schwarz information criterion, HQ Hannan-Quinn information criterion. * indicates lag order selected by the criterion (each test at 5% level).

A determination of optimal lag order without following established lag length criteria is not unusual in the VAR literature. Berkelmans (2005) does not follow the optimal lag length criteria in estimating a small structural vector autoregression (SVAR) model for Australia, which explains the intertwined connections of credit with other key macroeconomic variables. A lag length of three is chosen in his study as it provides reasonable dynamics without shortening the estimation too much. To avoid autocorrelations among residuals, Vonnak (2005) uses three lags in a study of Hungary. Using quarterly data in a study of Thailand, Disyatat and Vongsinsirikul (2003) use two lags while the established optimal lag length criteria suggest that one lag is optimal. They argue that one quarter is too short a period to capture the dynamics of a system.

5.5. Reduced Form VAR and LR Test for Structural Break

The reduced form vector autoregression model is estimated to investigate the effect of monetary policy shock and other macroeconomic shocks in the housing sector with seven variables; growth rate of real GDP, trimmed mean inflation rate, cash rate, nominal exchange rate, dwelling investment on housing construction and renovation, real estate price index and total number of purchase residential properties. To avoid any econometric problems in the estimation process, all variables except real GDP growth rate, inflation rate, and cash rate are taken in logarithm form. Besides seven endogenous variables, two dummy variables are included in the estimations in order to capture the structural breaks observed in the series.

To explore whether these structural breaks have significant impact on the economy, reduced form VAR models are estimated with dummies (unrestricted VAR)[10], and without dummies (restricted VAR), and following the LR test is applied to test the significance of structural breaks

$$LR= (T\text{-}m) \ln(S|\Sigma_r|)\text{-}\ln(|\Sigma_u|) \sim \chi^2(q)$$

Where, T is the number of observations and m is the number of parameters in each equation of the unrestricted model, $|\Sigma_r|$ and $|\Sigma_u|$ are determinants of the residual covariance matrix of restricted and unrestricted VAR respectively, and q is degrees of freedom, which is determined by multiplying the number of dummies and number of equations.

The LR test result reveals that the null hypothesis of no significant impact from structural breaks is accepted at 14 degrees of freedom for the χ^2 distribution. It implies that overall, there is no significant impact of structural breaks on the present housing market model, though a few housing market and macroeconomic variables were affected by these structural breaks in the economy. The impact of the introduction of the Goods and Service Tax (GST) in 2000, and the impact of the GFC in 2007–2008 were counterbalanced by the introduction of the First Home Owner Grant (FHOG) scheme in 2000, and the National Building and Jobs Plan (the Economic Stimulus Plan) after the GFC. To stabilise the housing market, the FHOG increases by the amount of $21000 for a first and new home buyer, (Lee and Reed, 2014). According to Costello et al. (2015), the four-year Economic Stimulus Plan with a budget of AUS$42 million for expenditure on building and construction was at record high levels during 2009–2010, and first home-buyers were subsidized by savings schemes, cash grants and a reduction in stamp duty. Therefore, the overall impact of the GFC on the Australian housing market as well as on the Australian economy was relatively low compared to other developed countries.

Estimated reduced form VAR models explain that housing market variables such as dwelling investment, real estate prices, and purchasing residential properties are influenced by their own

[10] Estimated restricted and unrestricted VAR models are available from the author upon request.

lag values as well as by past values of macroeconomic and policy variables. The VAR result shows that the real GDP growth rate has small and insignificant influence on dwelling investment in different lag periods, but the cash rate of lag three and the exchange rate of lag four have significant impact on dwelling investment. Besides the past value of policy variables and own value, dwelling investment significantly influenced by the housing prices. The real GDP growth rate and the cash rate have significant influence on housing prices and the purchasing of residential properties.

5.6. Estimated Structural VAR:

Using estimated reduced form VAR model short- run SVAR model is estimated (Appendix C and D) first then estimated shocks are used to generate the structural impulse response functions and forecast error of variance decomposition for assessing the dynamic impacts of monetary policy shock and macroeconomic shocks on housing sector variables. The estimated contemporaneous coefficient matrix A (Appendix C) incorporates the over-identifying restriction. The likelihood ratio test statistics for the null hypothesis of the over-identifying restriction is 1.575865 (prob. 0.4548). Under the null hypothesis, this statistic has a chi-square distribution with two degrees of freedom and it shows that the identified restriction cannot be rejected at the 5% significance level. It implies that restrictions of zero contemporaneous effect of several endogenous variables are valid.

CHAPTER 6

Results:

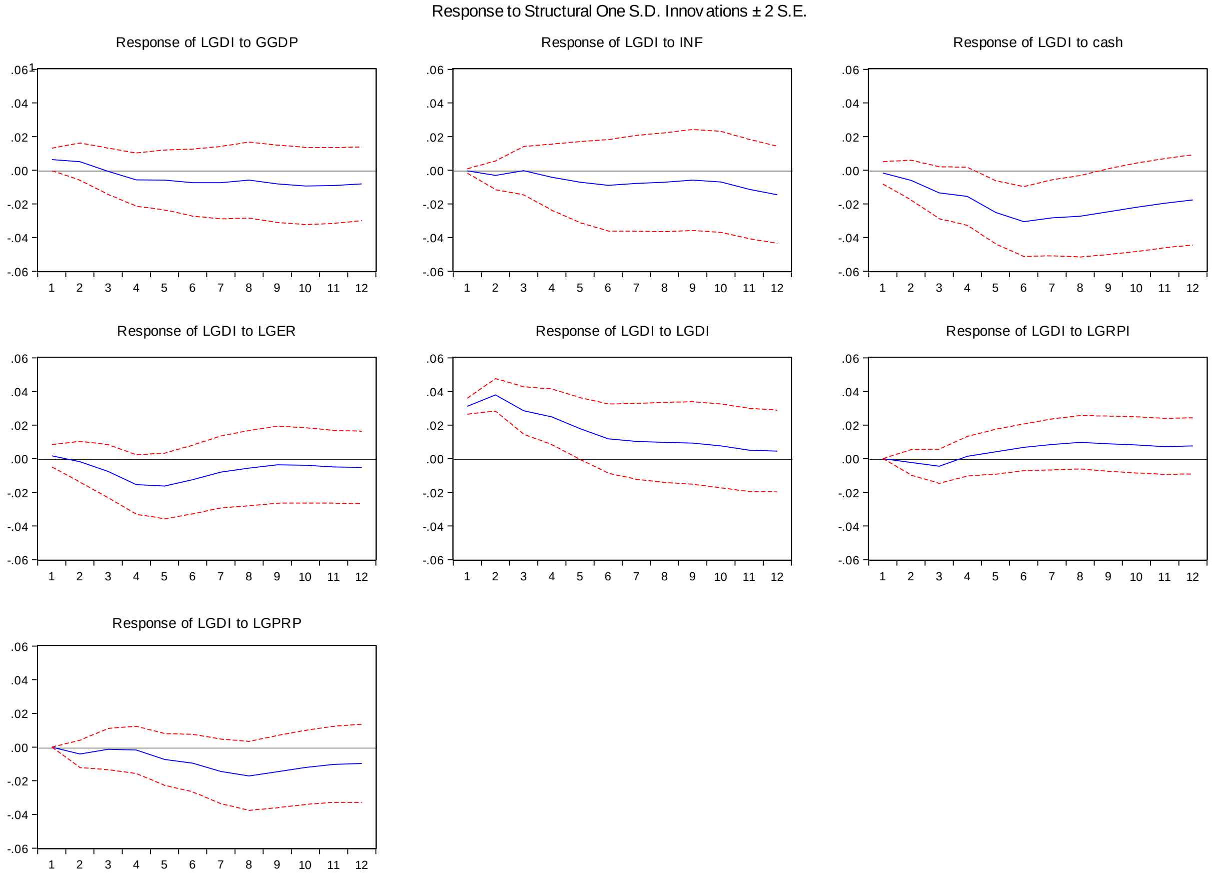
6.1: Impulse Response Analysis

To analyse the short-run dynamics in the housing market and policy variables, this study estimates several impulse response functions based on the structural VAR specification. The objective is to find out how each of the housing market variables responds to monetary policy shocks, macroeconomic shocks and own sectoral shocks. To identify the response of the monetary policy variable to housing market shocks and macroeconomic shocks is also an aim of this research. The impulse response functions of dwelling investment, real estate prices, purchasing residential properties, and monetary policy rate to a one-standard-deviation positive structural shocks are shown in Fig. 6.1.1 to Fig. 6.1.4, where different structural innovations are presented based on the order of the variables. However, an explanation of the impulse response of the housing sector follows the order of the monetary policy shocks, own sectoral shocks and macroeconomic shocks for each of the housing market variables. The two standard-error (95%) confidence intervals are shown by short dashed lines.

6.1.1 Response of dwelling investment:

The impulse response function of dwelling investment shows that investment on construction of new dwellings and renovation of established dwellings reduces significantly for seven quarters following a one-standard-deviation monetary policy shock (contractionary monetary policy shock). After two years, the negative impact of a monetary policy shock on dwelling investment reduces slightly, but persists over the whole considered horizon of 12 quarters. This negative relationship between monetary policy rates and dwelling investment are found in several earlier studies. Vargas-Silva (2008) finds that residential investment is negatively affected by the federal fund rate for the US economy and this finding shows that residential investment reduces by about 0.5 percent in response to monetary policy shocks. Erceg and Levin (2006) find that residential investment dropped by around 0.7 percent because of contractionary monetary policy. Iacoviello and Neri (2007) show in their small-scale dynamic stochastic general equilibrium model that residential investment dropped by more than 3 percent in response to monetary policy shocks.

Figure 6.1.1: Impulse response functions of Dwelling Investment



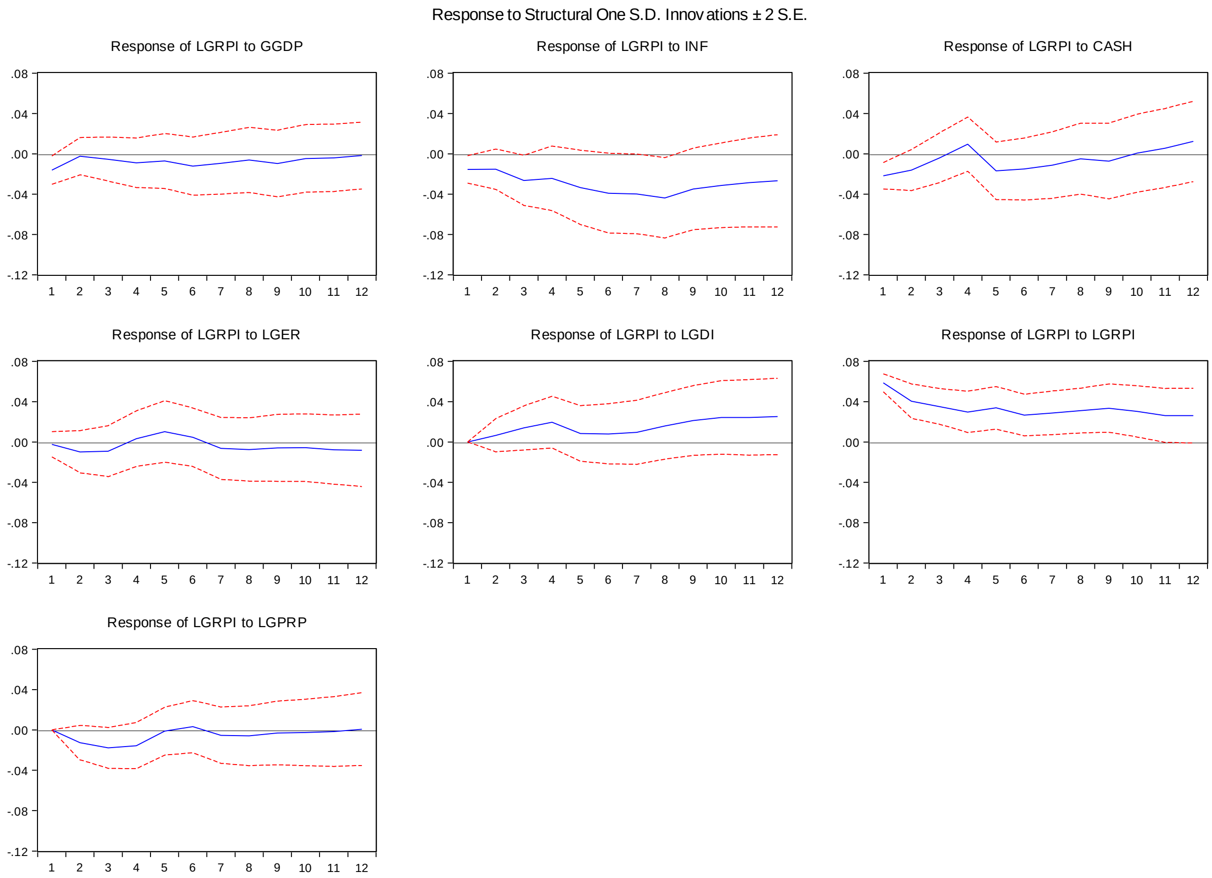
It is expected that dwelling investment will have a positive reaction to real estate price shocks and purchasing residential properties shocks. The estimated results are consistent with expectation partially because impulse response functions explain that after three quarters, dwelling investment increases due to higher housing prices, but for the same time horizon, it moves in the opposite way for purchasing residential property shock.

Regarding the macroeconomic shocks, dwelling investment has a significant and consistent response to exchange rate shocks. The appreciation of the Australian currency negatively impacts on dwelling investment, since Australian currency becomes more expensive to the foreign investors to invest on new constructions. In addition, there are significant and consistent impacts from structural innovations of the inflation rate on housing investment. Fig. 6.1.1 shows that dwelling investment responds negatively to an inflation rate after three quarters of positive inflation shock. This is consistent with other economic behaviours, because costs such as materials and labour increase due to the higher inflation rate, and therefore, investment in residential properties reduces. Wadud et al. (2012) also gets similar results regarding house supply response to inflation shock. They specify inflation shock as an adverse supply shock that reduces the real economic activities including the building of new houses. Moreover, similar to previous studies, an inconsistent response in dwelling investment is found for structural innovation of GDP growth.

6.1.2: Response of real estate prices

The impulse response function in Fig. 6.1.2 shows that the response of real estate prices to monetary policy rate shock is slightly cyclical and, except in the fourth quarter, it remains below the base line until the 9th quarter. In the first quarter, the nominal real estate prices decrease by 0.02188 for one standard positive shock (0.0065) of cash rate. It implies that monetary policy shock has significant and consistent contemporaneous effects on real estate prices. This finding is not comparable with previous studies, for example with Fry et al. (2010) and Wadud et al. (2012), because they use relative house prices in terms of land cost and CPI respectively. In the present research, nominal real estate price is used as a house prices indicator and shows that the monetary policy rate has a negative impact on nominal housing prices with low levels of fluctuation. Iacoviello and Minetti (2008) find both negative and positive relationships between policy rate and house prices in their five-variables VAR model, which includes the total loan, house prices, GDP, inflation and interest rate for four developed economies (Finland, Germany, Norway, and the UK). Their findings suggest that the monetary policies of Finland and Germany have a significant and instantaneous negative effect on house prices, whereas the monetary policy of the UK has a significant and instantaneous positive effect on house prices, and in Norway monetary policy has a positive and insignificant impact on housing prices.

Figure 6.1.2: Impulse response functions of Real Estate Prices



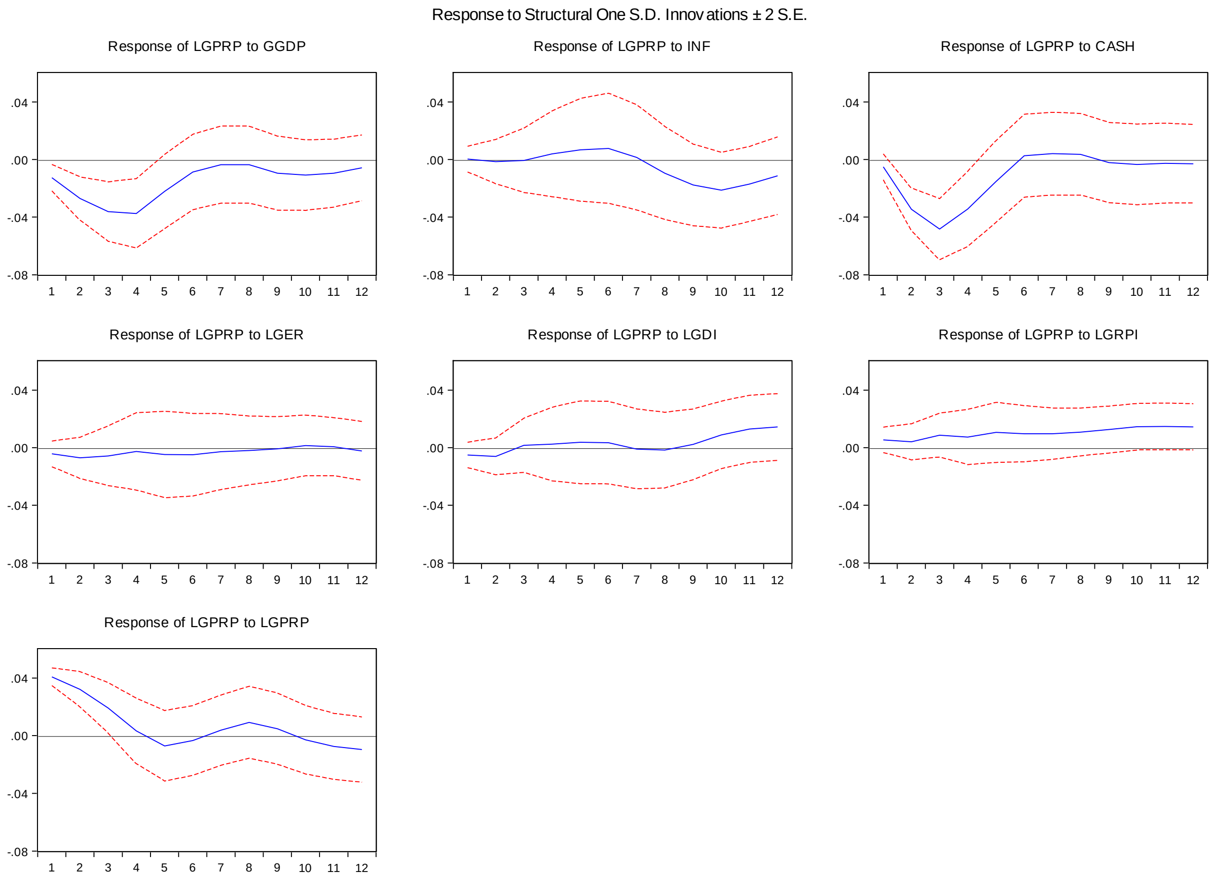
The structural innovation of dwelling investment affects real estate prices positively. Since dwelling investment is considered as investment on new construction and renovation, the price is higher for new and renovated properties. The real estate prices respond inconsistently to the shock of purchased residential properties.

In the case of the macroeconomic variables, it was expected that the exchange rate may affect Australian housing prices through cash inflow, but the exchange rate does not have significant impact on housing prices. The real GDP growth rate also does not have significant impact on house prices. Costello et al. (2015) find that real GDP growth shock can impact real house prices significantly after quarter nine, but not contemporaneously. In addition, the nominal house prices are significantly and negatively influenced by the inflation rate. Since high inflation rate or high expected inflation rate influences to the central bank to apply the contractionary monetary policy, which has negative impact on house prices. Moreover, households' purchasing power with same level of income may reduce for the high inflation rate, therefore, demand for residential properties may goes down and the prices of residential properties move downwards. This findings is justified by the housing market research of Tsatsaronis & Zhu (2004), Wadud et.al (2012). Tsatsaronis & Zhu (2004) explain that inflation rate has strong negative impact on real estate prices, although they explained that real house prices are more affected by the inflation rate rather than nominal house prices. The repayment of the mortgage principle are overburdened by the high inflation or high nominal interest rate, therefore dampening the residential property demand. Wadud et.al (2012) also found that the real house prices are negatively influenced by the price level.

6.1.3: Response of purchasing residential properties:

The impulse response function explains that the number of purchased residential properties falls instantaneously after one-standard-deviation shocks of policy rates, and continues to decrease for more than two quarters. After the third quarter, the effect of monetary policy shocks begins to disappear. Overall, the purchasing residential property variable seems to be reasonably sensitive to the monetary policy rate. It is very much consistent with expectation that explain that the households' and investors' purchasing decision are contemporaneously influenced by the cash rate.

Figure 6.1.3: Impulse response functions of the Purchase Residential Properties



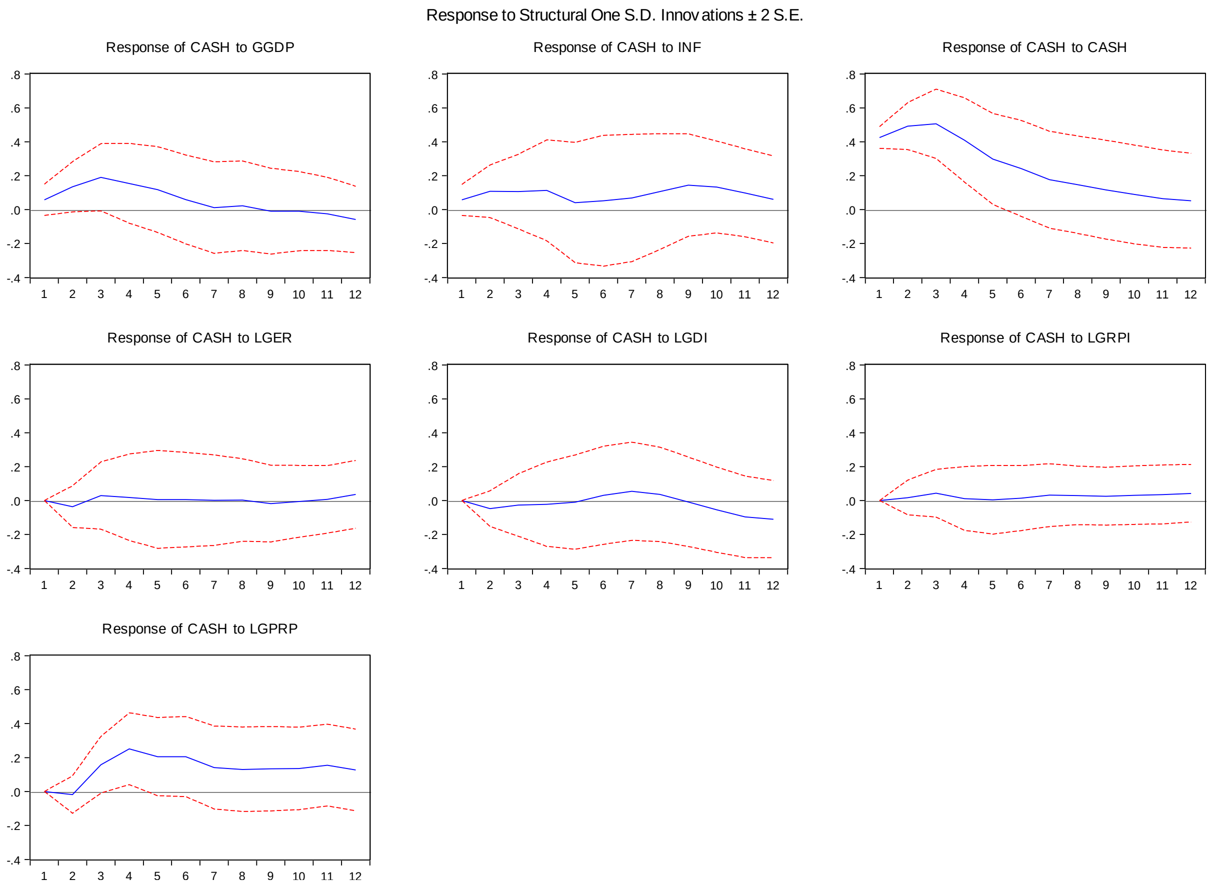
It was expected that the number of purchased residential properties would reduce for positive shocks in housing prices (the demand theory), but in the real estate market, the law of demand is not effective. This may be explained in two different ways. First, the number of purchased residential properties has dual characteristics: it reflects both purchased and sold properties. When house prices are high, more properties come into the market for sale, therefore, the number of purchased and sold properties increases. Second, when house prices rise, equity value also increases for the second home buyer, therefore, their borrowing capacity increases and they can purchase another property. In addition, when residential property prices rise, the expected future residential property price also rises, thus investors want to buy property to make profits in the future, and first home- buyers also want to buy property because they may think it would not be possible to buy property with higher prices in the future. Thus the number of purchased residential properties increases for one-standard-deviation positive shocks in housing prices.

The exchange rate does not have a significant impact on the purchasing residential properties variable, whereas growth rate of real GDP has significant but inconsistent impact. Besides monetary policy, real estate price and own shocks, purchasing residential properties is influenced significantly and consistently by the inflation rate, but only several quarters after the shock.

6.1.4: Response of monetary policy rate

The findings of this study show that real estate price shocks cannot influence interest rates over the whole period of the shock, and that dwelling investment has insignificant impact on monetary policy. More significant and consistent responses to policy rates are noticed for the shock of purchasing residential properties. Fig. 6.1.4 shows that for a one-standard-deviation shock in purchasing residential properties, the cash rate increases after three quarters as demand for housing loans increases. Therefore, since fluctuation in purchasing residential properties involves housing demand and supply shocks, it is possible to say that housing demand and housing supply are important factors to changes in interest rate through changes in demand for housing loans. Wadud et al. (2012) also suggest that there are often interest rate rises after one or two quarters following positive housing demand and supply shocks, and this positive response in the interest rate persists over the next three years. They also argue that housing demand and supply shocks impact on the monetary policy rate via demand shocks in housing loans.

Figure 6.1.4: Impulse response functions of the monetary policy rate



In Australia, the main objective of monetary policy is to keep the inflation rate at target levels. The empirical results of this study are consistent with this policy objective. The impulse response functions presented in Fig 6.1.4 explain that the monetary policy rate responds positively to one-standard-deviation positive shocks of the underlying inflation rate in the economy. If inflation goes up, the RBA increases the cash rate to keep the inflation rate at the target levels. For the Australian economy, previous studies such as Wadud et al. (2012) and Berkelmans (2005) also find the same response of monetary policy rate to inflation shock. They also argue that the immediate increases to the interest rate following a one- standard-deviation positive shock in the inflation rate expose the existence of inflation-targeting monetary policy in Australia. Besides the inflation and purchasing residential properties, the cash rate variable has a positive response to a one-standard-deviation positive shock of the GDP growth rate from steady state level.

6.2. Forecast Error and Variance Decomposition

The variance decomposition provides information about the relative importance of each random shock in affecting the variables in the SVAR. Moreover, the variance decomposition reports the sizes of the forecast errors, created by the structural vector autoregression, that are attributable to shocks in each of the variables in the model. In Table 6.2, the reported numbers show the proportion of forecast error in each variable that can be attributed to innovations in other variables at four different time horizons such as, quarters 1, 4, 8 and 12.

Table 6.2: Structural Variance Decomposition

Variance Decomposition of Cash Rates (CASH)							
Period	LGGDP	INF	CASH	LGER	LGDI	LGRPI	LGPRP
Q1	1.754	1.748	96.496	0.000	0.000	0.000	0.000
Q4	7.635	3.670	79.583	0.241	0.326	0.219	8.323
Q8	6.937	4.142	73.186	0.185	0.616	0.313	14.619
Q12	6.382	6.848	66.292	0.271	2.049	0.568	17.587
Variance Decomposition of Dwelling Investment (LGDI)							
Period	LGGDP	INF	CASH	LGER	LGDI	LGRPI	LGPRP
Q1	3.944	0.019	0.264	0.289	95.482	0.000	0.000
Q4	2.069	0.577	9.698	6.298	80.328	0.577	0.452
Q8	2.692	2.645	34.551	7.873	43.305	2.455	6.477
Q12	4.184	5.015	38.448	6.416	33.466	3.637	8.832
Variance Decomposition of number of Purchased Residential Properties (LGRPI)							
Period	LGGDP	INF	CASH	LGER	LGDI	LGRPI	LGPRP
Q1	5.946	5.495	10.837	0.125	0.000	77.595	0.000
Q4	3.239	15.199	7.246	1.691	5.269	61.151	6.202
Q8	3.047	34.121	6.536	1.815	4.674	46.370	3.435
Q12	2.550	35.145	5.273	1.868	10.032	42.665	2.463
Variance Decomposition of Real Estate Price Index (LGPRP)							
Period	LGGDP	INF	CASH	LGER	LGDI	LGRPI	LGPRP
Q1	8.265	0.003	1.351	0.976	1.359	1.491	86.552
Q4	30.587	0.152	40.188	0.915	0.605	1.467	26.084
Q8	31.074	1.587	37.048	1.235	0.742	4.362	23.950
Q12	27.456	8.485	30.532	1.063	3.384	8.378	20.698

When considering the structural variance decomposition of dwelling investment in the housing market model, it is found that in the first quarter more than 95 percent of the variations come from its own shocks. However, after two years only 43 percent of the variation in dwelling investment can be explained by its own movements. After own shock in dwelling investment, the cash rate accounts for larger percentages of dwelling investment fluctuation than the other macroeconomic and housing market variables, though it accounts for only a 0.264 percent variation of dwelling investment in the first quarter. After three years, more than a 38 percent fluctuation in dwelling investment can be explained by monetary policy shocks. Besides this, shocks to exchange rate and real GDP growth are also responsible for the variation in dwelling investment. Shocks to the exchange rate account for around 6 percent of dwelling investment fluctuation, whereas variations in real GDP explain around 3 percent of this fluctuation over the time. From the second year, purchases of residential properties also explain more than 6 percent fluctuations of dwelling investment.

In the first three months, 77.5 percent of the forecast variance of the real estate prices are accounted by its own shocks, while 5.9 percent variation of real estate prices come from the growth rate of real GDP shocks. In an explanation of the fluctuation in the real estate price index, inflation and monetary policy rates are both important. The monetary policy rate is more important in the short run in identifying the variation in real estate prices, but in the long run the inflation rate accounts for a larger proportion of the fluctuation of the real estate price index. In the first quarter, monetary policy shocks explain 10.8 percent of the fluctuation in the real estate price index, whereas the inflation rate can explain only 5.5 percent of the fluctuation in real estate prices. However, in two years the cash rate shocks account for 6.5 percent of the fluctuation in house prices, whereas inflation shocks account for more than 34 percent of the variation in house prices. Tsatsaronis and Zhu (2004) find similar forecast errors of variance for housing prices.

In addition, the purchasing residential properties and dwelling investment variables are also important factors in explaining the forecast variance of real estate prices from four quarters. The number of purchased residential properties can explain a 6.2 percent variation in real estate prices in the fourth quarter, while a 5.2 percent variation is explained by the dwelling investment variable.

When considering the structural variance decomposition of purchasing residential properties, 86.5 percent fluctuation can be explained by own shock in the first quarter. However, after one year, a large proportion of the variation in purchasing residential properties comes from monetary policy shocks and from growth rate of real GDP shocks. In year one, around 40 percent and 30 percent variations in purchasing residential properties are attributed to shocks in the monetary policy rate and real GDP growth rate respectively, whereas only 26 percent of variations in purchasing residential properties are attributed by its own shocks. In addition to these three sources of variation in purchasing residential properties, shocks in the trimmed mean inflation rate and in real estate prices can account for the smaller amount of forecast variance in purchasing residential properties. In the first quarter, the inflation rate can explain only 0.003 percent of the variation in purchasing residential properties, whereas in quarter 12, it can explain more than 8.485 percent of the variation in this housing sector variable. Similarly, real estate prices can account for a 1.49 percent variation in the first quarter, and around 8.38 percent of the variation of purchasing residential properties in quarter 12.

Structural variance decomposition of the monetary policy rate (first segment of Table 6.2) shows that more than 96 percent of the fluctuation is explained by its own innovations in the first quarter, while own shock can explain around 79 percent, 73 percent and 66 percent of variation after the first year, second year and after three years respectively. As Australia follows an inflation targeting monetary policy, shocks of inflation rates play a significant role in describing the fluctuation in monetary policy rates. Inflation rate shocks account for 1.74 percent of the fluctuation of the cash rate in three months and after 3 years, inflation shocks account for around 6.8 percent of the fluctuation in the monetary policy rate. Moreover, achieving the target growth rate is an important goal of monetary policy; therefore, fluctuation in the real GDP growth rate is also an important factor in measuring forecast variance of the monetary policy rate. Empirical results suggest that real GDP growth rate innovations can account for 1.75 percent of the variation in the policy rate in the first quarter, however, after one year it explains the 7.6 percent fluctuation of the cash rate, and around 6.5 percent of the variation of the cash rate after two years. Besides inflation shocks and output growth rate shocks, housing market shocks (fluctuation in purchasing residential properties) are also important in describing the variation in the policy rate after one year. In the first year, the variability of purchasing residential properties influences 8.3 percent of the fluctuation in the cash rate, whereas in quarter 12, the variability of this housing sector variable is responsible for around 17 percent of forecast errors in the policy rate.

Overall, the structural forecast error variance decomposition analysis suggests that monetary policy rate innovation is an important indicator accounting for the fluctuation in the housing market, and that housing market shocks are also important in any measure of the variation in the monetary policy rate.

6.3 Robustness Check

While a short-run structural vector autoregression model is subject to a robustness check, the estimated coefficients matrix A and B (Appendix C and D) shows that there is a large number of significant coefficients in the model. For robustness, a pairwise Granger-Causality[11] relationship is used to test for all variables and to check individual influences on another variable, small dimensional VARs are estimated with two or four variables and the small dimensional shows that the coefficients are consistent with a seven-variable VAR. To check the robustness of using trimmed mean inflation instead of headline inflation, a SVAR model is also estimated with headline inflation. The stability test of the SVAR with headline inflation shows that model becomes unstable with headline inflation series (Appendix J). In this study, the model also satisfies the following tests.

6.3.1: Stability test:

According to Lütkepohl (1993) and Hamilton (1994), if the modulus of each eigenvalue of the contemporaneous coefficient matrix is strictly less than one, then the estimated VAR or SVAR is stable (stationary). In this research, AR (1) root test is used to identify whether or not eigenvalues of the VAR or SVAR model lie within the unit circle, and how the VAR and SVAR models satisfy the stability condition. Test results show (in Appendix E) that all inverse roots of the characteristic AR polynomial have modulus less than one and they lie inside the unit circle, indicating that at the chosen lag length (of order five), the estimated model is stationary. Therefore, the estimated structural vector autoregression model of this study satisfies the stability condition.

6.3.2: Autocorrelation test:

To investigate whether or not residuals are autocorrelated, the Lagrange Multiplier test is conducted and test results (in Appendix F) show that there is no evidence of serial autocorrelation among the residuals in the lag orders 4, 5 and 6. Since this model considers the

[11] See Granger C.W.J. (1969), 'Investigating causal relations by econometric models and cross spectral methods', *Econometrica* 37:424–438.

lag order 5 to estimate the effect of monetary policy shock and macroeconomic shocks on the Australian housing market, the model satisfies the no autocorrelation hypothesis.

6.3.3: Heteroskedasticity test:

To check the heteroskedasticity of SVAR residuals, the White test with no cross terms (only level and squares) is applied and test results (Appendix G) explain that there is no heteroskedasticity, therefore the SVAR residuals are homoskedastic.

CHAPTER 7

Conclusion

This thesis has developed a seven-variable structural vector autoregression model based on Amisano and Giannini (1997) for Australia to examine the impact of monetary policy on the housing market. The Australian housing sector is represented by dwelling investment on new construction and renovation for established dwelling, house prices, and purchase of residential properties, whereas monetary policy is represented by the overnight cash rate. In addition, to find out the impact of macroeconomic shocks on the housing market, three macroeconomic variables are included in this model: growth rate of real GDP, trimmed mean inflation rate, and exchange rate. To construct the SVAR model, the reduced form vector autoregression model has been estimated with two dummy variables for the better fitting of the model. Dummies are considered for two economic structural breaks, such as the introduction of the GST in year 2000, and the GFC during 2007–08. The impact of these structural breaks are identified in several housing sector and macroeconomic variables but the overall impact of this economic turbulence on the Australian economy is insignificant during the sample period 1992–2014. Depending on the reduced form VAR model, an over-identified structural vector autoregression model is estimated, where the main focus point of housing sectors variables are contemporaneously influenced by the cash rate and nominal exchange rate. Another important focus point of this research is a consideration of how purchasing residential properties is influenced by the structural innovation of housing prices. The response of the housing market to all structural innovations is explained by impulse response analysis.

The empirical results from this study suggest that the Australian housing sector is more sensitive to monetary policy in the cases of dwelling investment and purchasing residential properties rather than housing prices. The model suggests that dwelling investment is adversely affected by contractionary monetary policy, and this adverse effect on housing investment or housing growth persists over a long time. It also explains that purchasing residential properties or selling properties are very sensitive to the interest rate and contemporaneously decrease in large proportion with tight monetary policy.

In response to the macroeconomic shocks, the exchange rate can influence dwelling investment more so than other macroeconomic variables. It was expected that the exchange rate could influence housing prices because if the Australian currency becomes less expensive, Australian migrant citizens can bring money from their home countries and can buy property. Therefore, in addition to foreign investment in housing properties, it is expected that the exchange rate would influence domestic housing demand also, but the empirical results suggest that the exchange rate does not have a significant impact on housing demand or on housing prices. The other macroeconomic variable, growth rate of real GDP has a significant but unexpected impact on purchasing real estate properties, but it does not have a dynamic impact on housing prices. Regarding the inflation rate, nominal house prices are negatively influenced by the underlying inflation rate, and have a similar impact on purchasing or on selling residential properties, but at the longer horizon.

Regarding housing sectoral structural innovation, the positive response of housing prices to dwelling investment shocks implies that dwelling investment on new construction and renovation increase the housing supply qualitatively and an upward movement of purchasing residential properties to the variation of house prices from a steady state level implies that more properties enter into the market for sale and the number of sold or purchased of residential properties increases during a housing boom.[12]

The positive response of the policy rate to the structural shocks in purchasing residential property along with growth rate of real GDP and inflation implies that the monetary policy decision rule in Australia, along with the inflation target and economic growth, also takes into account the housing market. Forecast error of variance decomposition results also explain that the larger part of variation in monetary policy rate comes from the structural innovation of purchasing residential properties. It is also found that a large percentage of forecast errors in housing sector variables are associated with fluctuations in the monetary policy rate.

Because of the endogenous characteristics of the variables in the SVAR model, the present study does not include the number of residents or size of households, which largely influence housing demand. Renting information in the Australian housing market is not considered in this research either. Rent is an important influencing factor in housing demand, especially for housing investment. These are the main limitations of this research. These issue will be included in further research on the Australian housing market.

[12] A time when the price of houses rises quickly.

REFERENCES:

Abelson, P., Joyeux, R., Milunovich, G., Chung, D. (2005), 'Explaining house prices in Australia: 1970–2003', *Economic Record*, vol. 81 (supplement s1), pp. 96–103.

Amisano, G., Giannini, C. (1997), *Topic in structural VAR econometrics*, 2nd Edition, Heidelberg, Springer, Berlin.

Aoki, K., Proudman, J., Vlieghe, G. (2004), 'House prices, consumption, and monetary policy: a financial accelerator approach', *Journal of Financial Intermediation*, vol. 13, pp. 414–435.

Berkelmans, L. (2005), 'Credit and monetary policy: an Australian SVAR', Reserve Bank of Australia Research Discussion Paper 2005-06.

Bernanke, B., Mihov, I. (1995), 'Measuring monetary policy', National Bureau of Economic Research Working Paper-97-7.

Bjømland, H.C., Jacobsen, D. H. (2010), 'The role of house prices in the monetary policy transmission mechanism in small open economy', *Journal of Financial Stability*, vol. 6, no. 4, pp. 218-229.

Blanchard, J.B., Quah, D. (1989), 'The dynamic effects of demand and supply disturbances' *American Economic Review*, vol.79, no.6, pp.655-673.

Boivin, J., Kiley, M. T., Mishkin, F.S. (2010), 'How has the monetary transmission mechanism evolved over time?', NBER Working Paper, No. 15879, Massachusetts, Cambridge.

Brischetto, A., Voss, G. (1999), 'A structural vector autoregression model of monetary policy in Australia', Reserve Bank of Australia Research Discussion Paper 1999-11.

Burke, T., Hulse, K. (2010), 'The institutional structure of housing and the sub-prime crisis: an Australian case study', *Housing Studies*, vol. 25, no. 6, pp. 821-838.

Carlino, G., Defina, R. (1998), 'The differential regional effects of monetary policy', *Review of Economics and Statistics*, vol. 80 (4), pp. 572-587.

Chowdhury, M., Mallik, G. (2004), 'Effects of housing allowances on housing prices in Australia: a cointegration analyses', *Journal of Economic Analysis & Policy*, vol. 34 (1), pp. 37-51.

Costello, G., Fraser, P., MacDonald, G. (2015), 'Monetary policy influences in Australian housing markets', *International Journal of Housing Markets and An*alysis, vol. 8, no. 2, pp. 265-286.

Disyatat, P., Vongsinsirikul, P. (2003), 'Monetary policy and the transmission mechanism in Thailand, *Journal of Asian Economies*, 2003 (14), 389-418.

Dungey, M., Pagan, A. (2000), 'A structural VAR model of the Australian economy', *Economic Record*, vol. 76(235), pp. 321-342.

Elbourne, A. (2008), 'The UK housing market and the monetary policy transmission mechanism: an SVAR approach', *Journal of Housing Economics*, vol. 17, pp. 65-87.

Ellis, L. (2011), 'Eight policy lessons from the US housing meltdown', *Housing Studies*, vol. 26, no.7/8, pp. 1215-1230.

Erceg, C., Levin, T. (2006), 'Optimal monetary policy with durable consumption goods', *Journal of Monetary Economics*, vol. 53, pp. 1341-1359.

Favero, C. A. (2001), *Applied Macroeconometrics*, 1st Edition, Oxford University Press Inc., New York.

Fry, R.A., Martin, V.L., Voukelatos, N. (2010), 'Overvaluation in Australian housing and equity markets: wealth effect or monetary policy?', *Economic Record*, 86, pp. 465-485.

Giuliodori, M. (2005), 'The role of house prices in the monetary policy transmission mechanism across European countries', *Scottish Journal of Political Economy*, vol. 52(4), pp. 519-543.

Gordon, D., Leeper, E. (1994), 'The dynamic impact of monetary policy: an exercise in tentative identification', *Journal of Political Economy*, vol. 102 (6), pp. 1228-1247.

Granger, C.W.J. (1969), 'Investigating causal relations by econometric models and cross spectral methods', *Econometrica*, vol. 37, pp. 424-438.

Grenville, S. (1997), 'The evolution of monetary policy: from money target to inflation target', Reserve Bank of Australia Conference Paper (1997).

Hamilton, J. D. (1994), *Time series analysis*, Princeton University Press.

Hasan, M.S., Taghavi, M. (2002), 'Residential investment, macroeconomic activity and financial deregulation in the UK: an empirical investigation', *Journal of Economics and Business*, vol. 54, pp. 447-462.

Hill, R. C., Griffiths, W. E., Lim, G. C. (2008), *Principle of econometrics*, 3rd edition, John Wiley and Sons, Inc, pp. 337.

Holly, S., Jones, N. (1997), 'House prices since 1940: cointegration, demography and asymmetries', *Economic Modelling*, vol. 14, pp. 549-565.

Hossain, B., Latif, E. (2007), 'Determinants of housing price volatility in Canada: a dynamic analysis', *Applied Economics*: 1-11

Iacoviello, M. (2002), 'House prices and business cycles in Europe: a VAR analyses, Boston College Working Paper-540.

Iacoviello, M., Minetti, R. (2008), 'The credit channel of monetary policy: evidence from the housing market', *Journal of Macroeconomics*, vol. 30, no. 1, pp. 69-96.

Iacoviello, M., Neri, S. (2007), 'The role of housing collateral in an estimated two- sector model of the US economy', Boston College Working Paper.

Johansen, S., Juselius, K. (1990), 'The full information maximum likelihood procedure for inference on cointegration with applications to the demand for money', *Oxford Bull Econ Stat*, vol. 52 (2), pp. 169-210.

Karame, F., Olmedo, A. (2002), 'The Asymmetric Effects of Monetary Policy shocks: a non-linear structural VAR approach', Unpublished Manuscript, 1-28.

Kim, S., Roubini, N. (2000), 'Exchange rate anomalies in the industrial countries: a solution with a structural VAR approach', *Journal of Monetary Economics*, vol. 45, pp. 561-586.

Lastrapes, W.D. (2005), ' Estimating and identifying vector autoregression under diagonality and block exogeneity restrictions', *Economics Letters*, vol. 87(1), pp. 75-81.

Lastrapes, W.D. (2002), 'The real price of housing and money supply shocks: time series evidence and theoretical simulations', *Journal of Housing Economics*, vol. 11, pp. 40-74.

Lee, C-C., Liang, C. M., Wu, W-H., You, S.M. (2013), ' Interactions between house prices, stock prices and monetary policy- using recursive VAR', *American Journal of Industrial and Business Management*, 2013,3, pp. 645-654.

Lee, C.L. (2009), 'Housing price volatility and its determinants', *International Journal of Housing Markets and Analysis*, vol. 2 (3), pp. 293-308.

Lee, C.L., Reed, R. (2014), 'Volatility decomposition of Australian housing prices', *Journal of Housing Research*, vol. 23(1), pp. 21-43.

Lee, N.J., Ong, S.E. (2005), 'Upward mobility, house price volatility, and housing equity', *Journal of Housing Economics*, vol. 14, pp. 127-146.

Leung, C.K.Y., Lau, G.C.K., Leong, Y.C.F. (2002), 'Testing alternative theories of the property price- trading volume correlation', *Journal of Real Estate Research*, vol. 23 (3), pp. 253-263.

Liu, J., Liu, C. (2012), 'Investigating the housing market fluctuation under an expansionary monetary policy in Australia', *Pacific Rim Property Research Journal*, vol. 18, no.1, pp. 81-89.

Liu, J., London, K. (2013), 'Modelling housing supply and monetary policy within the context of global economic turbulence, *International Journal of Strategic Property Management*, vol. 17(1), pp. 1-20.

Luciani, M. (2015), 'Monetary policy and the housing market: a structural factor analyses, *Journal of Applied Econometrics*, vol. 30, pp. 199-218.

Lütkepohl, H. (1993), *Introduction to multiple time series analysis*, 2nd edition, New York, Springer.

Miller, N., Peng, L. (2006), Exploring metropolitan house price volatility', *Journal of Real Estate Finance and Economics*, vol. 33(1), pp. 5-18.

Mishkin, F. S. (1996), 'The channels of monetary transmission: lessons for monetary policy', NBER Working Paper-5464.

Mishkin, F. S. (2007), 'Housing and monetary transmission mechanism', NBER Working Paper-13518.

Musso, A., Neri, S., Stracca, L. (2011), 'Housing, consumption and monetary policy: how different are the US and the euro area?', *Journal of Banking & Finance*, vol. 35(2011), pp.3019-3041.

Ortalo-Magne, F., Rady, S. (2005), 'Housing market dynamics: on the contribution of income shocks and credit constrains, Governance and the Efficiency of Economic System (GESY) Discussion Paper-50.

Richards, T. (2006), 'Measuring underlying inflation', Reserve Bank of Australia, Speeches, November, 2006.

Richards, T., Rosewall, T. (2010), 'Measures of underlying inflation', Reserve Bank of Australia, Bulletin, March, 2010.

Sims, C., Zha, T. (1998),'Does monetary policy generate recessions?', Federal Reserve Bank of Atlanta Working Paper- 98-12 (July 1998), 1-61.

Sims, C., Stock, J., Watson, M. (1990), 'Inference in linear time series models with some unit roots', *Econometrica* , 58 (1), 113-144.

Sims, C. (1986), 'Are forecasting models usable for policy analysis?', *Federal Reserve Bank of Minneapolis Quarterly Review*, 10 (1), 2-15.

Sims, C. (1980), 'Macroeconomics and reality', *Econometrica*, vol. 48 (1), pp. 148.

Stein, C.J. (1995), 'Prices and trading volume in the housing market: a model with down-payment effects', *The Quarterly Journal of Economics*, vol. 110 (2), pp. 379-406.

Suzuki, T. (2004), 'Is the lending channel of monetary policy dominant in Australia', *Economic Record*, vol. 80(249), pp. 145-156.

Tashrifov, M. Y. (2005), 'Monetary policy model of Tajikstan: a structural vector autoregression approach', Australian National University Working Paper.05-9.

Tsatsaronis, K., Zhu, H. (2004), 'What drives housing price dynamics: cross- country evidence', *BIS Quarterly Review*, March 2004.

Tumbarello, P., Wang, S. (2010), 'What drives house prices in Australia? A cross- country approach', International Monetary Fund WP/10/291.

Uhlig, H. (2005), 'What are the effects of monetary policy on output? Result from an agnostic identification procedure', *Journal of Monetary Economics*, vol. 52, pp. 381-419.

Vargas-Silva, C. (2008), 'Monetary policy and the US housing market: a VAR analysis imposing sign restrictions, *Journal of Macroeconomics*, vol. 30(2008), pp. 977-990.

Vonnak, B. (2005), 'Estimating the effects of Hungarian monetary policy within a structural VAR framework', Magyar Nemzeti Bank Working Paper 2005/1, 1-37.

Wadud, I.K.M.M., Bashar, O.H.M.N., Ahmed, H.J.A. (2012), 'Monetary policy and the housing market in Australia', *Journal of Policy Modelling*, vol. 34, pp. 849-863.

Wheeler, M., Chowdhury, A. (1993), 'The housing market, macroeconomic activity and financial innovation: an empirical analysis of US data', *Applied Economics*, vol. 25, pp. 1385-1392.

Xiao, Q. (2010), 'Crashes in real estate prices: causes and predictability', *Urban Studies*, vol. 47(8), pp. 1725-1744.

Yates, J., Berry, M. (2011), 'Housing and mortgage markets in turbulent times: is Australia different?', *Housing Studies*, vol. 26(7/8), pp. 1133-1156.

APPENDIX

Appendix A: Data and Sources of Data

Variables	Definition	Sources	Seasonally adjusted	Code/ Series ID
ggdp	Year-ended real GDP growth rate	ABS	Seasonally adjusted	GGDPCVGDPY
inf	Year-ended Trimmed mean inflation rate	RBA/ABS	Seasonally adjusted	GCPIOCPMTMYP
cash	RBA Cash Rate Target	RBA, DataStream	n/a	AUPRATE
lger	Log (AUD to USD)	Bank of England	n/a	AUXRUSD
lgdi	Log (dwelling investment)	DataStream/ABS	Seasonally adjusted	AUFXCPDWD or GGDPECCVPSD
lgrpi	Log (Real Estate Price Index)	DataStream	n/a	RLESTAU(PI)
lgprp	Log (total number of purchased residential properties	ABS	Seasonally adjusted	A2412500A And A2412502F

Appendix B: KPSS test for stationarity:

Variables	KPSS test statistic	Asymptotic critical values (at 5% level)	Stationarity
GGDP	0.063	0.146	stationary
INF	0.112	0.146	stationary
CASH	0.109	0.146	stationary
LGER	0.218	0.146	Non-stationary
LGDI	0.229	0.146	Non-stationary
LGRPI	0.240	0.146	Non-stationary
LGPRP	0.259	0.146	Nonstationary

Appendix C: Coefficient Matrix A

	GGDP	INF	CASH	LGER	LGDI	LGRPI	LGPRP
GGDP	1	0	0	0	0	0	0
INF	0.0759 (0.033)	1	0	0	0	0	0
CASH	-0.117 (0.077)	-0.306 (0.244)	1	0	0	0	0
LGER	0.0229 (0.008)	-0.031 (0.025)	0.060 (0.11)	1	0	0	0
LGDI	-0.0116 (0.005)	0	0.002 (0.009)	-0.039 (0.075)	1	0	0
LGRPI	0.0282 (0.011)	0.069 (0.034)	0.054 (0.017)	0.0536 (0.143)	0	1	0
LGPRP	0.0170 (0.008)	-0.008 0.024)	0.0126 (0.013)	-0.087 (0.100)	0.164 (0.140)	-0.092 (0.074)	1

Log likelihood 499.1694
LR test for over-identification:
Chi-square (2) 1.575865 Probability 0.4548, ( ) represent the corresponding standard error.

Appendix D: Coefficient matrix B

0.607 (0.046)						
	0 0.186 (0.014)	0	0	0	0	0
0		0 0.424 (0.032)	0	0	0	0
0	0		0 0.044 (0.003)	0	0	0
0	0	0		0 0.031 (0.002)	0	0
0	0	0	0		0 0.058 (0.004)	0
0	0	0	0	0		0 0.041 (0.003)
0	0	0	0	0	0	

Note: ( ) represent the corresponding standard error.

Appendix E: Stability Test

Roots of Characteristic Polynomial
Endogenous variables: GGDP INF CASH LGER LGDI LGRPI LGPRP
Exogenous variables: C DUMMY1 DUMMY2
Lag specification: 1 5
Date: 09/05/15 Time: 08:24

Root	Modulus
0.997302 - 0.015327i	0.997420
0.997302 + 0.015327i	0.997420
0.607328 + 0.729109i	0.948919
0.607328 - 0.729109i	0.948919
0.506456 - 0.738238i	0.895261
0.506456 + 0.738238i	0.895261
0.884450	0.884450
-0.702823 + 0.528336i	0.879261
-0.702823 - 0.528336i	0.879261
0.834897 - 0.216374i	0.862479
0.834897 + 0.216374i	0.862479
0.718707 - 0.372827i	0.809654
0.718707 + 0.372827i	0.809654
-0.568473 + 0.564319i	0.801010
-0.568473 - 0.564319i	0.801010
0.614387 + 0.505835i	0.795827
0.614387 - 0.505835i	0.795827
-0.029409 + 0.748440i	0.749018
-0.029409 - 0.748440i	0.749018
-0.510172 + 0.546434i	0.747573
-0.510172 - 0.546434i	0.747573
-0.713710 - 0.176124i	0.735120
-0.713710 + 0.176124i	0.735120
0.732515	0.732515
0.660379 + 0.198924i	0.689689
0.660379 - 0.198924i	0.689689
-0.270756 - 0.581521i	0.641464
-0.270756 + 0.581521i	0.641464
-0.604198	0.604198
0.274620 + 0.497914i	0.568625
0.274620 - 0.497914i	0.568625
-0.022617 + 0.448511i	0.449081
-0.022617 - 0.448511i	0.449081
0.156714 + 0.265606i	0.308393
0.156714 - 0.265606i	0.308393

No root lies outside the unit circle.
VAR satisfies the stability condition.

Appendix F: Autocorrelation test

VAR Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 09/05/15 Time: 08:25
Sample: 1992Q1 2014Q4
Included observations: 87

Lags	LM-Stat	Prob
1	69.69909	0.0275
2	69.93782	0.0264
3	69.75299	0.0273
4	48.97917	0.4740
5	44.20529	0.6675
6	38.98844	0.8464

Probs from chi-square with 49 df.

Appendix G: Heteroskedasticity test:

VAR Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Date: 11/23/15 Time: 09:08
Sample: 1992Q1 2014Q4
Included observations: 87

Joint test:

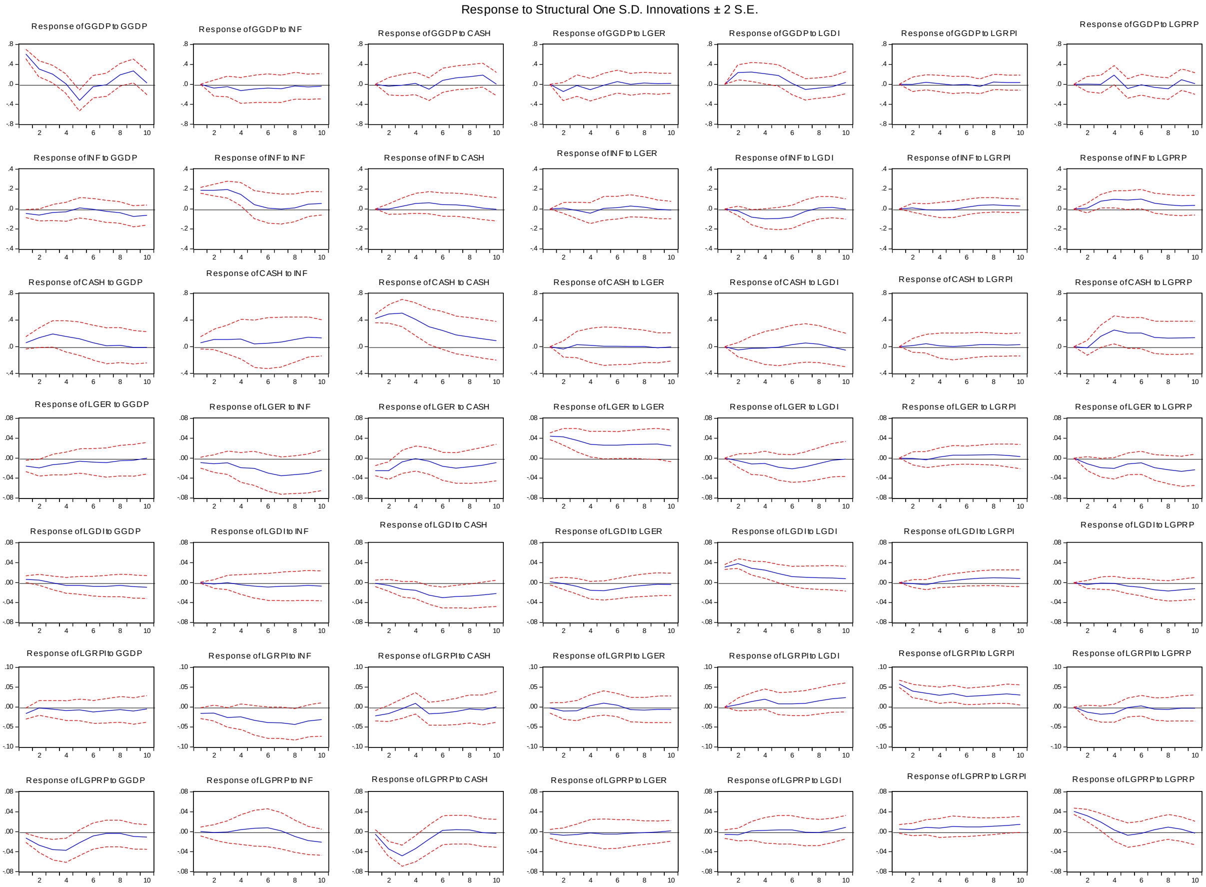
Chi-sq	df	Prob.
1982.455	2016	0.6987

Individual components:

Dependent	R-squared	F(72,14)	Prob.	Chi-sq(72)	Prob.
res1*res1	0.731415	0.529515	0.9580	63.63312	0.7486
res2*res2	0.753888	0.595620	0.9207	65.58825	0.6897
res3*res3	0.924767	2.390124	0.0358	80.45474	0.2315
res4*res4	0.827255	0.931170	0.6049	71.97118	0.4788
res5*res5	0.844006	1.052042	0.4889	73.42852	0.4310
res6*res6	0.902164	1.792999	0.1115	78.48823	0.2808
res7*res7	0.886466	1.518210	0.1941	77.12255	0.3183
res2*res1	0.853185	1.129975	0.4222	74.22711	0.4055
res3*res1	0.808010	0.818342	0.7209	70.29691	0.5348
res3*res2	0.740129	0.553790	0.9459	64.39123	0.7263
res4*res1	0.784978	0.709857	0.8284	68.29311	0.6020

res4*res2	0.869326	1.293569	0.3060	75.63137	0.3620
res4*res3	0.880372	1.430959	0.2318	76.59233	0.3335
res5*res1	0.854278	1.139906	0.4143	74.32217	0.4025
res5*res2	0.785521	0.712144	0.8263	68.34031	0.6004
res5*res3	0.693343	0.439633	0.9877	60.32084	0.8353
res5*res4	0.744200	0.565699	0.9393	64.74543	0.7157
res6*res1	0.863803	1.233225	0.3452	75.15085	0.3767
res6*res2	0.867186	1.269596	0.3211	75.44522	0.3677
res6*res3	0.942043	3.160535	0.0099	81.95774	0.1978
res6*res4	0.927967	2.504924	0.0292	80.73310	0.2250
res6*res5	0.752152	0.590086	0.9243	65.43722	0.6944
res7*res1	0.865208	1.248110	0.3351	75.27312	0.3729
res7*res2	0.728827	0.522606	0.9612	63.40798	0.7551
res7*res3	0.863465	1.229697	0.3476	75.12150	0.3776
res7*res4	0.921191	2.272848	0.0443	80.14363	0.2389
res7*res5	0.929933	2.580684	0.0256	80.90419	0.2211
res7*res6	0.853698	1.134620	0.4185	74.27175	0.4041

Appendix H: Impulse response function for whole model:



Appendix I: Variance Decomposition for whole model:

Variance Decomposition of Real GDP (LGGDP)							
Period	LGGDP	INF	CASH	LGER	LGDI	LGRPI	LGPRP
Q1	100	0.00	0.00	0.00	0.00	0.00	0.00
Q4	66.203	3.233	0.2988	4.591	21.103	0.205	4.363
Q8	61.045	4.680	5.445	3.657	19.648	0.550	4.971
Q12	59.945	4.432	7.623	3.625	18.265	0.829	5.277
Variance Decomposition of Inflation rate (INF)							
Period	LGGDP	INF	CASH	LGER	LGDI	LGRPI	LGPRP
Q 1	5.777	94.222	0.000	0.000	0.000	0.000	0.000
Q4	4.675	73.206	2.071	1.237	9.810	0.177	8.820
Q8	4.468	56.311	5.092	1.537	14.613	1.554	16.423
Q12	8.410	51.961	4.741	1.800	14.226	2.511	16.347
Variance Decomposition of Cash Rates (CASH)							
Period	LGGDP	INF	CASH	LGER	LGDI	LGRPI	LGPRP
Q1	1.754	1.748	96.496	0.000	0.000	0.000	0.000
Q4	7.635	3.670	79.583	0.241	0.326	0.219	8.323
Q8	6.937	4.142	73.186	0.185	0.616	0.313	14.619
Q12	6.382	6.848	66.292	0.271	2.049	0.568	17.587
Variance Decomposition of Nominal Exchange Rate (LGER)							
Period	LGGDP	INF	CASH	LGER	LGDI	LGRPI	LGPRP
Q1	8.722	2.882	22.344	66.051	0.000	0.000	0.0000
Q4	9.333	6.735	13.520	57.878	2.934	0.162	9.436
Q8	5.607	21.586	11.678	42.471	7.519	0.854	10.283
Q12	4.268	26.208	9.880	38.748	5.755	0.776	14.362
Variance Decomposition of Dwelling Investment (LGDI)							
Period	LGGDP	INF	CASH	LGER	LGDI	LGRPI	LGPRP
Q1	3.944	0.019	0.264	0.289	95.482	0.000	0.000
Q4	2.069	0.577	9.698	6.298	80.328	0.577	0.452
Q8	2.692	2.645	34.551	7.873	43.305	2.455	6.477
Q12	4.184	5.015	38.448	6.416	33.466	3.637	8.832
Variance Decomposition of number of Purchased Residential Properties (LGRPI)							
Period	LGGDP	INF	CASH	LGER	LGDI	LGRPI	LGPRP
Q1	5.946	5.495	10.837	0.125	0.000	77.595	0.000
Q4	3.239	15.199	7.246	1.691	5.269	61.151	6.202
Q8	3.047	34.121	6.536	1.815	4.674	46.370	3.435
Q12	2.550	35.145	5.273	1.868	10.032	42.665	2.463
Variance Decomposition of Real Estate Price Index (LGPRP)							
Period	LGGDP	INF	CASH	LGER	LGDI	LGRPI	LGPRP
Q1	8.265	0.003	1.351	0.976	1.359	1.491	86.552
Q4	30.587	0.152	40.188	0.915	0.605	1.467	26.084
Q8	31.074	1.587	37.048	1.235	0.742	4.362	23.950
Q12	27.456	8.485	30.532	1.063	3.384	8.378	20.698

Appendix J: Stability test with headline inflation:

Roots of Characteristic Polynomial
Endogenous variables: GGDP INFLATION CASH LGER LGDI LGRPI LGPRP
Exogenous variables: C DUMMY1 DUMMY2
Lag specification: 1 5
Date: 12/02/15 Time: 11:44

Root	Modulus
1.029107	1.029107
0.992019	0.992019
0.926538 - 0.155766i	0.939540
0.926538 + 0.155766i	0.939540
0.444170 + 0.820110i	0.932667
0.444170 - 0.820110i	0.932667
0.585348 + 0.710481i	0.920551
0.585348 - 0.710481i	0.920551
-0.696919 + 0.548040i	0.886591
-0.696919 - 0.548040i	0.886591
0.777007 - 0.393788i	0.871096
0.777007 + 0.393788i	0.871096
0.579527 - 0.601746i	0.835434
0.579527 + 0.601746i	0.835434
0.834920	0.834920
-0.555170 + 0.617806i	0.830601
-0.555170 - 0.617806i	0.830601
-0.778809 - 0.137853i	0.790915
-0.778809 + 0.137853i	0.790915
0.735603 - 0.222093i	0.768399
0.735603 + 0.222093i	0.768399
-0.019855 - 0.740255i	0.740522
-0.019855 + 0.740255i	0.740522
-0.265150 - 0.662349i	0.713450
-0.265150 + 0.662349i	0.713450
0.124704 - 0.686757i	0.697987
0.124704 + 0.686757i	0.697987
-0.600424 - 0.325272i	0.682869
-0.600424 + 0.325272i	0.682869
0.529904 + 0.363757i	0.642742
0.529904 - 0.363757i	0.642742
-0.422444 - 0.460672i	0.625042
-0.422444 + 0.460672i	0.625042
0.349662	0.349662
-0.169519	0.169519

Warning: At least one root outside the unit circle.
VAR does not satisfy the stability condition.