Discovering Key Drivers of House Price Growth in Eight Australian Capital Cities: 1994–2017

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Abstract

This study adopts the user cost of housing framework and uses dynamic models to identify the key drivers of real house price growth in Australia's eight capital cities between 1994 and 2017. The real mortgage rate and the real investment loan growth rate are found to be significantly associated with real house price growth. A 25 basis points increase in the real mortgage rate will reduce the long-run growth rate of real house price in Sydney by about 0.69 per cent per quarter. A 1 per cent increase in investment loan growth per quarter will increase the long-run real house price growth by 0.95 per cent per quarter in Sydney. The results show that investor demands have a lot more influence on house price growth compared to owner-occupier demands in most Australian capital cities. The study also discovers that price-to-rent ratio and population growth have strong influences on real house price growth. For most Australian capital cities, economic factors explain around 50 to 60 per cent of the variation in the growth rate of house prices.

Statement of Originality

This work has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

Aaron Ding ____

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Table of Contents

Acknowledgements 2

Abstract 3

Statement of Originality 4

1. Introduction 7

2. The User Cost Model 10

3. Data 14

4. Results 16

  4.1 Summary Statistics and Correlations for Real House Price Growth Rates 16

  4.2 ADF Test Results 17

  4.3 Empirical Results 21

    4.3.1 Benchmark User Cost Model 22

    4.3.2 Additional Explanatory Variables 25

    4.3.3 General Model 28

    4.3.4 General Model with "Sydney Effect" 34

5. Further Discussion 36

6. Conclusion 40

Appendix 43

List of Tables

Table 1 Summary Statistics for Real House Price Growth Rates, 1994:1–2017:4 16
Table 2 Correlation Matrix of Real Housing Price Growth for Eight Capital Cities of Australia 17
Table 3: Unit Root Tests, 1994:1–2017:4 19
Table 4: Structure Break Unit Root Tests, 1994:1–2017:4 21
Table 5 Benchmark User Cost Model for the Growth Rate of Real House Prices, 1994:1–2017:4 24
Table 6: Effects of Additional Explanatory Variables, 1994:1–2017:4 (4 lags)...26
Table 7:The Generalised User Cost Model, 1994:1–2017:4...33
Table 8: The Generalised User Cost Model with Sydney Effect, 1994:1–2017:4 35

Table A- 1:: Effects of Additional Explanatory Variables, 1994:1–2017:4 (8 lags)..................................43

List of Figures

Figure 1 :Time Series Plots of Significant Variables in ADF Test with Structural Break..........................20

1. Introduction

The Australian economy has not had a recession since 1991, a period of 27 years. During this unprecedented growth period, property prices in the country have grown substantially and delivered a remarkable growth in wealth for Australians. For example, Sydney house prices increased 45 per cent from March 2012 to March 2015 (Source: REIA REMF1). According to CoreLogic's Housing Market Update in April 2018, the total value of Australian housing sits at \$7.5 trillion dollars, and 52.1 per cent of Australian household wealth is held in housing (CoreLogic 2018). As housing has a significant wealth effect, it plays a crucial rule in driving household consumption and therefore economic activity.

There has been a lot of research interest in house price inflation. One focus has been on detecting house price bubbles, such as Shi et al. (2016) who conducted tests on Australian capital cities from 1995 to 2015, and confirmed the existence of speculative housing bubbles. Hatzvi & Otto (2008) also examined the existence of speculative bubbles in the Local Government Areas (LGAs) of Sydney from 1991 to 2006. Their findings show that possible speculative bubbles existed in Western Sydney LGAs.

Another focus is on the relationship between house prices and monetary policy. For example, by using structural VARs with data from the UK, Norway and Sweden, Bjørnland & Jacobsen (2010) found that house prices react quickly and vigorously to monetary policy shocks, and the house prices fall strengthen the negative response in consumer price inflation and output. Iacoviello & Minetti (2008) tested a credit channel of monetary policy in the housing market and found a straightforward relationship between the efficiency of housing finance, the type of institutions active in mortgage provision and the presence of the credit channel in Norway, the UK, Germany, and Finland.

An important strand of the literature examines the link between house prices and economic fundamentals. For example in Australia, Abelson (1994) identified determinants of house prices in Sydney, Melbourne and Adelaide since 1970. He found that where there is a shortage of higher density housing, the average market price of an established dwelling will rise with household income growth. This explains why, from 1970 to the early 1990s, Sydney's higher growth in income delivered higher house prices compared to Melbourne. Similarly, using data from 1979 to 1993, Bourassa & Hendershott (1995) found that the growth rate in real wage income (primarily coming from employment growth) and net overseas migration growth were the main forces driving real house prices in Australia's six capital cities. However, one shortcoming of Bourassa & Hendershott (1995) is that they implicitly assume a common model for all six cities. Using data from 1970 to 2003, Abelson et al. (2005) find that in the long run, the consumer price index and the real disposable income have a significant positive relationship on real house prices. They also discover that housing stock, real mortgage rates, unemployment rate and equity prices have a significant negative relationship on real house prices. Using data from 1986 to 2005, Otto (2007) built dynamic models for each capital city in Australia and found that the variable mortgage rate was an important influencer of the house price growth rate in all eight capital cities. On the supply side, Gitelman & Otto (2012) found that when the median time taken by a local council to decide on a development application is included in the supply curve, the supply of residential property is negatively affected. McLaughlin (2011) highlighted the effects of excessive government urban planning restrictions and the role this play in causing the delay to housing stock being able to meet market demand in a timely manner. These restrictive policies are found to decrease new housing supply.

The general consensus in the literature is that the key driving force behind house price growth seems to be: population growth (Bodman & Crosby 2004; Bourassa & Hendershott 1995); mortgage rates (Abelson et al. 2005; Otto 2007); wages growth (Abelson 1994; Bourassa & Hendershott 1995); and housing stock supply (Gitelman & Otto 2012; McLaughlin 2011). However, the literature also seems to suggest that the key drivers behind house price growth differ according to the time periods under consideration. Since the Australian housing market experienced a significant expansion during 2013–2015, it is important to re-examine the key driving forces that cover this period. This study follows Otto (2007) closely to investigate how various economic variables impacted on house price growth rate in Australia's capital cities between 1994 and 2017. One of the key advantages of this approach is that Otto (2007) does not impose a common model across all capital cities. Instead, he allows a different model for each capital city, recognizing that the key driving force behind house price growth in each city may be different.

One of the downsides of the current record high house prices in Australia is the record high debts that have come with it. According to CoreLogic's Housing Market Update in April 2018, the total outstanding mortgage debt in Australia is $1.74 trillion (CoreLogic 2018, p. 2). Australian households' record level of indebtedness has not gone unnoticed. In a media release published on 13 September 2017, ABS Chief Economist Bruce Hockman revealed that "Nearly half of our most wealthy households (47 per cent) who have a property debt are over-indebted, holding an average property debt of $924,000. This makes them particularly susceptible if market conditions or household economic circumstances change" (ABS Media Release 2017). In the AMP.NATSEM Income and Wealth Report "Buy Now Pay Later – Household Debt in Australia", published in December 2015, it was also stated that "Households with high levels of debt have loaded up with even more during the past 10 years. Debt levels for households with the top 10 per cent of debt are six times higher than their annual income, up from four times 10 years ago" (AMP.NATSEM 2005, p. 24). This further supports the existence of a debt concentration situation for some Australian households and to an extent, validates the statement, "Note that Australian consumers both want and need to borrow to satisfy their insatiable desire for immediate gratification, and the more they borrow the more they need to borrow; because not only must they continue to buy but they must also meet their increasing debt repayment demands" (Griffiths 2007, p. 5). Recognizing the importance of credit growth, this study also seeks to extend the list of the variables used in Otto (2007) to include credit growth for both owner-occupiers and investors.

This thesis follows Otto (2007) approach to model the growth rate of house prices in Australia's capital cities based on the user cost of housing framework. A distinct benefit of developing capital city-based models is that we can identify region-specific determinants of house price growth. This study finds that the real mortgage rate and real investment loan growth rate are important drivers of house price growth in Australia's eight capital cities. Otto (2007) also identifies the mortgage rate as an important influence on house price growth rates, with a 25 basis points rise in the mortgage rate reducing the long-run quarterly growth rate in house prices by about 1 per cent in Sydney. Our results show that the same 0.25 per cent hike in the real mortgage rate will reduce the long-run quarterly house price growth by 0.69 per cent in Sydney. Otto (2007) shows that for most Australian capital cities, economic factors explain around 40 to 60 per cent of variation in the growth rate of house prices. Our study has a similar result of 50 to 60 per cent.

This thesis is organised as follows. Part 2 contains a discussion of the development of a baseline econometric model for the growth rate of house prices, using an equilibrium condition for the user cost of housing and rents framework from Himmelberg, Mayer & Sinai (2005). Part 3 covers a description of the data used in this study. Part 4 presents the results of the study. Part 5 involves further discussion of the findings, and Part 6 is the conclusion.

2. The User Cost Model

Imputed rent is the annual cost of homeownership (user cost) and is the sum of six components representing both costs and offsetting benefits (Hendershott & Slemrod 1983; Poterba 1984), which represent the opportunity cost of capital. According to Himmelberg, Mayer & Sinai (2005), the first component is the cost of foregone interest that the home owner could have earned by investing in something other than a house. The second component is the annual cost of property taxes. The third component is the tax deduction associated with the mortgage interest and property taxes. The fourth is the maintenance costs associated with house ownership. The fifth is the expected capital gain, and the sixth component is the additional risk premium to compensate homeowners for the higher risks of owning versus renting. The sum of these six parts represents the total annual cost of homeownership.

Brown et al. (2011) employed the user cost of housing method to study house prices in Brisbane, Melbourne and Sydney for the period 1988–2010. They found that tax policy has far less effect on the user cost of housing than interest rate policy. Bourassa (1995) found that including user cost in the tenure choice model for Sydney and Melbourne produced a substantial improvement in goodness-of-fit and a corresponding reduction in the prediction error rate on the probability of ownership.

Otto (2007) adopted the user cost of housing and rents model (Himmelberg, Mayer & Sinai 2005) to identify the main influences on house prices for the eight Australian capital cities. He found that the variable mortgage rate is an important driver of house price growth rate in all eight capital cities in Australia. Abelson et al. (2005) developed models that use the level of house prices to identify key determinants of house price inflation. This method faces non-stationary issues concerning data and the need to use co-integration techniques to estimate error correction models. The study found that over the long term, real house prices are driven by real disposable income and the CPI. To avoid problems with stochastic trends in the level of house prices, Otto (2007) used the house price growth rate.

This study uses the user cost framework and econometric model developed by Otto (2007), which follows the previous works done by Himmelberg, Mayer & Sinai (2005). It centres on the concept of comparing the price of owning a home to the cost of renting to determine whether it is worthwhile to buy a property. The difference in the cost of home ownership and the cost of renting will yield arbitrage opportunities but a competitive market is expected to eliminate this over time through rent or house price adjustments. The house hunter could be indifferent to the decision about whether to buy or rent when the price of owning a home is equal to the cost of renting. The econometric model starts from a no-arbitrage situation that makes the annual rent equal to the sum of the yearly costs of home ownership,

$$R_t^h = P_t^h \mu_t \qquad (1)$$

where R_t^h is rent per period, P_t^h represents house price and μ_t is the user cost of housing.

By rearranging equation (1), we have,

$$\frac{P_t^h}{R_t^h} = \frac{1}{\mu_t}$$

We can write μ_t as a function of the real interest rate r_t and the expected capital gains on housing $E_t \Delta \log P_{t+1}^h$, to get the following as equation (2),

$$\frac{P_t^h}{R_t^h} = \frac{1}{\mu(r_t, E_t \Delta \log P_{t+1}^h)} \qquad (2)$$

Equation (2) assumes that the user cost of housing is rising in the real interest rate and falling in future capital gains. Due to the nature of high transaction costs associated with changing between rental accommodation and house ownership, equation (2) is not likely to hold on a period-by-period basis. Since any arbitrage opportunities will be eliminated over time through adjustments to house prices, we can rewrite equation (2) as,

$$\Delta \log P_{t+1}^h = \lambda \left[\frac{P_t^h}{R_t^h} - \frac{1}{\mu(r_t, E_t \Delta \log P_{t+1}^h)} \right] \qquad (3)$$

where $\lambda < 0$. λ measures the responsiveness of the price-to-rent ratio, real interest rate and expected capital gains.

Equation (3) shows that for a given user cost of housing, an increase in the current ratio of house prices to rent will cause a decline in future house prices. A real interest rate increase will lift the user cost of housing. Ceteris paribus, this will cause negative growth in house prices. When the expected capital gains increase, the user cost of housing will decrease. This will require the house price growth rate to rise in order to restore equilibrium.

Price-to-rent ratio is commonly used in the literature as a measure of housing affordability and is often a subject of investigation itself. Equation (3) shows that one of the key drivers behind house price growth is the price-to-rent ratio. This potentially explains the exuberant growth in Australian housing prices. For example, Shi et al. (2016) used the PSY testing procedure (Phillips, Shi & Yu

2015) to confirm the existence of speculative house price bubbles using the price-to-rent ratio in seven Australian capital cities, excluding Darwin. Price-to-rent ratio was also used in the study conducted by Hatzvi & Otto (2008) to test for speculative bubbles in the 36 LGAs in Sydney during the period 1991 to 2006.

We follow Otto (2007) closely in further embedding equation (3) in a general autoregressive distributed lag model,

$$\Delta \log P_t^h = \mu + \sum_{i=1}^{k} \gamma_i \Delta \log P_{t-1}^h + \sum_{i=1}^{k} \lambda_{1i} \log \frac{P_{t-i}^h}{R_{t-i}^h} + \sum_{i=1}^{k} \lambda_{2i} i_{t-1} + \sum_{i=1}^{k} \lambda_{3i} \pi_{t-i} + \lambda_4 E_t \times \Delta \log P_{t+1}^h + v_t \quad (4)$$

In equation (4), the real interest rate is allowed to enter in an unrestricted form by separately including the nominal interest rate i_t and inflation π_t. The user cost model can predict $\lambda_{1i} < 0$, $\lambda_{2i} < 0$, $\lambda_{3i} > 0$ and $\lambda_4 > 0$. λ_{1i} is the responsiveness of house price growth from the price-to-rent ratio. If the price-to-rent ratio increases, then house price growth will decrease. Again, λ_{2i} is the responsiveness of house price growth to the nominal interest rate which affects house price growth negatively. λ_{3i} measures the responsiveness of house price growth to the inflation rate which influences housing price growth positively. λ_{4i} represents the responsiveness of house price growth to the expected future housing capital gain and is expected to change house price growth in the same direction as the expected capital gain change. Considering the large number of coefficients in equation (4), this study will not focus on each individual coefficient, but only examine the significance and the signs of the sums of the coefficient, such as $\lambda_{11} + ... + \lambda_{1k}$, and the long-run effects such as $(\lambda_{11} + ... + \lambda_{1k}) / (1 - \gamma_1 - ... - \gamma_k)$.

As the expected capital gain on housing is difficult to determine, this study follows Otto (2007) by first estimating a version of equation (4) excluding $E_t \Delta \log P_{t+1}^h$. This will provide a benchmark model for house price growth rate in Australian capital cities by highlighting the effects of inflation, price-to-rent ratio and the mortgage rate. Then we introduce economic variables that are potentially drivers of future house price growth in each city to strengthen the benchmark model. Four variables are included. To assess the effects of local economic activities, we use the growth rate of state final demand and the unemployment rate. To estimate the effect of demographic changes, we use the population growth rate. The dwelling approval rate per capita was selected as the fourth variable by Otto (2007), as Caplin et al. (2003) argue that government policies that restrict the availability of new housing supply can inflate house prices in some Australian cities. In this study, dwelling completion per capita was chosen instead to account for building approvals that never move to building completion stage.

Real equity return is considered as another variable, as share market investment and housing investment can be viewed as substitutes. Investors can switch between these two forms of investment depending on timing and the potential returns. The "Sydney effect" variable is motivated by findings that Sydney house prices have a spill over effect, causing house price fluctuations in other Australian cities (Abelson 1994; Bewley, Dvornak & Livera 2004). Finally, real owner-occupier loan growth rates and real investment home loan growth are considered as potential influences on the real growth of house prices. The introduction of these two variables is motivated by the findings of Tsatsaronis & Zhu (2004), which show that feedback from house prices to credit growth is stronger in countries that have market sensitive valuation methods for mortgage accounting. Growth in home loans and investment loans are separately identified so that we can individually measure the effects of owner-occupier housing loan growth and investment property loan growth on house price growth.

3. Data

The definitions and sources of the variables used in this study are listed below. All data series are quarterly, and the sample period is from the first quarter in 1994 to the fourth quarter in 2017 (1994:1–2017:4).

House Prices

The real growth rates of house prices in the eight capital cities around Australia are derived from the quarterly median house prices provided by the Real Estate Institute of Australia (REIA). (Source: REIA REMF1). These growth figures are deflated to real terms by the CPI of the relevant capital cities (Source: ABS 6401.0 Tables 1 and 2). The quarterly house price growth rate is calculated as the first -difference of the logarithm of this ratio multiplied by 100.

Unemployment Rate

Unemployment rate (seasonally adjusted) comes from the Australian Bureau of Statistics (ABS) (Source: ABS 6202.0).

Population Growth

The population growth rate for the eight capital cities in Australia is provided by the ABS (Source: ABS 3101.0).

Mortgage Rate

The nominal mortgage rate is measured by the standard variable home loan rate data from the Reserve Bank of Australia (RBA) (Source: RBA F5). The nominal mortgage rate is then deflated to produce the real mortgage rate. The real mortgage rate is derived from the nominal mortgage rate minus city-based CPI.

State Final Demand

The growth rate of final demand for the states and territories is derived from the seasonally adjusted figures from the ABS (Source: ABS 5206.0). It is then deflated using city-based CPI sourced from ABS to produce the real state final demand growth rate.

Dummy Variables

A dummy variable was created for the introduction of the goods and services tax (GST) in 2000. It takes the value 1 in the September quarter 2000 and 0 elsewhere.

All models include a constant; therefore, three seasonal dummies have been created for the first, second and third quarters of a calendar year. These seasonal dummies 1, 2 and 3 take the value 1 in their corresponding periods and 0 otherwise. The fourth quarter does not have a dummy; it serves as the reference quarter.

An outlier dummy has been created for the second and third quarters in 2003.

Dwelling Completion per capita

The quarterly number of dwelling units completed for each capital city is provided by the ABS (Source: ABS 8731.0). These numbers are divided by the respective state and territory populations to obtain dwelling completions per capita.

Stock returns

The quarterly ASX 200 accumulation index is provided by Bloomberg. A real return series is obtained by subtracting the state or territory inflation rate from the nominal growth rate.

Rent

Data on rents are obtained from the Real Estate Institute of Australia (REIA) and are weekly median rents for three-bedroom houses in each capital city (Source: REIA REMF5). The series is deflated by the city-specific CPI.

Real Investment Property Loan Growth

Data on investment property loan growth is sourced from the RBA (Source: RBA D1). The monthly growth rate is then converted to quarterly. The series is deflated by CPI to produce the real investment property loan growth rate.

Real Owner-occupier Loan Growth

Data on home loan growth is sourced from the RBA (Source: RBA D1). the monthly growth rate is then converted to quarterly and the series is deflated by CPI to produce the real owner-occupier loan growth rate.

Inflation Rate

Inflation rates for the state and territory capitals are derived from the corresponding CPIs (Source: ABS Table 6401.0 Tables 1 and 2).

4. Results

In this section, we report and analyse all the results, and summarize our initial findings.

4.1 Summary Statistics and Correlations for Real House Price Growth Rates

Table 1 reports some summary statistics on the quarterly growth rates of real house prices for the eight capital cities in Australia. Over the sample period, Sydney and Melbourne outgrow the average house price growth rate, increasing at 1.325 per cent and 1.235 per cent per quarter respectively. The remaining six capital cities grew at a significantly lower rate, with average growth rates ranging between 0.718 and 0.94 per quarter. These results seem to agree with some media commentaries about the "tale of two cities" situation in the housing market, in which Sydney and Melbourne, as Australia's mega-cities, grow a lot faster than the second-tier capital cities (Edwards 2014). Growth rates of house prices are mostly positively correlated across all eight capital cities, except for Melbourne in relation to three other cities – Darwin, Hobart and Perth. In contrast, Otto (2007) reports all positive correlations across all cities. This may indicate that Melbourne's fast-growing population rate could have been achieved at the expense of some low-growth capital cities.

In terms of standard deviation, the values reported for Melbourne, Hobart, Canberra and Darwin are much higher, indicating more house price growth volatility in these cities. AR(1) is the first-order autoregressive coefficient result. In the case of Sydney, a 1 per cent growth in this quarter implies a 0.338 per cent higher growth above the mean. It is interesting to note that Melbourne, Adelaide, Hobart and Canberra report negative numbers, while all AR(1) coefficients in Otto (2007) are positive.

Table 1 Summary Statistics for Real House Price Growth Rates, 1994:1–2017:4

	Sydney	Melbourne	Brisbane	Adelaide	Perth	Hobart	Canberra	Darwin
Mean	1.325	1.235	0.818	0.869	0.891	0.940	0.787	0.718
Std	2.686	4.771	3.030	2.938	2.878	5.205	4.329	4.157
AR(1)	0.338	-0.353	0.162	-0.027	0.395	-0.173	-0.222	0.008
	(0.132)	(0.107)	(0.138)	(0.104)	(0.108)	(0.113)	(0.127)	(0.127)

Note: Std is the standard deviation and AR(1) is the first-order autoregressive coefficient. Numbers in the parenthesis are heteroskedasticity robust standard errors (White 1980).

Table 2 Correlation Matrix of Real Housing Price Growth for Eight Capital Cities of Australia

Correlation	Hpg_Ade	Hpg_Bri	Hpg_Can	Hpg_Dar	Hpg_Hob	Hpg_Mel	Hpg_Per	Hpg_Syd
Hpg_Ade	1.000							
Hpg_Bri	0.575	1.000						
Hpg_Can	0.450	0.617	1.000					
Hpg_Dar	0.220	0.217	0.052	1.000				
Hpg_Hob	0.566	0.611	0.473	0.224	1.000			
Hpg_Mel	0.058	0.007	0.105	-0.002	-0.014	1.000		
Hpg_Per	0.401	0.395	0.225	0.406	0.438	-0.201	1.000	
Hpg_Syd	0.324	0.438	0.323	0.115	0.341	0.356	0.132	1.000

As per results reported in Table 2, there is closed to zero correlation on house price growth between Melbourne and Brisbane, Melbourne and Darwin, and Melbourne and Hobart. In addition, Melbourne and other remaining capital cities display a weak linear relationship on house price growth rates. Melbourne also shows a negative linear relationship with Darwin, Hobart and Perth. Comparing with Melbourne, Sydney has positive correlation with all the other seven capital cities, showing a much stronger linear relationship. This supports indirectly the presence of the "Sydney effect". As ABS data shows Melbourne is the fastest population growth capital city in Australia, and most of the growth comes from net overseas migration, it is possible that the house price growth driven by population growth in Melbourne is showing a very different pairwise correlation coefficients compared with other Australian capital cities.

4.2 ADF Test Results

It is important to confirm the stationarity of the relevant variables, as the specification of our model crucially depends on the order of integration. We proceeded with an ADF test in this study in order to find the stationary status of variables in their level form.

Table *3* reports the results of the augmented Dickey-Fuller (ADF) unit root tests for all of the variables selected for the study (Dickey & Fuller 1981). The null hypothesis of the ADF test is that there is a unit root present in the data. The ADF test in Table *3* shows that the real growth rate of house prices in eight Australian capital cities are a stationary I(0) series. In all cases we can reject the null hypothesis at 1 per cent significance level. This is also the case for the growth of state final demand, inflation, real equity returns, real mortgage rate, real owner-occupied loan growth and real investment loan growth. However, for the variables of unemployment, population growth, Log price-to-rent ratio and dwelling completion per capita, the results in a few cities show that we cannot reject the null hypothesis. A visual examination of the data shows that some of these data may indicate the presence of a structural break. Figure 1 shows some of these data. For price-to-rent ratio in Adelaide, Brisbane, Canberra and Hobart, around 2002, there seems to be a structural break in the graph presented in Figure 1.Therefore, we conducted structure break ADF tests to further examine the insignificant results in Table 3.

Table 3: Unit Root Tests, 1994:1–2017:4

	Sydney	Melbourne	Brisbane	Adelaide	Perth	Hobart	Canberra	Darwin
Growth of real house prices	-3.95***	-5.38***	-3.97***	-5.22***	-6.31***	-11.41***	-5.44***	-9.54***
Real Growth of state final demand	-9.27***	-12.27***	-9.73***	-11.56***	-5.04***	-13.21***	-8.62***	-11.12***
Unemployment rate	-3.89***	-4.85***	-1.91	-2.39	-2.19	-1.99	-1.85	-4.16***
Population growth	-3.18*	-4.91***	-2.72*	-1.79	-2.21	-2.08	-2.92**	-3.71**
Inflation rate	-7.83***	-8.69***	-8.53***	-8.42***	-7.52***	-8.50***	-7.23***	-7.55***
Log price-to-rent ratio	-1.25	-1.87	-1.62	-1.97	-2.44	-2.53	-1.92	-2.84
Real equity returns	-8.36***	-8.40***	-8.39***	-8.35***	-8.34***	-8.35***	-8.36***	-8.33***
Dwelling completion per capita	-1.39	-2.95	-4.64***	-3.25*	-4.29***	-2.72*	-3.89***	-2.00
Real Mortgage rate	-7.83***	-7.98***	-8.45***	-7.94***	-7.81***	-8.12***	-7.30***	-8.00***
Real Owner-occupied loan growth	-7.14***	-7.76***	-8.27***	-8.19***	-7.54***	-8.33***	-7.46***	-7.01***
Real Investment loan growth	-4.23***	-3.33**	-3.23**	-4.88***	-4.46***	-4.55***	-4.35***	-4.49***

Notes:

- All of the test statistics are computed using the augmented Dickey-Fuller test (Dickey & Fuller 1981)
- The null hypothesis is the presence of a unit root
- ***, **, * represent 1%, 5% and 10% level of significance respectively
- ADF statistic is reported in the table can be with constant or no constant or trend-constant. Following the sequence of constant, no constant and trend-constant, ADF statistics is reported when it is found significant. If insignificant, the statistics are obtained with trend-constant
- Lags were selected based on SBIC

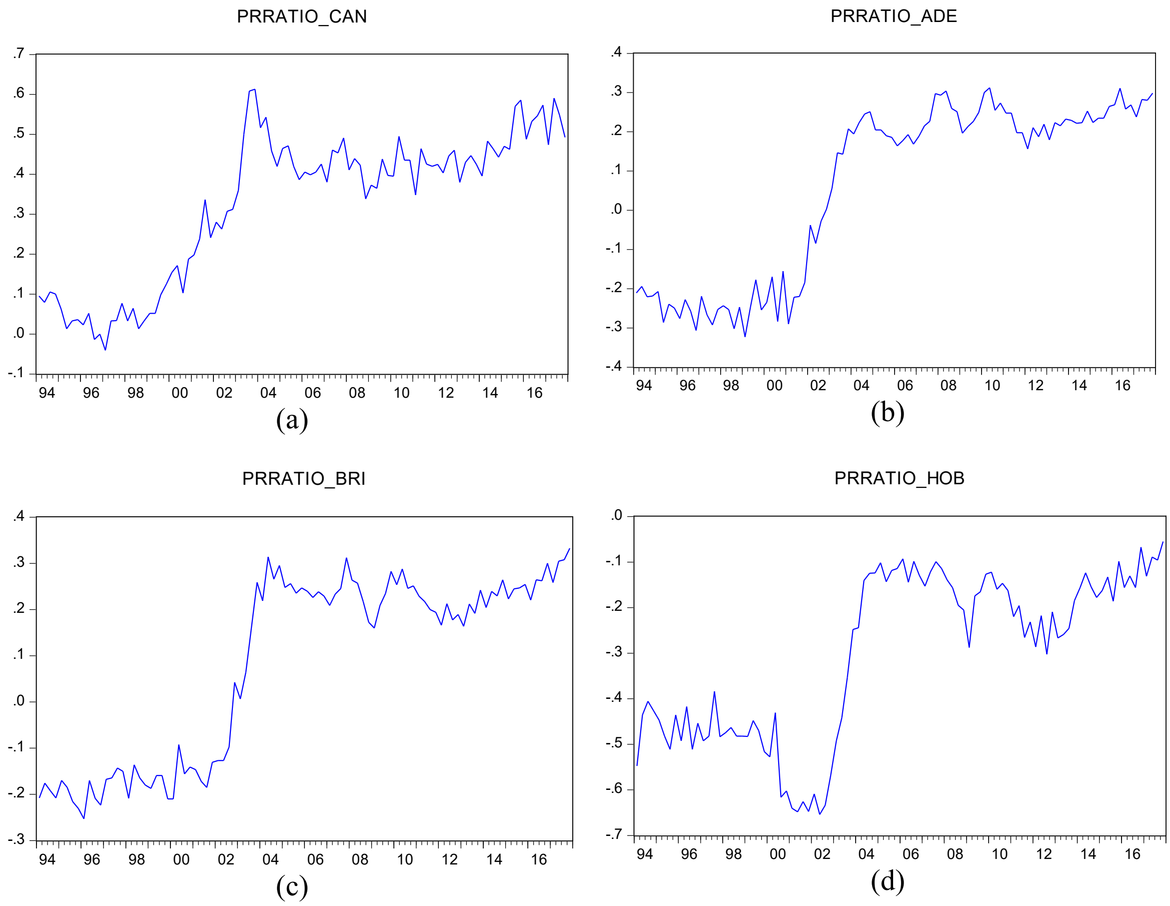

Figure 1 :Time Series Plots of Significant Variables in ADF Test with Structural Break

The ADF test is biased towards not rejecting the null hypothesis of the unit root presence (Perron 1989). The structural break ADF test takes this into account when testing stationarity. Table *4* presents the results of the structural break ADF test.

Following the structural break ADF tests, it is reasonable to conclude that dwelling completion per capita is a stationary I(0) process. In this case, the Sydney dwelling completion result reports a p-value of 0.1130, which is quite close to the 10 per cent significance level. Table *4* shows the mixed results from the breakpoint ADF test on other explanatory variables. For the unemployment rate and the log price-to-rent ratio, the formal evidence against the presence of a unit root is weak in four cities out of eight. In the case of population growth, it is the same in two cities out of eight. In addressing the same issues in similar ADF test results, Otto (2007) argues against the use of first-difference on these variables because the dependent variable is expressed in growth rates. Therefore, it is reasonable to also use growth rates or ratios for the independent variables. It is also noted that the model allows for k lags of each regressor, so variables can enter the model in first-differences because the coefficient estimates on the lags can sum to zero. Also providing at least two of the regressors in equation (4) are I(1), this equation can be balanced and treated as an unrestricted error correction model. For the reasons outlined by Otto (2007), this study applies the same logic and considers the few insignificant results as acceptable for this research project.

Table 4: Structure Break Unit Root Tests, 1994:1–2017:4

	Sydney	Melbourne	Brisbane	Adelaide	Perth	Hobart	Canberra	Darwin
Unemployment rate			-3.17	-3.90	-2.85	-3.51	-4.28*	
Population growth				-6.02***	-3.60	-4.04		
Log price-to-rent ratio	-2.39	-3.04	-5.92***	-6.09***	-3.49	-4.59**	-4.23*	-3.60
Dwelling completion per capita	-4.15	-7.16***						-7.33***

Notes:

- Breakpoint ADF test (Perron 1989) Structural Break statistics are reported for insignificant ones in Table *3*
- The null hypothesis is the presence of a unit root.
- ***, **, * represent 1%, 5% and 10% level of significance respectively.
- Lags were selected based on SBIC.

4.3 Empirical Results

We present the results of estimating a series of regression models based on Equation (4) in this section. All models include a constant term and three seasonal dummies to account for the first, second and third quarters in a calendar year (seasonal dummy 1, seasonal dummy 2 and seasonal dummy 3), with the fourth quarter serving as the reference quarter. After a visual inspection of residual graphs, an outlier dummy was created for the second and third quarters of 2003 (out03_2_3). The housing market reached its peak around quarter 2 and quarter 3 of 2003, which could not be predicted by our model. The RBA responded by raising interest rates in quarter 4 of 2003.

For each model, the results of several specification tests are reported along with the coefficient estimates. These specification tests include:

1. A test for serial correlation up to order twelve (Breusch 1978; Godfrey 1978). This study has chosen 12 lags for the serial correlation test, as this will cover a period of three years.
2. A BPK test for heteroskedasticity (Breusch & Pagan 1979; Koenker 1981).
3. A misspecification RESET test (Ramsey 1969).
4. A Normality Jarque-Bera test (Jarque & Bera 1987).
5. t and F-statistics are computed using heteroskedasticity consistent variance matrices (White 1980).

4.3.1 Benchmark User Cost Model

The first results are for the benchmark of the user cost model that restricts the focus to inflation, price-to-rent ratio and the real mortgage rate only. The estimates for each capital city are reported in Table 5. The number of lags for each variable is selected to ensure the elimination of serial correlation in the model. A common lag structure is used for each variable across all capital cities. Because of the large number of estimated coefficients, the report includes the sum of coefficient estimates on the lagged values of each variable for the stochastic regressors, and the p-value associated with an F-test for the joint significance of the k lags of each variable.

The real mortgage rate is reported to have a significantly negative effect on the real growth rate of house prices in majority of these cities. This is consistent with the real mortgage rate being the important driver on the real house price growth rate. The coefficients range from -5.894 to -0.998, with the cities of Sydney, Melbourne, Hobart and Canberra showing higher magnitudes compared to other cities. In the case of Canberra, which shows the highest impact, a 1 per cent increase in mortgage rate is associated with a 5.89 per cent decrease in house price growth. The sums of the coefficient estimates on the lags of the price-to-rent ratio are all negative, with the majority of these cities showing significant effects. This means that an increase in house prices relative to rents is associated with a subsequent decline in the future house price growth rate. For the lags of the dependent variable, only Sydney, Brisbane, Perth and Canberra show statistical significance, with a small negative coefficient result for Canberra. These results are not consistent with prior expectations.

It is expected that inflation rates will have a positive effect on real house price growth, and this is consistent with the results in Otto (2007). In the user cost model, house price growth is associated positively with the real interest rate, and to be consistent with the responsiveness to the real interest rate, the nominal interest rate will be negatively associated, and inflation will be positively associated. However, the results of this study show that inflation has a negative effect on house price growth, except in Adelaide which has a small positive coefficient of 0.008. The data in Otto (2007) covers the period between the second quarter of 1986 and the second quarter of 2005, whereas our data covers the period from the first quarter of 1994 to the fourth quarter of 2017. In both cases, the data covers the period from the first quarter of 1994 to the second quarter of 2005. Otto (2007) has an average inflation rate of 5.70 per cent between 1986 and 1993; however, for this study, the average inflation rate between 2006 and 2017 is only 2.46 per cent. This suggests that expectations of simultaneous high inflation and high house price growth did exist in the past. Since the Global Financial Crisis (GFC), however, Australia has been largely in a low inflation and high house price growth environment, and this combination seems to have changed the relationship between inflation and the house price growth rate.

In general, data covering the sampling period for Australia's capital cities provides support for the simple user cost model, but there are also mixed results that are not consistent with prior expectations. In Table 5, the model explains at least 44 per cent of the variation in the house price growth rates for 6 of the 8 capital cities. The only city where the variables have little explanatory power is Darwin (*R-square* is 0.035). In most cases, the estimated effects of the explanatory variables are statistically significant.

The results presented in Table 5 show Brisbane has significant serial correlation at 10 per cent, and the low p-values for the RESET tests for Sydney, Canberra and Darwin may imply the possible misspecification of this model. The benchmark model does not have serial correlations for all cities except Brisbane (with a p-value of 0.072). The RESET tests for Sydney, Canberra and Darwin suggest that there is some degree of non-linearity in variables. However, due to the complexity of the model, we focus on the linear specifications in this thesis.

Table 5 Benchmark User Cost Model for the Growth Rate of Real House Prices, 1994:1–2017:4

Dependent variable: real house price growth

Variable	**Sydney (1)**	**Melbourne (2)**	**Brisbane (3)**	**Adelaide (4)**	**Perth (5)**	**Hobart (6)**	**Canberra (7)**	**Darwin(8)**
Constant	9.707	15.035	5.636	2.883	3.947	6.989	13.563	2.522
sig	0.000	0.004	0.001	0.095	0.014	0.007	0.000	0.476
GST dummy	-3.199	5.098	-1.117	3.389	-2.591	-34.443	-5.791	-5.073
joint sig	0.000	0.000	0.000	0.000	0.032	0.000	0.000	0.000
Seasonal dummy1	-1.303	-4.883	-2.624	-0.824	-1.013	-1.876	-2.913	2.068
joint sig	0.008	0.001	0.006	0.387	0.183	0.117	0.017	0.105
Seasonal dummy2	0.353	-0.678	-1.072	-0.873	-2.163	-4.968	-2.014	0.689
joint sig	0.563	0.497	0.169	0.156	0.007	0.000	0.130	0.625
Seasonal dummy3	-0.733	-2.075	-2.719	-3.236	-2.469	-5.032	-3.856	-0.640
joint sig	0.187	0.057	0.002	0.000	0.000	0.000	0.000	0.636
Outlier dummy	3.625	0.902	6.928	4.559	2.938	7.619	13.654	-0.808
sig	0.001	0.355	0.000	0.000	0.002	0.001	0.000	0.756
Housing Price Growth(real) $\left(\sum_{i=1}^{3}\Delta\log P_{t-i}^{h}\right)$	0.205	-0.026	0.693	0.483	0.746	0.374	-0.055	0.410
joint sig	0.000	0.213	0.003	0.242	0.000	0.520	0.056	0.118
Real Mortgage rate $\left(\sum_{i=1}^{5} i_{t-i}\right)$	-4.217	-5.711	-2.526	-0.998	-2.033	-4.165	-5.894	-2.350
joint sig	0.001	0.188	0.155	0.046	0.000	0.011	0.003	0.079
Inflation $\left(\sum_{i=1}^{5}\pi_{t-i}\right)$	-2.491	-4.135	-1.079	0.008	-0.167	-0.259	-2.745	-0.360
joint sig	0.001	0.020	0.050	0.022	0.000	0.041	0.012	0.084
Log(price rent ratio) $\left(\sum_{i=1}^{5}\log\frac{P_{t-i}^{h}}{R_{t-i}^{h}}\right)$	-4.447	-7.290	-2.671	-1.536	-0.928	-6.389	-6.572	-2.273
joint sig	0.000	0.187	0.007	0.044	0.250	0.060	0.005	0.252
R-bar2	0.585	0.483	0.532	0.432	0.368	0.470	0.449	0.035
SC(12)	0.134	0.269	0.072	0.617	0.920	0.241	0.727	0.496
Heteroskedasticity	0.884	0.421	0.277	0.733	0.747	0.381	0.388	0.866
Normality	0.711	0.219	0.950	0.000	0.016	0.467	0.531	0.452
RESET	0.007	0.195	0.580	0.291	0.852	0.650	0.070	0.044

Notes:

- Sum of coefficients are reported in the table where applicable
- p values are reported for test of joint significance
- SC (12) is a test for serial correlation up to order twelve Breusch (1978), Godfrey (1978)
- BPK is a test for heteroskedasticity Breusch & Pagan (1979); Koenker (1981)
- RESET is a test for functional form misspecification Ramsey (1969)
- Normality test is based on Jarque & Bera (1987)

4.3.2 Additional Explanatory Variables

This section will examine whether the inclusion of additional explanatory variables can improve the performance of the benchmark model. The benchmark model only includes those variables that are suggested by the user cost model. However, the user cost model is based on a set of assumptions that may be overly restrictive for modelling the Australian market. Therefore, we consider a set of important additional variables. In total, eight additional variables are included in the benchmark user cost model. These variables include the real growth rate of state final demand, the unemployment rate, the rate of dwelling completions per capita, and the population growth. These four additional variables can be perceived as drivers of the expected growth in future price increases. The other additional explanatory variables include lags of Sydney house price growth rates, real equity returns, the real owner-occupier loan growth rate and the real investment loan growth rate (investment property). Taking into account the inclusion of many variables in the model, each variable was initially introduced one-by-one into the basic user cost model to address the issue of degree of freedom, and the results are reported in Table 6 and Table A- *1*. To avoid confusion between these two tables, *Table A- 1* is included in the Appendix section. The tables report the sum of the coefficients on the lags and a test for the joint significance of all the lags for each new variable.

The results in Table 6 and Table A- 1 include four lags and eight lags respectively. Models with eight lags are separately estimated in the regression in order to address potential multicollinearity issues. We generally favour the four-lags results, because of the issues concerning degrees of freedom and the number of variables included in the model. But we also made exceptions for the eight lags results in special circumstances that are detailed later in this section.

There is no overwhelming evidence to show that any of the additional regressors have a statistically significant effect on house prices in all Australian capital cities. However, some variables have a statistically significant effect in the majority of these cities. The real growth rates of state final demand and unemployment rates serve as a proxy for local economic conditions, influencing the local house price growth rate. In Table 6, the growth of real state final demand has a significant effect on the growth rate of house prices in Adelaide, Canberra and Darwin. However, for Darwin the effect is negative, which is at odds with prior expectations. The odd situation also applies to unemployment, which shows that Brisbane is the only city in which the unemployment rate has a significant and negative effect on the growth rate of house prices.

Table 6: Effects of Additional Explanatory Variables, 1994:1–2017:4 (4 lags)

Variable	Syd	Mel	Bri	Ade	Per	Hob	Can	Dar
Real state final demand (4)	0.612	-0.61	0.249	0.491	0.41	0.41	0.683	-0.065
joint sig	0.173	0.085	0.196	0.014	0.108	0.54	0.005	0.007
Unemployment (4)	0.362	-0.318	-0.743	-0.686	0.232	-0.587	-0.9	0.23
joint sig	0.074	0.253	0.037	0.137	0.161	0.507	0.317	0.794
Population growth (4)	6.488	12.146	9.901	1.46	-2.03	22.05	1.017	-7.39
joint sig	0.002	0.012	0	0.027	0.311	0	0.277	0.05
Dwelling completion per capita (4)	231.204	-1413.33	915.474	225.217	4.114	5816.705	-498.901	-6595.59
joint sig	0.332	0.548	0.019	0.578	0.766	0.223	0.017	0.128
Real equity return(4)	0.025	0.22	0.129	0.056	0.071	0.119	0.148	0.077
joint sig	0.335	0.001	0.001	0.493	0.354	0.007	0.362	0.844
Real owner-occupier loan growth (4)	0.047	-0.51	1.727	2.271	1.674	3.918	2.908	3.15
joint sig	0.874	0.611	0.004	0.002	0.013	0.041	0.06	0.103
Real investment loan growth(4)	-0.245	-1.559	0.983	0.5	1.303	2.085	1.018	1.766
joint sig	0.004	0.17	0.202	0.769	0.477	0.189	0	0.108
Sydney effect (4)		-0.15	-0.251	0.112	-0.267	-0.113	0.217	-0.76
joint sig		0.607	0.137	0.718	0.001	0.599	0.227	0.179

Population growth is often expected to have a positive effect on house price growth. The results in Table 6 confirm that five out of eight cities demonstrate that population increase has a positive and significant effect. The Canberra and Perth results are insignificant, and while Darwin exhibits a significant effect right on 5 per cent, the effect is negative, contrary to prior expectations.

Otto (2007) uses state-based dwelling approvals per capita as a proxy for the possible effects of supply restrictions on house prices. We use state based dwelling completions per capita in this study, as approval numbers could include housing approvals that never proceeded to building or completion stage and therefore should be excluded from the housing supply estimates. Even when approvals proceed to completion, there is a time lag that could distort the measurement of its effect on house price growth. When new housing supply is restricted by government policies, dwelling completions per capita numbers will be affected. This reduction in supply should boost the real growth rate of housing prices. From the results in Table 6, however, there seems to be no systematic effect on the growth rate of house prices due to dwelling completions per capita, indicating that variations in supply have no significant effect on house price growth.

Table 6 shows that the performance of the Australian stock market has a positive effect on the house price growth rate in all eight cities. In Melbourne, Brisbane and Hobart, the results are significant. This suggests that both the stock market and housing market move in the same direction, so in these cities, the results show that when share market returns are growing, the real house price also grows. However, overall, in statistical terms, it does not prove any direct or causal relationship.

As Table 6 shows, the real owner-occupier loan growth rate appears to have a positive effect on house price growth rates. The cities of Brisbane, Adelaide, Perth, Hobart and Canberra all show significant effects on house price growth rate. This seems to suggest that the credit growth rate on owner-occupier home loans has a positive influence on the house price growth rate. It is interesting to note that the Sydney and Melbourne results are insignificant, whereas the results for the majority of the smaller capital cities are significant.

An exception is made for the real investment loan (investment property) growth rate by adopting the eight lags results in Table A- *1* instead of the four lags results in Table 6. Both the four lags and the eight lags results are significant for Canberra and Sydney (Sydney's eight lags result is on the borderline). The four lags results in Table 6 showing Melbourne, Brisbane, Adelaide, Perth and Darwin are insignificant but turn out to be significant for their eight lags results in Table A- *1*. Due to this special situation, the eight lags results are included in the models for all cities. As reported in Table A- *1*, for six out of eight cities that show real investment loan growth having a significant effect on the real house price growth rate, only Sydney, Melbourne and Adelaide show negative effects, while the remaining cities are positive. Despite this difference, the real investment loan growth appears to show strong influence in all capital cities except Hobart and Sydney.

It is important to note that the growth rate for owner-occupier loans and investment property loans are national figures rather than city-based numbers. Overall, as shown in Table A- *1*, there are six cities showing real investment loan growth having a significant influence on house price growth. This seems to suggest that investor influences have a wider presence in the market compared to owner-occupier influences on house price growth, as the cities with owner-occupied loan significance are limited to only four out of eight capital cities as reported in Table 6. This seems to suggest that the recent government and regulator policy initiatives to crack down on investor mortgage lending are correctly targeted.

On the other hand, if we look at the results for Brisbane, Adelaide and Perth in Table A- *1*, where both investment loan growth and owner-occupier loan growth show significant effects on house price growth, the coefficient value indicates that owner-occupier loans have a higher impact on driving up house prices, especially in Adelaide where investment loan growth has a negative coefficient. In these three cities, house price growth appears to increase more in response to owner-occupier loan growth than to investment loan growth. In this case, policy makers may feel more comfortable knowing that owner-occupiers are driving up house prices rather than speculative investors.

Bewley, Dvornak & Livera (2004) find that the Sydney housing market can influence the performance of other housing markets in Australia. An exception was made for this "Sydney effect" by adopting the city's eight lags results instead of its four lags results. Both the four lags and the eight lags results are significant for Perth. The four lags results for Melbourne, Brisbane, Adelaide and Darwin in Table 6 are insignificant but their eight lags results reported in Table A- *1* turn out to be significant. Due to this special situation, the eight lags results are included in the model for these five cities. As shown in Table A- *1*, for the five seven cities that have a significant "Sydney effect" on the real house price growth rate, all signs are negative, indicating the reverse direction of the Sydney growth situation.

The results in Table 6 and Table A- 1 indicate that further improvements can be made to the benchmark user cost model in all cities by including additional explanatory variables. Therefore, we can develop a general model for the growth rate of house prices in each of the eight capital cities.

4.3.3 General Model

We rely on the results from Table 6 and Table A- *1* as a guide to determine which variables and how many lags should be included to strengthen the benchmark user cost models, in order to construct the most suitable general model for each capital city. Table 7 reports the initial set of estimates without the "Sydney effect" on house prices in the other capital cities.

The empirical results in Table 7 show that the real mortgage rate plays an important role in influencing the real growth rate of house prices. For all capital cities, the estimated marginal effect of the real mortgage rate on the real growth rate of house prices is negative. Except in Darwin, the estimates are statistically significant at 5 per cent, while the estimate for Darwin is significant at 10 per cent. Although the estimates are all statistically significant, however, the magnitude of this effect is quite different across these cities. Housing markets in Melbourne and Sydney are most responsive to changes in the real mortgage rate, while Darwin is the least responsive city. For example, a 1 per cent increase in the real mortgage rate will reduce house price growth by 8.39 (5.34) per cent for Melbourne (Sydney), while house price growth in Darwin will only be marginally reduced, by 0.22 per cent. These results are consistent with the finding that house prices are more sensitive to changes in real interest rates in high appreciation rate cities (Himmelberg, Mayer & Sinai 2005).

As discussed in the Introduction, one advantage of the autoregressive distributed lag model is that it allows us to calculate the long-run impact of our variables on house price growth. Ceteris paribus, a 25 basis points increase in the real mortgage rate will reduce the long-run growth rate of real house prices in Melbourne (Sydney) by 1.99 (0.69) per cent per quarter. [1] It is interesting that the real mortgage rate has a much bigger effect in the short run compared to the long run for Melbourne and Sydney. This is due to the puzzling fact that the sum of the auto-regressive terms is negative. Further analysis shows that for both Sydney and Hobart, it is the population growth that caused the sum of the auto-regressive terms turning negative. For Canberra, the real investment loan growth is responsible since the only significant additional variable for this capital is the real investment loan growth.

In the general model, inflation seems to play a limited role, as reported in Table 7. Only Perth, Hobart and Canberra show significant inflation effects on the house price growth rate. Ceteris paribus, a 1 per cent inflation hike will increase the long-run growth rate of the real house price in Perth by 1.740 per cent per quarter.[2] In this case, inflation has a bigger effect in the long run compared to the short run for Perth, as the sum of the auto-regressive terms is positive.

It is interesting to note that the sums of the coefficient estimates for the lags of the price-to-rent ratio are negative and significant for Sydney, Melbourne, Brisbane and Adelaide, but positive for the rest of the four capital cities. Out of the four capital cities that have a positive coefficient, the estimates for Perth and Hobart are significant at 1 per cent. Theoretically, the user cost model implies a negative coefficient on the price-to-rent ratio because an increase in the current ratio of house prices to rent implies that renting becomes more attractive, pushing up the demand for renting and reducing the demand for buying. This will lead to a fall in future house prices. Therefore, the Perth and Hobart situation are at odds with prior expectations. It is also evident that the magnitude of the price-to-rent ratio effect shows quite large differences between cities. The growth rates of house prices are most responsive to a change in the price-to-rent ratio in Melbourne and Hobart, and least responsive in Sydney. Their coefficients range from -4.193 to -19.714. Ceteris paribus, a 1 per cent increase for the lags of the price-to-rent ratio will reduce the long-run growth rate of the real house price in Sydney by 2.16 per cent.[3]

The real state final demand shows limited influence in the general model, with only Adelaide and Darwin showing significant effects. In addition, the sign of these significant coefficients is

[1]The calculation for Melbourne is (-8.388/(1-(-0.054)))*0.25 =-1.99) for the long-run effect and the calculation for Sydney is (-5.335/(1-(-0.939)))*0.25 =-0.69) for the long-run effect.

[2] The calculation for Perth is 0.72/(1-0.586)=1.74 for the long-run effect.

[3] The calculation for Sydney is (-4.193/(1-(-0.939)) =-2.16) for the long-run effect.

negative, which is at odds with the expectation of a positive relationship between price and demand. The short-run coefficient of real state final demand in Adelaide is -0.731, which means that a 1 per cent increase in real state final demand will decrease house price growth rate by 0.73 per cent per quarter. Ceteris paribus, a 1 per cent increase in real state final demand will reduce the long-run growth rate of the real house price in Adelaide by 1.29 per cent.[4] The real state final demand has a bigger effect in the long run compared to the short run for Adelaide.

The unemployment rate only shows a significant negative effect in the city of Brisbane. The irrelevance of the unemployment rate may reflect the fact that the unemployment rate is relatively low and stable due to 27 years of continuous growth, and therefore has less influence on the house price growth rate. The results in Otto (2007) show that the unemployment rate has a negative and significant effect only in Brisbane and Adelaide, a similar result to this study.

Regarding population growth, Sydney, Melbourne, Adelaide and Hobart show a positive and significant effect on house price growth. Sydney and Melbourne are the top destinations for inbound overseas migration, so the results are consistent with prior expectations. Hobart is characterized by demographic changes where more young people leave the island for better job opportunities on the mainland, and more senior citizens move into the state for retirement. Compared with the results in Otto (2007), we find that these same four cities have the highest increases in their quarterly average growth rate. Hobart shows the strongest house price growth, up from 0.31 per cent per quarter in Otto (2007) to 0.94 per cent per quarter in this study, as shown in Table 1. This seems to indicate that population growth is a strong driving force for the real house price growth in these four cities, especially towards the later part of the sample period.

It is not immediately clear why the other four cities do not report significant results regarding the population growth variable. One possibility could be that these cities have a larger housing stock relative to smaller inbound immigration, and therefore the change in population is not strong enough to impact on house price growth.

Melbourne, Brisbane and Hobart show positive and significant effects from the real share market return to the real house price growth rate. Otto (2007) reports that Sydney, Brisbane, Hobart and Canberra show a statistically significant negative relationship between stock returns and the real house price growth rate. One possible explanation for this contradiction could be that Otto's (2007) sample period ends at 2005, and this study includes the post-GFC period, in which the Australian share market moved from around 3,100 points during the GFC to around 6,000 points in December 2017. During the same period, house prices also achieved solid growth, so the significant effect

[4] The calculation for Adelaide is (-0.731/(1-0.435) =-1.29) for the long-run effect.

between these two variables shows a positive sign in this study. The real share market return has a similar magnitude in both the long run and the short run for Melbourne. Ceteris paribus, a 1 per cent increase in the real share market return will lift the short-run and long-run growth rates of the real house price in Melbourne by 0.39 per cent and 0.37 per cent respectively.[5]

As reported in Table 7, Brisbane and Adelaide are the only cities demonstrating that owner-occupier loan growth rates have a significant effect on the growth rates of house prices. However, these happen to be the only two cities that show investment loan growth having a negative significant effect on house price growth in the long-run model. The magnitude of these coefficients is much higher than those of investment loan growth, indicating that owner-occupier buyers have a much bigger influence on house price growth compared to investors in Brisbane and Adelaide. The real owner-occupier loan growth has a bigger effect in the long run compared to the short run for Brisbane. Ceteris paribus, a 1 per cent increase in the real owner-occupier loan growth will increase the short-run and long-run growth of the real house price in Brisbane by 1.65 per cent and 3.04 per cent respectively.[6]

With the exceptions of Melbourne and Hobart, real investment loan growth rates are found to have a significant effect on house price growth rates. Generally, residential property investors are considered to be more speculative and more resourceful compared owner-occupier home owners. If they are active in the housing market, we would expect to see high investment property loan growth rates. Increases in investment loans will increase the demand for the housing market, causing house prices to grow. The increase in house prices may further spur investors' speculations on future house price growth, leading to an even higher growth rate. The real investment loan growth rate has a smaller magnitude in the long run compared to the short run for Sydney. Ceteris paribus, a 1 per cent increase in the real investment loan growth will increase the short-run and long-run growth of the real house price in Sydney by1.84 per cent and 0.95 per cent respectively.[7]

The results from Table 7 show that in the general model, for most of the cities, the real investment loan growth rate has a positive effect on the house price growth rate. For Brisbane and Adelaide, however, the relationship is negative. The reason for this negative effect is not immediately clear. One possibility could be that because the investment loan growth rate is a nationwide figure, and

[5] The calculation for Melbourne is (0.389/(1-(-0.054)) =0.37) for the long-run effect

[6] The calculation for Brisbane is (1.647/(1-0.458) =3.04) for the long-run effect

[7] The calculation for Sydney is (1.838/(1-(-0.939)) =0.95)

Sydney, Melbourne, Brisbane and Adelaide account for most of the investor activities in the country due to their economic, geographic and infrastructure connections, investor loan volume growth is more directed towards the Sydney and Melbourne markets at the expense of Brisbane and Adelaide.

Considering both types of loans, the results suggest that investor credit growth is a more important determinant than owner-occupier credit growth in driving the house price growth rate. This is an important finding with implications for government policy. In the long run, in order to reduce excessive house price growth, government policies might need to address the current competitive advantages that investors enjoy compared to owner-occupiers. These advantages include rental income, negative gearing deductions and capital gains tax treatment, etc.

Table 7:The Generalised User Cost Model, 1994:1–2017:4

Variable	Sydney	Melbourne	Brisbane	Adelaide	Perth	Hobart	Canberra	Darwin
Constant	3.164	14.543	11.761	4.172	2.144	3.507	8.678	-2.056
Sig	0.194	0.005	0.000	0.003	0.356	0.119	0.025	0.541
GST dummy	-10.288	5.840	0.451	-1.465	0.648	-22.554	14.331	-11.584
joint sig	0.000	0.000	0.000	0.000	0.022	0.000	0.000	0.000
Seasonal dummy1	0.939	-6.620	-1.690	-1.951	-1.045	1.094	-2.478	1.868
joint sig	0.401	0.006	0.011	0.105	0.162	0.458	0.036	0.077
Seasonal dummy2	1.455	-1.041	-1.118	-0.631	-1.733	-3.772	-1.957	0.441
joint sig	0.041	0.523	0.068	0.482	0.032	0.009	0.103	0.773
Seasonal dummy3	1.262	-0.269	-2.717	-3.623	-1.634	-3.085	-4.104	0.081
joint sig	0.299	0.908	0.000	0.000	0.025	0.034	0.000	0.952
Outlier dummy	3.993	5.302	8.749	5.898	3.287	4.764	15.263	-1.363
Sig	0.000	0.010	0.000	0.000	0.013	0.047	0.000	0.664
Housing Price Growth(real)	-0.939	-0.054	0.458	0.435	0.586	-0.514	-0.491	0.266
joint sig	0.000	0.053	0.000	0.037	0.019	0.253	0.019	0.678
Real Mortgage rate	-5.335	-8.388	-3.244	-3.163	-2.632	-4.968	-4.555	-0.219
joint sig	0.000	0.011	0.000	0.000	0.000	0.020	0.002	0.090
Inflation	-0.317	-3.453	-0.755	1.108	0.720	-6.673	-1.367	3.319
joint sig	0.291	0.807	0.166	0.193	0.000	0.004	0.085	0.330
log(price-rent ratio)	-4.193	-19.714	-9.946	-7.129	4.126	-18.482	0.217	3.086
joint sig	0.000	0.000	0.000	0.000	0.003	0.000	0.397	0.257
Real state final demand (4)				-0.731				-0.175
joint sig				0.001				0.021
Unemployment (4)			-0.804					
joint sig			0.000					
Population growth (4)	18.693	20.966		9.345		30.136		
joint sig	0.000	0.003		0.012		0.000		
Real equity return(4)		0.389	0.216			0.324		
joint sig		0.000	0.000			0.000		
Real owner-occupier loan growth (4)			1.647	4.555				
joint sig			0.005	0.000				
Real investment loan growth(8)	1.838	0.372	-0.878	-1.134	1.577		1.116	2.106
joint sig	0.000	0.143	0.000	0.009	0.036		0.000	0.034
R-barsq	0.673	0.585	0.655	0.603	0.361	0.610	0.539	0.064
SC(12)	0.475	0.600	0.059	0.434	0.865	0.621	0.823	0.895
Heteroskedasticity	0.979	0.691	0.955	0.821	0.999	0.885	0.377	0.541
Normality	0.535	0.265	0.006	0.036	0.076	0.675	0.315	0.588
RESET	0.572	0.009	0.003	0.235	0.289	0.768	0.108	0.000

Notes:

- Sum of coefficients are reported in the table where applicable
- P-values are reported for test of joint significance

- lag lengths are mentioned in the parenthesis
- SC (12) is a test for serial correlation up to order twelve Breusch (1978), Godfrey (1978)
- BPK is a test for heteroskedasticity Breusch & Pagan (1979); Koenker (1981)
- RESET is a test for functional form misspecification Ramsey (1969)
- Normality test is based on Jarque & Bera (1987)

4.3.4 General Model with "Sydney Effect"

Table 8 shows the estimation results for the general model with the "Sydney effect". Since only Brisbane, Adelaide, Perth and Darwin have a significant "Sydney effect", we focus our discussion on these four capital cities. Brisbane and Adelaide have a positive "Sydney effect", while Perth and Darwin show a negative relationship. The "Sydney effect" has a slightly bigger effect in the long run compared to the short run for Brisbane. The estimates suggest that other things being equal, a 1 per cent rise in the growth rate of house prices in Sydney is estimated to increase the short-run and long-run growth rates in Brisbane by 0.526 per cent and 0.612 per cent respectively.[8]

Note that in some cases, including the "Sydney effect" causes changes in the estimates of other variables. Comparing the estimates for Brisbane, the inclusion of the "Sydney effect" causes inflation to become significant, and the serial correlation test p-value improves from 0.059 to 0.419. For Perth, the RESET p-value changes from 0.289 to 0.009, and the inclusion of the "Sydney effect" changes the inflation sign from positive to negative. In the case of Adelaide, inflation becomes significant while real investment loan growth becomes insignificant. For Darwin, the real mortgage rate becomes significant and the real investment loan growth rate becomes insignificant. This may be due to the fact that the Sydney house price growth rate is correlated with other explanatory variables such as investment loan growth.

In addition Bewley, Dvornak & Livera (2004) claiming the predictive power of Sydney's housing prices on other Australian cities, Otto (2007) has also confirmed that this "Sydney effect" in Melbourne, Brisbane, Perth and Canberra is significant and positive. Valadkhani & Smyth (2017) find that when unit prices are on the increase, meaning the market is bullish or "self-excited", house prices show significantly greater positive influences on unit prices. Their research finds evidence of varying degrees of herd mentality in the Australian property market with Sydney as the most "excitable" capital city. The reasons for this "Sydney Effect" is not immediately clear. Otto (2007) suggests that it may represent a true causal relationship, where changes in the returns to housing in Sydney induce buyers to move into (and out of) housing markets in other capital cities. This suggestion seems to match the "herd mentality" described in Valadkhani & Smyth (2017). As Sydney is the most prominent city in Australia, both from a national and an

[8] The calculation for Brisbane is (0.526/(1-0.141) =0.61) for the long-run effect

international perspective, having various degrees of "Sydney effect" from time to time seems to be logical.

Table 8: The Generalised User Cost Model with Sydney Effect, 1994:1–2017:4

Variable	Brisbane	Adelaide	Perth	Darwin
Constant	13.339	2.794	10.268	14.626
sig	0.000	0.357	0.001	0.015
GST dummy	3.678	-0.279	-4.586	-8.012
joint sig	0.000	0.000	0.023	0.019
Seasonal dummy1	-2.938	-1.672	-0.742	1.892
joint sig	0.000	0.204	0.323	0.116
Seasonal dummy2	-1.280	-0.916	-2.578	-1.310
joint sig	0.041	0.327	0.002	0.353
Seasonal dummy3	-3.895	-3.664	-1.726	-0.381
joint sig	0.000	0.000	0.013	0.761
out2003_2_3	8.966	6.549	2.961	-0.711
sig	0.000	0.000	0.014	0.826
Housing Price Growth(real)	0.141	0.234	0.119	0.044
joint sig	0.000	0.254	0.248	0.990
Real Mortgage rate	-1.259	-2.685	-6.983	-9.481
joint sig	0.001	0.014	0.000	0.000
Inflation	0.587	1.323	-0.887	-3.446
joint sig	0.013	0.038	0.000	0.146
log(prratio)	-12.610	-5.690	0.528	-5.747
joint sig	0.000	0.004	0.044	0.171
Real state final demand (4)		-0.536		-0.372
joint sig		0.005		0.025
Unemployment (4)	-1.475			
joint sig	0.002			
Population growth (4)		10.108		
joint sig		0.017		
Real equity return (4)	0.270			
joint sig	0.000			
Real owner-occupier loan growth (4)	2.222	4.463		
joint sig	0.003	0.000		
Real investment loan growth (8)	-1.344	-0.633	2.612	2.636
joint sig	0.000	0.262	0.001	0.073
Sydney effect (8)	0.526	0.097	-1.139	-1.761
joint sig	0.002	0.009	0.000	0.035
R-barsq	0.652	0.560	0.457	0.047
SC(12)	0.419	0.721	0.724	0.769
Heteroskedasticity	0.759	0.947	0.992	0.699
Normality	0.003	0.013	0.041	0.341
RESET	0.001	0.046	0.009	0.000

Notes:

- Sum of coefficients are reported in the table where applicable
- p-values are reported for test of joint significance
- lag lengths are mentioned in the parenthesis
- SC (12) is a test for serial correlation up to order twelve Breusch (1978), Godfrey (1978)
- BPK is a test for heteroskedasticity Breusch & Pagan (1979); Koenker (1981)
- RESET is a test for functional form misspecification Ramsey (1969)
- Normality test is based on Jarque & Bera (1987)

5. Further Discussion

This study identifies the economic fundamentals that determine housing price growth in Australia's eight capital cities. Except for Darwin, our generalised user cost model explains real house price growth well, with more than half of the fluctuations in growth explained for Sydney, Melbourne, Brisbane, Adelaide, Hobart and Canberra. Our results show that real mortgage rate, price-to-rent ratio and the growth of real investment loans are very important in driving the real house price growth across most capital cities. However, the results also indicate that the housing market in each capital city is distinct and responds to a different set of economic fundamentals.

This thesis closely follows the framework used by Otto (2007), with two main differences: (1) we extend the sample period to 2017; and (2) we introduce real owner-occupier loan growth and investment loan growth to reflect the most recent developments in the housing markets. Otto (2007) finds that the mortgage rate and inflation rate were the main determinants of house price growth between 1986 and 2005. Although the mortgage rate remains important in our model, inflation is no longer important. Instead, we find the growth of real investment loans is very important in driving real house price growth, at least in six capital cities.

There have been important developments in the housing market since 2005. In Otto's sample period, the variable mortgage rates were more closely linked to the RBA's cash rate. Post 2005, and especially since the GFC, the variable mortgage rates are influenced by both the RBA and the international wholesale funding market. This is characterized by "out of cycle" mortgage rate changes independent of the RBA's cash rate decisions, which are a result of increasing reliance on capital imports by the Australian banking industry. Even when they change mortgage rates in response to the RBA's cash rate movements (Valadkhani & Worthington 2014) show that the banks pass on 120 per cent of any rate rise, but only 85 per cent of any rate cut. In this regard, the findings in Otto (2007) and the results of this study regarding variable mortgage rates might have different implications for monetary policy, as the mortgage rate is no longer indexed to the cash rate. It is also interesting to note that contrary to Otto (2007) findings, inflation is not identified as a major driver of house price growth in this study. This could be caused by the fact that the sample period for the prior study covers times with higher house price growth and CPI inflation, whereas this study covers a unique post-GFC period featuring high house price growth and low CPI inflation. Lower and more stable inflation as an independent variable by itself would exert less influence on the real house price growth as a dependent variable.

Bourassa & Hendershott (1995) studied the period between 1979 and 1993. They found that the growth rate in real wage income (primarily coming from employment growth) and net overseas migration growth were the main forces driving real house prices in Australia's six capital cities.

Our results conform with Bourassa & Hendershott (1995) and indicate that population growth remains one of the important factors driving growth in the Australian housing market.

It is interesting that variable mortgage rates do not play a prominent role in the house price growth rate in Bourassa & Hendershott (1995), while both Otto (2007) and our results indicate otherwise. The sample of Bourassa & Hendershott (1995) is characterized by the implementation of financial deregulation and the creation of a new financial and economic environment in Australia. Covering a period of roughly 13 years, deregulation starts from the removal of interest rate controls in 1973. It continues through the tendering of Treasury notes in 1979 and Treasury bonds in 1982, to the floating of the Australian dollar in 1983. Finally, deregulation concludes with approval being granted for foreign banks to enter the Australian financial market, easing the requirements to establish new domestic banks to increase competition (Kohler & Van Der Merwe 2015). Interest rates during this time were mostly in double digits and were as high as 17 per cent before the last Australian recession. In such an environment, the majority of consumers choose fixed mortgage rate products to protect themselves from potential interest rate increases. Therefore, variable mortgage rate adjustments did not play a significant role in driving house price growth.

Another major development in the housing market since the era of financial deregulation is that the mortgage finance market has become competitive, which allows easier access to credit, and is more cost effective for consumers. In addition, since the 2008 GFC, Australian housing markets are safer and offer relatively stable returns, thus receiving elevated attention from both domestic and foreign investors. As the Reserve Bank Assistant Governor Michele Bullock put it, "Australians borrow not only to finance their own homes but also to invest in housing as an asset". This is different from many other countries, where a significant proportion of rental stock is owned by corporations or cooperatives (Kadib 2018b). Indeed, the investor share of the housing market is increasing. In 1991, 26.9 per cent of dwellings were investment properties; in the 2016 Census this number had increased to 30.9 per cent (ABS Census 2016).

In addition, starting in August 2015, banks lifted the standard variable mortgage rate on investment property loans while keeping the standard variable mortgage rate on owner-occupier property loans unchanged. Prior to this change, standard variable rates on investment property loans and owner-occupier property loans were the same (Source: RBA F5). From the author's working experience, these two rates were set as the same starting in around the year 2000; prior to that, the standard variable rate for investment property loans was one per cent higher than the standard variable rate for owner-occupier property loans.

These developments in the banking sector significantly increased the demand for housing, from both owner-occupiers and investors, resulting in the fast growth of housing loans, accompanied by high house price growth. As a result, we find a significant link between loan growth and house price growth for the majority of capital cities. Among the loan types, our results indicate that investment loan growth has had a far more pervasive effect on real house price growth compared to residential loan growth.

Our results also show that the price-to-rent ratio, as a measure of housing affordability, plays a significant role in real house price growth. The 2016 Census shows a consistent decline in the home ownership ratio in Australia over the last three decades for people under 55 years. In 2016, around 31 per cent of total dwellings in Australia were rental properties, whereas this was about 27 per cent in 1991 (ABS Census 2016). Our results indicate a fall in the price-to-rent ratio would result in a rise in the house price growth in Sydney and Melbourne. This has a significant policy implication in that government efforts to increase housing affordability may result in an unintended increase in house price growth.

On the supply side, in our generalised user cost model, we do not find any evidence that housing supply is a major factor behind real house price growth. As Professor Rachel Ong put it, "there is no major shortage of houses for Australians to live in. If there were, rents would be taking off"(Commins 2018).

Our results highlight the importance of heterogeneity in the Australian housing market, and therefore advocate for separate models to model the individual markets. This is consistent with the findings of Himmelberg, Mayer & Sinai (2005) that house price dynamics are a local phenomenon and aggregated data at national level could obscure important economic differences among cities. The former Commonwealth Bank CEO, Ian Narev, goes further to claim that "Australia has about 2,000 housing markets". He argues that "The market with a five-kilometre radius of where we are now (in Sydney) or within a five-kilometre radius of the CBD in Melbourne has very different characteristics from what you might see in other parts of those states, or indeed in other parts of the country". He breaks down the whole Australian housing market into small patches with different characteristics such as population growth, urbanisation, the supply of new housing stock, transport infrastructure, foreign buyer interest and the buying tendency of the Australian economy. Such detailed market segmentation for Australia represents the view of Commonwealth Bank that this housing market is not a generalised one with common characteristics (Kane 2017).

Most of the capital cities' housing markets have experienced a significant slowdown since 2016. Although our results indicate that real state final demand and unemployment rates were not important in driving the housing market for most of the capital cities, there may exist a nonlinear relationship that only operates in economic downturns. This may stem from excessive risk taking during the good times but result in excessive financial stress in bad times. In the case of an economic downturn, a borrower may lose their job and thus potentially default on their loan. This would increase supply and reduce demand, and thus lower house price growth. This lower growth (or perhaps reduction) in household wealth would have important implications, amplifying or even creating economic downturns. Therefore, it is important for the Australian Prudential Regulation Authority (APRA) to regulate the banks to mitigate excessive risk taking during good times.

We have heard the unbelievable but true stories from the Banking Royal Commission on how the banks have conducted their lending practices over the years. If mortgage loans are provided to borrowers due to irresponsible lending practices by the banks, and the banking regulators do not stop such harmful conduct due to their own oversight, both the banks and the government have a duty of care to assist those borrowers should they find themselves struggling with their mortgage repayments. Once a loan is given and a house is purchased, it is impossible to rewind without the borrowers incurring substantial costs during an economic shock. In such circumstances, the borrowers should be given special considerations to meet their refinance or interest-only reset needs. Otherwise, the consequences will be dire for as the borrowers face mountains of debts and reducing property prices during an economic downturn.

6. Conclusion

Using data from the period 1994 to 2017, we show that the real house price growth in eight Australian capital cities is closely related to the real mortgage rate and real investment loan growth rate. Both of these two factors are related to banks and their lending practices, which suggests further investigation into how banks' lending policies can affect house price growth. This study shows that a 25 basis points increase in the real mortgage rate will reduce the long-run growth rate of the real house price in Sydney by about 0.69 per cent per quarter. The results show that investor demands have a lot more influence on house price growth compared to owner-occupier demands in most Australian capital cities, and that Melbourne is prone to owner-occupier loan growth, while investment property loan growth is important for Sydney. The study also shows that the price-to-rent ratio and population growth have strong influences on real house price growth. Compared with the results of Otto (2007), Sydney, Melbourne, Adelaide and Hobart have the highest increases in average house price growth rates, and population growth also has a positive significant effect in these four cities. For most Australian capital cities, economic factors explain around 50 to 60 per cent of variation in the growth rate of house prices.

The results of this study are consistent with the government's efforts to contain house price growth by restricting lending to investors. Housing affordability has become a major concern. Indeed, Sydney recorded a cumulative house price growth of 180 per cent over the sample period, but the cumulative wage growth was only 99.6 per cent for the same period (Angus 2017). By varying profit margins on lending rates, and controlling credit availability to both investors and owner-occupiers, banks have a lot of influence on mortgage rates and investment loan growth rates, and these two drivers are identified as important determinants of house price growth in Australia' s eight capital cities. Additional research into how bank behaviour influences house price growth in Australia is warranted.

This thesis also finds that there are substantial differences between the housing markets in Australia's eight capital cities. This heterogeneity indicates that it is important to separately identify the key determinants in each of the markets.

Our model is based on the user cost model, which is partial equilibrium in nature (Fox & Tulip 2014). There are other important factors, such as taxation on foreign purchases or negative gearing policies, that are not feasible to consider in this thesis but that would have very important policy implications. Future research may investigate the impact of these factors should the data become available.

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Appendix

Table A- 1:: Effects of Additional Explanatory Variables, 1994:1–2017:4 (8 lags)

Variable	Syd	Mel	Bri	Ade	Per	Hob	Can	Dar
Real state final demand (8)	-0.287	-1.333	0.369	0.337	0.106	0.589	1.282	0.396
joint sig	0.007	0.116	0.009	0.016	0.202	0.209	0.003	0.01
Unemployment (8)	0.532	-0.582	-0.415	-0.608	0.194	-0.375	-1.2	0.495
joint sig	0.084	0.085	0	0.331	0.031	0.086	0.021	0.945
Population growth (8)	6.262	11.576	8.977	-3.536	-2.048	19.372	2.255	-8.684
joint sig	0.002	0.005	0	0.008	0.035	0	0.447	0.138
Dwelling completion per capita (8)	724.181	-2400.94	734.368	1620.964	803.257	3525	-2032.42	-7741.46
joint sig	0.02	0.838	0.122	0.516	0.362	0.194	0.001	0.041
Real equity return (8)	0.033	0.121	0.108	0.02	0.024	-0.074	0.03	-0.12
joint sig	0.112	0	0.002	0.373	0.09	0	0.039	0.067
Real owner-occupier loan growth (8)	-0.46	0.096	1.688	1.369	2.547	5.016	2.099	3.864
joint sig	0.103	0.587	0	0	0.006	0.06	0.002	0.102
Real investment loan growth (8)	-0.174	-1.573	1.173	-0.647	1.577	2.332	1.116	2.226
joint sig	0.106	0.041	0.009	0.012	0.036	0.17	0	0.028
Sydney effect (8)		-0.482	-0.346	-0.18	-0.355	-0.038	0.124	-0.611
joint sig		0.096	0.029	0.066	0	0.14	0.298	0.036