Housing Affordability and Housing Submarkets: The Case of Greater Sydney

By

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A thesis submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy at the Western Sydney University

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I.

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While Western Sydney University staff may have offered supervision and advice to the author, the Western Sydney University is unable to accept responsibility for any advice, recommendations, suggestions or conclusions contained in this piece of work.

The Western Sydney University gratefully acknowledges the co-operation given to the student author, since studies such as these permit students to examine real world issues in a context which provides an opportunity for meaningful research to be conducted and reported.

II.

DECLARATION

This thesis has been prepared to meet the requirements of a Doctor of Philosophy degree at the Western Sydney University.

I declare that this thesis represents my work, except where due acknowledgement is made, and it has not been previously included in a thesis, dissertation or report submitted to this University or to any other institution for the award of a degree, diploma or other qualification.

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III.

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All praises to God for giving me good health and strength to overcome all the difficulties that I faced during this research. I have experienced your guidance day by day and I will keep on trusting you for my future.

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IV.

PREFACE

The work herein was undertaken by the candidate in the School of Business, Western Sydney University. The candidate was supervised by Associate Professor Chyi Lin Lee, Associate Professor Partha Gangopadhyay and Associate Professor Maria Estela Varua during July 2016 to October 2019.

The integrity and calibre of this study has been validated by several publications and presentations at various real estate conferences in Asia, Pacific-Rim, Europe and the United States. Consequently, the following journal papers and conference presentations have been generated during this research project:

Published Journal Articles:

1. Bangura, M & Lee C, L 2019 "House price diffusion of housing submarkets in Greater Sydney", *Housing Studies*, vol. 36, no. 7, pp. 1-32 (2018 Impact Factor: 1.882)
2. Bangura, M & Lee C, L 2019 "The differential geography of housing affordability in Sydney: a disaggregated approach", *Australian Geographer*, vol. 50, no. 3, pp. 295-313 (2018 Impact Factor: 1.639)

Under-Revision Journal Article

1. Bangura, M & Lee C, L 2019 "The Determinants of Homeownership Affordability in Greater Sydney: Evidence from a Submarket Analysis", *Housing Studies*

2. Bangura, M & Lee C, L 2019 "Housing Price Bubbles in Greater Sydney: Evidence from a Submarket Analysis", *Housing Studies*

Conference Papers and Presentations:

1. Bangura, M & Lee, C, L 2019 "House affordability and house price bubbles nexus: Evidence from Greater Sydney", presentation at the 26th European Real Estate Society (ERES), Cergy-Pontoise Cedex, France
2. Bangura, M 2019 "PhD Thesis", presentation at the 35th American Real Estate Society (ARES), Phoenix, Arizona USA

3. Bangura, M & Lee C, L 2019 “House price diffusion of housing submarkets in Greater Sydney”, presentation at the 35th American Real Estate Society (ARES), Phoenix, Arizona USA
4. Bangura, M & Lee, C, L 2019 “House affordability and house price bubbles nexus: Evidence from Greater Sydney”, presentation at the 25th Pacific Rim Real Estate Society (PRRES), Melbourne, Australia
5. Bangura, M 2019 “PhD Thesis”, presentation at the 25th Pacific Rim Real Estate Society (PRRES)”, Melbourne, Australia
6. Bangura, M 2019 “House price diffusion of housing submarkets in Greater Sydney”, presentation at the 25th Pacific Rim Real Estate Society (PRRES), Melbourne, Australia
7. Bangura, M 2018 “PhD Thesis”, presentation at the 24th Pacific Rim Real Estate Society (PRRES)”, Auckland, New Zealand
8. Bangura, M & Lee, C, L 2018 “Drivers of ownership affordability of the regions of Greater Sydney”, presentation at the 24th Pacific Rim Real Estate Society (PRRES), Auckland, New Zealand
9. Bangura, M & Lee, C, L 2018 “House price diffusion in Greater Sydney: Evidence from cointegration approach”, presentation at the 23rd Asian Real Estate Society (AsRES), Incheon, Korea
10. Bangura, M 2017 “PhD Thesis”, presentation at the 23rd Pacific Rim Real Estate Society (PRRES), Sydney Australia
11. Bangura, M 2017 “Housing affordability in Greater Sydney”, presentation at the 23rd Pacific Rim Real Estate Society (PRRES), Sydney Australia

NOTE

Some of the materials used in this thesis are obtained directly from the publications above.

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LIST OF ABBREVIATIONS

AUS$	Australian Dollar
ABS	Australian Bureau of Statistics
ADF	Augmented Dickey Fuller
AHURI	Australia Housing and Urban Research Institute
AIC	Akaike Information Criteria
API	Average Personal Income
AR	Auto Regressive
ARDL	Auto Regressive Dynamic Model
ASX	Australian Stock Exchange
Aus.	Australia
BIC	Bayesian Information Criteria
BSADF	Backward Supremum Augmented Dickey Fuller
CBA	Commonwealth Bank of Australia
CGT	Capital Gains Tax
CtI	Cost to Income
DF	Dickey Fuller
DIRD	Department of Infrastructure and Regional Development
DoE	Department of Education
DoH	Department of Housing
DOLS	Dynamic Ordinary Least Square
DSS	Department of Social Services
ECM	Error Correction Model
EG	Engle Granger
FE	Fixed Effect
FHOB	First Home Owners Boost
FHOG	First Home Owner Grant
FHOS	First Home Owners Scheme

GDP	Gross Domestic Product
GMM	Generalised Method of Moments
GSADF	Generalised Supremum Augmented Dickey Fuller
GST	Goods and Services Tax
HAF	Housing Affordability Fund
HAI	Housing Affordability Index
HCAP	Housing Construction Acceleration Plan
HDAA	Home Deposit Assistance Act
HIC	Hannan-Quinn Information Criteria
HP	House Price
HS	Housing Stock
HSGS	Home Savings Grant Scheme
HUD	Housing and Urban Development
I(0)	Non Stationary
I(1)	First Difference Stationary
IPS	Im-Pesaran-Shin
IV	Instrumental Variable
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
LM	Lagrange Multiplier
LGA	Local Government Area
LLC	Levin-Lin-Chu
MACROC	Macarthur Regional Organisation of Councils
MG	Mean Group
MLR	Mortgage Lending Rate
MR	Median Rent
NAHA	National Affordable Housing Agreement
NHS	National Housing Strategy
NRAS	National Rental Affordability Scheme
NSROC	Northern Sydney Regional Organisation of Councils
NSW	New South Wales

NSWDoP	New South Wales Department of Planning
OECD	Organisation for Economic Cooperation and Development
OLS	Ordinary Least Square
OSR	Office of State Revenue
PCR	Productivity Commission Report
PMG	Pooled Mean Group
PP	Phillips-Perron
PSY	Phillips-Shu-Yu
PWY	Phillips-Wu-Yu
Q1	Quarter One
Q2	Quarter Two
Q3	Quarter Three
Q4	Quarter Four
RBA	Reserve Bank of Australia
RE	Random Effect
REIA	Real Estate Institute of Australia
RESC	Revised European Social Charter
RO	Research Objective
RP	Resident Population
RQ	Research Question
RSSB	Renting and Strata Services Branch
SEIFA	Socio-Economic Indexes for Areas
SFD	State Final Demand
SGMM	System Generalised Method of Moments
SHOROC	Shore Regional Organisation of Councils
S&P	Standard & Poor
SSROC	Southern Sydney Regional Organisation of Councils
UDIA	Urban Development Institute of Australia
UK	United Kingdom
USA	United States of America

VAR	Vector Auto Regression
VECM	Vector Error Correction Model
WSROC	Western Sydney Regional Organisation of Councils
%	Percentage

IX.

EXECUTIVE SUMMARY

To date, the existing body of literature on housing affordability and house price behaviour focused largely on international, national, state and city-based levels. Specifically, metropolitan city-based studies are done at aggregate levels despite the enormous empirical evidence pointing out the existing socio-economic and demographic discrepancies in these cities. In Greater Sydney, for example, studies such as Baum (2004), Costello (2009), Forster (2006), and Randolph and Tice (2014), have reported these socio-economic divergences within the city. These socio-economic discrepancies are also evident in other capital cities of Australia (Hulse et al. 2014). Specifically, they found that there is stronger concentration of social and spatial disadvantages in Sydney, Melbourne and Brisbane. Recognising these differences, the study adopted a sub-city empirical analysis of housing affordability and house price behaviour within Greater Sydney. The aim of this research is to enhance our understanding of housing affordability and house price dynamics in Greater Sydney from a disaggregated perspective. These methods and findings could also be possibly adopted in other capital cities of Australia.

The analysis of the study is divided into two major components over June 1991 to June 2016. The first component examines entry and ongoing affordability, local drivers of affordability, and housing price bubble in each of the five delineated regions of Greater Sydney – western, inner-west, southern, eastern and northern regions. Each region is a collection of several local government areas (LGAs). Based on the findings of the first sub-study, the second component collapses these five regions into two housing submarkets (low-priced and high-priced submarkets) and examines house price diffusion pattern in these submarkets.

The empirical results reveal that entry-level housing remains extremely unaffordable in all regions of Greater Sydney, although the level of unaffordability varies across regions. Specifically, the deterioration of housing affordability is more obvious in low-income regions such as Western Sydney. In addition, the ongoing housing affordability of those who have entered the market improves considerably within five to ten years, although there are significant variations between different regions. Apparently, residents in low-income regions such as Western Sydney take a longer period to improve their ongoing housing affordability compared to those in the high-income regions (eastern and northern regions). The results indicate a differential geography of housing affordability across the regions of Greater Sydney.

As a results of this disproportionate levels of the deterioration in housing affordability across the regions of Greater Sydney, the study examines the local factors driving affordability in each region. The study finds significant differences in the effect of local housing variables on affordability between the high-income and low-income regions of the city. Essentially, the homeownership affordability of the relative low-income regions (western, inner-west and southern) is more susceptible to changes in key housing variables (such as population, housing supply and rent) than in high-income regions. Increasing housing supply, for example, plays an important role in improving affordability, particularly in the western, inner-west and southern regions, while it is insignificant in the high-income eastern and northern regions. These asymmetric effects are also found in rent and population. The findings of this study generally support the shelter poverty hypothesis, as residents from low socio-economic background are more sensitive to a change in income, rent, house price, demographics and other socio-economic factors than their counterparts in the high-income regions.

By examining the link between house price and key market fundamental, the empirical results show no cointegration between house price and rent in the relative low-income western, inner-west and southern regions of Greater Sydney, while there is evidence of cointegration in high-income regions. This confirms the existence of housing submarkets in Greater Sydney in general and gives a preliminary indication of housing bubble formation in low-priced regions in particular. Further, the formal bubble tests reveal evidence of price bubbles in the western, inner-west and southern regions, while no comparable evidence is found in the high-income eastern and northern regions of Sydney. This confirms the importance of a submarket analysis and supports the Shiller's (2007) Psychological Theory, where investors expect higher house prices that are not always realised.

The second component examined two housing submarkets to test two competing hypotheses of house price diffusion - equity transfer and migration. The study found a long-run relationship in house price between these two submarkets in Greater Sydney. Importantly, the empirical results show that a large degree of house price diffusion takes place from the less prosperous submarket to the high-end submarket. This supports the equity transfer hypothesis via a filtering process in which house prices in the low-priced submarket will be transmitted into the high-priced submarket. The study also finds that the low-priced submarket is the primary reactor to changes in economic fundamentals.

Both theoretical and practical contributions are made in this research. The main practical contribution is the extension of the body of knowledge on housing affordability and house price

behaviour by incorporating the socio-economic disparities across Greater Sydney into the analyses. The findings have provided the rudiments for addressing socio-economic imbalances arising from housing affordability within major cities in Australia, especially Greater Sydney. This would be of great importance to policy makers who are seeking to address the growing social, economic and spatial polarisation across Greater Sydney. The theoretical contribution of this thesis are classified into two broad themes. The first theme envelops the application of a broad array of theories from various disciplines such as Finance, Property, Urban Studies, Macroeconomics, Sociology and Geography. These theories are used to develop the theoretical framework of each research question of the study. This multi-disciplinary approach has provided more insights into how theories and models from other disciplines can be situated in research within the property discipline. The second theme clusters the extensive application of statistical and econometric analyses. For example, the combined study of the interaction between house price and rent on the one hand using panel unit root and panel cointegration techniques, and formal tests of housing price bubbles (BSADF) on the other hand, is a novelty approach that has enhanced our understanding of the dramatic behaviour of house prices in the different regions of Greater Sydney.

In conclusion, this research has filled an important gap in the housing literature in general and regional housing analysis in particular. The study has revealed the varying rates at which entry-level affordability is declining across the regions of Greater Sydney. The study found that the increasing number of property investment in the relative low-income regions of the city (western, inner-west and southern regions) could be a causative agent of the significant decline in entry-level affordability of these regions. Further, some households use low-income regions to get their feet in the property market and then move to the higher-end of the market as their equity improves. This trade-up housing strategy, combined with the growing property investment activities in the relative low-income regions of Greater Sydney, is contributing to the deterioration of entry-level affordability in these regions of the city. Policy makers could consider the findings of this study in formulating a more targeted and regionally-balanced housing policy.

CHAPTER 1

INTRODUCTION

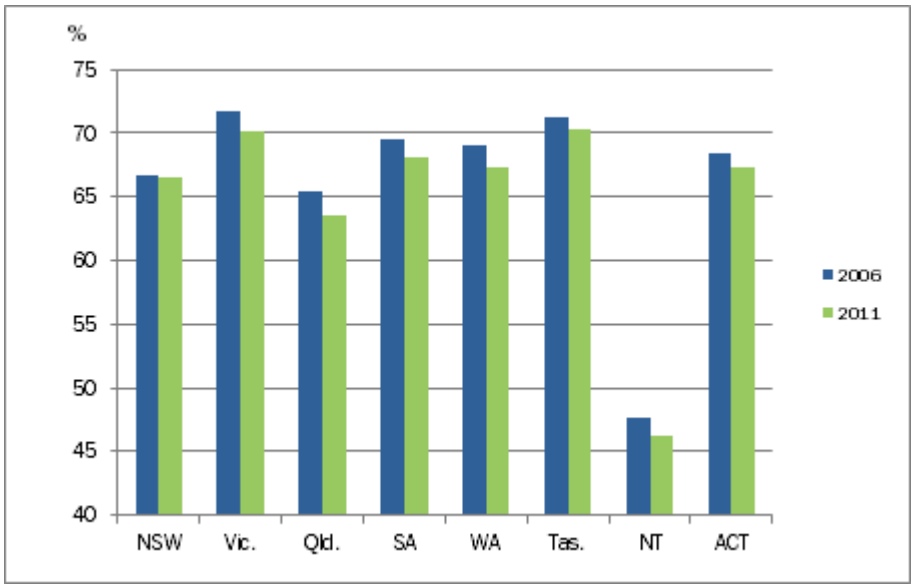
1.1 Background

Australia has a long history of high homeownership rate Healey (2016). Apart from its traditional role of providing shelter, safety and stability (Holmes et al. 2008), housing is a great form of investment for many households in Australia, accounting for more than two-third of their investment (Lee 2017). Therefore, housing is an important sector to many Australian households. From an economic perspective, the property development industry contributes significantly to the Australia Gross Domestic Product (GDP) and it is the fourth largest industry in the Australia economy. The industry directly accounts for 7.3 percent of GDP and indirectly delivers an extra 6.2 percent to the national economy (Urban Development Institute of Australia [UDIA] 2014). The industry also employed approximately one in ten Australian workers and generated both directly and through associated industries, around AUS$29.7 billion of State and Federal taxes in 2007-08 financial year (UDIA 2014). Despite these features of the Australian housing market, a declining trend in home ownership, especially among the middle to low-income earners in Australian capital cities and major towns, has been evident in recent years (Holmes et al. 2008; Worthington & Higgs 2013).

Importantly, house prices in Australia have increased at a considerably faster pace than income growth (Berry 2003; Yates 2008; Worthington 2012), a situation that continues to attract the attention of researchers, policy makers, developers and property investors. Worthington and Higgs (2013) found that Australian houses were ranked as the most expensive in the world with an increase of 220 percent between 1997 and 2010. This growth rate is significantly higher than other advanced economies such as Britain (181 percent), France (141 percent), New Zealand (108 percent) and the US (70 percent), over the same period. Maschaykh (2016) found that Sydney is one of the least affordable cities in terms of housing in the world. Massola (2016) further highlighted that house prices in capital cities, particularly in Sydney and Melbourne, grew by 65 percent and 40 percent respectively over 2012 to 2016. Between June 2010 and June 2015, the minimum time required for a dual income couple to save for a 20 percent deposit in Sydney had also increased from 5.8 years to 7.9 years (Massola 2016). All of these suggest a deterioration in housing affordability and a continuous decline in homeownership rate in Australia. In fact, homeownership rates are declining for all age groups, even for Australians in their 60s and 70s (Healey 2016). Figure 1.1 shows the consistent decline in home ownership

rates in all states and territories across Australia between 2006 and 2011 (Australian Bureau of Statistics [ABS] 2013).

Figure 1.1: Homeownership Rate by State and Territory (2006-2011)



Source: ABS Census of Population and Housing, 2006 and 2011

International evidence on the declining trend of housing affordability is also available. In the United States (US), several studies on housing affordability have shown the need for more affordable housing (Downs & Johnson 2004; Brassil 2010; Hamidi et al. 2016). Downs and Johnson (2004) used data from the 2001 American Housing Survey and found that almost 25 percent of American households, including 85 percent of poor households, spend more than 30 percent of their incomes on housing. In the United Kingdom (UK), Poon and Garratt (2012) suggested that UK households are more sensitive to interest rates volatility due to deterioration of housing affordability in the country. Comparable findings have been documented by Del Pero et al. (2016) in which many households in Organisation for Economic Cooperation and Development (OECD) countries, especially low-income households, are confronted with very high housing costs relative to their income. Due to rapid urbanisation, housing affordability has also become a critical issue in many developing countries. Burger et al. (2014) highlighted that the rapid urbanisation in India requires new strategies to meet the demand for affordable housing for the millions of low-income workers in the country. In Malaysia, housing affordability is deteriorating among middle-income households, especially in major Malaysian cities, where purchasing a home is increasingly difficult (Baqutaya et al. 2016).

As housing affordability continues to deteriorate in most metropolitan cities across the globe (Worthington 2012; Demographia 2019), it heightens the need to examine its key drivers. But as argued by De Bruyne and Van Hove (2013), housing affordability varies geographically, even between neighbouring local councils. They attributed this variation to the differences in local socio-economic variables. Therefore, housing affordability should be analysed in a submarket perspective. This is because different geographical areas are expected to have different drivers of housing affordability (Worthington & Higgs 2013; Lee & Reed 2014). Some of these studies have shown that house price, income and mortgage lending rate are key inputs in measuring affordability (Yates 2007; Muellbauer & Murphy 2008; Yates 2008; Kim & Cho 2010; Brown et al. 2011; Worthington & Higgs 2013; Lee & Reed 2014; Del Pero et al. 2016). More generally, other studies have also identified population, housing supply and rent as key local drivers of housing affordability (Quigley 2002; Productivity Commission Report 2004; Holmes et al. 2008; Yates 2008; Brassil 2010; Chakraborty et al. 2010; Gurran & Whitehead 2011; Ruming et al. 2011; Worthington 2012; Liu & Otto 2017). Apart from Worthington and Higgs (2013) and Lee and Reed (2014), who adopted a quantitative approach each, the other studies are highly narrative.

The rapid housing price growth leads to the question of whether there is a housing price bubble. Although several studies have been devoted to examine whether the increase in house price can be justified by market fundamentals (Li & Chand 2013; Al-Masum & Lee 2019), a number of these studies were dedicated to housing price bubbles by examining the relationship between house price and rent. Their findings are mixed. This can be attributed to the failed attempt to recognise the existence of housing submarkets. Further, homeownership affordability does not operate in solitary within the housing market. Property investment also comes into play, which motivates the need to examine the long run relationship between house price and rent (Stone 2004; Gallin 2006; Girouard et al. 2006; Yates 2008; Worthington 2012; Kivedal 2013; Healey 2016). Girouard et al. (2006), for example, asserted that the house price-rent ratio is a suitable benchmark for over or undervaluation of property. It is also a useful tool for predicting real house prices, which determines affordability (Gallin 2006). As such, the interplay between house price and rent over time gives an indication of possible housing bubble formation (Kivedal 2013; Gregoriou et al. 2014; Chen & Cheng 2017), as higher house price without the proportionate or even higher rent has strong implications for property investment (Shiller 2007; Fox & Tulip 2014). Again, as house prices continue to rise in major Australian cities (Healey 2016; Angus 2017), coupled with the lessons from the global financial crisis in 2008, it

provides solid grounds for investigating the existence of housing price bubbles in these cities (Shi et al. 2016). Apart from providing strong financial implications for both homebuyers and renters (Meen 2011), housing bubbles test also helps to monitor house prices in metropolitan cities.

To further enhance our understanding of house price behaviour, it is also important to examine whether house prices between submarkets are linked over time. Previous studies on house price linkages such as Luo et al. (2007), Akimov et al. (2015), Gupta et al. (2015), and Hudson et al. (2018) produced mixed results. Again, these studies did not consider housing submarkets. As argued by Leishman et al. (2013), housing submarkets have strong analytical significance. They provide a framework that gives more insights into housing market dynamics and housing policy analysis (Galster 1996). Leishman et al. (2013) concluded that neglecting housing submarkets in housing analysis can affect the predictive accuracy of housing market models. This is supported by Wilhelmsson (2004), who used a hedonic price model to show that submarket price modelling does increase the goodness-of-fit more than a single price model. Galster (1996) added that changes in one submarket has significant and expected consequences for price change and migration flow into other submarkets. A similar study by Chen et al. (2009) also noted that submarket models perform better in forecasting house price than a model without submarkets. In the same light, Bates (2006) earlier stressed that an understanding of submarket structure can facilitate the decision-making process of numerous housing stakeholders. Certainly, over the long run, it is expected that house price behaviour in one submarket does influence price behaviour in another submarket (Wilson et al. 2011). Therefore, housing submarket analysis could uncover patterns of home price movements between submarkets within a metropolitan city.

Overall, previous housing studies on affordability and house price behaviour have shown mixed results from different markets. This can be attributed to the diversity in the demographic, social and economic characteristics of these housing markets (Bramley et al. 2008). So far, there is little empirical housing literature at regional or sub-city level. Only few region-specific housing and policy studies about Greater Sydney, particularly Western Sydney exist. Some time ago, Latham (1992) reported that new estates were struggling to provide the services required by the rising population of Western Sydney. This study also found that urban growth continues to widen the backlog in the provision of basic services and employment opportunities in Western Sydney. Mee (2002) used the 1996 and 2001 inter-censual data and information to analyse the quality of life in Western Sydney with a focus on the environment and housing

affordability. This study found that rapid urbanisation and the changes to government housing policies were narrowing the capacity of Western Sydney region to provide a better quality of life for its residents, particularly the disadvantaged households. Gleeson (2006) found that social segregation in Western Sydney is deepening. He therefore argued that state planning policies should prohibit gated residential development, and federal government policies should focus on funding programs that renew public and communal spaces, facilities and services to reverse the segregation in Western Sydney.

Therefore, using a disaggregated approach to examine entry and ongoing housing affordability, the causality between affordability and key local housing factors, housing price bubbles, and house price linkages within a metropolitan city would generate important tools and critical information in the housing literature. This would also form an integral component of regional housing market analysis, which has strong and several housing implications. This research clearly departed from previous studies on housing affordability and housing submarkets in methodology, timeframe, and delineation of the study area. The study examines the different regions of Greater Sydney and it is conducted in the context of econometric modelling and other quantitative techniques using yearly and quarterly data at local government area (LGA) level spanning 1991 to 2016. To the best of my knowledge, this is the first sub-city housing analysis to examine various issues surrounding housing affordability and housing submarkets within Greater Sydney.

1.2 Research Gap

To date, the existing body of housing literature on Australia was done largely at international, national, state and city-based levels. Specifically, metropolitan city-based studies are done at aggregate levels despite the enormous empirical evidence pointing out the existing socio-economic and demographic discrepancies in these cities. In Greater Sydney, for example, studies such as Baum (2004), Costello (2009), Forster (2006), and Randolph and Tice (2014) have reported these socio-economic divergences within the city. Further evidence of socio-economic disparities across the regions of Greater Sydney is provided in Table 2.4. Thus, a comprehensive review of the literature on housing affordability in Australia reveals the following research gaps.

First, previous studies on housing affordability such as Berry (2003), Berry and Hall (2005), Milligan et al. (2007), Yates (2007), Holmes et al. (2008), Yates (2008), Susilawati and Armitage (2010), Gurran and Whitehead (2011), Worthington (2012), Worthington and Higgs

(2013), Lee and Reed (2014), Healey (2016), and Angus (2017) focus largely on aggregate levels. They ignore regional effects despite the differences in the socio-economic characteristics of metropolitan cities. This means big complex urban systems like Greater Sydney need to be understood at disaggregated level. However, no study has provided any empirical evidence of entry and ongoing affordability in Greater Sydney using a disaggregated approach. Such sub-city studies on affordability, which is a finer level housing analysis, is still very limited.

Second, as housing affordability continues to deteriorate, an assessment of its local drivers becomes highly relevant, especially within metropolitan cities. Only few studies such as Lee and Reed (2014), and Worthington and Higgs (2013) have modelled the drivers of housing affordability at much broader geographical levels. These studies do not integrate local characteristics, and they cover different time periods and employ different methods. Limited data might also affect their study findings. Further, there has not been any study that capitalised on the recent advances of panel econometrics (such as panel unit root, system generalised method of moments, and panel error-correction model) to examine the causal effect of local housing variables such as population, housing supply and rent on affordability at disaggregated level. Therefore, identifying the local drivers of homeownership affordability and estimating their impact using these econometric techniques is another significant gap in housing affordability literature.

Third, previous studies have shown that the relationship between house price and rent over time gives an early indication of housing price bubble formation (Shi et al. 2016; Teng et al. 2017; Hudson et al. 2018). Notwithstanding the extent to which they influence housing decisions, there is virtually no empirical evidence in Australia, particularly at a sub-city level, to examine the trend of change in house price and rent over time. Further, there has not been any formal test for the existence of bubble contagion among the different property types (i. e. strata and non-strata) in the different regions of Greater Sydney. This is in spite of the existing socio-economic disparities across the regions of Greater Sydney. Hence, an enhanced understanding of the long run nexus between house price and rent, combined with a formal housing bubble test at sub-city level would provide significant tools and critical information for monitoring house prices in Greater Sydney.

Last but not least, despite the importance of housing submarket analysis, no study has done a formal test to determine whether there is a spillover effect in the house prices of Greater Sydney. In addition, house price dynamics need to be linked to some causal framework for

their salience to be understood. Testing house price diffusion hypotheses such as migration, and equity-transfer hypotheses is therefore significant in enhancing our understanding of the behaviour of house prices in any major Australian city. Astonishingly, there is virtually no theoretical explanations of how house price spreads from one submarket to the other in Greater Sydney, which made it difficult to predict the behaviour of house prices in Australia's most populous and diverse city.

1.3 Research Questions

Researchers from various disciplines have studied housing affordability and housing submarkets from different perspectives using different methodologies and covering different timeframes. Recent submarket analysis suggests that a disaggregated analysis offers further insights into the housing market. However, limited studies have been conducted at a sub-city level leading to several questions about housing market within metropolitan cities, particularly Australia. Thus, the overall research objective of this study is to examine how housing affordability plays out in the context of a submarket. More specifically, the study will address the following research questions:

RQ 1: What are the levels of entry and ongoing housing affordability in each region of Greater Sydney?

RQ 2: What are the local drivers of homeownership affordability in each region of Greater Sydney?

RQ 3: Have the regions of Greater Sydney experienced any housing bubble contagion?

RQ 4: Are the housing submarkets of Greater Sydney integrated in house price?

1.4 Objectives of the Study

The principal aim of this research is to examine housing affordability and house price dynamics in Greater Sydney at disaggregate level. Specifically, the objectives of the study are:

RO. 1: To determine the levels and differences, if any, in entry and ongoing housing affordability across the various regions in Greater Sydney.

RO. 2: To examine the key local drivers of homeownership affordability and investigate whether they differ in each region of Greater Sydney.

RO. 3: To investigate whether there is a housing bubble contagion in each region of Greater Sydney.

RO. 4: To examine whether there is a long run equilibrium relationship in house price between two broad housing submarkets in Greater Sydney and provide some theoretical explanations if house price spillover exists between these markets.

1.5 Hypotheses of the Study

Based on the above research questions, this study hypothesised the following:

- Hypothesis 1: There are striking differences in both entry and ongoing housing affordability across the five regions of Greater Sydney.

- Hypothesis 2: The causal effect of local housing variables on homeownership affordability is more significant in the relative low socio-economic regions (western, inner-west and southern) of the city than the high socio-economic regions (eastern and northern).

- Hypothesis 3: There is evidence of housing price bubble in the relative low-income regions, while no housing price bubbles are expected in the high-income regions.

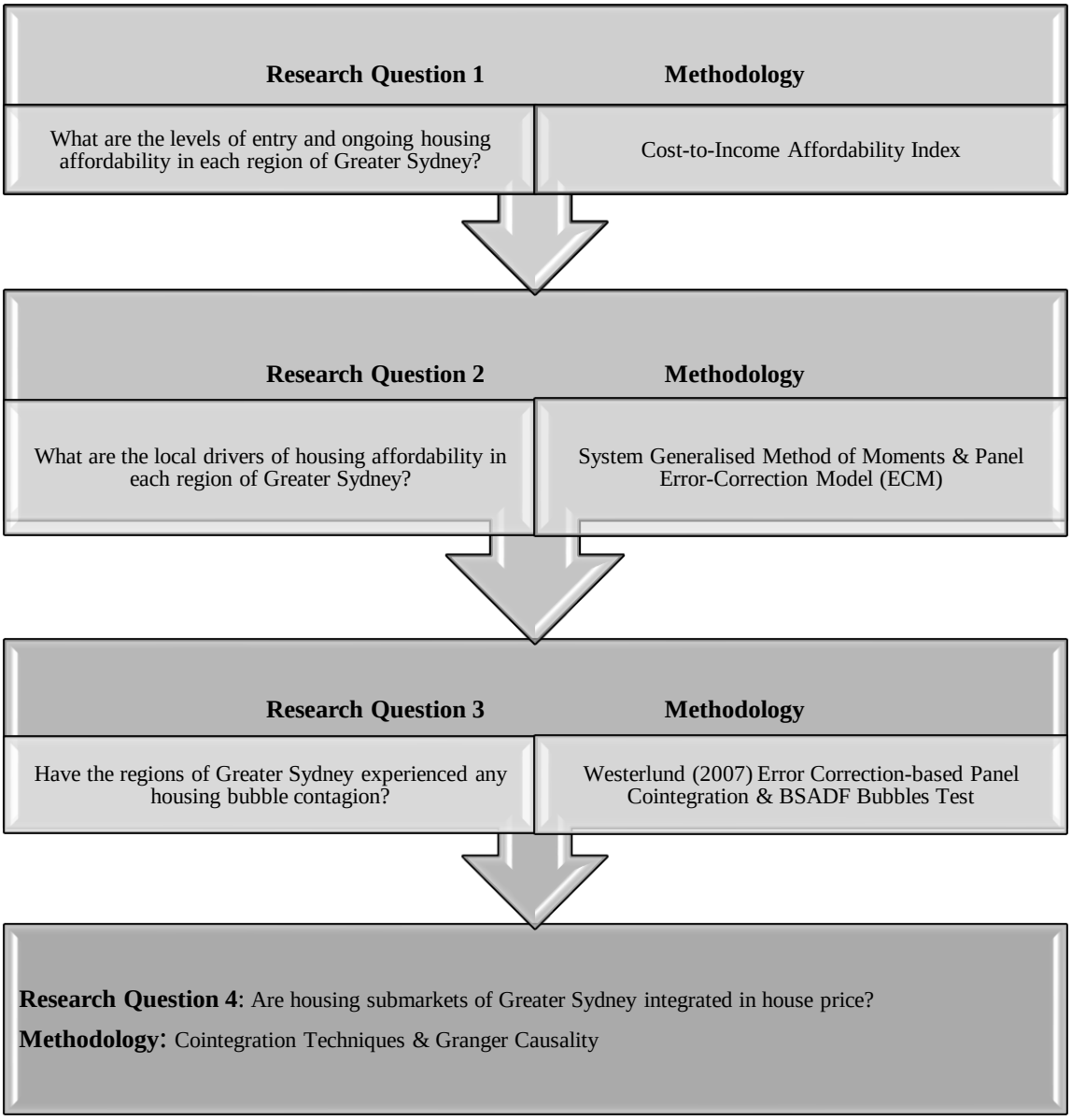
- Hypothesis 4a: There is a spillover effect within Greater Sydney. 4b: If house prices diffuse from the relative low-priced submarket to the relative high-priced submarket, the equity transfer diffusion pattern is hypothesised. 4c: If house prices diffuse from the relative high-priced submarket to the relative low-priced submarket, the migration diffusion pattern is hypothesised.

1.6 Research Methodology

Given the research framework of the above objectives, the overall research process is divided into two major sub-studies over June 1991 to June 2016. The first sub-study examines entry and ongoing affordability, local drivers of affordability, and housing price bubble in each of the five delineated regions of Greater Sydney – western, inner-west, southern, eastern and northern regions. Each region is a collection of several local government areas (LGAs). Based

on the findings of the first sub-study, the second study collapses these five regions into two housing submarkets (low-priced and high-priced submarkets) and examines house price diffusion pattern in these submarkets. Figure 1.2 gives a synopsis of the interconnectedness between these two broad studies. The study generally follows a cascading framework, which demonstrates how each research question is addressed and progressively motivated the modelling and analysis of the successive research question.

Figure 1.2: Flow of the Research Questions and Methodology



Source: Author's construct

The framework begins with a comparative analysis of entry and ongoing housing affordability across the five regions of Greater Sydney using the cost to income index. The entry level affordability index utilises the market value of the property, down-payment, and mortgage

lending rate and it is expressed as a percentage of the average personal income of an LGA. Since ongoing affordability evolves after entry into the housing market, we compute the ongoing affordability index by incorporating the loan balance into the cost to income index, instead of the market value.

To examine the local drivers of homeownership affordability in each region, the study deploys the system generalised method of moments (SGMM) estimator. This autoregressive model regresses entry affordability index against local housing variables such as resident population, housing supply, media rent, and the lag of the affordability index. To shed more light on the local drivers of homeownership affordability in the long run, the Westerlund (2007) cointegration and panel error correction model (ECM) were employed. This estimation is preceded by some diagnostic tests and a panel unit root test to establish the stationarity of the variables in the model. These methods provide the causal effect of these regressors on the affordability of each region.

The third research question utilises Westerlund (2007) error correction-based cointegration test to evaluate the relationship between house price and rent. This empirical analysis provides information about early signs of housing price bubble formation. This is followed by a formal housing bubble test using the Backward Supremum Augmented Dickey Fuller (BSADF) to test whether there is evidence of housing price bubble in each region.

Finally, the findings of the preceding research questions highlight significant similarities in the housing characteristics between the eastern and northern regions. In the same vein, identical characteristics are also observed among the western, inner-west and southern regions of Greater Sydney. This suggests clustering the five delineated regions of Greater Sydney into two main submarkets – relative low-priced (western, inner-west and southern regions) and relative high-priced (eastern and northern regions) – to evaluate house price behaviour between these submarkets. In this second study, Meen (1999) stationarity procedure was employed to check for an indication of a spillover effect between these submarkets. Several unit root tests such as the Augmented Dickey Fuller (ADF), Phillips–Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests were employed to check the stationarity of house price indices. The study also employed three cointegration tests - the Engel-Granger, Phillip-Ouliaris, and Johansen bivariate cointegration tests to assess the existence of a long run equilibrium relationship in house price between these two submarkets. Granger causality was deployed to establish which submarket leads and which one follows. These various econometric techniques

were used to evaluate the diffusion pattern of house price in Greater Sydney. Lastly, the dynamic ordinary least square (DOLS) procedure is utilised to check whether the dominant role of a submarket can be attributed to its responsiveness to market fundamentals. In other words, the DOLS model investigates whether different housing submarkets respond to changes in market fundamentals differently.

1.7 Contribution of the Study

The study has provided an empirical analysis of housing affordability and house price dynamics in Australia's most populous and highly socio-economically diverse metropolitan city, namely Greater Sydney. The study integrates local characteristics to offer an enhanced understanding of housing affordability and house price behaviour within urban systems like Greater Sydney. The following section discusses the contributions and practical implications of the study.

i. Firstly, the study has contributed to the body of knowledge by investigating housing affordability at a sub-city level. This study is the first to estimate both entry-level and ongoing housing affordability for the different regions of Greater Sydney spanning 1991 to 2016. Further, the study conducted a detailed analysis of the trend of both forms of affordability in the different regions, an approach that offers a deeper understanding of housing affordability in a metropolitan city. The study in its entirety has provided solid grounds for ongoing disaggregated housing studies. As reported in the Productivity Commission Inquiry Report (2004), although house price increases tend to flow across market segments, differences do occur. This is particularly the case for both Sydney and Melbourne, where real prices had fallen in some suburbs, while there were increases in other suburbs by as much as 15 percent a year. Therefore, this study has provided empirical evidence to support the earlier findings of the Productivity Commission. Policy makers and other housing players could use this information for a more robust analysis and informed policy decision.

ii. This is the first submarket analysis to identify the local drivers of homeownership affordability index in each region of Greater Sydney. The study addresses a significant knowledge gap in the housing literature in general and the submarket or regional literature in particular. These findings could be of great interest to policy makers, property researchers, property developers, housing investors, lobby groups and other relevant stakeholders in the housing sector in Australia. These stakeholders could use

these findings as evidence and tools for better analysis for more informed policy decisions. This could also ignite a debate on the current uniform housing policies across regions of Greater Sydney such as the First Home Owner Grant.

iii. Another contribution of the study is the evaluation of the interplay between house price and rent, which could be used as an early indication of housing price bubble. The study has examined whether equilibrium relationship exists between house price and rent, and conducted a formal housing price bubble test in each region. These two elements of Sydney's housing market have never been previously investigated in the housing literature. Therefore, the study is the first to show the existence of housing bubbles within a metropolitan city from a disaggregated perspective. Policy makers could use these results to minimise the gap in house price increase and rental growth, and to monitor house prices in Sydney. More importantly, this approach has provided a more solid empirical analysis for formulating regionally balanced housing affordability policies within metropolitan cities.

iv. Previously, there was no empirical evidence of the behavioural linkages of house price in Greater Sydney. This study is the first to test the presence of a spillover effect and uncover the diffusion pattern of house price in Greater Sydney. By considering location, house price and socio-economic characteristics, the study delineated two broad housing submarkets, and empirically tested two competing hypotheses of spillover effect (i.e. the migration hypothesis and the equity-transfer hypothesis). Such test between submarkets is carried out for the first time. The results have provided some theoretical explanation of how house price spreads from the relative low-priced submarket to the relative high-priced submarket of the city. An understanding of this house price movement in the city goes beyond academic interest. It has diverse implications for various housing stakeholders. These behavioural linkages have provided important information to housing investors and policy makers for better market analysis and predictions.

v. The study applied a range of theories from diverse disciplines such as Finance, Property, Macroeconomics, Sociology and Geography. This study, for example, is the first to apply the novel spatial approach across space and time within the context of affordability. This theory helps to articulate the status of entry-level and ongoing

affordability across the different regions of Greater Sydney over time. By synthesising theories and concepts from other academic disciplines such as annuity, market fundamentals, migration and equity-transfers, filtering process, residential mobility, Alonso-Mills-Muth model, and Stone's (1990) shelter poverty model, this study has demonstrated how property discipline is intertwined with other disciplines. This multi-disciplinary approach has provided more insights to how theories and models from other disciplines can be situated in research within the property discipline.

vi. The study draws together a suite of econometric and quantitative techniques. A new index for estimating ongoing affordability index was developed and this should be of considerable interest to both academics and practitioners. The study also applied the system generalised method of moments (SGMM) within the context of sub-city for the first time, and further utilised recent advances in panel econometrics such as the Westerlund (2007) error correction-based panel cointegration test and the panel error-correction based model (ECM) within sub-city housing markets. The study is also the first to employ the BSADF housing bubble test at disaggregated level. The methodology has provided useful research tools for future housing research.

Generally, the study has contributed to the limited literature on regional housing studies. As previous literature on housing affordability in Australia is largely done at aggregated levels and ignored local effects, this study has presented an alternative approach this is highly locally-focused.

1.8 Structure of the Thesis

Figure 1.3 describes the structure of the thesis. This layout consists of an introduction [Chapter 1], disaggregation of Greater Sydney into regions [Chapter 2], literature review [Chapter 3], data and methodology [Chapter 4], analysis of both entry-level and ongoing housing affordability [Chapter 5], analysis of local drivers of homeownership affordability [Chapter 6], analysis of the interplay between house price and rent, and housing price bubbles test [Chapter 7], analysis of house price linkages between submarkets [Chapter 8], and conclusion [Chapter 9].

Chapter 1 gives an overview of housing affordability in Australia, which highlights the research gap in micro level housing affordability literature, particularly for Greater Sydney. The chapter

also outlines the research questions, objectives of the study, research methods, contribution of the study, and the structure of the thesis.

Chapter 2 sets the scene for sub-city housing analysis, disaggregating Greater Sydney into five major regions. Various socio-economic and demographic housing parameters across the delineated regions of Greater Sydney were examined to give more insights into housing affordability and price behaviour at a disaggregated level. The chapter further discusses the conceptual framework, and the interactive role of the various housing stakeholders in Australia.

Chapter 3 reviews three strands of housing literature - housing affordability; housing price bubbles; and house price linkages. Within the scope of housing affordability, the study reviews the literature on the declining trend of housing affordability, various housing affordability indexes, determinants of homeownership affordability, institutional environment, previous and current Australia housing policies, and advocacy for more affordable houses. The literature reviews these sub-headings at various geographical levels including country/state, regions and major cities. The second strand of literature reviews house price and market fundamentals (rent and income), and house price bubbles. The third strand of the literature essentially reviews the importance of submarket analysis, house price diffusion patterns between countries, regions and cities, and the relationship between house price and market fundamentals.

Chapter 4 presents the data and the various sources of the data, a brief description of the data, and definitions of key variables. The chapter further discusses the various methods and tools, and the estimation procedures in addressing each research question.

Chapters 5-8 envelop the analytical section of the study. Specifically, chapter 5 estimates the yearly entry-level and ongoing affordability indices for each region using the cost-to-income index for the period 1991 to 2016. The chapter further discusses the estimated indices and presents a graphs of the trend of these results.

Chapter 6 analyses the causal relationship between homeownership affordability and local drivers of the housing market for each region of Greater Sydney. The chapter discusses the designed autoregressive model used in estimating the drivers of affordability, and how these factors affect affordability in these different regions.

Chapter 7 explores the long run equilibrium relationship between house price and rent to ascertain the existence of early signs of housing price bubbles. A formal bubble test in each region is also discussed in this chapter. These analyses are carried out using various econometrics tools and techniques.

Figure 1.3: Structure of the Thesis

Source: Author's construct

Chapter 8 is the final component of the analytical section of this study. This chapter presents the house price diffusion pattern between the two broad housing submarkets of Greater Sydney. The chapter discusses the delineation process of these submarkets and sets out two hypotheses that were tested to determine the diffusion pattern of house prices in Greater Sydney. The procedures of the various econometric tools and techniques used in the analyses are also reported.

Chapter 9, the final chapter, provides a summary of the findings, the practical and theoretical implications of these findings and recommendations. The chapter further highlights some significant features of housing affordability in Greater Sydney and concludes with a discussion on the limitation of the study and some recommendations for future research.

1.9 Conclusion of the Chapter

Chapter 1 provides the context and motivation for this study. The chapter presents an overview of housing affordability in Australia and highlights the research gap in micro level literature on housing affordability and house price behaviour, particularly for Greater Sydney. This is followed by the research questions, objectives of the study, research methods and the contribution of the study. The structure of the thesis is also explained. The nature and scope of the study is also articulated in this chapter. Generally, the chapter has laid out the preliminary scene for conducting the research at disaggregated level in Australia's most populous and socio-economically diverse capital city, namely Greater Sydney. To give more credence to this approach, the next chapter has provided a profile of the study region and narrated its delineation into five major regions.

CHAPTER 2

DISAGGREGATION OF GREATER SYDNEY INTO REGIONS

2.1 Housing Profile of Greater Sydney

Since the formation of the Commonwealth of Australia in 1901[1], Greater Sydney has been the capital of the state of New South Wales (NSW). Geographically speaking, Greater Sydney being a Greater Capital City Statistical Area (GCCSA) as classified by the Australian Bureau of Statistics[2], extends from Wyong and Gosford in the north to the Royal National Park in the south and follows the coastline in between. Towards the west, the region includes the Blue Mountains, Wollondilly and Hawkesbury (City of Sydney [CoS] 2019). Greater Sydney covers 12,367.7 square kilometres, and since the proclamation of the amalgamation of some councils on the 12 May 2016 and 9 September 2016, the city now has 33 local government areas[3] and more than 650 suburbs that are largely linked by a complex transport network that includes heavy and light rail services, public and private bus services, ferry services, taxis and a road and cycle network (CoS 2019; NSW Department of Planning 2019). Appendix 1 shows the iconic Sydney Opera House and the Harbour Bridge, a view that attracts millions of tourists to Sydney every year (Murray 2003).

Over the last 100 years, Sydney has grown into a major international city with a population of over 5 million people. This has seen many housing opportunities and challenges as this housing market evolved. More specifically, Greater Sydney is the most populous metropolitan city in Australia over the past two or more decades.

Table 2.1 shows the estimated resident population of Greater Sydney from 2013 to 2018. Throughout this period, Greater Sydney is home to more than 64% of people residing in the state of NSW. At a national level, at least one in every five residents of Australia lives in Greater Sydney. The annualised population growth rate of Greater Sydney (1.91%) is also greater than the overall growth rate of both NSW (1.53%) and Australia (1.56%). Compared to another metropolitan city, the 5,230,330 population size of Greater Sydney in 2018, for example, is more than Greater Melbourne's 4,963,349 in the same period (ABS 2018b).

[1] Australia became a nation on 1 January 1901 when six British colonies—New South Wales, Victoria, Queensland, South Australia, Western Australia and Tasmania—united to form the Commonwealth of Australia. This process is known as federation (Parliamentary Education Office 2019)

[2] Greater Capital City Statistical Areas (GCCSA): Greater Capital City Statistical Areas are geographical areas that are designed to represent the functional extent of each of the eight state and territory capital cities. Within each state and territory, the area not defined as being part of the greater capital city is represented by a Rest of State region (ABS 2019)

[3] See Table 2.4 for all LGAs prior to the amalgamation.

Table 2.1: Resident Population of Greater Sydney 2013-2018

Area	2013	2014	2015	2016	2017	2018	Annualised Growth
Sydney	4,757,364	4,841,349	4,930,189	5,024,923	5,136,919	5,230,330	1.91%
NSW	7,404,032	7,508,353	7,616,168	7,732,858	7,867,936	7,988,241	1.53%
Australia	23,128,129	23,475,686	23,815,995	24,190,907	24,601,860	24,992,860	1.56%
% of NSW	64.25%	64.48%	64.73%	64.98%	65.29%	65.48%	0.38%
% of Aus.	20.57%	20.62%	20.70%	20.77%	20.88%	20.93%	0.35%

Source: Author's compute using data from ABS

More importantly, the population of Greater Sydney is projected to grow by 1.6 million in the next 20 years and about 900,000 of this growth is projected to occur in Western Sydney (Griffith 2015). This concentration of the population in Greater Sydney has strong housing implications. As the population in Greater Sydney is expected to grow, this will continue to put pressure on the demand for housing. This means new homes are expected to add to the existing housing stock in Greater Sydney. This is supported by the recent forecast of new housing supply across all LGAs in Greater Sydney by the NSW Department of Planning, Industry and Environment for the period 2017/18 to 2021/22. From Appendix 2, it is quite evident that new houses are expected in all LGAs of the city to catch up with the growing population[4].

Appendix 2 further reveals that the biggest increase in housing supply is expected in Western Sydney, particularly in the Blacktown, Parramatta, Penrith and Camden LGAs. Apparently, these results produced a nexus between housing stock and population growth, with housing stock growing directly with the total number of resident population. This is consistent with the study of Glaeser et al. (2005), who reported that the relationship between housing stock and population change provides a necessary tool for understanding urban dynamics. However, due to the slow response of housing supply to demand, there is generally a housing supply-demand gap in Greater Sydney, with supply trailing demand (Yates 2008). This gap, among other factors, translates to higher house prices in the city. As shown in Table 2.2, house price for all dwellings in Greater Sydney increased from AUS$150,000 in March 1991 to AUS$778,000 in June 2016, representing a quarterly increase of 1.60% (NSW Department of Housing [DoH] 2019). A similar quarterly increase is recorded for strata dwellings. However, non-strata dwellings had the biggest upsurge. The house price of this dwelling type rose from

[4] The NSW Department of Planning, Industry and Environment used the LGAs after the amalgamation in 2016.

AUS$151,000 in March 1991 to AUS$870,000 in June 2016. This represents a quarterly increase of 1.7% during this period. Several studies have also provided evidence of rising house prices in Greater Sydney such as Haylen (2014), Healey (2016) and Massola (2016). All these studies reported a sustained increase in house price in Greater Sydney.

Table 2.2: House Prices in Greater Sydney for the Period 1991Q1-2016Q2

Housing Type	March 1991	June 2016	Quarterly Change
All Dwellings	AUS$150,000	AUS$778,000	1.60%
Strata	AUS$135,000	AUS$696,000	1.59%
Non-strata	AUS$151,000	AUS$870,000	1.70%

Source: Author's construct using data from DOH

The annual rent for all dwelling types also take an increasing trend over 1991Q1-2016Q2. From Table 2.3, there is a steady quarterly increase in the weekly rental payment for all dwellings, strata and non-strata properties. Specifically, the quarterly increase in rental payment for strata is greater than non-strata properties. This can be attributed to the increase in demand for rental apartments. This increase in rental payment in Greater Sydney has also been documented in other studies such as Yates (2008), Hatzvi and Otto (2008) and Shi et al. (2016). In 2016, for example, the average monthly household rental payment of Greater Sydney was AUS$1996, while the average for Australia was AUS$1954 (ABS 2018b). As discussed earlier, house prices in Greater Sydney have continuously risen over time. The asset pricing theory predicts that this rise in house prices should reflect investor's expectations (Hatzvi and Otto 2008). This certainly explained the steady increase in rental payment in Greater Sydney.

From the economic and employment perspectives, Greater Sydney is generally regarded as the financial and business services hub of Australia, with a large concentration of jobs in the service sector of the economy. Specifically, more than 75% of all foreign and domestic banks in Australia are headquartered in Sydney (CoS 2019). However, there is a general disparity in the nature of jobs across the city. While numerous high value, knowledge-intensive industries including finance, IT, professional services, engineering, research, healthcare, marketing and media jobs are concentrated in the eastern and northern regions of the city (NSW Department of Planning [NSWDoP] 2010; Wade 2017), economic activities in the western region are mainly manufacturing, warehousing, education, social and transport services.

Table 2.3:Weekly Median Rent in Greater Sydney for the Period 1991Q1 to 2016Q2

Housing Type	March 1991	June 2016	Quarterly Change
All Dwellings	AUS$175	AUS$520	1.05%
1 Bedroom	AUS$135	AUS$480	1.23%
2 Bedroom	AUS$175	AUS$520	1.05%
3 Bedroom	AUS$200	AUS$510	0.90%
Above 3 Bedroom	AUS$290	AUS$620	0.73%
Strata	AUS$160	AUS$520	1.14%
1 Bedroom	AUS$140	AUS$495	1.22%
2 Bedroom	AUS$170	AUS$520	1.08%
Non-Strata	AUS$190	AUS$520	0.97%
2 Bedroom	AUS$168	AUS$450	0.95%
3 Bedroom	AUS$190	AUS$470	0.87%

Source: Author's construct using data from DoH

To further elucidate the social and economic disparity across the regions of Greater Sydney, using the ABS 2016 Index of Relative Socio-economic Advantage and Disadvantage, the city is viewed as a blend of highly advantaged LGAs such as Ku-ring-gai, Mosman, Woollahra, North Sydney, Lane Cove and Hunter Hills in the eastern and northern regions, and highly disadvantaged LGAs such as Auburn, Bankstown, Blacktown, Burwood, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith in the inner-west and western Sydney regions. This socio-economic disparity in Greater Sydney is well documented in the housing literature (Mee 2002; Baum 2004; Randolph & Tice 2014). This disparity is also reflected in the income levels of the residents across regions, with those in the eastern and northern regions on the higher-end, while those in the western region are on the lower-end (Randolph & Holloway 2005a).

Globally, taking into consideration the city's social, economic, environmental and cultural indicators, Greater Sydney has been continuously ranked among the 10 most connected cities. The Loughborough University's globalisation and world cities research network, which measures the connectivity of cities in terms of position and influence ranked Greater Sydney in the top 10 most connected cities alongside New York, London, Tokyo, Paris and Hong Kong. The 2015 Anholt-GfK City Brands Index also ranked Greater Sydney as the fourth best city in the world for its brand appeal and image. Further, in 2016, the Global Financial Centres Index, which measures competitiveness among 75 international finance centres and their performance in global business environment, finance sector development, infrastructure, human capital and

reputation ranked Greater Sydney eighth globally and fourth in the Asia-Pacific region (CoS 2019). These features make Greater Sydney a global city.

These varying demographic, cultural and socio-economic characteristics of Greater Sydney have resulted in several housing arrangements and as such various housing submarkets have ensued. This was earlier echoed by Bunker et al. (2005), who reported the polarised spectrum of housing opportunities in Sydney as higher income households mainly live in waterfront and inner city areas, while low-income households live in the middle and outer suburbs of the city. The photos in Appendices 3 and 4 give a pictorial view of the diversity in the housing arrangements of Greater Sydney.

In conclusion, Greater Sydney is a city of diverse characteristics – global city, finance city, socio-culturally diverse, economically diverse, and it has a history of being a divided city in terms of socio-economic context with the eastern and northern regions being on the higher-end of the scale. The sum total of these diversities make Greater Sydney a fascinating case for a disaggregated study on the topical issue of housing affordability and house price behaviour.

2.2 The Importance of Submarket Studies

The section of the study focuses on the importance of submarket studies. Highlighted as one of the limitations of their research, Worthington and Higgs (2013) argued that housing studies on a broader geographical dimension such as national, state and city levels often provide suboptimal results as local dynamics are often largely ignored. This validates the importance of disaggregated studies. Further, Randolph and Holloway (2005a) argued that industrial and employment market reforms triggered by economic globalisation continue to have varying and diverse effects on Australian cities. They also argued for region-specific policies. More importantly, Greater Sydney is a socio-economically diverse city (Randolph & Tice 2014), which calls for the need to understand how prosperity in the city could affect different regions of the city (Mee 2002). Bunker et al. (2005) earlier reiterated the polarised spectrum of housing opportunities in Sydney in the sense that higher income households mainly live in waterfront and inner city areas, while their lower income counterparts live in the middle and outer suburbs. This polarisation has resulted in diverse household living arrangements leading to the existence of housing submarkets across Greater Sydney. This means the living conditions of municipalities have a huge impact on people's quality of life and should therefore take centre stage in the public policy domain (González et al. 2011). Further, Taylor and Wren (1997) earlier argued that strong and effective regional policies could result in direct economic and

social benefits. Hincks (2012) found that the interaction of housing and labour markets often generates conflict between residential and workplace location decision-making, yielding a strong case for region-specific policies to address these effects. Meen (1996) and Adair et al. (2000), who highlighted that housing market dynamics are better analysed as a series of interconnected submarkets due to the complex relationships that exist between submarkets within metropolitan areas, also support submarket studies. All of these studies point to the importance of submarket studies, particularly in metropolitan cities.

Nevertheless, no study on affordability, housing price bubble or price linkages has considered a disaggregated approach, despite the importance of such analysis particularly in metropolitan cities (Galster 1996). It is therefore critical to examine affordability from a housing submarket perspective. Yates (2008), for example, found that homeownership affordability varies across different regions of Greater Sydney due to the socio-economic and demographic disparities across the city. Similarly, Zhang et al. (2017) empirically showed that house prices in most regions have diverse responses to changes in macroeconomic variables. Further, Ying et al. (2013) reported that household socio-demographic characteristics play a critical role in determining housing choices in China. Kim and Cho (2010) reiterated that local demand and supply factors as well as the broader macroeconomic environment are fundamental drivers of housing affordability. As highlighted by Kutty (2005), regional and locational variables therefore play a critical role in determining affordability, suggesting that homeownership affordability could vary across regions within a metropolitan city. Hence, an understanding of local demographic, social and economic characteristics is significant for national and local housing policymakers (Galster 1996; Bramley et al. 2008).

2.3 Disaggregation of Greater Sydney into Regions and Analysis of Housing Parameters

To demonstrate the importance of micro housing analysis, this section examines key housing parameters across Greater Sydney. Specifically, this section shows whether there are socio-economic discrepancies across the different regions of Greater Sydney in the context of housing. In general, there are five major regions in Greater Sydney. They are: western region, inner-west region, southern region, eastern region, and northern region. By definition, Western Sydney combines two major urban regional governance groupings, the Western Sydney Regional Organisation of Councils (WSROC), which constitutes eleven local government areas (LGAs), and the Macarthur Regional Organisation of Councils (MACROC), representing three local government areas. This sums up to the following fourteen local government areas – Auburn, Bankstown, Blacktown, Blue Mountain, Camden, Campbelltown, Fairfield,

Hawkesbury, Holroyd, Liverpool, Parramatta, The Hills Shire, Penrith, and Wollondilly (Gleeson 2006). This is the geographical definition of Western Sydney region used in previous research and policy papers such as Hodge (1996), Mee (2002), and Parramatta City Council [PCC] Parramatta City Council (2012). Given that The Hills Shire has officially separated from WSROC, the study excludes 'The Hills Shire' from the definition of Western Sydney region above, and places it in the northern region of the city (Robertson 2014).

Similarly, the northern region combines both the Northern Sydney Regional Organisation of Councils (NSROC), which represents Ryde, Ku-ring-gai, North Sydney, Hornsby, Hunter Hills, Lane Cove and Willoughby, and the Shore Regional Organisation of Councils (SHOROC), which represents Manly, Mosman, Pittwater, and Warringah LGAs. The eastern, southern and inner-west regions were identified using the definition provided by the Southern Sydney Regional Organisation of Councils (SSROC). Accordingly, the eastern region constitutes Waverley, Randwick, Sydney and Woollahra LGAs; the southern region encompasses Botany-Bay, Hurstville, Rockdale, Kogarah and Sutherland Shire LGAs; and the inner-west envelops Ashfield, Burwood, Canada Bay, Strathfield, Leichhardt, and Marrickville LGAs. These LGAs are presented in Table 2.4.

The delineation of these regions also takes into consideration the high degree of house price substitutability in each region and the median house price in each of the LGAs that makeup the region. For example, in 2016Q2, the median house price for all dwellings in the western region was AUS$690,000 and house prices across all LGAs in this region range from AUS$589,00 to AUS$690,000. This shows greater substitutability within the region when compared to LGAs in other regions such as AUS$715,000 to AUS$1,324,000 in the inner-west region; AUS$760,000 to AUS$900,000 in the southern region; AUS$1,100,000 to AUS$1,709,000 in the eastern region, and AUS$835,000 to AUS$1,780,000 in the northern during the same period (DoH 2019). This is reinforced by Gibler and Tyvimaa (2014), who argued that economists often define housing substitutability through similar house price based on certain attributes that include the socio-cultural choices made by households. This is also consistent with the notion of social spatial-polarisation as documented by Baker et al. (2016), Doney et al. (2013), and Randolph and Tice (2014). Disaggregating Greater Sydney into these regions, is therefore, a unique approach in examining housing affordability. Figure 2.1 shows the spatial delineations of these regions.

In examining socio-economic differences within metropolitan cities, the smaller the size of the spatial determination, the more the social contrasts will be glaring (Randolph & Holloway

2005a). As reported by Lim et al. (2011), socio-economic status is often gauged by the level of access to income or financial assets, networks, social capital and the interaction with other social and economic factors. Therefore, developing an index at a lower geographical level is one practical way of determining socio-economic status (Lim et al. 2011), since wealthy suburbs are almost always well-positioned in terms of infrastructure, public services, green space and shading (Jean-Taylor et al. 2016). As such, they can influence decisions around planning process including the location of high density communities thereby widening socio-economic inequality in cities (Jean-Taylor et al. 2016).

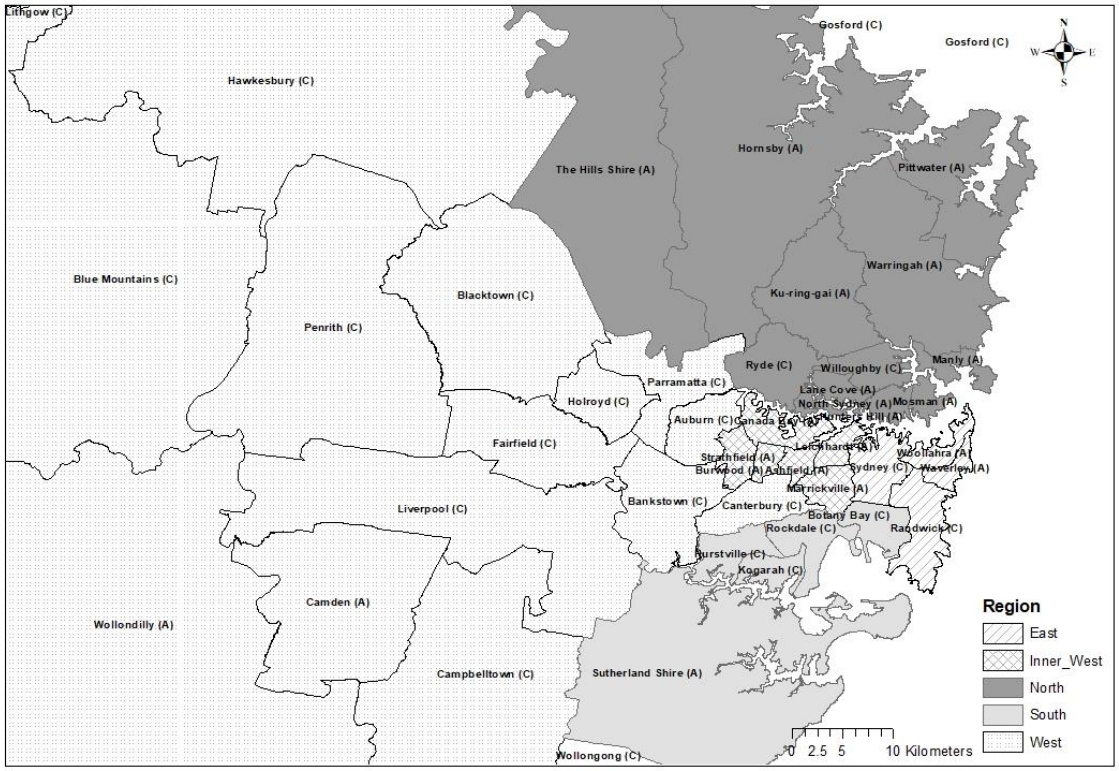
Table 2.4: Disaggregation of Greater Sydney into Regions

Western	Inner-West	Southern	Eastern	Northern
Auburn	Ashfield	Botany Bay	Randwick	Hornsby
Bankstown	Burwood	Hurstville	Waverley	Hunter Hills
Blacktown	Canada Bay	Kogarah	Sydney	Ku-ring-gai
Blue Mountains	Leichhardt	Rockdale	Woollahra	Lane Cove
Camden	Marrickville	Sutherland		Manly
Campbelltown	Strathfield	Botany Bay		Mosman
Fairfield				North-Sydney
Hawkesbury				Pittwater
Holroyd				Ryde
Liverpool				The Hills Shire
Parramatta				Warringah
Penrith				Willoughby
Wollondilly				

Source: Author's compilation using information from WSROC, NSROC, SHOROC and SSROC

Spatial polarisation and social disadvantage have also been widely discussed in the geographic literature (Doney et al. 2013; Baker et al. 2016). For instance, Dufty-Jones (2018) demonstrated that sustained growth in house prices in Australia has had diverse implications for different geographical areas. Specifically, the impact has been higher for metropolitan cities compared with regional cities (Costello 2009). Randolph and Holloway (2005b) showed that there is a link between housing tenure and social spatial polarisation, implying the importance of considering the differences between different regions in housing policies. Other studies such as Randolph and Tice (2014) and Baum (2004) reveal striking differences in key socio-economic and demographic characteristics across the regions of Greater Sydney. However, Forster (2006) found that the current metropolitan strategies across major cities in Australia are at odds with the increasing geographical complexity that emerges from such spatial polarisation.

Figure 2.1: Spatial Delineation of the Regions of Greater Sydney



Source: (ABS 2019)

As a result of these socio-economic discrepancies across space, particularly metropolitan cities, the ABS often computes several socio-economic indexes to evaluate these differences. The ABS index of Relative Socio-Economic Advantage & Disadvantage is one of such measures that is derived from certain socio-economic parameters such as income, unemployment, skilled occupations and education levels. The index scores each area around a national mean of 1000. Localities with a score above 1000 are considered relatively more advantaged, while those with a score below 1000 are relatively disadvantaged (Randolph & Holloway 2005b). Using this index, from Table 2.5, as at 2016, Western Sydney had a score below 1000 which shows strong signs of relative socio-economic disadvantage in the region. The score in the inner-west and southern regions is slightly above the 1000 threshold.

On the other hand, the northern and eastern regions of Greater Sydney had a score above 1000 (ABS 2016d), which means LGAs in these regions are relatively advantaged in terms of access to income, human and social capital. These indexes signify that residents in Western Sydney are more likely to get into poverty, deprivation and social exclusion than the other regions across Greater Sydney.

Table 2.5: Key Housing Parameters of the Regions of Greater Sydney

Housing Parameter	Western	Inner-West	Southern	Eastern	Northern
Total estimated resident population as at 2016 (no of persons)	2,094,918	371,728	567, 894	284,052	904,932
Average annual estimated population growth rate 1991-2016 (%)	1.54	0.77	0.85	0.79	0.88
Average household size as at 2016 (no. of persons)	3.02	2.63	2.85	2.4	2.63
Outright home ownership 2013 (%)	28.3	29.17	34.7	29.62	35.23
Owned with a mortgage 2013 (%)	39.94	29.2	33.18	23.86	32.32
State Housing Authority tenancy 2013 (%)	5.73	3.07	3.9	2.89	1.85
Real Estate tenancy 2013 (%)	15.75	27.43	18.73	29.77	20.38
Average weekly personal income 2015/2016 (AUS$)	1,072	1,336	1,184	1,756	1,776
Average annual personal income growth rate 1991-2016 (%)	1.29	2.21	2.25	3.95	2.59
Unemployment rate 2016 (%)	6.7	5.6	5.6	4.2	4.2
Average index of Relative Socio-Economic Advantage & Disadvantage 2016	990	1084	1045	1134	1135

Source: Author's construct using data from ABS, DIRD and DoE

This summary measure supports the findings of Randolph and Holloway (2005b), who pointed out that industrial and employment market reforms that are triggered by economic globalisation in the policy domain continue to have major effects on the location and level of disadvantage in Australian cities. Consequently, in Greater Sydney, some of these consequences are manifested by the increasing number of public housing being built in Mt. Druitt, Blacktown, Liverpool, Fairfield, Bankstown, Campbelltown and other parts of Western Sydney region. In addition, communities with significant disadvantaged private housing can be found in some areas of Penrith, and high concentrations in Fairfield, Liverpool, Auburn and Bankstown/Canterbury axis (Randolph & Holloway 2005b). Therefore, a clear difference in the socio-economic status between regions of Greater Sydney has been evident using this index.

Table 2.5 further reveals that the population of Western Sydney is significantly higher than the other regions. The region's estimated resident population in 2016 is slightly below the sum

of all the other regions. This region also has the highest population growth rate (1.54 per annum from 1991 to 2016), adding to an already bigger population. Northern Sydney region has the second highest population followed by the southern region (ABS 2017a). Average household size, another important characteristic of the population, is highest in the western region, followed by the southern region (ABS 2013). As population is a significant demand side driver of housing (Productivity Commission Report [PCR] 2004; Yates 2008), these indicators suggest that housing demand is expected to be significantly higher in Western Sydney, which has important implications for housing affordability.

An examination of personal income in the different regions reveals that in the 2015/16 financial year, the average weekly personal income of Western Sydney region (AUS$1,072 per week) was significantly below the average weekly personal income of (AUS$1,272) for Greater Sydney (ABS 2018b). The northern and eastern regions, on the other hand, reveal an average weekly personal income of at least AUS$1,750. The average weekly personal income of the inner-west and southern regions swings within the western region and the high-income eastern and northern regions. The annualised income growth over 1990/91 - 2015/16 is also the lowest in Western Sydney, while the eastern and northern regions have the highest income growth during the same period. This is consistent with the findings of Randolph and Tice (2014), who reported greater income polarisation between the high-income northern and eastern suburbs of Greater Sydney, and the low-income western and southern suburbs of Greater Sydney. From a macroeconomic perspective, Wade (2017) reported that the eastern and northern regions of Greater Sydney accounted for about 24 percent of Australia Gross Domestic Product (GDP) in the 2015/16 financial year.

This income discrepancy across regions of Greater Sydney can be attributed to the differences in terms of industry mix combined with the pool of skills across regions (NSW Department of Planning [NSWDoP] 2010; Wade 2017). The western region constitutes some of the most dynamic and deprived communities of Sydney, and broadly speaking, income and educational attainments in this region are below average (Gleeson 2006). The eastern and northern regions, on the other hand, house numerous high value, knowledge-intensive industries including finance, IT, professional services, engineering, research, healthcare, marketing and media jobs (NSWDoP 2010; Wade 2017). This growing income disparity has two housing implications especially for families in the lower income bracket. Firstly, it results in limited budget for non-housing consumption (Saunders 2017), and secondly, it narrows housing choice for lower

income households with a further deterioration in housing affordability (Boymal et al. 2013). In short, this clearly highlights income disparities in Greater Sydney.

Using the unemployment data from the Department of Employment (DoE), in 2016, the 6.7 percent unemployment rate in Western Sydney is significantly higher than the 4.2 percent in the eastern and northern regions of the city (Department of Employment [DoE] 2016). This further highlights that Western Sydney region is relatively socio-economically disadvantaged than the other regions of Greater Sydney. In the context of housing, as reported by Tian et al. (2016), both household unemployment and the local unemployment rate are important predictors of mortgage default, while savings for unforeseen circumstances and shorter duration of unemployment benefits can minimise the likelihood of a mortgage default significantly. Deng et al. (2000) had also earlier reported a positive association between mortgage default rate and unemployment rate, suggesting that default rate will be higher in areas with higher unemployment rate.

Additional discrepancies in key housing determinants are reported in Table 2.5. In 2013, the northern region recorded the highest percentage of outright home ownership, while western Sydney has the lowest outright home ownership in the same period. Western Sydney also has the highest percentage of tenancy with state housing authority. As reported by Randolph and Holloway (2005a), areas with high numbers of public housing often have excessively high proportions of households whose incomes are below AUS$400 per week.

Table 2.6: Percentage Change in Quarterly Median Sale Price

Region	December 2000	December 2015	% Change
Western	226	663	193
Inner-West	344	930	170
Southern	347	880	154
Eastern	440	1150	161
Northern	525	1280	144
Greater Sydney	294	788	168
NSW	230	600	161

Source: Author's calculations using data from NSW Department of Housing

Looking into the housing market, the annual growth of house prices in Greater Sydney depicts another significant disparity. From Table 2.6, it is evident that house prices in Greater Sydney exhibits an increasing trend between the quarter of December 2000 and the quarter of December 2015 (DoH 2019). The 193 percent increase in house price in western region is more than the increase in all the other regions as well as Greater Sydney and NSW. In fact, the

region of Greater Sydney with the lowest average weekly personal income had experienced the biggest upsurge in house price, followed by the inner-west region. The affluent northern region had the smallest increase. This upsurge in price posits a significant housing challenge for low-income residents especially first homebuyers.

In summary, there are significant differences between the regions of Greater Sydney in key housing parameters such as income level and growth, population growth, average household size, homeownership rate, dependency on state housing, unemployment rate, and median house prices. These are important factors in examining housing affordability as they influence both the supply and demand sides of the housing market. This variation in the socio-economic and demographic characteristics has raised pertinent questions on the appropriateness of aggregate housing affordability studies for informed policy decision.

2.4 Conceptual Framework of Affordability

This study adopts a novel spatial approach for comparing housing affordability and evaluating house price linkages across time and space. This approach largely considers location, and several socio-economic and demographic dynamics to examine several elements of housing affordability, housing price bubble and the diffusion pattern of house prices across the different regions of Greater Sydney from 1991 to 2016. Generally, housing affordability has been topical among policy makers, researchers, developers, households and other housing interlocutors. Despite this attention, there is no universally accepted definition of housing affordability. However, most of the widely-used definitions have key elements in common which provide useful guidelines in explaining housing affordability. Some of the prominent definitions of housing affordability include:

- The Urban Development Institute of Australia (UDIA), the peak body representing the interests of the development industry around Australia defined "housing affordability at its most basic level to mean the level of income required to attain a reasonably adequate standard of housing. According to UDIA, housing may be unaffordable if it requires a high proportion of household income (above 30 percent is a common guideline) or if the level of housing expenditure impacts on the ability of households to meet other basic needs. Whilst 'housing affordability' for rental households is simply a function of rent, for owner occupier households, affordability depends predominantly on mortgage repayments at prevailing median house prices, and the size of the deposit required to enter the market (UDIA 2014).

- In the National Housing Strategy (NHS), the term affordable housing "conveys the notion of reasonable housing costs in relation to income: that is, housing costs that leave households with sufficient income to meet other basic needs such as food, clothing, transport, medical care, and education" (National Housing Strategy [NHS] 1991).

- According to the Revised European Social Charter (RESC) of 1996, "a dwelling is considered affordable if it costs less than 30 percent of the household's pre-tax income. This is different for renters and house-owners: for renters, it includes rent and utilities such as water, fuel and municipal services; for home-owners it includes all the utilities, as well as mortgage repayments, property taxes and any condominium fees" (Maschaykh 2016).

- According to the United States Department of Housing and Urban Development (HUD), "total housing costs at or below 30 percent of gross annual income are affordable. This is often considered as the definition of housing affordability and has shaped views of who has affordability problems and the extent of the problems" (Hamidi et al. 2016).

- The 30/40 Rule is the preferred measure of housing affordability among many Australian policy makers, lobby groups, researchers and the media – housing is unaffordable if a household in the bottom forty percent of income distribution spends more than 30 percent of their income on housing costs (Beer et al. 2007; Yates 2007; Costello 2009).

Despite some slight differences, there is a point of convergence in these definitions that provides some insights into what housing affordability entails. These definitions reveal that the use of 30 percent of household income is a key component of housing affordability. In other words, housing affordability is essentially an interplay between the cost of obtaining a residential property and household income. Some of the associated costs of obtaining a housing property includes house prices, mortgage lending rate, and rent (Karamujic 2015). In terms of its computation, Holmes et al. (2008) and Worthington (2012) outline the following as the most commonly used measures of housing affordability by housing policy makers, financial and mortgage institutions in Australia:

- "Real Estate Institute of Australia Housing Affordability Index – Deposit Power- the ratio of median household income to average loan repayments, with the average determined by the average size of new loans for each quarter".

- "The BIS Shrapnel Home Loan Affordability Index – the ratio of mortgage repayments on a 'typical' housing loan to average full-time male earnings. The mortgage repayments assume a 25-year loan for 75 percent of the median house price".

- "The Commonwealth Bank of Australia (CBA) – Housing Affordability Index – the ratio of average household disposable income to the 'qualifying' income required for a 'typical' first-home loan. Qualifying income employs the assumption that the repayments on a 25-year loan, for 80 percent of the price of a 'typical' property purchased by a first-home buyer, are equal to 30 percent of household income".

- "The UDIA/Matusik Affordability Measure is based on the average household being able to afford to buy 51 percent or more of the housing for sale in their local area assuming 30 percent of household income is used to make mortgage payments. The UDIA compare average full-time earnings and median house prices to create a National Income Multiple measure of house prices".

These indices place great emphasis on the ability of the household to repay mortgage but without any direct consideration for renters, location/site value, and the housing stress that it may put on households. The indices principally define the entry requirements into mortgage without desirable attention into the amortisation of the loan. They are home loan affordability measures. In general, most of the direct concerns of housing affordability relate to the impact that housing costs put on household incomes and the ramifications it has on other household outlays. The higher the proportion of household budgets into housing and its related expenses, the less likely that these households will have adequate financial resources to meet their non-housing needs (Yates 2007). Looking beyond home loan affordability, there are other measures of housing affordability with extensive application in housing research. They include the housing price-to-income, price-to-rent, rent to income, residual income, and the 30/40 Rule.

Housing price-to-income and price-to-rent ratios are widely applied in housing market conditions (André et al. 2014). Worthington and Higgs (2013), for example, used the ABS housing price-earnings multiple (a ratio of house prices to household earnings) to report the

substantial deterioration of housing affordability in Australia. Using ABS data from September 1985 to June 2010, they found that median house prices increased significantly, from AUS$65,900 in the September quarter of 1986 to AUS$534,800 in the June quarter of 2010. This represented an eightfold increase in house prices, generating an annualised growth rate of approximately 8.9 percent. Average annual full-time earnings, on the other hand, increased from AUS$20,191 to AUS$65,114. This denoted a threefold increase and an annualised growth rate of 4.8 percent. Consequently, the housing price-earnings multiple index increased from 3.3 in September 1985 to 8.2 in June 2010, indicating a sharp decline in housing affordability. McLaughlin (2012) used the median multiple, the ratio of median housing price to median income in a given period to highlight the decline in affordability in the six largest cities of Australia for the period 1981 to 2009. Gan and Hill (2009) also used ratios to construct and articulate two forms of affordability in Sydney for the period 1996 to 2006 - purchase affordability (ability of a household to purchase a house) and repayment affordability (the burden imposed on the household for repaying the mortgage). They found that purchase affordability remained fairly stable, while repayment affordability decline considerably. In a similar study by Berry (2003), over the period 1986 and 1996, the percentage of low-income households living in housing stress in the nation's capital cities increased from less than 67 percent to almost 75 percent, with up to 80 percent in Sydney. By mid-2000, low-income households could not meet the financial requirements of buying the standard, average price three-bedroom house in almost any area of Sydney or Melbourne (Berry 2003). Most of these results used the house price-income ratio to measure and compare affordability across different countries, provinces and cities.

The rent-to-income ratio is also one of the oldest and the most regularly used affordability measure. When there is insufficient data, researchers usually resort into using the ratio of average rents to transaction prices to proxy housing returns (Tang 2012). Residual income, generally defined as, the difference between household income and rent payment, is another useful measure for comparing affordability across localities, where a lower value would suggest relative unaffordability (Karamujic 2015).

For a more detailed measure of affordability, in Australia, the adjusted Henderson poverty line is used. The Henderson poverty line identifies low-income households with possible housing 'stress' by considering the equivalent after-tax income rather than the unadjusted gross income. This approach is convenient in identifying those families whose after-tax income is below the set poverty line (Karamujic 2015), which is reflected in the 30/40 Rule. The 30/40 Rule, a

concept that is widely used in explaining "housing stress" in Australia, is restricted to households in the lowest two quintiles of the equivalised disposable income distribution paying at least 30 percent of their income in meeting their housing costs (Yates 2007). Using the 30/40 Rule, since 1996, the number of Australian residents experiencing housing stress or affected by the dearth of affordable housing has increased significantly. This measure of housing stress has different impacts on households depending on the demographics and other household characteristics (Costello 2009).

Overall, housing affordability is not a new phenomenon in property and housing research and its importance to households, policy makers, financial institutions and other players is so glaring. Various researchers and housing institutions have presented various definitions and computations of housing affordability using ratios and residual approaches, resulting in varying interpretations. The strengths and weaknesses of each of these methods as well as their implications on housing affordability were examined. One drawback of all these methods is the assessment of affordability at a given point in time with no consideration for the future. To address this issue, this study adopted two housing affordability indices that integrate standard annuity to account for both entry and ongoing affordability.

2.5 Housing Affordability Stakeholders Interaction

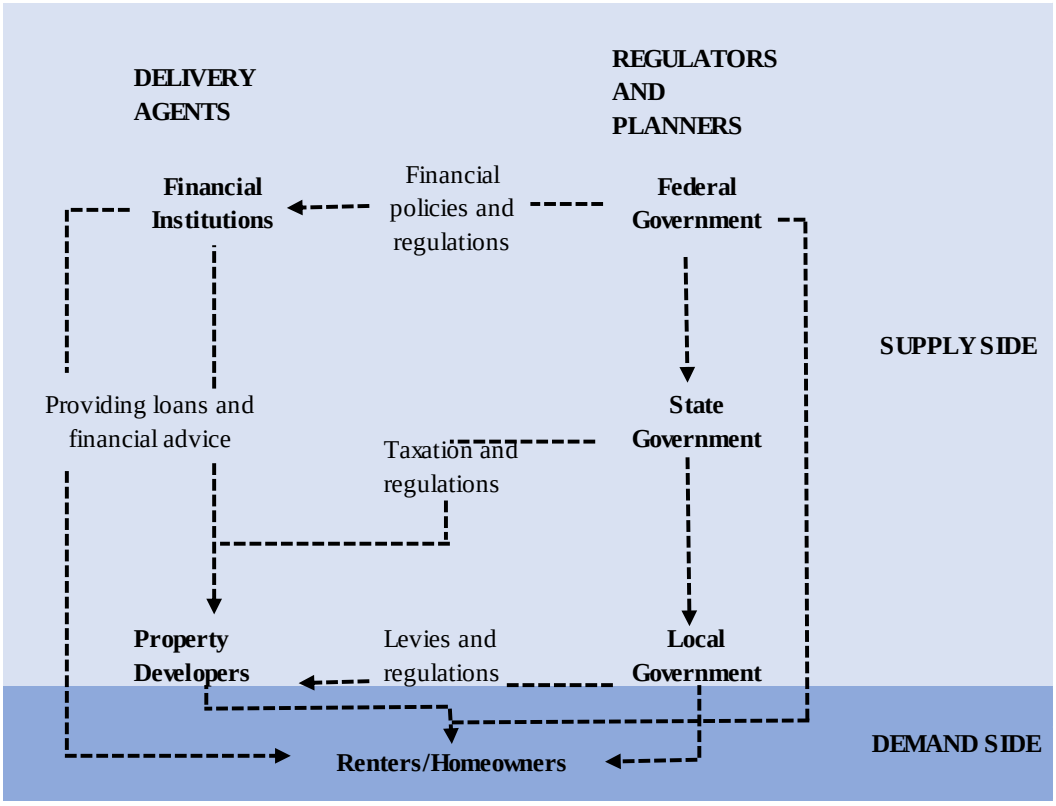
For a broader understanding of housing affordability, it is imperative to examine the interaction among key stakeholders in the housing sector in Australia. The collaboration among federal, state and local governments, financial and mortgage institutions, property developers, and home demanders (renters and homebuyers) within the housing domain, has significant implications for housing affordability. As shown in Figure 2.2, similar to other markets, there are two sides of the housing delivery system – the supply side and the demand side. The supply side is sub-classified into delivery agents and the regulators and planners. The regulators and planners are the three levels of governments in Australia, while the delivery agents are mainly property developers and financial institutions. The demand side constitutes largely renters and homebuyers.

As outlined in the National Affordable Housing Agreement (NAHA), the federal government provides leadership, financial sector regulations and Commonwealth taxation settings that influence housing affordability. While the state government provides leadership at state level, land use and supply, urban planning and development policy, and levy housing-related state and territory taxes and charges that influence housing affordability, the local government

provides building approval, local urban planning and development approval and levy rates and charges that influence housing affordability.

The direction of federal, state and local government policies and regulations set the tone and shape the environment for the delivery of housing affordability. These roles apparently impact housing prices and hence housing affordability. For example, a cash rate increase by the Reserve Bank of Australia (RBA) will certainly increase the mortgage lending rate, which will have an impact on renters and homebuyers. This will also raise the cost of servicing loans given out to property developers by financial institutions. Similarly, higher development levies and stamp duties that are imposed by state government as well as higher local rates and levies by local councils may intrinsically translate into higher house prices, which inevitably reduces affordability.

Figure 2.2: Housing Affordability Stakeholders Interaction



Source: (Productivity Commission Report 2004; Yates 2008; Worthington & Higgs 2013; Lee & Reed, 2014)

Federal government and home demanders (renters and homebuyers) have a two-dimensional relationship. Firstly, according to NSW Office of State Revenue (OSR), through the First Home Owner Grant (FHOG) currently at AUS$10000 and with a home value cap of AUS$600,000 in NSW and provided your purchase date is on or after 1 January 2016, the federal government

assist eligible first homeowners to purchase a new home (OSR 2016a). Studies have shown that higher FHOG will not only improve housing affordability but will also enhance the chances of low-income earners entering the housing market (Lee & Reed 2014). For example, the launch of the First Home Owners Grant Boost (FHOB) in October 2008 as part of the Australian Government's Economic Stimulation Plan, shows that Sydney's middle and outer regions, and in particular the lower income areas in the west and south-west regions were the highest performing, both in numerical and value terms (Randolph et al. 2013). The FHOB largely improves housing affordability between 2008 and 2010. The second channel is through the financial assistance provided by the federal government to low-income renters. There are two main forms of housing assistance policies in Australia targeting renters – Commonwealth rent assistance, and public housing (Berry 2003; Wood & Ong 2011). Obviously, an increase in housing assistance will improve housing affordability for low-income earners.

In summary, the interaction between income levels and house prices plays a key role in determining housing affordability. According to Schwartz (2016), limited housing affordability has spillover effects ranging from economic to social, and it is an issue even for the broad spectrum of employees. The availability of affordable houses for various income levels is essential for sustaining our communities, economic opportunities and a good quality-of-life. Thus, the concept of housing affordability requires wide-ranging synergy among all levels of government in Australia, households, property developers, financial institutions, regional and housing governance institutions, researchers and other stakeholders.

2.6 Conclusion of the Chapter

Chapter 2 provides a housing profile of Greater Sydney and sets the scene for sub-city housing analysis by disaggregating Greater Sydney into five major regions. Various socio-economic and demographic housing parameters across the delineated regions of Greater Sydney were examined to give more insights into housing affordability and house price behaviour at a disaggregated level. The chapter further discusses the conceptual framework, and the interactive role of the various housing stakeholders. The chapter has therefore put together the premises for undertaking such sub-city approach.

CHAPTER 3

LITERATURE REVIEW

3.1 Housing Affordability in Australia

Numerous issues surrounding housing affordability in Australia have been widely discussed such as institutional make-up, measures of housing affordability and evidence of declining housing affordability, key determinants of housing affordability, housing affordability studies for various geographical levels, and advocacy for more affordable housing (Yates 2008; Gurran & Whitehead 2011; Worthington & Higgs 2013). Researchers from various disciplines have examined housing affordability from different standpoints using various methodologies and covering different time periods. Among the prominent studies on housing affordability in Australia are Berry (2003); Berry and Hall (2005); Gurran and Phibbs (2017); Gurran and Whitehead (2011); Lee (2008); Lee and Jin (2011); Milligan et al. (2007); Milligan (2005); Worthington and Higgs (2013); Worthington (2012); Yates (2007); (Yates 2008). In addition, research and property development agencies have regularly published related papers and reports on housing affordability such as the Australia Housing and Urban Research Institute (AHURI) and Urban Development Institute of Australia (UDIA) as well as governance institutions such as New South Wales (NSW) Department of Housing, Western Sydney Regional Organisation of Councils (WSROC), Macarthur Regional Organisation of Councils (MACROC), South Sydney Regional Organisation of Councils (SSROC), and local councils.

3.1.1 Evidence of Declining Housing Affordability

Evidence of declining housing affordability in Australia is enormous. Worthington (2012), for example, used a descriptive analysis to examine housing affordability across 25 years and found a rapid rate of decline in housing affordability in Australia. For instance, in Sydney, Australia's largest city, in 1980, average house prices were 4.7 times average earnings. Ten years later, average house prices went up to 5.9 times average earnings, and then 6.6 times average earnings in 2000. By 2010, average house prices were 10.1 times average earnings. A study by Berry (2003), over the period 1986 to 1996, showed that the percentage of low-income households living in housing stress in the nation's capital cities increased from around 67 percent to almost 75 percent and up to 80 percent in Sydney. By mid-2000, most low-income households could not meet the financial requirements of buying the standard, average price three-bedroom house in almost any area of Sydney or Melbourne (Berry 2003). Holmes et al. (2008) further reported the declining trend of home ownership especially among the middle to

low-income earners in capital cities and major towns in recent years. By 2010, major Australian cities like Melbourne and Sydney had experienced a significant increase in house price that was beyond the levels of other global cities like New York and Tokyo (Bessant & Johnson 2013). Sydney has become one of the least affordable cities in terms of housing in the world (Maschaykh 2016). This is reinforced in a recent report of housing affordability that highlighted Sydney as the third-least-affordable housing market, trailing Hong Kong and Vancouver (Demographia 2019). Over the 25-year study period, 1991 and 2016, a sustained and significant increase in house price was evident in Greater Sydney. In comparison to other major cities of Australia, using the median house price, house prices in Sydney are the most expensive in Australia (Angus 2017).

An analysis of ABS 2011 census data by Wulff et al. (2011) further demonstrated that very low-income households are confronted with serious affordability difficulties due to shortage of affordable housing in the market. Using the ratio of median detached house prices to the median household, Birrell and McCloskey (2016) found that by the third quarter of 2015, the index increased to 12.2 from 9.0 in 2013. This decline in affordability is further supported by Healey (2016), who argued that homeownership rates are declining for all age groups, even for Australians in their 60s and 70s. Virtually all demographics are holding mortgages for longer. People in the age bracket 50-59 years are experiencing the biggest drop in house ownership since 2002. In addition, only a small proportion of low-income earners are entering the housing market (Healey 2016). In explaining the decline in affordability in Australia, Worthington and Higgs (2013) employed an autoregressive distributed lag (ARDL) on six sets of proxy variables ranging from economic, demographic, financial to social to examine their short and long-run effects on housing affordability over September 1985 to June 2010. They found that economic growth has an adverse effect on housing affordability in the short run, while taxes related to housing affordability, including personal income tax, negative gearing, and the GST, have significant effect on housing affordability in the long run.

Outside Australia, in China, the house price-income ratio is greater in the country than in Europe and America. This can be attributed to some cultural background that most Chinese are unwilling to move from their native land (Lin et al. 2014). Using the house-price-income ratio to determine access to the housing market, Chen et al. (2010) reported a declining trend of entry-level affordability for each cohorts of Shanghai over 1999-2008. By comparing house price with an index of life time income, Abeysinghe and Gu (2011) found that the escalation in house price over income has resulted in a substantial decline in housing affordability in

Singapore. In Europe, Pittini (2012) found that in 2010, 10.1 percent of European households, and 36.9 percent of households with an income below 60 percent of median equalised income, expended more than 40 percent of their disposable income on housing. Generally, Pittini (2012) noted that housing related expenses take about 22.9 percent of total household consumption expenditure, which represents an increase of 2.5 percent from the year 2000. More specifically, Dewilde and De Decker (2016) recently echoed the skewed effect of the deteriorating affordability in western European countries. They highlighted that low-income households experience more affordability problems compared to their middle-income counterparts. In the US the disproportionate increase in house price over income is well documented in Brassil (2010) Montagnoli and Nagayasu (2015) and Hamidi et al. (2016). By and large, there is evidence of declining affordability across the globe.

3.1.2 Determinants of Entry-Level Housing Affordability

This section reviews the related literature on the determinants of entry-level housing affordability. Two strands of the literature were examined – the supply-side and demand-side of the housing market. To a greater extent, previous studies on the determinants of housing affordability adopted a narrative (Productivity Commission Report 2004; Holmes et al. 2008; Yates 2008).

From the supply side, Ruming et al. (2011) reported that infrastructure levies have profound implications on house prices. Similar findings were earlier reported by Holmes et al. (2008). They found that higher levies imposed by both state and local authorities can result in higher house prices, which can cause a deterioration in housing affordability. Comparable results were also reported in the National Housing Strategy (1991) and the Productivity Commission Report (2004). Furthermore, Yates (2007) found that supply side factors that may affect the cost of the delivery of affordable housing include the availability of land, land development processes and policies, infrastructure costs (including development charges), the cost of construction, and property-related taxes. Brassil (2010) found that at the state and local level, issues related to zoning and land use also affect housing affordability through housing supply. Similar results were reported by Chakraborty et al. (2010), who found that zoning as practised by suburban governments in six metropolitan areas in the US can be a deterrent to the construction of certain houses below market determined levels. Previously, Knaap (1998) reported that metropolitan planning in the US can contribute to both the cause and solution to ownership affordability problem. Kohler and Van Der Merwe (2015) argued that the response rate of housing supply to changes in demand for housing determines house price. They further argued that empirical

studies have shown that, in the short run, housing supply is less responsive to demand, and this can be attributed to the duration and complexity of the planning process, the time requires to construct new dwellings, the difficulty in the provision and funding of required infrastructure, and the cost of readying undeveloped land for construction and availability of suitable sites. In a similar study, McLaughlin (2011) argued that there are time-invariant factors that vary between cities that could potentially determine the supply of new housing units. These factors include natural topography, climate, political will towards development, investment in infrastructure, geographic proximity to raw materials, local industrial structure of the development sector, and labour costs. Therefore, infrastructure levy, difficulties involved in the release of developable land and its associated cost, expensive regulatory process, and inconsistent and complex development approval process can result in slow response of housing supply to its demand, which can cause a decline in affordability (Holmes et al. 2008; Liu & Otto 2017). Gurran and Whitehead (2011) argued that limited financial resources and the lack of policy mandate by local councils in Australia to undertake large scale property development also affect affordability. At federal level, the commonwealth government in Australia takes an indirect role in urban policy and planning and provides housing assistance through the states (Austin et al. 2014).

From the demand standpoint, de Bandt et al. (2010) found real long-term interest rates, total investment, real credit and real stock prices as the key factors that inflate house prices, resulting in a decline in housing affordability. In other words, house prices are more responsive to monetary policies than the level of economic activities (de Bandt et al. 2010). A similar study by Brown et al. (2011) reported that the effect of interest rate policy on the user cost of housing far outstripped the tax policy. Kim and Cho (2010) reported that in Korea, ownership affordability is largely driven by the access to and the terms of mortgage credit. All these studies show that mortgage lending rate has a material effect on affordability (Chen et al. 2010). Yates (2008) identified household growth resulting from natural increase and immigration, real incomes, real wealth, house price, rent, cost and availability of finance for housing, and the institutional structure affecting housing finance provision as the main demand side determinants of housing affordability. Yates (2008) argued that any increase in house price would deteriorate affordability significantly especially for low-income households. Comparable evidence was also reported by Worthington and Higgs (2013). Yates (2008) also asserted that relative low-income households will face significant consequences as affordability declines due to their low residual income. The Productivity Commission Report

(2004) also noted similar effects of house price and income on affordability. Similar results were obtained in China by Ying et al. (2013), who found an inverse relationship between both permanent income and transitory income and the homeownership affordability of the lower middle class. In the United Kingdom, Muellbauer and Murphy (2008) found that income, demography, available credit, and interest rates are the key determinants of house prices, and by extension ownership affordability.

The Productivity Commission Report (2004) highlighted that the impact of population growth on homeownership affordability through the demand for housing particularly in cities and regions is subtle and complex. The report found that if the increase in population growth is not sourced from higher immigration, it will offset the upward pressure on house prices coming from, amongst other things, economic growth and cheaper finance, which will improve affordability. This view is supported by Haylen (2014, who found that the impact of housing demand emanating from overseas and interstate migration is more immediate as they require accommodation upon arriving, whether owner occupied or rental. Gitelman and Otto (2012) and Worthington and Higgs (2013) also reported an inverse relationship between population growth and homeownership affordability in the short run. Stone (2004) identified rent as a key determinant of affordability especially for potential first home buyers. Stone (2004) found that renters are more likely to be shelter poor than homeowners when affordability deteriorates. Further, the Productivity Commission Report (2004) and Yates (2008) reported that an increase in rent has an inverse relationship with entry to the housing market for first home buyers through its effect on savings to make a deposit for a home.

While supply side factors are mostly influenced by the actions and policies of the various levels of government in Australia, the demand-side determinants are primarily driven by demographics and market fundamentals. However, most of these studies are highly narrative. Few studies have provided empirical evidence on the determinants of ownership affordability such as Lee and Reed (2014), who revealed some empirical evidence to suggest that First Home Owner Grant (FHOG) policy is an effective tool in boosting the affordability of first time buyers in Australia, and Worthington and Higgs (2013), who modelled ownership affordability in Australia against several economic, demographic and cost variables spanning 1985 to 2015. They found empirical evidence to support that housing finance, dwelling approvals and financial assets are the main long run drivers of ownership affordability in Australia, while the influence of population and economic growth on affordability is only in the short run. However, these studies largely ignored the presence of housing sub-markets. As highlighted by Bramley

et al. (2008), housing markets should be analysed at a disaggregated level to integrate local demographic, social and economic characteristics that form housing sub-markets. As such ownership affordability varies across different regions in respect to the socio-economic and demographic disparities across metropolitan cities. This is further supported by Zhang et al. (2017), who classified 35 metropolitans in China using geographical location and regional economic performance. They found that house prices in most regions have diverse responses to changes in macroeconomic variables. Also in China, Ying et al. (2013) found that household's socio-demographic characteristics play a critical role in determining housing choices for the lower middle class. Kim and Cho (2010) found that local demand and supply factors as well as the broader macroeconomic environment are key determinants of house price in Korea. Earlier, Kutty (2005) employed an analytical model in the US and found that regional and locational variables are significant determinants of affordability. Their study further highlighted that regional and locational characteristics can enhance the propensity of housing-induced poverty. Even though these studies suggest that the determinants of affordability could vary across regions, empirical evidence of such approach within a metropolitan city is limited.

As a result, this study modelled ownership affordability using a sub-city approach. The study collapsed the literature to these key drivers of housing affordability - house price, income, housing supply, resident population and rent. As reported by Worthington and Higgs (2013), house price increase can deteriorate affordability, while growing housing supply is expected to improve affordability (McLaughlin 2011). Resident population is indeterminate depending on the effect of net-migration and/or natural increase (Birrell & Healy 2003; Productivity Commission Report 2004; Yates 2008). Growing incomes as a demand side driver can improve affordability (Worthington & Higgs 2013). Furthermore, increases in rent usually place an impediment on potential homebuyers as savings for a deposit becomes more difficult and as such their affordability deteriorates as rent increases (Healey 2016).

In summary, house price, income, housing supply, resident population and rental activities have been argued as the key determinants of ownership affordability, although empirical evidence of housing determinants are somewhat limited. Again, two exceptions are Worthington and Higgs (2013) and Lee and Reed (2014). However, these studies largely ignored local effects, which raises the question of generalisation of their findings, especially in Greater Sydney where there are clear socio-economic disparities across the city.

3.1.3 Determinants of Ongoing Affordability

Several studies have also been devoted on the drivers of ongoing affordability due to the adverse financial and social effects of mortgage default (Tian et al. 2016). Some scholars such as Deng et al. (2000), Goodman et al. (2010) and Pennington-Cross and Ho (2010) reported that the current loan-to-value ratio is a good predictor of mortgage default and by extension ongoing affordability. Their empirical evidence consistently suggest that higher loan-to-value will increase the risk of mortgage default. Deng et al. (2000) also found that unemployment and divorce rates significantly affect mortgage default. In their study, Goodman et al. (2010) found that unemployment is a catalyst to mortgage default for borrowers with negative equity. Pennington-Cross and Ho (2010) found that the probability of mortgage default is higher when payment shocks are mixed with low or no equity in the home. They also found that borrowers will automatically benefit from lower payment when there is a lower interest rate.

Furthermore, Quercia et al. (2012) used a unique sample of community reinvestment loans in the United States to examine the relationship between default rate and income level, especially moderate to low-income households. Their study found that lower or very low income is associated with higher default and lower probability of prepayment probabilities. Their study further revealed that factors such as credit ratings, the value of equity in the property and local labour market conditions can have varying impacts on default and mortgage deposits. More recently, Quercia et al. (2016) found that mortgage default and mortgage deposits are more sensitive to changes in the structural component of the local unemployment rate than in the cyclical component. Riley (2013) discussed the concept of strategic default among low-income homeowners, who received community reinvestment loans as part of the Community Advantage Program. Their study defined strategic default as a situation where the borrower has the financial resources to make mortgage payment but opts to default on the mortgage primarily because they believe the loan is more than the value of the property. Riley (2013) found that strategic default behaviour of low-income homeowners is largely driven by factors such as income, interest rate, geographic location, the timing of loan origination, and the loan servicer.

3.1.4 Institutional Environment and Policy Framework

From an institutional perspective, recent studies on housing affordability highlighted the processes and policies that regulate housing supply in Australia. Ruming et al. (2011), for instance, used a case study and key informant interview approach and found that the planning process in Australia contributes greatly to the cost of building a house, and by extension, raises

the price of houses for both existing and new building sites. Development levies and charges deemed as contribution to local infrastructure are directly impacting on house prices (Holmes et al. 2008; Ruming et al. 2011; Healey 2016). In a related study, van den Nouwelant et al. (2015) found that urban renewal has the propensity to raise land and house prices, causing a decline in the availability of affordable housing. Thus, strong government role in urban policy and land regulation is strategic for the successful provision of affordable housing, as it was seen in the United Kingdom and the Netherlands. However, in Australia, the limited role of Commonwealth Government in urban policy and planning is affecting the delivery of affordable housing (Gurran & Whitehead 2011; Austin et al. 2014). The public sector in Australia has been less committed in the direct provision of affordable housing (Susilawati & Armitage 2010). Since 2004, there has been a push towards a policy framework that supports a larger and more diversified affordable housing sector. Milligan (2005) further argued that to realise the envisaged national industry, the current housing delivery framework requires close collaboration among the following four key interlocutors - stakeholders identified as dealing with structural, governance, ownership and regulatory issues. Therefore, authorities in Australia should integrate housing planning and regulatory frameworks that support not-for-profit housing providers to expand in their service delivery. However, by the start of 2008, evidence shows that not-for-profit providers could not grow substantially, primarily due to limited public investment (Milligan et al. 2007).

3.1.5 Advocacy for Housing Affordability

As the need for more affordable housing intensifies, it lends itself into growing advocacy for more affordable housing by governance institutions, researchers, lobby groups and the media. In their submission to Senate Select Committee on Housing Affordability in Australia in 2008, UDIA argued that housing affordability in Australia is a national issue that requires strong synergy among the three levels of government, with Commonwealth Government taking the leadership role (UDIA 2008). In another submission to Senate in 2014, UDIA reiterated their 2008 submission by calling for adequate collaboration among all levels of government to ensure all Australians have access to appropriate and affordable housing (UDIA 2014). Their submission further highlighted that state and local governments have a crucial role to play in ensuring an adequate supply of land, providing sufficient local infrastructure and services, and ensuring an efficient and effective planning system to support new housing. Equally so, the federal government is crucial in funding urban infrastructure that will improve affordability.

At state level, in 2014, WSROC made a submission to the state of New South Wales (NSW) Upper House Inquiry into Social, Public and Affordable Housing, in which they articulated that the supply and maintenance of public and affordable housing is a crucial issue for many local councils in Western Sydney, a region that is characterised by high social disadvantage (WSROC 2014). There have also been several publications by media institutions including Sydney Morning Herald, calling for more actions from all levels of government to increase the availability of affordable housing (Massola 2016). Peak housing advocacy bodies pointed out the adverse consequences on low-income families of the proposed federal government cuts on housing programs and advocated for a discontinuation of such policy (Donovan 2014).

3.1.6 Housing Policies and Regulations

This section of the literature review examines the existing housing policies in Australia. Given the clear socio-economic and demographic disparities across the various housing submarkets, it is essential to examine whether existing housing policies are reflective of these differences. Randolph et al. (2013) summarised Australia's Commonwealth government policies that seek to assist first home buyers from 1964 to 2013. Introduced by the former Prime Minister Menzies in 1964, the Home Savings Grant Scheme (HSGS) provided assistance to 'young married persons' buying or building their own home by granting AUS$1 for each AUS$3 of approved savings up to a maximum of AUS$2000 provided savings were held for three years. Some amendments were made to the HSGS through the 1960s and early 1970s. In 1976, the Fraser Government implemented an Amendment Act to enable the continuation of the HSGS and it was eventually replaced by the Home Deposit Assistance Act (HDAA) in 1982. The HDAA runs till July 1983.

Under the HDAA, first homebuyers were eligible for matched 1:1 'acceptable' savings in the first two years immediately preceding the purchase date. Grants of AUS$1250 and AUS$2500 were available for savings held for a year and over two years respectively. Both the HSGS and the HDAA set the scene for the introduction of the First Home Owners Scheme (FHOS) introduced by the former Prime Minister Hawke in 1983. Under this scheme, after a means test that is related to the number of dependent children (Hicks et al. 2008), assistance was provided typically over the first five years of homeownership through monthly payments into a financial institution as opposed to the one lump sum payment at the time of purchase.

Since its inception in July 2000, the First Home Owner Grant (FHOG) has gone through some reforms (Office of State Revenue [OSR] 2019). From July 2000 until the period before the

global financial crisis, the FHOG in NSW provided AUS$7000 to assist eligible first home owners to purchase a new home. Table 3.1 shows the top 20 recipients of the FHOG by value by postcode since its inception in 2000.

Table 3.1: Top 20 Suburbs of the FHOG by Value from July 2000 to July 2019

No.	Postcode	Suburb/Town	Number of Homes	Value
1	2170	Liverpool	11,398	AUS$105,012,800
2	2145	Westmead	8,669	AUS$80,697,500
3	2560	Campbelltown	8,060	AUS$71,938,000
4	2148	Blacktown	7,629	AUS$69,373,000
5	2150	Parramatta	5,186	AUS$50,368,500
6	2250	Gosford	5,928	AUS$49,787,000
7	2747	Werrington	5,595	AUS$54,093,000
8	2077	Hornsby	5,218	AUS$47,811,000
9	2200	Bankstown	5,271	AUS$48,608,500
10	2770	Mount Druitt	5,686	AUS$47,675,500
11	2750	Penrith	4,675	AUS$40,343,000
12	2650	Wagga wagga	5,722	AUS$51,034,000
13	2166	Cabramatta	5,699	AUS$46,201,000
14	2155	Kellyville	4,504	AUS$49,941,000
15	2760	St Marys	4,127	AUS$39,975,000
16	2620	Queanbeyan	4,716	AUS$43,281,000
17	2570	Spring Farm	3,652	AUS$43,273,500
18	2259	Wyong	4,439	AUS$42,250,000
19	2763	Quakers Hill	4,274	AUS$35,983,500
20	2099	Dee Why	4,178	AUS$36,471,000
Top 20 Total			**114,626**	**AUS$1,054,117,800**
NSW Total			**599,669**	**AUS$5,347,115,664**
% of Top 20 to NSW			**19.11%**	**19.71%**

Source: NSW Office of State Revenue

The first reform in the FHOG is during the global financial crisis in 2008. As part of the Australian Government's Economic Security Strategy, former Prime Minister Kevin Rudd introduced the First Home Owners Boost (FHOB) or the 'Boost' in October 2008 (Randolph et al. 2013). The Boost provided a total of AUS$21000 for buying or building a new home and

continued until the end of September 2009 and then halved from October to December. During the Boost period, the NSW Government's New Home Buyers Supplement provided an extra AUS$3000 for newly constructed property giving a total of AUS$24000 (Randolph et al. 2013). Recent studies indicated that FHOB improves housing affordability among low income earners and enhances their chances of entering the housing market. Randolph et al. (2013) show that Sydney's lower income areas in the west and south-west regions were the highest performing, both in numerical and value terms during the FHOB era. Lee and Reed (2014) also found out that FHOB did enhance housing affordability of first home buyers, whilst there is no evidence to suggest that it destabilised the housing market.

With the elimination of the Boost, the NSW Government introduced the Housing Construction Acceleration Plan (HCAP) as part of the 2009/10 state budget, a policy that offered a 50 percent cut in stamp duty for all purchasers of newly constructed homes not exceeding AUS$600,000 in value (OSR 2016a). The savings made by home buyers from the HCAP are shown in Table 3.2. From the 1 July 2016, the First Home Owner Grant (FHOG) changed to AUS$10000 and with a home value cap of AUS$600,000 to assist eligible first homeowners to purchase a new home or substantially renovate their home (OSR 2016b).

Table 3.2: Housing Construction Acceleration Plan (HCAP) Calculations

Purchase Price (AUS$)	Usual Duty (AUS$)	HCAP Duty (AUS$)	Savings (AUS$)
250, 000	7, 240	3, 620	3, 620
300, 000	8, 990	4, 495	4, 495
350, 000	11, 240	5, 620	5, 620
400, 000	13, 490	6, 745	6, 745
450, 000	15, 740	7, 870	7, 870
500, 000	17, 990	8, 995	8, 995
550, 000	20, 240	10, 120	10, 120
600, 000	22, 490	11, 245	11, 245

Source: NSW Office of State Revenue

As shown in Table 3.1, the FHOG has provided a sum of AUS$5,347,115,664 across NSW from 1 July 2000 to 31 July 2019. The top 20 postcodes by value accounted for 19.71% of this amount. More specifically, the top 5 postcodes by value are in the western Sydney region. In fact, 13 of these postcodes are in the western Sydney, while only 2 are in the northern region

of Sydney. The remaining 5 postcodes are in the regional cities and towns of NSW[5]. These results generally support the earlier findings of Randolph et al. (2013) about the FHOG. They reported that Sydney's lower-income areas in the western and south-western regions are the highest performing, both in numerical and value terms.

The Housing Affordability Fund (HAF) is a five-year investment initiative developed by the Australian Government to the tune of AUS$512 million. The HAF was implemented between 2008/09 financial year to 2012/2013 with the overarching aim of reducing the cost of new homes for homebuyers. HAF seeks to address two significant obstacles to increasing the supply of affordable housing – the 'holding' costs incurred by developers due to long planning and approval times; and the infrastructure costs that include laying of water pipes, sewerage, transport and the creation of parks. Operationally, according to the Department of Social Services (DSS), HAF provides grants to state, territory and local governments, to work in close collaboration with the private sector, to reduce housing-related infrastructure and planning costs, with the aim of passing savings to new home buyers (Department of Social Services [DSS] 2016b).

From the rent perspective, there are two main forms of housing assistance policies in Australia - Commonwealth Rent Assistance and public housing (Berry 2003; Wood & Ong 2011). The Commonwealth Rent Assistance is a non-taxable cash supplement provided by the Commonwealth government to private or community renter households who receive pensions, allowances or Family Tax Benefit Part A (DSS 2016a). Public housing is subsidised housing that are typically managed by state and territory housing authorities such as Housing NSW. Public housing is offered to eligible tenants at below-market rents, thereby creating a demand-supply gap (Wood & Ong 2011). In addition, the National Rental Affordability Scheme (NRAS) is part of the Australian Government's long-term response to the issue of housing affordability. Commencing on 1 July 2008, the NRAS seeks to stimulate the supply of new affordable rental dwellings through collaboration with state and territory governments. NRAS homes are rented to eligible tenants at a rate that is at least 20 percent below the market value rent subject to meeting a set of eligibility criteria that principally includes household income (DSS 2016). The NRAS will provide a relatively stable income stream that will improve affordability (Newell et al. 2015; Newell et al. 2015a).

[5] Suburbs in Western Sydney are Liverpool, Westmead, Campbelltown, Blacktown, Parramatta, Werrington, Bankstown, Mt Druitt, Penrith, Cabramatta, St Marys, Spring Farm, and Quakers Hill; in Northern Sydney are Hornsby and Kellyville; and in the regional towns and cities are Gosford, Wagga Wagga, Queanbeyan, Wyong, and Dee Why.

To summarise, housing assistance policies are largely driven by federal and state governments. Since the 1960s, federal government housing policies are mostly on home ownership for first home buyers starting from the Home Savings Grant Scheme (HSGS) in 1964 to the current First Home Owner Grant (FHOG) of AUS$10000. These policies seek to assist eligible first home owners to purchase a new home or build their home (OSR 2016a). Other federal government housing policies between 1964 to date include the Home Deposit Assistance Act (HDAA) in 1982, First Home Owners Scheme (FHOS) in 1983, First Home Owners Boost in 2008, and the five-year Housing Affordability Fund (HAF) between 2008/09 to 2012/13.

The federal government also assist eligible renters in paying their rents through the Commonwealth Rent Assistance and the National Rental Affordability Scheme. In NSW, subject to income and other criteria, public housing is provided to eligible renters by Housing NSW. Overall, various housing policies have been applied in Australia in general and NSW in particular. However, current government policies on housing affordability are not well tailored to adequately address affordability especially for low-income earners (Costello 2009).

3.2 Housing Price Bubbles

Two sub-strands of housing literature are reviewed under housing price bubble – house price and market fundamentals (income and rent), and housing price bubbles.

3.2.1 House Price and Housing Bubble Fundamentals (Rent and Income)

The relationship between house price and rent is an important tool in identifying possible housing bubble and evaluating potential investment yield (Leyshon & French 2009). Gallin (2008) found that the rent to price ratio is a useful tool in predicting changes in real prices over time. Himmelberg et al. (2005) reported that the single most fundamental value that explains house price is rent. Girouard et al. (2006) used the price-to-rent ratio as a benchmark of over or undervaluation of properties in OECD countries. Their study found that countries reporting high real house price such as Australia and the Netherland experienced a significant increase in the ratio ranging from 25% to 50% above its long-term average; and countries where real house prices have been stable or falling recorded a price-to-rent ratio that is below its long-run average. This variation in the ratio could indicate instability in the housing market. Hiebert and Sydow (2011) found similar results as they attributed the variability of house price movements in the euro area to movements in the rental yield. The use of house-price-rent ratio in predicting stability in the housing market is also documented in Engsted and Pedersen (2015). Kim (2015) used the house-price-rent ratio to identify the fundamental drivers of the UK housing market.

They found housing premium largely influences the ratio, while interest rate only accounts for a small proportion of the variation in the ratio. By constructing quarterly time series of the rent-price ratio of aggregate stock of owner-occupied housing in the United States, Davis et al. (2008) show that the rent-price-ratio is within the range 5% and 5.5% between 1960 and 1995, but rapidly declined after 1995. By the end of 2006, the ratio recorded its lowest level at 3.5%. These results indicate instability in the housing market. Campbell et al. (2009) applied the dynamic Gordon growth model to examine the fundamental drivers of price to rent ratios in 23 metropolitan housing markets in the US. They found that real interest rates, housing premia, and rent growth contribute significantly to variation in the price to rent ratio. Kivedal (2013) also used the price to rent ratio to measure the potential deviation of house prices from their fundamental values. They reported that the significant rise in house prices before 2007 financial crisis is not accompanied by a proportionate increase in rent, which suggests that the large increase in house prices is driven by factors other than rental price. All these studies have shown the importance of using house-price-rent ratio to define and detect housing bubbles.

Income is also another key market fundamental. The relationship between house price and income is complex (André et al. 2014), and has wider application in housing literature. A number of housing studies have employed house price-income ratio to assess housing bubble (Berry 2003; Girouard et al. 2006; Gan & Hill 2009; Chen et al. 2010; Leung & Tang 2015; Chen & Cheng 2017). Girouard et al. (2006), for example, found that the price-to-income ratios in 2005 are significantly higher than their long-term averages in countries such as Ireland, the Netherlands, Spain, Australia and New Zealand. The ratios in these countries exceeded their long-term averages by more than 40%. Similar increase in this ratio is reported in Australia by Berry (2003) and Worthington and Higgs (2013), especially in metropolitan cities. Chen and Cheng (2017) employed variance decomposition and found that interest rate and real income growth appear to be the drivers of the deviations in the price-income-ratio in Taiwan over 1979Q1–2015Q3. Other studies have gone further to examine the stability and long run equilibrium between house price and income using econometric techniques. In this light, using panel unit root tests, Malpezzi (1999) could not reject the presence of unit roots in the price-to-income ratio in 133 US major metropolitan areas spanning from 1979 to 1996. Girouard et al. (2006) also failed to reject the presence of a unit root in the ratios of 18 OECD countries for a period of more than 30 years. Chen et al. (2007) rejected the presence of unit root in the house price-income ratio, suggesting stability in these variables in Taiwan for the period 1973Q3 to 2002Q4. Gregoriou et al. (2014) found that the house price-to-earnings (income) ratio is non-

stationary in the UK over 1983Q2–2009Q1, suggesting that house prices may permanently depart from earnings.

From a cointegration point of view, some studies have suggested that house prices and market fundamentals such as income are cointegrated (Abraham & Hendershott 1996; Capozza et al. 2002; Black et al. 2006), while others have produced contrasting results. Using national level data from 1975 to 2002 or a panel of 95 metropolitan areas from 1978 to 2000, Gallin (2006), for example, finds no evidence of cointegration between house price and per capita income in the United States. Meen (2002) rejected no cointegration between house prices and fundamentals. Mikhed and Zemčík (2009) also found no cointegration between house price and income using panel data. In contrast, Malpezzi (1999) deployed panel analysis and found evidence of cointegration. The literature has also highlighted that the interaction between house price and income (or rent) goes beyond the mere construction of ratios. Insightful knowledge to whether house price and rent (or income) drift apart temporarily or they tend to return to their long-run equilibrium is important because it gives an indicator of possible housing bubble formation (Chen & Cheng 2017). If cointegration is found between house price and rent (or income), any fissure between the two will indicate when house prices are above or below their equilibrium values. This process provides a useful tool for predicting the change in future house-prices (Gallin 2006).

3.2.2 Housing Price Bubbles

There is a rising trend of house prices in real terms in all advanced economies (Knoll et al. 2017). This trend continues to attract the attention of the media, researchers and general economic policy forums. In Australia, the issue of housing affordability and the influence of negative gearing and other incentives in property investments contribute significantly to this discussion (Valadkhani et al. 2016). No doubt, the property market continues to play a central role in the determination of the cash rate (Baur & Heaney 2017). Specifically, contractionary monetary policy significantly lowers housing activities but does not have any significant adverse effect on the real house prices (Wadud et al. 2012). In the United States, Alpanda and Zubairy (2017) found that monetary tightening reduces the stock of real mortgage debt, but leads to an increase in the household debt-to income ratio. Generally, this means, house prices play an important role in diffusing shocks to the real economy (Bodman & Crosby 2003; Anundsen 2013). It is therefore important to examine housing price dynamics and how it is linked to key macroeconomic variables (Anundsen 2013; Nneji et al. 2013).

Using a dynamic present value model within a vector autoregressive (VAR) framework to construct fundamental time series of house prices, Costello et al. (2011) found evidence of sustained deviation of house prices from their fundamental values in all Australia state capitals. Their study also revealed that this deviation is driven by income and the highest deviation of house prices from their fundamental prices occurs in the NSW market commencing around 2000. Glindro et al. (2011) argued that house price deviations from their fundamental values can be attributed to some unique characteristics of the real estate market such as asset heterogeneity, loan to value, short-sale restrictions, lack of information, and housing supply lags. The greater the variation in house prices the more it triggers significant changes in the level of household wealth and non-housing household consumption (Fisher et al. 2010). Positive shocks to interest rates, for example, can have varying effects on the house prices of capital cities, particularly Greater Sydney, due to wealth and leverage differentials. (Costello et al. 2015). Valadkhani et al. (2016) therefore argued that there is serious overvaluation of real house prices in Australia due to demand shocks and wealth effects arising from equity markets. Bodman and Crosby (2003) specifically reported significant overvaluation of median house prices in Sydney. Shi et al. (2016) found evidence of an asset bubble in Sydney's housing market since 2014. This rise in price has diverse implications for various households. However, Baur and Heaney (2017) found relative stability in the house prices of Australia over the past 20 years. Wang et al. (2018) also found cointegration between house price and market fundamentals, suggesting the absence of price bubbles in the Australian housing market. This discourse has ignited an interesting debate on the decision and ability of the average household to buy or rent a home due to the current trend of house prices, rents, and interest rates (Fox & Tulip 2014).

International evidence is also available. In the US, several studies have shown the lack of cointegration between house prices and any of the market fundamentals, suggesting an evidence of price bubbles especially in the 2000s (Gallin 2006; Mikhed & Zemčík 2009; Clark & Coggin 2011; Duca et al. 2011). Anundsen (2013) asserted that the housing bubble during this period can be attributed to the rise in more risky loans of the market. Other studies have found cointegration between house price and fundamental economic variables (Abraham & Hendershott 1996; Meen 2002). Therefore, the results of the cointegration between house prices and market fundamentals in the US are somewhat mixed (Anundsen 2013). In China, Bian and Gete (2015) used structural vector auto-regressions and identified population increase, an increase in the savings rate and tax policy as some of the key drivers of housing

dynamics in the country. Shih et al. (2014) used data from 28 provinces of China spanning 2000 to 2012 to measure house price bubbles and their diffusion patterns. They found that house price bubbles diffuse from a core province to the peripheral provinces of China.

Several studies have also identified monetary factors as key drivers of price bubbles (McMillan & Speight 2010; Kohn & Bryant 2011; McDonald & Stokes 2013; Miles 2014). McDonald and Stokes (2013), for example, used Granger-causality and VAR modelling methods and found interest rate to be an important cause of price bubbles in the US. Kohn and Bryant (2011) used structural equation modelling and found evidence of housing bubble in the US. They also identified the 30-year mortgage interest rate as a major driver of price bubbles. Teng et al. (2017) employed several econometric techniques including Engle-Granger cointegration analysis and Granger-causality to demonstrate that house price bubbles spillover from the city centre to the suburbs of Taipei city. Bredthauer and Geppert (2013) used the variance ratio procedure to demonstrate that changes in economic fundamentals can result in price bubbles. Checking for price bubbles is therefore vital in understanding housing market behaviour. However, the results of previous studies are somehow mixed. Besides, none of these studies has tested for real time bubble period within metropolitan cities despite the socio-economic differences in these cities.

Therefore, the results of housing bubble formation are somehow mixed. Again, this can be attributed to the heterogeneity in the housing market, suggesting a housing submarket analysis. Previous studies such as Doney et al. (2013), Baker et al. (2016) and Dufty-Jones (2018) have all echoed the importance of submarket housing analysis especially within metropolitan cities. This is particularly true in this housing bubble context since the motives of homeowners and property investors are different (Kohler and Rossiter (2005). The goal of the homebuyer is outright ownership, while investors are driven by income and wealth factors. Submarket analysis in this context is quite compelling for several reasons. To start with, more than 60% of Australian households are investing in property (Lee 2017). Other motivating factors of property investment in Australia have been examined and two-third of these investors do so to secure long-term investment. Others invest in property to hedge against inflation (Lee 2014) that is very appealing to institutional investors (Lee et al., 2014; Lee at al., 2018; Newell et al., 2015a; Lin et al., 2019). By 2013, two-third of households invest for negative gearing, compared with 25 percent by the late 1990s (David & Soos 2015). More importantly, the Australia taxation policies have long been favourable to property investors (Berry 2000; Bloxham et al. 2011). In particular, Bloxham et al. (2011) noted that the net cash flow from

rental property was enhanced by the capital gains tax rate. The capital gains tax reformed in 1999 has also facilitated the idea of households using negative gearing to obtain loans against the equity in their current property to buy an investment property (Valadkhani & Smyth 2017). Specifically, evidence of the growing demand for investment in inner-city housing and apartments in Sydney from both local and overseas investors is well documented in Birrell and Healy (2013), and Valadkhani and Smyth (2017). As such, when the demand for property investment continues to grow, it tends to escalate house prices particularly in metropolitan Sydney (Valadkhani & Smyth 2017). This can potentially raise house price to a non-sustainable level, which may signal the existence of price bubbles. This means low-income households will likely remain renters and will continue to face extreme challenges in entering the housing market (Meen 2011). In Australia, about 45 per cent of these renters live in semi-detached and apartments, while more than half live in detached housing (Stone et al. 2013).

To sum up, there is limited empirical evidence of the long run relationship between house price and rent (or income) for metropolitan cities. In addition, previous studies on house price and rent (or income) are narrative and the findings are mixed. This can be attributed to the complexity of housing markets. Most of these studies were done at city, state and country level, with no consideration for intra-metropolitan cities despite the existence of socio-economic discrepancies across metropolitan cities, particularly Greater Sydney. This is particularly the case of housing price bubbles as most housing investments are concentrated in low-income housing submarkets. However, no study has been done in this area.

To the best of my knowledge, this is the first study to test for cointegration between house price and rent at a sub-city level in Australia's most populous and socio-economically diverse city, namely Greater Sydney. This will shed light on whether house prices temporarily or permanent diverge from rent or income, and whether there is evidence of housing price bubbles in the different regions of Greater Sydney.

3.3 Housing Submarkets and House Price Linkages

The discrepancy in the socio-economic and demographic characteristics of the regions across Greater Sydney has resulted in various housing submarkets (Randolph & Holloway 2005a). Beer et al. (2007) reported that housing submarkets can also be the result of the interplay between activities at the labour market and demographic process, as well as the interaction between local demand and supply of housing. This greater complexity of micro-level relationships within urban systems continues to heighten the need for submarkets studies

(Adair et al. 2000). Therefore, submarket analytical framework should be embraced for applied housing studies (Watkins 2001).

There is therefore a growing academic interest in house price dynamics and housing submarkets analysis in the housing literature (Begiazi & Katsiampa 2018). As such, three strands of submarket literature are reviewed in this study – the relevance and predictability power of submarket analysis; house price diffusion patterns at various geographical levels such as cities, regions and countries; and the relationship between house prices and economic fundamentals.

3.3.1 Relevance and Predictability Power of Submarket Analysis

Housing submarkets exist because of the differences in key socio-economic, demographic, cultural and spatial factors (Galster 1996). Thus, a housing market, particularly in metropolitan areas, should be analysed as a segmented and interconnected collection of housing submarkets, where each submarket characterises a set of exchange possibilities that include structural and locational attributes such as building, infrastructure, neighbourhood condition and status, environment, and public services (Galster 1996). Adair et al. (2000) highlighted that a broader scope of market analysis tends to ignore local influences on residential property values. They found that the highly segmented city will lead to a greater localised effect. As a result, they argued that housing markets should be analysed at the local level. Their argument is premised on the notion that sub-systems arise from structural and locational attributes. Fik et al. (2003) found that the effect of externalities on property values is unique at each location and it varies over space. Therefore, property location must interact with other determinants of property value. Bunker et al. (2005) found that series of typical housing submarkets have emerged from the urban consolidation policy in Sydney, which are overlapping and have unique locational and spatial characteristics. Bramley et al. (2008) viewed submarkets as properties and locations that are likely considered as relatively close substitutes to housing demand. Hence location is an inherent attribute for both rental and sale dwelling properties (Galster 1996). Bramley et al. (2008) further reported that an understanding of the demographic, social and economic characteristics of a neighbourhood is vital for both national and local housing policy makers. This is because house prices, especially those in metropolitan areas, are diverse and they tend to vary steadily with their characteristics (DiPasquale & Wheaton 1996).

One implication of housing submarkets is that the actual price of a given property may be different from its predicted price, which is primarily due to its attributes. Therefore, as

demonstrated in previous studies, submarket models have greater power to predict property prices using different functional relationships (Chen et al. 2009). For example, Chen et al. (2009) compared the forecasting accuracy of a single market hedonic model with seven spatially segmented markets. Their study revealed that spatially disaggregated submarket models outperform an aggregated submarket analysis in forecasting house prices. Using data on housing transactions from Perth, Western Australia, Leishman et al. (2013) developed and compared three competing submarket modelling strategies - city-wide 'benchmark'; series of submarket-specific hedonic estimates; and multilevel model. They found that submarket models have superior predictive power to the benchmark city-wide ordinary least square (OLS) hedonic model. They also reported that, over time, multilevel models are superior in addressing the dynamics in the composition of submarkets and they have the potential to capture the multiple geographical mix that exists within local housing systems. Montagnoli and Nagayasu (2015) found that house prices in London will inform the prediction of future house prices in the rest of the UK through the spillover effect. Therefore, both attributes and submarket conditions are crucial factors in predicting house prices (Galster 1997).

3.3.2 House Price Diffusion Patterns at various Geographical Levels

Extensive housing studies have been placed on the diffusion pattern of house prices at city, national and international levels. The work of Meen (1996) asserted that house price in one region is driven by house prices in other regions. Meen (1996) indicated that housing market can be viewed as a collection of several interrelated submarkets. Given these submarkets are interconnected, forces affecting one submarket would create signals there that would eventually lead to systematic but non-uniform consequences on other submarkets (Galster & Rothenberg 1991). This is known as the spillover effect. In the United Kingdom (UK), for instance, and MacDonald and Taylor (1993), Alexander and Barrow (1994), Meen (1999) and Holly et al. (2011) used various methods including cointegration analysis and Granger-causality tests to provide evidence of spillover effects (spillover effects) across cities. Specifically, these studies found that changes in house prices in London will spillover to the other cities or regions in the country. Recently, Hudson et al. (2018) used an autoregressive distributed lag bounds testing approach to investigate the long-run relationships between house prices across the regions of Great Britain for new, old and modern properties. They found that shocks in house price spillover across regions, although the nature of the spillover varies across housing types. Like Oikarinen (2004)'s study in Finland, Stevenson (2004) used the Johansen

cointegration test and a vector-error correction model (VECM) and found that house prices spread from Dublin to the regional centres and then to the peripheral areas.

Jones and Leishman (2006) asserted that Glasgow is the leading housing market in the Strathclyde sub-region of Scotland. Using cointegration analysis and Granger causality tests, their study found a lead–lag relationship between Glasgow and the 'Paisley cluster' of the local housing market areas. Wilson et al. (2011) also employed cointegration analysis to investigate the long run interaction among submarkets across the urban area of Aberdeen in the UK. Their study investigated how the different housing submarkets respond to different economic circumstances. By classifying house prices into low-priced, medium-priced and high-priced markets, Wilson et al. (2011) found that, price movement is varyingly binding over the long run in all three housing markets. Their findings imply that price behaviour in a 'micro' market does influence price behaviour in the same submarket over the long run. However, except for the short run, interest rate does not seemingly appear to influence the behaviour of any of these submarkets over the long run. Comparable evidence is found by Lee (2008). But Brown et al. (2011) showed lending rates play a significant role in influencing housing price.

In Australia, Luo et al. (2007) examined the spillover effects of house prices across Australia eight capital cities using a cointegration test and an error correction model. They revealed a diffusion pattern across these cities with Sydney having the most equilibrium relationships with other cities followed by Melbourne. This reflected the earlier findings of Tu (2000), who reported that subnational housing markets in Australia are highly segmented in the long run and demonstrated some causal relationships in the short run. House prices in Sydney therefore have an influence on house prices in Melbourne in the short run (Tu 2000). Akimov et al. (2015) used business cycle techniques and documented cyclical behaviour among the eight largest metropolitan housing markets in Australia. Specifically, they found high level of house price interaction between Sydney and Melbourne compared with the rest of the metropolitan cities.

These studies, however, focused mainly on house price diffusion among different cities. On a broader geographical scale, Gupta et al. (2015) examined co-movement of house prices in Euro area using a fractional cointegration approach. They found that the Euro area is cointegrated with Belgium, Germany and France, and cointegration does exist between some European countries. In their submarket study in the US, Doh-Khul et al. (2006) used a cointegration approach and found that existing properties are more responsive to expansionary monetary policies than new properties. McCord et al. (2014) explored the dynamic linkages and causal

relationships between six key property types in Northern Ireland. Their findings showed causal relationships between house price at particular pricing structures, but limited causalities at different ends of the price spectrum. Lean and Smyth (2013) also found that house prices spread from the most developed states to the less developed states of Malaysia. Galster and Rothenberg (1991) also argued that the spillover effect could be caused by the fact that housing submarkets respond to changes in market fundamentals in systematic ways, but the pattern and magnitude of response is not uniform across submarkets.

3.3.3 House Price and Market Fundamentals

House prices are also influenced by broader macroeconomic variables such as Gross Domestic Product (GDP), interest rate and activities at the stock market (Lee 2009; Nneji et al. 2013). Al-Masum and Lee (2019) found that GDP is one of the long run determinants of house prices in Greater Sydney. Lee and Reed (2014) asserted that high-profile government policies such as the FHOG scheme can be a useful tool in stabilising the housing market. Adams and Füss (2010) distinguished the effect of short term and long term interest rates on house prices. They argued that the effect of the short term interest rate is more instantaneous than the long term interest rate because of its impact on mortgage lending rate and the cost of financing new developments. Zhu et al. (2017) also reported that interest rate is one of the main channels through which monetary policies can affect house prices. Lee et al. (2017) argued that activities at the stock market may not be directly applicable in the Australian housing market. He argued that the risk-return profile of the Australian stock market may not similar to the Australian housing market since most homebuyers are risk averse and they require significant risk premium to compensate for greater risk (Lee, et al. 2007; 2008; Lee, et al. 2008).

Further, Zhang et al. (2017) delineated 35 metropolitans in China into panels using geographical location and regional economic performance. Their empirical findings show that house prices in most regions are generally consistent with the national average, but they show diverse responses to changes in macroeconomic variables. Mikhed and Zemčík (2009) found a misalignment between house price and market fundamentals in the US in sub-samples prior to 1996 and from 1997 to 2006. Waltl (2016) noted the large variation in house price growth within a city during changes in market fundamentals. Hui and Yue (2006) found no causal relationship between house prices and GDP in Beijing, but reported a one-way causality flowing from house prices to GDP in Shanghai and Hong Kong. Yang et al. (2018) proposed a spillover index of high-dimensional generalized VAR framework and found that Chinese cities with a higher administrative status (e.g. Shenzhen), larger population, higher GDP and higher

population with secondary education are significant drivers of the (net) positive spillover pattern among 69 large- and medium-sized cities of China from July 2005 to June 2015. Lee and Reed (2013) also found different key determinants of housing price volatility in different capital cities in Australia, highlighting the issue of geographical differentials.

3.4 Conclusion of the Chapter

So far, the existing body of housing literature highlighted that, in Australia, while international, national, state and city based studies on housing affordability and housing submarkets are well researched and established, the focus on sub-city level or regional segmentation, which is a finer level housing analysis is still exploratory.

Previous studies on housing affordability have examined the declining trend of housing affordability and the key supply-side factors that have contributed to rising house prices using various methodologies. The literature also highlighted significant demand side factors that are contributing to the need for more affordable housing. The findings show lags in housing supply to respond to changes in demand at least in the short run due to complex planning process and construction costs. As housing affordability is largely an interplay between housing prices and income, the resulting demand-supply gap, with supply trailing demand, is causing an increase in housing price without a proportionate increase in income, thereby worsening housing affordability. Nevertheless, government housing policies over the years were uniform without the necessary consideration of the existing socio-economic, spatial and demographic profile of the various housing submarkets that make up metropolitan cities in Australia. The literature also revealed that housing market in a metropolitan area should be analysed as a segmented, interconnected collection of housing submarkets, where each submarket characterises a set of exchange possibilities that include structural and locational attributes.

With the clear socio-economic differences highlighted in section 2.2, it is reasonable to raise the question of whether housing affordability differs across these regions of Greater Sydney. Moreover, no study has been dedicated to examine the issues surrounding the housing affordability of Greater Sydney and housing price bubble at a disaggregated level. In the same light, studies on housing price linkages, which give an enhanced understanding of the patterns in home price movements between submarkets is limited in Australia. There is clearly a knowledge gap in the literature on housing affordability and housing price bubble at sub-city level. The literature on house price diffusion of housing submarkets in the metropolitan cities of Australia, particularly Greater Sydney is also limited. Therefore, filling this gap is at the heart of this study.

CHAPTER 4

DATA, METHODOLOGY AND ESTIMATION PROCEDURE

4.1 Data of the Study

Quarterly and yearly data at local government area (LGA) level spanning 1991 to 2016 was obtained for the five regions of Greater Sydney - western, inner-west, southern, eastern and northern regions. The LGAs that make up each region are reported in Table 2.4. The ABS Australian Statistical Geographical Standard is used for defining these local government areas (Department of Housing [DoH] 2019). This study period offers a relatively large dataset with which to demonstrate trends in housing affordability and house price diffusion patterns. This estimation period has greater relevance to current market circumstances than the inclusion of earlier period data (Brailsford et al. 1997; Worthington & Higgs 2013). Moreover, Greater Sydney has experienced a sustained and significant increase in house prices over this study period (Haylen 2014; Healey 2016). The study used both time series and panel data to address the research questions. Panel data were derived from the LGAs data in each region. The composition of the panels is reported in Table 2.4. Quarterly time series data were used in measuring entry-level and going housing affordability, housing price bubble test, and in determining the patterns in home price movements between submarkets in Greater Sydney. On the other hand, panel data was used to estimate the causal relationship between affordability and its local drivers, and to evaluate the nexus between house price and rent in each region of Greater Sydney. The generation of panel data helps to address the general lack of adequate housing market data, which researchers often face when testing long-run relationships (Adams & Füss 2010).

The study period did not go beyond 2016 since the amalgamation of local councils within NSW commenced this year, which essentially affects LGA data beyond 2016. However, the amalgamation of LGAs does not overlap across regions. Four of the study regions of Greater Sydney were affected by this amalgamation. In the western region, the City of Canterbury and Bankstown is a merger of the previous Bankstown and Canterbury councils; and the Cumberland Council combined the previous Holroyd and Auburn councils. In the inner-west region, the Inner-West Council was formed by the merger of the former Ashfield, Leichhardt and Marrickville councils. In the southern region, the Georges River Council merged the former Kogarah and Hurstville councils; and the Bayside Council is a merger of the former Botany Bay and Rockdale councils. In the northern region, Northern Beaches Council replaced

the former Manly, Pittwater and Warringah councils. There is no merger in the eastern region. This disaggregation of the data for sub-city approach to housing affordability and house price dynamics could also be relevant for other capital cities of Australia such as Brisbane and Melbourne since these cities are also characterised by socio-economic discrepancies (Hulse et al. 2014). This could reveal the trend of affordability over time and the diffusion pattern within these cities, highlighting whether there are similarities in key elements of residential properties.

4.1.1 Data Sources and Description

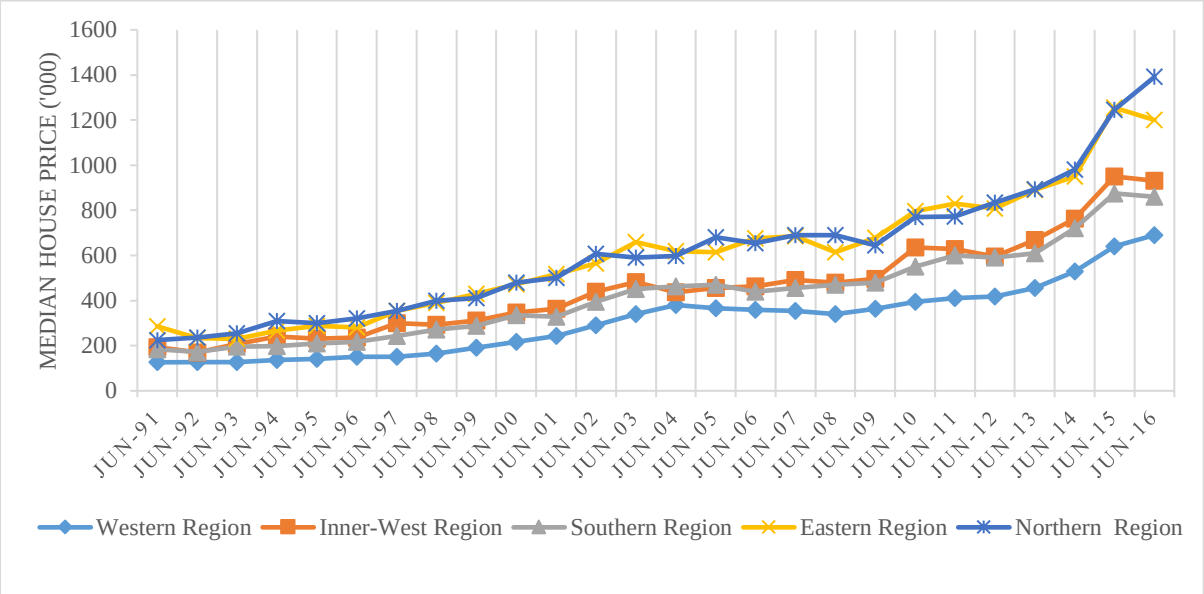
The study data was collected from various federal, state and local government institutions and agencies such as the Australian Bureau of Statistics, Department of Infrastructure and Regional Development, Department of Employment, NSW Department of Housing, NSW Fair Trading, Federal Reserve Bank of Australia and local councils in NSW. Data was also obtained from private companies.

4.1.1.1 Median House Price

The data on quarterly median house prices was collected from the NSW Department of Housing (DoH) for the study period. House sales statistics were derived from the information provided on the 'Notice of Sale or Transfer of Land' lodged with Land and Property Information NSW. Due to the considerable time lapse that sometimes exists between the contract and transfer dates, in assigning a time period date to each property sale, the Department of Housing NSW considers the contract date to be more relevant for market price analyses than the transfer date. House sale prices in local government areas where the number of sales is 10 or below are not reported and the median value is used since this measure of central tendency is not affected by extreme values (DoH 2019).

Figure 4.1 shows an upward trend in house price of all dwellings for all the regions from 1991 to 2016. The figure demonstrates the sustained increase in house prices in metropolitan cities of Australia reported in previous studies such as Haylen (2014), Worthington and Higgs (2013), and Yates (2008). House prices generally increase from 1991 to the year before the global financial crisis in 2008. However, the increase in house price from 1991 to 1999 is lower than the increase from 2000 to 2008. Between the years 2008 and 2009, there is virtually a flat trend in all regions, reflecting some cooling periods in the housing market. This can be attributed to the implementation of several federal and state policies including the First Homebuyers Boost (the Boost) between 2008 and 2009.

Figure 4.1: Trend of Median House Price of all Dwellings



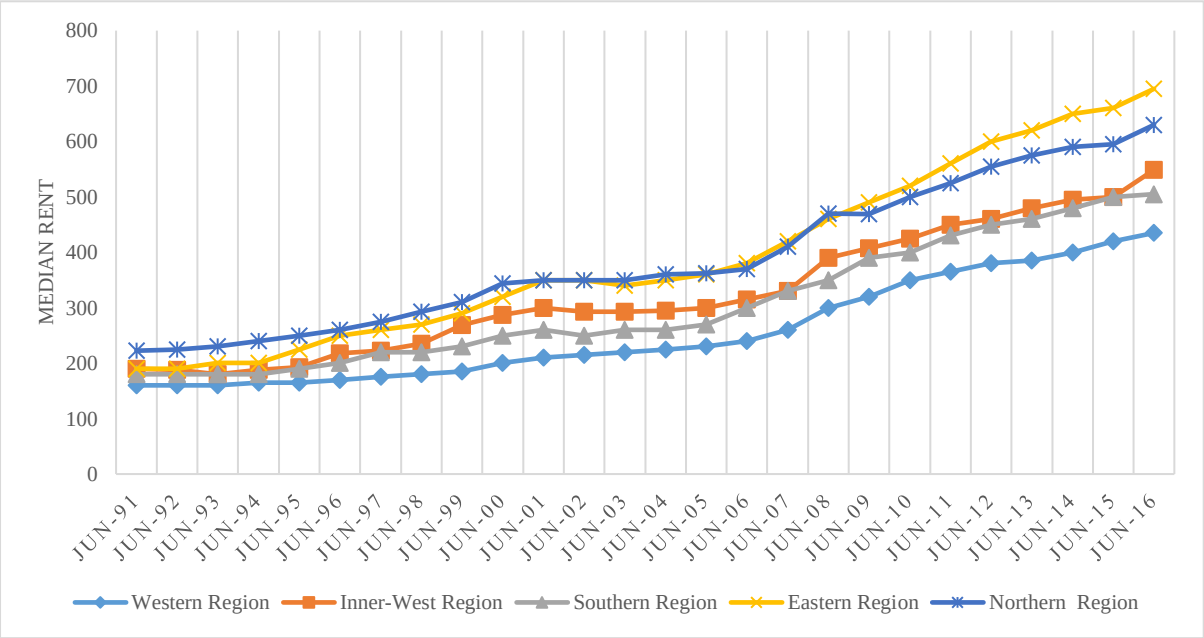
Source: Author's construct using data from NSW Department of Housing

House prices start to rise again continuously from the year 2010 to 2016. Generally, there are differences in the upward trend of these house prices. The eastern and northern regions reveal similar rising trend in house prices over time. The trends in the inner-west and southern regions are also quite similar. The pattern of the trend in the western region is akin to the inner-west and southern regions but its trend lies at the bottom.

4.1.1.2 Median Rent

The data on quarterly median rent for all dwellings as well as strata and non-strata was collected from the NSW Department of Housing (DoH) for the study period. Rent figures were obtained from the rental bond lodgement with 'Renting and Strata Services Branch (RSSB) of the Office of NSW Fair Trading'. Total bonds held are those live bonds at the last date of the quarter. It should be noted that the total number of bonds held by RSSB at any point in time is not necessarily equal to the total number of rental properties because there are vacant properties at any given time and there could be cases of informal lettings where bonds may not be required by the landlord. Rent figures in local government areas where the number of rent is 10 or below are not reported and the median value is used since this measure of central tendency is not affected by extreme values (DoH 2019). The trend of median rent for all dwellings in the different regions are shown in Figure 4.2.

Figure 4.2: Trend of Median Rent of all Dwellings



Source: Author's construct using data from NSW Department of Housing

There is a general upward trend in the median rent of all regions in Greater Sydney over the study period. However, the rise in median rent from the year 2008 to 2016 is higher than the period 1991 to 2008. More importantly, the disparity in median rent across regions is more glaring after the year 2008. Similar to the pattern of house prices in Figure 4.1, the trend of median rent in the eastern and northern regions are comparable as well as those in the inner-west and southern regions. Western Sydney has a similar pattern with the inner-west and southern regions even though it is lying at the bottom of the other regions.

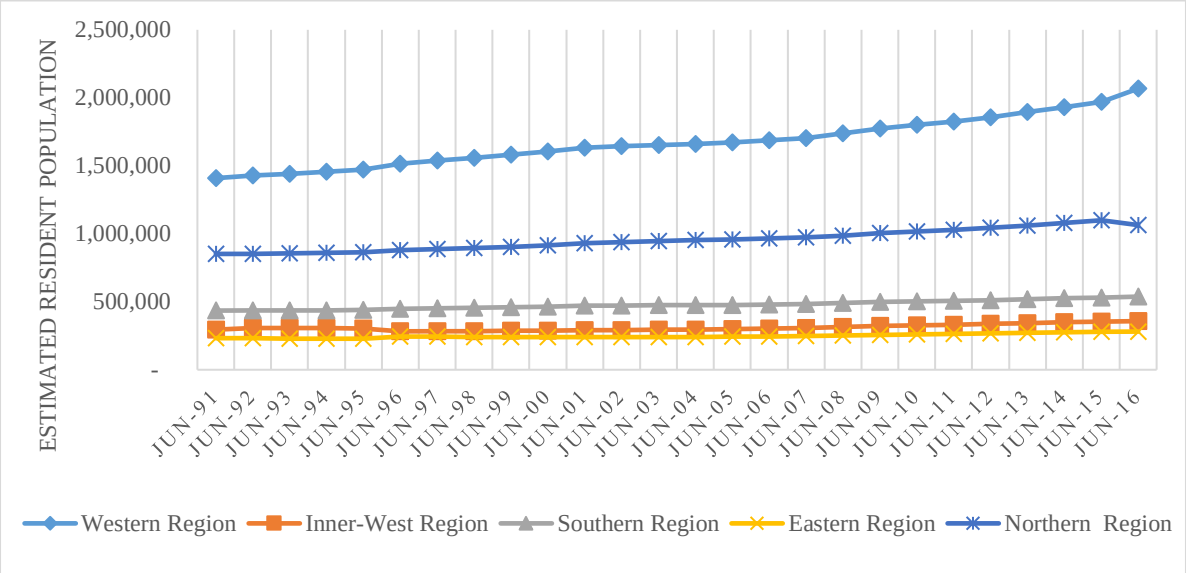
4.1.1.3 Estimated Resident Population

Data on annual estimated resident population was collected from the Australian Bureau of Statistics. The estimated resident population (ERP) is the official estimate of the population in the local government area, which links people to a place of usual residence for six months or more in a given reference year. It refers to all people, regardless of nationality, citizenship or legal status, who usually live in Australia, with the exception of foreign diplomatic personnel and their families. The ERP includes usual residents who are overseas for less than 12 months and excludes overseas visitors who are in Australia for less than 12 months. In the Census year, the ERP is first calculated at the Census date (9 August for the 2016 Census), and is then backdated to calculate the ERP at 30 June of the Census year. After each Census, estimates for

the preceding inter-censal period are revised to ensure that the total inter-censal increase agrees with the difference between the estimated resident populations at the two 30 June dates in the respective Census years. The trend of the annual estimated resident population is presented in Figure 4.3.

From 1991 to 2016, it is clear from Figure 4.3 that Western Sydney has the biggest population followed by Northern Sydney. Figure 4.3 also revealed that the annualised population growth rate in the western regions is glaringly higher than all the other regions. This is evident in Table 2.5, which shows that the annual population growth rate of 1.54 percent in the western region is higher than all the other regions. In fact, the population growth rate in the western region nearly doubled the growth rate in the other regions of Greater Sydney.

Figure 4.3: Trend of Estimated Resident Population



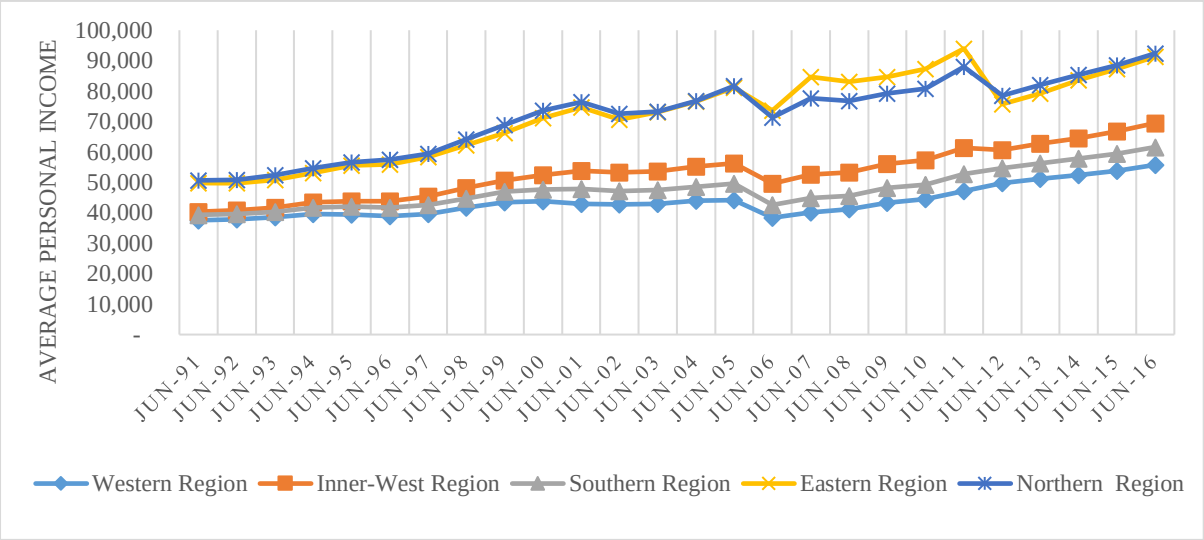
Source: Author's construct using data from the Australian Bureau of Statistics

4.1.1.4 Average Personal Income

The average personal income per LGA for the period 1990/91 to 2004/05 was obtained from the Department of Infrastructure and Regional Development (DIRD), and from the Australian Bureau of Statistics (ABS) for the period 2005/06 to 2015/16. Average personal income (API) is the sum of the employee income, own unincorporated business income, investment income, superannuation and annuities, other income (excluding Government pensions and allowances) in a given financial year. It should be noted that some low-income earners, for example, those receiving Government pensions and allowances, or those who earned below the tax-free threshold, may not be present in the data, as they may not be required to lodge personal tax

forms. Persons with income which was completely tax free or completely tax exempt are also excluded from the data. For example, a change to legislation relating to superannuation, taking effect from 1 July 2007, meant that people aged 60 years and over who receive superannuation income in the form of a lump sum or income stream (such as a pension) from a taxed source, receive that income tax free. If a person has no other income, or their total income is below the tax-free threshold, or any tax payable is mitigated by a tax offset, then this person may not be required to lodge a tax return. The trend of average personal income is reported in Figure 4.4.

Figure 4.4: Trend of Average Personal Income



Source: Author's construct using data from the Australian Bureau of Statistics

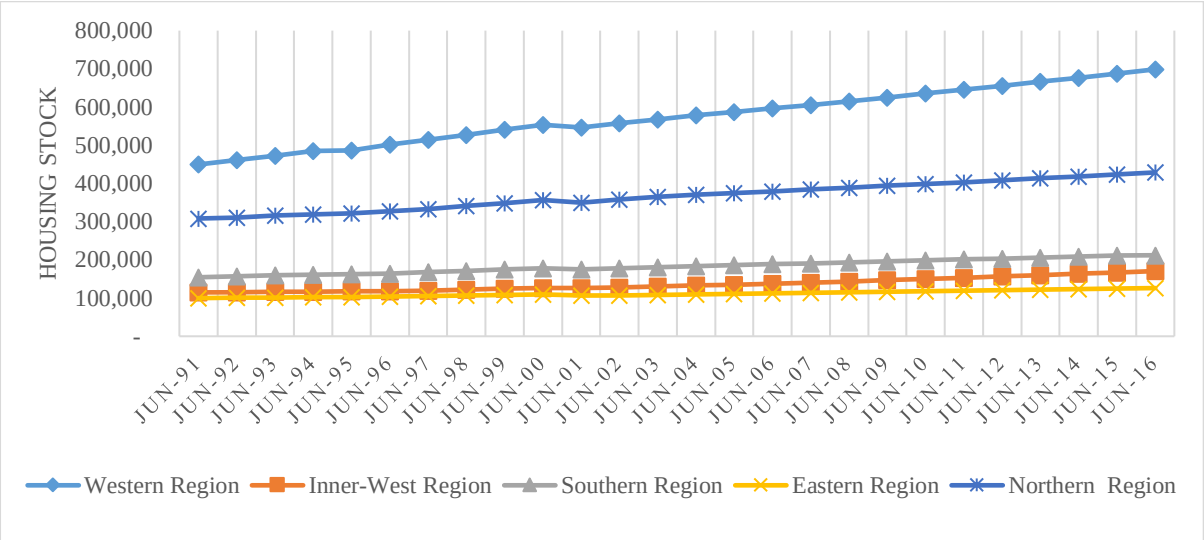
Figure 4.4 shows two distinct types of trends. The first is the close proximity in income between the eastern and the northern regions, and the similarity in income among the western, inner-west, and southern regions of Greater Sydney. Again this highlights the disparity in income level between the high-income eastern and northern regions and the relative low-income western, inner-west, and southern regions of Greater Sydney.

4.1.1.5 Housing Stock

The data on housing stock at census years and building approvals as proxy for housing supply for inter-censal periods per local government area was collected from the Australian Bureau of Statistics (ABS). Housing stock (HS) refers to the sum total of separate houses; semi-detached, row or terrace house, town house etc.; and flat, unit or apartments in a given census year. A separate house is a house which is separated from other dwellings by at least half a metre. A separate house may have a flat attached to it, such as a granny flat or converted garage (the flat

is categorised under flat, unit or apartment). The number of storeys of separate houses is not recorded. Semi-detached, row or terrace house, townhouse refers to dwellings that have their own private grounds and no other dwelling above or below them. They are either attached in some structural way to one or more dwellings or are separated from neighbouring dwellings by less than half a metre. Flat, unit or apartment refers to all dwellings in blocks of flats, units or apartments. These dwellings do not have their own private grounds and usually share a common entrance foyer or stairwell. This category also includes flats attached to houses such as granny flats, and houses converted into two or more flats. For inter-censal periods, the aggregate of building approvals was added progressively to the reported census housing stock.

Figure 4.5: Trend of Housing Stock



Source: Author's construct using data from the Australian Bureau of Statistics

ABS defines building approvals as the number of residential (dwelling) building permits issued by local government authorities and other principal certifying authorities in a given period. A dwelling is a self-contained suite of rooms, including cooking and bathing facilities, intended for long-term residential use. A dwelling may comprise part of a building or the whole of a building. Regardless of whether they are self-contained or not, rooms within buildings offering institutional care (e.g. hospitals) or temporary accommodation (e.g. motels, hostels and holiday apartments) are not defined as dwellings. Such rooms are included in the appropriate category of non-residential building approvals. Dwellings can be created in one of four ways: through new work to create a residential building; through alteration/addition work to an existing residential building; through either new or alteration/addition work on non-residential building; or through conversion of a non-residential building to a residential building. As the demand for

housing grows over time due to factors such as population growth and income (Yates 2008), it validates the need to examine the trend of housing supply, particularly for a city that is characterised by diverse socio-economic and demographic mix. This is reinforced by Glaeser et al. (2005), who reported that housing supply is pivotal in understanding changes in population and house prices within metropolitan cities. However, analysis of housing stock in Australia at a disaggregated level has been limited especially at sub-city level. Figure 4.5 shows the trend of housing stock for the different regions of Greater Sydney from 1991 to 2016.

The trend is generally flat for the different regions, indicating a sluggish rate of growth of housing stock over time. Throughout the twenty-five period, there was no significant jump or decline in the housing stock of all regions, which can be linked to growing demand for housing in Greater Sydney. The shape of Figure 4.5 generally reflects the findings of Yates (2008), who argued that housing supply in Australia is generally perfectly less elastic. The western region has the highest number of housing stock, growing from 449,583 in 1991 to 698,662 in 2016, representing an annualised growth rate of 1.7 percent. This is trailed by the northern region, growing from 308,268 in 1991 to 428,811 in 2016 and producing an annualised growth rate of 1.1 percent. Housing stock in the remaining regions lie within the bounds of the western and the northern regions. With housing supply being generally less responsive to its demand (Yates 2008), it is worthwhile to investigate whether there are significant differences in the rate of growth of housing supply across the regions of Greater Sydney. The study employed both the parametric t-test and non-parametric Wilcoxon matched-pairs signed-ranks test to check whether there are differences in the rate of growth of housing stock across the regions of Greater Sydney. The results are presented in Table 4.1.

Both the t-test and the non-parametric test show similar results despite some minor differences. Following the non-parametric test, the results reveal insignificant difference in the growth of housing stock between the western and inner-west, inner-west and southern, and the northern and southern regions. However, there is a significant difference in the rate of growth of housing stock between the western and eastern, northern and southern regions at the 1% significance level.

Table 4.1: Parametric and Non-Parametric Tests of Housing Stock Growth

Region	Parametric (T-Statistic)	Non-Parametric (Z-Score)
Western and Inner-West	-0.7670	-0.1084
Western and Eastern	3.6783***	4.3647***
Western and Northern	2.5719**	3.8767***
Western and Southern	2.1035**	3.9499***
Inner-West and Eastern	3.0328***	3.7954***
Inner-West and Northern	1.8515	2.6567***
Inner-West and Southern	1.4052	1.7314
Eastern and Northern	-1.3334	-4.0122***
Eastern and Southern	-1.5441	-3.5170***
Northern and Southern	-0.3296	-1.2692

The parametric assumes that the data is normally distributed, while the non-parametric relaxed this assumption. Both tests however test the null hypothesis of no significant variation in the growth of housing stock between two regions. Rejecting the tested hypothesis means the rate at which new houses are added to housing stock significantly varies between the two regions. *** rejects the null hypothesis at 1% significance level and ** rejects at 5% significance level.

Another highlight is the significant difference between the inner-west region and the eastern and northern regions as well as the eastern region and the northern and southern regions all at the 1% significance level. The results generally reveal that housing supply tends to grow at different growth rates across the regions of Greater Sydney but these rates are not commensurate to the growing demand for housing even in highly populated regions such as Western Sydney.

4.1.1.6 Key Market Fundamentals

Various studies have shown that house prices and by extension housing affordability are often influenced by the vicissitudes of market fundamentals. Li and Chand (2013), for example, found that key market fundamentals such as the level of income, construction costs, impending marriages, user cost and land prices are the principal drivers of house prices in urban China. Mikhed and Zemčík (2009) also modelled housing prices in the US as a function of some economic variables such as personal income, population, house rent, stock market wealth, building costs, and mortgage rate. They found that property prices take long swings from their fundamental value. The empirical findings of Adams and Füss (2010) indicate that house prices tend to increase in the long-run when there are expansionary economic activities. These

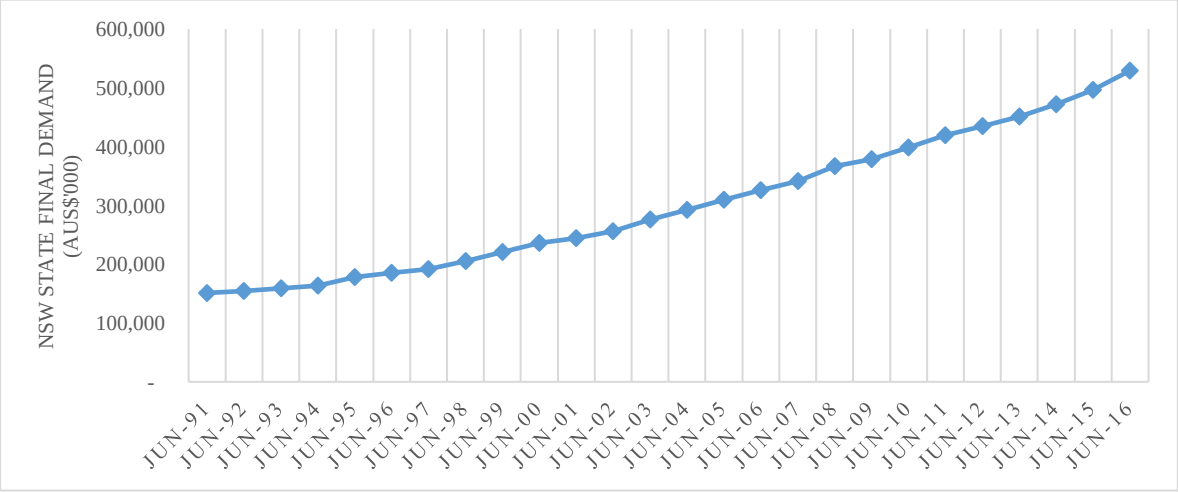
macroeconomic variables are also considered in modelling house prices in other studies such as Brady (2014), Bhattacharya and Kim (2011), Hoesli et al. (2008) and Hui and Yue (2006).

Therefore, some of the market fundamentals included in this study include NSW state final demand, mortgage lending rate, and the Australia S&P 300. Data on NSW state final demand was collected from the Australian Bureau of Statistics (ABS). The data on the Australia S&P 300 was obtained from Thomson Reuters Eikon and the information and data on unemployment was sourced from the Department of Employment (DoE). The quarterly mortgage lending rate was obtained from the Reserve Bank of Australia.

State Final Demand

The ABS defines state final demand (SFD) as the estimate obtained by summing government final consumption expenditure, household final consumption expenditure, private gross fixed capital formation and the gross fixed capital formation of public corporations and general government. The household final consumption expenditure is the largest component of state final demand. The trend of state final demand from 1991 to 2016 is shown on Figure 4.6. It shows an upward trend over the study period, indicating an improvement in the level of economic activities in NSW.

Figure 4.6: Trend of NSW State Final Demand



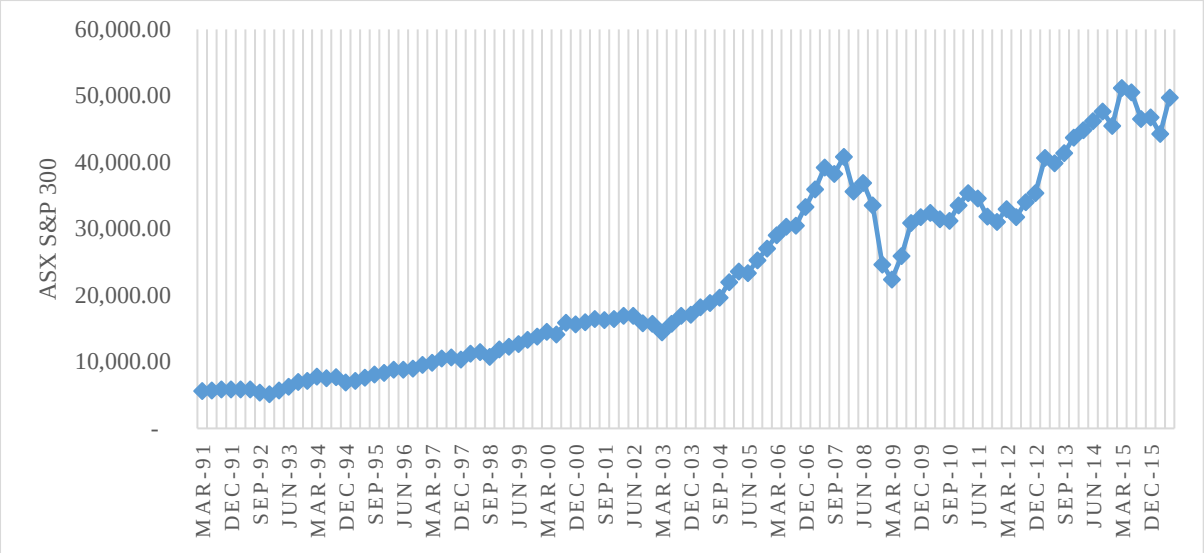
Source: Author's construct using data from the Australian Bureau of Statistics

Australia S&P 300

Data on the Australia S&P 300, which gives insightful knowledge of the performance of the Australia stock market was obtained from Thomson Reuters Eikon. The Australia S&P/ASX 300, as defined by the Australian Stock Exchange, is a real-time volatility index that provides

investors, financial media, researchers and economists an insight into investor sentiment and expected levels of market volatility. The index tracks S&P/ASX 300 index option prices as a means of monitoring anticipated levels of near-term volatility in the Australian equity market.

Figure 4.7: Trend of Australia S&P 300



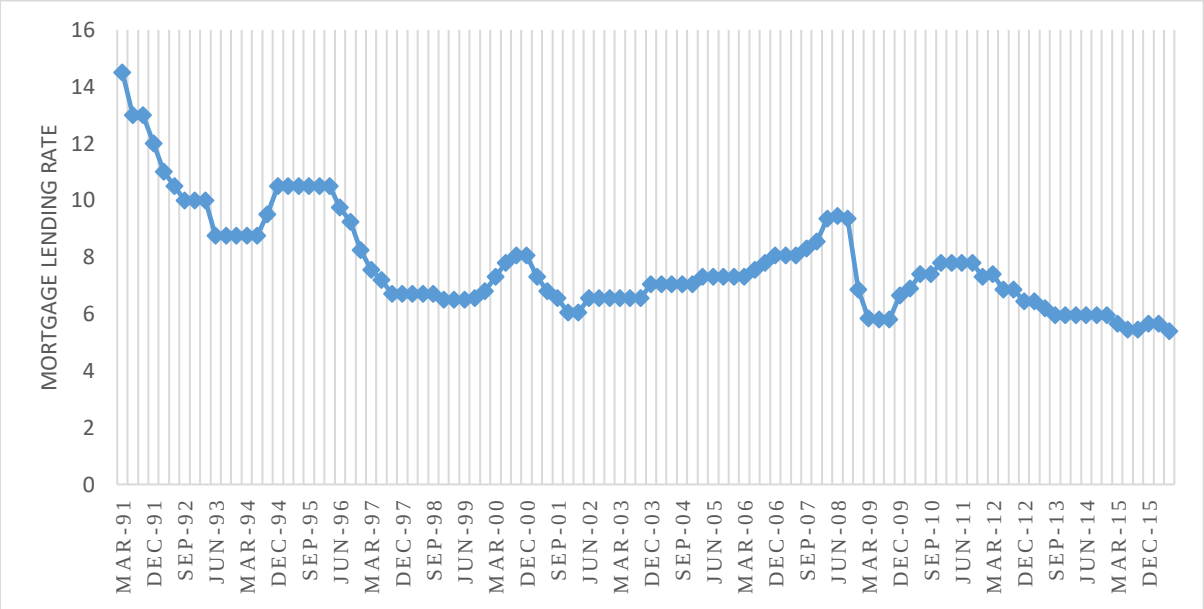
Source: Author's construct using data from Thomson Reuters Eikon

The quarterly trend of Australia S&P 300 is reported on Figure 4.7. It shows a general upward trend from the second quarter of 1991 to the second quarter of 2003 and an even higher trend from 2003 to the year before the global financial crisis in 2008. However, a vivid decline in the performance of the stock market is observed between 2008 and 2009. This can be attributed to the global financial crisis during this period. There is also high degree of volatility after 2008.

Mortgage Lending Rate

The mortgage lending rate (MLR) is a monetary policy instruments that was obtained from the Reserve Bank of Australia (RBA). The mortgage lending rate as defined by RBA is the average interest rate on new conventional single-family mortgages. The trend of the quarterly mortgage lending rate is reported on Figure 4.8. The graph shows that mortgage lending rate is volatile over time, responding to the different economic environment and events. The biggest decline in mortgage lending rate is from June 2008 to June 2009 as the rate drops from 9.45 to 5.8, which has significant implications for mortgage payments. This is consistent with the findings of Chen et al. (2010), who reported that a sharp decline in mortgage lending rate alone could materially lower the burden of mortgage payments.

Figure 4.8: Trend of Quarterly Mortgage Lending Rate



Source: Author's construct using data from the Reserve Bank of Australia

4.2 Methodology and Estimation Procedure

This section discusses the methods and estimation procedure used in each research question. It details the synopsis presented in Figure 1.2 of the study. These quantitative and econometric methods are employed in four stages as follows:

- Stage 1 examines entry-level affordability for the different regions of Greater Sydney using the cost-to-income affordability index. This index is modified by replacing the initial loan amount with the loan balance to measure ongoing affordability.

- Stage 2 employed a two-staged methodology to examine the causality between housing affordability and local housing variables in the five regions of Greater Sydney. The first step of this methodology used the entry-level affordability index in stage 1 to compute the entry-level affordability index of the different LGAs that make a region. The second step regresses the computed LGA entry-level affordability against key local housing variables in different regions of Greater Sydney using the system generalised method of moments (SGMM). The Westerlund (2007) error-correction based cointegration and panel error correction model (ECM) were also employed to check the long run causality between housing affordability and local housing variables.

- Stage 3 also deployed a two-staged methodology to test for the existence of housing price bubbles in the five regions of Greater Sydney. While the first step of this methodology examined the cointegration of house price and key fundamentals (such as rent and income) to determine the potential for housing price bubble formation, the second stage is a formal housing price bubble test following the backward supremum ADF (BSADF) procedure using the house-price-rent ratio or rental yield for all dwellings.

- Stage 4 employed Meen's (1999) constancy ratio and a suite of cointegration techniques to examine whether there is house price spillover between two broad submarkets in Greater Sydney – relative low-priced and relative high-priced submarkets.

4.2.1 Measuring Entry and Ongoing Affordability

This methodology and estimation procedure is used on time series data to address research question one. To assess the housing affordability of Greater Sydney from a sub-city perspective, the study adopted a two-staged approach. In the first stage, the study examined the entry-level affordability of housing across the different regions of Sydney, which provides an indication of how housing affordability for first homebuyers changes over time. The second stage estimated ongoing housing affordability across these same regions to provide further insights into the way affordability evolves after an entry into the housing market.

4.2.1.1 Entry-Level Affordability

Entry-level housing affordability refers to the affordability level at the time of entering into a mortgage in any one year. This index measures the financial costs (interest and amortisation) of a median house as a percentage of average personal income. To examine entry-level housing affordability in the different regions of Greater Sydney, we employed a cost-to-income (CtI_{Aus}) index that utilises the market value of the property, down-payment, and mortgage lending rate. The CtI_{Aus} is expressed as a percentage of average personal income in an LGA. Thereafter, the study further applied parametric t-test and non-parametric Wilcoxon matched-pairs signed-ranks tests to test the differences in entry-level affordability across regions. The CtI_{Aus} index formula is given as:

$$\mathbf{CtI_{Aus}} = \frac{100}{\mathrm{I}} \mathbf{x} \left(\mathbf{MV\ x\ LTV\ x} \frac{\frac{r}{12}}{1-\left(\frac{1}{\left(1+\frac{r}{12}\right)12n}\right)} \right) \mathbf{x\ 12} \qquad (1)$$

where I denotes average personal income, MV is the market value which is the median house price, usually the market price, LTV is the loan to value ratio, r is the mortgage lending rate, Aus represents Australia and n is the term of the loan. The formula gives the annualised effective cost of servicing the loan (in parenthesis) and it is computed by means of a standard 25-year annuity formula (i.e. n=25) with monthly compounding, where the loan is fully amortised over the term and then compared to the annualised average personal income (Bentzien et al. 2012). In other words, the entry-level housing affordability index is the ratio of the annualised effective cost of servicing the loan to the average annual personal income of the LGA. The modifications in the formula are the threshold, LTV, r, and the loan term. In Australia, the housing affordability threshold is 30 percent of income (Yates 20072008; Worthington & Higgs 2013), the LTV is 90 percent, reflecting a minimum down-payment of 10 percent plus transaction costs, the mortgage lending rate is variable, and the loan term is 25 years. Hence housing in a region is considered affordable if the cost to income index value CtI_{Aus} is less than 30. A higher index value in a region suggests housing it is less affordable in that region and vice versa.

4.2.1.2 Ongoing Housing Affordability

While entry affordability measures access to mortgaged homeownership at any point in time (Chen et al. 2010), ongoing affordability estimates the level of affordability experienced by the homebuyer after entering the housing market. In other words, ongoing housing affordability examines how affordability evolves from the year after entry into the housing market for each cohort of entrants over a twenty-five-year payment period. Assessing ongoing affordability is critical in homeownership because, as reported by Vandell (1995), mortgage default can be engendered by several factors such as transaction costs of terminating a mortgage, the ability to pay, job loss, divorce, and relocation. Therefore, to compute the ongoing housing affordability index for each period, we modified the CtI_{Aus} index discussed in Equation (1) by using the loan balance (LB) instead of the original loan amount (i.e. MV*LTV) over time. This was combined with the mortgage lending rate at a given period and average personal income to highlight the trend of ongoing affordability for each region. This formula reflects the option-theoretic mortgage pricing model, which considers the current loan-to-value and interest rate variables as important predictors of mortgage default (Vandell 1995; Deng et al. 2000; Pennington-Cross & Ho 2010). Therefore, the ongoing housing affordability index is given as follows:

$$\mathbf{CtI_{Aus}} = \frac{100}{\mathrm{I}} \mathbf{x} \left(\mathbf{LB\ x} \frac{\frac{r}{12}}{1-\left(\frac{1}{\left(1+\frac{r}{12}\right)12n}\right)} \right) \mathbf{\ x\ 12} \quad (2)$$

where I denotes average personal income, LB is loan balance of the property, r is the mortgage lending rate, Aus. represents Australia and n is the remaining term of the loan. The formula gives the annualised effective cost of servicing the loan (in parenthesis) and it is computed by means of a standard n-year annuity formula (i.e. n = remaining number of years) with monthly compounding, where the loan is fully amortised over the remaining term and then compared to the annualised average personal income (Bentzien et al. 2012).

The key features of the ongoing affordability index include the incorporation of mortgage payments in the previous periods, the change in average income of the homebuyer over time, and the change in the mortgage lending rate over time. The dynamics of the ongoing affordability index are, therefore, caused by the changes in these elements. Since the goal of homebuyers is to eventually own the home (outright), it is imperative to identify how affordability changes after entering the housing market. This is particularly the case where there is strong housing market and a general decline in mortgage lending rate, creating a robust refinancing climate (Quercia & Spader 2008). This will also highlight the likelihood of residents in different regions staying in the housing market.

Therefore, the CtI_{Aus} formula was applied to intrinsically capture both entry and ongoing housing affordability indexes using a standard annuity formula. This also delivers a graphical display of both trends of affordability over the study period. Other reasons for applying this method include its appropriateness for comparability, convenience and data suitability (Bentzien et al. 2012). Unlike Chen et al. (2010), the study used individual income as opposed to household income to demonstrate the worst-case housing affordability scenario across the different regions. The use of individual income is validated by the greater flexibility in current economic policies that culminated into diverse economic, social and structural changes, resulting in increased systematic risk, making housing affordability more problematic, particularly for low income earners (Yates 2008). Labour markets, for example, are presently less regulated than they were in the past resulting in more fixed-term contracts, part-time, and casual work, a situation that puts working class at risk of income instability (Yates 2008). It is therefore important to examine affordability using individual income. A similar measure is employed by the BIS-Shrapnel housing loan affordability index to determine entry-level affordability (Abelson 2009).

4.2.2 Estimating the Causality between Housing Affordability and Local Drivers

The study employed a two-staged methodology to estimate the local drivers of homeownership affordability. First, the study estimated the entry-level homeownership affordability index for each LGA that make up the different regions of Greater Sydney using the cost-to-income affordability index (**HAI_{CI}**) in Equation (1). Entry-level affordability is the affordability level at the time of entering the housing market. The second stage of the study involves a panel analysis. Specifically, the study regresses homeownership affordability against key local housing variables in different regions of Greater Sydney using the system generalised method of moments (SGMM). The SGMM allows us to test Stone's (1990) shelter poverty theory in which low-income households are more likely to be shelter poor due to lower residual income. These panel estimators are preceded with a panel unit root test to establish the stationarity of the data. To shed more light on the local drivers of homeownership affordability in different regions of Greater Sydney in the long run, Westerlund (2007) cointegration and panel error correction model (ECM) were employed.

4.2.2.1 Panel Unit Root Test

Extensive research has been dedicated to developing techniques for detecting the presence of a unit autoregressive (AR) root in time series (Harris & Tzavalis 1999). The application of these techniques to the analysis of panel data is also crucial to study the dynamic behaviour of several economic units. Therefore, prior to the application of the SGMM, we tested the stationarity of the panels. Following Herwartz and Siedenburg (2008), we consider the AR(1) panel data model below using house price (HP):

$$HP_{it} = \lambda_i HP_{it-1} + \mu_{it,}\ t = 1,\ldots\ldots\ldots..., T,\ i = 1,\ \ldots\ldots\ldots\ldots\ldots\ldots N,\quad \lambda > 0 \qquad (3)$$

where HP_{it} denotes house price on the ith LGA at time t. The autoregressive dynamics are defined by the coefficient λ_i, which can vary across panel members. Assuming, first, that the error vectors $\mu_t = (\mu_{1t}\ldots, \mu_{Nt})$ are independently and identically distributed, μ_{it} are i.i.d.$(0, \text{ɤ})$, where ɤ is a positive definite matrix, and second, that the vector of initial values $HP_0 = (HP_{10},\ldots.HP_{N0}) = 0$, using the usual t test, the process is stationary if and only if λ_i is < 1. Rejecting the null hypothesis of a unit root implies we have a stationary series. (The rejection of H_0: $\lambda_i = 1$ against H_1: $\lambda_i < 1$ means that we can also safely reject $\lambda_i > 1$.) However, the presence of a lagged dependent variable means the OLS estimator of λ_i will be biased in small samples. Hence, we cannot rely on the test statistic being normally distributed even in large samples. This problem led to the application of the Dickey Fuller test. If there is autocorrelation

problem in the residuals of the OLS estimated version of the Dickey-Fuller regression, the Augmented Dickey-Fuller (ADF) addresses this problem by including more lags of the dependent variable as regressors until serial correlation is removed. This process is repeated for all the other variables of the model including the dependent variable.

Several tests exist for unit roots in panel datasets such as the Levin et al. (2002), Harris and Tzavalis (1999), Breitung and Das (2005); Im et al. (2003), and Fisher-type Choi (2001). Most of these tests assume a balanced panel dataset, but the Im–Pesaran–Shin allow for unbalanced panels. Besides, if a large lag order is selected for the underlying ADF regressions, then the finite sample performance of the Im-Pesaran-Shin test is reasonably satisfactory and generally better than the Levin–Lin–Chu test (Im et al. 2003). As there are missing data in some panels resulting in unbalanced panel data as well as its superior test power in analysing long-run relationships in panel data, the study deployed the Im–Pesaran–Shin (IPS) panel data unit root test. The other panel unit root tests were used to check the consistency of the IPS results. The IPS follows the widely known Dickey-Fuller estimation procedures that address the issue of low power often associated with single series ADF tests by averaging the test statistics across the panel and assumes that errors are independently and identically distributed (Maddala & Wu 1999). The hypotheses of IPS tests are:

- Null hypothesis, H_o: all panels contain unit root
- Alternative hypothesis, H_a: some panels are stationary

The IPS test process begins by specifying a separate ADF regression for each cross-section with individual effect and no time trend as follows:

$$\Delta HP_{it} = \alpha_i + \varphi_i HP_{it\ 1} + \sum_{k=1}^{m_i} \beta_{ij} \Delta HP_{it\ k} + \varepsilon_{it} \quad \text{where i = 1, . . ., N and t = 1, . . ., T} \tag{4}$$

The IPS uses separate unit root tests for the N cross-section units and averages the Augmented Dickey-fuller (ADF) statistics across panels. The average of the t-statistics for from the individual ADF regressions is defined as:

$$t_{iT_i}(m_i):\ \bar{t}_{NT} = \frac{1}{N}\sum_{i=1}^{N} t_{iT}(m_i \beta_i) \tag{5}$$

The standardised t-bar statistic converges to the standard normal distribution as N and T and performs better when N and T are small (Im et al. 2003).

4.2.2.2 System Generalised Method of Moments (SGMM) Model Specification

Once the stationarity of homeownership affordability indices has been established, the study assessed the causality between local homeownership affordability and local factors with a system generalised method of moments (SGMM) model. This is because dynamic models continue to play an increasing significant role in empirical analysis of panel data (Im et al. 2003). While fixed effect (FE) and random effect (RE) models are common procedures for estimating and analysing panel data (McLaughlin 2011), the study avoids the use of these estimators for these reasons. First, random effect estimator is inappropriate when using panel data with relatively few panels and many time periods (McLaughlin 2011). This is particularly the case for the eastern region with three LGAs, the southern region with five LGAs, and the inner-west region with six LGAs. Second, the fixed effects (FE) estimator is inconsistent in dynamic panel since the within transformation does not remove the individual effect completely from the error process, suggesting that an instrumental variable (IV) estimator is more efficient (Hansen & Tarp 2001).

Given that the generalised method of moments (GMM) addresses potential model misspecifications and gives more consistent estimates in the presence of endogenous regressors (Hansen & Tarp 2001) than the simpler IV alternatives introduced by Anderson and Hsiao (1981), the study follows this technique. Two forms of GMM are often employed in dynamic panel data – difference GMM and system GMM (Roodman 2009). Because the difference GMM often performs poorly due to weak instruments that results in bias estimation (Roodman 2009; Bun & Sarafidis 2015), the system GMM is employed. Further, the SGMM has a lower bias and higher efficiency (Soto 2009; Fukase 2010).

The SGMM also known as Arellano–Bover/Blundell–Bond estimator augments the difference GMM by making an additional assumption that first differences of instrument variables are uncorrelated with the fixed effect and introduces more instruments to improve efficiency. NSW state final demand and the mortgage lending rate were used as external instruments as they are key market fundamentals that induce changes in the explanatory variables but they do not have any direct effect on housing affordability. This process will uncover the causal effect of the explanatory variables on the dependent variable. The null hypothesis of no autocorrelation was tested using the Arellano-Bond Test and natural logarithms were introduced in the model to address any scaling effects in the data. We also conducted the Hansen's J test of the validity of over-identifying restrictions. Rejecting the null hypothesis of the Hansen's J test implies that we need to reconsider our model or our instruments, unless the rejection can be due to

heteroskedasticity in the generation of the data (Parente & Santos Silva 2012). The general model of the SGMM is given as:

$$\ln HAI_{it} = \beta_0 + \beta_1 \ln HA_{it-1} + \beta_2 \ln RP_{it} + \beta_3 \ln HS_{it} + \beta_4 d\ln MR_{it} + \beta_5 d_{it} + \varepsilon_{it} \quad (6)$$

Where $\varepsilon_{it} = \alpha_i + \mu_{it}$ and $E(\alpha_i) = E(\mu_{it}) = E(\alpha_i \mu_{it}) = 0$

From Equation (6), the disturbance term has two orthogonal components: the fixed or LGA effect, α_i which is a time-invariant error term that represent geo-physical characteristics, the social ledger etc. and the idiosyncratic shocks, μ_{it}, which captures all other factors that influence housing affordability other than the specified regressors. HAI_{it} denotes homeownership affordability index for LGA_i at time t; HAI_{it-1} denotes lagged homeownership affordability for LGA_i at time t; RP_{it} denotes resident population for LGA_i at time t; HS_{it} denotes housing supply for LGA_i at time t; MR_{it} denotes median rent for LGA_i at time t, and a dummy variable (d) is included to gauge the effect of the introduction of the goods and services tax (GST) in July 1999 and the FHOG in July 2000 on homeownership affordability.

The coefficients of the lagged dependent variable cannot be determined a priori. β_2 is indeterminate, depending on the effect of net-migration and/or natural increase (Productivity Commission Report 2004; Yates 2008); β_3 is expected to be negative as an increase in housing supply is expected to improve affordability (McLaughlin 2011; Gitelman and Otto 2012); and β_4 is hypothesised to be positive because as median rent increases, homeownership affordability of potential first home buyers deteriorates[6] (Yates 2008).

The documented results from the system GMM allow the examination of the study hypothesis. As hypothesised, it is expected that the magnitudes of local drivers in low-income regions are stronger compared with high-income regions. Further, the low-income regions are affected by more homeownership affordability drivers than the high-income regions. This reflects the shelter poverty approach; as low-income households would be more sensitive to changes in these housing variables.

4.2.2.3 Westerlund (2007) Panel Cointegration and Panel ECM Model Specification

The second stage of the methodology involves testing the presence of a long run relationship between homeownership affordability and its regressors. Following the IPS panel unit root test is Westerlund (2007) panel cointegration test to formally check the existence of cointegration

[6] Further, the Hansen's J test of the validity of over-identifying restrictions was also conducted. Rejecting the null hypothesis of the Hansen's J test implies that we need to reconsider our model or our instruments, unless the rejection can be due to heteroscedasticity in the generation of the data (Parente and Santos 2012).

in Equation (6). Westerlund (2007) is an error correction-based model (ECM) panel cointegration test. It performs better in small samples and is more powerful than residual based cointegration tests (Agnello & Schuknecht 2011; Hassan & Salim 2015).

Once the order of integration in the variables has been established, the presence of cointegration will confirm the existence of a long run relationship in the variables of our baseline and robustness results. Westerlund (2007) proposed four panel cointegration tests that are intended to test if the error correction term in a conditional error correction model is equal to zero. Each test embodies individual specific short run dynamics, including serially correlated error terms and non-strictly exogenous regressors, individual specific intercept and trend terms, and individual specific slope parameters. The test also incorporates a bootstrap procedure to address applications with cross-sectional dependent data. The tests produce consistent results and show better size accuracy and higher power than residual-based tests.

Once cointegration is found, we estimate the panel ECM. We re-parameterised Equation (6) into an ECM to examine a stable long run relationship among it variables that change over time. The ECM contains both the long run equilibrium relationship and a short run equation that describes how the long run solution is derived through an error correction (Hoesli et al. 2008). Therefore, the long run relationship becomes:

$$HAI^*_{it} = \beta_0 + \sum_{i=1}^{n} \beta_{it} K_{it} \quad (7)$$

where HAI_{it} is homeownership affordability and K is a vector of local drivers of homeownership affordability such as RP_{it}, HS_{it}, and MR_{it}. The residual term of Equation (7) becomes:

$$\mu_{it} = HAI_{it} - a - \sum_{i=1}^{n} bK_{it} \quad (8)$$

where a and b are the estimated parameters of β_0 and β_{it}. Stationarity of this residual term means there is cointegration between homeownership affordability and its regressors, and this can be used in the short term as an error correction term. This means the short-term changes in HAI are influenced by the changes in its regressors and by the lagged equilibrium. Therefore, the short run ECM becomes:

$$\Delta HAI_{it} = con - \varphi ECT_{it-1} + \beta_0 \Delta RP_{it} + \gamma_0 \Delta HS_{it} + \psi_0 \Delta MR_{it} + \varepsilon_{it,} \quad (9)$$

where $\varphi = (1-\alpha_1)$, where $ECT_{it-1} = (HAI_{it-1} - \Theta_1 RP_{it-1} - \Theta_2 HS_{it-1} - \Theta_3 MR_{it-1})$

It is hypothesised that the low income or socio-economic regions (i.e. western, south-west and inner-west Sydney) have higher magnitudes of housing variables in a long run compared with high income or socio-economic regions (i.e. eastern and northern Sydney).

From (9), if $\varphi < 0$, then there is an error correction, which implies that HAI_{it} is cointegrated with RP_{it}, HS_{it} and MR_{it}. However, if $\varphi = 0$, this reflects that there is no cointegration. This suggests that the null hypothesis of no cointegration for cross-sectional unit i can be implemented as a test of H_0: $\varphi = 0$ versus H_1: $\varphi < 0$. In these tests, the null hypothesis of no error correction is identical to the null hypothesis of no cointegration. Therefore, a rejection of the null hypothesis means rejecting the tested hypothesis of no cointegration. This intuition culminates in four panel statistics. Two of the tests are designed to test the alternative hypothesis that the panel is cointegrated as a whole and they are referred to as panel statistics (P_t), while the other two test the alternative that there is at least one individual that is cointegrated and they are referred to as group-mean (G_t) statistics (Agnello & Schuknecht 2011).

For the panel statistics, the null hypothesis H_0: $\varphi = 0$ is tested against the alternative hypothesis H_1: $\varphi_i = \varphi < 0$ for all i, which specifies that a rejection is considered an evidence of cointegration for the panel as a whole. On the other hand, for the group-mean statistics, the null hypothesis H_0: $\varphi = 0$ is tested against the alternative hypothesis H_1: $\varphi_i < 0$ for at least some i, signifying that a rejection is an evidence of cointegration for at least one of the cross-sectional units.

To estimate the ECM, as discussed by Pesaran et al. (1999), we often employ the dynamic fixed effect and instrumental variable estimators. However, these estimators can produce inconsistent and potentially very misleading estimates of the average values of the parameters in dynamic panel data models except where the slope coefficients are identical. This is due to the fact that the dynamic fixed-effect and the instrumental variable estimators generally impose homogeneity of all slope coefficients, allowing only the intercepts to vary across LGAs (Tan 2009). As there is the possibility of heterogeneity in the slopes, the use of these estimators could be inappropriate (McLaughlin 2011). As such, and Pesaran et al. (1999) suggested the application of two separate estimators - mean group (MG) and pooled mean group (PMG) estimators.

The MG estimates separate regressions for each LGA and calculates averages of the LGA-specific coefficients to generate the region's coefficient. It allows both slope and intercepts to vary across LGAs but imposes less restrictions on the long run coefficients. The PMG estimator

allows short run coefficients, intercepts, and error variances to differ across LGAs, but imposes homogeneity on long run coefficients (Tan 2009). The null hypothesis of long run slope homogeneity in the coefficients (PMG being the preferred estimator) is tested using the Hausman test. Rejecting the tested null hypothesis at the usual level of significance means the MG is the efficient estimator. As autoregressive distributed lag models are sensitive to lag length (Tan 2009), the Akaike Information Criterion and the Schwarz Bayesian Criterion are imposed to determine the maximum lag length.

4.2.3 Testing for Housing Price Bubbles

The study also adopted a two-staged methodology to address the third research question. The first stage examined the cointegration of house price and rent to determine the potential for housing price bubble formation. It involves a panel cointegration analysis to evaluate whether house price temporarily or permanently diverges from rent. A temporal departure implies that house price and rent will return to their long run equilibrium, which minimises the occurrence of a housing bubble. On the other hand, a permanent departure means there is no long run equilibrium relationship between house price and rent, and this shows an early sign of a housing bubble. Cointegration analysis of house price and income was also done to balance check the results of house price and rent. Of course, the panel unit root test was done before conducting the cointegration test.

Cointegration analysis of house price and rent is an important measure of potential deviation of house price from its fundamentals (Kivedal 2013). In addition, it is a suitable benchmark for over or undervaluation of property (Girouard et al. 2006), and it is a useful tool in predicting real house prices (Gallin 2008). This econometric approach is also well situated within the traditional valuation approach, which is a freehold market valuation method that establishes the value of a property using the ratio of rent and the capitalisation rate. More importantly, as asserted in the four-quadrant housing price model, rent plays an important role in determining new housing supply and property investment activities. All of these support the argument that the relationship between house price and rent is essential in signalling the existence of a bubble.

The second stage is the formal housing price bubble test. This stage involves the application of the backward supremum ADF (BSADF) procedure to test for real time housing bubble period using the house-price-rent ratio or rental yield for all dwellings. Further analysis was done to validate our baseline findings using strata and non-strata dwellings.

4.2.3.1 Panel Cointegration Modelling

To test for cointegration between house price (P_{it}) and rent (R_{it}) in each region, the study employed the bivariate version of Westerlund (2007) error correction-based panel cointegration procedure discussed in section 4.2.2.3. Prior to conducting the cointegration test between house price and rent, the study established the order of integration of these variables following the panel unit root test procedure discussed in section 4.2.2.1. Consider an autoregressive distributed lag (ARDL) as follows:

$$P_{it} = \delta + \gamma_0 I_{it} + \pi_1 P_{it-1} + \ldots. + \pi_q P_{it-q} + \alpha_1 R_{it-1} + \ldots\ldots. + \alpha_r R_{it-r} + \varepsilon_{it} \quad \text{where } \varepsilon_{it} = \sigma_i + \mu_{it} \qquad (10)$$

Equation (10) is denoted by an ARDL (q, r), as there are q lags with respect to P; and r lags with respect to R. From Equation (10), the error term has two components: the fixed effects, σ_i which is a time-invariant error term and the idiosyncratic shocks, μ_{it}. P_{it} denotes house price for LGA_i at time t; R_{it} denotes median rent for LGA_i at time t; P_{it-1} denotes lagged house price for LGA_i at time t; and R_{it-1} denotes lagged median rent for LGA_i at time t.

Equation (10) can be re-parameterised into a bivariate error-correction model (ECM) to evaluate a stable long run relationship between house price and rent over time. The ECM for P_{it} becomes:

$$\Delta P_{it} = con - \varphi ECT_{it-1} + \pi_0 \Delta R_{it} + \varepsilon_{it,} \text{ where } \varphi = (1-\alpha_1) \text{ and } ECT_{it-1} = (P_{it-1} - \Theta R_{it-1}) \qquad (11)$$

The ECM in Equation (11) can only be stable if P_{it} and R_{it} are both stationary. Thus as $P_{it-1} - \Theta_1 R_{it-1}$ must be stationary, Θ defines a long-run equilibrium relationship between P_{it} and R_{it}, and of course, provided the error term is also stationary. Any deviation from this equilibrium relationship lead to a correction by the proportion $-2 < \varphi \leq 0$, which Westerlund (2007) referred to as the error correction parameter. From Equation (11), if $\varphi < 0$, then there is error correction, which implies P_{it} is cointegrated with R_{it}, and if $\varphi = 0$, then the error correction is lacking and there is no cointegration. This suggests that the null hypothesis of no cointegration for cross-sectional unit *i* can be implemented as a test of H_0: $\varphi = 0$ against the alternative H_1: $\varphi < 0$. From this hypothesis, as discussed in section 4.2.2.3, Westerlund (2007) proposed four new panel statistics.

4.2.3.1.1 Panel Cointegration Procedure

Again, as proposed by Westerlund (2007), two of the tests are designed to test the alternative hypothesis that the panel is cointegrated as a whole and they are referred to as panel statistics, while the other two test the alternative that there is at least one individual that is cointegrated and they are referred to as group mean statistics.

4.2.3.1.2 The Panel Statistics

The panel statistics estimated by pooling the information regarding the error correction along the cross-sectional dimension of the panel. The null hypothesis, H_0: $\varphi = 0$ for all *i*, is tested against the alternative hypothesis, H_1: $\varphi < 0$ for all *i*, which specifies that a rejection is considered an evidence of cointegration for the panel as a whole. The panel statistics are more complicated since both the parameters and dimension of Equation (11) are allowed to differ between the cross-sectional units. A three-step procedure is followed to carry out this test. The first step is to determine the individual lag order, N_i. We then regress ΔP_{it} and P_{it-1} on the constant (con), the lags of ΔP_{it} as well as the contemporaneous and lagged values of ΔR_{it}. This results in the projection errors:

$$\Delta\hat{P}_{it} = \Delta P_{it} - \widehat{con_i} - \hat{\alpha}_i R_{it-1} - \sum_{k=1}^{N} \hat{\pi}_{it} \Delta P_{it-k} - \sum_{k=1}^{N} \hat{\alpha}_{it} \Delta R_{it-k} \quad (12)$$ and

$$\hat{P}_{it} = P_{it} - \widehat{con_i} - \hat{\alpha}_i R_{it-1} - \sum_{k=1}^{N} \hat{\pi}_{it} \Delta P_{it-k} - \sum_{k=1}^{N} \hat{\alpha}_{it} \Delta R_{it-k} \quad (13)$$

The second step involves using $\Delta\hat{P}_{it}$ and $\hat{P}_{it}$ to estimate the common error correction parameter π and its standard error. Therefore, we compute:

$$\hat{\pi} = \left(\sum_{i=1}^{N} \sum_{t=2}^{T} \hat{P}_{it-1}^2\right)^{-1} + \sum_{i=1}^{N} \sum_{t=2}^{T} \frac{1}{\hat{\pi}_i(1)} \hat{P}_{it-1} \Delta\hat{P}_{it} \quad (14)$$

The standard error (SE) of $\hat{\pi}$ is given as:

$$SE(\hat{\pi}) = \left((\hat{S}_N^2)^{-1} \sum_{i=1}^{N} \sum_{t=2}^{T} \hat{P}_{it-1}^2\right)^{-1/2} \text{ where } \hat{S}_N^2 = \frac{1}{N} \sum_{i=1}^{N} \hat{S}_i^2 \quad (15)$$

The third and final step is to compute the panel statistics as follows:

$$P_\tau = \frac{\hat{\pi}}{SE(\hat{\pi})} \text{ and } P_\pi = T\hat{\pi} \quad (16)$$

It is hypothesised that the panel statistic of a region is statistically significantly different from zero, suggesting there is no indication of housing bubble in the region.

4.2.3.1.3 The Group Mean Statistics

Conversely, for the group mean statistics, the null hypothesis, H_0: $\varphi = 0$ is tested against the alternative hypothesis, H_1: $\varphi_i < 0$ for at least some i, signifying that a rejection is an evidence of cointegration for at least one of the cross-sectional units. Three steps are also involved in the estimation of the group mean statistics. Step one is to estimate Equation (11) by least squares for each *i*, which yields:

$$\Delta P_{it} = \widehat{con_i} + \hat{\pi}_i P_{it-1} + \hat{\alpha}_i R_{it-1} + \sum_{k=1}^{N} \hat{\pi}_{it} \Delta P_{it-k} + \sum_{k=1}^{N} \hat{\alpha}_{it} \Delta R_{it-k} + \widehat{\varepsilon_{it}} \quad (17)$$

The lag order N_i is allowed to vary across individuals, and can be determined by using information criterion such as Bayesian information criterion. Alternatively, the number of lags can be set as a fixed function of T. The second step involves estimating:

$$\pi_i(1) = 1 - \sum_{k=1}^{N} \hat{\pi}_{it} \quad (18)$$

The final step is to compute the test statistics as follows:

$$G_t = \frac{1}{N}\sum_{i=1}^{N} \frac{\widehat{\alpha_i}}{SE(\widehat{\alpha_i})} \text{ and } G_\alpha = \frac{1}{N}\sum_{i=1}^{N} \frac{T\widehat{\alpha_i}}{\widehat{\alpha_i}(1)} \quad (19)$$

Where $SE(\widehat{\alpha_i})$ is the conventional standard error of $\widehat{\alpha_i}$.

It is hypothesised that the group mean ($\mathbf{G_t}$) statistic of a region is statistically significantly different from zero, suggesting that there is at least one individual that is cointegrated and no indication of bubble in the region.

4.2.3.2 House Price Bubbles - Backward Supremum ADF

The second-staged methodology of the third research question is a formal housing bubble test using the BSADF. Generally, there is no universally accepted method of testing price bubbles because the pathway of a bubble in the data may create an error in modelling the expectations of the economic agent (Teng et al. 2017). Some of the widely used methods of testing price bubbles include the benchmark housing prices against the equilibrium prices predicted by economic models. These methods were applied in Case and Shiller (2003), Mayer and Shiller (2006), Rapach and Strauss (2009), Ren et al. (2012) and Dreger and Zhang (2013). Because of the possibility of some model misspecifications in these method, other studies such as Alessandri (2006), Man Hui and Gu (2009), Xiao and Park (2010), Al-Anaswah and Wilfling (2011), Teng et al. (2013), Teng et al. (2017) have used the state-space model to test for price bubbles. State-space model has the advantage of applying an indirect method for estimating the Kalman Filter. This means any unobservable state variables can mostly be obtained by observing the model that composed of observable variables using Maximum Likelihood Estimation (Man Hui & Gu 2009). However, these tests do not specifically highlight real time bubble period.

The Phillips-Wu-Yu (PWY) method proposed by Phillips et al. (2011) is a recursive method that can identify and provide real time exuberance in asset price series during an inflationary period. The PWY is an anticipative procedure that provides an early bubble signal (Phillips et al. 2011). The PWY approach is effective if there is a single-bubble episode in the sample data (Phillips et al. 2015). However, multiple bubbles do occur within a given sample data and when

this occurs, it diminishes the discrimatory power of the PWY bubble test. This is particularly the case when long time series data are used or when there are rapidly changing market circumstances in the period under review. In Australia, for example, the tax system has undergone several changes in the past 30 years and this is expected to impact on house prices (Shi et al. 2016). The Phillips-Shi-Yu (PSY) framework addresses this gap in bubble-testing by extending the work of PWY to test for multiple bubbles in a given sample data (Phillips et al. 2015). Even though both the PWY and PSY procedures rely on recursive right-tailed ADF test that may be used in real time to identify the origination and termination dates of bubbles (Phillips et al. 2013), the PSY procedure is a consistent dating algorithm even in the case of multiple bubbles. The PSY is based on flexible window widths in the recursive regressions (Phillips et al. 2015). This is the recent bubbles test procedure and it is well-designed to analysing bubbles in long historical time series. The study therefore employed the backward supremum Augmented Dickey Fuller (BSADF) of the PSY framework to conduct the housing bubble test.

The PSY procedure proposed a generalised supremum ADF (GSADF) method to test for the presence of bubbles and a recursive backward regression technique to time-stamp the origination and collapse dates of the bubble. The tested hypothesis is that the series contains a random walk with some local drift. This means, property bubbles are the periods in which the escalation in house prices is not accompanied by a proportionate increase in property income or rent (Greenaway-McGrevy & Phillips 2016). By representing the house-price-rent ratio by Z, null hypothesis is specified as:

$$H_o: Z_t = kT^{-\eta} + \theta Z_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim_{iid} N(0, \sigma^2), \theta = 1 \tag{20}$$

where k is a constant, η is the localising coefficient that controls the magnitude of the drift as the sample size, T, approaches infinity, and ε_t is the error term. The test is based on some reduced form empirical equation as follows:

$$\Delta Z_t = \alpha + \gamma Z_{t-1} + \sum_{i=1}^{p} \lambda \Delta Z_{t-1} + \varepsilon_t \tag{21}$$

Where Z_t is the variable of interest which is the house-price-rent ratio at time t in any given region of Greater Sydney, α is the intercept, p is the optimum number of lags, for i =1……. p are the differenced lags coefficients, which is determined by the Bayesian information criterion, and ε_t is the error term. For each observation Z_τ, the procedure uses all information before time τ to determine if there is sufficient evidence to reject the null that Z_τ belongs to the martingale null in favour of the mildly explosive alternative.

The backward supremum ADF (BSADF) provides real time monitoring of housing bubbles than the GSADF (Shi et al. 2016). In addition, the BSADF also enhances identification accuracy (Phillips et al. 2015). As a result, we chose this approach over the GSADF in our study. Therefore, the BSADF procedure performs a supremum ADF on a backward expanding sample sequence where the termination point of each sample is fixed at τ_2 and the start point varies from 0 to $\tau_2 - \tau_0$. The corresponding ADF statistic sequence is:

$$(ADF)_{\tau_1}^{\tau_2} \quad \tau_1 \epsilon (0, \tau_2 - \tau_1) \tag{22}$$

The BSADF statistic is then defined as the supremum value of the ADF statistic sequence over the interval:

$$\text{BSADF}\tau_2(\tau_0) = \sup (ADF)_{\tau_1}^{\tau_2} \quad \tau_1 \epsilon (0, \tau_2 - \tau_1) \tag{23}$$

The PSY model specifies that the asymptotic distribution of this test statistic under the null hypothesis. $Z\tau$ is considered a bubble episode if the value of the BSADFτ test statistic is larger than the right-tailed critical value of the distribution. The estimated BSADFτ can signal a quarterly early warning of the property market in the region. In the quarterly data used, the study follows the recommendation of Phillips et al. (2015) to set τ_0 to 19 using $0.01 + 18/\sqrt{T}$ of the sample size to minimise the probability of size distortion. This means the ADF test statistic sequence starts after the twentieth (20^{th}) observation of the time series. The critical values of the BSADFτ test statistic at the 95 percent level are based on a Monte Carlo simulation with 2000 replications run with Eviews (Itamar 2017).

4.2.4 Assessing House Price Diffusion Pattern

This study utilised a number of tests to examine the existence of spillover effects between two housing submarkets in Greater Sydney, and to provide some theoretical explanation of this casual mechanism, if any. Firstly, Meen (1999)'s constancy ratio test was used to test the stationarity of a ratio of house price in one housing submarket to house price in a broader housing market. The test is a preliminary indicator of the existence of a spillover effect (Meen 1999). To further confirm the existence of the spillover effect of a housing market, a cointegration test was utilised to examine whether house prices in both markets have a long run equilibrium relationship (or moved in the same direction in the long run). If both series were cointegrated, it would indicate that house prices of both submarkets are linked, which reinforces the existence of a spillover effect among these submarkets. Thereafter, a Granger-causality test was employed. This test allows us to identify the price leader (or dominant

submarket) in the housing submarket, and to test the hypotheses in section 4.3.4 to ascertain if house price in the relative low-priced region will lead house price in the relative high-priced region or vice versa.

The abovementioned three tests provide robust empirical evidence to support the existence of a spillover effect in the housing markets of Greater Sydney. To shed more light into the mechanism of housing price movements, we further tested whether the region with a dominance role is more responsive to market fundamentals, whereby the dominant submarket creates some price signals for other submarkets, which facilitates the formulation of a spillover effect. To assess the mechanism of housing price movements, a Dynamic Ordinary Least Square (DOLS) was employed.

4.2.4.1 Meen's (1999) Constancy Ratio

An indication of the existence of spillover effect in Greater Sydney was examined using Meen (1999)'s ratio of house price procedure. Meen (1999) procedure is essentially a stationarity test of a ratio of house price in one housing submarket to the house price in a broader housing market. This differs from the well-known unit root test, which tests the stationarity of a single variable. As highlighted by Meen (1999), failure to detect stationarity in the ratio suggests regional and national house prices are segregated. This is an indication of segmentation or long-run divergence. This means the change in house price in one submarket does not spill over to other submarkets. In other words, the submarkets do not converge to a single market over time. On the other hand, if the ratio of house prices in a given region to the national house price is stationary, it can be asserted that house price should be constant in the long run, which gives an indication of a spillover effect. Again, the test offers a preliminary indication of the existence of a spillover effect among different housing submarkets.

To examine the existence of a spillover effect for the two submarkets in Greater Sydney, both the Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) unit root tests discussed in the following section were applied to test the ratio of the median house price of each submarket of Greater Sydney to the median house price of Greater Sydney. The null hypothesis implies that house prices are segregated between regions. However, the alternative hypothesis suggests a long-run constancy in the ratio, indicating the existence of a spillover effect among housing submarkets of Greater Sydney. The study further performed a more robust test for stronger evidence of the existence of a spillover effect by employing the cointegration test and the

Granger-causality test. Again, these three tests provide robust empirical evidence to support the existence of a spillover effect in the housing markets of Greater Sydney.

4.2.4.2 Cointegration Test and Granger Causality Test

For further enlightenment on the diffusion pattern of housing submarkets, the second stage of the analysis examines the long-run equilibrium relationship between these housing submarkets. The process starts with a unit root test of the variables before conducting the cointegration test. A cointegration test was used to assess whether both submarkets are linked together over time. The price leader submarket is also identified using the Granger-causality test.

4.2.4.2.1 Unit Root Test

A unit root test was used to test for the stationarity of a variable and the order of integration (Gujarati 2004). Following Lee and Lee (2014), three forms of the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and two forms of the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root models were employed. Tests with no intercept and trend, intercept but no trend, and intercept with a trend were conducted using ADF and PP. In other words, this may have a stochastic process with no drift, or it may have a drift, or it may have both deterministic and stochastic trends. These approaches are robust in dealing with heteroskedasticity and serial correlation (Wilson et al. 2011). In case of the KPSS, tests were done for intercept but no trend, and intercept with a trend. To allow for these various scenarios, the tests are estimated in all these forms. The denotation I(0) means the variable has a unit root and it shows unpredictability in the growth of the time series data. First difference stationarity I(1) denotes there is a steady rate of change in the variable over time. Statistically, a stationary time series implies the mean and variance of the variable are constant over time (Gujarati 2004). Suppose our price time series (P_t) follows a first-order autoregressive process as follows:

$$P_t = \rho P_{t-1} + \mu_t \qquad (24)$$

This process is stationary if and only if $\rho < 1$. One way to proceed is to apply OLS in Equation (24) and test $\rho = 1$ versus $\rho < 1$, using a usual t test. Rejection of the null hypothesis implies that we have a stationary series. (Rejection of H_0: $\rho = 1$ against H_1: $\rho < 1$ means that we can also safely reject $\rho > 1$). One problem with this method is that the presence of a lagged dependent variable means that the OLS estimator of ρ will be biased in small samples. In fact, it can be demonstrated that $\hat{\rho}$ is biased downwards. In addition, under the null hypothesis (H_0: $\rho = 1$) the process is non-stationary and therefore standard large sample distribution results are

invalid. Therefore, we cannot rely on the test statistic to be normally distributed even in large samples. This has led to the development of the Dickey-Fuller (DF) test. If there is autocorrelation problem in the residuals of the OLS estimated version of the Dickey-Fuller regression, the Augmented Dickey-Fuller (ADF) addresses this problem by including more lags of the dependent variable as regressors until serial correlation is removed. This process is repeated for all the other variables of the model including the dependent variable.

4.2.4.2.2 Cointegration Test

To examine the long run equilibrium relationship in house prices between the two submarkets of Greater Sydney, and between Greater Sydney and NSW regional cities, the study adopted a pairwise cointegration technique. This econometric approach was introduced by Johansen (1988) with subsequent extensions by Johansen (1991) and Inoue (1999). The technique has been applied in numerous housing studies (Chowdhury & Malik 2004; Doh-Khul et al. 2006; Luo et al. 2007; Wilson et al. 2011; McCord et al. 2014; Gupta et al. 2015). Again, cointegration is a technique of establishing whether two or more variables are linked together over time. Failing to test for cointegration may lead to spurious regression results between/among the variables being specified (Wilson et al. 2011).

Once the two variables are tested to be of the same order using the unit root test, we proceed with the cointegration test for each pair of variables. Cointegration helps identify the long run relationship between house prices of the two submarkets. If cointegration exists, house price in one submarket will drift (upwards or downwards) and then allow the house price in the other submarket to adjust. This means house prices tend to return to a long run equilibrium since they do not drift too far away from each other. In other words, if submarkets are cointegrated, it indicates that house prices in the submarkets are linked, which would further confirm that there is a spillover effect among these markets. Three cointegration tests were employed in the study. They are: Engle-Granger; Phillips-Ouliaris; and Johansen bivariate cointegration tests. As reported by Ong and Sing (2002), the Engel and Granger (1987) cointegration test is one of the most popular approaches in testing for the long-run relationship between two variables. The Phillips-Ouliaris procedure is also widely used to estimate the cointegration between two variables. It does so by estimating both the variance ratio test and the multivariate trace statistic (Phillips & Ouliaris 1990). The Johansen bivariate cointegration test was employed as a robustness check to the results of the these two cointegration tests.

Two house price time series, relative high-priced (P_1) and relative low-priced submarket (P_2) are cointegrated if (i) both time series are I(1) (so the series are stationary on first-differencing) and (ii) there is some linear combination of P_1 and P_2, that is I(0) (i.e. non-stationary). When conditions (i) and (ii) hold, we can conclude that the series P_1 and P_2 are cointegrated and any correlation over time between P_1 and P_2 is not spurious. Two types of cointegration tests are often applied – with trend and without a trend.

$$P_1 = \widehat{P_1} + e_t = \widehat{\alpha_0} + \widehat{\alpha_1} P_2 + \mu_t \quad (25)$$

$$P_1 = \widehat{P_1} + e_t = \widehat{\alpha_0} + \beta_t + \widehat{\alpha_1} P_2 + \mu_t \quad (26)$$

The product of β and t is a time trend. In applying cointegration technique, first we regress P_1 on P_2 as in Equation (25) and Equation (26), then we estimate μ_t as follows:

$$\hat{\mu} = P_1 - \widehat{P_1} \quad (27)$$

We now test the OLS residual for stationarity using ADF regressions. Stationarity in the residuals would imply that the variables, house prices in the high-priced submarket are cointegrated with those in the low-priced submarket. This process is a two-staged cointegration test.

4.2.4.2.3 Granger-causality Test

The cointegration analysis could not show the mechanism that links the two trends. To address this, a Granger causality test was employed. Specifically, once cointegration between the relative high-priced and relative low-priced submarkets is established, a Granger-causality test was employed to examine which submarket leads and which one follows. In other words, the price leader submarket is identified using the Granger causality test. The Granger causality test provides some empirical evidence to support the theoretical explanation of a spillover effect. Specifically, it allows us to assess which of the two hypotheses holds (the second or third hypothesis) from the block of hypothesis four. The test also complements Meen (1999) procedure to establish the existence of spillover effect between these submarkets.

Granger-causality test is based on the framework of a lag model to investigate the influence of house price on each other. Let the high-priced submarket be represented by X and the low-priced submarket by Y with house prices $\mathbf{P_x}$ and $\mathbf{P_y}$ respectively, the test is expressed as follows:

$$P_{xt} = \omega_0 + \omega_1 P_{xt-1} + \ldots\ldots\ldots + \omega_p P_{xt-p} + \delta_1 P_{yt-1} + \ldots\ldots\ldots + \delta_q P_{yt-q} + \varepsilon_t \quad (28)$$

$$P_{yt} = \omega_0 + \omega_1 P_{yt-1} + \ldots\ldots\ldots + \omega_p P_{yt-p} + \delta_1 P_{xt-1} + \ldots\ldots\ldots\ldots + \delta_q P_{xt-q} + \varepsilon_t \quad (29)$$

Granger-causality test is done with a Vector Error Correction (VEC) model[7] that employs the Wald Chi-square test and F test to test the joint hypotheses: $\delta_1 = \delta_2 = \ldots\ldots\ldots \delta_q = 0$ for Equation (28) and Equation (29). In other words, we test the null hypothesis P_y does not Granger-cause P_x in Equation (28) and P_x does not Granger-cause P_y in Equation (29). If P_y is Granger-caused by P_x, it indicates that past house prices in the high-priced submarket contain useful information for predicting house price in the low-priced submarket.

4.2.4.3 Dynamic Ordinary Least Square Model (DOLS)

Lastly, to further elucidate the mechanism of house price movements, the study tested whether the region with a dominant role is more responsive to market fundamentals. As highlighted by Galster and Rothenberg (1991), forces impacting on one submarket would create signals that eventually lead to non-uniform consequences on other submarkets. This is due to the fact that different submarkets respond to market fundamentals at a different magnitude. The dynamic ordinary least square (DOLS) model was employed[8] to address questions relating to whether price shocks or changes in the dominant market result in changes in other regions. That is, is the dominant region more responsive to market fundamentals?

It is hypothesised that the dominant submarket should be more responsive to market fundamentals, and is expected to create price signals for other submarkets. If the dominant role of a submarket can be attributed to its responsiveness to market fundamentals, the DOLS results for the dominant submarket should show that housing price in this submarket can be largely explained by market fundamentals.

The DOLS is a cointegrating estimator (i. e. estimates long run effects) and it is well designed to deal with potential simultaneity bias and small-sample bias among the explanatory variables. This is done by incorporating lagged and lead values of differences of these explanatory variables (Bentzen 2004; Lee & Reed 2014). DOLS model produces only long run coefficients of the explanatory variables to gauge the causal effect of these variables on house price in each submarket. Its appropriateness in this study relates to the existence of a cointegrating relationship among house price and the explanatory variables in each submarket.

[7] As discussed by Engel and Granger (1987), VEC models should be employed if the variables are cointegrated as the dynamic relationship would be mis-specified if a traditional unrestricted Vector Autoregressive (VAR) was employed.

[8] As highlighted by Stock and Watson (1993), the DOLS model is able to deal with potential simultaneity bias and small-sample bias among the explanatory variables. DOLS essentially regresses a first difference variable on other first difference variables, non-stationary variables, and the lags and leads of the first difference variables (Narayan & Narayan 2005).

To determine the impact of market fundamentals on the house prices of the two submarkets of Greater Sydney, the following DOLS model is set out in Equations (30) and (31). Let P_1 represents house price in the high-priced submarket and P_2 is the house price in the low-priced submarket:

$$P_1 = \beta_0 + \beta_1 SFD_t + \beta_2 BLDSTAT_t + \beta_3 POP_t + \beta_4 STKS_t + \sum_{p=-m}^{m}\left(a_{2p}(\Delta SFD_{t+p}\right) + \sum_{p=-1}^{p}\left(a_{3p}(\Delta BLDSTAT_{t+p}\right) + \sum_{p=-1}^{p}\left(a_{4p}(\Delta POP_{t+p}\right) + \sum_{p=-1}^{p}\left(a_{5p}(\Delta STKS_{t+p}\right) + \varepsilon_t \quad (30)$$

$$P_2 = \beta_0 + \beta_1 SFD_t + \beta_2 BLDSTAT_t + \beta_3 POP_t + \beta_4 STKS_t + \sum_{p=-m}^{m}\left(a_{2p}(\Delta SFD_{t+p}\right) + \sum_{p=-1}^{p}\left(a_{3p}(\Delta BLDSTAT_{t+p}\right) + \sum_{p=-1}^{p}\left(a_{4p}(\Delta POP_{t+p}\right) + \sum_{p=-1}^{p}\left(a_{5p}(\Delta STKS_{t+p}\right) + \varepsilon_t \quad (31)$$

where the variables SFD is state final demand, a proxy of the economic performance of the state of NSW. The study hypothesised a positive relationship between house price in the submarket and SFD since favourable economic activities will boost household income and drive housing demand (Worthington & Higgs 2013); BLDSTAT is building starts, representing the commencement of residential buildings. The study expects a positive relationship due to the slow pace of housing supply responding to its demand (Yates 2008); POP is the estimated resident population and it is expected to be a positive relationship as growing population is expected to drive housing demand (Worthington & Higgs 2013); and STKS is the S&P/ASX 300 index, representing the stock market. The study hypothesised a positive relationship between STKS and house price (Lee 2017). The symbol Δ in Equations (30) and (31) represents the inclusion of lagged and lead values of differences of these explanatory variables.

4.3 Development of Hypotheses and Theoretical Framework

The formulation of the hypotheses of the study in section 1.5 is on the back of some theoretical background. Below are the various theories from which these hypotheses were developed.

4.3.1 Development of Hypothesis 1

The study adopted the novel spatial approach for comparing entry-level housing affordability across time and space. This model recognises the view that different regions have different socio-cultural, economic and demographic characteristics (Doney et al. 2013; Baker et al. 2016; Dufty-Jones 2018). As reported by Gibler and Tyvimaa (2014), these characteristics have varying effects on house price, resulting in various levels of housing affordability. Dufty-Jones (2018), for example, found that the sustained growth in house prices in Australia has had

various implications for different geographical areas. In particular, the impact has been higher for metropolitan cities compared with regional cities (Costello 2009). The polarisation of income across regions of Greater Sydney is also well documented (Randolph & Tice 2014). All of these support the view that entry-level affordability is expected to vary across the regions of Greater Sydney.

The study also relates the option-theoretic mortgage pricing model to ongoing affordability. This model considers the current loan-to-value and interest rate variable as important predictors of mortgage payment (Vandell 1995; Deng et al. 2000; Pennington-Cross & Ho 2010). These factors are well situated in the ongoing affordability index in Equation (2). Changes in the mortgage lending rate, for example, will have material effect on mortgage payment (Chen et al. 2010). Because of it link to changes in market fundamentals, Fei (2010) argued that the option-theoretic mortgage pricing model has laid solid theoretical and empirical grounds for assessing mortgages in many housing markets. Further, as income varies across the regions of Greater Sydney (Randolph & Tice 2014), changes in the components of ongoing affordability index such as mortgage lending rate will have varying impact on the ongoing affordability of households across the city. On the background of these two models, the study states the first hypothesis as follows:

Hypothesis 1: There are striking differences in both entry and ongoing housing affordability across the five regions of Greater Sydney

Because of the key differences in key determinants of both entry and ongoing affordability across regions, we expected both forms of affordability to vary across the regions of Greater Sydney.

4.3.2 Development of Hypothesis 2

This study aims to assess how the causal relationship between homeownership affordability and local housing factors varies across different regions by testing the shelter poverty model postulated by Stone (1990). The shelter poverty theory posits a sliding scale of affordability that varies with income, rent, demographics and other socio-economic factors (Stone 2004). The notion of this model is the varying residual income among households (remaining household income after housing expenses). Specifically, the model demonstrates that low-income households with three or more persons can spend less than 25% of their combined income on housing-related expenses but are nonetheless "shelter poor" insofar as their residual income may not be adequate to meet their non-shelter necessities. That is, they have shelter but

remain poor or in poverty – they are "shelter poor". On the other hand, the model shows that high-income households and many small households of middle income can spend more than 25% of their income on housing related expenses, yet are still able to consume non-shelter necessities adequately and are therefore not shelter poor. The model puts emphasises on the sensitivity of income, rent and demographics to the housing affordability of various households (Stone 2004). Considering the socio-economic polarisation in Sydney, this model is well situated for examining local drivers and the magnitude of their effect on the affordability of the different regions of Greater Sydney. The operationalisation of the shelter poverty model in this study relates to the varying sensitivity of households to changes in key housing market variables such as income, rent, house price, demographics and housing supply. The cost to income index (CtI_{Aus}) index in Equation (1) shows that the more sensitive these variables are to this index; the less residual income the household will have. As discussed in section 4.2.1, the cost to income index is an annuity-based formula that relates housing expenses to income. It shows the proportion of income that is spent on housing related expenses and highlights the residual income. This is a measure of Stone's residual income. For example, a big increase in house price will cause a significant decline in affordability, which translates to lower residual income of the household. This upsurge in house price means households will spend more on housing related expenses which reduces their residual incomes. As such, low-income residents will be left with limited income compared with their high-income counterparts (Yates 2008). This mechanics relates Stone's shelter poverty model to the sub-city modelling of affordability in this study.

Therefore, the formulated hypothesis is based on the fundamental idea of the shelter poverty model. Again, the literature pointed out that house price, income and mortgage lending rate are the major factors in constructing an index that measures housing affordability (Muellbauer & Murphy 2008; Yates 2008; de Bandt et al. 2010; Kim & Cho 2010; Brown et al. 2011; Ying et al. 2013). Some of these and other studies have also identified housing supply, rent and population growth as key determinants of affordability (Productivity Commission Report 2004; Yates 2007; Brassil 2010; Chakraborty et al. 2010; Gurran & Whitehead 2011; Ruming et al. 2011; Worthington 2012; Liu & Otto 2017). As the shelter poverty model proposed, these factors are expected to have varying effect on the housing affordability of the different regions of Greater Sydney. Based on this discussion, we formulate the following hypothesis:

Hypothesis 2: The causal effect of local housing variables on homeownership affordability is more significant in the relative low socio-economic regions of the city than the high socio-economic regions.

The study hypothesised that households from relative low socio-economic background are more susceptible to changes in these local factors than those with higher socio-economic status. This suggests that low-income households will have lower residual incomes (remaining income after housing expenses) than high-income families. Kutty (2005) and Yates (2008) also argued that household consumption of non-housing goods and services potentially depends on the proportion of income spent on housing-related expenses. In other words, low-income families have limited household non-shelter expenditure due to their low residual income. Again, in the case of Greater Sydney, this can be attributed to the existing disparity in income between high-income regions (i.e. eastern and northern regions) and low-income regions (i.e. western, inner-west and southern regions) of the city (Randolph & Tice 2014).

4.3.3 Development of Hypothesis 3

Shiller (2007) psychological theory of housing bubbles posits that the notion of a speculative housing bubble can be predicated to a feedback mechanism operating through public observations of price increases and public expectations of future price increases. This feedback is widespread, and often results in social conceptions and ideas that lead to emotional speculative interest in the markets and, therefore, to price increases. This speculative perception further encourages more investment in housing, raising investors' expectations of continuous higher prices. However, the feedback is not perpetual, and when prices do not continue to grow or meet the growing expectation of investors, housing prices may drop sharply, which results in a burst housing bubble.

Shiller (2007) further states that purchasing a house is both a consumption decision and an investment decision. Kohler and Rossiter (2005) also noted the distinction between housing investors (investment motives) and home occupiers (consumption motives). Ioannides and Rosenthal (1994) had earlier provided some empirical evidence to show that the consumption motives are more related to outright homeownership, while the investment motives are driven by income and wealth factors. Lee (2017), unlike other housing markets, also found that a strong positive return-risk relation (an intuitively appealing investment relationship) in the Australian housing markets (an owner occupiers-dominated market), implying owner occupiers are less sensitive to investment motives. This means both groups are determined by

different households' characteristics. The theory of Shiller (2007) ties well with Stiglitz (1990) definition of housing bubble - "if the reason that the price is high today is only because investors believe that the selling price will be high tomorrow - when "fundamental" factors do not seem to justify such a price, then a bubble exists" (Stiglitz 1990, p. 13). These fluctuations in investors' heterogeneous beliefs could speculate a bubble in asset prices (Xiong 2013). As such, speculative behaviour could be more relevant to investors instead of homeowners. This is also supported by Kivedal (2013), who argued that psychological factors can cause housing bubble.

The core of Shiller's (2007) psychological theory can be related to the speculative perceptions of housing investors across the regions of Greater Sydney. As reported by CoreLogic (2016), more investment activities are concentrated in the relative low-income regions of Greater Sydney than the high-income areas of the city. Birrell and Healy (2013) also noted the growing investment activities in the low-income regions of Greater Sydney. This is further supported by the statistics presented in Table 4.2. As can be seen, the low-income regions have a total of 359,216 rented dwellings, representing 64.93 percent of the rental market in Greater Sydney. On the other hand, the high-income regions have a total of 194,605 rented dwellings, which represents 35.1 percent of the city's rental market. These census statistics further reveal the discrepancy in the scope of rental activities between the low-income and high-income regions of Greater Sydney. Furthermore, Yates (2008) found that the deterioration in housing affordability is more obvious in low-income regions such as Western Sydney. This raises the question of whether housing investors and their speculative behaviours lead to the significant deterioration in housing affordability in this region. Consequently, this psychology factor that underpins Shiller's (2007) theory of housing bubble is more evident in the low-income regions since a significant proportion of investors are more active in these areas, adding to an existing greater demand for housing in these regions. In other words, investors will be more sensitive to Shiller's (2007) psychological theory of housing bubble due to the expansive investment activities in these areas.

To provide some empirical evidence for this theory, we scrutinised the relationship between house price and key fundamentals. As asserted by Kivedal (2013) and earlier by Himmelberg et al. (2005), rent is the fundamental value that explains house prices, especially for investment decision.

Table 4.2 Percentage of Rental Properties in Low-Income and High-Income Regions

Region	Number of Rental Properties	Percentage to Greater Sydney
Low-income	359,216	64.93%
High-income	194,605	35.07%
Greater Sydney	553,249	100.00%

Source: Author's construct using 2016 census data from ABS

Girouard et al. (2006) reported that the house price-rent ratio or rental yield provides a good indication of the value of a property. This index is similar to the price-to-dividend ratio in the stock market, and it could be interpreted as the cost of owning versus renting a house. Similar findings were echoed by (Taipalus 2006), who also reported that the price-rent ratio in the housing market is akin to the dividend yield ratio in the stock markets. As house price rapidly rises relative to rent, potential buyers find it more advantageous to rent, which should in turn exert downward pressure on house prices (Girouard et al. 2006). Further, Tumbarello and Wang (2010) reported that sustainable levels can be achieved if incomes and rents grow faster than house prices. The index helps to predict changes in real price of properties (Gallin 2008). This makes the price-rent ratio a suitable index for identifying and date-stamping periods with explosive behaviour (Engsted et al. 2016). Coupled with most investment properties are concentrated in the relative low-income regions and housing investors are more likely to engage in short-term investment or speculate on higher house prices in line with the notion of Shiller's (2007) psychological theory of housing bubbles, the study hypothesised the following:

Hypothesis 3: There is evidence of housing price bubble in the relative low-income regions, while no housing price bubbles are expected in the high-income regions.

The combined application of panel cointegration and BSADF housing bubble test will enable this study to uncover whether there is a housing bubble contagion in the different regions of Greater Sydney The house price-rent-ratio is therefore one of the main theoretical approaches that examines the relationship between house prices and fundamentals (Anundsen 2013). It is a ratio that moves with interest rates, running costs and other elements of the user cost of housing (Fox & Tulip 2014). This makes it an appropriate index for testing the existence of housing bubbles.

4.3.4 Development of Hypothesis 4

As discussed earlier, enormous literature has shown that housing submarket studies offer critical information that is not available at the aggregate level (Bourassa et al. 1999; Chen et al. 2009; Leishman et al. 2013). In addition, Meen (1996) and Adair et al. (2000) asserted that housing market dynamics are better analysed as a series of related submarkets to deal with its complex price behaviour. Because of this complexity, Jones and Leishman (2006) further argued that spillover effects could be greater in local housing markets such as metropolitan cities than in regional or broader geographical housing markets. Waltl (2016) recently reported the dynamics in house price growth within a city during changes in market fundamentals. However, despite these studies, few have examined the linkages between housing submarkets within a metropolitan city.

Even though a number of theoretical models have advanced some propositions about spillover effects, none has provided a clear explanation about the workings of how price linkages actually occur. Previous studies such as Adair et al. (2000), Jones et al. (2003), Jones and Leishman (2006), Hui (2010), Holly et al. (2011), Leishman et al. (2013), Zhang et al. (2017), Awaworyi Churchill et al. (2018), and Yang et al. (2018) have demonstrated the existence of spillover effects in various housing markets. However, these studies do not provide the theoretical explanation of how the spillover effect unfolds. This study departs from previous spillover effect studies by providing some theoretical explanation of how the spillover effect plays out within metropolitan Sydney. Based on the socio-economic polarisation of Greater Sydney (Randolph & Tice 2014), the theoretical models that can explain how spillover effect is transmitted in this city are the equity transfer and migration models.

The equity-transfer model is the diffusion of house price from the relative low-priced submarket to the relative high-priced submarket as a result of a gain in equity through market valuation. The change in house price is first observed in the low-end submarket before spreading to the high-end submarket. Specifically, the spread occurs when households trade up to the more desired submarkets due to a gain in the equity of their current property resulting from favourable economic climate. The change in equity arising from favourable economic conditions is well documented in Waltl (2016). Evidence of such spillover effect was found in the study by Ho et al. (2008). They found that households scale up from the relative low quality submarket to the relative high quality submarket. On the other hand, the migration model asserts that spillover effect occurs when house price spreads from the relative high-priced submarkets to the relative low-priced submarkets through migration. This diffusion pattern, as

described by Jones et al. (2003) and Meen (1999), occurs when households move to areas with relative low price. Ling and Hui (2013), for example, found a flow from city centre to the periphery areas (or high-priced areas to low-end areas) of Hangzhou.

These two models (equity transfer and migration) of spillover effect are linked to prominent urban theories such as the residential mobility theory and the Alonso-Mills-Muth model. The residential mobility theory asserts that households move to improve their housing circumstance and explore economic opportunities (Clark 2017). This urban theory is closely linked with the equity transfer model as households move to more prosperous areas when their equity improves due to market valuation. The Alonso-Mills-Muth, on the other hand, posits that households would relocate to relative low-priced areas, by taking advantage of price differentials, and commute to the high-end submarket (Lai & Tsai 2008). As the relative high-priced submarket in Greater Sydney is largely characterised by higher income and higher socio-economic status (Randolph & Tice 2014), households can potentially trade up to these areas when their equity increases. This urban theory is very connected with the migration model as households relocate to the relative low-priced submarkets in response to changes in the spatial distribution in house prices. On the back of these theories, the study formulates the following hypotheses:

- *Hypothesis 4a: There is empirical evidence to support the notion of spillover effect within Greater Sydney.*
- *Hypothesis 4b: If house prices diffuse from the relative low-priced submarket to the relative high-priced submarket, the equity transfer diffusion pattern is hypothesised.*
- *Hypothesis 4c: If house prices diffuse from the relative high-priced submarket to the relative low-priced submarket, the migration diffusion pattern is hypothesised.*

To sum up, housing submarket studies have strong analytical significance (Leishman et al. 2013). Disaggregating the housing market into submarkets provides better views of housing market dynamics and greater housing policy analysis (Galster 1996). Restricting housing studies to a single metropolitan market can result in less accurate inferences about house price dynamics. Although there is an increasing contention on the existence of a spillover effect amongst housing submarkets within a metropolitan city, the theoretical explanation of this phenomenon is still an open question. Additionally, housing submarket analysis within metropolitan cities is still very limited in Australia despite the economic and social diversity in these cities, particularly Greater Sydney.

4.4 Conclusion of the Chapter

This chapter discussed the data, methods and estimation procedures for addressing each research question, and the theoretical framework for developing the hypotheses of the study. More specifically, the chapter elaborates on the types and sources of the data used in the study, and provides brief descriptions and graphical displays of the trend of the variables used in the study. The key features of the entry-level and ongoing housing affordability indexes employed in the study are also documented in this chapter as well as the parametric t-test and non-parametric Wilcoxon matched-pair signed-rank test to test whether differences in entry-level affordability across regions exist. Further, the chapter discussed the various econometric tools and techniques employed - the system generalised method of moments (SGMM) for estimating the local drivers of housing affordability in each region; the panel cointegration, Westerlund (2007) error correction panel cointegration tests, and the BSADF test to check for housing price bubble; and several cointegration techniques to uncover patterns in home price movements between submarkets in Greater Sydney. Table 4.3 presents a summary of the research questions, data, methodology, and the hypotheses of the study. This array of methods is premised on the existing socio-economic and demographic disparity across Greater Sydney. As most metropolitan cities of Australia are characterised by urban poverty, locational disadvantage, and socio-economic disadvantage (Hulse et al. 2014), this approach can be extended to other Australian capital city markets to examine housing affordability and house price analysis at disaggregated level. The adoption of this methodology will inform housing policies that seek to address socio-economic imbalances within these cities.

Table 4.3: Summary of Research Questions, Data, Methodology and Expected Results

Research Question	Data	Methodology	Expected Results
RQ1: What are the levels of entry and ongoing housing affordability in each region of Greater Sydney?	House price and rent from NSW Department of Housing Average total income per LGA from the Australian Bureau of Statistics (ABS)	Cost-to-income index	Hypothesis 1: There are striking differences in both entry and ongoing housing affordability across the five regions of Greater Sydney
RQ2: What are the local drivers of homeownership affordability in each region of Greater Sydney?	Resident population, housing supply, average total income from ABS House price and rent from NSW Department of Housing	System generalised method of moments (SGMM) Westerlund (2007) Panel cointegration and Panel Error Correction Model (ECM)	Hypothesis 2: The causal effect of local housing variables on homeownership affordability is more significant in the relative low socio-economic regions of the city than the high socio-economic regions.
RQ3: Have the regions of Greater Sydney experienced any housing bubble contagion?	House price and rent from NSW Department of Housing Average total income per LGA from ABS	Westerlund (2007) Panel Cointegration Backward Supremum Augmented Dickey Fuller (BSADF)	Hypothesis 3: There is evidence of housing price bubble in the relative low-income regions, while no housing price bubbles are expected in the high-income regions.
RQ4: Are the housing submarkets of Greater Sydney integrated in house price?	House price from ABS State final demand, building starts, and resident population from ABS Australian S&P/ASX 300 from Thomson Reuters Eikon	Meen's (1999) Constancy Ratio Cointegration Techniques	Hypothesis 4a: There is empirical evidence to support the notion of spillover effect within Greater Sydney. Hypothesis 4b: If house prices diffuse from the relative low-priced submarket to the relative high-priced submarket, the equity transfer diffusion pattern is hypothesised. Hypothesis 4c: If house prices diffuse from the relative high-priced submarket to the relative low-priced submarket, the migration diffusion pattern is hypothesised.

CHAPTER 5

HOUSING AFFORDABILITY IN THE REGIONS OF GREATER SYDNEY

5.1 General Analysis of Housing Affordability in the Regions of Greater Sydney

As discussed in section 4.3.1, this paper adopted a novel spatial approach for comparing housing affordability across time and space. In this study, a spatial approach is used in the context of housing affordability in the different LGAs across Sydney from 1991 to 2016. The study is clearly a departure from previous research as it comparatively examines housing affordability in the regions that makeup Greater Sydney. Specifically, the study investigates whether entry and ongoing housing affordability differs across the five regions of Greater Sydney – western, inner-west, southern, eastern, and northern regions; and highlights the magnitude of the differences in housing affordability across these regions.

As discussed earlier, the study examined the spatial distribution of both entry-level and ongoing housing affordability across these five regions of Greater Sydney. By examining both forms of affordability among cohorts of entrants in the different regions, the study seeks to provide an enhanced understanding of housing affordability in Australia's most populous and socio-economically diverse city, namely Greater Sydney. Recognising the increasing geographical complexity that emerges from spatial polarisation, this study focuses on housing affordability for local populations in their own local areas. It also explores changes in affordability over time for the different regions across Greater Sydney. From a geographical point of view, this study provides a detailed examination of housing affordability within LGAs of similar socio-economic characteristics that form regions within metropolitan Sydney.

The study considers enclaves of high-and low-income earners, combined with other socio-economic dynamics that make up Greater Sydney. This is premised on the fact that Greater Sydney is moving towards a socially imbalanced city with growing income polarisation that could have adverse effects on its local economy (Irvine 2017).

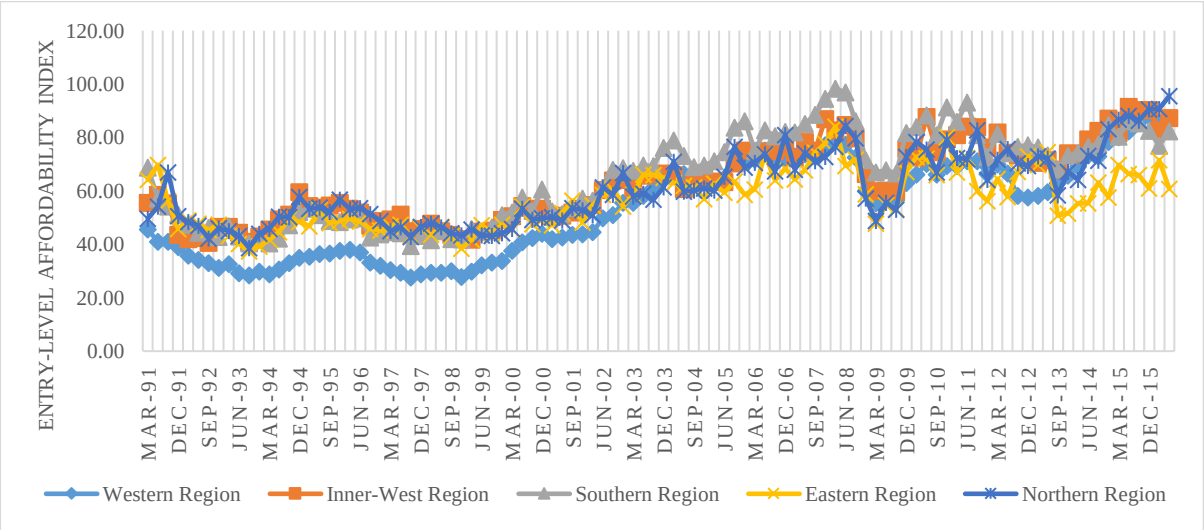
5.1.1 Entry-Level Housing Affordability Index in the Regions of Greater Sydney

To provide an indication of housing affordability across regions of Greater Sydney, the entry level housing affordability index is firstly presented. Figure 5.1 generally demonstrates a steady increase in entry level housing affordability index for all cohort of entrants in the different regions across Greater Sydney, indicating a gradual decline in housing affordability over the study period. An increase in the index value is interpreted as a deterioration of entry-level housing affordability and vice versa. This result is consistent with the findings of Angus (2017)

and Worthington (2012), who also found a deterioration in housing affordability across Greater Sydney in recent years.

More importantly, Figure 5.1 shows that entry-level housing affordability has declined in different magnitudes across different regions. This suggests that different regions have different entry levels of housing affordability. Notably, a significant difference in entry-level affordability exists between Western Sydney and the other regions of Greater Sydney between 1991 and 1999. During this period, housing was relatively affordable in Western Sydney and there were moderate differences in the entry-level affordability index among the remaining regions of the city.

Figure 5.1: Entry-Level Housing Affordability of the Regions of Greater Sydney



Source: (ABS 2019; NSW Department of Housing 2019)

Specifically, the entry-level housing affordability index for the western region fluctuated within an index value ranging from 30 points to 45 points over this study period, whilst other regions, particularly the eastern region, recorded a range of around 40 points to 70 points. This suggests that housing was relatively affordable in Western Sydney during this period. In addition, there was little difference in terms of entry-level affordability among other regions. The western region had relatively low house prices throughout this period, which attracted low-income households to settle in the region. As a result, Western Sydney became the first port of call for new arrivals, immigrants and refugees (WSROC 2014). The region has also been a settlement attraction for lower income immigrants due to the introduction of apartments and cottages on relatively low-cost land (Burnley 2005). Western Sydney is therefore a highly culturally diverse region, and historical entry-level housing affordability in the region has

contributed to this diversity. The results confirm our preceding argument of clear disparity across the different regions of Greater Sydney.

Despite being relatively affordable in the 1990s, Western Sydney is characterised by several socio-economic disadvantages, including the lowest median weekly household income and the lowest annualised income growth rate from 1991 to 2016 (ABS 2016a) combined with a relatively high rate of unemployment (DoE 2016) as shown in Table 2.5. Average annual income spanning 1990/91 to 2015/16, for example, grew at 1.29 percent for residents in Western Sydney, while the annual income of residents in the eastern and northern regions of the city grew at 3.95 and 2.59 percent respectively (ABS 2016a). These socio-economic disadvantages were previously highlighted by Baum (2004), who reported that clusters of socio-economic suburbs are located in Western Sydney and the region is marred by several measures of deprivation such as low-incomes, high unemployment, and heavy reliance on public housing.

However, entry-level affordability has declined since 2000 in all regions. These results are in line with the findings of Gan and Hill (2009), although the magnitude of the differences in affordability has widened across all regions. For instance, the entry-level housing affordability for the western region declined sharply from an index value of 40 points in 2000 to almost 80 points in 2007, representing a change of almost 100 percent over this period (an increase of the index is interpreted as a deterioration of housing affordability). Although the eastern and northern regions also recorded a deterioration of housing affordability, in which the index rose from 54 points in 2000 to 77 points in 2007 and from 53 points in 2000 to 72 points in 2007 respectively, these regions did not decline to the extent of the western region. Apparently, the deterioration of housing affordability was most obvious in Western Sydney, making it no longer the most affordable region from September 2003 to 2008. The decline in affordability in Western Sydney was certainly caused by the low growth rate of income and strong growth of house prices and mortgage lending rates. The decline could also be explained by the introduction of new federal government policy after 1996 that restricts unemployment benefits for new arrivals only to refugees and allows persons other than refugee migrants to qualify for such benefits after two years (Burnley 2005). With difficulty and the inability to speak English, this cohort in general has lower incomes; resulting in households in Western Sydney spending as much as 60 percent of income on housing related expenses (Ley et al. 2000). Given that Western Sydney is socially relatively disadvantaged, changes in housing affordability have a profound impact on households in the region. This again supports our earlier discussion of the

clear difference between different regions in Sydney, highlighting the importance of a disaggregated analysis for housing affordability. On the other hand, a less significant deterioration was observed in the eastern and northern regions of the city. This can be attributed to income growth for households in these regions, which help to cushion the impact of declining affordability.

Nevertheless, a slight improvement of housing affordability in all regions was observed during the global financial crisis. This can be attributed to the implementation of the First Homebuyers Boost (the Boost) between 2008 and 2009. This is highlighted by Lee and Reed (2014), who found that the Boost did enhance housing affordability for first homebuyers. Importantly, Randolph et al. (2013) highlighted that the Western Sydney region accounted for the highest proportion of Boost receipts. Therefore, an improvement of housing affordability in all regions was documented during this period, particularly in Western Sydney (the index improved from 79 points in 2008 to 55 points in 2009). Similarly, all other regions experienced significant improvement in affordability during this period, particularly the southern region (from 98 points in 2008 to 66 points in 2009). However, a deterioration of housing affordability in all regions was also identified after Boost period, with different magnitudes. The western region recorded the highest deterioration of housing affordability (10 points), while the eastern region experienced the lowest deterioration of housing affordability by 1 point. In addition, as shown in Figure 5.1, between 2013 and 2016, the deterioration of housing affordability in the western region is more critical comparing with the eastern region of the city. This again could be explained by income growth disparities between these regions.

To sum up, the results of entry-level affordability clearly show some discrepancies across regions. To further investigate whether the differences in entry-level housing affordability across regions are statistically significant, we employed both the parametric t-test and non-parametric Wilcoxon matched-pairs signed-ranks test. The results of these tests are shown in Table 5.1. Both tests can address group differences. However, the key difference is the Wilcoxon Matched-Pairs Signed Ranks Test is often used for data that are generally considered as being non-parametric and therefore pays more attention to the median, whereas the Student's t-Test for Matched Pairs is generally used for data that are viewed as parametric distributions and with great emphasis on the mean (MacFarland & Yates 2016).

Table 5.1: Parametric and Non-Parametric Tests of Entry-Level Housing Affordability

Region	T-Statistic	Non-Parametric (Z-Score)
Western and Inner-West	-15.62***	-8.50***
Western and Eastern	-2.94**	-3.10***
Western and Northern	-9.68***	-7.01***
Western and Southern	-21.39***	-8.62***
Inner-West and Eastern	7.52***	6.68***
Inner-West and Northern	4.29***	4.04***
Inner-West and Southern	-3.65***	-3.14***
Eastern and Northern	-5.05***	-4.80***
Eastern and Southern	-9.67***	-7.23***
Northern and Southern	-5.32***	-4.57***

Testing the null hypothesis of no variation in housing affordability between regions. *** indicates rejecting the tested hypothesis at the 1% significance level; and ** rejects the tested hypothesis at the 5% significance level. A rejection of the null hypothesis suggests there is a significant statistical difference in housing affordability levels between regions over the study period.

The results show that the differences in entry-level housing affordability across all regions of Greater Sydney are indeed significant at the 1 percent significance level, which further reinforces our earlier argument on the existing disparities in housing affordability of Greater Sydney. Despite being in the same metropolitan city, it shows that different households have experienced different levels of affordability. The findings are also consistent with the Productivity Commission Report (2004), which noted that differences do occur in housing affordability even though house price increases tend to flow across market segments. The disparities in housing affordability for Greater Sydney can be attributed to the increase in socio-economic segregation between rich and poor, which is typically represented across locations within metropolitan areas. As can be seen from Table 5.1, housing affordability in less prosperous areas such as the western region is statistically significant different from affluent regions (e.g. the eastern and northern regions). These results are also consistent with the findings of Healey (2016), who reported that income disparity is widening the gap in housing affordability between high-income earners and those on low and middle incomes.

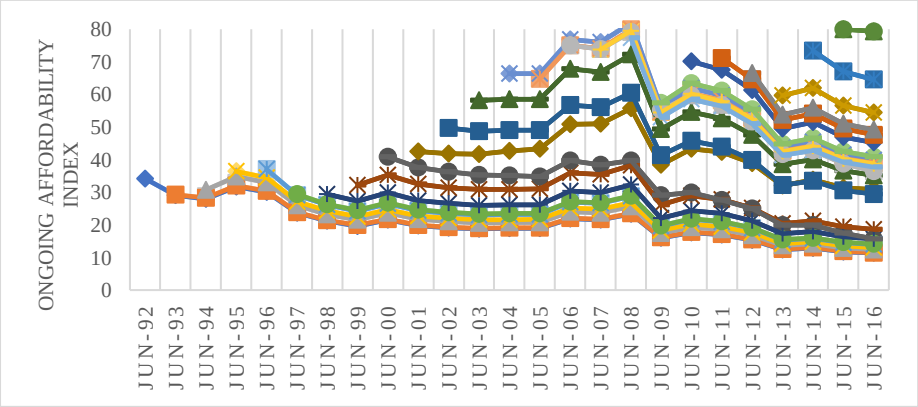
Overall, the study finds that entry-level housing remains extremely unaffordable in all regions of Greater Sydney, although the level of unaffordability varies across regions. Specifically, the deterioration of housing affordability is more obvious in low-income regions such as Western Sydney.

5.1.2 Ongoing Housing Affordability Index in the Regions of Greater Sydney

To offer an enhanced understanding of housing affordability, this study introduced a dynamic element into the measure of affordability. This section discusses a household's level of affordability after entry to the market. Ongoing affordability has some significant implications on the welfare of homebuyers, as the consumption basket of other goods and services potentially depends on the proportion of income spent on housing related expenses. The ongoing housing affordability levels of different regions are depicted in Figure 5.2(a-e).

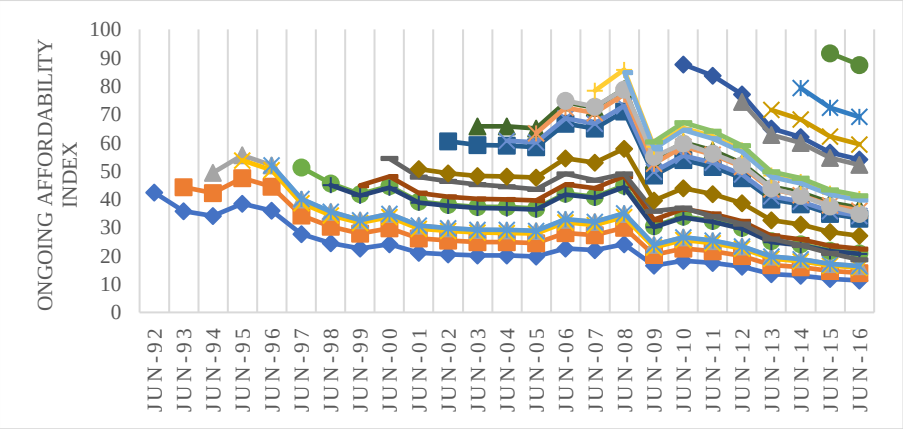
Figure 5.2: Ongoing Affordability Index of the Regions of Greater Sydney (a-e)

Figure 5.2a: Ongoing Affordability Index of Western Sydney Region



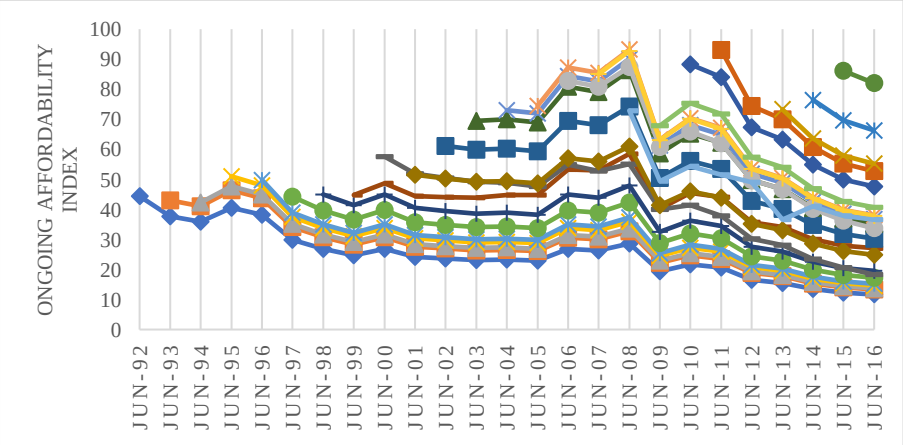
Source: (ABS 2019; NSW Department of Housing 2019)

Figure 5.2b: Ongoing Affordability Index of Inner-west Sydney Region



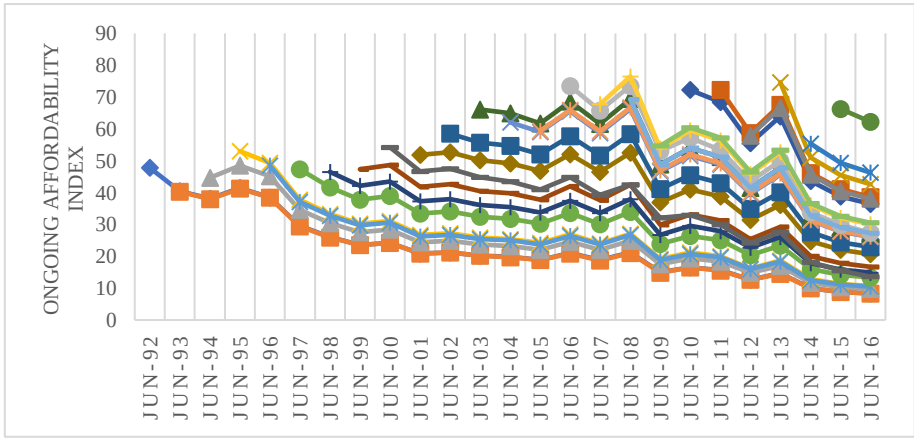
Source: (ABS 2019; NSW Department of Housing 2019)

Figure 5.2c: Ongoing Affordability Index of Southern Sydney Region



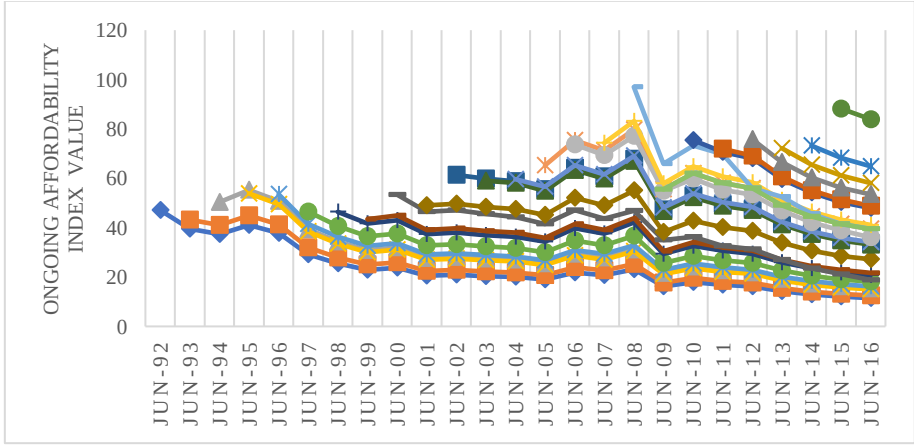
Source: (ABS 2019; NSW Department of Housing 2019)

Figure 5.2d: Ongoing Affordability Index of Eastern Sydney Region



Source: (ABS 2019; NSW Department of Housing 2019)

Figure 5.2e: Ongoing Affordability Index of Northern Sydney Region



Source: (ABS 2019; NSW Department of Housing 2019)

As can be seen from Figure 5.2 (a-e), ongoing affordability in all five regions of Greater Sydney generally fluctuates in the first five years of entry into the housing market but improves continuously over time. Ongoing housing affordability stress in all regions improves significantly from the tenth year after entering and continuously staying in the market. For instance, ongoing housing affordability in the eastern region for the cohorts who entered the market in 1992 had improved significantly from an index value of 47 points in 1992 to around 21 points in 2002, and then further improvement to 8.3 points by 2016. Similar evidence is also observed for different regions and different entry years. This shows a continuous improvement in ongoing housing affordability over time.

To highlight the divergences between different regions, the discussion of the ongoing housing affordability indices focusses on four different phases, reflecting changes in major government policies and economic events. These four phases are: (i) prior to the introduction of the GST (1990- 1999); (ii) prior to the global financial crisis (2000-2007); (iii) the era of the Boost (2008-2009); and (iv) the post-Boost era (2009-2016).

In phase one, ongoing housing affordability does improve moderately for all cohorts in the different regions. Despite relatively high mortgage lending rates during this phase, the improvement in the ongoing affordability index in Western Sydney exceeded the other regions. Specifically, the ongoing housing affordability index value dropped from 34 points in 1992 to 19 points in 1999 (a drop in the index suggests an improvement in housing affordability). This can be attributed to the relatively low house prices in Western Sydney during this phase. In addition, the income disparities between Western Sydney and the other regions during this period were relatively smaller compared with other phases of the study period. Therefore, it is reasonable to find an enhanced ongoing housing affordability in Western Sydney during this period. Importantly, five years after entry into the housing market, a substantial improvement rate of 34 percent on average in ongoing affordability was evident in all regions. The improvement in housing affordability suggests an increment in residual income (income after housing expenses), thereby reducing the tendency for housing-induced poverty especially among low-income households (Chen et al. 2010).

Phase two presents a different scenario. Even though ongoing affordability slightly improves in most regions in the first five years of entry and up to the tenth year onwards, an average improvement of 18 percent in housing affordability during the first five years was observed in this phase. The improvement rate is comparatively below the rate of improvement in phase one. Importantly, the ongoing housing affordability in Western Sydney deteriorated

significantly during this period. This result can be explained by the growing income disparity between Western Sydney and the other regions during this phase.

More importantly, households in Western Sydney who entered the housing market after 2000 experienced housing stress for almost ten years, whilst those in the eastern and northern regions had a slight improvement in their affordability five years after their entry to the market. This can be explained by the income disparities across regions. This result also provides some indirect empirical evidence to the findings of Berry (2003), in which a significant deterioration of housing affordability for low-income households was reported. Due to the growing income disparity across these regions, ongoing affordability differs significantly, particularly between a low-income region such as Western Sydney region and higher-income regions (i.e. eastern and northern regions). The result has had an adverse effect on low-income households by heightening the propensity for housing-induced poverty in lower income regions such as Western Sydney (Yates 2008).

In the era of the Boost between 2008 and 2009 (the third phase in this discussion), ongoing housing affordability markedly improved in all regions due to the significant decrease in mortgage lending rates. In fact, this was the most obvious improvement in terms of ongoing affordability in all regions of Greater Sydney. Specifically, an improvement of 32 percent was evident during this period. This also indicates that mortgage lending rates have a significant impact on ongoing housing affordability. Even though other factors such as average personal income, tax policies and housing policies do have an effect on ongoing affordability, the substantial decline in mortgage lending rates from 9.45 percent in June 2008 to 5.80 percent in June 2009 improved ongoing affordability in all regions of Greater Sydney significantly. This reflects the findings of Chen et al. (2010), who reported that a sharp decline in mortgage lending rate alone could materially lower the burden of payments. However, ongoing affordability in all regions deteriorated again during the post-Boost era. This can be linked to an increase in interest rates, again reflecting the role of mortgage rates on ongoing housing affordability. However, a slight improvement was observed in all regions entering the fourth phase to 2016.

In phase four, ongoing affordability marginally improved in all regions in the first five years of entry into the market due to the steady rate of decline in the mortgage lending rate. Nonetheless, the rate of improvement in housing affordability in this phase (12 percent) is far below the rate of improvement in all preceding phases. Furthermore, income disparities across regions were widening in this phase, as income levels of residents in the eastern and northern regions grew faster than those in low-income regions such as Western Sydney. Relatively high

house prices also exacerbated ongoing housing affordability in this phase. This trend might have some critical implications, in which residents in Western Sydney will be priced out with further deterioration in housing affordability as those with higher incomes in other regions may tend to move to relatively affordable areas (Dowling & Mee 2000). Any sustained deterioration in housing affordability will heighten the already overwhelming housing stress among residents in this region.

In general, differential geography of ongoing affordability was evident. Using the threshold of affordable housing index value of 30, the results indicate that residents in low-income regions take a longer period to reach this threshold than residents in high-income regions. This situation has the potential to generate housing-induced poverty especially for residents in low-income regions. The trend of ongoing affordability is likely to affect the consumption and welfare of households especially those from low-income regions. As a result, households in low-income regions such as Western Sydney are likely to be confronted with housing-induced poverty, which has a significant impact on non-housing consumption. This highlights the importance of sub-city level housing affordability studies. These results have provided important tools and evidence for a more informed and integrated policy approach to address the issues raised.

In short, the ongoing housing affordability of those who have entered the market improves considerably within five to ten-years, although there remains a differential geography of housing affordability, as shown by residents in low-income regions such as Western Sydney taking a longer period to improve their ongoing housing affordability.

5.2 Region-Specific Analysis of Housing Affordability

The sustained decline in housing affordability in Australia has had diverse implications for different geographical areas (Dufty-Jones 2018). Specifically, the impact has been higher for metropolitan cities compared with regional cities (Costello 2009). There is particularly the case with Greater Sydney, where previous studies have recorded glaring socio-economic polarisation in the city (Randolph & Holloway 2005b; Randolph & Tice 2014). Such spatial polarisation and social disadvantage have been widely discussed in the geographic literature (Doney et al. 2013; Baker et al. 2016).

Therefore, in addition to the previous discussion of both entry-level and ongoing affordability across the different regions, the study expanded the analysis by quantitatively describing the main features of the results of each region displayed in Figure 5.1. Specifically, the study highlights some descriptive statistics of the entry-level and ongoing affordability index values

of the different regions of Greater Sydney over 1991-2016. An examination of region specific results reveals some important features of affordability across the various regions of Greater Sydney. These descriptive statistics are reported in Table 5.2.

Table 5.2: Descriptive Statistics of Entry-Level Affordability Index

Statistics	Western	Inner-west	Southern	Eastern	Northern
Mean	53.59	63.14	65.23	56.89	61.05
Median	57.03	62.24	68.35	56.29	58.39
Mode	69.41	61.11	40.40	55.44	59.22
Standard Deviation	18.20	14.61	16.77	10.70	13.77
Minimum	27.62	40.67	39.36	37.35	38.65
Maximum	88.07	91.61	98.26	84.17	95.58

Source: (ABS 2019; NSW Department of Housing 2019)

5.2.1 Region Specific Entry-Level Housing Affordability

5.2.1.1 Western Sydney Region

Western Sydney region experienced relatively low housing affordability index values between September 1991 and September 1999. Entry-level housing affordability during this period was much better than all other periods. Specifically, the region constantly maintained an index that is below the 30-point thresholds between June 1997 and March 1999, which is the most affordable period in the region over the study period 1991-2016. This can be attributed to the moderate growth in house price in the region from 1991 to 1999 and the decline in mortgage lending rate from 7.2 in the quarter of June 1997 to 6.5 in the March quarter of 1999. As shown in Figure 5.1, the region experienced its lowest entry-level housing affordability index in the quarter of September 1997 (i.e. an index value of 27) and its highest index value in the quarter of December 2015 (i.e. an index of 88). From the quarter of March 2000, the index increased continuously until the year before the global financial crisis in 2008. As discussed earlier, the increase in house price from the year 2000 to 2008 far exceeded house price growth from 1991 to 1999. In addition, the mortgage lending rate also increased from 7.3 in March 2000 to 9.35 in March 2008. The affordability index values improved during the era of the Boost. However, these values were below the 1991-1999 index values. From March 2010, the index continuously rises reaching 88 points in December 2015.

The results in Table 5.2 indicated that entry-level housing affordability index in Western Sydney region ranged from 25 points to 88 points over the study period. The region also has the highest standard deviation of 18 points and the highest modal index value of 69 points. Despite being the region with the lowest income level (ABS 2016a), the highest unemployment (DoE 2016), and the largest population (ABS 2016c), the results suggest that residents in Western Sydney are expected to experience more changes (often upwards) in their affordability level than all the other regions of Greater Sydney. The results also indicated that residents in the region will continue to expend more than 30 percent of their individual income in housing related expenses. In fact, as revealed by the modal index value, it is likely that their housing related expenses will double as they enter the market. This is particularly the case after the elimination of the First Home Owner Boost in 2010. This again highlights the relative socio-economic disadvantages that characterise Western Sydney as highlighted by Mee (2002), Baum (2004) and Randolph and Tice (2014).

5.2.1.2 Inner-West Sydney Region

Similar to the Western Sydney region, entry-level affordability index is lower from 1991 to 1999 than the remaining period under review. In particular, the region experienced its most affordable period from December 1991 to March 1994. From Table 5.2 the lowest entry-level housing affordability index value in the inner-west Sydney region was in the quarter of September 1992 (i.e. an index value of 40) and its highest index value in the quarter of June 2015 (i.e. an index of 91). The index value started to increase from 2000 until 2008. The sustained increase in house prices during this period, coupled with the introduction of the GST in 2000 largely contributed to this steady decline in affordability in the region. The index value significantly improves during the Boost declining from 84 points in June 2008 to 59 points in September 2009. Beyond 2009, the index value picks up to reach 91 points in June 2015.

From Table 5.2, it is clear that the index values are closer to being normally distributed. This indicates that housing affordability in the inner-west region is relatively stable compared with the western and southern region. The region experienced less fluctuations throughout the study period. With a standard deviation of 14 points, it indicates that the value index in this region is less volatile compared with the western and southern regions. However, the modal index value in the region is around 61 points, suggesting that housing expenditure of residents in this region is likely to double the 30-point thresholds when they enter the market.

5.2.1.3 Southern Sydney Region

Similar to other relatively low-income regions, the southern region experienced relative affordability spanning 1991 to 1999. Housing was most affordable in the southern region from March 1991 to June 1994. Specifically, the region has its most affordable period in March 1994 with an index of 39 points and its least affordability in March 2008 with an index of 98 points. This means the index value in the region swings between 39 points and 98 points inclusive over 199-2016. From Figure 5.1, it is clear that the southern region is the least affordable region in Greater Sydney from the year 2000 to the period before the global financial crisis. Even though affordability improves during the Boost in the southern region, its level of affordability was even higher than the level of the high-income eastern and northern region. In fact, the southern region was the least affordable from 2000 to 2013. Similar to other regions, the affordability index value rises after the Boost.

The index value in the southern was the second most volatile region as revealed by its standard deviation of almost 17 points. It swings around a range of 59 points, indicating the level of index change that residents in the region are likely to experience. This is further explained by the fact that the index values in the region are short of being normally distributed. In addition, looking at the average index over the study period, residents in the region are also likely to double the 30-point thresholds as they enter the housing market.

5.2.1.2 Eastern Sydney Region

The eastern region is generally classified a high-priced region as the difference in median house price between June 1991 and June 2016 is almost one million dollars. This house price range is only similar to the northern region of the city. The most affordable period of the region is from 1991 to 1995. The increase in house price during this period is moderate when compared with the increase from the year 2000 to 2016. In addition, this region has the highest average personal income (ABS 2016a), and the highest annualised income growth (ABS 2016a) rate over the study period, which contributed to the improvement in the region's affordability. The most affordable period is September 1993 with an index of 37 points and the least affordable is March 2008 with an index of 84 points. Affordability in the region deteriorates from June 2000, increasing from an index of 54 points to 84 points in the quarter just before the global financial crisis. The affordability index improves during the Boost and the post Boost era saw an upward trend of the index.

The index values of the eastern region are almost normally distributed with an average, median and modal index of around 56 points. With a standard deviation of 10 points, the deviation from the expected index is relatively low in this region compared with the relatively low-income western, inner-west and southern regions. This means affordability is more stable in this high-income eastern region. Even though the housing expenses of residents in this region are above the 30-point thresholds throughout the study period, the results in Table 5.2 show there are greater chances that their expenses will not double the threshold after entering the housing market. This suggests that residents in the eastern region are expected to reach the 30-point threshold before those in the relatively low-income regions.

5.2.1.2 Northern Sydney Region

The entry-level affordability trend in the northern region is similar to the pattern of the eastern region. The northern region is another high-priced region with its median house price rising from AUS$225,000 in March 1991 to AUS$1,391,000 in June 2016, representing an annualised increase of 7.5 percent. The region's most affordable period is between March 1993 and March 1994. Again, house prices in the region had modest increase during this period and the mortgage lending rate also drop from 10 in March 1993 to 8.75 in March 1994. The most affordable quarter is September 1993 with an index of 38 points and the least affordable period is June 2016 with an index of 95 points. After 1994, the region experienced a gradual increase in its affordability index value. In 1996, the affordability improved and later followed the trend of the eastern region. Even though affordability improves during the Boost, the region was the least affordable during this period. Affordability continues to deteriorate after the era of the Boost.

The index values are close to being normally distributed around a central tendency of 60 points. With a standard deviation of 13 points, the deviation from the expected index in the northern region is relatively low compared with the western region with 18 points, inner-west region with 14 points, and the southern region with 16 points. There is also more stability in the affordability of the high-income northern region. The results in Table 5.2 indicate that, despite being above the 30-point thresholds throughout the study period, residents in the region have higher chance of reaching the 30-point thresholds before those in the relatively low-income. regions.

In summary, the highlights of the region-specific entry-level affordability are: affordability is better in the 1990s than any other period due to the modest increase in house prices; volatility

of the index is higher in the relatively low-income regions than the high-income regions. This means affordability is less stable in the low-income regions and more stable in the high-income regions; and finally, residents in the high-income regions have greater chances of reaching the 30-points threshold after entering the housing market than those in the low-income regions.

5.2.2 Region Specific Ongoing Housing Affordability

The study extended the analysis by looking into the trend of affordability in each region after entering the housing market. This is validated by the clear socio-economic and demographic disparities across the regions of Greater Sydney demonstrated in Table 2.5. As discussed earlier, ongoing affordability has profound implications on the welfare of homebuyers since the consumption bundle of other household goods and services potentially depends on the proportion of income spent on housing related expenses. In other words, as asserted by Yates (2008), and Kutty (2005), household consumption of other goods and services depends on their residual income (the income after housing expenses).

5.2.2.1 Ongoing Affordability in Western Sydney Region

There is a general decline in ongoing affordability in the region over 1991-2016. Specifically, there is a significant improvement in affordability for entrants in the years spanning 1996 to 2004. For example, the index of homebuyers who entered in June 1996 declined from 37 points to 23 points in June 2004. A similar declining trend in the index value was shown for entrants from 1997 to 1999. However, the index did not improve immediately for entrants from June 2005 to the year before the global financial crisis. For example, the ongoing index of households who entered the market in the year 2006 increased from 75 points to 79 points in June 2008. This can be attributed to the rise in mortgage lending rate from 7.55 in June 2006 to 9.45 in June 2008. Ongoing index improved for all entrants in the era of the Boost. The index of households who entered the market in June 2008 dropped from 77 points to 52 points in June 2009. The index was even lower for those who entered the market before the Boost. The decline in the index during the Boost is highly attributed to the sharp reduction in the mortgage lending rate from 9.45 in June 2008 to 5.80 in June 2009. The relative stability in house prices during this period also contributed to the decline in the index value. With the elimination of the Boost, the index value takes an upward trend continuously.

In addition, homebuyers who entered the market before the year 2000 take an average of less than 5 years to reach the 30-point thresholds, while those who entered the market in later years take an average of more than 10 years to reach the threshold. An important caveat from these

results is that households in this region take a longer time to reach the 30-points threshold than those in the high-income eastern and northern regions. For example, entrants of June 2009 in the western region take seven years to lower the index to 40 points, while those in the eastern region who entered the market in the same year takes seven years to reach the 30-point thresholds.

5.2.2.2 Ongoing Affordability in Inner-west Sydney Region

Ongoing affordability largely declined in the region for the period under review. This is particularly the case for households who entered the housing market from the year 1996 to 2005. For example, the index of households who entered the market in June 1996 dropped from 52 points to 28 points in June 2005. Similar trends were observed for households who got into the market from the year 1997 to 1999. This declining trend in ongoing affordability can be linked to the relative low house prices and mortgage lending rate as well as the steady rise in incomes during this period. Households who entered the market after 2005 until the year before the global financial crisis did not experience an immediate decline in affordability. For example, the index of entrants in the year 2006 increased from 74 points to 78 points in June 2008. This can be due to the rise in mortgage lending rate from 7.3 in June 2005 to 9.45 in June 2008, which increased the burden of payment on homebuyers. The ongoing index improved for all entrants in the era of the Boost and it was much lower for those who entered the market before the Boost. The decline in the index during the Boost is highly attributed to the decline in the mortgage lending rate and the relative stability in house prices during this period.

Furthermore, households who got into the market before the year 2000 take an average of 5 years to reach the 30-point thresholds, while those who entered in later years take an average of more than 10 years to reach the thresholds. When compared to the high-income eastern and northern regions, households in this region take lengthier time to reach the 30-points threshold. For example, entrants of June 2009 in the inner-west region take seven years to reduce the index to 41 points, while those in the eastern region, who entered the market in the same year take 7 years to reach the 30-points thresholds.

5.2.2.3 Ongoing Affordability in Southern Sydney Region

There is a general decline in the ongoing affordability index of the southern region over 1991-2016. The improvement in ongoing affordability is more glaring for entrants in the decade 1995 to 2004. The index of homebuyers who entered in June 1995, for example, declined from 51 to 29 in June 2004. The ongoing index of those who entered from 1996 to 2004 followed a similar

declining trend in index values. However, there is no immediate improvement in the index of homebuyers who entered the market from 2005 to the year before the global financial crisis. In fact, the index increased significantly for some entrants during this period. The non-improvement of the index was certainly caused by the rise in mortgage lending rate from 7.3 in June 2005 to 9.45 in June 2008. Similar to other relatively low-income regions, ongoing index improved for all entrants in the era of the Boost. Further, homebuyers who entered the market before the Boost experienced a significant improvement in their index during the Boost. Again, this decline in the index during the Boost can be linked to the decline in the mortgage lending rate and the relative stability in house prices during this period.

Comparatively, homebuyers who entered the market before the year 2000 take an average of 5 years to reach the 30-point thresholds. On the other hand, households who entered the market in later years take an average of 12 years to reach the threshold. In addition, households in this region take a longer time to reach the 30-point thresholds than those in the high-income eastern and northern regions of the city. Entrants of June 2009 in the southern region, for example, take 7 years on average to lower the index to 40 points, while those in the eastern region who entered the market in the same year take 7 years to reach the 30-point thresholds.

5.2.2.4 Ongoing Affordability in Eastern Sydney Region

An obvious declining trend in ongoing affordability was recorded in the eastern region over 1991-2016. In particular, there is a steady and significant improvement in ongoing affordability for entrants in the years spanning 1995 to 2004. For example, the index of households who entered the market in June 1995 declined from 53 points to 25 points in June 2004. The ongoing affordability of entrants from 1996 to 2004 had similar declining trends in their index values. Unlike the relative low-income regions, residents in the eastern region experienced marginal improvement in their ongoing index from 2005 to the year before the global financial crisis. The considerable improvement in the personal income of residents in the region helped to cushion the impact of the rise in mortgage lending rate during this period. Furthermore, the ongoing index markedly improved for all entrants in the era of the Boost. The improvement during the Boost is more glaring for those who entered the market before the Boost. The decline in the index during the Boost is attributed to the decline in the mortgage lending rate and the relative stability in house prices during this period.

However, homebuyers who entered the market before the year 2000 take a shorter period (an average of 5 years) to reach the 30-point thresholds than those who entered in later years (they

take more than 5 years). More importantly, households in this region generally take a shorter period to reach the 30-points threshold than those in the relatively low-income western, inner-west and southern regions. For example, entrants of June 2009 in the eastern region take 7 years to reach the 30-point threshold, while those in the relatively low-income regions who entered the market in the same year take more than 7 years to lower the index to at least 40 points. This highlights the role of income in improving ongoing affordability.

5.2.2.5 Ongoing Affordability in Northern Sydney Region

There is a continuous improvement in the ongoing affordability in the region over 1991-2016. Specifically, there is a steady decline in the index for the entrants in the years spanning 1992 to 2004. For example, the index of households who entered in June 1995 declined from 53 points to 26 points in June 2004. This is identical to the eastern region. Ongoing affordability of entrants from 1996 to 2004 experienced similar declining trends in their index values. Like those in the eastern region, residents in the northern region experienced marginal improvement in their index for the period 2005 to the year before the global financial crisis. The significant improvement in the personal income of residents in the region helped to minimise the effect of the rise in mortgage lending rate during this period. The ongoing index also markedly improved for all entrants in the period of the Boost. The improvement during the Boost is more obvious for those who entered the market before the Boost. The decline in the index during the Boost can be linked to the decline in mortgage lending rate and the relative stability in house prices during this period.

However, homebuyers who entered the market before the year 2000 take an average of five years to reach the 30-point thresholds, while those who entered in later years take an average of more than 5 years to reach this threshold. More importantly, households in this region take a shorter time to reach the 30-points threshold than those in the relatively low-income western, inner-west and southern regions. For example, entrants of June 2009 in the northern region take 7 years to reach the 30-point threshold, while those in the relatively low-income western, inner-west, and southern regions who entered the market in the same year take more than 7 years to lower the index to 40 points. Again, this shows the effect of income in improving affordability after households have entered the market.

In summary, a closer look into the region-specific ongoing affordability index value reveals three key findings. First, mortgage lending rate has material effect on ongoing affordability, as a decline in the rate will improve ongoing affordability, while an increase will escalate the

burden of mortgage payment. Second, after entering the housing market, residents in the high-income regions such as eastern and northern regions of Greater Sydney generally take a shorter period to reach the 30-point threshold than those in the relatively low-income western, inner-west, and southern regions of the city. Last but not least, affordability of homebuyers improves the longer homebuyers stay in the house market. This highlights an important finding which shows that homeownership is an important way of minimising housing stress.

5.3 Conclusion of the Chapter

This study modified the novel spatial approach to compare entry-level affordability across time and space. The study also relates the option-theoretic mortgage pricing model to ongoing affordability. On the back of the differential spatial and socio-economic characteristics, the study conducted a more detailed examination of affordability in each of the defined regions – western, inner-west, southern, eastern, and northern regions. Using a disaggregated approach, the study developed both entry and ongoing housing affordability indexes for the five different geographical regions for the period 1991 to 2016.

We found that entry-level affordability generally takes an upward trend in all regions over 1992 to 2016, reflecting a deterioration of housing affordability in all regions. This suggests that it is harder for low-income households to access housing across Sydney. Since house price and the initial deposit are key drivers of entry-level housing affordability, the deterioration in entry-level housing affordability across Greater Sydney translates into a decline in the proportion of first homebuyers entering the housing market. Despite a deterioration of housing affordability in all regions, differences in entry-level housing affordability also occur between the regions, reflecting the differential geography of housing affordability. An obvious difference in entry-level housing affordability is observed between Western Sydney and the other regions of Greater Sydney. As the increase in house price continues to outstrip income growth, housing entrants from low-income Western Sydney are likely to be most affected, especially when residents from other parts of the city tend to move to the relatively affordable areas.

After entry into the housing market, the study found that ongoing affordability generally improves over time. Depending on their income level and the mortgage lending rate, households from across Greater Sydney may experience some level of housing stress in the first five years but may improve from the tenth year onwards. Further, an enhanced improvement of ongoing affordability is found in high-income regions (e.g. eastern and northern) compared with low-income regions. This again highlights the differential geography

of housing affordability in which significant disparities between high-income regions and low-income regions of Greater Sydney are observed.

A closer look into the region-specific ongoing affordability index value reveals three key findings. First, mortgage lending rate has material effect on ongoing affordability, as a decline in the rate will improve ongoing affordability, while an increase will raise the burden of mortgage payment. Second, after entering the house market, residents in the high-income regions such as eastern and northern regions of Greater Sydney generally take a shorter period to reach the 30-point threshold than those in the relatively low-income western, inner-west, and southern regions of the city. Last but not least, affordability of homebuyers improves the longer homebuyers stay in the house market. This highlights an important finding which shows that homeownership is an important way of minimising housing stress.

CHAPTER 6

OWNERSHIP AFFORDABILITY AND LOCAL HOUSING VARIABLES

6.1 Background

Homeownership affordability has attracted extensive research interest in recent years. A number of factors are involved here. First, significant deterioration of homeownership affordability has been observed in many metropolitan cities across the globe such as Hong Kong, Vancouver Los Angeles, San Francisco, and Sydney (Wetzstein 2017). Healey (2016) has also observed that house prices in Sydney have increased at a faster pace than income growth. Importantly, the deterioration of homeownership affordability has a significant spillover effect on households from various aspects, ranging from economic to social (Schwartz 2016). Further, the decline in affordability also has direct and indirect repercussions on the broader economy (Lee & Reed 2014). Hence, governments and policymakers have been seeking an effective solution to enhance homeownership affordability. Second, the empirical evidence on the divers of homeownership affordability is mixed and dependent on the sample being examined (Worthington & Higgs 2013; Lee & Reed 2014).

Housing affordability index is therefore an important benchmark for evaluating households' ability to meet their housing expenses. As a result, several studies over the years have examined various aspects of this topic (Productivity Commission Report 2004; Holmes et al. 2008; Muellbauer & Murphy 2008; Yates 2008; Chakraborty et al. 2010; Kim & Cho 2010; Susilawati & Armitage 2010; Ying et al. 2013; Haylen 2014; Angus 2017). Although these studies have enhanced our understanding of the issues surrounding homeownership affordability, however, they generally employed a narrative approach and their findings are generic. As reported by De Bruyne and Van Hove (2013), housing affordability varies geographically, even between neighbouring local councils. They attributed this variation to the differences in local socio-economic variables. Therefore, an examination of the relationship between affordability index and local factors is critical to developing an effective housing policy in addressing the deterioration of homeownership affordability (Gabriel et al. 2005; Yates 2008).

However, the literature that links affordability index and local factors is limited. Worthington and Higgs (2013) and Lee and Reed (2014) examined the causality between housing affordability index and key market fundamentals. Lee and Reed (2014) revealed some empirical evidence to suggest that the First Home Owner Grant (FHOG) policy is an effective

tool in boosting the affordability of first-time homebuyers in Australia. Worthington and Higgs (2013) modelled homeownership affordability in Australia against several economic, demographic and cost variables. They found empirical evidence to support that housing finance, dwelling approvals and financial assets are the main long run drivers of homeownership affordability in Australia, while the influence of population and economic growth on affordability is only in the short run. Nevertheless, the results of both these studies are mixed and broad. The inconclusive empirical results of the driving forces of local homeownership affordability index could be explained by the complexity of housing submarkets as both studies do not consider the existence of socio-economic and geographical disparities across regions of a metropolitan city. In Greater Sydney, for example, the differences in key socio-economic characteristics between different regions are wide. This is clearly demonstrated by Table 2.5. In general, western, inner-west and southern regions in Greater Sydney are known as low-income regions (low income and socio-economic status and higher unemployment rate), while the eastern and northern regions of the city are considered as high-income regions.

Importantly, the polarisation of housing affordability has been evident in recent years. Specifically, Yates (2008) found that the deterioration of housing affordability is more obvious in low-income regions of Greater Sydney. The disparities between low-income and high-income regions could be supported by Stone's (1990) shelter poverty theory, in which low-income households have lower disposable income and are more likely to be "shelter poor" (i.e. with housing but without adequate non-shelter resources) compared with high-income households. This again highlights the geographical differential of housing affordability. Nevertheless, current government policies on housing in Australia, particularly housing affordability, are not well tailored to adequately address affordability for low-income earners (Costello 2009). This can be attributed to the ignorance of housing submarkets. Further, Doney et al. (2013), Baker et al. (2016), and Dufty-Jones (2018) discussed the increasing geographical complexity and social spatial polarisation. Forster (2006) and Randolph and Holloway (2005a) also highlighted the importance of considering the differences between different regions in formulating effective housing policies and strategies. All of these assert that a metropolitan city (e.g. Greater Sydney) is socially highly segregated. Therefore, it is important to have a dedicated study from a sub-city perspective.

Acknowledging the importance of disaggregated housing analysis, this study is the first to examine the causality between local homeownership affordability index and local housing

variables. Unlike previous studies, a disaggregated approach was utilised to examine the key drivers of homeownership affordability index in the regions of Greater Sydney. It allowed us to effectively gauge how local factors could impact on the homeownership affordability index in different regions so, a more targeted housing policy could be formulated for each region. Specifically, we examined whether the impact of whether these local housing factors varies across the five regions of Greater Sydney – western, inner-west, eastern, northern and southern.

To the best of my knowledge, this study is the first dedicated sub-city housing analysis to examine the local drivers of ownership affordability with a sub-city approach. As highlighted by Randolph and Tice (2014), Sydney is characterised by diverse socio-economic and demographic mix. These features make Greater Sydney an ideal case study for a sub-city modelling of homeownership affordability. An examination of local factors driving local affordability index could offer more information to policymakers for informed decision-making on housing affordability.

6.2 Results and Discussion

The following section presents the results of the entry-level affordability of the LGAs in each region, the panel unit root, and the causality between ownership affordability and its local housing variables.

6.2.1 Results of Entry-Level Affordability of the LGAs in the Regions

The results of the entry-level housing affordability of each LGA in each region are reported in Appendix 1. As discussed earlier, this index is the dependent variable that is regressed against the explanatory variables as specified in Equation (6). As discussed in section 4.2.2, the index is computed using the cost-to-income formula specified in Equation (1).

The results exhibit an upward trend, indicating a steady decline in the level of affordability across all LGAs. Apparently, the index is above the 30% threshold across all LGAs over time. However, despite the general rising trend, the annualised increase in the index is highest for LGAs in the low-income western region[9]. Wollondilly LGA in Western Sydney, for example, had the highest increase in the index, representing an annualised growth of 5.24% over the study period. This is followed by Liverpool LGA with 4.54%. Importantly, the annualised growth rate of the index in all other LGAs in the western region ranges from 2.27% in Holroyd LGA to 5.24% in Wollondilly LGA. The annualised growth of the index in the inner-west

[9] $HA_{it} = (HA_{2016}/HA_{1991})^{\wedge(1/25)} -1$

region is similar to most LGAs in western Sydney region. The index in this region starts from 2.26% in Leichhardt LGA to 3.25% in Burwood LGA. In the southern region, apart from Kogarah and Rockdale LGAs with an annualised increase of 2.12% and 2.92% respectively, the remaining LGAs show an annualised increase of less than 2%.

Glaring differences in the results are observed when compared to LGAs in the high-income regions. In the eastern region, for example, the annualised growth rate is less than 2% across all LGAs. In the northern region, the annualised increase in most of the LGAs is also less than 2%. The differences can be attributed to two main factors: the adverse effect of rising house price on homeownership affordability as reported by Berry (2003), Yates (2008), Bandt et al. (2010), Worthington and Higgs (2013) and Healey (2016) is stronger in the relative low socio-economic regions; and secondly, as the increase in average personal income is expected to improve affordability (Productivity Commission Report 2004; Yates 2008), the annual increase in average personal income is sluggish in the relative low socio-economic regions when compared with the high-income eastern and northern regions, thereby worsening affordability. These results confirm the existence of housing submarkets in Greater Sydney. The results set the scene for the estimation of the causality between the index and its key local drivers.

6.2.2 Panel Unit Root Results

The unit root results show non-stationarity in all the variables of the panels. The panel unit root test results are reported in Table 6.1. The results indicate that ownership affordability index, house price, average personal income, resident population, housing supply and median rent contain unit root across all regions, but become stationary after first difference. This means the series are first differenced stationary I(1)[10]. The stationarity in the panel data for each region means any estimation of the specified model will not be spurious. It has been established that our variables behave in a stable way after first differencing and any results obtained from these variables will not be misleading. This initial procedure sets the scene for the estimation of Equation (6) for each region of Greater Sydney. Thereafter, the SGMM was employed to estimate the causal relationship between affordability and its local drivers in each region.

[10] In the case of the additional instruments used in the SGMM, mortgage lending rate is stationary at level, while NSW state final demand is also first-differenced stationary.

6.3 Homeownership Affordability and Local Drivers

This section examines the key local factors impacting on homeownership affordability in the different regions. Using robust standard errors, the SGMM results of the five regions of Greater Sydney are presented in Table 6.2.

Housing supply has the expected sign in all regions, supporting the literature that an increase of housing supply will improve affordability. Despite the fact that it is highly inelastic in all regions, the results show that housing supply is a statistically significant local driver of homeownership affordability in the relative low-income western, inner-west and southern regions at 1% significance level. However, housing supply is insignificant in the eastern and northern regions. Since population growth and household size are key indicators of housing demand, the sluggish population growth in the eastern and northern regions largely accounted for the insignificance of housing supply in determining affordability in these regions. From Table 2.5, over 1991-2016, western Sydney region has an annual population growth of 1.54%, while it is 0.79% and 0.88% in the eastern and northern regions respectively. These indices culminate in relative low housing demand in these regions which translate to less housing supply. This again highlights the differences among different regions, particularly housing supply, which is not an important factor in explaining homeownership affordability in the relative high-income regions (i.e. eastern and northern regions). With an elasticity that is far below unity, it shows the sluggish rate of response of housing stock to improve affordability in the relative low-income western, inner-west and southern regions of Greater Sydney. This can be attributed to the nature and unique characteristic of housing supply: for example, not being instantaneous due to factors such as decision lags, longer construction periods, and meeting consumers' tastes and preferences. Housing supply inelasticity can also be linked to the cost of land development processes and policies, levies, construction cost and property-related taxes (Yates and Milligan 2007). These results are consistent with the finding of Yates (2008), who asserted that there is a less than perfectly elastic supply of housing despite its growing demand. One caveat from this result is that even though increasing housing supply is expected to improve affordability in the relative low-income regions of Greater Sydney, the inelasticity of housing supply creates undue bottlenecks towards the improvement of affordability.

Table 6.1: Im-Pesaran-Shin (IPS) Panel Unit Root Results

Variable	Western	Inner-West	Southern	Eastern	Northern	Western	Inner-West	Southern	Eastern	Northern
	Level	Level	Level	Level	Level	1st Difference	1st Difference	1st Difference	1st Difference	1st Difference
lnHAIndex	0.99	0.59	0.69	0.50	0.35	0.00***	0.00***	0.00***	0.00***	0.00***
lnHousePrice	0.42	0.99	0.99	0.99	0.99	0.00***	0.00***	0.00***	0.00***	0.00***
lnAverageIncome	0.96	0.97	0.81	0.98	0.93	0.00***	0.00***	0.00***	0.00***	0.00***
InResidentPop	1.00	1.00	1.00	1.00	1.00	0.00***	0.00***	0.00***	0.00***	0.00***
lnHousingSupply	0.99	1.00	0.22	0.48	0.90	0.00***	0.00***	0.00***	0.00***	0.00***
lnMedianRent	1.00	1.00	1.00	0.98	1.00	0.00***	0.00***	0.00***	0.00***	0.00***
lnSFD	1.00	1.00	1.00	1.00	1.00	0.00***	0.00***	0.00***	0.00***	0.00***
lnMLR	0.00***	0.00***	0.00***	0.00***	0.00***					

The IPS test the null hypothesis all panels contain unit root against the alternative hypothesis that some panels are stationary for each variable. The results of the IPS failed to reject the null hypothesis on level at P<0.05, but there is clear rejection after first difference at P<0.01 for all the variables in all the regions. *** denotes a rejection of the tested hypothesis at the 1% level, ** is rejection of the null hypothesis at 5% level, * is a rejection of the tested hypothesis at 10% level. Mortgage lending rate is the only variable to be stationary on level at 1% significance level.

Table 6.2: System GMM Regression Results of the Western, Inner-west, Southern, Eastern and Northern Regions

lnHAIndex	Western Coeff.	t-Stat	Inner-West Coeff.	t-Stat	Southern Coeff.	t-Stat	Eastern Coeff.	t-Stat	Northern Coeff.	t-Stat
lnlagHAIndex (-1)	0.08	(2.06)**	0.38	(3.09)***	0.45	(8.83)***	0.14	(2.19)**	0.39	(5.46)***
lnResidentpop	–0.19	–(3.97)***	–0.63	–(4.08)***	–0.70	–(3.33)***	–0.18	-(1.79)	–0.89	–(1.34)
lnHousingSupply	–0.43	–(2.46)**	–0.08	–(2.02)**	–0.58	–(2.74)***	–0.21	–(1.27)	–0.03	–(0.94)
InMedianRent	0.56	(3.31)***	0.01	(2.11)**	0.68	(3.29)***	0.41	(0.64)	0.19	(0.62)
Dummy @ 2000	0.13	(8.43)***	0.10	(4.08)***	0.08	(2.13)**	0.22	(6.28)***	0.10	(5.17)***
Constant	2.16	(3.91)**	0.80	(1.99)**	0.02	(2.10)**	4.85	(4.61)***	0.28	(0.86)
P-Value (F)	0.00***		0.00***		0.00***		0.00***		0.00***	
Arellano-Bond Test	p-value	0.05	p-value	0.09	p-value	0.06	p-value	0.08	p-value	0.09
Hansen's J Test	p-value	0.10	p-value	0.12	p-value	0.24	p-value	0.60	p-value	0.10

The general model of the SGMM is given as: $HA_{it} = \beta_0 + \beta_1 HA_{it-1} + \beta_2 RP_{it} + \beta_3 HS_{it} + \beta_4 MR_{it} + \beta_5 d_{it} + \varepsilon_{it,}$ where $\varepsilon_{it} = \alpha_i + \mu_{it}$ and $E(\alpha_i) = E(\mu_{it}) = E(\alpha_i \mu_{it}) = 0$ in Equation (6). The disturbance term has two orthogonal components: the fixed effects (α_i) which is a time-invariant error term that could represent variables such as the geophysical characteristics and the social ledger of the LGA; and the idiosyncratic shocks ($\mu_{it,}$) which captures all other factors that influence homeownership affordability other than the specified regressors. The P-value of the F-test shows the overall significance of the SGMM, while the Arellano–Bond tests the null hypothesis of no autocorrelation and the results failed to reject at $P < 0.05$ for both first and second orders. The p-value of the Hansen's J test failed to reject the tested hypothesis of overidentifying restrictions are valid. This indicates that our instruments are valid. *** denotes variable is significant at the 1% level, ** denotes variable is significant at 5% level, and * means the variable is significant at 10% level.

Contrary to its expected sign, resident population has a negative sign in all regions, implying that affordability improves with rising population growth. Specifically, the coefficients of resident population in the relatively low-income western, inner-west and southern regions are statistically significant at the 1% level. Resident population is insignificant in the eastern and northern regions. As discussed earlier, the Productivity Commission Report (2004) argued that the impact of population growth on homeownership affordability through the demand for housing particularly in cities and regions is somewhat elusive. Specifically, if the increase in population growth is not sourced from higher immigration, it will offset the upward pressure on house prices coming from, amongst other things, economic growth and cheaper finance, which will improve affordability. Haylen (2014) supported this view, stating that the impact of housing demand emanating from overseas and interstate migration is more immediate as they require accommodation upon arriving, whether owner occupied or rental. This discussion certainly explains the paradoxical result of the effect of resident population on the affordability of the different regions across Greater Sydney. The increase in population growth might be sourced more from the upsurge in natural increase than from immigration. Consequently, the natural increase of population growth is less likely to have an immediate impact on housing demand than immigration. Gitelman and Otto (2012) and Worthington and Higgs (2013) also reported an inverse relationship between population growth and homeownership affordability at least in the short run. Similar to housing supply, the elasticity of population is below one in all the relative low-income regions. As discussed earlier, the negative effect of population on affordability can be explained by the complexity of population growth. Hence homeownership affordability could have varying degrees of responses to changes in resident population.

Median rent is included in Equation (6) to evaluate its effect on the affordability of potential first home buyers. As discussed in the literature, Stone (2004) found that renters are more likely to be shelter poor than homeowners. An increase in rent has an inverse impact on entry to the housing market for first home buyers through its effect on savings to make a deposit for a home (Productivity Commission Report 2004; Yates 2008). Further, higher rental income will stimulate housing investment, which will create competition among the limited housing supply thus driving house prices. Those who own an investment property benefit from price increases while the savings of low-income renters will be affected adversely (Healey 2016). As expected, median rent has a positive sign across all regions, meaning as rent increases, it minimises the likelihood of potential first home buyers entering the housing market. The net losers of this result are renters or prospective homebuyers. Median rent is statistically significant at 1% in

the relative low-income western and southern regions, and 5% in the inner-west region. However, it is insignificant in the high-income eastern and northern regions. This further highlights the asymmetric effect of median rent across households in Sydney. It indicates that potential first home buyers, particularly those in the relative low-income regions, are more likely to be affected by higher rents than those in high-income regions. As median rent is relatively low in the western region, a general increase in rent in Greater Sydney is expected to crowd in residents from other regions to this region. Consequently, this might have a stronger impact on low-income residents in the region and potentially reduces their chances of entering the housing market.

A dummy variable is introduced in the model to assess the effect of key policy changes between 1999 and 2000 (i.e. introduction of the FHOG and GST; Lee and Reed 2014). The dummy variable evaluates the effect of the introduction of the GST in July 1999 and the FHOG in July 2000 on homeownership affordability. The results show that homeownership affordability deteriorates after 2000 in all regions, indicating that the effect of the FHOG in improving affordability could not effectively cushion the impact of the GST on affordability. The net effect of the FHOG and GST on affordability is adverse. As shown by the results of housing affordability index in section 6.2.1, this result means the relative low-income western, inner-west and southern regions are more sensitive to these policy changes than the high-income regions. This again highlights the spatial polarisation of housing affordability across Greater Sydney. The results also reveal that previous affordability has a direct relationship with current affordability. This shows the expected decline in the level of affordability across all regions.

In conclusion, the results reveal important asymmetric effects of local housing variables on affordability. It shows that homeownership affordability in the relative low-income regions (western, inner-west and southern) are affected by key local factors such as housing supply, rent and resident population. However, there is no comparable evidence in the high-income regions. This has provided empirical evidence on the existence of submarkets within Greater Sydney and how local socio-economic factors would affect local homeownership index. These findings are generally in conformity with the hypothesis of the study and reflect the central idea of the shelter poverty model, as the relative low-income regions are more susceptible to changes in key housing market variables than the high-income regions. The differences in income level, unemployment rate and general socio-economic characteristics across the regions of Sydney largely account for the disparity in the effect of these regressors.

6.4 Westerlund (2007) Cointegration and Panel ECM

The previous section highlights the key local drivers of affordability in each region of Greater Sydney. To further authenticate our SGMM results, we extend the analysis by examining the long run relationship in Equation (6) using Westerlund (2007) and employing another estimator, panel ECM. The results of Westerlund (2007) are reported in Table 6.3.

The panel cointegration test results show the existence of an error correction for both the individual group and for the panel as a whole for all regions at the 1% significance level. The cointegration test confirms the existence of a long run relationship between affordability and the explanatory variables modelled in Equation (6). The results further validate the baseline and robustness check results. With the existence of cointegration, we estimated the ECM to examine the long run drivers of affordability in each region using mean group (MG) and pooled mean group (PMG) estimators. The ECM results are reported in Table 6.4.

The Hausman test shows that the PMG is the more consistent estimator for all the regions. The results of the ECM reveal housing supply and resident population as the statistically significant drivers of affordability at the 1% level in all the relative low-income regions. Rent is also significant in the western region at the relevant significance level. Apart from housing supply being statistically significant in the northern region, the other variables are insignificant in both the eastern and northern regions of Greater Sydney.

The results are generally in line with our baseline results in which local socio-economic factors are more sensitive in the relative low-income western, inner-west and southern regions than the high-income (eastern and northern) regions. Further, the ECM also reveals that Western Sydney is the only region whose affordability is affected by all the regressors. This indicates that affordability in Western Sydney is more susceptible to changes in key local variables even in the long run. The ECM results largely support our hypothesis and the shelter poverty model as there is enormous evidence of variation in the effect of local housing market variables on households across the regions of Greater Sydney.

Table 6.3:Westerlund 2007 Panel Cointegration Results

Statistic	Western		Inner-west		Southern		Eastern		Northern	
	Z-value	P-value	Z-value	P-value	Z-value	P-value	Z-value	P-value	Z-value	P-value
G_t	–5.07	0.00***	–3.81	0.00***	3.27	0.00***	–6.93	0.00***	–4.70	0.00***
G_a	–6.59	0.00***	–4.53	0.00***	3.98	0.00***	–4.93	0.00***	–7.71	0.00***
P_t	–3.26	0.00***	–6.12	0.00***	–3.61	0.00***	–3.60	0.00***	–6.72	0.00***
P_a	–12.81	0.00***	–17.06	0.00***	–3.51	0.00***	–9.62	0.00***	–13.57	0.00***

For the group statistics (G_t and G_a), the null hypothesis H0: $\varphi = 0$ is tested against the alternative hypothesis H1: $\varphi i = \varphi < 0$ for all i, which specifies that a rejection is considered an evidence of cointegration for the group as a whole. For the panel statistics (P_t and P_a), the null hypothesis H0: $\varphi = 0$ is tested against the alternative hypothesis H1: $\varphi i < 0$ for at least some i, signifying that a rejection is an evidence of cointegration for at least one of the cross-sectional units. *** denotes a rejection of the tested hypothesis at the 1% level, ** is rejection of the null hypothesis at 5% level, * is a rejection of the tested hypothesis at 10% level.

Table 6.4: ECM Results of the Regions of Greater Sydney

Regions	**Western**		**Inner-west**		**Southern**		**Eastern**		**Northern**	
lnHaIndex	**Coeff.**	**t-Stat**	**Coeff.**	**t-Stat**	**Coeff.**	**t-Stat**	**Coeff.**	**t-Stat**	**Coeff.**	**t-Stat**
lnResidentpop	–0.30	–(2.44)**	-0.73	-(5.58)***	-0.34	(4.50)***	–0.93	–(0.23)	–0.75	–(1.48)
lnHousingsupply	–1.23	–(3.42)***	–1.82	–(3.80)***	–1.41	–(2.60)***	–0.29	–(1.26)	–0.73	–(2.94)***
lnMedianrent	0.90	(2.14)**	0.27	(1.15)	0.52	(1.49)	0.12	(0.09)	0.13	(0.73)
Constant	0.10	(4.12)***	0.50	(3.80)***	0.06	(2.55)	0.43	(6.05)***	0.07	(3.70)***
Hausman (p-value)	0.51		0.48		0.38		0.48		0.53	
Estimator	PMG		PMG		PMG		PMG		PMG	

The long run results of $HAI^*_{it} = \beta_0 + \sum_{i=1}^{n} \boldsymbol{\beta}_{it}\mathbf{K}_{it}$ (7), where HAI_{it} is homeownership affordability and K is a vector of local housing variables such as RP_{it}, HS_{it}, and $MR_{it.}$ The residual term of (7) becomes $\mu_{it} = HAI_{it} - a_{-} \sum_{i=1}^{n} \mathbf{bK}_{it}$ (**8**). The Hausman tests the null hypothesis of long run slope homogeneity in the coefficients of the LGAs (PMG being the preferred estimator). Rejecting the tested null hypothesis at the usual level of significance means the MG is the efficient estimator. *** means variable is significant at the 1% level, ** means variable is significant at the 5% level, * means variable is significant at the 10% level.

Overall, our long run results are in line with our baseline results in which a geographical differential is evident among different regions of Greater Sydney. Importantly, low-income regions are more susceptible to changes in housing variables. The results are in line with the shelter poverty model in which low-income households have lower disposable incomes and as such are more sensitive to changes in housing variables compared with higher income households.[11]

6.5 Robustness Checks

Two important robustness checks were conducted to evaluate the robustness of the baseline findings. Even though there is some degree of correlation between the affordability index and house price and income each, our first robustness check finds out the consistency of our results by incorporating house price and income in Equation (6) and re-estimate the model. The results are reported in Table 6.5. As expected, house price is directly related to homeownership affordability in all regions of Greater Sydney, suggesting that homeownership affordability deteriorates as house price increases. Average personal income also produces its expected inverse relationship with homeownership affordability across all regions. This indicates that affordability is enhanced with an increase in average personal income. The results generally show that the inclusion of house price and average personal does not affect the model. A closer look at the results in Table 6.5 further reveals that affordability in the relative low-income regions (western, inner-west and southern) is determined by more local socio-economic housing variables than the high-income eastern and northern regions. Specifically, affordability in the high-income regions is only influenced by house price and income, while affordability is driven by these factors and several other factors such as housing supply, rent and population in the relative low-income regions. Further, affordability in the relative low-income regions is more sensitive to changes in these housing market variables than the high-income regions. The results reveal a differential geography of the drivers of affordability across the regions of Sydney. These findings are generally in conformity with the hypothesis of the study and reflect the crux of the shelter poverty model, as the relative low-income regions are more affected by changes in key housing market variables than the high-income regions.

[11] Since there is no trend in the data, the existence of cointegration suggests that any linear combination of the variables would not make them deviate too far from each other. However, the individual variable of the model could fluctuate significantly (Hui and Yue 2006). Therefore, we focus more on the long run results of the ECM, with little attention on the short run results. Succinctly, the short run results of the ECM (though not reported here) show that apart from resident population, the remaining regressors are all significant in the western region; in the inner-west region, resident population and housing supply are significant; in the southern region, all the regressors are significant; in the eastern region, some of the variables are significant; and in the northern region, median rent and housing supply are significant. The short run results are somehow mixed across the regions in terms of the magnitude of the coefficients and the significance of the variables. This is expected because the preferred PMG estimator allows short run coefficients and error variances to differ across groups. This means the sensitivity of the regressors are more evident in the long run. This is expected since housing decisions are not instantaneous.

Table 6.5: System GMM Regression Results of the Regions of Greater Sydney

Regions	**Western**		**Inner-west**		**Southern**		**Eastern**		**Northern**	
lnHAIndex	**Coeff.**	**t-Stat**	**Coeff.**	**t-Stat**	**Coeff.**	**t-Stat**	**Coeff.**	**t-Stat**	**Coeff.**	**t-Stat**
lnHouseprice	1.02	8.78***	1.04	7.17***	1.07	5.44***	0.82	3.81***	0.29	5.96***
lnAverageincome	–1.21	–5.4***	–1.05	–7.89***	–1.01	–7.84***	–0.88	–7.56***	–0.77	–6.42***
lnResidentpop	–0.65	–2.03**	–0.19	–2.76***	–3.10	–2.77***	–0.18	–0.24	–0.79	–1.90
lnHousingSupply	–0.08	–2.55**	–0.05	–1.98**	–0.04	–3.85***	–0.18	–1.53	–0.05	–0.92
InMedianRent	0.84	8.81***	0.28	4.22***	0.94	4.16***	0.01	0.02	0.01	0.75
Dummy @ 2000	0.05	4.13***	0.05	9.69***	0.08	6.95***	0.11	2.63***	0.12	2.84***
Constant	0.81	2.32**	0.20	0.81	0.35	3.05	3.02	2.29**	0.49	0.97
P-Value (F)	0.00***		0.00***		0.00***		0.00***		0.00***	
Arellano–Bond Test	p-value	0.07	p-value	0.08	p-value	0.08	p-value	0.06	p-value	0.09
Hansen's J Test	p-value	0.10	p-value	0.12	p-value	0.24	p-value	0.60	p-value	0.10

The re-defined model (6) of the SGMM is given as $HA_{it} = \beta_0 + \beta_1 HA_{it-1} + \beta_2 RP_{it} + \beta_3 HS_{it} + \beta_4 HP_{it} + \beta_5 API_{it} + \beta_6 MR_{it} + \beta_7 d_{it} + \varepsilon_{it}$, where $\varepsilon_{it} = \alpha_i + \mu_{it}$ and $E(\alpha_i) = E(\mu_{it}) = E(\alpha_i \mu_{it}) = 0$. The disturbance term has two orthogonal components: the fixed effects (α_i) which is a time-invariant error term that could represent variables such as the geophysical characteristics and the social ledger of the LGA; and the idiosyncratic shocks (μ_{it},) which captures all other factors that influence homeownership affordability other than the specified regressors. The P-value of the F-test shows the overall significance of the SGMM, while the Arellano–Bond tests the null hypothesis of no autocorrelation and the results failed to reject at $P < 0.05$ for both first and second orders. The p-value of the Hansen's J test failed to reject the tested hypothesis of overidentifying restrictions are valid. This indicates that our instruments are valid. *** denotes variable is significant at the 1% level, ** denotes variable is significant at 5% level, and * means the variable is significant at 10% level.

The differences in income level, unemployment rate and general socio-economic characteristics across the regions of Sydney largely account for the disparity in the effect of these determinants.

The second robustness check investigates whether our regression coefficients will be consistent if we re-modify our model. One could argue that, based on the similarity in income level, house prices and socio-economic characteristics, the inner-west and southern regions could be deemed as the medium-income region, while the eastern and northern regions are the high-income region. The western region remains the low-income region. A similar taxonomy is employed by Housing NSW to disaggregate the housing market in Greater Sydney into the inner-ring, which comprises mostly LGAs in the northern and eastern regions; middle-ring, which constitutes mostly LGAs in the inner-west and southern regions; and the outer-ring, which is predominantly the collection of LGAs in the western region. We follow the system generalised method of moments (SGMM) discussed in section 4.2.2 to estimate the regressions of low-income, medium-income and high-income regions. The variables are all first difference stationary (as reported in Table 6.1) and the regression results are reported in Table 6.6.

Table 6.6: System GMM Results of Low, Medium and High Income Regions

lnHaIndex	**Low-Income** **Coeff/t-stat**	**Medium-Income** **Coeff/t-stat**	**High-Income** **Coeff/t-stat**
lnlagHaindex (-1)	0.08 (2.06)**	0.51 (3.14)***	0.51 (4.40)***
lnResidentpop	-0.19 (-3.97)***	-0.98 (-5.11)***	-0.25 (-3.52)***
lnHousingSupply	-0.43 (-2.46)**	-0.62 (-2.96)***	-0.01 (-0.04)
InMedianRent	0.56 (3.31)***	0.34 (2.58)***	0.04 (0.21)
Dummy @ 2000	0.13 (8.43)***	0.15 (5.44)***	0.11 (2.72)***
Constant	2.16 (3.91)***	0.11 (3.21)***	0.02 (0.69)
P-Value (F)	0.00***	0.00***	0.00***
Arellano-Bond Test (p-value)	(0.05)**	(0.32)**	(0.31)**
Hansen's J Test (p-value)	0.22	0.31	0.10

The general model of the SGMM is given as: $HA_{it} = \beta_0 + \beta_1 HA_{it-1} + \beta_2 RP_{it} + \beta_3 HS_{it} + \beta_4 MR_{it} + \beta_5 d_{it} + \varepsilon_{it,}$ where $\varepsilon_{it} = \alpha_i + \mu_{it}$ and $E(\alpha_i) = E(\mu_{it}) = E(\alpha_i \mu_{it}) = 0$ in Equation (6). The disturbance term has two orthogonal components: the fixed effects, α_i which is a time-invariant error term that could represent geo-physical characteristics, the social ledger etc. and the idiosyncratic shocks, μ_{it}, which captures all other factors that influence ownership affordability other than the specified regressors. The P-value of the F-test shows the overall significance of the SGMM, while the Arellano–Bond tests the null hypothesis of no autocorrelation and the results failed to reject at $P < 0.05$ for both first and second orders. The p-value of the Hansen's J test failed to reject the tested hypothesis of overidentifying restrictions are valid. This indicates that our instruments are valid. *** denotes variable is significant at the 1% level, ** denotes variable is significant at 5% level, and * means the variable is significant at 10% level.

Our regression results suggest that rent, housing supply and resident population are statistically significant drivers of housing affordability in both low-income and medium-income regions. These variables in these two regions are statistically significant at the 1% level. In the high-income region, housing affordability is only influenced by resident population. These results confirm that our baseline results are robust to the five regions of Greater Sydney. This offers further evidence to support that homeownership affordability in the western, inner-west and southern regions of Greater Sydney is affected by more local housing variables factors.

To further validate our baseline results, we compute homeownership affordability index for strata and non-strata dwellings and regress each housing type against local housing variables using Equation (6). As reported by Chakraborty et al. (2010) and Lee (2017), different housing types usually have different market determinations in metropolitan areas. Again, strata title includes townhouses, terraces/villas and flats/units, whereas non-strata title properties refer to detached houses (DoH 2016). The system GMM results of the strata and non-strata of the low-income, medium-income, and high-income are generally consistent with our baseline findings[12]. This confirms that our baseline results are robust to different housing types.

6.5 Conclusion of the Chapter

This study recognised the existing disparities in the demographic and socio-economic characteristics of Greater Sydney and adopted a system GMM and panel ECM to evaluate the impact of local housing variables on homeownership affordability in the different regions of Greater Sydney – western, inner-west, southern, eastern and northern – from 1991 to 2006. This sub-city approach has documented some important findings on homeownership affordability in Greater Sydney. These findings contribute to the limited quantitative literature on homeownership affordability.

The study has shown that there is a differential geography of the drivers of homeownership affordability. This supports our hypothesis in the sense that the relative low-income regions are affected by more local housing variables than the high-income regions. First, the results show that the affordability in the LGAs of the low-income western, inner-west and southern regions is more sensitive to changes in house price and income than the high-income eastern and northern regions. A rise in house prices, for example, will deteriorate affordability and narrow the residual income of residents in low-income regions more than those in high-income regions. Second, the homeownership affordability of the relative low-income regions is more

[12] The system GMM results of both the strata and non-strata housing types are not reported for brevity.

susceptible to changes in other housing variables (such as housing supply, rent and resident population) than in high-income regions. Increasing housing supply, for example, plays an important role in improving affordability, particularly in the western, inner-west and southern regions, while it is insignificant in the high-income eastern and northern regions. In addition, a rise in the median rent in the relative low-income regions would reduce the chances of potential first homebuyers entering the market, while there is no comparable evidence in the high-income regions. Resident population is also a significant local housing variable in the relative low-income regions but not the high-income regions. The results show the differences in the effects of local housing variables on homeownership affordability (and implicitly on residual income) across regions. Various robustness checks were conducted to evaluate the validity of the baseline results. These include re-clustering of the initial five regions into low-income, medium-income, and high-income regions, examining strata and non-strata housing types, and checking whether a long run relationship exist between ownership affordability and the regressors in Model (6). All these robustness checks are largely consistent with our baseline results. The results generally support Stone's (1990) shelter poverty model in the sense that residents in the relative low-income regions will be more shelter poor than their counterparts in the high-income regions of the city.

CHAPTER 7

HOUSING PRICE BUBBLES

7.1 Background

Recognising the rapid increase in housing prices in many metropolitan cities across the globe (Demographia 2019), several studies have examined the existence of housing price bubble in these cities. As defined by Stiglitz (1990), any increase in house price that is not justified by economic fundamentals is indicative of a bubble. Specifically, housing investors, particularly investors with speculation of future higher price could cause price increase that would result in a bubble, and market fundamentals play a minimal role in driving this increase (Kivedal 2013). Bubble contagion also often affects the broader economy (Kivedal 2013). In the US, for example, there was evidence of a speedy rise and subsequent collapse in residential housing prices, which contributes to the global financial crisis of 2007-2009 (Granziera & Kozicki 2015). Hence housing price bubble could potentially prompt some policy intervention that would have a significant impact on the broader economy. This highlights the need to examine the presence of bubble in the housing markets (Shi et al. 2016).

Numerous studies have been devoted to identifying and detecting a housing bubble. Engsted et al. (2016) reported evidence of explosiveness in 16 OECD countries (the only two exceptions are Germany and Italy). Their study empirically shows a large degree of housing price bubble in the early 2000s and to a certain degree in the 1990s in 16 OECD countries. Housing price bubbles have also been examined by numerous studies such as Reinhart and Rogoff (2008), Costello et al. (2011), Fox and Tulip (2014), Shi et al. (2016), and Baur and Heaney (2017). Baur and Heaney (2017), for example, identified lengthy periods of explosive positive price changes followed by some corrections. However, the empirical works of Malpezzi (1999), Meen (2002) and Black et al. (2006) found no evidence of housing bubble formation. The work of Black et al. (2006) preclude the existence of an explosive rational bubble in the UK.

As such, the results of previous studies are mixed and most of these studies failed to detect the housing bubble precisely. This can be attributed to the ignorance of housing submarkets, particular in metropolitan cities such as Greater Sydney, where there are significant socio-economic discrepancies (Randolph & Tice 2014). Further, there is also evidence of growing demand for investment in inner-city housing and apartments in Sydney from local and overseas investors (Birrell & Healy 2013). CoreLogic (2016) reported that 58.8% of investment by housing investors in Sydney is concentrated in low-priced areas of the city. Specifically,

CoreLogic (2016) reported that the highest concentration of these investments is located in the inner-west and western regions within the relative low-income region of Greater Sydney. All these factors highlight that more housing investment is concentrated in relative low-income regions compared to high-income regions of Sydney.

These characteristics make Greater Sydney a compelling case for a housing bubble test at a disaggregated level. Moreover, housing investors and owner-occupiers have different ownership motives. Income and wealth factors (e.g. capital gains) are more related to housing investors, whilst owner-occupiers are less sensitive to these factors (Ioannides & Rosenthal 1994; Kohler & Rossiter 2005). Further, the Australian tax system (e.g. negative gearing[13]) does favourable to property investors (Berry 2000; Bloxham et al. 2011; Valadkhani & Smyth 2017). The tax incentives (e.g. negative gearing) encourage housing investors outweigh future capital gain of a rental property (Blunden 2016). Consequently, housing investors are more likely to have emotional speculative interests in housing markets. It is also known as a psychological factor. As posited by Shiller's (2007) psychological theory of housing bubbles, this psychological factor could cause the formulation of housing price bubbles. As such, housing price bubbles are more likely to exist in low-income regions that are dominated by housing investors in response to housing investors, unlike owner-occupiers, are more likely to have emotional speculative interested. This psychological factor leads to the formulation of a bubble. However, no study has considered the existence of housing bubbles in different housing submarkets from a disaggregated perspective.

To fill this gap, this study expands upon the limited literature to examine whether there is there is housing price bubble in Greater Sydney, Australia from a sub-city perspective. By considering several socio-economic and demographic characteristics and key housing variables such as house price, income and rent to delineate Greater Sydney into five regions, this study is the first to investigate the existence of housing bubbles from a disaggregated perspective. It should throw light on the early signs of housing bubbles and real time bubbles in various regions of Greater Sydney by examining the long run relationship between house price and rent. The use of house-price-rent ratio to define a housing bubble stems from the intuition that property investors invest to realise capital gains and rental income is a fundamental value that explains house prices (Himmelberg et al. 2005; Kivedal 2013). It also reflects the expectations

[13] Australia is the only developed country that offers negative gearing for housing investors. This is a controversial policy. It allows losses on a rental property to be deductible against housing investors' taxable income if their rents are not enough to cover the interest expenses and depreciations of their housing investments. However, the policy is confined to housing investors, and owner-occupiers do not qualify for the negative gearing (Blunden, 2016).

of future growth (Clark & Coggin 2011). Therefore, an examination of the trend of house price and rent over time is a useful tool for gauging dramatic behaviour in house prices, and providing an indication of a housing bubble (Girouard et al. 2006). The price-to-rent ratio has been widely used in a number of housing bubble studies such as Mikhed and Zemčík (2009), Clark and Coggin (2011), Greenaway-McGrevy and Phillips (2016). Unlike these studies, this research also includes testing for real time housing bubbles following the backward supremum augmented Dickey–Fuller (BSADF) procedure to assess the existence of a bubble within a metropolitan city level for the first time. The results provide further insights that allow policymakers and homebuyers to monitor house prices in the city more accurately.

7.2 Delineation of Submarkets for Bubbles Test

As discussed in sections 2.1, 2.2 and 2.3, there are glaring socio-economic and demographic discrepancies across Greater Sydney. In addition to these discrepancies, this study employed a suite of statistical and econometric tests to define submarkets using key housing variables such as house price, income, rent, housing supply and population.

Table 7.1 compares the disparities across different regions in Greater Sydney. Firstly, housing prices of northern and eastern regions are significantly higher than the median housing prices of western, inner-west and southern regions of the city. Importantly, the median housing prices of the LGAs that makeup each region are relatively similar within each region. This highlights a high degree of housing price substitutability within each region. This is confirmed by the results from the cointregation tests. The results from Table 7.2 suggest that there is a long run equilibrium in house price for all LGAs that makeup each region. Nevertheless, Table 7.3 shows no comparable results for the housing prices among these 5 regions. This suggests that housing prices in these 5 housing submarkets are segmented. To further confirm the existence of housing price disparities across regions, a parametric t-test is undertaken. The results in Appendix 6 suggest that there are clear differences between these 5 regions. The only exception is between North and Eastern region. In sum, our result confirms that there are similarities in house price adjustment within each of the regions but not across the regions.

Table 7.1:Key Housing Parameters across Regions of Greater Sydney

Housing Parameter	Western	Inner-west	Southern	Eastern	Northern
Median house price for all dwellings, June 2016, (AUS$)	690,000	931,000	861,000	1,200,000	1,391,000
Median rent for all dwellings per week, June 2016, (AUS$)	435	549	505	695	650
Average personal income in 2015-16 (AUS$)	55,475	69,486	61,597	85,489	90,768

Author's compilation

Table 7.2: Johansen Cointegration Results of House Price across LGAs in a Region (Trace and Max-Eigen statistics)

	Western				Inner-west				Southern			
Hypothesis	Trace Stat.	Prob.	Max-Eigen Stat	Prob.	Trace Stat.	Prob.	Max-Eigen Stat	Prob.	Trace Stat.	Prob.	Max-Eigen Stat	Prob.
None	1373***	0.00***	317***	0.00***	79.25***	0.00***	34.55**	0.04**	75.08**	0.01**	34.61**	0.04**
At most 1	1056***	0.00***	232***	0.00***	44.70*	0.09*	20.60	0.00	40.47	0.20	29.29**	0.002**

The Johansen cointegration tested the null hypothesis of no cointegration in house price across all LGAs in a region. The results rejected the tested hypothesis of no cointegration across all housing regions at P<0.01 and P<0.05. *** denotes a rejection of the tested hypothesis at the 1% level, ** denotes a rejection of the tested hypothesis at 5% level, * denotes a rejection of the tested hypothesis at 10% level.

	Eastern				Northern			
Hypothesis	Trace Stat.	Prob.	Max-Eigen Stat	Prob.	Trace Stat.	Prob.	Max-Eigen Stat	Prob.
None	48.87***	0.00***	29.38**	0.00***	842***	0.00***	174***	0.00***
At most 1	19.48***	0.01**	17.15	0.01**	668***	0.00***	133***	0.00***

The Johansen cointegration tested the null hypothesis of no cointegration in house price across all LGAs in a region. The results rejected the tested hypothesis of no cointegration across all housing regions at P<0.01 and P<0.05. *** denotes a rejection of the tested hypothesis at the 1% level, ** denotes a rejection of the tested hypothesis at 5% level, * denotes a rejection of the tested hypothesis at 10% level.

Table 7.3: Johansen Cointegration Results of Key Housing Variables (Trace and Max-Eigen statistics)

	House Price				Income				Rent			
Hypothesis	Trace Stat.	Prob.	Max-Eigen Stat	Prob.	Trace Stat.	Prob.	Max-Eigen Stat	Prob.	Trace Stat.	Prob.	Max-Eigen Stat	Prob.
None	60.72	0.21	22.53	0.56	61.04	0.20	23.56	0.48	49.20	0.11	26.92	0.26
At most 1	38.18	0.29	18.77	0.43	37.47	0.32	17.55	0.53	42.27	0.15	21.53	0.24

The Johansen cointegration tested the null hypothesis of no cointegration in each variable (e.g. house price) across all submarkets (western, inner-west, southern, eastern, and northern). The results failed to reject the tested hypothesis of no cointegration in house price, income and rent across all housing submarkets at P<0.01 and P<0.05. *** denotes a rejection of the tested hypothesis at the 1% level, ** denotes a rejection of the tested hypothesis at 5% level, * denotes a rejection of the tested hypothesis at 10% level.

	Housing Supply				Population			
Hypothesis	Trace Stat.	Prob.	Max-Eigen Stat	Prob.	Trace Stat.	Prob.	Max-Eigen Stat	Prob.
None	75.09**	0.02**	27.33	0.24	80.04***	0.00***	40.55***	0.00***
At most 1	37.75	0.10	22.47	0.19	39.49	0.24	22.86	0.17

The Johansen cointegration tested the null hypothesis of no cointegration in each variable (e.g. house price) across all submarkets (western, inner-west, southern, eastern, and northern). The results failed to reject the tested hypothesis of no cointegration in house price, income and rent across all housing submarkets at P<0.01 and P<0.05. *** denotes a rejection of the tested hypothesis at the 1% level, ** denotes a rejection of the tested hypothesis at 5% level, * denotes a rejection of the tested hypothesis at 10% level.

Table 7.4: SEIFA Index of Relative Socio-Economic Advantage and Disadvantage by LGA

Western		Inner-west		Southern		Eastern		Northern	
LGA	**Index**	**LGA**	**Index**	**LGA**	**Index**	**LGA**	**Index**	**LGA**	**Index**
Auburn	959	Ashfield	1097	Botany Bay	1028	Randwick	1096	Hornsby	1115
Bankstown	961	Burwood	1043	Hurstville	1043	Sydney	1095	Hunter Hills	1143
Blacktown	993	Canada Bay	1107	Kogarah	1043	Waverly	1140	Ku-ring-gai	1166
Blue Mountains	1042	Leichhardt	1097	Rockdale	1023	Woollahra	1165	Lane Cove	1154
Camden	1056	Marrickville	1097	Sutherland	1088			Manly	1120
Campbelltown	948	Strathfield	1063					Mosman	1165
Fairfield	961							North Sydney	1159
Hawkesbury	896							Pittwater	1120
Holroyd	1014							Ryde	1088
Liverpool	959							Hills Shire	1133
Parramatta	972							Warringah	1120
Penrith	1063							Willoughby	1136
Wollondilly	988							Hornsby	1115
Average Score	**985**		**1084**		**1045**		**1124**		**1134**

Source: (ABS 2016d)

Table 7.4 shows the existence of socio-economic discrepancies across regions using the Socio-Economic Indexes for Areas (SEIFA) computed by the Australian Bureau of Statistics (ABS 2016d). The LGAs in western, inner-west and southern regions of Greater Sydney generally have an Index of Relative Socio-Economic Advantage and Disadvantage below the average index for the city. This reveals that these regions are relatively more socio-economically disadvantaged. The northern and eastern regions reveal contrary results. This shows greater divergences in the social and economic features of Greater Sydney. For instance, Ku-ring-gai, an LGA in the northern region of Greater Sydney, recorded the highest index in Australia (the most socio-economically advantaged LGA), whilst Auburn and Liverpool LGAs in the western region appear the most socially disadvantaged LGAs in Australia. To sum up, the prevailing differences in the socio-economic and demographic characterisation of the different regions across Greater Sydney has been clearly highlighted. This also implies that within a metropolitan city, spatial arbitrage is likely to be greater than between cities, resulting into housing submarkets with similar social and economic characteristics.

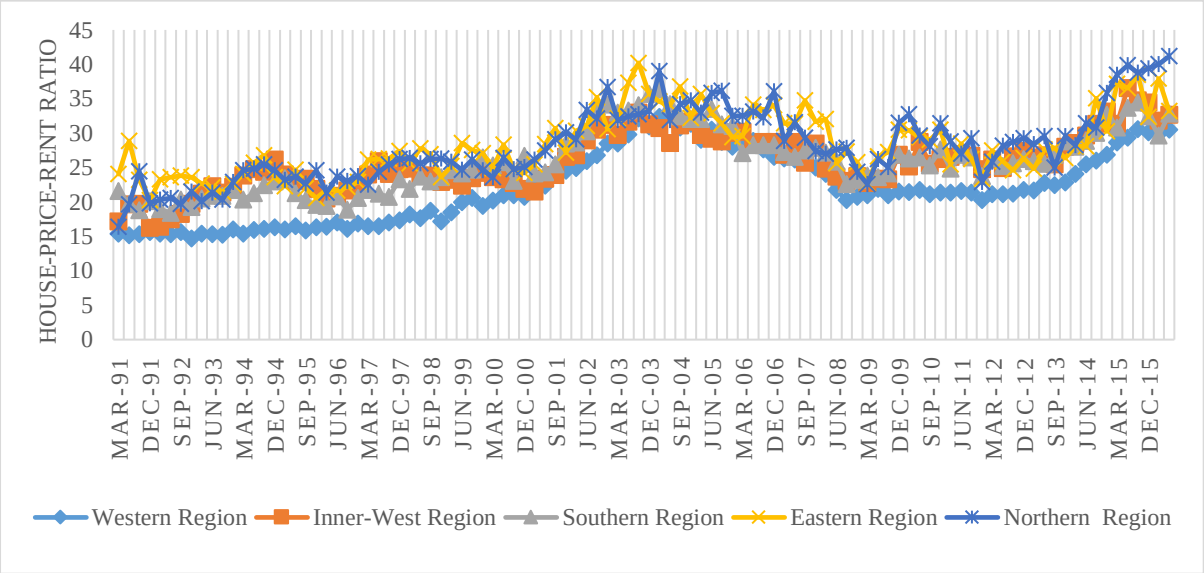
Given the SEIFA index is an aggregated score that considers a number of socio-economic variables such as income, employment, education level, and access to resources, we also tested income inequality among LGAs for each region. Again, the income levels among LGAs for each region are cointegrated. However, no comparable evidence is found among different regions. This asserts that there is an income inequality among different regions. The parametric t-test results in Appendix 6 and the cointegration results in Table 7.3 also confirm the existence of housing price inequality among different regions. We found the comparable evidence for rent. This further highlights the existence of housing submarkets in Greater Sydney.

All of the abovementioned highlighted the existence of housing submarkets in Greater Sydney. Specifically, there is empirical evidence to suggest that income, rent and housing prices in these 5 regions are segmented. As such, housing prices in some regions should move faster than other regions. Importantly, some of the increases might not be justified by key market fundamentals such as income and rents. This also implies that the presence of housing bubbles, if any, are not homogenous across a city. As such, 5 major regions across Greater Sydney were delineated - western region, inner-west region, southern region, eastern region, and northern region. These regions and the local government areas (LGAs) included in each region are portrayed in Table 2.4.

7.3 Descriptive Analysis of House Price and Rent

Prior to the presentation of the bubble test results, the study exhibits the quarterly house-price-rent ratio of the different regions of Greater Sydney in Figure 7.1. All five ratios exhibit a general increase over 1991Q1-2004Q1. As shown in Figure 7.1, there is a continuous increase in the house-price-rent ratio in the first part of 2000s across all regions though with varying magnitudes. The increase in the ratio during this period can be attributed to housing policy change that encouraged an increase in rental property investment (Shi et al. 2016). Beyond this period the ratios in all five regions generally decline until the year before the global financial crisis. The ratios decline to the levels of the year 2000. Post 2010, the ratios take an upward trend to reach the level of 2003.

Figure 7.1: Trend of House-Price-Rent-Ratio



Source: (NSW Department of Housing 2019)

The trend of the ratio, as shown in Figure 7.1, generally demonstrates some degree of instability over time, which highlights the relative risk in property investment. To ascertain the instability, the Phillips-Perron unit root test is conducted. The results are reported in Table 7.5.

Table 7.5: Unit Root Results of House-Price-Rent Ratio

Unit Root Test	Western	Inner-west	Southern	Eastern	Northern
Phillips-Perron (PP)	-1.17	-1.16	-1.15	-3.75**	-3.22*

The PP test the null hypothesis of a unit root in the house-price-rent ratio of the five regions of Greater Sydney – western, inner-west, southern, eastern and northern regions. The PP results reject the null hypothesis on level at P<0.05 in the western, inner-west and southern regions, but failed to reject in the eastern and northern regions. *** denotes a rejection of the tested hypothesis at the 1% level; ** denotes a rejection of the tested hypothesis at the 5% level; and * denotes a rejection of the tested hypothesis at the 10% level.

The ratio in the western, inner-west and southern regions failed to reject the presence of unit root on level at the relevant significance level, but reject after first difference. The results confirm that the house-price-rent ratio in these regions are I(1), which suggests the lack of stability in the movement of house price and rent in these regions. Even though both house price and rent tend to move in the same direction, as demonstrated in Figure 7.1, the results point out the unbalanced rate of growth of these variables. On the other hand, the unit root test of the house-price-rent ratio in the high-income eastern and northern regions of Greater Sydney are rejected on level at the 5% and 10% significance level respectively. The results indicate stability in the movement of house price and rent in these regions. This essentially means the increase in house price in these regions is usually accompanied by a significant increase in rent, which tend to cushion the likelihood of a housing price bubble. These unit root results are skewed. The lack of stationarity in the house price-rent ratio in the relative low-income regions is an early indication of a housing price bubble, while no comparable evidence is found in the high-income eastern and northern regions of Sydney. In other words, there is no early sign of bubble occurrence in the high-income regions. The results further highlight the socio-economic imbalances in Greater Sydney. However, these preliminary results should be formally and empirically examined.

7.4 Results and Discussion

7.4.1 Panel Unit Root Results

The results of the IPS panel unit root test of house price, rent and income of the different regions of Greater Sydney are reported in Table 7.6. Unlike the results in Table 7.5 (the stationarity tests of the house-price-rent ratio), the IPS panel unit root tests the stationarity of each variable separately. The results clearly show that all the tested variables contained unit root across all regions, but they become stationary after first difference. This means these series are all first-differenced stationary or I(1).

The stationarity in the panel data for each region means any estimation of the specified model will not be spurious. Essentially, we have established that our variables behave in a stable way after first differencing and any results obtained from these variables will not be misleading. This precursory procedure leads to the estimation of Equation (11) for each region of Greater Sydney. Westerlund's (2007) procedure was employed to estimate the long run equilibrium relationship between house price and rent, and for house price and income to check the robustness of our results in each region of Sydney.

7.4.2 Panel Cointegration Results

Once the stationarity has been established, the study conducted a panel cointegration analysis to see if the interplay between house price and rent exhibits a long run equilibrium relationship in each region. As discussed earlier, the panel cointegration results will inform the existence of early signs of housing price bubble explosion. The cointegration results for each region are reported in Table 7.7.

The results show no cointegration for both the individual panel and for the panel as a whole for the western, inner-west, and southern regions at the 5% significance level. A rejection suggests the lack of a long run equilibrium relationship between house price and rent in the relative low-income regions of Greater Sydney. Apparently, any drift apart between house price and rent does not tend to return to a steady state, which indicates the formation of housing bubble in these regions. In other words, investors speculation of a higher market value for their property is precluded, as the increase in house price is not accompanied by the rental income. However, the results show a cointegrating relationship between house price and rent in the high-income eastern and northern regions of the city. For any drift apart between house price and rent in these regions, the system will return to their long run equilibrium. There are no indications of housing bubbles in these regions. This highlights the differential geography of housing price bubbles in Greater Sydney. The results reveal important information about the early signs of a housing bubble formation in Greater Sydney. The divergence between high-income and low-income regions can be attributed to the stronger investment activities in the low-income regions. Again, this disparity in the level of investment activities across the regions of Greater Sydney is well documented in Birrell and Healy (2013), CoreLogic (2016) and Valadkhani and Smyth (2017) with the highest concentration in the low-income regions of the city. Therefore, investors are more likely to engage in short-term investment or speculate on higher house prices in the low-income regions.

Given income is also a significant factor in explaining housing bubbles, the cointegration of house price and income is also scrutinised as a robustness check. The results are reported in Table 7.8. There is a lack of cointegration between house price and income in the relative low-income regions, while cointegration is found in the high-income regions. The existence of cointegration in the high-income regions means house price would stagnate or fall to allow income to catch up (Zhou 2010). Even though both house price and income tend to move in the same direction, the results point out the disproportionate rate of growth of these variables, as house prices continue to grow faster than income, especially in the relative low-income

Table 7.6: Im-Pesaran-Shin (IPS) Panel Unit Root Results

Variable	Western	Inner-West	Southern	Eastern	Northern	Western	Inner-West	Southern	Eastern	Northern
	Level	Level	Level	Level	Level	1st Difference	1st Difference	1st Difference	1st Difference	1st Difference
lnHPrice	0.42	0.99	0.99	0.99	0.99	0.00***	0.00***	0.00***	0.00***	0.00***
lnRent	1.00	1.00	1.00	1.00	1.00	0.00***	0.00***	0.00***	0.00***	0.00***
lnIncome	0.96	0.99	0.81	0.98	0.93	0.00***	0.00***	0.00***	0.00***	0.00***

The various unit root tests test the null hypothesis all panels contain unit root against the alternative hypothesis that some panels are stationary. The results failed to reject the null hypothesis on level at P<0.05 in all regions, but there is clear rejection of the tested hypothesis in all regions after first difference at P<0.01. *** denotes a rejection of the tested hypothesis at the 1% level, ** is rejection of the null hypothesis at 5% level, * is a rejection of the tested hypothesis at 10% level. IPS is the Im-Pesaran-Shin test panel unit root test.

Table 7.7: Panel Cointegration of House Price and Rent

Tests	Western		Inner-West		Southern		Eastern		Northern	
	Z-Value	P-value	Z-Value	P-value	Z-Value	P-value	Z-Value	P-value	Z-Value	P-value
G_t	1.92	0.97	-1.33	0.88	0.18	0.57	-1.40	0.08*	-1.91	0.06*
G_a	2.41	0.99	-1.22	0.58	0.17	0.57	-1.90	0.02**	-1.64	0.05*
P_t	1.92	0.97	-0.88	0.86	-0.22	0.41	-2.14	0.01**	-2.35	0.00***
P_a	1.35	0.91	-1.25	0.34	-1.14	0.13	-3.36	0.00***	-4.74	0.00***

Westerlund (2007) error-correction test the null hypothesis of no cointegration for cross-sectional unit i in (3). This is implemented as a test of H_0: $\varphi = 0$ versus H_1: $\varphi < 0$. The results of the test failed to reject the null hypothesis on level at P<0.05 in the western, inner-west and southern regions. However, the tested hypothesis of no cointegration is soundly rejected at the 1% significance level in the high-income eastern and northern regions. *** denotes a rejection of the tested hypothesis at the 1% level, ** is rejection of the null hypothesis at 5% level, * is a rejection of the tested hypothesis at 10% level. P_t and P_a are designed to test the alternative hypothesis that the panel is cointegrated as a whole and they are referred to as panel statistics, while G_t and G_a test the alternative that there is at least one individual that is cointegrated and they are referred to as group mean statistics.

Table 7.8: Panel Cointegration of House Price and Income

Tests	Western		Inner-West		Southern		Eastern		Northern	
	Z-Value	P-value	Z-Value	P-value	Z-Value	P-value	Z-Value	P-value	Z-Value	P-value
G_t	0.49	0.68	0.61	0.73	2.11	0.98	-7.64	0.00***	-50.01	0.00***
G_a	1.66	0.95	0.21	0.58	2.05	0.98	-12.22	0.00***	-43.37	0.00***
P_t	-0.33	0.37	1.09	0.86	1.47	0.93	-7.95	0.00***	-73.23	0.00***
P_a	0.01	0.51	-0.46	0.32	0.88	0.81	-21.58	0.00***	-70.74	0.00***

Westerlund (2007) error-correction test the null hypothesis of no cointegration for cross-sectional unit i in (3). This is implemented as a test of H_0: $\varphi = 0$ versus H_1: $\varphi < 0$. The results of the test failed to reject the null hypothesis on level at P<0.05 in the western, inner-west and southern regions. However, the tested hypothesis of no cointegration is soundly rejected at the 1% significance level in the high-income eastern and northern regions. *** denotes a rejection of the tested hypothesis at the 1% level, ** is rejection of the null hypothesis at 5% level, * is a rejection of the tested hypothesis at 10% level. P_t and P_a are designed to test the alternative hypothesis that the panel is cointegrated as a whole and they are referred to as panel statistics, while G_t and G_a test the alternative that there is at least one individual that is cointegrated and they are referred to as group mean statistics.

regions. The strong growth of house prices in Australia, particularly Sydney is well documented (Haylen 2014; Shi et al. 2016; Angus 2017). The income polarisation in Sydney is also reported in the literature (Randolph & Tice 2014). These results further highlight the disproportionate rate of growth in these two variables, which supports the cointegration results of house price and rent.

In summary, there is evidence of significant deviation of house price from key fundamentals such as income and rent in the relative low-income regions, while there is no evidence of such deviation in the high-income regions. These results suggest that there is high propensity of housing bubble formation in the relative low-income regions, while bubble is less likely to occur in the high-income regions. However, these results are indicative of a bubble. A formal test is required to confirm the existence of housing bubble in these regions.

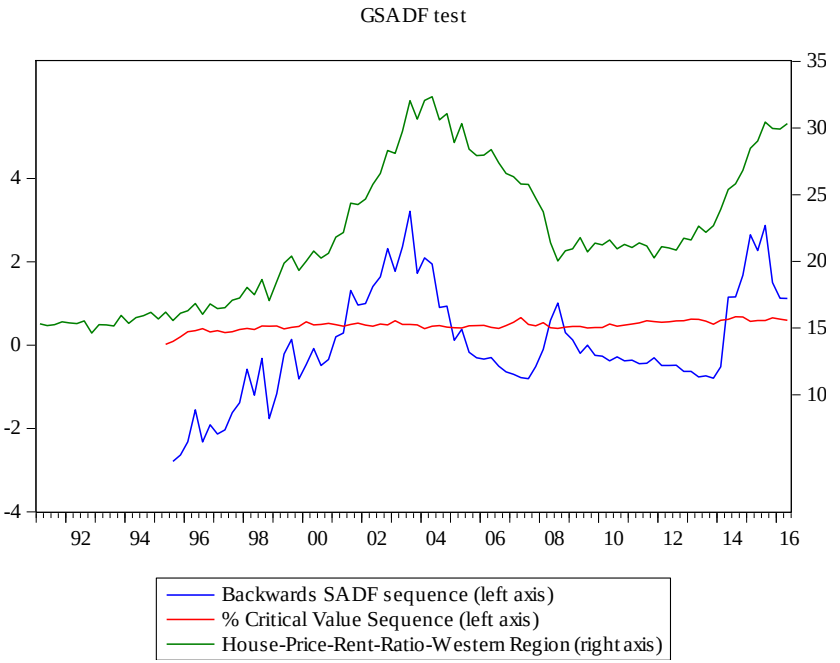
7.4.3 BSADF Price Bubbles Results

The preceding sections suggest that there is an early indication of housing price bubble in low-income region, whilst this section formally tests the existence of housing price bubble and it examines the real time bubbles using the BSADF method. The results of the BSADF are reported in Figure 7.2 (a-e). We estimated the BSADFτ statistic using Equation (20) and imposing a window size equal to 19 quarters. $Z\tau$ is considered a bubble episode if the value of the BSADFτ test statistic is larger than the right-tailed critical value of the distribution. This process utilises all information before time τ to determine if there is sufficient evidence to reject the null that $Z\tau$ belongs to the martingale null in favour of the mildly explosive alternative. In Figure 7.2 (a-e), the green line is the house-price-rent ratio, the red line denotes the 95% critical value, while the blue line is the BSADFτ. Evidence of bubble in a given quarter occurs when the blue line (BSADFτ) is above the red line (the 95% critical Value) (Itamar 2017).

The results in Figure 7.2 (a-e) exhibit evidence of an explosive bubble in the relative low-income western and inner-west regions. In the western region, there was an explosive bubble from 2001Q2 until 2005Q1, and again from 2014Q1 to 2016Q2. Even though no evidence of bubble was found in the southern region, shorter bubbles were recorded in the inner-west region from 2002Q2 to 2003Q1 and from 2003Q3 to 2004Q1. During these periods, the BSADFτ is consistently greater than the 95% critical values. Generally, the bubbles from 2001Q2 to 2005Q1 in western and inner-west regions correspond with the Australian housing boom in the 2000s (Shi et al. 2016).

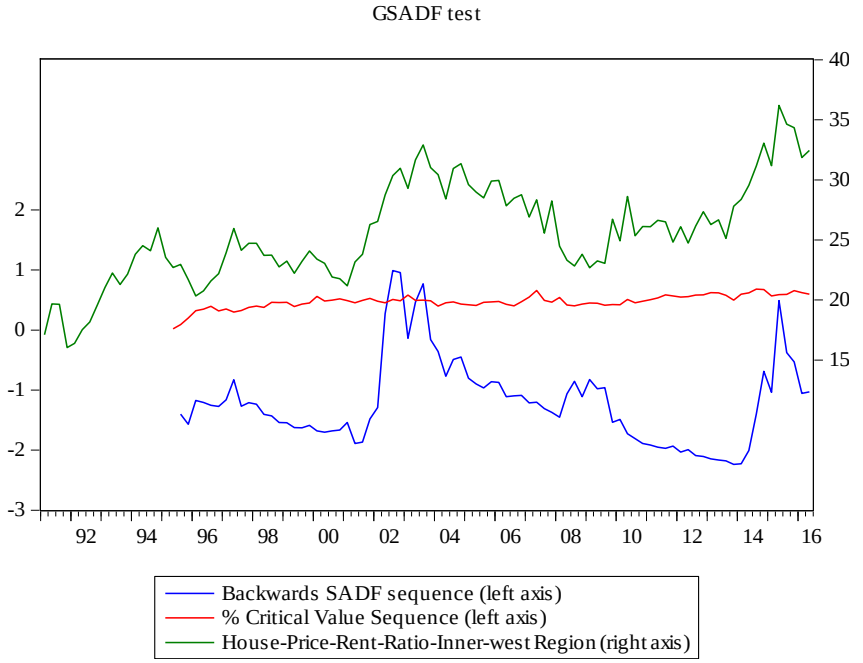
Figure 7.2: BSADF Bubbles Results for all Dwellings (Nominal)

Figure 7.2a: BSADF Bubbles Result of Western Region



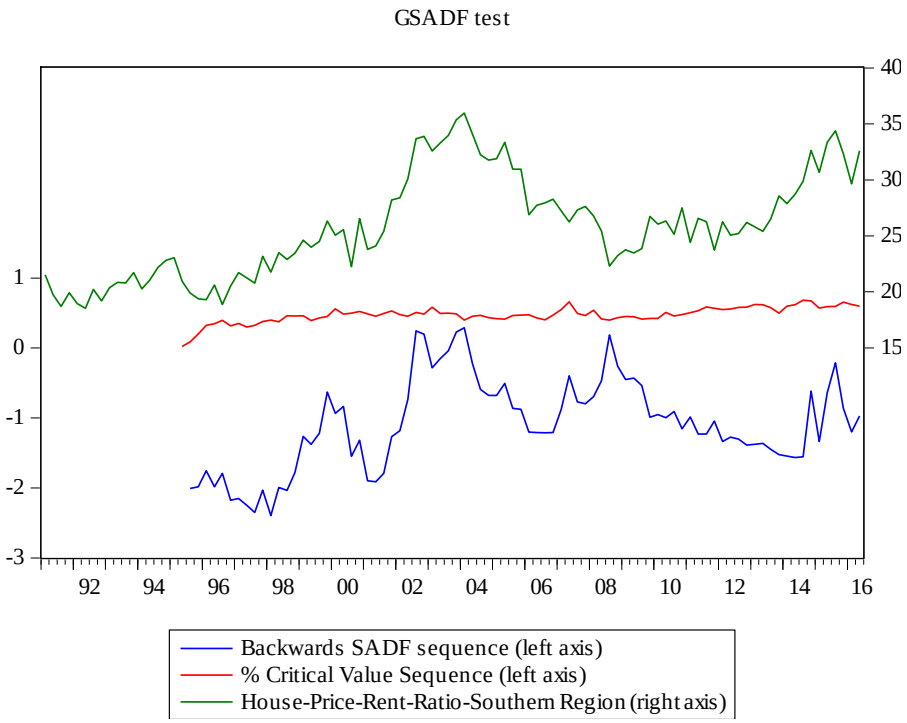
The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

Figure 7.2b: BSADF Bubbles Result of Inner-west Region



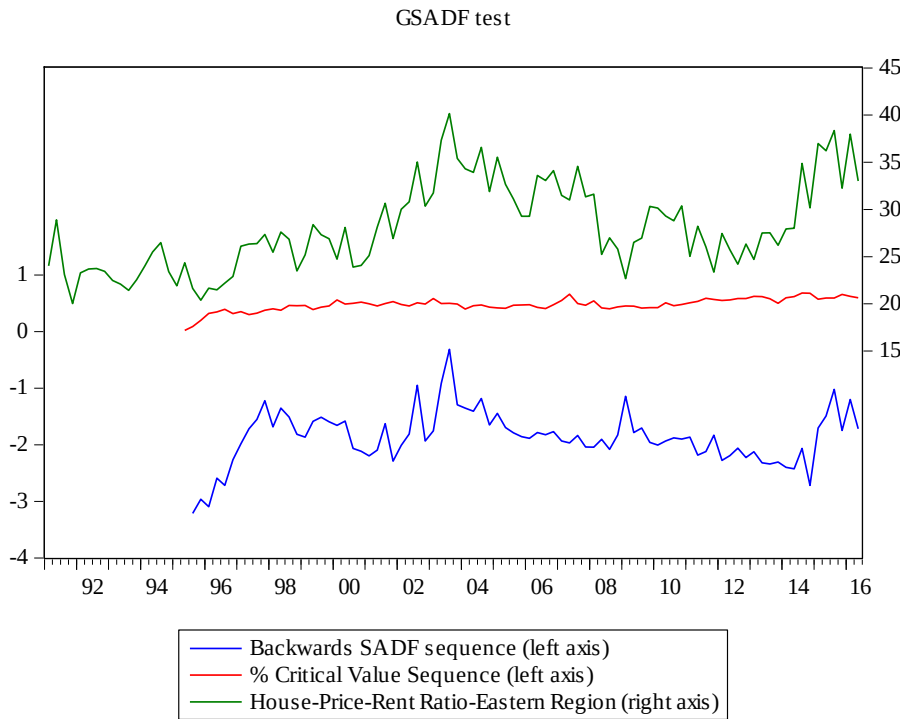
The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

Figure 7.2c: BSADF Bubbles Result of Southern Region



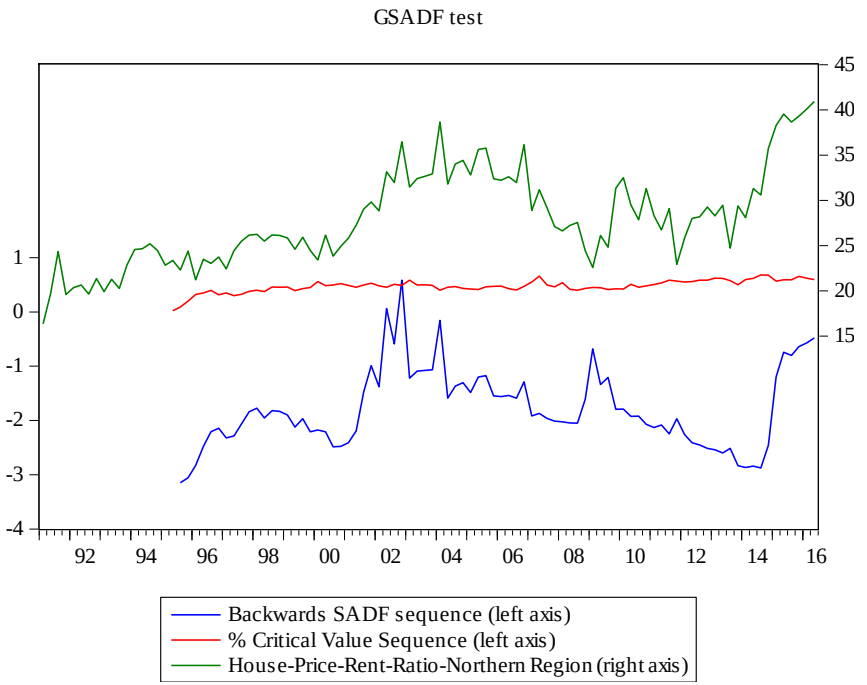
The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

Figure 7.2d: BSADF Bubbles Result of Eastern Region



The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

Figure 7.2e: BSADF Bubbles Result of Northern Region



The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

This period also corresponds with significant changes in the capital gains tax in September 1999, which gives investor a 50 percent discount on tax payable if they hold their property investment for one year (Bloxham et al. 2011). Consequently, about 45 percent of all new housing loans were for investment purposes by the year 2003 (Bloxham et al. 2011) and it can be argued that housing policy change induced an increase in rental property investment. Tax and investment policy change therefore stimulate property investment, which drives house price. The house prices subsequently collapse because, as revealed by the cointegration results, the growth in rent and income is not proportionate to the rise in house price especially in the relative low-income regions. As such investors' expectations of higher market value for their properties could not be eventuated. The results are similar to the findings of Bloxham et al. (2011), who also found the growth in house prices between 2002 and 2003 to be non-sustainable.

Again, the evidence of housing bubble between 2014 and 2016 cannot be unconnected to the rise in demand for property investment in these regions. As asserted by Wokker and Swieringa (2016), there was a concentration of investment in residential real estate in Melbourne and Sydney during this period, with more than 20,000 foreign investment approvals in Sydney alone. More importantly, the rapid growth in the demand for investment in inner-city housing and apartments in Sydney is also reported by Birrell and Healy (2013) and Valadkhani and Smyth (2017), particularly Chinese investors (Dallas et al. 2015; Zhang et al. 2019). They found that the significant increase in property investment has expanded housing demand, which drives house prices, particularly in the western and inner-west regions of Sydney. In 2016, for example, 28.9 percent of all dwellings in Greater Sydney were owned by investors and most of these investments were concentrated in the relative low-income western and inner-west regions of the city (CoreLogic 2016). In the high-income eastern and northern regions, there are no indications of housing bubbles throughout the study period. Apparently, there is no significant deviation of house price from key fundamentals such as rent and income in the high-income regions. This shows that house prices in these regions tend to grow steadily with these fundamentals. This further supports Shiller's (2007) psychological assertion and reinforces our hypothesis of housing price bubbles are only evident in the relative low-income regions. This is due to the fact that housing investments are concentrated in these regions and housing investors, unlike owner-occupiers, are more likely to speculate.

To sum up, the results suggest that there is evidence of housing bubbles in the relative low-income western, inner-west and southern regions of Greater Sydney. This shows the

importance of disaggregated housing studies, as they reveal significant information that is often ignored in aggregated studies. These regional differences are usually not highlighted in aggregate studies. The existence of housing bubbles in the relative low-income regions can be attributed to stronger investment activities in the regions. Given housing investors are more likely to speculate compared with owner-occupiers, the differential geographical results between low-income and high-income regions is reasonable. This also supports the Shiller's (2007) psychological assertion.

7.4.4 Robustness Check

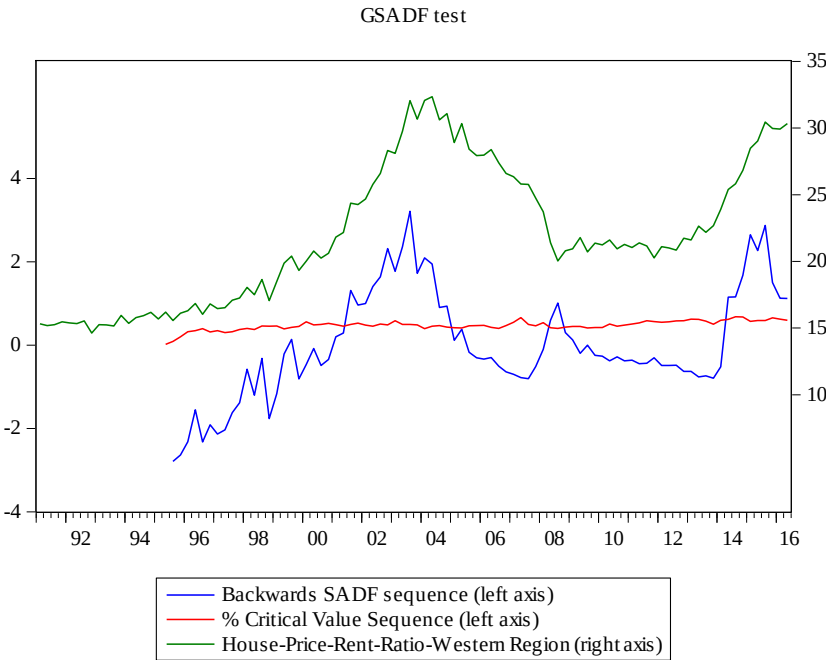
To check the robustness of the baseline findings of housing bubble test, the study performed several balanced checks. First, we conducted a test of the real house-price-rent-ratio. We used the quarterly consumer price index (CPI) computed by the ABS to derive the real house price-rent-ratio. The CPI used in our study is a basic measure of the change in the expenditure of a basket of goods and services between two quarters resulting from a change in the price of the items in the basket (ABS 2017b). The CPI index measures price changes relating to the spending pattern of all households in the metropolitan cities of Australia. This makes the CP1 appropriate in our study since we examine house price bubbles in one of the metropolitan cities of Australia, namely Greater Sydney[14].

The results of the real house-price-rent ratios are consistent with our baseline findings. Two key caveats can be drawn from these results: first, the results of the real house-price-rent ratio bubbles test are similar to the nominal house-price-rent ratio, and second, house prices in the low-income region is not cointegrated by rents, whilst there is no comparable evidence in the high income region, confirming the notion of areas with housing investment concentration is more sensitive to psychological factors, which leads to the formulation of housing bubble. The robustness results of the BSADF are reported in Figure 7.3 (a-e). Similar to our baseline findings, we estimated the BSADFτ statistic using (20) and imposing a window size equal to 19 quarters. Again, Zτ is considered a bubble explosion if the value of the BSADFτ test statistic is greater than the right-tailed critical value of the distribution. From Figure 7.3 (a-e), the results show evidence of an explosive bubble in the relative low-income western and inner-west regions. Similar to our earlier findings, there is an evidence of explosive housing bubble in three separate periods in the western region. It starts from 2001Q2 until 2005Q1, a spike from

[14] Real House Price-Rent-Ratio = PRR_t /(CPI_t/CPI_{t-1}) where PRR_t is the house price-rent-ratio at quarter t, CPI_t is the CPI at quarter t, and CPI_{t-1} is the CPI in the previous quarter.

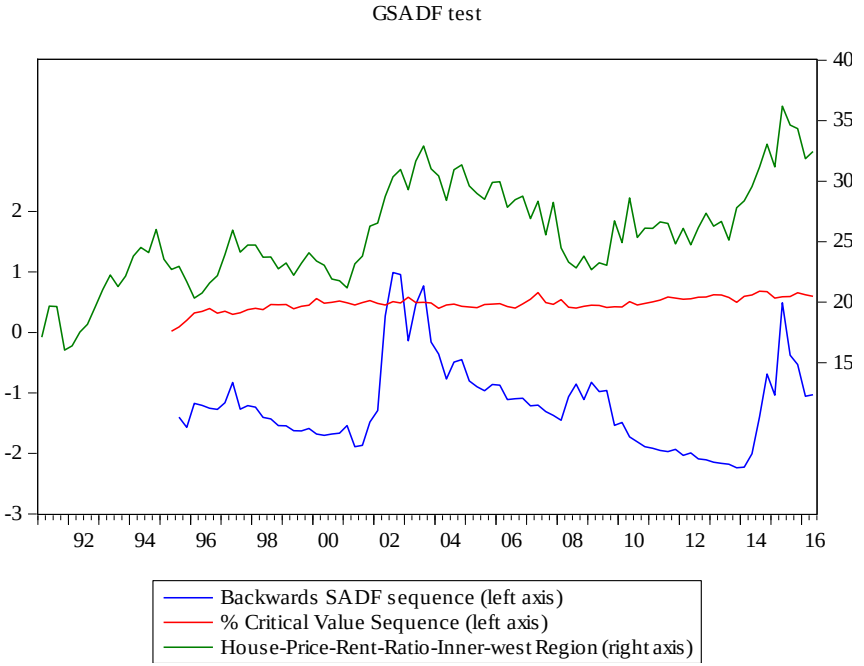
Figure 7.3: BSADF Bubbles Results for All Dwellings (Real)

Figure 7.3a: BSADF Bubbles Result of Western Region



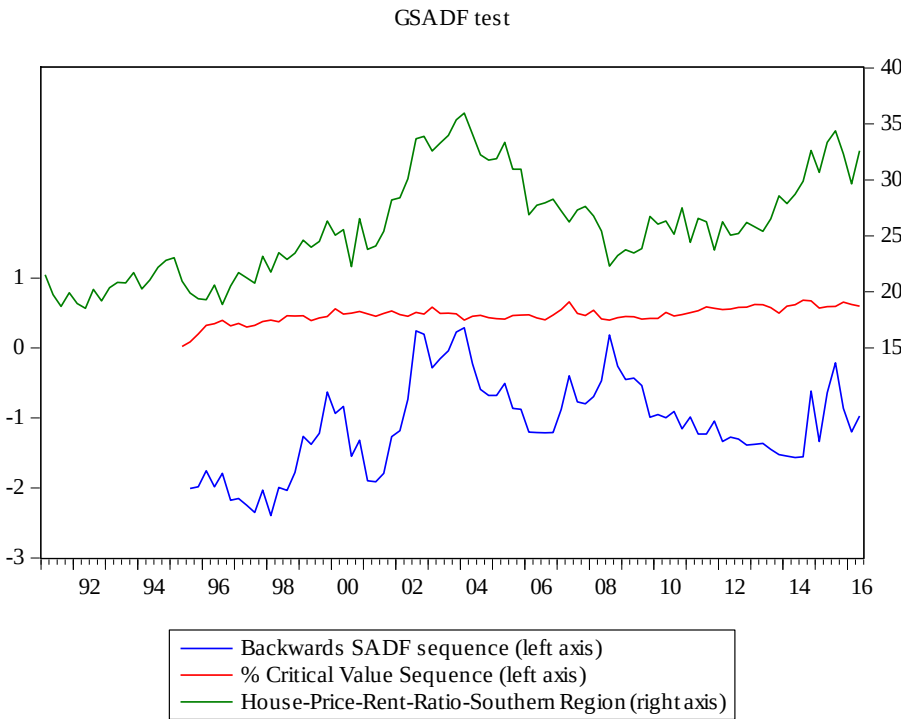
The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

Figure 7.3b: BSADF Bubbles Result of Inner-west Region



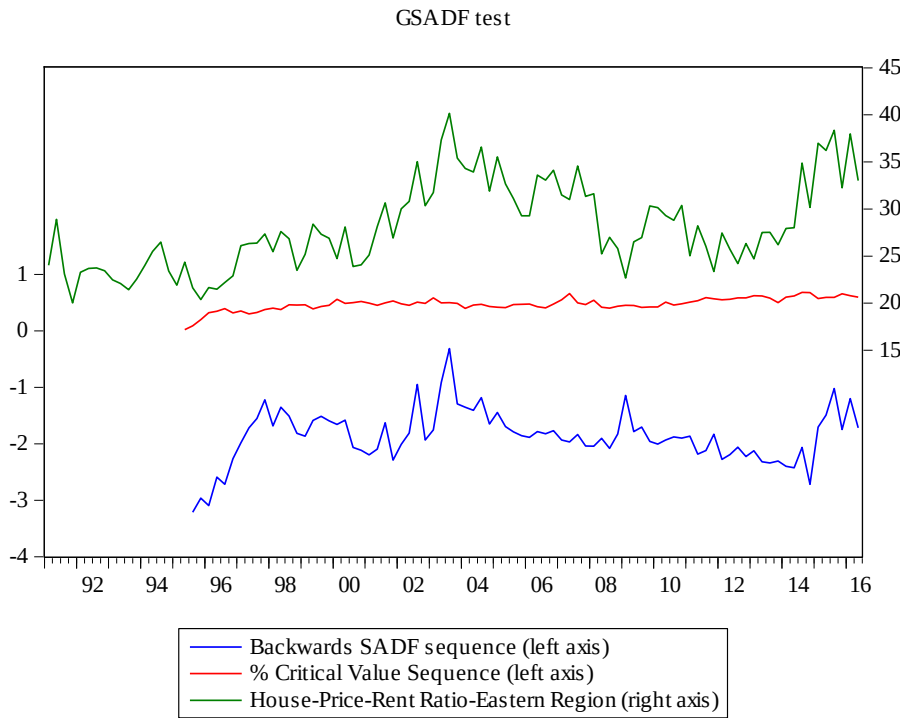
The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

Figure 7.3c: BSADF Bubbles Result of Southern Region



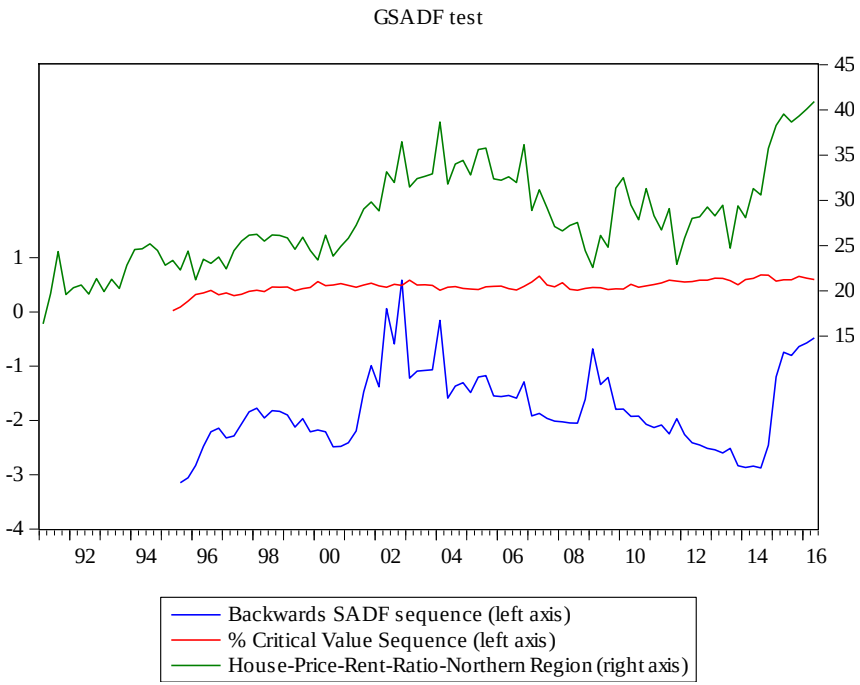
The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

Figure 7.3d: BSADF Bubbles Result of Eastern Region



The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

Figure 7.3e: BSADF Bubbles Result of Northern Region



The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

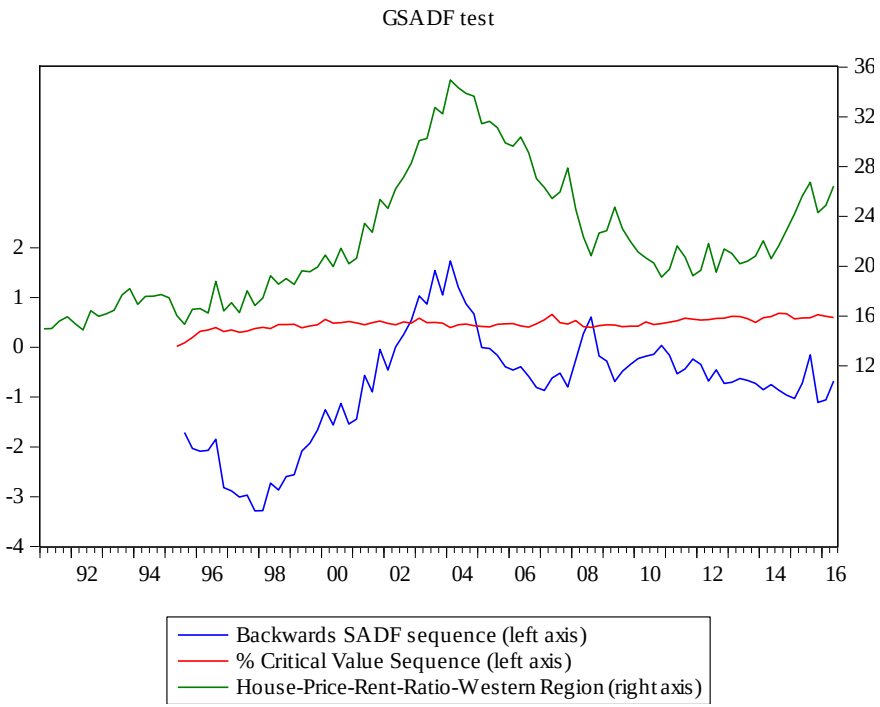
2008Q1 to 2009Q4, and again from 2014Q1 to 2016Q2. There is no evidence of housing bubble in the southern region, while evidence of shorter bubbles was recorded in the inner-west region from 2002Q2 to 2003Q1 and from 2003Q3 to 2004Q1. During these periods, the BSADFτ is consistently greater than the 95% critical values, which exhibits housing bubbles. Conversely, there are no indications of housing bubbles in the high-income eastern and northern regions throughout the study period. This means house prices tend to grow steadily with rent in the high-income regions of Greater Sydney. The results are also consistent with the panel error-correction based results discussed earlier, which show cointegration between house price and income in the eastern and northern regions of Greater Sydney, but not in the relative low-income regions.

Secondly, as reported by Valadkhani and Smyth (2017), there is a complex interplay between house and unit prices in the major cities of Australia including Sydney. Further, Morley and Thomas (2016), and Lee (2017) found that different types of housing have different risk-return profiles and as such, different housing types can make up different housing submarkets. CoreLogic (2016) also reported that housing investment in Sydney is mostly concentrated within the unit/apartment housing market. Since our baseline findings are based on all dwellings, our next balanced check is a housing bubble test of strata and non-strata using median quarterly price and rent. Strata titles, as defined by Housing NSW, include town houses, terraces/villas, flats/units, whereas non-strata title properties refer to detached houses. The bubble tests of these housing types were estimated and the results are reported in Figure 7.4 (a-e) and Figure 7.5 (a-e).

Generally, the results for both strata and non-strata are consistent with our earlier findings. While there is evidence of housing bubbles for strata dwellings in the relative low-income western and southern regions of the city, no comparable evidence was found in the high-income eastern and northern regions. In the case of non-strata dwellings, there is clear evidence of a housing bubble in all the relative low-income regions of Greater Sydney. However, in the high-income regions, apart from a minor bubble sign in the northern region between September 2003 and December 2003, there is no other evidence of a housing bubble in these regions. These robustness results offered some further evidence to support our earlier argument that housing price bubble predominantly occurs in the relative low-income regions. These findings have provided critical information that could be used by policy makers to stabilise the growth of house price in the relative low-income regions.

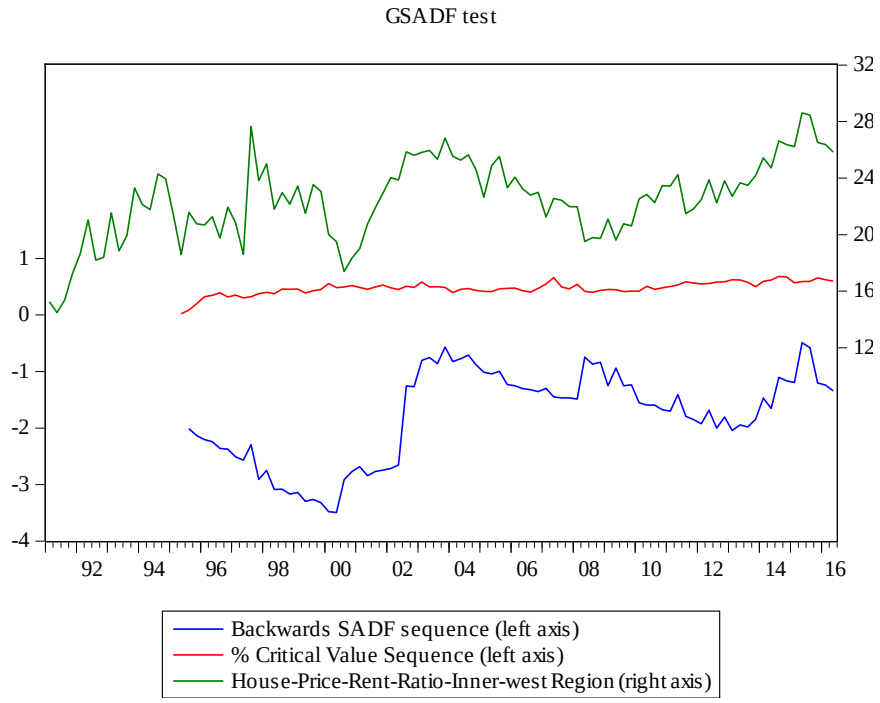
Figure 7.4: BSADF Bubbles Results for Strata Dwellings

Figure 7.4a: BSADF Bubbles Result of Western Region



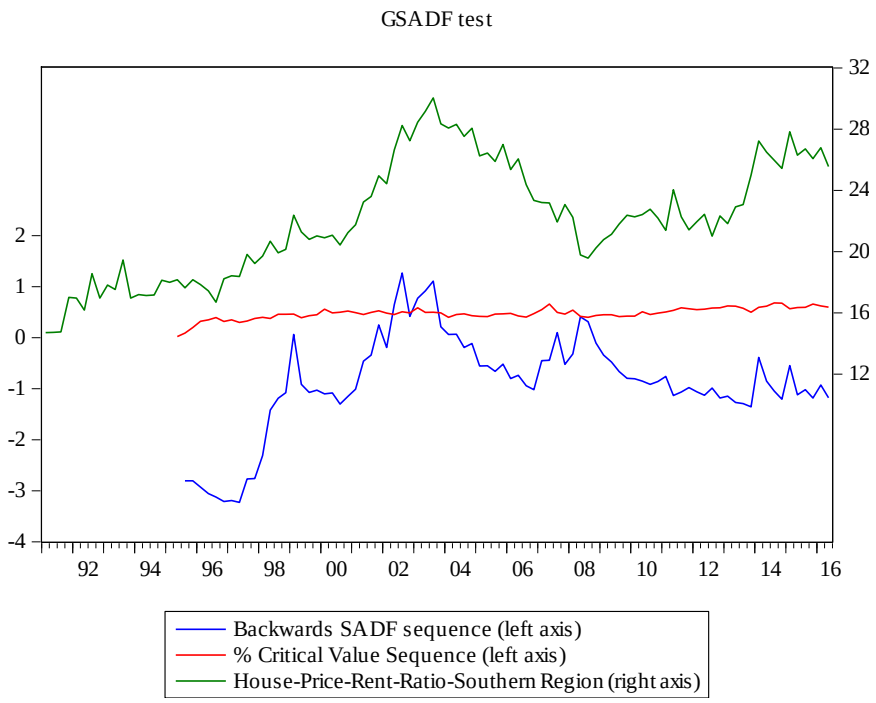
The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

Figure 7.4b: BSADF Bubbles Result of Inner-west Region



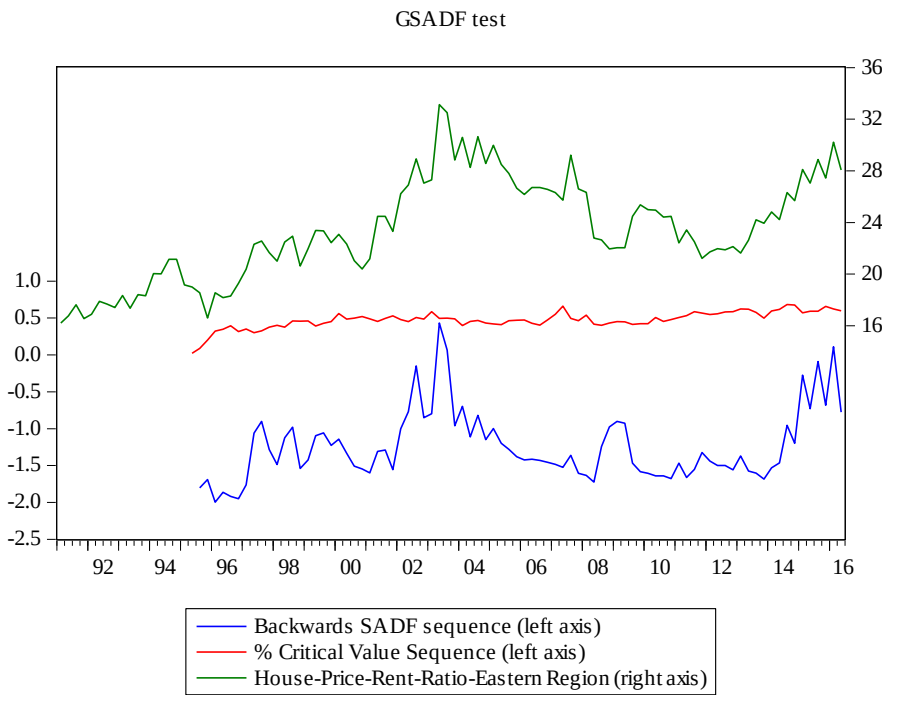
The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

Figure 7.4c: BSADF Bubbles Result of Southern Region



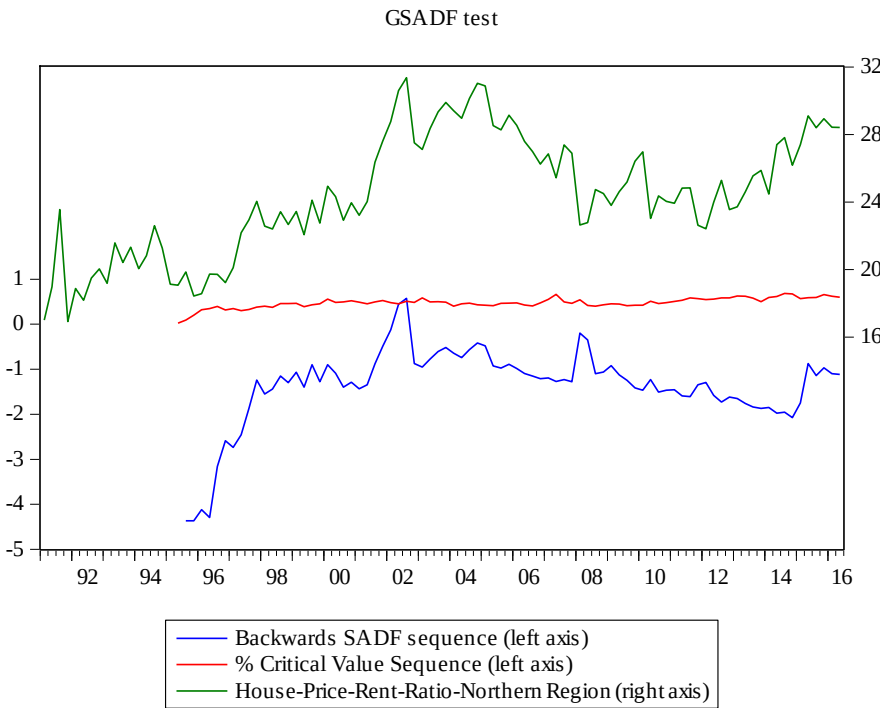
The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

Figure 7.4d: BSADF Bubbles Result of Eastern Region



The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

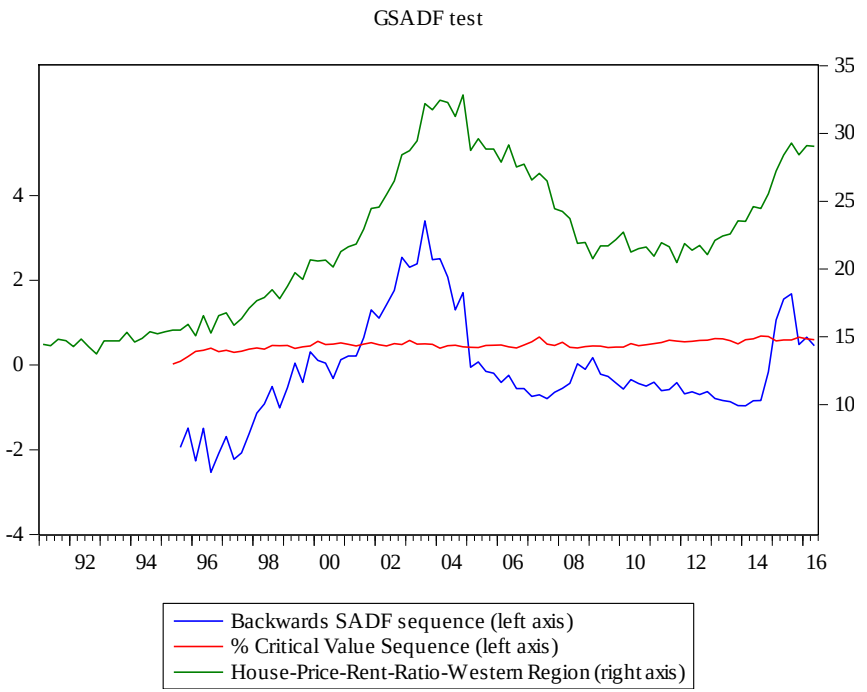
Figure 7.4e: BSADF Bubbles Result of Northern Region



The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

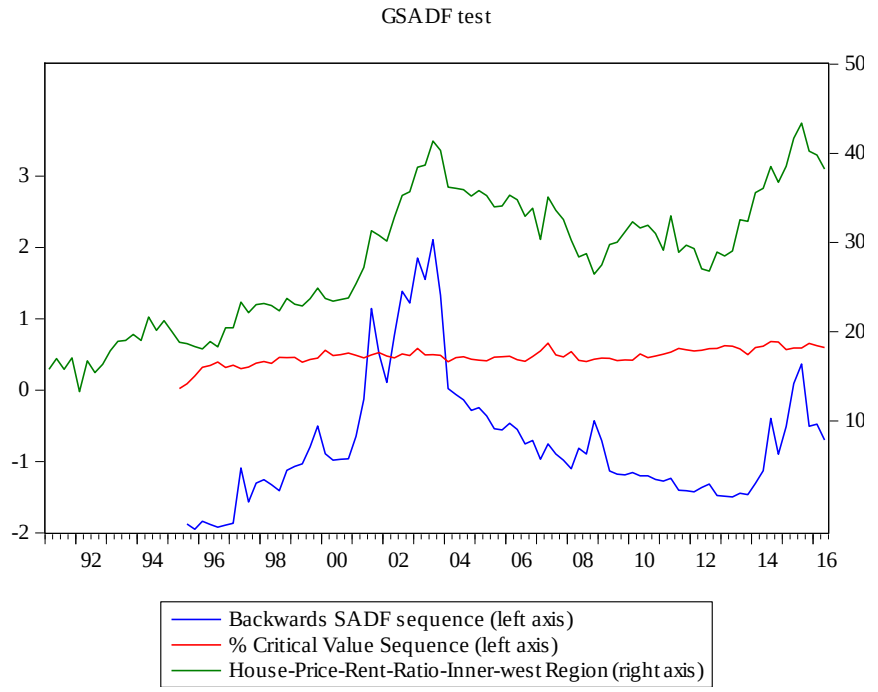
Figure 7.5: BSADF Bubbles Results for Non-Strata Dwellings

Figure 7.5a: BSADF Bubbles Result of Western Region



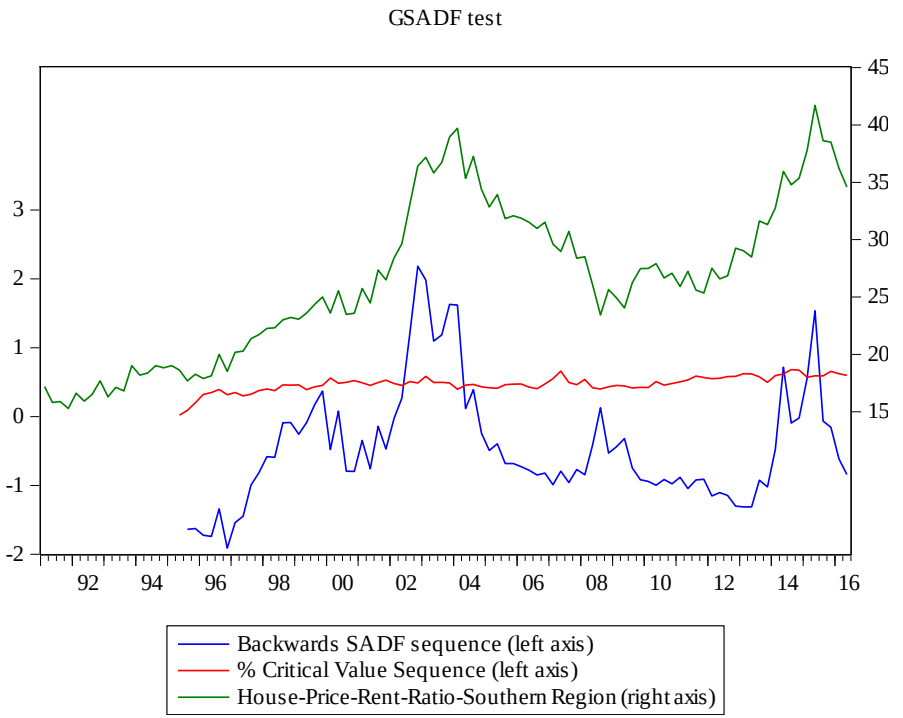
The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

Figure 7.5b: BSADF Bubbles Result of Inner-west Region



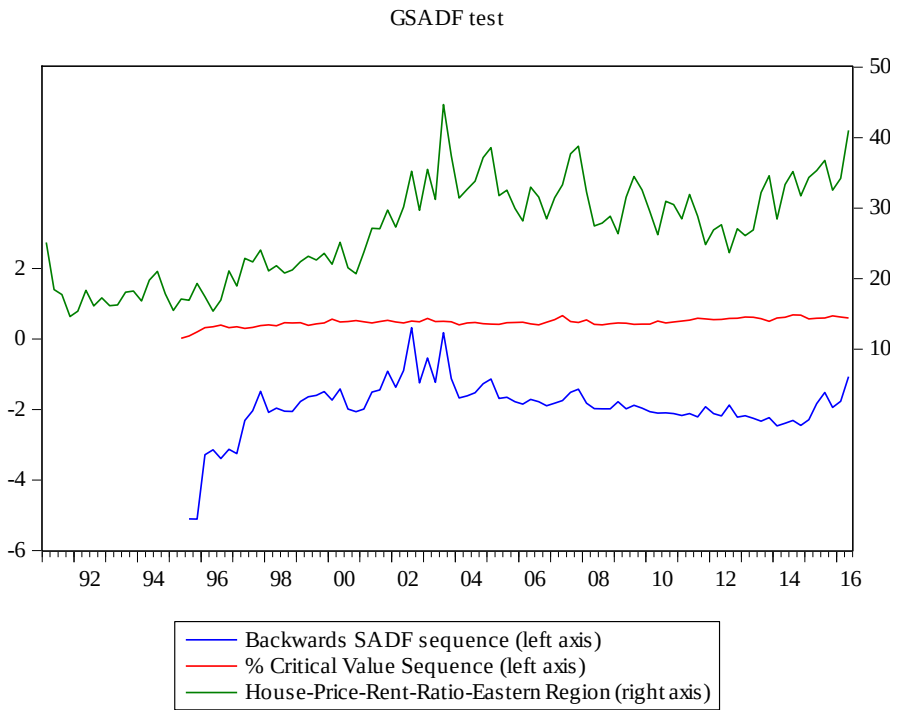
The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

Figure 7.5c: BSADF Bubbles Result of Southern Region



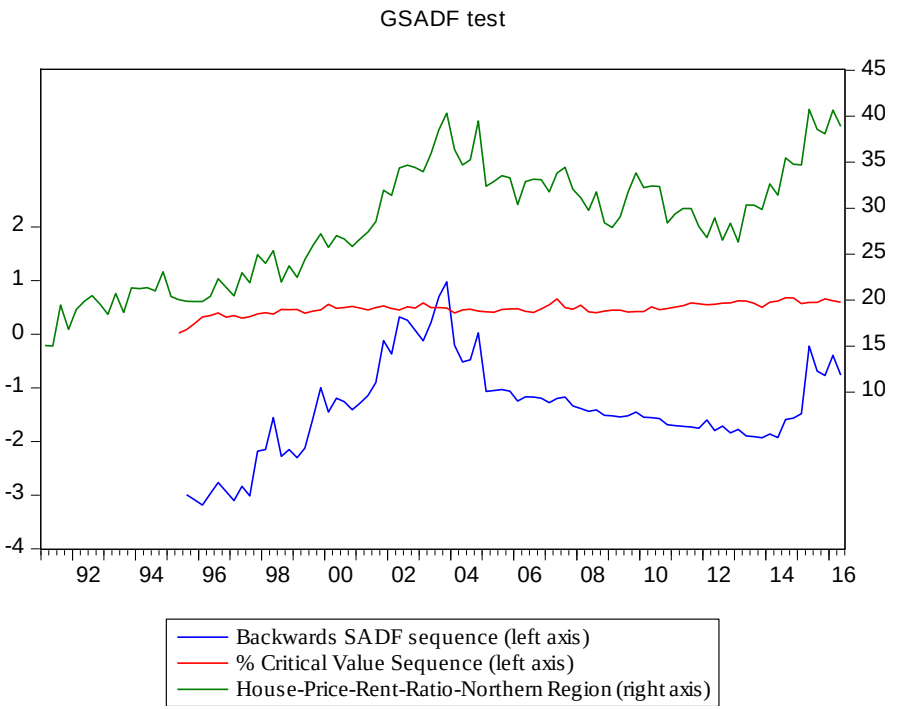
The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

Figure 7.5d: BSADF Bubbles Result of Eastern Region



The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

Figure 7.5e: BSADF Bubbles Result of Northern Region



The figure is a test of the null hypothesis of no bubbles for each quarter starting from the 20th quarter over 1991Q1-2016Q2 against the alternative that there is a mildly explosive bubble. This means there is evidence of a bubble in a quarter where the blue line is above the red line. The red line is the 95% critical value and the blue line is the BSADFτ (Phillips et al. 2015; NSW Department of Housing 2019)

7.5 Conclusion of the Chapter

Recognising the socio-economic and demographic disparities within a metropolitan city that are often largely ignored in housing analyses, we adopted a sub-city approach and employed panel unit root and Westerlund (2007) error-correction based panel cointegration test to examine the existence of housing price bubble in the different regions of Greater Sydney– western, inner-west, southern, eastern, and northern - over 1991-2016. A formal housing price bubble test was also done following the BSADF procedure to check for real time bubble period for each region of Sydney using both nominal and real house-price-rent ratio for various housing types. Several key findings have been documented.

Using Westerlund (2007) panel cointegration analysis, the results show no cointegration between house price and rent in the relative low-income western, inner-west and southern regions of Greater Sydney. This confirms that house price and rent are growing disproportionately and do not return to an equilibrium. This is an early housing bubble indication. The results, however, reject the tested hypothesis in the eastern and northern regions of the city. This shows in turn that house price and rent are linked over time, which shows the lack of a housing bubble in these regions. The cointegration analyses have signalled evidence of housing bubble formation in the relative low-income regions but not in high-income regions. The results show the geographical variation in the interplay between house price and rent over time across the regions of Greater Sydney. The results consistently provide an indication of a housing bubble in the relative low-income regions.

To shed more light into the geographical differential of Greater Sydney, a formal housing bubble test was also conducted using the BSADF test. The BSADF results show evidence of housing bubbles in the relative low-income western and inner-west regions for all dwellings. However, there is no evidence of housing bubbles in the high-income eastern and northern regions. Considering non-strata dwellings, there is clear evidence of a housing bubble in all the relative low-income regions of the city, while no such evidence exists in the high-income regions. Similar results are obtained for strata dwellings. These results indicate that investment from housing investors is possibly contributing to the strong housing demand in these regions, which are unrelated to fundamentals (i.e. rents) and drives house prices to non-sustainable levels. These results reflect Shiller's (2007) psychological theory of house prices, where investors expect higher house prices that are not always realised.

CHAPTER 8

HOUSE PRICE LINKAGES

8.1 Background

The increasing social and economic polarisation of Greater Sydney has been discussed in the housing literature in recent years (Randolph & Holloway 2005b; Randolph & Tice 2014). Bunker et al. (2005) also discussed the polarised spectrum of housing opportunities in Sydney. They found that higher income households mainly live in waterfront and inner city areas, while the most disadvantaged households live in the middle and outer suburbs. These shades of socio-economic differences have led to more diverse household living arrangements, resulting in the existence of housing submarkets across Greater Sydney.

Even though extensive studies have examined house price linkages between regional housing markets, these studies have focused largely on the extent to which regional housing markets, instead of housing submarkets, are interrelated and what is known as a spillover effect (i.e. the spread in house price from one market to another).[15] A spillover effect refers to the patterns of home price movements among different markets. The spread or co-movement of house prices from one market to the other can be due to changes in economic conditions such as mortgage lending rate, business cycle, financial market and activities in the property industry. Although empirical evidence of the existence of the spillover effect has been demonstrated in regional housing markets, the theoretical explanations of this phenomenon are still inadequate and unclear. This could be attributed to the complexity of housing market dynamics. As such, this complexity continues to heighten interest in exploring the relationships of housing submarkets.

Importantly, housing submarket analyses may unveil important information (e.g. residential asset wealth distribution) that is often overlooked by aggregate studies - national or capital city level (Gibler & Tyvimaa 2014; Teng et al. 2017; Teye et al. 2018). This is supported by the earlier studies of Meen (1996) and Leishman (2009), who highlighted that housing market dynamics are better analysed as a series of interconnected submarkets due to the complex relationships that exist between submarkets within metropolitan areas. Thus, submarket studies provide useful tools and information for analysing housing market dynamics. Further submarket analysis allows policy makers, households, investors and lending institutions to utilise this information for better house price behavioural analysis and decision making (Gibler & Tyvimaa 2014; Teng et al. 2017; Teye et al. 2018).

[15] Spillover effect and price diffusion are used interchangeably in this study.

Nevertheless, limited attention has been paid on the spillover effect of housing submarkets. While there is some evidence of the distinct features of different housing submarkets (Doh-Khul et al. 2006; Leishman et al. 2013), few studies have explicitly explained their interrelationships (Ho et al. 2008; Wilson et al. 2011; Teye et al. 2018). Specifically, Teye et al. (2018) found that house prices causally flow from the central to the peripheral submarkets in Amsterdam, implying the migration hypothesis in which households will relocate to a region where house price is relatively low. This hypothesis is consistent with the notion of the Alonso-Mills-Muths theory, which posits that households would relocate to relative low-priced areas, by taking advantage of price differentials, and commute to the central business district (Lai & Tsai 2008). This implies that households can relocate to the relative low-priced region and commute to regions with economic opportunities. However, the findings of Ho et al. (2008) supports the hypothesis of equity transfer in which households, particularly repeat buyers would like to move up the property ladder. This means submarkets with lower prices (or quality tiers) will diffuse to submarkets with higher quality tiers. This hypothesis is consistent with the residential mobility urban theory, which asserts that households would improve their housing circumstance and explore economic opportunities in more prosperous regions (Clark 2017). This is also consistent with the filtering concept in urban housing markets that was proposed by Galster and Rothenberg (1991). They suggest that submarkets, that are segmented by quality, are interrelated as households tend to switch between them. Stein (1995) further highlight that households, particularly current home owners tend to trade up for higher quality homes in desirable areas as their equity improves (or rising housing prices). Importantly, Galster and Rothenberg (1991) asserted that the filtering process results in forces impacting on one submarket would create signals there that eventually lead to non-uniform consequences on other submarkets.

Both competing hypotheses are therefore available to explain the causes of interrelationships of housing submarkets. Nevertheless, there remains much to be explained. Although the existing literature has shown the growing attention on housing submarkets studies within metropolitan cities, most of these studies have not fully considered how and why there is a spillover effect among submarkets. This study therefore aims to contribute to the literature by complementing the existing work on house price diffusion through an analysis of housing submarkets in the context of Greater Sydney, one of the most diverse housing markets in Australia.

Greater Sydney provides an interesting case study. It is the most populous city in Australia (ABS 2016b), and characterised by high social and economic polarisation (Baum 2004; Randolph & Holloway 2005b; Randolph & Tice 2014). Bunker et al. (2005) also discussed the polarised spectrum of housing opportunities in Sydney. This implies the existence of a spillover effect between the housing submarkets of the city. This purported spillover effect is likely to be channelled through the equity transfer hypothesis. This posits that households, particularly those living in the relative low-priced areas, would likely move up the property ladder. This causes house price in the relative low-priced submarket to move first. The rising prices in this submarket will result in rising prices in the relative high-end submarket. However, the spillover effect, if any, can also be explained by the migration hypothesis. It asserts that households and businesses move to areas with relative low price to take advantage of price differentials. As a consequence, house prices in affluent submarkets will react to these shocks or movements first. This results in price movements in less prosperous submarkets. Coincidentally, all levels of the Australian governments have introduced a number of policies to spur economic development in relative low-priced areas such as Western Sydney. These include the launch of City Deal and the Western Sydney airport, relocating public servants to Western Sydney (NSW [DoP] 2010). In other words, an examination of Greater Sydney has provided a natural experiment to examine these two competing hypotheses. As such, this study examines the rationale of spillover effect behind house price changes. The study takes in-depth investigations to find out why housing price increase (or decrease) in a housing submarket (e.g. low-income submarket), would lead to, or not long after indicate, a rising or dropping of housing prices in another housing submarket (e.g. high-income submarket) in Greater Sydney.

8.2 Definition and Identification of Housing Submarkets in Greater Sydney

There is no universally accepted definition of housing submarkets (Michaels & Smith 1990; Bourassa et al. 1999; Leishman 2009) and the identification process of submarkets is still fraught with numerous theoretical and methodological challenges (Bourassa et al. 1999). Watkins (2001), for example, outlines some of the challenges in developing housing submarket models. They include the variation in the urban area under investigation, variation in the timeframe and the effect of changes in market fundamentals, as well as the differences in the statistical means of testing the existence of submarkets. Even though housing submarkets can be differentiated socially and spatially (Straszheim 1975; Randolph & Tice 2014), Michaels and Smith (1990) argue that spatial factors are more important than structural factors in defining submarkets. Despite all these challenges, researchers have put forward several

definitions of housing submarket that incorporate spatial connotation, socio-economic characteristics, culture, households' taste and preferences.

Generally, housing submarkets are defined as clusters of dwellings, which are practically and reasonably close substitutes of one another, but unsuitable substitutes for dwellings in other groups at the same time (Bourassa et al. 1999; Kauko et al. 2002). This presents differences between neighbourhoods within a city to homebuyers and developers (Baum 2017). The formation of housing submarkets are also the result of income and preferences of the residents combined with their administrative setups. Kauko et al. (2002) reported that housing market segmentation is often based on the following factors: tenure or lease agreements, house types, source of financing, age of the building stock, and the location. Leishman et al. (2013) added further insights to the discourse on submarket delineation. They asserted that housing submarkets are the result of the difference in preferences among households in relation to house types, sizes and locations. These definitions of housing submarkets from previous studies are well situated with the urban theories discussed earlier. They are the residential mobility theory, which posits that households move for an improved housing circumstance, whilst the Alonso-Mills-Muths theory, which postulates that households would reallocate to relative low-priced areas and commute to areas with strong economic activities. Consequently, the identification process of submarkets may take several forms subsumed into pricing clusters, non-pricing clusters or a combination of the two.

To consider both pricing and non-pricing clusters, the delineation of submarkets in this study is based on these three key factors: the degree of house price substitutability (Kauko et al. 2002; Gibler & Tyvimaa 2014); socio-economic characteristics (Chen et al. 2009; Ling & Hui 2013); and spatial delimitation (Jones & Leishman 2006; Ling & Hui 2013; Zhang et al. 2017). Economists often define high degree of housing substitutability as households comparing similar house prices based on certain attributes that include the socio-cultural choices made by households (Gibler & Tyvimaa 2014). From the viewpoint of the homebuyers, the substitution is not necessarily in close spatial proximity (Leishman et al. 2013). Adair et al. (2000) and Ling and Hui (2013) argued that socio-economic attributes should be an integral part in the identification of housing submarkets. This stems from the notion that local characteristics often influence housing market that often results in some dynamic interlinkages (Miao et al. 2011). Jones and Leishman (2006) and Michaels and Smith (1990) argued that location is an integral part in defining submarkets. These three elements are, therefore, fundamental in defining submarkets within Greater Sydney.

Recognising the importance of these elements in defining housing submarkets, this study combines pricing and non-pricing approaches dubbed 'socio-economic localisation'. It follows an identification process that examines location as defined by governance institutions such as Western Sydney Regional Organisation of Councils (WSROC), Northern Sydney Regional Organisation of Councils (NSROC), and Southern Sydney Regional Organisation of Councils (SSROC). We group local government areas (LGAs) into five major regions of Greater Sydney - western region, inner-west region, southern region, eastern region, and northern region. These regions are reported in Table 2.4 in section 2.3. However, these regions are further regrouped into relative high-priced submarket and relative low-priced submarket. The difference in terms of median house prices between high-priced and low-priced submarkets is depicted in Figure 8.1. The relative high-priced submarket consists of LGAs whose median house price is above the median house price of Greater Sydney. They are LGAs in the eastern and northern regions of the city. On the other hand, the relative low-priced submarket is a cluster of LGAs whose median house price is below the median house price of Greater Sydney. The relative low-priced submarket consists of LGAs in the western, inner-west and southern regions of the city[16]. Overall, there is greater house price substitution by households in this submarket.

This identification of housing submarket in Greater Sydney is further guided by the index of relative socio-economic disadvantage (one of the SEIFA indexes)[17] computed by the Australian Bureau of Statistics (ABS). As highlighted by Chen et al. (2009) and Ling and Hui (2013), clustering LGAs with similar socio-economic features is an effective way to identify housing submarkets since wealthy suburbs tend to have more resources for the effective delivery of infrastructure, public services, green space and shading. Furthermore, relative affluent LGAs can influence decisions around planning process including the location of high-density submarkets thereby widening socio-economic inequality in cities (Jean-Taylor et al. 2016).

[16] Even though the median house price in the Sutherland LGA is above the median price of Greater Sydney, it has similar socio-economic characteristics with LGAs in the low-priced submarket. We therefore classified this LGA in the low-priced submarket.

[17] SEIFA is the Socio-Economic Indexes for Areas computed by the Australian Bureau of Statistics (ABS) to measure relative socio-economic advantages and disadvantages in Australia's local councils. The index of relative socio-economic disadvantage is one of such indexes that compares relative socio-economic disadvantages in areas. It is computed by incorporating household income, participation in the work force, education, family dynamics and housing arrangement. A score below 1000 indicates relative socio-economic disadvantage.

Figure 8.1: Comparative Median House Prices of Greater Sydney

Source: (ABS 2019; NSW Department of Housing 2019)

A clear socio-economic disparity between the two submarkets has been identified from Figure 8.1, comparing the socio-economic characteristics in these LGAs. As reported in Figure 8.1, the average SEIFA index for the low-priced submarket (1005) is below the average score of Greater Sydney (1039). In addition, some LGAs in this submarket depict a very low score such as Fairfield (856), Auburn (929), Holroyd (929), Liverpool (952).

Conversely, the average SEIFA index for the high-end submarket is above the average score of Greater Sydney. Importantly, all LGAs in this wealthy submarket show a SEIFA index that is above the average score of Greater Sydney. The only exception is Sydney LGA. Some LGAs in this affluent submarket reveal a very high SEIFA index, including Ku-ring-gai (1121), Woollahra (1115) and Mosman (1115).

Table 8.1: 2016 ABS Index of Relative Socio-Economic Disadvantage of the Submarkets

Low-Priced Submarket	Score	High-Priced Submarket	Score
Auburn	929	Randwick	1052
Bankstown	935	Sydney	1027
Blacktown	986	Waverley	1091
Blue Mountains	1045	Woollahra	1115
Camden	1056	Randwick	1052
Campbelltown	950	Hornsby	1091
Fairfield	856	Hunter Hills	1098
Hawkesbury	1028	Ku-ring-gai	1121
Holroyd	929	Lane Cove	1111
Liverpool	952	Manly	1092
Parramatta	1039	Mosman	1115
Penrith	999	North Sydney	1108
Wollondilly	1043	Pittwater	1092
Botany Bay	1001	Ryde	1058
Hurstville	1020	The Hills Shire	1107
Kogarah	1020	Warringah	1092
Rockdale	1002	Willoughby	1083
Sutherland	1080	**Average score**	**1088**
Ashfield	1053		
Burwood	999		
Canada Bay	1068		
Leichhardt	1053		
Marrickville	1053		
Strathfield	1026		
Average score	**1005**		

The 2016 ABS index of relative socio-economic disadvantage of the LGAs of the low-priced and high-priced submarkets. A score below 1000 denotes relative disadvantaged and above 1000 denotes relative advantaged. All LGAs in the high-priced submarket had a score above 1000, whilst those in the low-priced submarket had mixed results. The average score of the high-priced submarket is significantly higher than the low-priced submarket, demonstrating the difference in the socioeconomic characterisation of the two submarkets.

This further highlights the socio-economic disparities between the low-priced and prosperous submarkets in Greater Sydney. These confirm the appropriateness of using socio-economic characteristics as part of the model use to delineate submarkets in this study. In summary, the disparities in house prices, socio-economic characteristics, and location of these submarkets validate the delineation of Greater Sydney into relative low-priced and high-priced submarkets.

8.3 Results and Discussion

8.3.1 The Meen's (1999) Ratio Unit Root Tests

The Meen (1999)'s procedure of house price ratio was firstly employed to provide an indication of the existence of a spillover effect among housing submarkets in Greater Sydney. The Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) unit root tests were used to test the stationarity of the ratio of the median house price of each submarket of Greater Sydney to median house price of Greater Sydney. The results are reported in Table 8.2.

Table 8.2: Meen (1999)'s Procedure

Unit Root Test	Ratio of Low-Priced to Greater Sydney (t-statistic)	Ratio of High-Priced to Greater Sydney (t-statistic)
ADF	-3.63***	-3.86***
PP	-6.30***	-6.44***

The ADF and PP test the null hypothesis of a unit root in the ratio of the median house price of the low-priced submarket to the median house price of Greater Sydney, and the ratio of the median house price of the high-priced submarket to the median house price of Greater Sydney. Both the ADF and PP results reject the null hypothesis on level at P<0.00, indicating the existence of a spillover effect in the housing market of Greater Sydney. *** denotes a rejection of the tested hypothesis at the 1% level.

The results reveal that the ratio, in each case, is stationarity at the 1% significance level. This shows there is long run constancy in these ratios. More importantly, it indicates that the existence of spillover effects between the submarkets of Greater Sydney. This is due to the existing differences in the socio-economic characteristics of the regions of Sydney. As such, changes in market fundamentals would have varying effects on house prices in these submarkets. The indication of a spillover effect highlights a long run time invariant mean, which suggests that some long run price differential between submarkets are mean reverting. The convergence of submarkets means house price in one housing submarket in Greater Sydney will rise or fall first, and then gradually spread out to the other sub-housing market over time. This is consistent with the filtering process that was proposed by Galster and Rothenberg (1991) in which signals will be created from one submarket as forces impacting on the submarket would have non-uniform consequences on other submarkets. The documented results are consistent with the findings of Chien (2010), Cook (2012), and Lean and Smyth (2013). They found a spillover effect among submarkets in their respective studies. Our result indicates that spillover effects are not only confine to regional housing markets, but also within a single housing market with strong heterogeneity such as metropolitan Sydney. The result also provides some empirical evidence to support the existence of a spillover effect in sub-housing markets.

Overall, evidence of an indication of convergence or a spillover effect within a single housing market is presented by Meen (1999)’s framework. Specifically, there is evidence of convergence or a spillover effect between high-priced and low-priced submarkets of Greater Sydney. However, Meen (1999)’s framework does not provide information about the house price diffusion pattern (i.e. how house prices spread) among different sub-housing markets. A more in-depth analysis is therefore required to assess the long-run relationships between different sub-housing markets.

8.3.2 The Long Run Relationship of Housing Submarkets

8.3.2.1 Unit Root Result

The first step for establishing the existence of a long-run equilibrium relationship between the housing submarkets is to assess the stationarity of their house prices. As such, the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root models were used. The results are reported in Table 8.3. In general, house prices of these two submarkets (relative low-priced and relative high-priced) have unit root on levels but become stationary after first difference for both the ADF and the PP at the 1% significance level. Both data series are first difference I(1) stationary. Stationarity indicates that house price in a given submarket is stable over time. The KPSS also rejects stationarity in level but it does not reject at first difference with a constant and a trend, confirming that the series are I(1).

Table 8.3: Unit Root Results of Low-Priced and High-Priced Submarkets

Submarket	**ADF** Level (t-statistic)	1st Difference (t-statistic)	**PP** Level (t-statistic)	1st Difference (t-statistic)	**KPSS** Level (t-statistic)	1st Difference (t-statistic)
Intercept without trend						
Low-Priced	1.42	-9.79***	1.45	-9.85***	21.69***	0.01
High-Priced	1.25	14.18***	0.61	-13.98***	22.16***	0.04
Intercept with trend						
Low-Priced	1.02	10.07***	-1.12	-10.10***	9.08***	0.44
High-Priced	-1.10	-14.40***	-2.43	-14.30***	9.25***	0.87
No intercept and trend						
Low-Priced	1.27	-4.27***	4.16	9.08***		
High-Priced	3.21	-13.37***	-1.92	-12.93***		

The ADF and the PP test the null hypothesis of a unit root in the house prices of both the low-priced and the high-priced submarket, whilst the KPSS tests the null hypothesis of no unit root. The results of the ADF and PP failed to reject the null hypothesis on level at P<0.05, but there is clear rejection after first difference at P<0.01 for all three scenarios: intercept without trend; intercept with trend; and no intercept and trend. The KPSS test supports these results, as it failed to reject stationarity on level but does not reject stationarity after first difference at P<0.01. *** denotes a rejection of the tested hypothesis at the 1% level, ** is rejection of the null hypothesis at 5% level, * is a rejection of the tested hypothesis at 10% level.

Overall, the house prices of both submarkets have unit root on level, but become stationary after first difference. This suggests that both series might be cointegrated over time; thereby a cointegration analysis was undertaken in light of both series being I(1).

8.3.2.2 Cointegration Results

To formally evaluate the long run relationship of both housing submarkets, three cointegration tests were employed. The results are reported in Table 8.4 (a-b).

Table 8.4: Cointegration Results (a-b)

	Dependent	Independent	tau-statistic	z-statistic
Engle-Granger	Low-priced	High-priced	-6.97***	-66.44***
	High-priced	Low-priced	-7.06***	-67.92***
Phillip-Ouliaris	Low-priced	High-priced	-7.19***	-73.00***
	High-priced	Low-priced	-7.26***	-73.97***

Table 8.4a showing the results of the Engle-Granger and Phillip-Ouliaris Cointegration tests. Both the Engle-Granger and the Phillip-Ouliaris cointegration tests reveal a contemporaneous long run relationship in house prices between the low-priced and high-priced submarkets. The null hypothesis of no cointegration is soundly rejected at P<0.01 by both tests. Each test used house price in one submarket as the dependent variable and the other as the independent and interchange the variables resulting into two set of results from both tests. All variables are I(1) as shown by the results of the ADF, PP and KPSS on Table 8.3.

	Trace-Statistic	Prob.	Max-Eigen-statistic	Prob.
None*	22.03***	0.00***	20.18***	0.00***
At most 1	1.84	0.17	1.84	0.17

Table 8.4b showing the results of the bivariate Johansen cointegration tests that is used to check the consistency of the results in table 6a. The results of the bivariate Johansen cointegration test support both the Engle-Granger and the Phillip-Ouliaris results of a contemporaneous long run relationship in house prices between the low-priced and high-priced submarkets. The null hypothesis of no cointegration is soundly rejected at P<0.05. Similarly, all variables are first differenced stationary as shown by the results of the ADF, PP and KPSS on Table 8.3.

As can be seen from Table 8.4a, the null hypothesis of no cointegration for both submarkets is clearly rejected at the 1% significance level by the Engle-Granger and Phillip-Ouliaris tests. This indicates the existence of a long run equilibrium relationship between these submarkets of Greater Sydney. Comparable evidence is obtained from the Johansen bivariate cointegration method in Table 8.4b, confirming the existence of a long run relationship between the two submarkets.

The cointegration results are generally supportive of long-run convergence in house prices between the housing submarkets of Greater Sydney. Precisely, there is a contemporaneous long run relationship between the relative high-end and low-priced submarkets of Greater Sydney. This indicates that, over time, the changes in house price in a submarket (for example, the relative low-priced submarket) will certainly affect house prices in another submarket (for example, the high-priced submarket). The results are consistent with the findings of Wilson et al. (2011), who reported at least one cointegrating relationship within each of the broad classifications of housing markets in Aberdeen. Similar evidence was also reported by Jones et

al. (2003) and Oikarinen (2004), which reflect the existence of spillover effect among housing submarkets.

To sum up, the combined long-run analysis of cointegration and convergence test indicates that a common long-run equilibrium relationship between housing submarkets in Greater Sydney exists. These results are consistent with the existence of a spillover effect among housing submarkets in Greater Sydney.

8.4.2.3 Granger-Causality Results

The existence of cointegration between the high-end and low-priced submarkets, it raises the question of how house prices diffuse between these two submarkets. This section investigates the causality between both submarkets using a pairwise Granger-causality test. The results of the Granger-causality are reported on Table 8.5. The test confirms the existence of spillover effects and allows us to identify the 'price leader' between both submarkets. The 'price leader' is essentially the submarket that drives the other. Further, the results offer some empirical evidence to support the theoretical explanation of the spillover effect.

Table 8.5: Pairwise Granger Causality Results

Housing Type	Null Hypothesis	F-Stat	Prob.
All dwellings	ΔHigh-priced does not Granger-cause Δlow-priced	1.09	0.34
All dwellings	ΔLow-priced does not Granger-cause Δhigh-priced	12.16	0.00***

House prices for all dwelling are I(1) stationary. *** denotes a rejection of the tested hypothesis at the 1% level, ** is rejection of the null hypothesis at 5% level, * is a rejection of the tested hypothesis at 10% level.

The Granger-causality test reveals that the relative low-priced submarket Granger-causes the relative high-priced submarket at 1% significance level. The relative low-priced submarket is therefore the dominant submarket in Greater Sydney. This suggests that the relative low-priced submarket contains useful past information that can be used to explain the movement of house prices in the high-priced submarket. Fundamentally, house prices in the relative low-priced submarket will be diffused to the relative high-priced submarket. This suggests that when there are changes in market fundamentals, house prices first increase in the relative low-priced submarket and then spread to the relative high-priced submarket. The spread occurs when current households trade-up as a result of the increase in the equity of their current houses.

The results can be interpreted as supporting the equity transfer hypothesis. Specifically, households, particularly repeat buyers are likely to purchase a more desired and expensive home if house prices are rising. As discussed by Waltl (2016), low-priced regions often

experience higher appreciation rates than high-priced regions in a city when there are positive changes in market fundamentals. Further explanation is provided by Stein (1995)'s model, which posits that rising house prices can increase current homebuyers' wealth and allow them to make a larger down payment for another home. This makes trading-up feasible. Similarly, households' ability to purchase another home is decreased significantly if house prices fall (Waltl 2016). The result further demonstrates the rationale of using the equity transfer hypothesis and the residential mobility urban theory to justify the existence of spillover effect.

Nevertheless, there is little evidence to suggest that house prices in relative high-priced submarkets Granger-causes relative low-priced submarkets. The results indicate that house prices in relative high-end submarket cannot diffuse to relative low-priced submarket. In other words, there is a unidirectional relationship between both submarkets. In fact, it demonstrates the lack of evidence to support the migration hypothesis in Greater Sydney. Although results here are a clear departure from the findings of Teye et al. (2018) in Amsterdam, the results are somewhat consistent with the findings of Oikarinen (2004) and Ho et al. (2008). This confirms that the spillover effect of housing submarkets is caused by the equity transfer channel, in which households relocate to houses of different qualities according to their affordability and willingness to pay.

In brief, the Granger-causality tests confirm that the relative low-priced submarket is the dominant submarket in Greater Sydney, and house price movement in this submarket will result in house price change in the high-end submarket, supporting the equity transfer hypothesis

8.3.3 Long-run Linkages between House Prices and Market Fundamentals

The previous section provided some indication of how shocks in the low-end submarket will spread to the high-end submarket, making the low-priced submarket the dominant market in the diffusion process. The next concern is whether the dominance role of the low-end submarket can be attributed to its responsiveness to market fundamentals. We also examine whether different housing submarkets respond to economic stimuli differently. More specifically, we assess whether house prices in the low-end submarket are more responsive to economic fundamentals compared with the high-end submarket. To assess this issue, the determinants of house prices in both submarkets are scrutinized using a long run equilibria estimator, the dynamic ordinary least square (DOLS). State final demand, building starts, the S&P/ASX 300 Index, and population are used as proxies of market fundamentals. These regressors are stationary after first difference I(1) and they are reported in Table 8.6. The

Johansen cointegration results of house prices in both the relative low-priced and relative high-priced submarkets and these regressors are reported in Table 8.7(a-b).

Table 8.6: Unit Root Results of the Regressors

Submarket	ADF Level (t-statistic)	ADF 1st Difference (t-statistic)	PP Level (t-statistic)	PP 1st Difference (t-statistic)	KPSS Level (t-statistic)	KPSS 1st Difference (t-statistic)
Intercept without trend						
State FD	0.84	0.00***	0.92	0.00***	28.03***	0.02
Building Start	1.19	0.00***	0.88	0.00***	67.37***	0.43
S&P ASX 300	0.96	0.00***	0.96	0.00***	16.58***	2.25
Population	0.99	0.00***	1.00	0.00***	34.19***	0.05
Intercept with trend						
State FD	0.61	0.01**	0.41	0.00***	50.51***	1.16
Building Start	0.21	0.00***	0.27	0.00***	82.13***	0.06
S&P ASX 300	0.32	0.00***	0.26	0.00***	32.10***	0.75
Population	0.97	0.00***	0.98	0.00***	68.81***	1.24
No intercept and trend						
State FD	0.99	0.00***	1.00	0.00***		
Building Start	0.83	0.00***	0.82	0.00***		
S&P ASX 300	0.98	0.00***	0.96	0.00***		
Population	0.99	0.00***	1.00	0.02**		

Table 8.6 showing the results of the unit root test of the variables used in DOLS. The ADF and the PP test the null hypothesis of a unit root in each explanatory variable, while the KPSS tests the null hypothesis of no unit root. The results of the ADF and PP failed to reject the null hypothesis on level at P<0.05, but there is clear rejection after first difference at P<0.01 and P<0.05 for all three scenarios: intercept without trend; intercept with trend; and no intercept and trend. The KPSS test supports these results, as it failed to reject stationarity on level but does not reject stationarity after first difference at P<0.01. *** denotes a rejection of the tested hypothesis at the 1% level, ** is rejection of the null hypothesis at 5% level, * is a rejection of the tested hypothesis at 10% level.

Table 8.7(a-b): Cointegration Results of House Price and the Regressors

	Trace-Statistic	Prob.	Max-Eigen-statistic	Prob.
None*	85.09***	0.00***	48.44***	0.00***
At most 1	36.65	0.36	17.00	0.56

Table 8.7a showing the results of the Johansen bivariate cointegration test of house price in the relative low-priced submarket and the regressors. The results rejected the null hypothesis of no cointegration at P<0.05. All variables are first differenced stationary as shown by the results of the ADF, PP and KPSS on Table 8.3 and Table 8.6.

	Trace-Statistic	Prob.	Max-Eigen-statistic	Prob.
None*	79.58***	0.00***	34.09**	0.04**
At most 1	45.49	0.08*	23.82	0.14

Table 8.7b showing the results of the Johansen bivariate cointegration test of house price in the relative high-priced submarket and the regressors. The results rejected the null hypothesis of no cointegration at P<0.05. All variables are first differenced stationary as shown by the results of the ADF, PP and KPSS on Table 8.3 and Table 8.6.

Three different information criteria, Akaike (AIC), Schwartz Bayesian (SIC) and Hannan-Quinn (HIC) were used to determine the appropriate lag length. The information criteria suggest a minimum lag length of 4 for both the relative low-priced and relative high-priced submarkets. Using the LM test, the null hypothesis of no serial correlation was rejected at 5% significance level in both models. These suggest that the DOLS is appropriate. The results of the DOLS are reported on Table 8.8.

Table 8.8: DOLS Results for Low-Priced and High-Priced Submarkets

$P_1 = \beta_0 + \beta_1 SFD_t + \beta_2 BLDSTAT_t + \beta_3 POP_t + \beta_4 STKS_t + \sum_{p=-m}^{m}(a_{2p}(\Delta SFD_{t+p}) + \sum_{p=-1}^{p}(a_{3p}(\Delta BLDSTAT_{t+p}) + \sum_{p=-1}^{p}(a_{4p}(\Delta POP_{t+p}) + \sum_{p=-1}^{p}(a_{5p}(\Delta STKS_{t+p}) + \varepsilon_t$

$P_2 = \beta_0 + \beta_1 SFD_t + \beta_2 BLDSTAT_t + \beta_3 POP_t + \beta_4 STKS_t + \sum_{p=-m}^{m}(a_{2p}(\Delta SFD_{t+p}) + \sum_{p=-1}^{p}(a_{3p}(\Delta BLDSTAT_{t+p}) + \sum_{p=-1}^{p}(a_{4p}(\Delta POP_{t+p}) + \sum_{p=-1}^{p}(a_{5p}(\Delta STKS_{t+p}) + \varepsilon_t$

Long Run Variable	**Low-priced Coefficient/t-statistic**	**High-priced Coefficient/t-statistic**
State final demand	(0.67)	(0.24)
	(1.97)*	(0.41)
Building starts	(1.39)	(0.57)
	(8.96)***	(1.73)*
Australia S&P 300	(0.48)	(0.15)
	(5.56)***	(1.40)
Population	(0.53)	(6.96)
	(0.22)	(1.51)
Constant	(-1.16)	(-6.97)
	(-0.57)	(-1.78)
Log likelihood	0.99	0.97

Table 8.8 showing the results of the DOLS model discussed in subsection 4.2.4. The dependent variable is the house price in each submarket and the explanatory variables are state final demand, building starts, Australia S&P 300 and population. These explanatory variables are proxies of economic fundamentals. *** means the variable is significant at the 1% level, ** means the variable is significant at the 5% level, * means the variable is significant at the 10% level. Coefficients are estimated with robust standard errors and the t-statistics are in parenthesis. The variables are scaled to 1.00 to address any scaling effects on the data.

It is clear from the results that, irrespective of submarkets, building starts are statistically significant in both submarkets. The results are consistent with the findings of Miles (2009) and Lee and Jin (2011). They found that housing starts are a form of "irreversible" investment. Importantly, Green (1997) reported that housing starts are leading indicators of the business cycle and a key measure of the prosperity of an economy. This shows house starts have a discernible impact on house prices. As a result, it is reasonable to document a long-run positive link between housing starts and house prices in both submarkets. Furthermore, housing starts have a stronger impact on the low-priced submarket than the high-priced submarket. This reinforces the dominant role of the low-priced submarket.

As hypothesised, the coefficient of state final demand is positive and statistically significant at 10% for the low-end housing submarket, but statistically insignificant in the high-end submarket. In short, state final demand has a direct relationship with house price in both submarkets. This indicates that expansionary economic activities can possibly increase households' incomes and drive housing demand and prices. Similarly, a recession would significantly reduce the demand for housing particularly in the low-priced submarket. Worthington and Higgs (2013) obtained comparable results at a national level.

Results in Table 8.8 further reveal that the movement of the broader stock market would have a significant impact on house prices in the low-priced submarket. In the high-end submarket, the coefficient of S&P/ASX 300 is positive but statistically insignificant. The results however imply that house prices in both submarkets responded positively to the stock market in the long-run. The long-run interrelationship between stocks and house prices have been widely discussed in the housing literature. The results support the earlier findings of Dvornak and Kohler (2007) and Lee (2017), who found a direct link between stock market wealth and housing wealth in Australia. Another interesting observation is that population does have a positive effect on house prices. The results are intuitively appealing as population growth reflects higher housing demand. However, it is statistically insignificant in both submarkets. This could be, at least to certain extent, attributed to the deterioration of housing affordability, particularly among first homebuyers in Australia over time (Lee & Reed 2014). Nevertheless, the results are in line with the findings of Productivity Commission Report (2004) and Yates (2008).

A comparison between the low-priced and high-priced submarkets does reflect some differences between both submarkets. Specifically, the low-priced submarket appears to be more responsive to market fundamentals, indicating that this submarket is more susceptible to changes in economic fundamentals. Specifically, state final demand, housing starts and stocks all have a significant impact on house prices in the low-priced submarket, whilst the high-priced submarket is only affected by housing starts in the long run. The results do not only highlight that the low-priced submarket is more responsive to changes in market fundamentals compared with the high-priced submarket, but also highlight the discrepancy between both submarkets. The finding can be interpreted as supportive of the equity transfer hypothesis, whereby the low-priced submarket leads the high-priced submarket. Given households in the low-priced submarket are likely to respond to changes in market fundamentals at a faster pace, it is reasonable to document that house price shocks in this submarket will be transmitted to

the high-priced submarket through a process of equity transfer. In summary, the dominant role of the low-end submarket can be attributed to its responsiveness to market fundamentals.

8.4 Robustness Check

A number of robustness checks were undertaken to enhance the robustness of the baseline findings. First, there is still a critical question of whether the abovementioned results can be generalised into different types of dwelling. To address this, we disaggregated all dwellings into strata and non-strata residential dwellings in the low-priced and high-priced submarkets. Similar taxonomy of housing types was documented in the study of Morley and Thomas (2016) and (Lee 2017). They demonstrated that different types of housing have different risk-return profiles and as such, different housing types can make up different housing submarkets. This is a key issue for policy makers and one that will improve housing market analysis for a more informed decision-making. Strata titles, as defined by Housing NSW, include town houses, terraces/villas, flats/units, whereas non-strata title properties refer to detached houses. The cointegration results of house prices of strata and non-strata dwellings between the relative low-priced and relative high-priced submarkets are reported in Table 8.9 and Table 8.10 respectively. The empirical results of the Granger-causality are presented Table 8.11.

Table 8.9: Cointegration Results of Strata Dwellings

	Dependent	Independent	tau-statistic	z-statistic
Engle-Granger	Low-priced	High-priced	-4.82***	-38.11***
	High-priced	Low-priced	-4.88***	-38.41***
Phillip-Ouliaris	Low-priced	High-priced	-4.68***	-34.83***
	High-priced	Low-priced	-4.74***	-34.90***

Table 8.9 showing the results of the Engle-Granger and Phillip-Ouliaris Cointegration tests of strata dwellings. Both cointegration tests reveal a contemporaneous long run relationship in house prices between the relative low-priced and relative high-priced submarkets strata dwellings. The null hypothesis of no cointegration is soundly rejected at P<0.01 by both tests. Each test used house price in one submarket as the dependent variable and the other as the independent and interchange the variables resulting into two set of results from both tests. All variables are I(1).

Table 8.10: Cointegration Results Non-Strata Dwellings

	Dependent	Independent	tau-statistic	z-statistic
Engle-Granger	Low-priced	High-priced	-3.65**	-16.52**
	High-priced	Low-priced	-3.12**	-15.55**
Phillip-Ouliaris	Low-priced	High-priced	-4.10***	-27.83***
	High-priced	Low-priced	-4.10***	-27.41***

Table 8.10 showing the results of the Engle-Granger and Phillip-Ouliaris Cointegration tests of non-strata dwellings. Both cointegration tests reveal a contemporaneous long run relationship in house prices between the relative low-priced and relative high-priced submarkets. The null hypothesis of no cointegration is soundly rejected at P<0.01 (***) and P<0.05 (**) by both tests. Each test used house price in one submarket as the dependent variable and the other as the independent and interchange the variables resulting into two set of results from both tests.

Table 8.11: Pairwise Granger-Causality Results (Strata and Non-Strata)

Housing Type	Null Hypothesis	F-Stat	Prob.
Non-strata	ΔHigh-priced does not Granger-cause Δlow-priced	1.70	0.10
Non-strata	ΔLow-priced does not Granger-cause Δhigh-priced	2.90	0.00***
Strata	ΔHigh-priced does not Granger-cause Δlow-priced	1.33	0.26
Strata	ΔLow-priced does not Granger-cause Δhigh-priced	2.27	0.06*

House prices for all housing types are I(1) stationary. *** denotes a rejection of the tested hypothesis at the 1% level, ** is rejection of the null hypothesis at 5% level, * is a rejection of the tested hypothesis at 10% level.

Our cointegration tests suggest a long run equilibrium relationship between strata units in the low-priced submarket and the high-end submarket. Similar evidence is also documented in non-strata houses at the 1% significance level using the Phillip-Ouliaris test and at 5% using the Engle-Granger test. Results here confirm the preceding findings that reported cointegration between the relative low-priced and relative high-priced submarkets. This relationship is robust to different types of housing. Importantly, the results from Table 8.11 show that non-strata house prices in the low-priced submarket Granger-causes non-strata dwelling prices in the high-end submarket. This suggests that price changes in non-strata dwellings in the low-priced submarket would diffuse to non-strata dwellings in the high-priced submarket. This unidirectional link between low-end and high-end submarkets also holds for strata dwellings. Overall, results here confirm that our baseline results are robust to different types of housing in general and there is a spillover effect through the household equity transfer mechanism in particular.

Second, one could make a case that a comparison of low-priced and high-priced submarkets in Greater Sydney could incorporate some biases in that inner-west and southern regions could be classified as a medium-priced submarket instead of a low-priced submarket. As such, the interrelationships of housing submarkets in Greater Sydney were re-estimated. Specifically, Greater Sydney is decomposed into three, namely low-priced, medium-priced, and high-priced submarkets. In a similar fashion to the 'price leadership' analysis, a pairwise Granger-causality analysis was undertaken and the empirical results are displayed in Table 8.12.

Table 8.12: Pair wise Granger-Causality Results

Housing Type	Null Hypothesis	F-Stat	Prob.
All dwellings	ΔLow-priced does not Granger-cause Δmedium-priced	4.41	0.00***
All dwellings	ΔMedium-priced does not Granger-cause Δlow-priced	1.89	0.12
All dwellings	ΔLow-priced does not Granger-cause Δhigh-priced	4.87	0.00***
All dwellings	ΔHigh-priced does not Granger-cause Δlow-priced	1.49	0.21
All dwellings	ΔMedium-priced does not Granger-cause Δhigh-priced	12.46	0.00***
All dwellings	ΔHigh-priced does not Granger-cause Δmedium-priced	1.41	0.24

House prices for all housing types are I(1) stationary. Inner-west and southern regions were excluded from the low-priced submarket to form the medium priced submarket. *** denotes a rejection of the tested hypothesis at the 1% level, ** is rejection of the null hypothesis at 5% level, * is a rejection of the tested hypothesis at 10% level.

The results exhibit that house prices in the low-priced submarket Granger-causes house prices in the medium-priced and high-priced submarkets. This offers some further evidence to support our earlier argument that the spillover effect of housing submarkets is caused by the equity transfer channel in which households would relocate to houses of different qualities according to their affordability and willingness to pay. When there is a positive shock, it leads to higher demand for the lower quality tier houses. This subsequently pushes up the demand and prices in higher priced markets due to the increased equity or wealth of current homeowners. Similarly, housing demand will drop in the low-priced submarkets first during a down turn market. As a result, it is reasonable to document that the causal flow in house price occurs fairly from the low-end submarket to the medium-price submarket. Importantly, the price leadership analysis further demonstrated that house price in the medium-end submarket diffuse to the high-end submarket. However, there is no evidence of recursive ripples to the low-priced submarket. Overall, the results are consistent with the baseline results, indicating that the equity transfer hypothesis still hold. Specifically, the low-priced submarket tends to feed information to the rest of other submarkets with higher prices.

As documented earlier, the results may not reflect other housing types such as strata and non-strata at prima facie. As a result, we examine the long run relationship of these housing types in the low-priced, medium-priced and high-priced submarkets. All variables are first difference stationary. The results reveal a causal flow that is similar to the preceding discussion. House price fairly flows from the low-end submarket to the medium-price submarket. The results further reveal that house price in the medium-end submarket diffuse to the high-end submarket and there is no evidence of reciprocity in causality among these submarkets.

Lastly, several robustness checks for the DOLS model were run. For the variables with high correlation such as state final demand and population (greater than 0.75), we dropped population and re-estimated the model. The results are similar to our baseline findings. Given that financial activities, particularly mortgage lending rates, play a significant role in influencing house price (Brown et al., 2011), we also included mortgage lending rate in our robustness check. However, the inclusion of mortgage lending rate in our DOLS model did not change the results significantly. Overall, the results are fairly consistent with our previous results, which again supports the equity transfer hypothesis.

8.5 Results of Greater Sydney and Non-Metropolitan Cities

The previous section discussed house price linkages for various dwelling types of two broad housing submarkets within Greater Sydney. To further examine the validation of studying housing submarket within metropolitan cities, especially Greater Sydney, the study investigates whether there are house price linkages between Greater Sydney and non-metropolitan cities of the state of NSW. Any lack of significant evidence of a long run relationship between Greater Sydney and these non-metropolitan cities will give more credence to the argument for studying intra- metropolitan house price movements. Further, an examination of the long run relationship in house prices between Greater Sydney and non-metropolitan cities of the state of NSW will enhance our understanding of house price behaviour of Australia's most populous state, namely New South Wales (ABS 2016b).

The study considers five non-metropolitan cities in the north of Greater Sydney namely, Cessnock, Lake Macquarie, Maitland, Newcastle and Port Stephens, and three on the south of the city, that is Kiama, Shellharbour and Wollongong (NSW DoH 2019). These cities were also described by Hillman and Rothman (2007) as non-metropolitan areas, that is, they are cities other than the major cities of Australia. Two house prices for non-metropolitan cities of NSW were considered. The first is the median house price for these non-metropolitan cities, and the second, is the median house price for each of these non-metropolitan cities. The study also deployed the cointegration and Granger-causality techniques discussed in section 4.2.4.

8.5.1 Long Run Relationship – Greater Sydney and all Non-Metropolitan Cities

8.5.1.1 Data Description

As discussed before, the housing price index used is based on the quarterly median house price sales collated by Housing NSW, covering the period 1991Q1 to 2016Q2. Median house price index for Greater Sydney is readily available and a sample of non-metropolitan cities whose

sales data was collected by Housing NSW was used to compute median house prices for the non-metropolitan cities. The summary statistics of these two submarkets of NSW cities are reported in Table 8.13.

Table 8.13: Descriptive Statistics of Median House Prices

Statistic	Greater Sydney	Non-metropolitan Cities
Mean	384	260
Standard Error	17	12
Median	413	318
Mode	435	325
Standard Deviation	173	118
Sample Variance	29,765	13,855
Range	650	371
Minimum	150	110
Maximum	800	481

Source: Author's computation using data from NSW Department of Housing

There is a clear difference between Greater Sydney and the non-metropolitan cities in all the statistics reported in Table 8.13. Housing prices have grown more rapidly in Greater Sydney than the non-metropolitan cities. This is expected since population growth rate has been substantially larger in metropolitan cities than in non-metropolitan cities (ABS 2016b). This is also explained by the fact that there are more economic activities in Greater Sydney than the non-metropolitan cities (Burnley et al. 2007; Burnley et al. 2016), which is an underlying motivation for people to migrate. House price volatility, in turn, has been lower in the non-metropolitan cities than the metropolitan area. Other factors such as the social gradient and the demographics also play a crucial role.

8.5.1.2 Unit Root Results

Table 8.14 reported the results of both the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) unit root tests of median house prices of Greater Sydney and NSW non-metropolitan cities. In all three tests, the null hypothesis of no unit root is rejected on level at 5% significance level. However, differencing the series results in stationarity of the series at the relevant significance level. This demonstrates that both data series are first difference stationary I(1). These results validate the application of cointegration techniques since both series are integrated of the same order, that is they are I(1).

Table 8.14: Unit Root Results - Greater Sydney and Non-Metropolitan Cities

Submarket	ADF Test Level (t-statistic)	ADF Test 1st Difference (t-statistic)	PP Test Level (t-statistic)	PP Test 1st Difference (t-statistic)
Intercept without trend				
Greater Sydney	1.20	-3.37***	1.42	-11.72***
Non-metropolitan	0.34	-4.47***	0.53	-9.28***
Intercept with trend				
Greater Sydney	-1.98	-12.21***	-1.50	-12.04***
Non-metropolitan	-2.64	-4.57***	-2.03	-9.40***
No intercept and trend				
Greater Sydney	3.76	-2.97***	4.23	-10.91***
Non-metropolitan	2.30	-3.65***	3.19	-8.36***

The ADF and the PP test the null hypothesis of a unit root in the house prices of both Greater Sydney and non-metropolitan submarket. The results of the ADF and PP failed to reject the null hypothesis on level at P<0.05, but there is clear rejection after first difference at P<0.01 for all three scenarios: intercept without trend; intercept with trend; and no intercept and trend. *** denotes a rejection of the tested hypothesis at the 1% level, ** is rejection of the null hypothesis at 5% level, * is a rejection of the tested hypothesis at 10% level.

8.5.1.3 Long Run Relationship

To formally examine whether there is a long run relationship between Greater Sydney and non-metropolitan cities of NSW, three cointegration tests were employed. They are Engle-Granger, Phillip-Ouliaris, and Johansen bivariate cointegration tests. The results are reported in Table 8.15.

Table 8.15 (a-b): Cointegration Results of Greater Sydney and Non-Metropolitan

Test	Dependent	Independent	tau-statistic	z-statistic
Engle-Granger	Greater Sydney	Non-Metro	-0.79	-2.31
	Non-Metro	Greater Sydney	-0.98	-2.78
Phillip-Ouliaris	Greater Sydney	Non-Metro	-1.41	-5.33
	Non-Metro	Greater Sydney	-1.56	-5.71

Table 8.15a showing the results of the Engle-Granger and Phillip-Ouliaris Cointegration tests. Both the Engle-Granger and the Phillip-Ouliaris cointegration tests failed to show the existence of a long run relationship in house prices between Greater Sydney and non-metropolitan housing submarkets. The null hypothesis of no cointegration cannot be rejected at P<0.01 by both tests. Each test used house price in one submarket as the dependent variable and the other as the independent and interchange the variables resulting into two set of results from both tests. All variables are I(1) as shown by the results of the ADF and PP in Table 8.14.

	Trace-Statistic	Prob.	Max-Eigen-statistic	Prob.
None*	8.66	0.39	7.70	0.41
At least 1	0.95	0.32	0.95	0.32

Table 8.15b showing the results of the Johansen bivariate cointegration tests that is used to check the consistency of the results in table 8.15a. The results of the Johansen bivariate cointegration test support both the Engle-Granger and the Phillip-Ouliaris results of no long run relationship in house prices between Greater Sydney and non-metropolitan housing submarkets. The null hypothesis of no cointegration cannot be soundly rejected at P<0.05. Similarly, all variables are first differenced stationary as shown by the results of the ADF and PP in Table 8.14.

All three forms of cointegration results are reported in Table 8.15 (a-b). Both the Engle-Granger and Phillip-Ouliaris tests failed to reject the tested hypothesis of no cointegration for the two combinations of house price at the 5% significance level. The tau and z-statistics in the Engle-Granger and Phillip-Ouliaris test results show no cointegration between Greater Sydney and NSW non-metropolitan cities. The Johansen bivariate cointegration method was used to check the robustness of the Engle-Granger and Phillip-Ouliaris cointegration results. This test further demonstrates the lack of cointegration between these two submarkets using both the trace and Max-Eigen statistics. The Johansen results vigorously support the Engle-Granger and Phillip-Ouliaris cointegration tests, failing to reject the null hypothesis of no cointegration at 5% significance level.

Generally, the results reveal a lack of convergence in house prices between Greater Sydney and NSW non-metropolitan cities. In other words, the behaviour of house prices in Greater Sydney does not have a significant influence on house prices in the non-metropolitan cities of NSW over the long run. The results suggest that the differences in the geographical features, population growth, property types, taste and the social gradient explain why house prices in Greater Sydney and NSW non-metropolitan cities are not linked over time. As noted by Miao et al. (2011), local characteristics often influence housing market that often results in some dynamics in house prices. The lack of cointegration shows that Greater Sydney and non-metropolitan cities of NSW are characterised by different socio-economic and cultural factors that uniquely determine their house prices. For example, the average personal income of Greater Sydney ranges from AUS$59175 in 2011 to AUS$69696 in 2016, representing an annualised increase of 3.33%. On the other hand, average personal income in NSW non-metropolitan cities is in the range of AUS$50387 in 2011 and AUS$58440 in 2016, which represents an annualised growth of 3.01%. In terms of resident population, Greater Sydney accounts for more than 60% of the population of NSW (ABS 2018b)

Similar results were found by Lean and Smyth (2013), who argued that house prices across diverse cities should not move together since house price in each regional housing market is determined by its local demand and supply. The role of local housing demand in driving house price is also well documented in Jones et al. (2003), Burnley (2005) and Fingleton (2006). Within NSW, as majority of people live in Greater Sydney (Yates 2007), it forms part of the driving force that swells housing demand and pushes house prices in Greater Sydney without a corresponding effect on house prices in non-metropolitan areas. Burnley et al. (2007) also noted that housing demand in most metropolitan cities of Australia including Greater Sydney

ranges between 60–75 percent of the population in the state. This is intensified by the large proportion of emigrants, who often settle in Greater Sydney (DSS 2015), further contributing to the growing local demand for housing. Housing supply on the other hand is indivisible and quite diverse in nature targeting various tastes and preferences and chasing the growing housing demand (Watkins 2008; Yates 2008; McLaughlin 2012). This can result in independent housing submarkets with prices distinct from other market segments even in the long run (Leishman et al. 2013). These differences over the years largely accounts for the lack of cointegration between Greater Sydney and NSW non-metropolitan cities. The results also support the findings of Meen (1996), who argued that housing market dynamics are better analysed as a series of interconnected submarkets due to the complex relationships that exist between submarkets within metropolitan areas. All of these provide solid grounds for studying house price movements within Greater Sydney, since it is distinct from the non-metropolitan cities of NSW in house prices.

8.5.2 Long Run Relationship – Greater Sydney & Individual Non-Metropolitan City

However, some biasness may have been introduced by clustering non-metropolitan cities since there could be some discrepancies in the spatial or socio-economic characteristics of these cities. To account for these discrepancies, the analysis is extended to individual non-metropolitan city. The study used cointegration analysis to investigate whether there is a long run relationship between Greater Sydney and each of these non-metropolitan cities of NSW - Cessnock, Lake Macquarie, Maitland, Newcastle, Port Stephens, Kiama, Shellharbour and Wollongong. The unit root tests of house prices of these non-metropolitan cities are reported in Table 8.16.

In general, the house prices of the eight non-metropolitan cities have unit root on levels but become stationary after first difference. This is the case for both the ADF and the PP at the 1% significance level. The series of these cities are all first difference stationary, that is they are I(1) series. The unit root result of Greater Sydney and reported in Table 8.14. Once the order of integration for all the variables has been established, the study formally tests for the existence of long run relationship between Greater Sydney and each of these non-metropolitan cities.

Table 8.16: Unit Root Results - Greater Sydney and Individual Non-Metropolitan Cities

Submarket	ADF Test Level (t-statistic)	ADF Test 1st Difference (t-statistic)	PP Test Level (t-statistic)	PP Test 1st Difference (t-statistic)
Intercept without trend				
Cessnock	0.14	-10.62***	0.21	-10.63***
Lake Macquarie	0.78	-9.27***	0.45	-9.65***
Maitland	0.83	-12.29***	1.42	-12.06***
New Castle	1.44	-5.85***	1.13	-11.76***
Port Stephens	0.47	-11.70***	-0.69	-11.59***
Kiama	0.23	-14.22***	-1.23	-14.33***
Shellharbour	1.03	-3.36**	-0.65	-13.18***
Wollongong	0.54	-11.66***	-0.39	-11.59***
Intercept with trend				
Cessnock	-2.20	-10.64***	-2.20	-10.65***
Lake Macquarie	-1.78	-4.47***	-2.07	-9.72***
Maitland	-2.43	-12.29***	-1.98	-12.15***
New Castle	-2.23	-6.05***	-2.38	-11.95***
Port Stephens	-2.82	-5.33***	-2.99	-11.55***
Kiama	-1.71	-14.20***	-3.48	-14.38***
Shellharbour	-2.29	-3.73**	-2.91	-13.46***
Wollongong	-3.05	-11.70***	-3.11	-11.67***
No intercept and trend				
Cessnock	2.47	-9.93***	2.65	-10.02***
Lake Macquarie	4.20	-4.47***	3.25	-9.72***
Maitland	3.94	-3.06***	3.36	-11.24***
New Castle	4.37	-2.22**	3.72	-11.09***
Port Stephens	0.96	-11.51***	1.05	-11.40***
Kiama	2.79	-4.71***	1.98	-12.85***
Shellharbour	2.20	-2.71***	2.59	-12.05***
Wollongong	1.70	-11.70***	2.10	-11.10***

The ADF and the PP test the null hypothesis of a unit root in house prices of both Greater Sydney and non-metropolitan cities. The results of the ADF and PP failed to reject the null hypothesis on level at P<0.05, but there is clear rejection after first difference at P<0.01 for all three scenarios: intercept without trend; intercept with trend; and no intercept and trend. *** denotes a rejection of the tested hypothesis at the 1% level, ** is rejection of the null hypothesis at 5% level, * is a rejection of the tested hypothesis at 10% level.

Again, the Engle-Granger, Phillip-Ouliaris, and the Johansen bivariate cointegration tests were deployed. The results of Engle Granger test are reported in Table 8.17. Both the tau-statistic and z-statistic are not large enough to reject the tested hypothesis of no cointegration at the relevant significance level, suggesting the absence of a long run relationship in house price between Greater Sydney and each of these non-metropolitan cities. The only exception is the city of Wollongong, which rejected the null hypothesis at P<0.1. This suggests that the housing markets of Greater Sydney and Wollongong are linked over time. The results of the Phillip-Ouliaris cointegration test are reported in Table 8.18. These results failed to reject the tested

hypothesis of no long run equilibrium relationship in house price between Greater Sydney and each of Cessnock, Lake Macquarie, Maitland, Newcastle and Port Stephens cities.

Table 8.17: Engle-Granger Cointegration Results

Cointegration	Dependent	Independent	tau-statistic	z-statistic
Engle-Granger	Greater Sydney	Cessnock	-1.66	-7.13
	Greater Sydney	Lake Macquarie	-1.69	-10.79
	Greater Sydney	Maitland	-1.37	-4.81
	Greater Sydney	New Castle	-1.86	-7.50
	Greater Sydney	Port Stephens	-1.54	-6.72
	Greater Sydney	Kiama	-2.67	-14.44
	Greater Sydney	Shellharbour	-2.09	-9.05
	Greater Sydney	Wollongong	-3.08*	-16.89*
Engel-Granger	Cessnock	Greater Sydney	-1.89	-7.99
	Lake Macquarie	Greater Sydney	-1.78	-10.04
	Maitland	Greater Sydney	-1.57	-5.39
	New Castle	Greater Sydney	-1.91	-7.53
	Port Stephens	Greater Sydney	-1.95	-8.81
	Kiama	Greater Sydney	-2.94	-16.25
	Shellharbour	Greater Sydney	-2.22	-9.67
	Wollongong	Greater Sydney	-3.39*	-18.91*

Table 8.17 shows the results of the Engle-Granger Cointegration test. The results failed to reject the tested hypothesis of no long run equilibrium relationship in house price between Greater Sydney and each of the non-metropolitan cities. The null hypothesis of no cointegration is soundly rejected at P<0.01 and P<0.05 by the Engle-Granger test. Each test used house price in Greater Sydney as the dependent variable and the non-metropolitan city as the independent and interchange the variables resulting into two set of results from both tests. All variables are I(1) as shown by the results of the ADF and PP on Table 8.14. *** denotes a rejection of the tested hypothesis at the 1% level, ** is rejection of the null hypothesis at 5% level, * is a rejection of the tested hypothesis at 10% level

However, the test rejected the null hypothesis of no cointegration in Kiama and Shellharbour at P<0.01 and Wollongong at P<0.05. Given the slight discrepancy in the results of the Engel-Granger and Phillip-Ouliaris cointegration tests, the study employed the Johansen bivariate cointegration to check the robustness of these results and the results are reported in Table 8.19. With the exception of Wollongong and Kiama cities, which rejected the tested hypothesis of no cointegration at P<0.05 and P<0.01 respectively, the results failed to reject the null hypothesis between Greater Sydney and each of the remaining cities at the relevant significance level, which suggests the lack of a long run relationship between Greater Sydney and these non-metropolitan cities of NSW.

Table 8.18: Phillip-Ouliaris Cointegration Results

	Dependent	Independent	tau-statistic	z-statistic
Phillip-Ouliaris	Greater Sydney	Cessnock	-1.56	-6.39
	Greater Sydney	Lake Macquarie	-1.34	-5.28
	Greater Sydney	Maitland	-1.49	-5.52
	Greater Sydney	New Castle	-1.82	-7.12
	Greater Sydney	Port Stephens	-2.11	-10.51
	Greater Sydney	Kiama	-5.71***	-48.76***
	Greater Sydney	Shellharbour	-2.09	-9.05
	Greater Sydney	Wollongong	-3.23*	-18.56*
Phillip-Ouliaris	Cessnock	Greater Sydney	-1.79	-7.18
	Lake Macquarie	Greater Sydney	-1.52	-5.84
	Maitland	Greater Sydney	-1.66	-5.97
	New Castle	Greater Sydney	-1.86	-7.06
	Port Stephens	Greater Sydney	-2.54	-13.14
	Kiama	Greater Sydney	-6.11***	-52.18***
	Shellharbour	Greater Sydney	-4.98***	-36.88***
	Wollongong	Greater Sydney	-3.55**	-20.97**

Table 8.18 shows the results of the Phillip-Ouliaris Cointegration test. The results failed to reject the tested hypothesis of no long run equilibrium relationship in house price between Greater Sydney and all the non-metropolitan cities. The null hypothesis of no cointegration is soundly rejected at P<0.01 and P<0.05 by the Phillip-Ouliaris test in these cities. Each test used house price in Greater Sydney as the dependent variable and the non-metropolitan city as the independent and interchange the variables resulting into two set of results from both tests. All variables are I(1) as shown by the results of the ADF and PP on Table 8.14. *** denotes a rejection of the tested hypothesis at the 1% level, ** is rejection of the null hypothesis at 5% level, * is a rejection of the tested hypothesis at 10% level

The conclusion from these tests is an evidence of a lack of cointegration between Greater Sydney and the cities north of Greater Sydney namely, Cessnock, Lake Macquarie, Maitland, Newcastle and Port Stephens. In contrast, there is some evidence of a contemporaneous long run relationship in house price between Greater Sydney and the cities south of Greater Sydney such as Kiama, Shellharbour and Wollongong. These results mean Greater Sydney is not linked with most of the cities in NSW non-metropolitan cities over time. In other words, the housing markets of the metropolitan city and most of the non-metropolitan cities are not dependent. This evidence of segmentation of the housing market provides strong argument for examining house price linkages within metropolitan cities as against linking them with non-metropolitan cities.

Table 8.19: Johansen Bivariate Cointegration Results

Cities	Hypothesis	Trace-statistic	Prob.	Max-Eigen-statistic	Prob.
Cessnock	None	4.01	0.90	3.33	0.92
	At most 1	0.67	0.40	0.64	0.40
Lake Macquarie	None	10.55	0.24	9.73	0.23
	At most 1	0.82	0.36	0.82	0.36
Maitland	None	8.07	0.45	7.25	0.45
	At most 1	0.81	0.36	0.81	0.36
Newcastle	None	4.29	0.87	3.70	0.88
	At most 1	0.58	0.44	0.58	0.44
Port Stephens	None	8.98	0.36	8.06	0.37
	At most 1	0.92	0.33	0.93	0.34
Kiama	None	18.86	0.06*	18.08	0.06*
	At most 1	0.78	0.37	0.78	0.37
Shellharbour	None	11.04	0.20	10.89	0.15
	At most 1	0.15	0.69	0.15	0.69
Wollongong	None	20.62	0.02**	21.72	0.02**
	At most 1	0.90	0.34	0.90	0.34

Table 8.19 shows the results of the Johansen bivariate cointegration tests that is used to check the consistency of the results in tables 8.17 and 8.18. The results largely support both the Engle-Granger and the Phillip-Ouliaris results of a lack of cointegration in house prices between Greater Sydney and the eight non-metropolitan cities of NSW. The test failed to reject the null hypothesis of no cointegration at P<0.01 and P<0.05. Similarly, all variables are first differenced stationary as shown by the results of the ADF, PP and KPSS on Table 8.14 and Table 8.16.

Again, this lack of dependence in house price over time between Greater Sydney and the cities north of Greater Sydney can be attributed to the discrepancies in their socio-economic, spatial and cultural characteristics among these cities. As argued by Lean and Smyth (2013), house prices are largely determined by the interaction between local demand and supply, which often culminates in varying house prices. Kauko et al. (2002) and Jones et al. (2003) also pinpointed the role of local factors in determining house price. They highlighted that factors such as geographic location, structural characteristics, and consumer perceptions about the ecological, cultural, and social considerations of regions and cities contribute largely to household housing utility.

Statistics from the ABS support the existence of discrepancies in key socio-economic characteristics between Greater Sydney and these non-metropolitan cities. From 2013 to 2018, for example, the 1.91% annualised population growth in Greater Sydney is greater than the growth in all the other cities of NSW (ABS 2018b). There is also a discrepancy in the annual unemployment rate. Greater Sydney recorded 6% unemployment rate in 2016, while the non-metropolitan cities have a higher unemployment rate such as Wollongong 7.1%, Shellharbour

6.9%, Newcastle 7.4%, and Cessnock 8.7% in the same year. Further, while economic activities in Greater Sydney are teeming with high value, knowledge-intensive industries including finance, IT, professional services, engineering, research, healthcare, marketing and media jobs (Wade 2017), the economies of these non-metropolitan cities are largely driven by health care and social assistance services, manufacturing, construction, retail and education and training (ABS 2018b). This difference in the nature of economic activities is also reflected in the income discrepancy between Greater Sydney and these non-metropolitan cities. In 2016, for example, the average personal income of Greater Sydney was AUS$69696, while it was AUS$58440 in the non-metropolitan cities (ABS 2018b).

Table 8.20: Pairwise Granger Causality Results

Null Hypothesis	F-Statistic	Prob.
ΔCessnock does not Granger-cause ΔGreater Sydney	0.36	0.87
ΔGreater Sydney does not Granger-cause ΔCessnock	1.91	0.10
ΔLake Macquarie does not Granger-cause ΔGreater Sydney	0.99	0.39
ΔGreater Sydney does not Granger-cause ΔLake Macquarie	1.93	0.11
ΔMaitland does not Granger-cause ΔGreater Sydney	0.34	0.93
ΔGreater Sydney does not Granger-cause ΔMaitland	1.91	0.10
ΔNewcastle does not Granger-cause ΔGreater Sydney	0.70	0.61
ΔGreater Sydney does not Granger-cause ΔNewcastle	0.81	0.51
ΔPort Stephens does not Granger-cause ΔGreater Sydney	0.79	0.53
ΔGreater Sydney does not Granger-cause ΔPort Stephens	0.92	0.11
ΔKiama does not Granger-cause ΔGreater Sydney	2.04	0.13
ΔGreater Sydney does not Granger-cause ΔKiama	11.68	0.00***
ΔShellharbour does not Granger-cause ΔGreater Sydney	0.89	0.41
ΔGreater Sydney does not Granger-cause ΔShellharbour	14.90	0.00***
ΔWollongong does not Granger-cause ΔGreater Sydney	0.30	0.93
ΔGreater Sydney does not Granger-cause ΔWollongong	2.28	0.04**

House prices are all I(1) stationary. *** denotes a rejection of the tested hypothesis at the 1% level, ** is rejection of the null hypothesis at 5% level, * is a rejection of the tested hypothesis at 10% level

In general, the robustness checks support all previous results. It shows the lack of long run relationship in house price between Greater Sydney and Cessnock, Lake Macquarie, Maitland, Newcastle, and Port Stephens in NSW. It provides an empirical evidence of the segmentation of the housing market among the cities of the state of NSW, which again supports our study to examine house price linkages within Greater Sydney. The existence of cointegration between Greater Sydney and the non-metropolitan cities south of Greater Sydney raises the question of

how house price diffuses between Greater Sydney and these cities. This section investigates the causality between these housing markets using a pairwise Granger-causality test.

From Table 8.13, it is clear that Greater Sydney is the high-priced submarket, while the non-metropolitan cities are the low-priced submarkets. Again, consistent with our hypothesis in section 1.6, any causality from the high-end to the low-end of the market supports the migration hypothesis, while the reverse supports the equity transfer hypothesis. The results of the Granger-causality are reported in Table 8.20**.**

The results reveal that the Greater Sydney housing market Granger-causes the housing market of Kiama and Shellharbour cities at $P<0.01$ and Wollongong city at $P<0.05$. Greater Sydney is therefore dominating these non-metropolitan cities. This suggests that the housing market of Greater Sydney contains useful past information that can be used to explain the movement of house prices in Kiama, Shellharbour and Wollongong. Essentially, house price in Greater Sydney will be diffused in these cities. This means when changes in market fundamentals occur, house prices first increase in Greater Sydney and then spillover to these cities. The spread occurs when households who are priced-out in Greater Sydney migrate to the cities south of Greater Sydney. Nevertheless, there is little evidence to suggest that house prices in Kiama, Shellharbour and Wollongong Granger-cause Greater Sydney. The relationship between these housing markets is therefore unidirectional.

The results can be interpreted as supporting the migration hypothesis. This diffusion pattern, as described by Jones et al. (2003) and Meen (1999), occurs when households move to areas with relative low price. Ling and Hui (2013) also found similar results, as they reported a flow from the main city to the periphery areas (or high-priced areas to low-end areas) of Hangzhou. The evidence of the migration hypothesis is connected with the Alonso-Mills-Muth discussed in section 4.3.4, which posits that households would relocate to relative low-priced areas, by taking advantage of price differentials, and commuting to the high-end submarket (Lai & Tsai 2008). The ABS 2016 census shows that internal migration is increasing population growth on the fringe of major Australian cities including costal centres which includes Kiama, Shellharbour and Wollongong (ABS 2018a). Further, there is strong transport connectivity of people and goods between Greater Sydney and the southern regions of NSW. For example, Port Kembla in the south of Greater Sydney, is NSW's largest terminal for vehicle imports and grain exports, and the second largest terminal for coal exports. This port has been identified as the location for the development of a future container terminal to augment capacity of Port Botany when required. The freight rail access to Port Kembla has also been recognised by

Infrastructure Australia as an initiative of national priority (Transport for NSW [TfNSW] 2018). All of these factors could stimulate households to move to Kiama, Shellharbour and Wollongong cities when priced-out in Greater Sydney.

8.6 Conclusion of the Chapter

This chapter of the study expands upon the limited literature to have examined house price diffusion of housing submarkets (namely, low-priced and high-priced submarkets) in Greater Sydney, one of the most diverse housing markets in Australia, using convergence tests, cointegration techniques, Granger-causality tests and dynamic ordinary least square estimator. The results show the existence of a long run relationship in house price between the two broad housing submarkets of Greater Sydney. Importantly, the empirical results show that a large degree of diffusion take place from the less prosperous submarket to the high-end submarket. This supports the equity transfer hypothesis in which house prices in the low-priced submarket will be transmitted into the high-priced submarket. The study also finds that the low-priced submarket is the primary reactor to changes in economic fundamentals. Further analyses were done to examine the long run relationship between Greater Sydney and key non-metropolitan cities of the state of NSW. The study found no cointegration between Greater Sydney and most of these cities, which suggested that house prices in these cities are largely driven by local demand and supply factors.

CHAPTER 9

CONCLUSION

9.1 Background

Previous studies of housing affordability focused largely on entry-level affordability at wider geographical levels such as city, region and country. Similarly, studies on the local drivers of affordability, housing price bubbles, and house price linkages were also done at broader geographical levels. All these studies were done against the backdrop of glaring socio-economic disparities in most metropolitan cities of Australia, particularly Greater Sydney. This study departs from previous studies on housing affordability and house price behaviour by adopting a disaggregated approach in Australia's most populous and socio-economically diverse city, namely Greater Sydney. The study provides detailed description of the five regions of Greater Sydney – western, inner-west, southern, eastern and northern using demographic, social and economic parameters. This forms the basis for the sub-city approach in this study. The study employs various descriptive and analytical statistical methods and applied econometrics, combined with a wide array of urban and housing theories to examine entry-level and ongoing affordability, local drivers of affordability, housing price bubbles, and house price movements in these five regions. The empirical results have been discussed and summarised in four main analysis chapters – Chapter 5: Housing Affordability; Chapter 6: Ownership Affordability and Local Housing Variables; Chapter 7: Housing Price Bubbles; and Chapter 8: House Price Linkages. The aim of this chapter is to synthesise the key findings of this study to provide answers to the research questions in Chapter 1. The theoretical and practical implications of the study are also highlighted. Finally, the limitations of the study are explained and possible future research areas are also outlined.

9.2 Main Findings

9.2.1 Differential Geography of Housing Affordability across Regions

This study has examined entry-level and ongoing affordability in Greater Sydney across time and space. It disaggregates Greater Sydney into five regions using spatial and socio-economic characteristics and conducts a more detailed examination of affordability in each of these defined regions – western, inner-west, southern, eastern and northern. With the use of the disaggregated approach, the study developed both entry-level and ongoing housing affordability indexes for these five different geographical regions spanning 1991 to 2016. Several important findings have been documented.

Entry-level affordability generally takes an upward trend in all regions over 1991 to 2016, highlighting a deterioration of housing affordability in all regions. This suggests that access to the housing market across Greater Sydney is becoming more challenging, particularly for low-income households to access housing across Sydney. Since house price and the initial deposit are key drivers of entry-level housing affordability, the continuous deterioration in entry-level housing affordability across Greater Sydney translates into a decline in the proportion of first homebuyers entering the housing market. The results also show differences in the magnitude at which entry-level housing affordability deteriorates across regions. This reflects the differential geography of housing affordability. An obvious difference in entry-level housing affordability is observed between Western Sydney and the other regions of Greater Sydney. As the increase in house price continues to outstrip income growth, housing entrants from low-income Western Sydney are likely to be most affected, especially when residents from other parts of the city tend to move to relatively more affordable areas. This means low-income residents from Western Sydney will be further disadvantaged compared to those in high-income eastern and northern suburbs. To further investigate whether the differences in entry-level housing affordability across regions are statistically significant, both the parametric t-test and non-parametric Wilcoxon matched-pairs signed-ranks test were employed. The results show that the differences in entry-level housing affordability across all regions of Greater Sydney are indeed significant at the 1 percent significance level. This further reinforces our earlier argument on the existing disparities in housing affordability of Greater Sydney.

After entry into the housing market, the study results show that ongoing affordability generally improves over time. Depending on their income level and the mortgage lending rate, households from across Greater Sydney may experience some level of housing stress (spending more than 30 percent of their income on housing related expenses) in the first five years but this will improve from the tenth year onwards. Further, an enhanced improvement of ongoing affordability is found in high-income regions (e.g. eastern and northern) compared with low-income regions. Using the threshold of affordable housing index value of 30, the results indicate that residents in low-income regions take a longer period to reach this threshold than those in high-income regions. Moreover, as ongoing affordability becomes more challenging for mortgage owners, it can potentially cause housing-induced poverty among households especially those with relatively low-income. The study generally highlights the differential geography of housing affordability in which significant disparities between high-income regions and low-income regions of Greater Sydney are observed.

9.2.2 Low-income Regions are more Sensitive to Local Housing Variables

The study adopted a system generalised method of moments (GMM) to evaluate the impact of local housing variables on ownership affordability in the five delineated regions of Greater Sydney - western, inner-west, southern, eastern, and northern. This sub-city approach has uncovered some important findings on the local drivers of ownership affordability, contributing to the limited empirical literature on the subject.

The results show that house price and average personal income have varying effects on the homeownership of the LGAs that makeup the regions of Greater Sydney. Specifically, the effect of the interplay between house price and income to determine the level of affordability has a greater effect on LGAs in the relative low-income regions than the high-income regions. An increase in house price, for example, has a greater adverse effect on the homeownership affordability of LGAs in the relative low-income regions than in the high-income eastern and northern regions. Further, LGAs in the relative low-income regions are more sensitive to income changes than high-income regions. The sluggish income growth in the relative low-income regions means their residents will continue to experience severe affordability, a situation that will be exacerbated with a sustained increase in house price combined with a uniform housing policy approach. These results support the shelter poverty model discussed earlier, which highlights the sensitivity of affordability to household incomes.

Additionally, there is a general differential geography of the causality between homeownership affordability and local housing variables. This supports our hypothesis in the sense that relative low-income regions have more significant drivers of affordability than high-income regions. This essentially means that affordability of relative low-income regions is more affected by changes in key housing variables than in high-income regions. Increasing housing supply, for example, plays an important role in improving affordability, particularly in the western, inner-west and southern regions, while it is insignificant in the high-income eastern and northern regions. Asymmetric impacts are also found in median rents and population, which further highlights the differences in the geographical distribution of the effects of local drivers of affordability. The study findings generally support the shelter poverty hypothesis, as residents from low socio-economic background are sensitive to a change in income, rent, house price, demographics and other socio-economic factors. The discrepancy can be attributed to the clear differences in the socio-economic and demographic characteristics of the various regions of Greater Sydney discussed earlier.

9.2.3 Detection of Housing Price Bubbles in the Low-income Regions

Similar to the previous two research questions, the study adopted a disaggregated approach to investigate whether there is a bubble contagion in the five regions of Greater Sydney. The study employed Im-Pesaran-Shin (IPS) panel unit root and Westerlund (2007) error-correction based panel cointegration test to examine the existence of housing price bubble in the different regions of Greater Sydney– western, inner-west, southern, eastern, and northern - over 1991 to 2016. A formal housing price bubble test was also done following the BSADF procedure to check for real time bubble period for each region of Sydney using both nominal and real house-price-rent ratio for various housing types. Several key findings have been documented.

The results show no cointegration between house price and rent in the relative low-income western, inner-west and southern regions of Greater Sydney. This confirms that house price and rent are growing disproportionately and do not return to an equilibrium. This is an early housing bubble indication. The results, however, rejected the tested hypothesis of no cointegration between house price and rent in the eastern and northern regions of the city. This shows in turn that house price and rent are linked over time in the eastern and northern regions, which shows the lack of a housing bubble in these regions. The cointegration analyses have signalled evidence of housing bubble formation in the relative low-income regions but not in high-income regions. The results show the geographical variation in the interplay between house price and rent over time across the regions of Greater Sydney. The results consistently provide an indication of a housing bubble in the relative low-income regions.

For a more enhanced analysis, a formal housing bubble test was also conducted using the BSADF test. The BSADF results show evidence of housing bubbles in the relative low-income western and inner-west regions for all dwellings. However, there is no evidence of housing bubbles in the high-income eastern and northern regions. Considering non-strata dwellings, there is clear evidence of a housing bubble in all the relative low-income regions of the city, while no such evidence exists in the high-income regions. Similar results are obtained for strata dwellings. These results indicate that investment from housing investors is possibly contributing to the strong housing demand in these regions, which drives house prices to non-sustainable levels and are unrelated to fundamentals (i.e. rents). This also offers some empirical evidence of Shiller's (2007) psychological theory of housing bubble in which housing investors view housing as an important investment opportunity as they are more likely to have speculative thinking of housing prices.

The combined study of the interaction between house price and rent on the one hand, and formal tests of housing price bubbles on the other hand, is a novelty approach that has enhanced our understanding of the dramatic behaviour of house prices in the different regions of Greater Sydney. This approach has enabled us to examine the long run interaction between house price and rent, and revealed the dramatic behaviour in house prices. This has provided a solid background for more informed and rational investment decisions.

9.2.4 Low-Priced Region Leads High-Priced Region Reflecting a Filtering Process

Following the growing interest in the inter-relationships of housing submarkets, the study examined house price diffusion between neighbourhoods of Greater Sydney using quarterly house price sales data from the first quarter of 1991 to the second quarter of 2016. The study re-categorised the disaggregated five regions of Greater Sydney into relative low-priced (western, inner-west and southern regions) and relative high-priced (eastern and northern regions) submarkets and explored the diffusion pattern between these. This taxonomy is based on the degree of house price substitutability, social and economic characteristics, and spatial factors. This is also supported by the results discussed in the previous sub-sections of this chapter. The study employed Meen's (1999) constancy ratio analysis, a pairwise cointegration and Granger causality tests to examine the spillover effect between both submarkets (relative low-priced and relative high-priced). The study extended the analysis by applying a dynamic ordinary least square (DOLS) estimator to gauge the long-run effect of economic fundamentals on house prices in these submarkets.

The study provides a number of important insights. Firstly, Meen's (1999) ratio, in each case, is stationary at the 1 percent significance level. This reveals the initial indication of a long-run constancy in these ratios. More importantly, it indicates the existence of a spillover effect between the submarkets of Greater Sydney. This again cannot be unconnected to the existing differences in the socio-economic characteristics of the regions of Greater Sydney. As such, changes in market fundamentals would have varying effects on house prices in these submarkets. The indication of a spillover effect highlights a long-run time-invariant mean, which suggests that some long-run price differential between submarkets are mean reverting. The convergence of submarkets means house prices in one housing submarket in Greater Sydney will rise or fall first, and then gradually spread to the other housing submarket over time.

Secondly, a contemporaneous long-run relationship in house price is established between the relative high-priced and relative low-priced submarkets of Greater Sydney. This indicates that

these two submarkets are not segmented but converge to a single market over time. It further validates the results of Meen's (1999) ratio that there is a spillover effect within a single housing market. This means, over time, the changes in house price in a submarket (e.g. the relative low-priced submarket) will certainly affect house prices in another submarket (e.g. the high-priced submarket)

Thirdly, house prices diffuse from the less economically prosperous submarket (low-priced) to the high-end submarket. This result supports the equity transfer hypothesis in which, as market fundamentals change, households move to the high-priced submarket because of the increase in their equity. The finding also supports the residential mobility theory, which posits that households move to improve their housing circumstance and explore economic opportunities by moving closer to more economically prosperous areas of the city. Further, the equity transfer hypothesis is also confirmed by the fact that the low-priced submarket is the first to react to changes in market fundamentals, and is therefore dominant. Specifically, house prices in this submarket are strongly associated with economic fundamentals (i.e. state final demand, S&P/ASX 300, population and building start), while no comparable evidence is found for house prices in the high-end submarket. Importantly, the strong linkage between the dominant submarket (i.e. the low-priced submarket) and market fundamentals, to a certain extent, provides some empirical evidence to explain the price-leading role of the low-priced submarket.

9.3 Contribution of the Study

This study has provided an empirical analysis of various elements of housing affordability and house price behaviour of the different regions of Greater Sydney. This study examines these concepts within a localised context, bringing to the fore the importance of considering local effects in the housing market. The following section discusses the practical and theoretical contributions and their implications for future housing submarket research.

9.3.1 Practical Contributions

This study has contributed to the body of knowledge by highlighting the socio-economic disparities across the regions of Australia's most populous city, namely Greater Sydney. The study is therefore the first to examine housing affordability on the back of these glaring demographic and socio-economic discrepancies across Sydney. As these socio-economic disparities are evident in most capital cities of Australia (Hulse et al. 2014), the findings have provided the rudiments for addressing socio-economic imbalances arising from housing

affordability within these cities of Australia. Importantly, the study highlighted the importance of policy makers taking into consideration the growing geographical complexities across metropolitan Sydney in particular, and other capital cities of Australian in general, with a focus on addressing the resulting spatial polarisation of these cities. Therefore, the findings of this study have important implications that are not only of interest to academics but also to state and local housing policy makers, property investors and current and potential homeowners.

First, the study has articulated the levels of the deteriorating affordability across the city, making a strong case for geographically balanced housing policies. As highlighted by Beer et al. (2007), existing housing policies are not adequately designed to ensure affordability for all households, particularly low-income households. Randolph et al. (2013) and Lee and Reed (2014) earlier propounded the view that the First Home Owner Grant (FHOG) will have greater impact if targeted towards lower income households. The findings of this study therefore support these propositions and assert for a more targeted approach to addressing housing affordability for residents across Greater Sydney (e.g. the introduction of an income test for the FHOG). Specifically, governments should provide assistance for first-time buyers to gain access to housing market as a means to address entry-level housing affordability disparities. Further, the findings about on-going housing affordability suggest that policy makers should promote home ownership as a means to address housing stress among homeowners as their on-going housing affordability improves over time. This should be articulated to stimulate prospective first-time buyers in the study area as well as other capital cities of Australia.

Second, as the sensitivity of house price to affordability is higher in the relative low-income regions than in the high-income regions, the study argues for more targeted housing policies that will leverage house prices and enhance entry into the housing market. Policy makers should take into consideration this varying sensitivity of house price across Greater Sydney in the design of policies that seek to improve house prices. Personal income has disproportionate effect on entry into the housing market and for sustaining mortgages. This is particularly the case for the relative low-income residents including potential first homebuyers. Existing housing support policies including the First Home Owner Grant (FHOG) would have its desired effect if directed at lower income households. This is on the back of the findings of this study, which reveal the susceptibility of low-income households to the deterioration of affordability. The study has provided sufficient evidence to housing policy makers for the formulation of regionally balanced housing policies to improve ownership affordability within metropolitan cities. Higher housing rents also makes entering to the market more challenging for potential

first homebuyers. Therefore, housing policy direction towards enhancing the income of residents from low-income regions is becoming more relevant to boost income levels. This will help in improving the affordability of potential first homebuyers. In addition, as housing supply is less responsive to housing demand, it generally worsens affordability and makes entry to the housing market too challenging. The study suggests a closer look into the existing levies and housing regulations to remove bottlenecks towards building approvals and building starts to boost housing supply. A more dedicated policy framework from the relevant interlocutors of residential property development is required to make inroads into the sluggish response of housing supply to demand. These findings and their implications could also be useful tools in examining the drivers of affordability in other Australian cities.

Third, the skewed effect of the change in house price and rent over time reveals important information about the behaviour of the housing market in the various regions of Greater Sydney. Hence, the findings could be used as a tool by policymakers to initiate well-informed housing policies that seek to create regional balance within a socio-economically diverse metropolitan city. The cointegration results of house price and income have also offered important tools and information in the hands of policymakers, which they could use to stabilise the growing gap between house price increase and income growth to improve affordability, especially for low-income households. Finally, evidence of housing bubbles in the relative low-income regions could make entry to the housing market more challenging for potential first home buyers in these regions. Policymakers could utilise this information to address elements of housing demand (i.e. housing investment) that may escalate house price, in order to improve affordability for potential first home buyers and reduce the risk of housing bubble formulation across Australian cities.

Fourth, the evidence of equity transfer diffusion patterns shows that households in Greater Sydney tend to initially buy properties in less desired areas but tend to trade up to the more desired areas as their equity improves. This is particularly the case for residents from the low-end submarket, who tend to use their initial purchase as a springboard to subsequent purchases. This pattern of housing trade-up has important implications for policymakers. It suggests that homeownership should be promoted and encouraged, and it is a critical strategy for most households to moving up the housing ladder. The existence of a contemporaneous long-run equilibrium relationship in house price between the high-priced and low-priced submarkets of Greater Sydney means current and potential homeowners are affected in varying ways by ongoing changes in house prices in the city. As submarkets are linked, residents from the

submarket with low socio-economic characteristics can potentially be affected more than those from the higher end of the spectrum. This is further exacerbated by the fact that the relative low-priced submarket in Sydney is more susceptible to market fundamentals compared with the relative high-priced submarket. This raises several questions about the appropriateness of uniform housing policies in addressing regional imbalances within the city. In addition, monetary policy makers should also be aware that any major monetary policy change that is related to housing markets would have a stronger impact on residents from the low-ended submarkets. The study has therefore provided useful tools to policy regulators in addressing socio-economic imbalances that are related to housing desirability within Greater Sydney and potentially for other capital cities of Australia.

9.3.2 Theoretical Contributions

The theoretical contribution of this thesis are classified into two broad themes. The first theme envelops the application of a broad array of theories from various disciplines such as Finance, Property, Urban Studies, Macroeconomics, Sociology and Geography. These theories are used to develop the theoretical framework of each research question of the study. The second theme clusters the extensive application of statistical and econometric analyses.

In the first theoretical theme, the study applied the novel spatial approach across space and time within the context of entry-level housing affordability. Combined with an annuity-based formula, this theory helps to examine the status of entry-level and ongoing affordability across the different regions of Greater Sydney over time. The study also adopted the option-theoretic mortgage pricing model to examine ongoing affordability across these regions of Greater Sydney. The shelter poverty model is applied in examining the causality between affordability and local housing variables in each region of Greater Sydney. Shiller (2007) psychological theory of housing bubble was adopted to examine the notion of a speculative housing bubble across the study regions. By synthesising other theories and concepts from other academic disciplines such as market fundamentals, migration and equity-transfers, filtering process, residential mobility, and the Alonso-Mills-Muth model, this study has uncovered the patterns in home price movements between submarkets. In general, the application of these theories has demonstrated that property discipline is intertwined with other disciplines. This multi-disciplinary approach has provided more insights into developing theoretical framework for future housing research.

The second theoretical contribution pulls together a suite of econometric and quantitative techniques. A new index for estimating ongoing affordability index was developed and this

should be of considerable interest to both academics and practitioners. The study also applied the system generalised method of moments (SGMM) in housing within the context of a metropolitan city for the first time, and utilised recent advances in panel econometrics including the Im-Pesaran-Shin (IPS) unit root test and the Westerlund (2007) error correction-based panel cointegration test within sub-city housing markets. The BSADF housing price bubbles test is also used within a sub-city model for the first time. Further, the study combined a range of econometric tools and analyses to test for spillover effects within the housing submarkets of a metropolitan city, and investigated how these submarkets are being influenced by market fundamentals using the dynamic OLS. Generally, the methodology of the study has provided useful research tools for future housing research.

9.4 Limitations of the Study

Even though significant efforts have been made toward the realisation of the study aims and objectives, there are some limitations in terms of data, methodology, and the scope of the study. These limitations are beyond the author's control.

The first limitation is the study period. The study period did not go beyond 2016 since the amalgamation of local councils within the state of NSW commences in 2016, which essentially affects LGA data beyond 2016. Four of the study regions of Greater Sydney were affected by this amalgamation. In the western region, the City of Canterbury and Bankstown is a merger of the previous Bankstown and Canterbury councils; and the Cumberland Council combined the previous Holroyd and Auburn councils. In the inner-west region, the Inner-West Council was formed by the merger of the former Ashfield, Leichhardt and Marrickville councils. In the southern region, the Georges River Council merged the former Kogarah and Hurstville councils; and the Bayside Council is a merger of the former Botany Bay and Rockdale councils. In the northern region, Northern Beaches Council replaced the former Manly, Pittwater and Warringah councils. There is no merger in the eastern region. However, the amalgamation of LGAs does not overlap across regions.

The second limitation of the study is the dataset. The study is constrained by the non-availability of data below the LGA level for all the variables used in the study such as house price, median rent, average personal income, housing supply, and resident population. The availability of data for these variables at ABS Statistical Area Level 2 (SA2) or below remains a constraint for this study. Time series data for other local housing variables such as median income could also not be obtained. Furthermore, median house price and median house rent

were used throughout in the analysis. This is due to the difficulty in obtaining other measures of these variables at LGA level.

The third limitation is the choice of the study region. The study only examines Greater Sydney, which is one of the six metropolitan cities of Australia. This limitation is purely based on the appropriateness of Greater Sydney for a sub-city housing analysis. As highlighted in section 2.3, the glaring disparity in the socio-economic and demographic characteristics across the regions of Sydney makes a stronger case for disaggregated studies in this city.

9.5 Recommendations for Future Research

This study has produced fascinating results on several elements of housing affordability and house price movements within Greater Sydney. However, the limitations highlighted in the previous section have offered possible areas that deserve further investigation.

Foremost, the study recognises the disparity in the socio-economic and demographic features that often characterise metropolitan cities to evaluate affordability and house price movement in Greater Sydney. The study has provided significant tools and information for developing regionally balanced housing policies in Greater Sydney. Therefore, similar studies should be done in the future for other metropolitan cities of Australia.

The study period did not go beyond 2016 due to the commencement of the amalgamation of LGAs across NSW in this year. The amalgamation of LGAs may generate new regulations and actions that may have greater influence on both the demand and supply sides of the housing market. Future research should therefore examine affordability in these regions beyond 2016. Future research should also look into affordability at geographical levels below the LGA level since there could be some differences in key housing parameters across LGAs in a given region.

Some studies have suggested that effective and efficient public transport system could improve housing affordability especially in metropolitan cities. This means an efficient transport network would enable households to live in relative low-priced regions and shuttle to the city centres. Future studies should examine the impact of an improved transport system on housing affordability across the various regions in metropolitan city.

As highlighted in the study, entry-level affordability is deteriorating across Greater Sydney. This has significant implications for various age brackets in terms of getting their feet in the housing market. A dedicated research is required in the future to evaluate accessibility to the housing market for younger generation amidst declining affordability and rising student loans.

It will be fascinating to conduct such contemporary research in the future to highlight how these factors would impact the ability of this cohort to enter and stay in the housing market.

One of the findings of this study is that increasing housing supply will improve housing affordability in the relative low-income regions of Greater Sydney. This issue of housing supply-demand gap, with supply trailing demand is well documented in the housing literature. This is also topical among policy makers and property developers. In the future, it will be important to develop more coherent ways of measuring housing deficit to enable policymakers and other housing stakeholders to make more informed decisions.

Finally, due to the increase in the number of 'rentvestors[18]' especially in the relative low-income regions of Greater Sydney, an examination of the linkage between property investment and negative gearing and how this can possibly affect housing rent, is another important research area in the future. This topic has been a subject of discussion among policymakers and politicians. Therefore, it will be essential to conduct further research on this issue to provide some empirical evidence to enhance the discussion.

9.6 Concluding Comments

The issue of housing affordability is beyond the interest of academics. It has become the subject of discussion among policy makers, politicians, investors, developers and other players of the housing sector. An enhanced understanding of affordability is therefore imperative for a more informed decision especially for geographical areas where there are significant socio-economic and demographic discrepancies. This thesis has vigorously examined several elements of affordability and uncovered the pattern of house price movements within a metropolitan city. The rigorous analyses undertaken in this study have highlighted the status of affordability in the different regions of Sydney. One of the key findings of this thesis is that the deterioration in affordability is more severe in the relative low-income western, inner-west and southern regions than in the high-income regions of the city. Specifically, the deterioration in the relative low-income regions is largely caused by the growing property investment in these regions, coupled with the equity approach used by some first homebuyers who purchase their first properties in these regions to gain equity and then spring to the high-income regions. These analyses have offered a fuller understanding of the Sydney housing market, an outcome that could be of interest to academics, policy makers, property investors and other housing stakeholders. The integrity and calibre of this study has been further validated by several

[18] Rentvestors is a coinage used in housing studies to refer to people who buy a property and put it on rent while they continue to rent.

publications and presentations at various real estate conferences in Asia, Pacific-Rim, Europe and the United States. Consequently, the following journal papers and conference presentations have been generated during this research project:

Published Journal Articles:

1. Bangura, M & Lee C, L 2019 "House price diffusion of housing submarkets in Greater Sydney", *Housing Studies*, vol. 36, no. 7, pp. 1-32 (2018 Impact Factor: 1.882)

2. Bangura, M & Lee C, L 2019 "The differential geography of housing affordability in Sydney: a disaggregated approach", *Australian Geographer*, vol. 50, no. 3, pp. 295-313 (2018 Impact Factor: 1.639)

Under-Revision Journal Article

1. Bangura, M & Lee C, L 2019 "The Determinants of Homeownership Affordability in Greater Sydney: Evidence from a Submarket Analysis", *Housing Studies*

2. Bangura, M & Lee C, L 2019 "Housing Price Bubbles in Greater Sydney: Evidence from a Submarket Analysis", *Housing Studies*

Conference Papers and Presentations:

1. Bangura, M & Lee, C, L 2019 "House affordability and house price bubbles nexus: Evidence from Greater Sydney", presentation at the 26th European Real Estate Society (ERES), Cergy-Pontoise Cedex, France

2. Bangura, M 2019 "PhD Thesis", presentation at the 35th American Real Estate Society (ARES), Phoenix, Arizona USA

3. Bangura, M & Lee C, L 2019 "House price diffusion of housing submarkets in Greater Sydney", presentation at the 35th American Real Estate Society (ARES), Phoenix, Arizona USA

4. Bangura, M & Lee, C, L 2019 “House affordability and house price bubbles nexus: Evidence from Greater Sydney”, presentation at the 25th Pacific Rim Real Estate Society (PRRES), Melbourne, Australia

5. Bangura, M 2019 “PhD Thesis”, presentation at the 25th Pacific Rim Real Estate Society (PRRES)”, Melbourne, Australia

6. Bangura, M 2019 “House price diffusion of housing submarkets in Greater Sydney”, presentation at the 25th Pacific Rim Real Estate Society (PRRES), Melbourne, Australia

7. Bangura, M 2018 “PhD Thesis”, presentation at the 24th Pacific Rim Real Estate Society (PRRES)”, Auckland, New Zealand

8. Bangura, M & Lee, C, L 2018 “Drivers of ownership affordability of the regions of Greater Sydney”, presentation at the 24th Pacific Rim Real Estate Society (PRRES), Auckland, New Zealand

9. Bangura, M & Lee, C, L 2018 “House price diffusion in Greater Sydney: Evidence from cointegration approach”, presentation at the 23rd Asian Real Estate Society (AsRES), Incheon, Korea

10. Bangura, M 2017 “PhD Thesis”, presentation at the 23rd Pacific Rim Real Estate Society (PRRES), Sydney Australia

11. Bangura, M 2017 “Housing affordability in Greater Sydney”, presentation at the 23rd Pacific Rim Real Estate Society (PRRES), Sydney Australia

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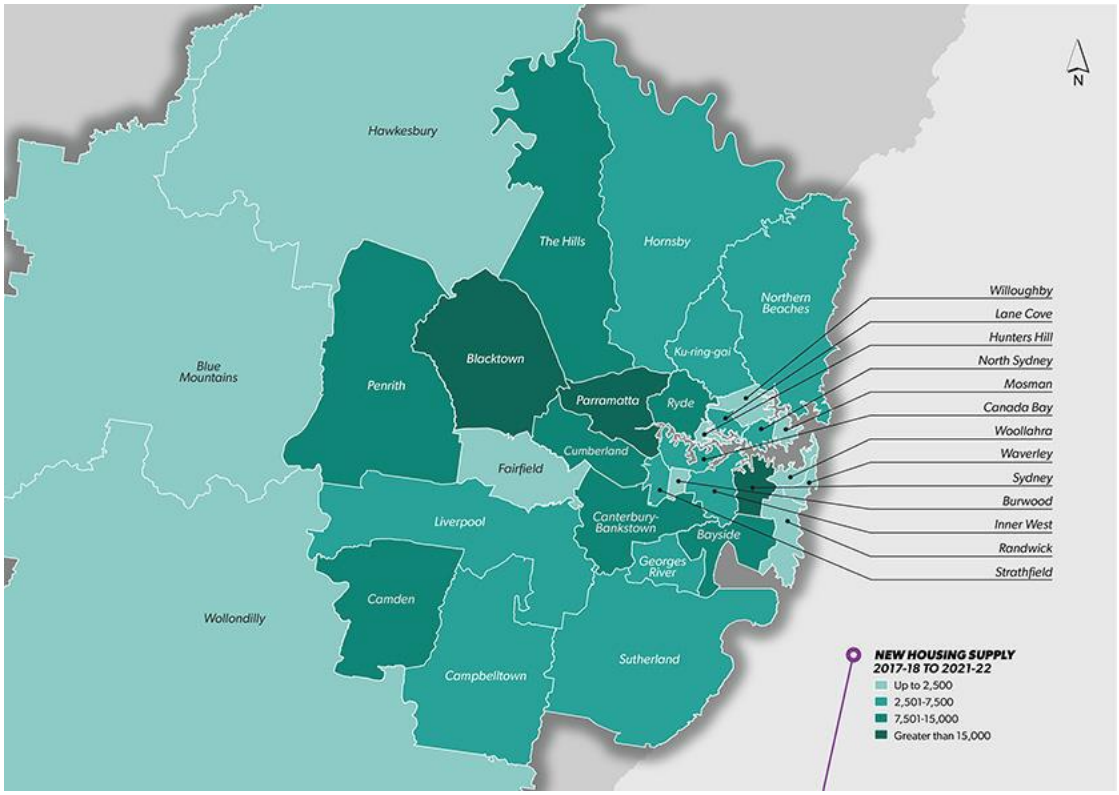
APPENDICES

Appendix 1: Iconic Opera House and Harbour Bridge of Greater Sydney

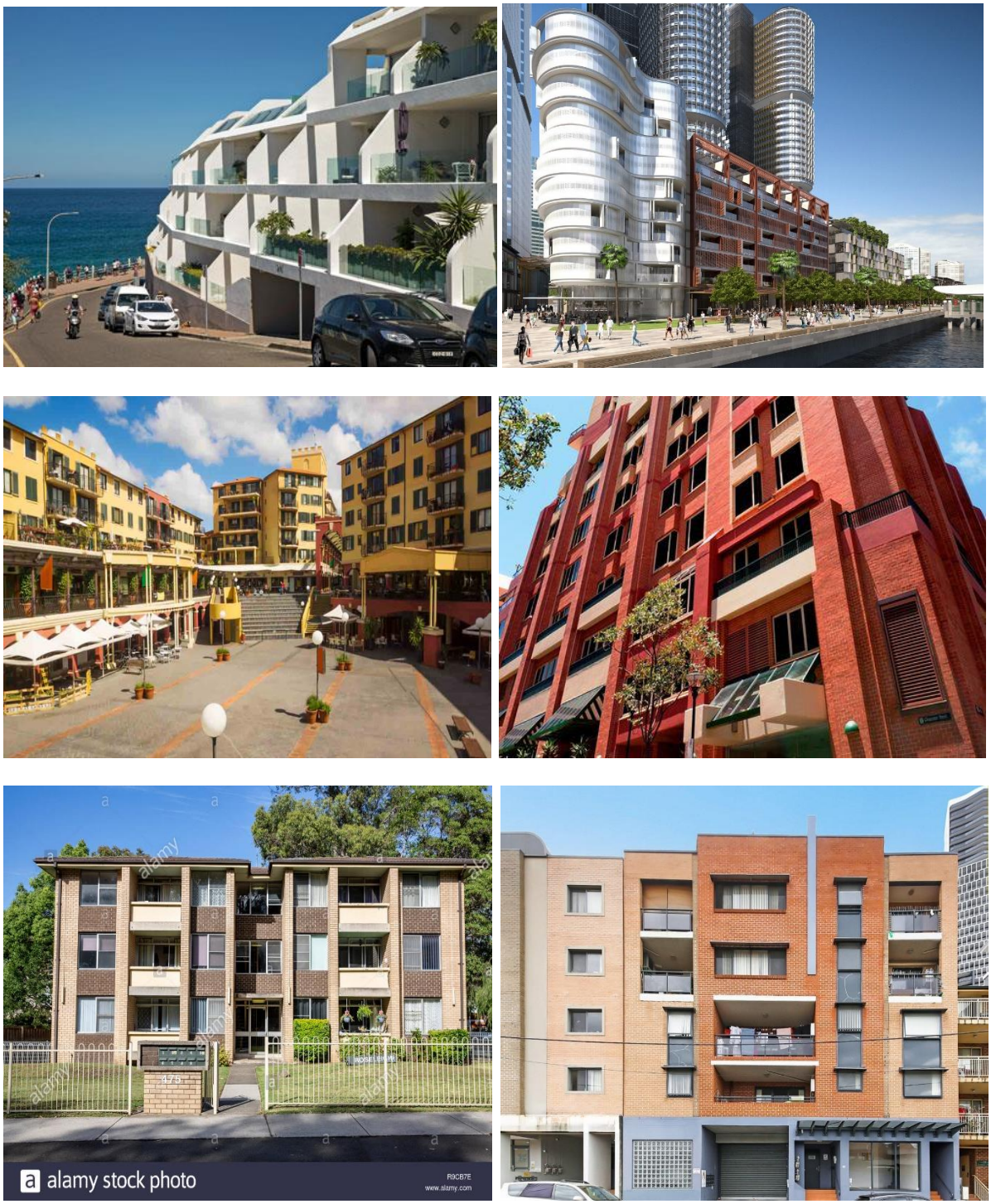
Source: ArchitectureAU 2019

Appendix 2: Greater Sydney Housing Supply Forecast (2017/18 - 2021/22)



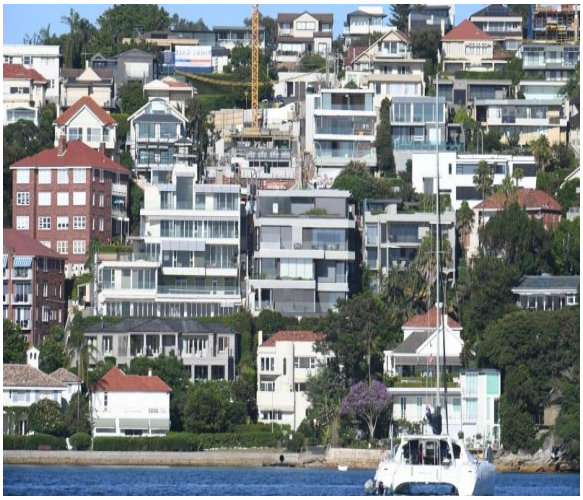
Source: NSW Department of Planning 2019

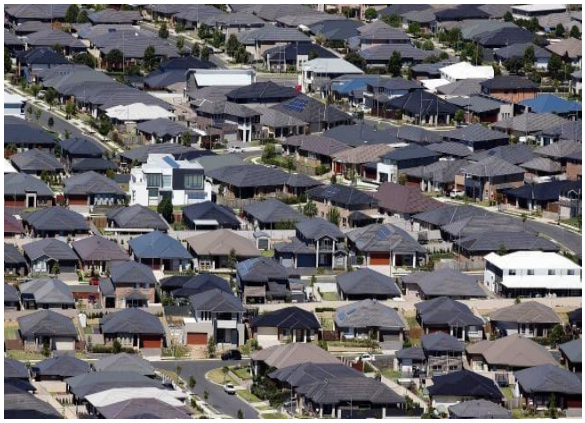
Appendix 3: Residential Apartments across Greater Sydney



Source: NSW Real Estate 2019

Appendix 4: Houses across Greater Sydney





Source: NSW Real Estate 2019

Appendix 5: Entry-Level Affordability Index for LGAs (a-e)

Appendix 5a: Yearly Entry-Level Affordability Index of LGAs in Western Sydney Region

LGA⬇ /Year➡	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Auburn	41	33	30	31	37	39	34	37	41	49	49	57	62	68	72	83	79	90	65	88	83	67	70	66	75	75
Bankstown	46	39	34	35	42	40	35	37	37	44	43	53	62	68	66	78	75	81	60	79	81	71	67	77	89	89
Blacktown	36	30	26	26	30	30	24	25	25	32	35	41	48	55	54	63	61	65	47	58	59	60	49	64	75	74
Blue Mountains	35	29	25	26	31	29	25	23	25	33	33	38	46	51	52	60	59	65	44	57	55	55	44	53	58	62
Camden	32	30	25	26	31	32	24	26	30	38	37	46	53	58	55	63	62	69	47	64	61	70	50	69	77	83
Campbelltown	29	26	24	24	28	27	22	21	21	27	29	37	43	50	49	53	54	56	43	52	52	50	41	54	64	65
Fairfield	41	42	36	37	35	33	27	27	27	36	37	45	55	60	60	69	68	69	53	68	73	61	61	68	82	80
Hawkesbury	37	32	26	27	30	33	25	26	26	35	36	43	50	56	55	63	61	68	51	60	62	60	52	65	71	74
Holroyd	41	40	41	38	35	34	29	32	34	41	40	48	55	61	59	69	68	69	52	66	64	56	54	63	75	72
Liverpool	27	28	26	26	34	34	27	28	29	38	39	47	58	64	64	68	67	67	51	63	62	62	54	67	79	82
Parramatta	42	34	31	31	38	35	31	33	34	42	42	47	56	58	58	67	68	74	54	67	71	61	58	61	74	72
Penrith	33	29	25	25	30	28	23	22	23	30	32	39	45	51	50	56	57	59	44	52	51	55	43	59	70	70
Wollondilly	22	23	23	23	28	32	26	25	28	34	37	41	49	57	56	64	64	67	49	57	60	60	48	68	70	79

Source: Author's computation using Equation (1)

Appendix 5b: Yearly Entry-Level Affordability Index for LGAs in Inner-west Sydney Region

LGA⬇ /Year➡	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Ashfield	41	36	33	36	36	40	34	35	37	46	42	49	51	48	52	64	64	64	50	70	76	78	55	79	87	87
Burwood	40	41	42	46	47	45	44	38	43	55	49	58	71	59	64	79	85	97	63	95	99	78	81	80	103	89
Canada Bay	52	39	40	45	49	51	46	44	44	50	45	57	60	56	63	71	75	83	59	74	71	73	59	83	97	96
Leichhardt	48	42	35	39	45	44	44	42	41	46	49	58	62	61	64	64	72	83	55	76	75	75	62	74	84	84
Marrickville	38	29	33	34	40	40	37	40	40	49	51	61	61	62	64	74	75	76	60	83	75	61	65	68	72	76
Strathfield	59	36	45	49	54	56	50	45	41	50	48	56	57	50	52	59	73	75	51	67	67	48	57	52	52	54

Source: Author's computation using Equation (1)

Appendix 5c: Yearly Entry-Level Affordability Index for LGAs in Southern Sydney Region

LGA⬇ /Year➡	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Botany Bay	55	40	31	32	40	44	46	43	41	60	54	60	80	70	75	84	80	87	60	81	82	46	67	46	51	47
Hurstville	51	40	38	39	45	44	35	40	40	49	44	54	63	68	68	77	78	88	63	81	85	77	70	79	93	81
Kogarah	52	46	39	40	50	49	41	42	38	49	43	52	55	57	55	71	73	86	59	78	82	75	63	79	92	88
Rockdale	50	41	37	38	43	41	37	39	38	50	49	56	60	62	60	75	71	79	57	77	79	54	65	59	62	60
Sutherland	52	41	38	42	44	43	36	37	41	49	46	54	61	65	63	74	75	82	55	76	79	93	63	95	108	107

Source: Author's computation using Equation (1)

Appendix 5d: Yearly Entry-Level Affordability Index for LGAs in Eastern Sydney Region

LGA⬇ /Year➡	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Randwick	64	49	44	49	53	54	50	50	43	54	56	64	70	65	62	81	81	88	58	79	84	45	65	50	52	56
Sydney	51	49	43	47	66	80	53	51	48	59	55	59	61	60	60	74	71	82	56	76	73	66	69	74	79	80
Waverley	70	47	36	43	54	48	47	46	48	56	54	59	65	62	59	73	68	68	53	69	69	49	71	47	56	51
Woollahra	75	55	41	43	47	51	46	55	48	46	47	60	62	61	56	68	59	65	49	75	62	61	75	66	84	73

Source: Author's computation using Equation (1)

Appendix 5e: Yearly Entry-Level Affordability Index for LGAs in Northern Sydney Region

LGA⬇ /Year➡	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Hornsby	56	44	38	39	43	42	36	37	39	45	43	52	56	59	56	72	74	84	59	78	83	88	65	90	109	118
Hunter Hills	46	47	44	51	55	45	50	44	44	44	43	47	46	71	55	57	66	73	76	63	75	76	55	78	89	86
Ku-ring-gai	50	52	51	49	57	51	45	44	43	51	49	59	65	68	67	80	79	93	59	72	71	66	65	71	95	93
Lane Cove	40	41	35	39	46	46	32	38	35	46	42	46	50	43	50	46	55	56	39	65	57	50	45	56	63	57
Manly	49	46	43	48	51	49	47	46	50	58	56	67	74	71	72	80	84	89	60	74	91	62	69	69	76	89
Mosman	43	45	47	48	50	41	44	37	39	41	40	36	50	45	52	58	48	46	34	62	71	60	58	67	73	70
North Sydney	40	41	36	39	44	44	36	37	35	41	39	42	46	42	45	52	54	62	39	58	53	57	51	58	62	65
Pittwater	51	52	54	54	55	54	48	54	49	63	56	71	79	82	82	97	98	110	73	97	95	76	84	74	89	96
Ryde	46	41	36	37	46	43	37	39	41	51	48	58	60	58	65	80	77	88	60	88	87	54	69	55	67	71
The Hills Shire	56	47	40	41	46	45	37	39	40	46	45	54	60	65	64	76	79	85	63	80	76	67	65	80	98	91
Warringah	44	47	44	46	51	50	43	48	48	55	53	66	70	71	71	80	86	99	59	80	80	59	69	63	70	67
Willoughby	48	50	51	54	55	48	41	39	39	48	45	55	52	52	59	66	67	75	50	67	66	61	68	59	88	83

Source: Author's computation using Equation (1)

Appendix 6: Parametric t-test of Key Housing Variables across the Submarkets

Submarkets	House Price	House Rent	Income	Housing Supply	Population
Western and Inner-west	-24.15***	-26.92***	-12.65***	1.36	1.58
Western and Southern	-24.04**	-23.81**	-15.92**	3.93***	5.11***
Western and Eastern	-20.65***	-20.05***	-13.49***	3.20***	3.15***
Western and Northern	-25.42***	-32.12***	-16.55***	3.54***	3.18***
Inner-west and Southern	11.35***	15.30***	10.70***	-0.32	-0.12
Inner-west and Eastern	-15.38***	-14.03***	-13.28***	0.53	-0.01
Inner-west and Northern	-20.97***	-31.10***	-19.08***	-0.27	-0.06
Southern and Eastern	-16.82***	-17.79***	-12.87***	1.29	0.23
Southern and Northern	-21.96***	-35.28***	-16.48***	0.11	0.20
Eastern and Northern	3.31***	0.10	0.20	-1.79	-0.13

The Parametric t-test tested the null hypothesis of no significant difference in the mean of each variable (e.g. house price) between two submarkets (e.g. western and inner-west submarkets) at a time. The results soundly rejected the tested hypothesis in house price, income and rent in almost all combinations of submarket at $P<0.01$ and $P<0.05$. This means the submarkets are separated in terms of average house price, income and rent. However, the results failed to reject the tested hypothesis for most combinations of submarket in housing supply and population. *** denotes a rejection of the tested hypothesis at the 1% level, ** denotes a rejection of the tested hypothesis at 5% level, * denotes a rejection of the tested hypothesis at 10% level.

Appendix 7: List of Publications

1. Bangura, M & Lee C, L 2019 "House price diffusion of housing submarkets in Greater Sydney", *Housing Studies*, vol. 36, no. 7, pp. 1-32 (2018 Impact Factor: 1.882)

2. Bangura, M & Lee C, L 2019 "The differential geography of housing affordability in Sydney: a disaggregated approach", *Australian Geographer*, vol. 50, no. 3, pp. 295-313 (2018 Impact Factor: 1.639)

Appendix 8: List of Papers Under-Revision

1. Bangura, M & Lee C, L 2019 "The Determinants of Homeownership Affordability in Greater Sydney: Evidence from a Submarket Analysis", *Housing Studies*

2. Bangura, M & Lee C, L 2019 "Housing Price Bubbles in Greater Sydney: Evidence from a Submarket Analysis", *Housing Studies*

Appendix 9: List of Conference Papers and Presentations

1. Bangura, M & Lee, C, L 2019 "House affordability and house price bubbles nexus: Evidence from Greater Sydney", presentation at the 26th European Real Estate Society (ERES), Cergy-Pontoise Cedex, France

2. Bangura, M 2019 "PhD Thesis", presentation at the 35th American Real Estate Society (ARES), Phoenix, Arizona USA

3. Bangura, M & Lee C, L 2019 "House price diffusion of housing submarkets in Greater Sydney", presentation at the 35th American Real Estate Society (ARES), Phoenix, Arizona USA

4. Bangura, M & Lee, C, L 2019 “House affordability and house price bubbles nexus: Evidence from Greater Sydney”, presentation at the 25th Pacific Rim Real Estate Society (PRRES), Melbourne, Australia

5. Bangura, M 2019 “PhD Thesis”, presentation at the 25th Pacific Rim Real Estate Society (PRRES)”, Melbourne, Australia

6. Bangura, M 2019 “House price diffusion of housing submarkets in Greater Sydney”, presentation at the 25th Pacific Rim Real Estate Society (PRRES), Melbourne, Australia

7. Bangura, M 2018 “PhD Thesis”, presentation at the 24th Pacific Rim Real Estate Society (PRRES)”, Auckland, New Zealand

8. Bangura, M & Lee, C, L 2018 “Drivers of ownership affordability of the regions of Greater Sydney”, presentation at the 24th Pacific Rim Real Estate Society (PRRES), Auckland, New Zealand

9. Bangura, M & Lee, C, L 2018 “House price diffusion in Greater Sydney: Evidence from cointegration approach”, presentation at the 23rd Asian Real Estate Society (AsRES), Incheon, Korea

10. Bangura, M 2017 “PhD Thesis”, presentation at the 23rd Pacific Rim Real Estate Society (PRRES), Sydney Australia

11. Bangura, M 2017 “Housing affordability in Greater Sydney”, presentation at the 23rd Pacific Rim Real Estate Society (PRRES), Sydney Australia