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ANALYSING THE TRANSMISSION PATTERN WITHIN THE FRAMEWORK OF HOUSING SUPPLY AND MONETARY POLICY IN AUSTRALIA

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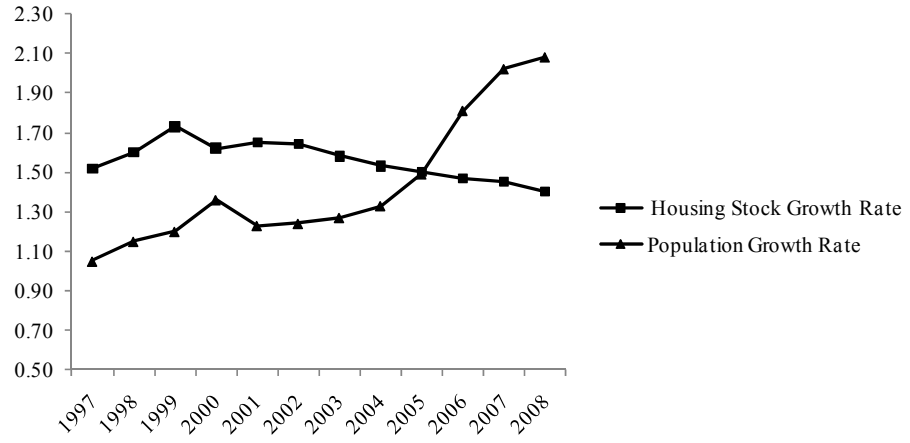
Abstract
Housing supply is one of important components of the housing sector. Compared with an increasingly strong housing demand, the growth rates of total housing stock in Australia have exhibited a downward trend since the end of the 1990s whilst the significant adjustments in the Australian monetary policy were being implemented. This research aims to estimate the nature of the relationship between housing supply and monetary policy by a vector error correction model. According to the empirical results, a transmission pattern comprised of the indicators associated with housing supply and monetary policy can be identified, which suggests that there is a significant interrelationship between monetary policy and the supply side of the housing sector in Australia.

Keywords: housing supply, monetary policy, transmission pattern, vector error correction model

INTRODUCTION

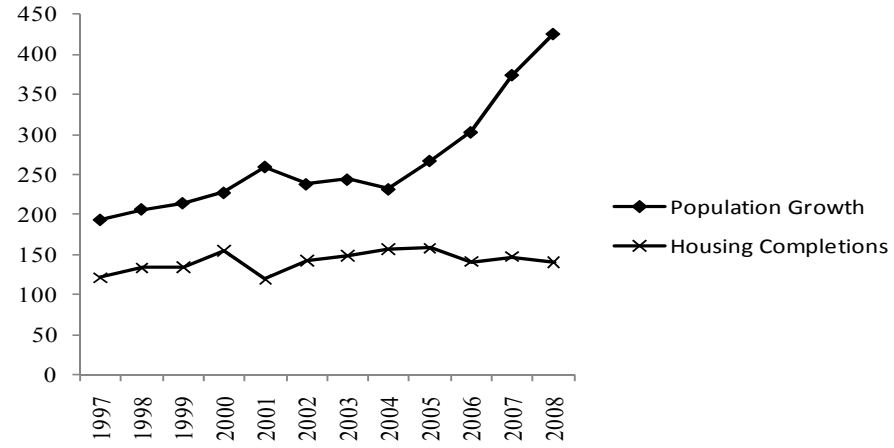
Housing supply is an essential component of the housing sector. However, Australia has been facing a challenge from inadequate housing supply since the 1990s while the demand for housing across Australia was extremely strong. The statistics from the Australian Bureau of Statistics (ABS) indicate that the growth rates of total housing stock have exhibited a downward trend accompanying a dramatic urban population growth in Australia since the 1990s. The movements in the growth rates of housing stock and urban population in Australia are illustrated by Figure 1. Urban economic theory claims that the growth of urban population is an indicator of the increase in housing demand and there should be a steady equilibrium (convergence) relationship between total housing stock and urban population (DiPasquale, 1999).

The housing literature demonstrates that the construction of new housing is a leading source of the increase of total housing stock. In Figure 2, compared with dramatic population growth, the number of new housing completion in Australia were highly stable over the past decade. It is able to be inferred from both Figure 1 and Figure 2 that a divergence between housing supply and urban population has gradually occurred in Australia. In simple terms, currently, the supply of housing can not keep pace with the demand for housing across Australia.



Source: ABS, 2009a

Figure 1: Growth rates of urban population and housing stock in Australia



Source: ABS, 2009a; 2009b

Figure 2: Population growth and new housing completions in Australia

Another statistic data regarding housing finance also indicates that the annual number of the housing mortgage for the purchases of owner-occupied dwelling in Australia increased from 412,032 to 598,566 with the increase rates of 45.3% during the period of 1997-2008 (ABS, 2009e). These data further explicitly reveal that the demand for housing in Australia is increasing. Owing to the strong housing demand and the inadequate housing supply, the annual report of the Housing Industry Association (HIA) argued that a housing shortage of approximately 110,000 had emerged in Australia in 2008 and this problem would be

exacerbated in the future (HIA, 2009).

Based on the reports of the Reserve Bank of Australia (RBA), from 1997 to 2008, the growth rates of the money supply in Australia had decreased and there had been a corresponding rise in the interest rates (RBA, 2009a; 2009b). The increase in the interest rates as well as a decrease in the money supply growth rates implies that the Australian monetary policy was adjusted significantly during the period of 1997-2008. RBA's (1999) announcement supported this perspective and stated that the expansionary monetary policy that had been implemented in Australia for a couple of years would be gradually slowed down.

Monetary policy is generally defined as a process by which the central bank or national monetary authority of a country adjusts the interest rates to a target level in economy (McTaggart *et al.*, 2003; RBA, 2007a). It is a key tool for government to regulate economic activities. In housing literature, many researchers have investigated how monetary policy affects housing demand while few empirical studies were concerned with the relationship between the supply of housing and monetary policy. Thus, a research question, 'What is the interrelationship between housing supply and monetary policy?', has emerged. This paper aims to contribute to the literature by developing a conceptual model as well as a methodology to estimate the relationship between housing supply and monetary policy.

The rest of this paper is laid out as follows. Next section will review the relevant literature with respect to the relationship between monetary policy and the housing sector. Then, the *Conceptual Model* followed by the *Methodology and Data* will be described. Finally, the empirical results yielded by the econometric model will be used to analyse the linkage between housing supply and monetary policy.

LITERATURE REVIEW

Monetary policy plays an active role in the governmental interventions on economy. It is considered to be an important tool that bridges policy makers to realistic economic system. Theoretically, monetary policy can affect both the supply of and the demand for housing (Elbourne, 2008).

The response of the housing sector to the shock of monetary policy has been well considered in numerous studies since the 1990s. The econometric technique employed for these studies is either the reduced-form vector autoregression (VAR) model or the sophisticated VAR [e.g. structural VAR (SVAR) and vector error correction model (VECM)]. The early research relevant to the effect of monetary policy on the housing sector in the 1990s is the study by Baffoe-Bonnie (1998), in which a reduced-form VAR was used to analyse the dynamic effects of monetary policy and macroeconomic aggregates on the house prices and the number of houses sold on a national and regional level in the US. The quarterly data on money supply, mortgage rates, house prices and the number of houses sold were selected for modelling. The estimates suggested that monetary policy had a strong impact on the mortgage rates, which in turn triggered immediate responses of the house prices and the number of houses sold in the

national and regional housing markets in the US (Baffoe-Bonnie, 1998).

Likewise, in 2004, Edelstein and Sau (2004) studied the relationships among monetary policy, house prices, wealth effect and macroeconomic situations in Singapore by a reduced-form VAR. Using the data on disposable income, interbank rates, real private and public house prices, transaction volume and real public housing wealth measure, the empirical evidence indicated that the shock of the interbank rates negatively affected the disposable income, private and public house prices and public housing wealth in Singapore (Edelstein & Sau, 2004).

Some prior VAR research demonstrated that the model misspecification is more easily triggered in the reduced-from VAR (Bernanke & Blinder, 1992; Sims, 1992). To avoid this problem, more and more studies in the recent decade identified the shock of monetary policy on the housing sector by the SVAR or the VECM. Take the research by Lastrape (2002) as an example, this study examined the impact of monetary policy on the housing market applying the SVAR. The primary interest of Lastrape (2002) was to interpret the response of the prices of owner-occupied housing to the shock of money supply across the metropolitan regions in the US. The results suggested that both real house prices and house sales were driven up within a short-run period in response to the positive shock of money supply (Lastrape, 2002).

It is noted that Lastrape's (2002) work focused on the influence of monetary policy on house prices on a regional level. However, Aoki *et al.* (2002) investigated this issue within a national context utilising the SVAR as well. The research by Aoki *et al.* (2002) sought to explore the relationship among monetary policy, house prices and consumption level in the UK. It was identified that 0.8% decrease in the house prices in the UK was triggered after the 50 basis point shock of the interest rates within five quarters (Aoki *et al.*, 2002).

In addition to Aoki *et al.* (2002), Iacoviello (2002; 2005) and Iacoviello and Minetti (2008) explored the linkage between monetary policy and housing sector on a national level by means of the SVAR and VECM respectively. In Iacoviello's (2002; 2005) research, six European countries, involving France, Germany, Italy, Spain, Sweden and UK, were considered as an integrated entity to estimate the role of monetary policy in the inflation of house prices. Under the identification scheme of King *et al.* (1991), the results yielded by the SVAR indicated that the house prices would decrease by 1.5% following a tightening of monetary policy. On the other hand, the study conducted by Iacoviello and Minetti (2008) contributed to the literature by uncovering the credit channels of the monetary policies of such four European countries as Germany, Finland, Norway and UK. The results of the VECM suggested that an approximately 0.25% fall of economic output [Gross Domestic Product (GDP)] and 1% drop in house prices were produced by a shock of interest rates.

Recently, a research by Elbourne (2008) emerged to clarify the relationships between house prices and the transmission mechanisms of monetary policy, which include commodity prices, interbank rates, retail sales, price level, money supply and nominal market exchange rates. Empirical evidence from the SVAR suggested that the retail sales in the UK fell by 0.4% after

receiving a positive 100 basis point shock of the interbank rates while house prices decreased up to 0.75% in response to 15% of the consumption drop caused by a monetary contraction.

In Australia, the research on the effect of monetary policy on the housing sector is sparse. The empirical study by Liu and Liu (2010) examined the linkage between monetary policy and housing affordability across eight state capital cities in Australia using the SVAR. In this study, the shock of monetary policy was measured by the interbank rates and the money supply (M1), and the housing affordability was associated with the house prices. The results show that the interbank rates triggered -1.28% effects on the house prices across Australia's eight state capital cities while the M1 positively affected the house prices by 1.08%.

It is able to be identified from this literature review that the past studies on the interrelationship between housing sector and monetary policy are primarily concerned with the impact of monetary policy on house prices, GDP and disposable incomes. These variables are the components of the housing demand function (Quigley, 1999; Hui & Yue, 2006). Summarily, while there is extensive empirical literature on the relationship between monetary policy and the demand for housing, far less has been written about housing supply.

Although the literature in terms of the impact of monetary policy on housing supply is sparse, the history of this type of research can be dated back to the 1950s. An early study is that undertaken by Wolff (1957), which sought to examine the effects of the variation caused by economic characteristics of different regions on the post-war housing market in the US. The focus of this study was on economic disparities rather than monetary policy, however it briefly mentioned that the new housing construction activities in the South and West regions of the US were more sensitive to monetary policy changes than the remaining US regions (Wolff, 1957). In the 1970s, the study by Bebee (1972) divided Canadian housing markets into five regional markets and analysed the effects of economic disparity (measured by inter-regional population flows, interest rate and the household number) on the volume of dwelling unit started for construction by a simple multivariate regression model. The results indicated that monetary policy and population growth had significant influenced the housing starts in all regional markets in Canada.

In summary, the literature review in this section suggests that a number of empirical studies investigated the relationship between monetary policy and the housing sector in the framework of VAR models. Nevertheless, the majority of them concentrated more on housing demand than housing supply. In addition, the previous research by Wolff (1957) and Bebee (1972) did not explore the linkage between housing supply and monetary policy in a comprehensive context, but just discussed this issue in a simple way. The limited research scope in regard to the housing sector and monetary policy provides this paper with an opportunity for further study.

CONCEPTUAL MODEL

To empirically estimate the impact of monetary policy on Australia's housing supply, the first step in this study is to develop a conceptual model comprised of the monetary policy function and the housing supply function. These two functions will allow monetary policy and housing supply to be investigated through a series of relevant economic variables. Figure 3 illustrates the master plan of this empirical research in a simplified manner.

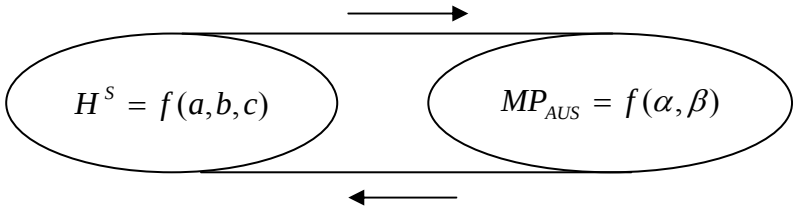


Figure 3: Simplified master plan of this research

Monetary Policy Indicators

In Australia, monetary policy is determined by the Reserve Bank of Australia in accordance with the *Reserve Bank Act 1959*, aiming to control inflation, stable currency, improve full employment and then maintain economic prosperity and people's welfare (RBA, 2007b). The RBA (2007a) stated that an inflation target is the centrepiece of Australian monetary policy.

As a country where the inflation-targeting monetary policy is implemented, the adjustment in interest rates is a key instrument (McTaggart *et al.*, 2003). Thus, interest rate is an indicator of the Australian monetary policy. However, in this research, money supply will be introduced as a variable for modelling because the interest rates and the money supply are inextricably interrelated. In Australia, a single tool left for the RBA after the removal of all direct controls on financial markets in the 1980s to achieve its objective is an open market operation (OMO). The OMO is a method used to adjust interest rates by changing money supply. Hence, employing 'money supply' for the analysis relevant to the Australian monetary policy is rational (Liu & Liu, 2010). The function of the Australian monetary policy can be written as Eq. (1).

$$MP_{AUS} = f(INT, MS) \tag{1}$$

where *INT* denotes the interest rates; and *MS* represents money supply.

Housing Supply Indicators

Quigley (1999) summarised that the supply of housing depends upon the prices of houses and new housing construction activities, thus housing supply is a function of house prices and new housing construction. Hui and Yue (2006) adopted Quigley's (1999) perspectives to study the house price bubbles in China and their empirical results supported Quigley's (1999) housing supply function.

Although the reliability of Quigley's (1999) conceptual model has been validated by Hui and Yue (2006), this function does not include the variable of construction costs. Somerville (1999)

argued that construction costs are the endogenous variables of the housing supply function. Liu and London (2011) further proved that residential construction costs and housing supply in Australia are significantly interconnected. Thereby, construction costs should be incorporated in the housing supply function. In some western countries, such as Australia, UK and US, new housing construction should involve the completely new dwelling construction and the addition as well as conversion to established housing. As claimed by Baer (1986), the addition and conversion to existing housing stock are also essential dynamics on the supply side of the housing sector in a lot of western countries. Therefore, a new housing supply function based on Quigley's (1999) perspective is developed as Eq. (2).

$$H^S = f(HP, Cost, Const^T) \tag{2}$$

where *HP* represents the house prices; *Cost* denotes the residential construction costs; and $Const^T$ stands for the construction of completely new dwelling and the addition as well as conversion to established housing.

Based on the research strategy illustrated as Figure 3, the analysis on the interactions between the endogenous variables in Eq. (1) and Eq. (2) can assist in identifying the interrelationship between housing supply and monetary policy. The interrelationship defined in this study is the causal and dynamic linkages.

METHODOLOGY AND DATA

Methodology

The econometric model used in this study for estimating the causal and dynamic relationships between housing supply and monetary policy is a vector error correction model. The VECM is useful for identifying the causal and dynamic links between the variables (Dinda & Coondoo, 2006; Liu & London, 2010).

The VECM was proposed by Engle and Granger (1987) through integrating the autoregressive and error correction representations into co-integrated systems. It is a vector autoregressive model with co-integrated restriction and error correction term. One of the most purported advantages of recognising co-integration in the VAR system is the improvement in forecasting performance (Engle & Yoo, 1987). The form of the VECM (*p*) is able to be represented as Eq. (3) and (4).

$$\Delta Y_t = \alpha\beta' Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \tag{3}$$

$$\Delta Y_t = \alpha ecm_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \tag{4}$$

where ΔY_t is a *k*-dimensional vector in difference; $ecm_{t-1} = \beta' Y_{t-1}$ denotes the error correction term; Γ_i is the coefficient matrices; and ε_t is a vector of error term.

The causal and dynamic relationships between the variables can be detected by the Granger causality test and the generalized impulse response function under the VECM. The Granger causality is a concept proposed by Granger (1969) in the 1960s and Sims (1972) developed the test for this causality depending upon the VAR model. The Granger causality test is utilised to examine whether or not the lagged values of a time-series variable *X* have explanatory power for the other time-series variable *Y*. If the changes in the *Y* can be explained by the lagged information of the *X*, it is concluded that *X* Granger-cause *Y*.

The impulse response function (IRF), on the other hand, is a technique used to trace the dynamic effect of a shock of the error term of an endogenous variable to other endogenous variables in the VAR or VECM. Koop *et al.* (1996) developed the traditional IRF and devised a unified method to impulse response analysis which is applicable to both linear and nonlinear models. This is the generalized impulse response function.

Data Collection and Description

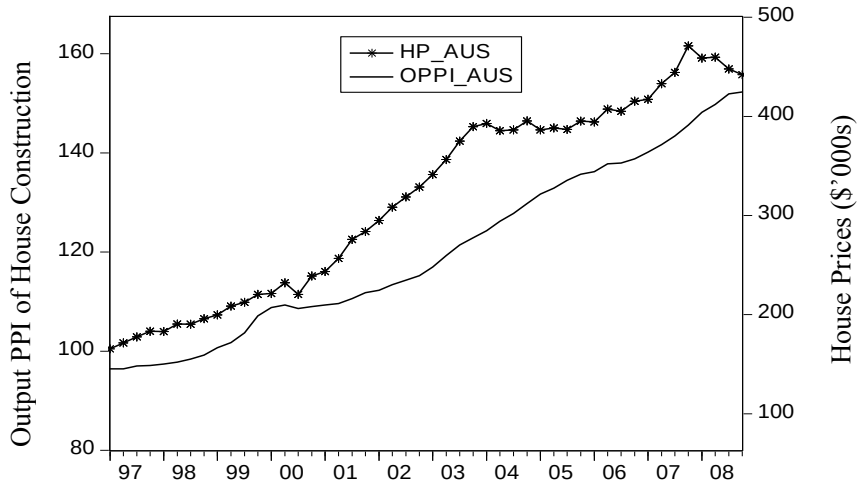
For the purpose of estimating model, the data were extracted from several reliable sources. Firstly, the house prices selected in this study are the median house prices (HP), which are published by the Real Estate Institute of Australia (REIA).

Secondly, the output producer price indexes (OPPIs) of housing construction will be employed as the proxy for residential construction costs. The output PPIs of housing construction are issued by the ABS. It is an index measuring the rates of changes in the costs (labour input costs, plant and material input costs) throughout the procedure of housing production (ABS, 2005; 2010a). In addition, new housing construction will be measured by the housing approvals (HA) published by the ABS as well. Housing approvals reflect the total number of dwelling (house and other residential buildings) approved for construction in given periods. The data on the output PPIs and the housing approvals include the information about the construction of new dwelling and the addition and conversion to established housing (ABS, 2009d; 2010a).

Finally, in the monetary policy function [Eq. (1)], interest rates and money supply are two endogenous variables. Therefore, the interbank rates (INT) and the M1 are the ideal data for measuring these two variables (Elbourne, 2008; Liu and Liu, 2010). The interbank rate is the rate of interest charged on the loan made between banks and it is the operation target of RBA's monetary policy adjustments (RBA, 2001). Moreover, the M1 is the total amount of currency and current deposits of private non-bank sector (RBA, 2009b). Both the interbank rates and the M1 are provided by the RBA.

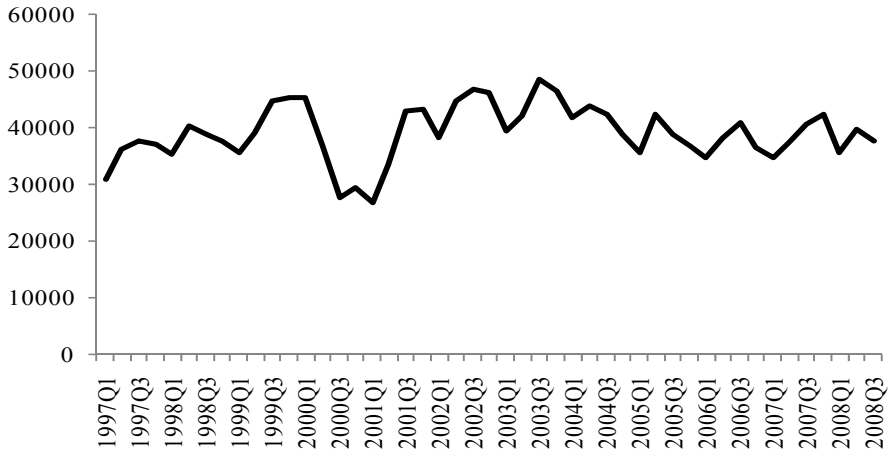
According to the statistics from the REIA (2009) and the ABS (2009a), the house prices and the output PPIs in Australia had dramatic movements during the period under study. Figure 4 illustrates the changes in the house prices and the output PPIs between the January quarter of 1997 (1997Q1) and the December quarter of 2008 (2008Q4) in the Australian housing and construction markets. It is discovered that the output PPIs of housing construction increased from 96.4 to 152.3 with the increase rates of 58% from 1997Q1 to 2008Q4. Meanwhile, the

house prices also maintained an upward trend and achieved a peak of AUD 471,200 in 2007Q4. Then the median house prices began to move down and decreased to AUD 442,000 in 2008Q4. In addition, Figure 5 indicates that the moving trend of the housing approval in Australia was stable. The average quarterly number of new housing (completely new dwellings and the units produced by the addition and conversion to established housing) approved for construction in the sample period was approximately 38,000.



Source: ABS, 2010b; REIA, 2009

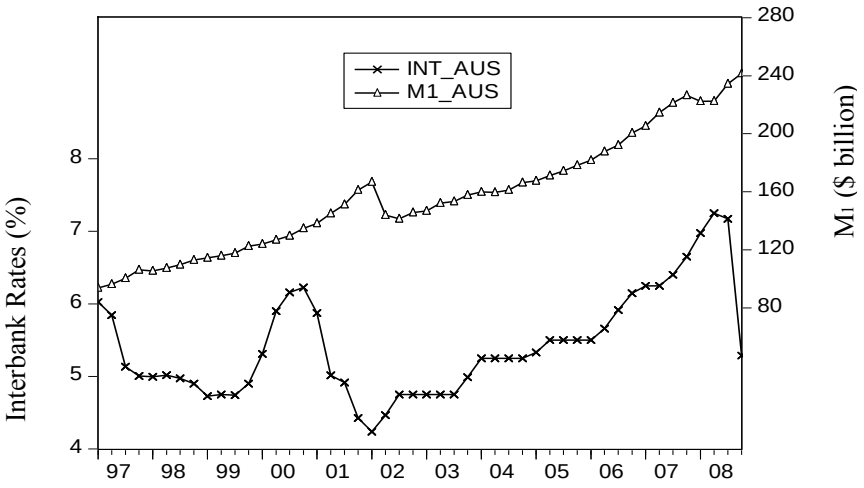
Figure 4: House prices and output PPIs of housing construction in Australia



Source: ABS, 2009c

Figure 5: Number of housing approvals in Australia

Apart from the house prices, output PPIs and housing approvals, Australia's interbank rates and money supply had also changed significantly over the past decade. Figure 6 illustrates that the interbank rates fluctuated upwards within a long-run context and climbed to 7.25% in 2008Q2, from which the interbank rates then suddenly declined to 5.29% in 2008Q4. Conversely, the movement in the M1 exhibited a smooth trend, rising from 93.8 to 241.5 billion dollars in twelve years.



Source: RBA, 2009a; 2009b

Figure 6: Interbank rates and money supply (M1) in Australia

The data description reflects that the supply side of the housing sector in Australia between 1997Q1 and 2008Q4 was exposed to the slowdown of an expansionary monetary policy. Therefore, the research question described previously is addressed again and it will be answered in accordance with the empirical results in next section.

ANALYSIS AND DISCUSSION

Unit Root Tests and Cointegration Tests

In time-series econometric modelling, the data imported must be stationary. Otherwise, a spurious regression would be triggered (Granger & Newbold, 1974). Therefore, the unit root tests will be the first test undertaken in this study. Table 1 reports the results of the PP tests of the selected variables [house price (HP), output PPIs (OPPI), housing approvals (HA), interbank rates (INT) and M1]. Based on this table, all data utilised are integrated of the order one, i.e. *I* (1).

Variables	**Level**		**First Difference**		**Results**
	Model specification (lags)	PP Test Statistics (5%, 1% sig. level)	Model specification (lags)	PP Test Statistics (5%, 1% sig. level)	
ln(HP)	Trend &Intercept (2)	-0.24 (-4.17, -3.51)	None (2)	-4.66 (-2.62, -1.95)	*I* (1)***
ln(OPPI)	Trend & Intercept (2)	-2.67 (-4.17, -3.51)	None (2)	-3.65 (-2.62, -1.95)	*I* (1)***
ln(HA)	Trend & Intercept (2)	-3.32 (-4.17, -3.51)	None (2)	-6.24 (-2.62, -1.95)	*I* (1)***
ln(INT)	Trend & Intercept (2)	-2.76 (-4.17, -3.51)	None (2)	-2.59 (-2.62, -1.95)	*I* (1)**
ln(M1)	Trend & Intercept (2)	-2.49 (-4.17, -3.51)	None (2)	-4.29 (-2.62, -1.95)	*I* (1)***

Notes: The PP Test, which is the unit root test similar to the ADF Test, contains three kinds of model specification: only intercept, trend and intercept, and no trend and no intercept. ** and *** denote the 95% and 99% significance level.

Table 1: Summary of the PP test results

The co-integration test is the second necessary step for constructing the VECM. The approach proposed by Johansen and Juselius (1990) (known as the JJ test) will be conducted after the PP unit root tests. As suggested by the Akaike Information Criterion and the Schwarz Information Criterion, one lagged term has been selected for the co-integration test. Although there are five models in the JJ test, this study is concerned with Model 3 and Model 4 (Model 3 has a linear data trend but no trend in the co-integration equation; and Model 4 has a linear data trend with both an intercept and a trend in co-integration equation) as the description on the data has confirmed that the majority of the data used in this research appears to be trending series. Table 2 summarises the results of the JJ tests, which suggest that a long-run equilibrium relationship exists among the observed variables.

Variables	Lagged difference	Model specification	Results (Trace test)	Results (Max-eigenvalue test)
ln(HP), ln(OPPI), ln(HA), ln(INT), ln(M1)	1	Model 3	1	1
		Model 4	1	1

Table 2: Summary of the JJ co-integration test results

In Table 2, one co-integration vector has been identified by both Model 3 and Model 4 under the Trace test and the Max-eigenvalue test. However, Krol and Ohanian (1990) claimed that there is a stationary deterministic trend in money supply. As a result, one co-integration vector of Model 4 will be selected because Model 4 is suitable for the situation that some of the series are trend stationary.

Causal Relationships between the Selected Variables

As the co-integration was found among the variables, the VECM can be formulated to carry out the Granger causality and the generalized impulse response function. Applying the Wald tests and joint *F*-tests, the null hypothesis that the independent variables do not Granger-cause the dependent variables is rejected at the 95% and 99% significance level. Table 3 indicates the results of the Granger causality tests. According to Table 3, a transmission pattern illustrated as Figure 7 can be identified. This transmission pattern not only confirms the interrelationship between housing supply and monetary policy, but also depicts how the monetary policy and the supply side of the housing sector interact with each other. In summary, there is a significant relationship existing between monetary policy and the supply of housing in Australia.

Dependent Variables	Directions	Chi-square	*P* values	Results
ln(INT)	ln(M1) → ln(INT)	5.63	0.02	Y
	ln(HP) → ln(INT)	0.24	0.62	N
	ln(OPPI) → ln(INT)	0.21	0.65	N
	ln(HA) → ln(INT)	2.28	0.13	N
ln(M1)	ln(INT) → ln(M1)	1.23	0.27	N
	ln(HP) → ln(M1)	5.39	0.02	Y
	ln(OPPI) → ln(M1)	0.29	0.59	N
	ln(HA)→ ln(M1)	8.83	0.00	Y
ln(HP)	ln(INT) → ln(HP)	3.91	0.05	Y
	ln(M1) → ln(HP)	0.33	0.56	N
	ln(OPPI) → ln(HP)	0.22	0.64	N
	ln(HA) → ln(HP)	1.35	0.24	N
ln(OPPI)	ln(INT) → ln(OPPI)	4.11	0.04	Y
	ln(M1) → ln(OPPI)	0.33	0.56	N
	ln(HP) → ln(OPPI)	1.90	0.17	N
	ln(HA) → ln(OPPI)	0.29	0.59	N
ln(HA)	ln(INT) → ln(HA)	2.52	0.11	N
	ln(M1) → ln(HA)	0.78	0.38	N
	ln(HP) → ln(HA)	9.22	0.00	Y
	ln(OPPI) → ln(HA)	13.09	0.00	Y

Table 3: Summary of the Granger causality test results

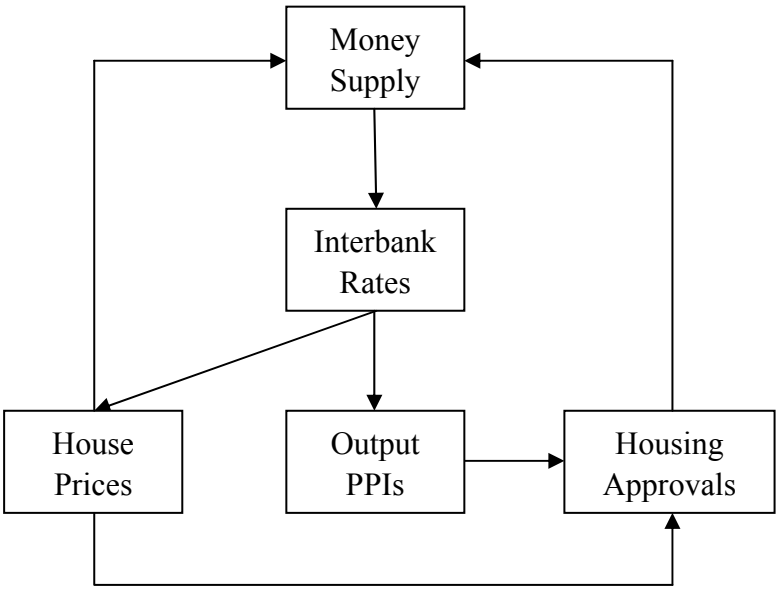


Figure 7: Transmission pattern between housing supply and monetary policy

The transmission pattern first suggests a one-way causality relationship between the money supply and the interbank rates. This finding is consistent with the reality that the RBA adjusts the interbank rates by changing the supply of money in realistic economic system. Furthermore, Figure 7 illustrates that the interbank rates Granger-cause the house prices and the output PPIs, both of which Granger-cause the housing approvals. Nevertheless, no causal relationship was identified from the interbank rates and the money supply to the housing

approvals, implying that house prices and construction costs perform as two transmission mechanisms of the shock of the monetary policy on new housing construction activities. In short, a ripple effect exists among the observed variables, and monetary policy influences new housing construction activities via house prices and residential construction costs.

The discussion previously mentioned focused on the causal links within the direction from monetary policy to housings supply. However, the empirical results also indicate that the house prices and the housing approvals Granger-cause the money supply without a feedback. Macroeconomic theory argues that the development of important economic sectors has been an essential factor in today's monetary policy decisions (McTaggart *et al.*, 2003). Hence, the changes in the housing sector can induce the monetary regime shifts.

Dynamic Relationships between the Selected Variables

The Granger causality test has identified the causal links between the observed variables, however it is not able to explore the dynamic linkages among the endogenous variable. Thus, the generalized impulse response function (GIRF) will be adopted in the following analysis and Figure 8 illustrates the results.

Firstly, there are dramatic effects produced by the interbank rates on the house prices. It is noted that the maximum values of the response of the house prices to the standard deviation of the interbank rates achieve -1.10%. The 'negative' values here indicate that the increasing trend of the house prices in Australia had been dramatically depressed by the increases in the interbank rates during the period under study. On the contrary, the response of the output PPIs to the interbank rates is positive. Specifically, a total of 0.43% dynamics on the output PPIs is yielded by the interbank rate disturbances, suggesting that an increase in construction costs was strengthened by a rise in the interbank rates. It is knowledge that an inflation of the interbank rates increases the payments on interests, which represent a major part of the costs of the construction projects financed by the loans of banks or other financial institutions. The ABS (2009d) reports that an approximately 50% of housing construction projects in Australia is under the loans. As a result, the construction costs in Australia can be easily affected by the changes in interest rates.

Compared with the interbank rates, the house prices and the output PPIs are less sensitive to the movement in money supply. The results indicate that the standard deviation of the M1 produces less effect on the house prices as well as the output PPIs than that of the interbank rates, 1.07% and -0.21% respectively in five quarters. These two values suggest that the house prices are positively related to the M1 and there is an inverse relationship between output producer prices and money supply.

It has been described in *Introduction* that the growth rates of the money supply in Australia from 1997 to 2008 exhibited a downward trend in conjunction with a rise in the interest rates. Thereby, the empirical results associated with the responses of the house prices and the output PPIs imply that the slowdown of an expansionary monetary policy had weakened the upward trend of the house prices but increased the residential construction costs in Australia.

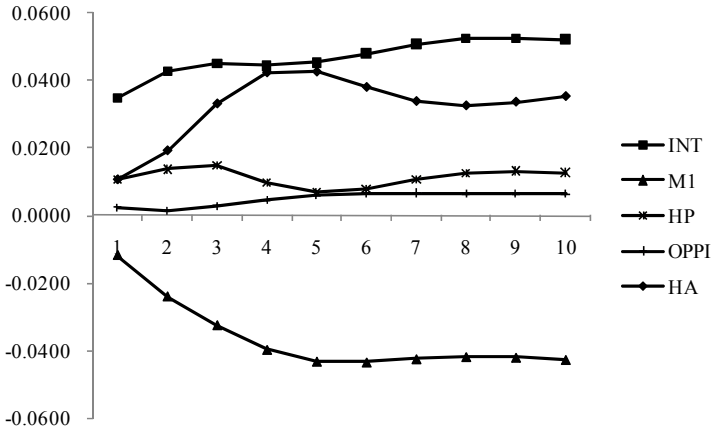
Secondly, new housing construction activities measured by the housing approvals are sensitive to the changes in the house prices and the construction costs. Overall, the house prices have a positive effect on new housing construction while an increase in the output PPIs reduces the construction for new housing. According to Figure 8, the responsive values of the housing approvals to the standard deviations of the house prices and the output PPIs reach 1.41% and -3.87% respectively in five quarters.

As discussed previously, the adjustments in monetary policy between 1997 and 2008 in Australia had depressed the house prices but driven up the residential construction costs. Due to the strong linkage between new housing construction and the changes in house prices and construction costs, the slowdown of monetary expansion surely can reduce new housing construction level across Australia. This conclusion can be supported by the results of the GIRF, which indicate that the housing approvals are decreased up to 1.65% in three quarters by the shock of the monetary policy.

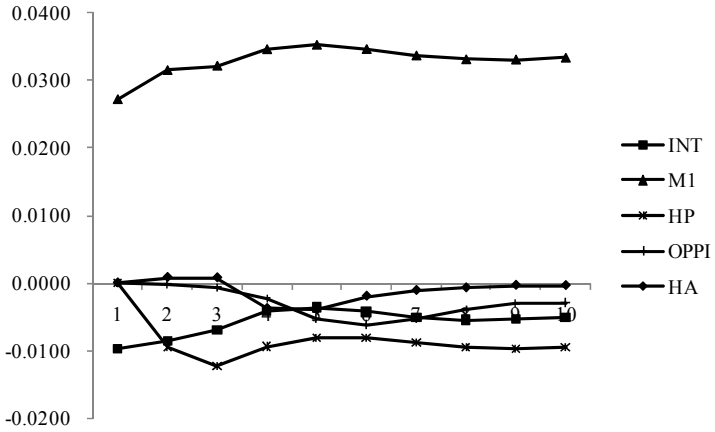
Finally, the influence of the supply side of the housing sector on monetary policy decisions can not be ignored. The empirical results indicate that the responses of the interbank rates and the M1 to the impulses of the house prices, output PPIs and housing approvals are: 1.25% and -0.85%, 1.17% and -0.65%, and 5.11% and -1.16% respectively. It is inferred from these values that Australia's central bank will decrease the money supply to increase the interbank rates when facing overheating investments in the housing sector. Conversely, if a recession occurred in the supply side of the housing sector, the central bank will lower the interbank rates to stimulate the investments on housing development. These findings comply with the conventional macroeconomic theory, thus the conceptual model and the VECM developed in this study are reliable.

Based on the empirical evidence displayed in Figure 7 and Figure 8, an overall outcome of this research is able to be summarised as Figure 9. In summary, the slowdown of an expansionary monetary policy had weakened the increasing trend of the house prices and raised the residential construction costs in Australia. Consequently, the level of new housing construction had been depressed by the price and cost changes triggered by the shock of monetary policy. In conclusion, the development of the supply side of the housing sector had been negatively affected by the monetary regime shifts during the recent decade in Australia.

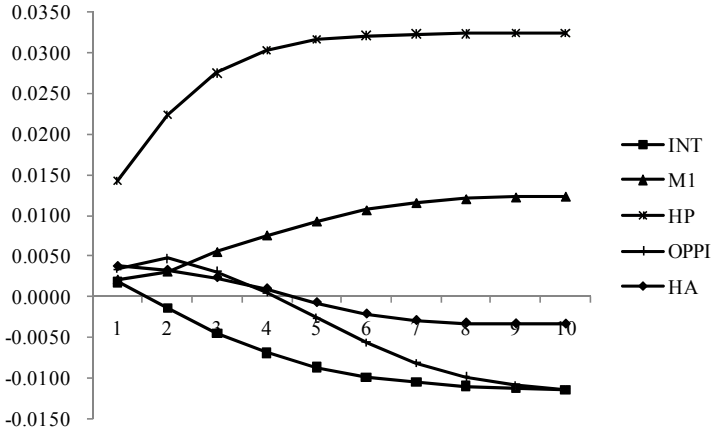
Responses of the interbank rates



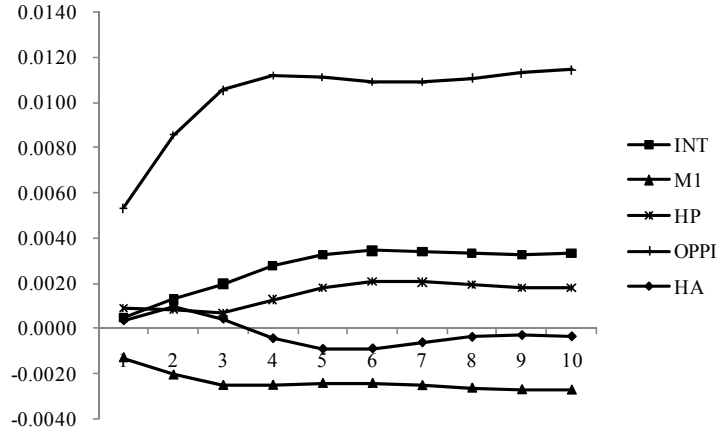
Responses of the M1



Responses of the house prices



Responses of the output PPIs of housing constructions



Responses of the housing approvals

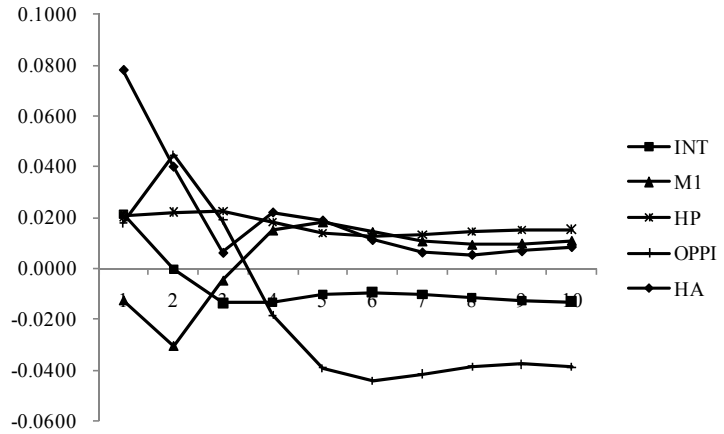


Figure 8: Results of the generalized impulse response function

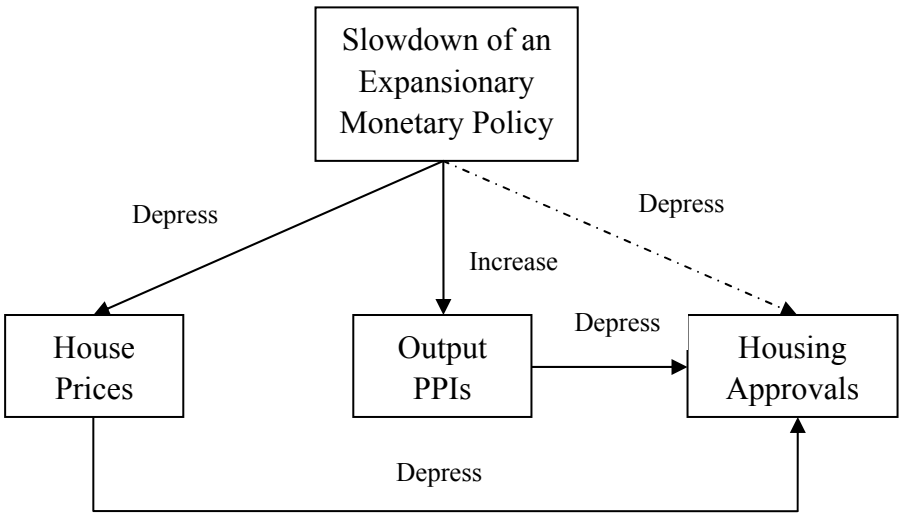


Figure 9: Impact of the slowdown of an expansionary monetary policy on the supply side of the housing sector in Australia

CONCLUSION

This empirical study has investigated the interrelationship between housing supply and monetary policy in Australia by a vector error correction model. Depending upon the Granger causality test, a transmission pattern within the framework of monetary policy and housing supply has been identified. This pattern illustrates that the interbank rates perform as an activator that transfers monetary policy makers' interventions to the supply side of the housing sector, and house prices and residential construction costs are two transmission mechanisms of the shock of monetary policy on new housing construction activities. According to results of the generalized impulse response function, it can be concluded that the slowdown of an expansionary monetary policy has significantly depressed housing supply in Australia.

This paper uncovers the negative effect of the slowdown of an expansionary monetary policy on housing supply. The models developed in this research is useful for policy makers to estimate the influence of monetary policy on the supply side of the housing sector and provides them with valuable insight to improve the housing supply across Australia. Furthermore, as suggested by the perspective of policy collaboration, some other policies (e.g. construction policies or taxation policies) in relation to residential construction can be enacted for construction industry by the Australian governments to reduce the negative impact from current monetary policy and then stimulate the investments on new housing developments. In reality, the construction policies for the supply side of the housing sector are a promising field for future study.

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