Three Essays on the Performance of Housing Markets in Australia

Haresh G. Pardasani

A dissertation submitted in fulfillment of the requirements for the degree of

Doctor of Philosophy

MACQUARIE
University
SYDNEY · AUSTRALIA

Department of Applied Finance
Faculty of Business and Economics
Macquarie University
Sydney, Australia

20 March, 2020

Statement of Originality

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

Haresh G. Pardasani

Sydney, 20 March, 2020

Dedication

To my mother, Maya; my father, Gurbux; my wife, Preeti; and my daughter, Niharikka,

in recognition of their generous love, support and encouragement throughout my life.

Acknowledgments

I acknowledge with sincere gratitude the guidance and support provided by my primary supervisor, Associate Professor Vito Mollica, for his relentless persistence in guiding me to completion. My dissertation has immensely benefited from his academic advice, continual patience, and thought-provoking ideas throughout my research. I would also like to thank my Associate Supervisor, Professor Stefan Trück, for his guidance, encouragement, and motivation over my candidature. His support, assistance, and comments have been most welcome.

I gratefully acknowledge the financial support provided by CoreLogic RP Data, Capital Markets Co-operative Research Center (CMCRC), and Macquarie University. Additionally, I also thank CoreLogic for providing the data for this dissertation. Their data have been used solely for this study and is not intended for replication or commercial purposes. The excellent facilities, resources, and opportunities provided by each of these institutions have been exceptionally beneficial to my thesis.

Thanks also to the American Real Estate Society, Griffith University, Capital Markets Co-operative Research Center (CMCRC), and CoreLogic RP Data for hosting conferences and seminars. The opportunity to present my paper on several occasions enabled me to build confidence in myself and my work. I would particularly like to thank Robert Simons, Michael Highfield, Velma Zahirovic-Herbert, Eduardo Roca, Scott Mathews, Kevin Ward, Terry Walter, and other participants at the seminars and conferences for comments and suggestions they provided, particularly for Chapter 3 of this dissertation.

I also humbly submit my thanks to my extended family and friends who have always shown support and encouragement throughout my life and have been available for help in difficult times. Your keen interest and encouragement were a great help throughout my research.

My family has my utmost gratitude—my mother, Maya, my father, Gurbux, my wife, Preeti, and my daughter, Niharikka—a special heartfelt thanks to you all. Attempting this candidature was a daunting task, and yet you make me feel like I can do anything. You are never insistent and always understanding. The sacrifices you made during this entire journey have been immeasurable, and without your love and support, none of this would have been possible.

Table of Contents

Statement of Originality i

Dedication ii

Acknowledgments iii

Table of Contents v

List of Tables viii

List of Figures x

Abbreviations xi

Synopsis xiv

1 Introduction 1

1.1 Overview . . . 1
1.2 Do Homeowners Overcapitalize? . . . 10
1.3 Persistence in Capital and Rental Components of Housing Market Returns 15
1.4 The Impact of Underquoting Regulation: A Case Study of the Housing Market in New South Wales and Victoria . . . 22
1.5 Structure of the Dissertation . . . 29

2 Literature Review 31

2.1 Introduction . . . 31
2.2 Studies of Home Improvements . . . 32
2.2.1 Testable Hypothesis - Home Improvement . . . 36
2.3 Studies Related to Persistence, Predictability and Market Efficiency . . . 37
2.3.1 Real Estate Markets . . . 37
2.3.1.1 Multifamily Housing: Units . . . 38
2.3.1.2 Single-family Housing: Houses . . . 39
2.3.1.2.1 Temporal . . . 39
2.3.1.2.2 Spatial . . . 45
2.3.1.2.3 Novel Paradigms . . . 46
2.3.1.2.4 Securitized Real Estate Markets . . . 47
2.3.2 Testable Hypothesis - Efficiency . . . 49

2.4 Studies Related to Underquoting . . . 50
2.4.1 Search Models and the Role of List Prices . . . 50
2.4.2 Role of Real Estate Agents . . . 56
2.4.3 Bidding Behaviors in Auction Setting . . . 57
2.4.4 Auctions versus Private Treaties . . . 60
2.4.5 Welfare Costs . . . 62
2.4.6 Testable Hypotheses - Underquoting Regulation . . . 64
2.5 Summary . . . 64

3 Do Homeowners Overcapitalize? 66
3.1 Introduction . . . 66
3.2 Institutional Setting . . . 67
3.3 A Model of House Price Returns . . . 70
3.4 Data and Summary Statistics . . . 73
3.5 Model Estimation and Variable Statistics . . . 79
3.6 Results . . . 86
3.7 Robustness . . . 92
3.7.1 Correcting Sample Selection Bias . . . 92
3.7.2 Including Improved Homes Purchased Post-2004 . . . 95
3.7.3 Construction of Repeat Sales Index . . . 96
3.8 Further Analyses: Investor Segmentation . . . 99
3.8.1 Speculators (Buy - Improve - Sell Homes) . . . 100
3.8.2 Consumers-cum-Speculators (Non-Flippers) (Buy - Live - Improve - Sell Homes) . . . 106
3.9 Conclusion . . . 111

4 Testing for Persistence in the Capital and Rental Components of Housing Market Returns in Australia 113
4.1 Introduction . . . 113
4.2 Methodology . . . 114
4.2.1 Variance Ratio Test of Random Walk . . . 115
4.2.2 Independent Runs Test . . . 121
4.3 Data and Region Summary Statistics . . . 122
4.4 Empirical Results . . . 131
4.4.1 Results for Different Regions . . . 131
4.4.2 Results: Wild Bootstrap AVR Test for Australia and GCC level . . . 138
4.4.3 Results: Independent Runs Test for Australia and GCC level . . . 144
4.5 Conclusion . . . 151

5 The Impact of Underquoting Regulation: A Case Study of the Housing Market in New South Wales and Victoria 154
5.1 Introduction . . . 154
5.2 Institutional Details: The Underquoting Law . . . 155
5.3 Data . . . 160
5.4 Model Estimation and Summary Statistics . . . 163
5.5 Results . . . 170

5.6 Specification Test: SA2 Level Location Fixed Effects 174
5.7 Conclusion 177

6 Conclusion **179**

Appendices **187**

Appendix A Australian Standard Geographic Classification Structure **188**

Appendix B Statistical Division and Statistical Subdivision Maps **190**

Appendix C Recent trends in Household Wealth **193**

Appendix D Recent trends in Household Consumption **195**

Appendix E Main Results with Full DA Sample **198**

Appendix F Main Results with SSD Regional Level Fixed Effects **200**

Appendix G House Price Index Prediction Error Distribution **202**

Appendix H Average Commencement and Construction times (Months) **204**

Appendix I Real Capital and Rental Price Indices: All Dwellings **205**

Appendix J Summary Statistics for All Dwellings **207**

Appendix K % Distribution of Regions with Persistence: All Dwellings **209**

Appendix L Results at SA3 Regional Level for Monthly Frequency **211**

Appendix M Results at SA3 Regional Level for Quarterly Frequency **213**

Appendix N Wild Bootstrap AVR Test Results for All Dwellings: Capital **215**

Appendix O Wild Bootstrap AVR Test Results for All Dwellings: Rental **217**

Appendix P Independent Runs Tests Results for All Dwellings: Capital **219**

Appendix Q Independent Runs Tests Results for All Dwellings: Rental **221**

Appendix R Underquoting Main Results with Market Change Variable **223**

References **225**

List of Tables

3.1 Distribution by DA Works and State 76
3.2 Summary Statistics – DA Cost (Constant Dollar 2016-Q3) 76
3.3 Variable Descriptions and Sample Statistics (2004-2016) 85
3.4 Main Model Results 89
3.5 Self Selection Bias Correction 94
3.6 Including Improved Homes Purchased Post 2004 97
3.7 Results for Speculators 102
3.8 Results for Speculators by Improvement works 104
3.9 Results for Consumption-cum-Speculators 108
3.10 Results for Consumption-cum-Speculators by Improvement Works 110

4.1 Summary Statistics: Real Capital Log Returns (2005–2017) 129
4.2 Summary Statistics: Real Rental Log Returns (2005–2017) 130
4.3 % Distribution of Regions with Persistence in the Capital Component of Housing Market Returns (2005–2017) 132
4.4 % Distribution of Regions with Persistence in the Rental Component of Housing Market Returns (2005–2017) 132
4.5 Wild Bootstrap AVR Test: Capital Index Return for Houses 140
4.6 Wild Bootstrap AVR Test: Capital Index Return for Units 142
4.7 Wild Bootstrap AVR Test: Rental Index Return for Houses 145
4.8 Wild Bootstrap AVR Test - Rental Index Return for Units 146
4.9 Independent Runs Test: Capital Index Return 149
4.10 Independent Runs Test for Houses: Rental Index Return 150

5.1 Data Distribution: New South Wales (Treatment Group) 162
5.2 Data Distribution: Victoria (Treatment Group) 162
5.3 Summary Statistics: Underquoting Ratio (New South Wales) 169
5.4 Summary Statistics: Underquoting Ratio (Victoria) 169
5.5 Underquoting Difference-in-difference Model Results 173
5.6 Specification Test: Results with Location Effect at SA2 Level 176

E Main Result Robustness: Full DA Sample 199

F Model Results: SSD Region level 201

J Summary Statistics: Real Capital Log Returns (2005–2017) 208

K Summary Results: % Distribution of Regions with Persistence in Capital Component of Housing Market Returns (2005–2017) 210
K Summary Results: % Distribution of Regions with Persistence in Rental Component of Housing Market Returns (2005–2017) 210
N Capital: Wild Bootstrap Automatic Variance Ratio Test Result for All dwellings 216
O Rental: Wild Bootstrap Automatic Variance Ratio Test Result for All Dwellings 218
P Independent Runs Test for All Dwellings: Capital Return 220
Q Independent Runs Test for All Dwellings: Rental Return 222
R Underquoting Model Results with Market Change Variable 224

List of Figures

3.1 Distribution of holding term for improved and unimproved homes and time of sale relative to DA for Improved Homes 79
3.2 Repeat Sales Index (2004–2016): DA vs Non-DA 98
3.3 Estimates Profile by Holding-Term 105

4.1 Real Capital Price Indices for Houses and Units 125
4.2 Real Rental Price Indices for Houses and Units 127

A Australian Standard Geographic Classification 2011 Structure 189

B1 Statistical Division and Statistical Subdivision Map - 105 Sydney 191
B2 Statistical Subdivision Maps - Sydney 192

C Household Assets and Liabilities 194

D Household Consumption and Income 196

G House Price Index Prediction Error Distribution 203

H Average Commencement and Construction Times (Months) 204

I Real Capital and Rental Price Indices for All Dwellings 206

L Results at SA3 Regional Level for Monthly Frequency 212

M Results at SA3 Regional Level for Quarterly Frequency 214

Abbreviations

ABS	Australian Bureau of Statistics
ACT	Australia Capital Territory
APRA	Australian Prudential Regulatory Authority
AVR	Automatic Variance Ratio
CAGR	Compound Annual Growth Rate
CAV	Consumer Affairs Victoria
CD	Complying Development
CI	Confidence Interval
CMA	Comparative Market Analysis
DA	Development Application
GADE	Greater Adelaide
GBRI	Greater Brisbane
GCC	Greater Capital Cities
GDAR	Greater Darwin
GFC	Global Financial Crisis
GHOB	Greater Hobart
GMEL	Greater Melbourne
GPER	Greater Perth

GSYD	Greater Sydney
HPI	House Price Index
NCD	Non-complying Development
NSW	New South Wales
NT	Northern Territory
OECD	Organization for Economic Co-operation and Development
PVAL	p-value
QLD	Queensland
RNSW	Rest of New South Wales
RNTE	Rest of Northern Territory
RQLD	Rest of Queensland
RSAU	Rest of South Australia
RTAS	Rest of Tasmania
RVIC	Rest of Victoria
RWAU	Rest of Western Australia
SA	South Australia
SA2	Statistical Area Level 2
SA3	Statistical Area Level 3
SA4	Statistical Area Level 4
SD	Statistical Division
SSD	Statistical Subdivision
STAT	Statistic
TAS	Tasmania
VIC	Victoria

VG Valuer General

VR Variance Ratio

WA Western Australia

Synopsis

This dissertation presents three empirical studies on the performance of housing markets in Australia. The evidence presented in this dissertation addresses a number of outstanding issues in the extant literature. Specifically, this dissertation: examines the returns derived by home owners undertaking government-sanctioned home improvements; assesses persistence in the components of housing returns, both rental and capital; and evaluates the impact of regulation introduced to reduce information asymmetry by penalizing real estate agents who underquote list prices during marketing campaigns.

The first study examines the realized returns of homeowners who undertake significant home improvements compared with those who do not. Using a proprietary data set of repeat home sales, this study finds that, overall, the cost-adjusted return to households who improve their homes is 2.4% lower vis-a-vis owners who make no alterations following a property purchase. The results are robust across multiple model specifications and additional tests, including sample selection bias. The findings are consistent with the consumption view that households undertake home improvements for hedonistic consumption purposes and consequently overcapitalize. Further analysis, which identifies speculators or flippers conditioned on the holding term, demonstrates that homeowners who buy-improve-sell within two years achieve higher returns (around 5.4%), particularly for works including extensions and alterations. This finding is consistent with speculative investment behaviour. Non-speculators, on the contrary, are consumption-motivated and are either unaware of, or undeterred by, the possibility that they may be overcapitalizing on home improvements for their distinct utility.

The second study examines the persistence in inflation-adjusted rental and capital index housing returns across multiple geographic demarcations including national, capital city and regional areas for both houses and units across Australia. Applying univariate variance ratio tests and non-parametric independent runs tests on both monthly and quarterly index returns between 2005 to 2017, this study provides empirical evidence of persistence in the rental and capital components of housing market appreciation in Australia. Overall, this study finds higher persistence in the capital component compared to the rental component of housing market returns. The study also finds higher persistence in greater capital cities (for example, Greater Sydney) relative to the regional areas. Analysis of smaller regions (i.e. SA3) through to the national level of aggregation reports that the proportion of regions with persistent returns systematically increases. This result suggests that, on average, the smaller regions with persistence must have at least a strong enough degree of persistence to be able to influence it in index returns at a higher level of aggregation. By property type, this study finds higher persistence in returns for houses than units with respect to the capital component of housing market returns, whereas the converse is true for the rental component of housing market returns. Additionally, the study also finds that, overall, there is more persistence at a monthly frequency than a quarterly frequency.

The final study investigates the impact of the introduction of regulation to stamp out underquoting practices by estate agents. Underquoting occurs when a property is listed for sale at a price that is lower than the likely selling price for that property. Despite opposition from the real estate industry, which believed that the regulation was unnecessary, two of eight state governments passed reforms on October 22, 2015, and November 02, 2016, which subsequently came into effect on January 01, 2016, and May 01, 2017, in New South

Wales and Victoria, respectively, providing a natural experiment. Utilizing the population of listings and home sales data from 2014 to 2018, classified into pre-enactment, enactment, and post-commencement periods, this study provides evidence of the widespread prevalence of the underquoting practice in the states, and a reduction in underquoting practices just after the law was enacted. The empirical findings for New South Wales show that, for 'Auction' sales, there is a 4.1% and 5.7% reduction in underquoting during the enactment period and after the commencement of the law, respectively. Meanwhile, for 'Private Treaty' sales, the study finds a 1.2% and 3.8% reduction in underquoting, respectively. Comparison of the change in underquoting ratio of listings in Victoria relative to other states shows that, in the case of 'Auction' sales, there is a 2.3% and 7.3% decrease in underquoting during the enactment period and post-commencement period, respectively. However, in 'Private Treaty' sales, the study finds the decrease in the underquoting practice is evident only after the law was effective, with a 2.7% reduction in underquoting, while there is a marginal increase in underquoting of 0.5% during the enactment period. These findings are robust to location fixed effects at the local geographic area level and controlled for market index estimates, various property and listing characteristics, and other factors—spatial or temporal.

"If I have seen further than others,

it is by standing upon the shoulders of giants."

— Sir Isaac Newton

Chapter 1

Introduction

1.1 Overview

The housing market plays an important role in the financial and economic stability of a nation. Developments in house prices can have major economic implications, and this is particularly so in Australia, where the household debt-to-income ratio is one of the highest—nearly 216%—among OECD countries (OECD, 2019). Iacoviello and Neri (2010) suggest that the housing sector is a driving force in the business-cycle dynamics, affecting the net wealth of individual households and, correspondingly, their capacity to borrow and spend, over and above the profitability and employability of firms in the construction and real estate industries. Further, according to Demary (2010), house price shocks increase output, inflation, as well as official interest rates[1], and they contribute significantly to the

[1] The interest rate is a tool used by the central banks to make changes in an economy. Lowering interest rate makes it more attractive to take on more debt and invest as repayments are smaller. The opposite is true when interest rate increases as it restricts our spending because we are paying more off our debt and have less "expendable income". Before raising interest rates, reserve banks take account of recent changes in the housing market including other factors. As such, housing market is an important determinant of interest rates. This is consistent with (Iacoviello and Neri, 2010) who suggest that the relationship between house price changes and interest rates is pro-cyclical.

variation in these variables.

Given the role of the housing sector and its significance to the macroeconomy, this dissertation aims to examine three key facets of the Australian housing market: the financial performance of additional housing acquired via home improvements; the persistence or weak-form market efficiency; and the performance of underquoting regulations.

The residential real estate market in Australia is the single largest asset class, with a total value of A$6.3 trillion across 10.2 million dwellings[2]. By comparison, the residential real estate market is worth more than twice the value of superannuation funds across the country (A$2.7 trillion[3]), more than three times the value of Australian listed stocks (A$2.02 trillion[4]) and more than six times the value of commercial real estate (A$970 billion)[1]. By the sheer size of the asset class, it is easy to deduce that the performance of the housing market in Australia is significant for the macroeconomy.

Residential real estate is the most pervasively held asset in Australia. According to the 2015–16 Survey of Income and Housing, it is estimated that approximately 67% of Australian households have some level of exposure to residential property assets[5]. While not unique among developed countries in this respect—similar home ownership rates are reported for the United States (U.S.) (64.2%)[6] and the United Kingdom (UK) (63.5)%[7]—home ownership rates are significantly lower in many other developed countries, including Germany and Switzerland, with home ownership rates of 51.4% and 42.5%, respectively[8].

[2]Source: CoreLogic (2019)

[3]Source: The Association of Superannuation Funds of Australia (2019)

[4]Source: Australian Securities Exchange (2019)

[5]Australian Bureau of Statistics (2017a) estimates that 30% of households owned their homes outright (i.e. without a mortgage) and 37% were owners with a mortgage. A further 25% were renting from a private landlord and 4% were renting from a state or territory housing authority.

[6]Source: The US Census Bureau (2019)

[7]Source: Nationwide Building Society (2019)

[8]Source: Statistica (2019)

This is attributed to the cultural factors, such as the often-discussed 'Great Australian Dream' (Moran, 2006), as well as government-backed schemes to increase home ownership, such as the First Home Owners Grant. Housing also accounts for a substantial proportion of wealth at both the individual and economy-wide levels[9]. It is estimated that Australian households hold more than half of their wealth in residential land and dwellings[1]. These factors illustrate that housing markets in Australia are of great importance not only for the macroeconomy but also for the average family.

Further, Australian banks have more than 60% of their balance sheet assets exposed to housing[10], which poses significant risks to the economy. Moreover, as mentioned above, Australia's household debt-to-income ratio has climbed to 216% with 85% of the total debt corresponding to housing (OECD, 2019). This further aggravates the risk factors and increases the odds of financial instability. According to Österling (2017), housing investments are typically known to lead the business cycles, and therefore, the busts in the housing markets are costlier for the economy than the stock market crashes. The Global Financial Crisis of 2007–2009 in the U.S. is a perfect example of how a housing market crash leads to economic recessions. While Australia was spared the worst consequences of the global financial crisis, internationally it demonstrated the impact that financial instability can have on growth and the well-being of households and businesses in the economy, and hence it cannot be taken lightly. In addition, the recent decline[11] of the Australian housing markets following the tightening credit conditions in the wake of the Royal Commission[12] into its banking sector has clearly underscored the importance of the

[9]See Appendix C for a discussion on the changes in housing wealth between 1992 and 2018.

[10]Source: APRA (2018)

[11]The total value of Australia's 10 million residential properties valued at $6.9 trillion in June Quarter 2018 has fallen by $248.7 billion in the three quarters to December 2018 (Australian Bureau of Statistics, 2019).

[12]The Royal Commission into Misconduct in the Banking, Superannuation and Financial Services Industry, also known as the Banking Royal Commission and the Hayne Royal Commission, was established

housing market for the stability of the financial system and the economy. Overall, these reasons highlight the importance of well-functioning housing markets in Australia.

The recent development in the housing market has drawn the attention of investors with the risk and return of housing, as well as the effectiveness of housing as an investment. Numerous studies in the real estate literature have also argued that housing is an effective investment vehicle (see, for example, Goetzmann (1993); De Roon et al. (2002); Flavin and Yamashita (2002); Donald et al. (2006); Melser and Hill (2019)). While these studies have provided additional insights into the performance and the role of the housing market, little research has been undertaken examining the risk and returns attributed to additional housing acquired via home improvements. It is estimated that home improvement investments account for a quarter of the value of total investments in new housing in Australia[13], which is a significant component of the total housing consumption[14] in Australia. While the performance of in situ or original[15] housing is extensively explored in the extant literature, performance of home improvements is considerably under researched. Specifically, studies concerning home improvements are mainly limited to Mendelsohn (1977), Boehm and Ihlanfeldt (1986), Galster (1987), Potepan (1989), Montgomery (1992), and Simons et al. (2009), and more recently, Choi et al. (2014), and Bian (2017). The first essay (Chapter 3) of this thesis studies the financial performance of home improvements. It presents original research on the returns derived from home improvement investments relative to owners who do not undertake any improvements.

on 14 December 2017 by the Australian government in accordance with the Royal Commissions Act 1902 to inquire into and report on misconduct in the banking, superannuation, and financial services industry in Australia (Seek Estate, 2017).

[13]Source: Australian Bureau of Statistics (2017c)

[14]See Appendix D for a discussion on the changes in housing consumption between 1993 and 2018.

[15]Original housing refers to the housing that is originally purchased or acquired via means other than home improvements.

The second topic of the thesis is persistence or assessment of weak-form inefficiency in the housing market. The inefficiencies in the housing markets are mainly attributed to high and unequal search costs and barriers to entry (Rayburn et al., 1987). High search costs exist due to information asymmetries in that all investors do not have access to the same information set, and consequently have different expectations (Rayburn et al., 1987). These information asymmetries are not just available to buyers and sellers, but also applies to borrowers and lenders. Grossman and Stiglitz (1980) have shown that efficient markets are impossible unless the information is available free of cost, which is both sufficient and necessary condition for prices to fully reflect all available information. The real estate markets are characterized by high cost of information and therefore the prices cannot reflect all information. Hence those who expend resources collecting the information would receive a reward in return for their effort.

Persistence or weak-form inefficiency is a crucial aspect of the housing market performance, and it reflects the extent to which short-term shocks in the current market conditions lead to permanent future house price changes (Gil Alaña et al., 2013). Therefore, a closer look at the time pattern of house price series is important. This is particularly so because very little is known about homeowners' and investors' reaction to housing price changes, nor about the turning points in the housing market. If price changes in housing markets show no certain pattern, but rather demonstrate random behavior, investors, homeowners, mortgage lenders, banks and others will not obtain any further information from analyzing historical prices. On the contrary, if there is any indication of temporal or structural patterns in the housing markets, historical house prices could contain useful and valuable information with respect to turning points in the markets and to adjusting the real estate position in the asset portfolio (Schindler, 2014). Hence, investigating the statistical characteristics of house price series is of paramount importance.

Furthermore, Shiller (2008) has emphasized the potential value of derivatives in creating efficient markets for single-family homes. There is a also well-developed property derivatives market in the U.S.[16] and UK[17], and there have been several attempts at creating a derivatives market in Australia[18]. Hence, it can be seen that the idea of introducing a well-functioning market to hedge housing market movements has been present in discussions, and despite several setbacks, people have not been able to prevent attempts at launching these markets. Therefore, it is expected that there will be future attempts to introduce derivatives in the Australian residential property market as well. Further, housing market players such as banks and other mortgage lenders, hedge funds and insurance companies can hedge their risk exposure using these derivative products (Schindler, 2013, 2014). For investors participating and trading in these markets, and for those pricing these products, the time series characteristic of the underlying indices are of particular interest, and the information contained in historical price series and its implications are important for their business. Hence, analysis of persistence in housing market index returns can play an important role in establishing a well-functioning derivatives market (Shiller, 2008; Schindler, 2013, 2014; Schindler et al., 2010).

The international literature testing for persistence, predictability or weak-form efficiency

[16]In May 2006, the U.S. launched property derivatives on eleven U.S. housing market indices at the Chicago Mercantile Exchange (CME), which includes the standardized and exchange traded options and futures on the Case–Shiller house price indices in addition to the various OTC products based on Case–Shiller indices. Source: CME (2006)

[17]In the UK, after several failed attempts since 1991, there is a well-developed property derivatives market based on the MSCI's Investment Property Databank index, which includes property futures and OTC products. Source: Cardeira (2007).

[18]In 2008, RP Data and Rismark (now part of CoreLogic) signed a deal with the Australian Securities Exchange to develop the residential property derivatives market based on the RP Data–Rismark Hedonic Home Value Index, which is currently called the CoreLogic RP Data Home Value Hedonic Index (Seek Estate, 2014). The analyses presented in this study are based on this index, originally developed to trade residential property derivatives products.

in the housing market returns is vast and extensive (see, for example, Gau (1984), Gau (1985), Linneman (1986), Rayburn et al. (1987), Karl et al. (1989), Case and Shiller (1989), Case and Shiller (1990), Hosios and Pesando (1991), Tirtiroğlu (1992), Clapp and Tirtiroglu (1994); Clapp et al. (1995), Gatzlaff (1994), Meese and Wallace (1994), Barkham and Geltner (1996), Clayton (1996), Dolde and Tirtiroglu (1997), Clayton (1998), Londerville (1998), Englund et al. (1999), Rosenthal (1999), Meen (2000), Gu (2002), Larsen and Weum (2008), Hjalmarsson and Hjalmarsson (2009), Elder and Villupuram (2012), Schindler (2013, 2014), Yajie (2016), and Glaeser and Nathanson (2017). However, studies of persistence, predictability or market efficiency in the Australian context are scarce. Furthermore, these studies have invariably focused on the capital component of housing returns, but the rental component, which is a significant component of the housing market returns, is, to the best of my knowledge, completely ignored. The second essay (Chapter 4) of this thesis fills these gaps in the literature by extending the idea of persistence testing to both capital and rental components of the housing market.

The third and the final aspect of the housing market examined in this thesis is the impact of regulatory changes seeking to reduce information asymmetry in the markets associated with the practice of underquoting. Underquoting, sometimes referred to as "price baiting", is reported as a practice in many housing markets worldwide[19], and particularly, in hot housing markets (Han and Strange, 2014). Underquoting has been of serious concern for buyers and regulators[20], whereby agents exploit the information asymmetry that exists between buyers and sellers in establishing the market value of a property by deliberately

[19]In North America, some headlines state, "In San Francisco's Bidding Wars, Home Prices Go Ballistic" (Wall Street Journal, August 27, 2015), "Lowered prices create bidding wars in hot housing market" (Boston Globe, March 31 2015), "Toronto real estate gimmickry hits the limit of our patience" (The Toronto Star, May 22, 2016).

[20]News in Australia are filled with headlines such as "25pc underquoting by real estate agents the new norm" (The Australian Financial Review, November 7 2014), "Real estate agent Fletcher and Parker fined $880k for underquoting in Melbourne's east" (ABC News, December 14, 2017).

understating the property prices in their marketing campaigns to draw more customers, despite it being illegal and known to hurt their reputation. The basic private value auction models suggest that the greater the number of bidders in an auction, the higher is the sale price. Malmendier and Lee (2011) also confirm this phenomenon in the online auction setting. In lowering list prices, agents are able to attract more customers to an auction, and given that bidders are typically susceptible to irrational overbidding, this leads to inflated sale price (Malmendier and Lee, 2011; Han and Strange, 2014). In an attempt to stamp out these rampant underquoting practices in Australia, state governments in New South Wales (NSW) and Victoria (VIC) imposed tighter underquoting penalties.

The role of list prices is amply documented in the literature (for example, Anglin et al. (2003); Malmendier and Lee (2011); Han and Strange (2014, 2016)), and there are studies that acknowledge that underpricing regimes result in inflated sale prices (See Malmendier and Lee (2011); Han and Strange (2016); Merlo et al. (2015); Albrecht et al. (2016)). Further, there exist studies that have allowed for understating list prices in their search models (see, for example, Han and Strange (2016); Merlo et al. (2015); Albrecht et al. (2016)). However, the research understanding the effectiveness of the laws that regulate these underpricing practices is quite limited. The internet media in Australia are flooded with articles on the potential costs of underquoting and speculations over the effectiveness of such regulations[21]. While Bender et al. (2008) studies the problem of underquoting in Australia to the extent of establishing the prevalence of underquoting practices in Victoria, to the best of my knowledge, there is no rigorous research conducted so far in terms of testing the effectiveness of the underquoting laws in Australia. Given that there is a significant amount of time, money, and resources invested in implementing these laws,

[21] For example, "Complaints about underquoting real estate agents soar in NSW despite new laws" (Sydney Morning Herald, January 28, 2017)

examining their impact is critical not only for the government and regulators, but also from the perspective of gaining an overall understanding of the functioning of the housing markets in Australia. The third essay (Chapter 5) of this thesis, thus, investigates the impact of regulations introduced to reduce the information asymmetry between buyers and sellers by penalizing the estate agents as part of the effort to curb underquoting practices in Australia.

Overall, evaluating the performance of the Australian housing market, through the lenses of the three aspects that are outlined in this dissertation is of critical importance to several market participants, financial institutions, regulators, and academics alike, in terms of influencing monetary policies concerning the calibration of interest rate changes; gaining a better understanding of the functioning of the housing market in Australia, which in turn can enable optimal allocation and distribution of resources; and maintaining the stability of the financial system and promoting the growth of the overall economy.

The analyses carried out for the three key topics in this dissertation benefit from access to a unique and extensive property database, which allows for the application of econometric techniques to residential real estate market data. This database covers a broader cross-section of properties and longer time series than has previously been used in Australian residential real estate market research. Supplied by CoreLogic RP Data, a public Australian property information and reporting company, the database is built upon the sales reported to the Valuer-General (VG) for each state and territory; in effect, it captures the total population of sales in the Australian housing market. CoreLogic further augments this set with attribute data collected from newspapers and online listings and its own real estate agent clients. The richness of this data allows the use of data-intensive regression-based methods for analyzing the performance of housing markets in Australia.

The data used in each of the three essays are described in greater detail in their respective chapters.

The remainder of this chapter delineates the objectives for each of the three issues raised in this dissertation, and it concludes with a summary and an overview of the structure of this dissertation.

1.2 Do Homeowners Overcapitalize?

The purchase of residential property typically represents the largest financial commitment a household makes in its lifetime. In the United States, the United Kingdom, and Australia, it is estimated that 50–80% of the wealth of individuals is tied to their home[22]. Despite the financial constraints associated with purchasing property, homeowners choose to further invest significant amounts of capital into their homes in the form of home improvements. In 1995, home improvement expenditure in Australia was estimated to be $2.2 billion, corresponding to 24% of the value of the new homes built that year. Over the past 22 years, this expenditure has been increasing at an average rate of 6% per annum and climbed to $7.6 billion in 2017[23]. These investments account for a large proportion of housing construction activity, with multiplier effects for the wider economy (Miles, 1992; Mena Report, 2016). In the United States, it is estimated that the one-year impacts of spending a million dollars on home improvements in a typical local area includes $841,000 in local income, $71,000 in taxes and other revenue for local governments, and 11.5 local jobs (National Association of Home Builders, 2015). These figures indicate that

[22] See Federal Reserve Bank of New York (1999), McCarthy (2004), and Headley, Bruce, Gary Marks and Mark Wooden (2004), respectively.

[23] See Value of Building Approvals; Australian Bureau of Statistics (2017c).

home improvements are an important contributor not only to property markets but also to the entire economy. However, despite their economic significance, relatively little is understood about the return on investment from such home improvements.

The Global Financial Crisis highlighted the significant impact a correction in the housing market has on financial market stability. Since a significant share of home improvements is typically funded by debt[24], failure to complete projects exposes banks to additional risk with homes not approved to be occupied[25]. This empirical work on the profitability of home improvements seeks to understand whether the "*buy-improve-live-sell*" strategy delivers financial rewards beyond the status quo of "*buy-live-sell*" for homeowners.

In this study, home improvements are defined as activities that increase housing capital by remodeling an existing dwelling or developing a new house[26]. Improvements are distinguished from maintenance activities, repairs or decorative works, which do not require the approval of a local government authority, and undertaken to offset the physical deterioration in housing capital. Examples of home improvements include additions, such as bedrooms or bathrooms, construction of a duplex[27], adding car parking space, and the installation of a swimming pool. Consequently, unlike maintenance activities, home improvement involves significant construction activity.

Several challenges exist in determining the incremental value of any home improvements. For sold homes, the value is implicitly incorporated in any resale price post-improvement.

[24] Galster (1987) shows, for example, that grants and subsidized loans are effective at stimulating home improvement behavior, which suggests that improvement investments are mostly funded by debt.

[25] Following the completion of the home improvement, an occupation certificate is required to grant approval to use and occupy the building (NSW Government, 2018). Failure to obtain a certificate may have implications for the future sale of a property, as it is an offence to occupy or use a building without an occupation certificate.

[26] I exclude commercial real estate, i.e., construction of buildings for offices, hotels, schools, etc., and alterations in multi-family dwellings, which I determine as affecting more than two dwellings.

[27] A duplex is a dwelling with occupancy for two separate households, typically identical in dimension and design

For homes not sold, the value of home improvements remains unobserved. In addition, market dynamics during the improvement phase confound the identification. Further, previous research has relied on aggregate and survey estimate data not directly attributable to a particular dwelling. I contribute to the literature by empirically examining the realized returns of owners who undertake significant home improvements. Using a large and unique data set with information on applications and costs for home improvements and matching it to individual house sales, I can identify the returns attributable to home improvements. The data set permits a comparison of returns from resales of improved homes with those from homes where the owners did not undertake any developments[28].

Choi et al. (2014) model two choices that motivate home improvement investments: *consumption* and *speculation*. Homeowners carrying out home improvements for consumption motives tend to indulge in improvements for hedonism or to "keep up with the Joneses". Consistent with the consumption-based views detailed in Choi et al. (2014) and Gyourko and Saiz (2004), which suggest that owner–occupiers may invest for non-financial reasons as they are the consumers of the housing stock, the study reports the cost-adjusted return for home improvers is -2.4% over the average holding term, relative to owners who make no alterations. This finding implies that individuals who decide to undertake major alterations and additions perform significantly worse than homeowners who do not undertake any remodeling expenditure. A major implication of this result is that many of the homeowners who improve their homes are unaware of, or are undeterred by, the possibility that they may be overcapitalizing. Further, this study reports significant variation in the degree of returns/losses delivered by undertaking improvement works. Construction of a

[28] I am unable to determine whether the homes in my sample carry out maintenance-related renovations that do not require development approval (DA) such as painting and flooring. However, such works are more likely for DA-approved homes.

new single dwelling delivers well below unimproved homes (around -10%), while the addition of verandas, pergolas, and decks provides -4% returns, and for carports the figure is around -2.5%. Returns earned by undertaking extensions or the addition of a swimming pool are not significantly different from those who do not improve their homes. An exception to these negative returns is the development of duplexes, which maximize the use of the available parcel of land to increase the number of dwellings—approximately 10% over and above households that buy-live-sell. My results are consistent after controlling for property attributes and temporal or location factors.

According to Potepan (1989), developing existing houses is typically subject to 'technological constraints'. For example, the presence of existing housing limits home improvements by impeding the application of specific construction techniques common in new housing production. For relatively modest increases in housing units, this technological difference may be negligible; however, for sizable additions, the technological constraints result in higher average home improvement costs. For a new house/single dwelling, development basically starts with a blank canvas and has no technological restrictions, and therefore the owner can capitalize on the efficiency gains availed from the lack of barriers. However, despite these efficiency gains, the return on new houses/single dwellings is the lowest among improvement works. This finding suggests that given the opportunity to overcapitalize on the entire new build, there is greater indulgence on the part of homeowners.

Furthermore, a Joint Centre for Housing Studies (2009) report suggests that the recoup values of home improvements (i.e., the estimated value-added of home improvements divided by the cost) increase with rising house prices. Moreover, according to Glaeser et al. (2008), house prices rise more in areas with low supply, where land is limited and there are greater zonal and development restrictions. Given that the majority of land in

Australia is uninhabitable and most people live in the capital cities along the coastline, there is continuous upward pressure on house prices to keep up with the growing demand. The rising house price in turn loosens the financial constraints for homeowners and leads to overcapitalization. This further validates the consumption-based argument, consistent with (Choi et al., 2014).

My results are also robust to a number of additional tests, including segmentation by holding term, estimation of repeat sales indices for improved and unimproved homes, and sample selection bias. I segment the observations based on holding terms to identify speculators or "flippers" (typically homeowners who *"buy-improve-sell"* quickly and undertake improvements for speculative motives) and homeowners who *"buy-and-sell"* with a long holding term, but towards the end of the holding period, they *"improve-and-sell"* quickly). I refer to such homeowners as consumers-cum-speculators, as they typically have a consumption purpose initially and a speculative motive with respect to the improvements (Choi et al., 2014). I find flippers perform better than homeowners who resell in the same investment horizon but do not undertake any improvements. The most economically significant change is identified in the extensions/alterations improvement category, 5.4% higher than unimproved homes. For consumers-cum-speculators, I find returns are 5.6% lower on average than for homeowners who buy-and-sell quickly but do not improve their homes. These results are consistent with the speculation-based results detailed by Choi et al. (2014).

In addition, the construction and analysis of a repeat sales index that compares improved with unimproved homes confirm my results. Based on the constructed indices, I find that cost-adjusted returns on improved homes over time are consistently lower than those for unimproved homes, verifying my original regression analysis results. The test results from sample selection bias correction are also consistent with the original results.

1.3 Persistence in Capital and Rental Components of Housing Market Returns

Persistence in housing returns is a measure of the extent to which short-term shocks in the current market conditions lead to permanent future house price changes, and such shocks could be transitory or permanent in nature (Gil Alaña et al., 2013). Persistence in housing returns have significant economic effects as they are indicators of momentum and strong demand in a period of growth and decline in a sluggish market (Agnello and Schuknecht, 2011). It can lead to the departure of house prices from the fundamentals, which can result into inappropriate investments that decrease the efficiency of the economy. According to Gil Alaña et al. (2013), the persistence of house price shocks may also be transmitted to other sectors and macroeconomic aggregates, essentially decreasing the efficiency of the overall economy[29].

Understanding the time series behavior of house prices is also critical in the assessment of the impact of house price shocks for banks and mortgage lenders. Clayton (1998) suggests time patterns in house price series have important implications for appraisals and the mortgage underwriting process. According to Garcia and Raya (2011), financial intermediaries, such as banks/mortgage lenders, rely on house price series to manage their lending activity. For example, banks/mortgage lenders use the loan-to-value ratio as a

[29]Demary (2010) show that the spillovers from the housing markets have stronger impact on macroeconomic variables than vice versa.

measure of their risk exposure. As such, persistent deviations in house prices over time significantly affects these ratios and consequently the lender's risk exposure. Therefore, it must be in the interest of banks/mortgage lenders to have non-persistent (or at least weak-form) efficient housing market with house prices conforming to their fundamental values[30]. Further, it is estimated that residential mortgages in Australia account for around 60% of ADI[31] lending, and for some ADIs, this proportion is even higher, according to a report by APRA (2018). Given the scale and materiality of the housing exposure on banks/lending institutions, persistence can be an important measure for assessing and mitigating risks for banks and lenders[32].

One of the challenges in the way persistence (or weak-form of market efficiency) is measured—either using serial correlation based models (or long-memory models) (see, for example, Karl et al. (1989); Hosios and Pesando (1991); Gatzlaff (1994); Englund et al. (1999); Gu (2002); Elder and Villupuram (2012)) or variance ratio methods that test the null of random walk (see, for example, (Schindler, 2013, 2014)), is that in both cases, the choice of lags is arbitrary. Further, in variance ratio tests, the estimators are based on asymptotic distribution and hence suffer from deficient small sample properties. This study extends and enhances the methodology applied by Schindler (2013, 2014) for testing persistence in the housing market index returns in two important ways: first, by employing an automatic data-dependent lag selection procedure of Choi (1999), thus making the model

[30]One should note that persistent returns can be in positive or negative direction. Therefore, while banks/mortgage lenders would not mind the rising collateral value, persisting downward trend in house prices would certainly hurt at the time of liquidation. Hence, in the long run it is risk-neutral for banks/mortgage lenders to have efficient (at least weak-form) housing market which would result in a stationary loan-to-value ratio over time. This does not, however, preclude banks/mortgage lenders from lending to home buyers in regions with persistence returns, provided they are aware and/or have accounted for those risks.

[31]ADIs are Australian Prudential Regulatory Authority (APRA) authorized deposit-taking institutions.

[32]Depending on the lending term, the risk for banks/mortgage lenders can be short, medium or long term. Accordingly, persistence can be tested at various frequencies tailored to meet the lender's risk profile.

free from an arbitrary choice of lag term, and second, by applying the wild bootstrapping approach to the automatic variance ratio method, which is shown to have desirable finite sample properties as compared to the traditional variance ratio tests (Kim, 2006). The application of this improved methodology for testing persistence in housing market returns is one of the novel contributions of this study.

The empirical research on persistence, predictability or efficiency in the capital component of housing market returns is well documented for most advanced countries: the U.S.[33], Canada[34], the UK[35], and other developed real estate markets[36]. However, studies that have investigated persistence (or weak-form market efficiency) in the capital component of Australian housing market returns are limited, and a lacuna exists with respect to the rental component. This absence, domestically and internationally, prevails despite the increased recognition that the housing market in Australia is one of the most overvalued housing markets among OECD countries (OECD, 2018).

Testing for persistence in the rental component of housing market returns is a contribution of this study. According to (Sinai and Souleles, 2005), the capital component of the housing market conforms to the rational expectations theory[37], whereby the future price expectations are priced into the current prices, and the market frictions[38] are inevitable.

[33]see, for example, Rayburn et al. (1987); Gu (2002); Elder and Villupuram (2012); Schindler (2013).

[34]see, for example, Gau (1984); Hosios and Pesando (1991); Clayton (1996, 1998); Londerville (1998).

[35]see, for example, Barkham and Geltner (1996); Meen (2000); Schindler (2014).

[36]see, for example, Englund et al. (1999); Larsen and Weum (2008); Yajie (2016).

[37]Rational Expectations theory posits that individuals base their decisions on three primary factors: their human rationality, the information available to them, and their past experiences (Tardi, 2019). The term is often used to describe many economic situations in which the outcome depends partly on what people expect to happen. The price of an agricultural commodity, for example, depends on how many acres farmers plant, which in turn depends on the price farmers expect to realize when they harvest and sell their crops. Similarly, the price of a house depends partly on what prospective buyers and sellers believe it will be in the future (Sargent, 2011).

[38]The capital housing markets are typically characterized by frictions caused by high transaction costs, low turnover volumes, carrying costs, specific tax issues and asymmetric information (Schindler, 2014).

By contrast, the rental housing market is relatively frictionless[39], and hence, the transactions in the rental component of housing market clear according to the forces of demand and supply that are not based on the future price expectations, but rather on prevalent market fundamentals (Sinai and Souleles, 2005). This is consistent with Clayton (1996), who also points out that the rental market better represents the contemporaneous market conditions. This also explains why rents are typically used as proxies for unobserved market fundamentals in many present value relationship-based studies of housing market efficiency. Therefore, tests of persistence in the capital component of housing return without examination of persistence in the rental component of housing market appreciation provide, at best, incomplete evidence on the (weak-form) efficiency of the housing market.

Turner and Thomas (2001) suggest that annual movements in rents influence changes in capital value. As such, the capital investment decisions must take account of both, capital and rental return to maximize their total return. Banks/mortgage lenders can use the knowledge of persistence, not only in the capital, but also in the rental component of housing market return, to inform their lending decisions. Furthermore, prior information on persistence in the rental component can also benefit homeowners in terms of timing the new build or remodeling of their house[40]. Overall, the examination of persistence in the rental component of housing market return is beneficial.

[39] Since in the rental market there is minimal outlay for entry, i.e. a small deposit paid which is refundable at exit, and there are no major transaction costs for the renter as opposed to the capital market where the entry cost is a down-payment of deposit which usually involves significant amounts of money.

[40] Since investors have to remove their properties from the rental market during a construction period, it may lead to significant loss of rent. Given the knowledge of persistence in rental market along with a strong signal of change in the market direction, homeowners can, instead, time the construction accordingly. For example, if investors are privy to information that rental returns are persistent with a downward trend, investors could potentially upgrade their rental homes while the rents are low.

An important and distinguishing characteristic of any real estate asset is its spatial attribute (Tirtiroğlu, 1992). According to Rosenthal (1999), the implicit market for residential buildings is efficient, and any inefficiencies (or price variations) in the housing market lie in the market for land itself. However, given that the physical location of a given piece of land (and consequently, the location of the asset) is fixed, and that the spatial attributes of the land provide much of the heterogeneity, significant price variations in the housing market must be attributed to the location of the asset. Despite the importance of the location in the housing market pricing process, studies of persistence have only conducted their examinations at nationwide or state levels, while ignoring the local areas or regional-level analysis. Another contribution of this study is the regional-level analysis of persistence in housing market returns.

Further, the regional differences in persistence can also potentially influence the regional variation in house prices. Liu et al. (2016) develop a model of house price movements to explain the formation of bubbles. They acknowledge that while different cities do not vary in their response to bubbles in a rising market, there is a strong heterogeneity in the falling markets. Despite this, as Liu et al. (2016) points out, most previous studies have implicitly assumed away within-city variation in house price volatility in response to a bubble. Therefore, this also stands to reason the importance of testing persistence at the local regional levels to account for regional-level heterogeneity.

Additionally, due to large differences in the regional economic conditions across Australia, and the accentuated spatial heterogeneity in the housing market[41], one would expect significant variations in persistence at the regional level. Hence, the analysis of persistence

[41] Australia's population is much smaller in comparison with the U.S. and the UK. However, given that most of the land in Australia is uninhabitable, its housing market is mostly concentrated in few regions that are geographically far apart—approximately 70% of the population in Australia lives in the five largest capital cities (Valadkhani et al., 2017).

in housing returns at local regional-area levels can provide a better understanding of regional housing market behaviour which is important from the housing policy perspectives. Moreover, from a banker's perspective, it is important to not only assess the idiosyncratic credit risk of an individual borrower, but also to consider the region-specific (systematic) risks for the borrower[42]. Therefore, the analysis of persistence across different regions can enable banks/mortgage lenders to assess the region-specific risks based on their lending concentrations in different regions, and thus, to hedge their loan book positions accordingly.

Overall, this study provides a comprehensive characterization of persistence in Australian housing market returns from several key perspectives. First, I examine persistence in both the capital and rental return components of housing market index return. Second, I test for persistence not only at the broader nationwide and state level, but also across all non-overlapping geographic demarcations at three additional regional levels—Greater Capital Cities (GCC), Statistical Area Level 4 (SA4)[43] and Statistical Area Level 3 (SA3)[44]. Third, I test for persistence in market index return by dwelling type: houses and units, considered separately[45]. Finally, the study also analyzes persistence at quarterly and

[42] Given that more than 60% of Australian bank's assets are tied to residential mortgages, banks remain uniquely exposed to this major risk. A rise in defaults will reduce profits, while falling collateral levels may compel them to raise even more capital.

[43] SA4s are the largest sub-state regions based on the Australian Statistical Geography Standards (ASGS) framework (2016 Census), and they are specifically designed for the output of Labour Force Survey data. In regional areas, SA4s tend to have populations in the range of 100,000 to 300,000 persons; in metropolitan areas, the SA4s tend to have larger populations of 300,000 to 500,000 persons. SA4s are aggregations of whole SA3s, without crossing state borders, gaps or overlaps (Australian Bureau of Statistics, 2016a).

[44] SA3s are regions based on the ASGS framework (2016 Census). SA3s create a standard framework for the analysis of Australian Bureau of Statistics (ABS) data at the regional level through clustering groups at a lower regional level (SA2s) that have similar regional characteristics, administrative boundaries or labour markets. SA3s generally have populations between 30,000 and 130,000 persons. They are often the functional areas of regional towns and cities with a population in excess of 20,000, or clusters of related suburbs around urban commercial and transport hubs within the major urban areas. SA3s are aggregations of whole SA2s, without crossing state borders, gaps, or overlaps (Australian Bureau of Statistics, 2016a).

[45] Over the past 25 years, the number of occupied apartments (including flats and units, excluding townhouses) in Australia has increased by 78% to 1,214,372 dwellings at the 2016 Census. (Source:

monthly frequencies[46], which is also one of the attractive features of this study.

The key findings show that, overall, both regional and national level transaction-based imputed real house price indices in Australia exhibit persistence in the returns, and that the random walk hypothesis is strongly rejected. These findings are robust to both parametric (variance ratio) and non-parametric (independent runs) tests of random walk. Specifically, this study finds that, overall, there is higher persistence in the capital component of housing market returns vis-a-vis the rental component. In terms of dwelling type, houses have more persistence than units[47], in general. However, when observed separately—for capital and rental housing markets—I find that houses in the capital component of housing market returns exhibit stronger persistence than units, and conversely, in the rental component of housing market return, units have higher persistence than houses. This result is consistent with the investment motives of speculators. Additionally, I find that there is a lot of variation in the degree of persistence at the SA3 and SA4 regional levels, and that regions with persistent returns are clustered together, mostly concentrated near greater capital cities. This result could be mainly attributed to the spatial heterogeneity in the regions and the related informational flows[48], and is strongly consistent with the literature on spatial diffusion or the spatial form of market inefficiency (e.g., Clapp and Tirtiroglu (1994); Clapp et al. (1995); Dolde and Tirtiroglu (1997)). This validates the importance of testing for persistence, not just at the broader levels, but also more locally,

2071.0 - Census of Population and Housing: Reflecting Australia - Stories from the Census, ABS 2016). There is now around one occupied apartment for every five occupied separate houses in Australia—compared with one to every seven, back in 1991. Given the strong surge in apartments in the recent years, examining persistence by houses and units separately is warranted.

[46] Unlike the house price indices produced by the Australian Bureau of Statistics that are published quarterly, CoreLogic's indices are available at a higher frequency.

[47] This is consistent with Gatzlaff and Tirtiroğlu (1995), who also reports higher persistence in houses than units.

[48] For example, Sydney typically leads the cycle i.e. when Sydney house prices rise, other capitals such as Melbourne and Brisbane follow suit. This is attributed in part to information flows from one region to another.

at lower regional levels. Furthermore, after examining persistence in regional-level indices through to broader (national) indices, I find that the number of regions with persistence in housing market returns systematically increases. This suggests that the smaller regions with persistence must have at least a strong enough degree of persistence to influence it in indices at a higher level of aggregation[49]. The study also finds stronger persistence in monthly returns as opposed to quarterly returns. Finally, the study contributes to the literature by employing a wild bootstrapped automatic variance ratio test of Kim (2006) which is an extension over the traditional variance ratio tests used by Schindler (2013, 2014). The enhanced methodology essentially makes the model free from arbitrary lag selection and provides estimators that have desired small sample properties.

1.4 The Impact of Underquoting Regulation: A Case Study of the Housing Market in New South Wales and Victoria

Buying a home is an important milestone in an individual's lifetime, and correspondingly, it can also be a stressful and overwhelming experience (Meyer, 1987; Moschis, 2007). A rational home buyer would want the expected sale price of the home to direct their search, and not some arbitrary list price. However, buyers are very rarely able to form realistic expectations of the market value of a home before spending a lot of time studying

[49]CoreLogic's house price indices are estimated from scratch for each level of aggregation using the hedonic house price index methodology.

a particular home[50]. As a result, the advertised list price is often the best estimate to direct potential buyers when searching for homes. This is true regardless of a particular market being underpriced, overpriced or fairly priced (Österling, 2017). Piazzesi et al. (2015) and Rae and Sener (2016) find that home buyers direct their search based on the list price in the U.S. and UK markets, respectively. Despite the crucial role list prices play in the housing market pricing dynamics, it is claimed they are often underquoted by real estate agents in their marketing campaigns who exploit the information asymmetries between buyers and agents, distorting the expected market value of a property. Further, these distortions are even larger as information asymmetry increases Levitt and Syverson (2008).

Underquoting occurs when a property is willfully advertised for sale at a price that is significantly below the estimated price, asking price, or an offer that is previously rejected by the vendor, with the intent of stimulating artificial demand, and consequently inflating the sale price Consumers Affairs Victoria (2018b). There are many reasons why hiring a real estate agent (REA) is necessary for the average seller. First, the agents manage the marketing campaign and facilitate auction/sale process on behalf of the seller. Second, depending on the jurisdiction, the legal framework may eliminate or introduce risks if selling a home without a licensed agent. Third, selling a home requires detailed knowledge not only of the legal aspects and sales, but also marketing, home styling, etc. Given that the brokerage fee for the agent is generally a percentage of the sale price of the property, a higher sale price would result in higher brokerage income for the agent. Hence, their incentives to achieve a high sale price are at least partly aligned with those of the seller.

[50]For example, Windsor et al. (2015) examine how well people price their homes, and they find significant variations in their estimates. While around half of all postcodes in Australia value their home within 11% of the average market value, about a quarter of postcodes provide valuations more than 20% away from the average market value.

This is the traditional problem of misaligned incentives, also known as the principal–agent problem (Rutherford et al., 2005). Thus, by underquoting the property prices to obtain higher sale price, agents act for vendors, or rather, implicitly, for themselves.

Underquoting is perverse for home buyers for several reasons. Firstly, it sets the wrong expectations about the market value of the property, and as a result, it may lead to increased search and opportunity costs. Time-constrained buyers may visit the wrong homes if they are unaware of the degree of underquoting[51]. Österling (2017) estimates the annual search cost of underpricing in Stockholm and Gothenberg in Sweden, and finds that it amounts to 950 million Swedish Kroners, corresponding to 0.71% of the value of homes sold. Furthermore, Jud and Frew (1986) shows that by obtaining the higher price for the homes they sell, an agent implicitly shifts part of the brokerage-commission burden on to the buyer. Moreover, at an aggregate level, underquoting also inflates the overall housing market and affects other market participants[52], which in turn has implications for optimal allocation of resources[53], market efficiency, and the broader economy. Despite the economic significance of underquoting practices, research on underquoting in real estate markets is limited.

In 2008, Bender et al. (2008) conducted the first study investigating the accuracy of advertised pricing compared to the actual selling price in Victoria. They establish the prevalence of widespread underquoting with average sale prices being 11.3% above the

[51]Potential buyers have to invest significant amount of time, effort, and money, inspecting properties, pre-purchasing building/pests/strata reports, attending auctions in belief that the property is within their price range, and even obtaining pre-auction legal advice—all based on the false estimates of the selling price, which in turn manifests into frustration and emotional strain for the buyers (Real Estate Monitor Worldwide, 2014; Consumer Affairs Victoria, 2017).

[52]Piazzesi and Schneider (2009) develop a search model and show that how a small number of optimistic investors can have a large effect on prices without buying a large share of the housing stock. This consequently inflates the overall housing market.

[53]Price auctions allocate the goods to the buyer with the highest willingness to pay, and hence are Pareto optimal (see, example, Milgrom and Weber (1982))

advertised price for auction sales where "price plus" was the advertised phrase. In order to stamp out the underquoting practices, the local state governments introduced underquoting laws in New South Wales and Victoria on January 01, 2016, and May 01, 2017, respectively. However, the effectiveness of these reforms in controlling the underquoting practices has been of considerable debate lacking evidence[54] (see, for example, Barnes (2017); Worrall (2017)). There are several anecdotal studies that claim that underquoting is still pervasive and that laws have done little to control it[55]. Moreover, any claims of reduction in underquoting practices post the commencement of new laws are also subdued by the some experts, attributing them to the slowing of the housing market, rather than to the effectiveness of the new laws (for example, (Bender et al., 2008)).

Complaint statistics received by NSW Fair Trading between October 2015 and October 2016 remained fairly stable at 236 and 227, respectively (Castle, 2017), suggesting that the new laws have done little to get rid of the problem[56]. However, NSW Fair Trading attributes this lack of decline in complaints to increased awareness among buyers rather than failure of new laws to work (Castle, 2017). Hence, there is a lack of clarity and consensus over the effectiveness of the new laws.

[54]Back in 2007, a similar row erupted in Victoria revolting against the 'supposed' success of the underquoting laws with practice still rife even three years after the laws were originally introduced in 2004. Many believed that the regulations enforced by Consumer Affairs Victoria were ineffective which led to the failure of the law (Schneiders, 2007). In a survey conducted by *The Age* of more than 800 property auctions in April and May 2007 found that the properties sold for an average of 21.2% more than their advertised prices, confirming the ineffectiveness of the laws (Schneiders, 2007).

[55]An investigation carried out by NSW Fair trading in the Northern Beaches of Sydney found 14 of 17 agents had breached laws (Syndey Morning Herald, 2018). Razaghi (2018) reports 18 agents across New South Wales were found guilty of underquoting in just the first two months of 2018, equivalent to 108 occurrences per annum. Further, Bright, quoted in Razaghi (2018), states that underquoting is quite widespread and the fines are too low to be a significant deterrent: tougher penalties, including the 'naming and shaming' of offenders and larger fines, are needed to eradicate the underquoting practices completely. Redman (2018) suggests that underquoting in the property market is still rampant and yet to be stamped out. Drummond, quoted in REINSW (2016), further endorses the view that underquoting legislation have not been effective in overcoming the problem of misleading buyers about what price sellers might accept or 'conditioning' sellers about what price buyers might pay.

[56]In Victoria, the complaints in 2016–17, on the contrary, had increased by 61% to 546 up from 339 in 2015–16 (Worrall, 2017).

One of the challenges in assessing the impact of underquoting regulations is estimation of underquoting itself. Underquoting is usually measured by comparing the list price to the actual sale price, since the actual market value of the property is unobserved at the time of listing. However, the list price is provided ex-ante at the time of publication, while the sale price is only available ex-post after the transaction. Hence, the actual level of underquoting is unobserved, and essentially, what I measure is the ex-post underquoting. By definition, if the listing price suffers from underquoting, it may result in inflated final selling price beyond the unobserved market value of the property. Therefore, as the listing price decreases further, it increases the actual (unobserved) underquoting; but there is a greater increase in the ex-post (observed) underquoting measure which occurs as a result of both lowering the listing price, and consequently, the increased sale price[57]. This is a joint hypothesis problem. Therefore, to control for the unobserved market value of a property, I include in the model the market index (level) variable at the time of listing and at a more local Statistical Area Level 2 (SA2)[58] as a proxy for the market value of the property[59].

Through this study, I investigate the impact of regulations on, underquoting practices in

[57]Say, for example, the underquoting metric is calculated as one minus the ratio of list price to the sale price. Then, at the time of listing, a property valued at $1 million (unobserved), listed for $950,000 at 5% true (unobserved) underquoting, and later sold for 1.05 million, has an estimated (observed) underquoting of 9.52%. However, if the same property at the same time were listed for $900,000 at a true (unobserved) underquoting of 10%, as per the problem definition of underquoting—it creates artificial demand and inflates the sale price—the property is sold at a price higher than $1.05 million, say $1.1 million at an estimated (observed) underquoting of 18.18%. Hence, this example shows how the calculated underquoting overestimates the actual underquoting that occurs, and how a small change in actual underquoting leads to a greater change in the observed estimates. In this example, we see that while there is an increase in the true (unobserved) underquoting of 5% from 5% to 10%, the estimated (observed) underquoting increases by 8.66% from 9.52% to 18.18%.

[58]SA2s are medium sized regions based on ASGS framework (2016 Census). SA2s represent a community that interacts together socially and economically. There are 2,310 SA2 regions covering the whole of Australia without gaps or overlaps. SA2s generally have a population range of 3,000 to 25,000 persons. SA2s are aggregations of whole SA1s, without crossing state borders, gaps, or overlaps (Australian Bureau of Statistics, 2016c)

[59]The home value indices at the SA2 geographic level estimated by CoreLogic are the most robust market index estimates with smallest geographical Statistical Areas, and therefore, the best approximation of the property value at the time of listing.

New South Wales and Victoria for both 'Auction' and 'Private Treaty' sales. I first define a metric to measure the degree of underquoting as the log ratio of list price to the sale price: referred as the "Underquoting Ratio". This allows me to quantify the compliance levels of underquoting, before and after the new laws were enacted and enforced, and then, by applying the difference-in-difference regression method, I measure the impact of the new laws on the underquoting practices. I use the population of home sales data and corresponding first and last listings[60] across New South Wales and Victoria between 2014 to 2018, and examine the amount of underquoting, following both enactment and commencement of the new laws. Comparisons of the change in underquoting for enactment and commencement periods with respect to the pre-enactment period, relative to the other states where no recent change in regulations is introduced, offer a simple method for evaluating the effects of regulation.

In addition to the simplicity of the empirical methodology, several other features of the new laws, and my data set and methodology, are also significant. First, I use the population of home sales data and their corresponding first and last listings, across New South Wales and Victoria. As such, I have complete information set on the property attributes, its sale prices, contract dates, list prices and the dates of listings, which makes this study more comprehensive, robust and reliable[61]. I, therefore, measure the overall effect of new regulations on underquoting practices after controlling for observables, and not simply for a subset of population.

[60]The home sales data and the listing data are provided by CoreLogic. I use in my analysis all home sales data and the first and last corresponding listing data that are within one year prior to the sale.

[61]According to NSW Fair Trading (2017a), a property selling for more than the advertised price isn't necessarily a proof of underquoting. For example, this could sometimes be the result of genuine competition among buyers, rather than irrational bidding, market factors such as supply and demand, and occasionally due to strong emotions attached to the particular properties which may result in offering more than the property's market worth Sanders (2017). Therefore, the use of a comprehensive data set in this study is more reflective of the overall market with rational bidding behaviour.

Second, the introduction of the reforms in underquoting occurred at the time when the housing market in Australia was appreciating. Since its peak in October 2017, the national housing market has been steadily declining (CoreLogic, 2019). The data from 2014 to 2018 covers the entire rising market before the commencement of the law and most of the falling market post commencement of the law. Therefore, given that underquoting is found to be correlated with property price level, and tends to increase in the rising market, and vice versa (Bender et al., 2008), it is possible that the effects of new laws may have been obscured by the volatility in the housing market[62]. Therefore, I control for the volatility in the housing market price levels using the hedonic housing price index[63] at the time of listing. In addition to controlling for the unobserved market value as discussed above, this allows me to simultaneously account for any variations in the underquoting ratio due to the volatile housing market conditions[64].

Third, New South Wales and Victoria are relatively large states in Australia, with respective capital cities: Sydney and Melbourne combined, accounting for almost 55% of total national housing value (CoreLogic, 2018). Therefore, on average, the sale price variations in the treatment states (New South Wales or Victoria) will be significantly larger in comparison to the other control states. However, given that underquoting is calculated as the (log) ratio of the list price to the corresponding sale price, which forms the dependent variable in my model, and that one would expect the list prices to be correlated with the sale prices, the size variations, on average, would cancel out in the ratio calculation: that is, the underquoting ratio would be normalized, and therefore would not bias the results.

[62] Han and Strange (2014); Bender et al. (2008) confirm that underquoting increases during booms and vice versa.

[63] I use the hedonic house price index provided by CoreLogic at the SA2 regional level.

[64] The effects captured in the corresponding coefficient are, however, inseparable.

Fourth, there is strong variation reported in the underquoting levels across different suburbs which may potentially bias the results[65]. Hence, my model also controls for any spatial variation in underquoting levels by including Statistical Area 4 (SA4) level fixed effects in the main model results (reported in Section 5.5), as well as the more local SA2 level fixed effects as part of a specification test (discussed in Section 5.6).

My empirical finding for New South Wales show that for 'Auction' sales, there is 4.1% and 5.7% reduction in underquoting during the enactment period and after the commencement of the law, respectively. While for 'Private Treaty' sales, I find 1.2% and 3.8% reduction in underquoting, respectively. Comparison of the change in underquoting ratio of listings in Victoria relative to other states shows that, in the case of 'Auction' sales, there is 2.3% and 7.3% decrease in underquoting during the enactment period and post-commencement period, respectively. However, in 'Private Treaty' sales, I find the decrease in the underquoting practice is evident only after the law was effective, with 2.7% reduction in underquoting, while there is a marginal increase in underquoting of 0.5% during the enactment period. These findings are robust to location fixed effects at the local geographic area level, and controlled for market index estimates, various property and listing characteristics, including property type, and other factors—spatial or temporal.

1.5 Structure of the Dissertation

The remainder of this dissertation is structured as follows. Chapter 2 of the dissertation provides a broad literature review of the published research on the three key topics

[65] An investigation conducted by NSW Fair Trading in the suburbs of Sydney finds stark contrast in the compliance levels of underquoting across the state with Dubbo showing no incidences of underquoting, while other areas like Sydney's inner west and Tweet Heads had more than 50% cases of underquoting (Burke, 2018).

raised in this dissertation. Specifically, it provides literature around the topics of home improvement, persistence or (weak-form) efficiency of the housing markets, and underquoting practices. Chapter 2 concludes with a statement of hypotheses to be tested in this dissertation.

The main body of the dissertation is contained in Chapters 3 to 5. More specifically, Chapter 3 examines the financial performance of investments in additional housing acquired via home improvements. Chapter 4 tests the performance in terms of housing market (weak-form) efficiency or persistence in the inflation-adjusted capital and rental components of market returns across multiple geographic areas in Australia. Chapter 5 investigates the regulatory performance of underquoting reforms in the housing market in New South Wales and Victoria.

Finally, Chapter 6 summarizes and concludes the dissertation.

Chapter 2

Literature Review

2.1 Introduction

This chapter provides an overview of the literature related to the three studies presented in this dissertation with the intention of providing further motivation for the empirical analyses conducted in subsequent chapters.

Section 2.2 first reviews the literature related to home improvements with focus on topics such modeling the consumption demand and identification of determinants. I further review studies such as the role of construction costs in home improvements, and trade-off faced between hired help and self-labor in carrying out home improvement works. I then look into recent studies that have examined the returns on home improvements and whether they are profitable investments. Section 2.3.1 reviews the literature related to the persistence or (weak-form) efficiency of housing market returns. I discuss the topic of persistence related to both multifamily housing (units) and single-family housing (houses) in Sections 2.3.1.1 and 2.3.1.2, respectively. Section 2.3.1.2 reviews studies related to persistence or weak-form efficiency for single-family housing across various segments such as temporal, spatial, Novel Paradigms, and securitized real estate markets. Section 2.4 then turns to studies related to underquoting or underpricing. I discuss housing search models and the role of list prices in Section 2.4.1. Sections 2.4.2 and 2.4.3 review the role of real estate agents and bidding behaviors in auction setting, respectively. In Section 2.4.4, I then discuss studies that compare underquoting in auctions and private treaties. Section 2.4.5 discusses the welfare costs associated with buyer search.

Finally, in view of the research reviewed, Section 2.4.6 puts forth a set of hypotheses to be tested in subsequent chapters.

2.2 Studies of Home Improvements

Home improvements research has focused on topics of modeling consumption demand (e.g., Potepan (1989) and Montgomery (1992)) and identification of determinants (e.g., Boehm and Ihlanfeldt (1986), Galster (1987), Plaut and Plaut (2010), Fisher and Williams (2011) and Bian (2017)). Potepan (1989) argues that homeowners face a choice between improving their existing homes and moving to obtain additional housing. They model demand for housing reinvestment as a function of interest rates and incomes, and they show that as interest rates increase, housing reinvestment also increases. By contrast, housing reinvestment is negatively related to income, as higher income would make homeowners more likely to move instead of reinvesting in their homes. Montgomery (1992) models housing improvement demand by simultaneously allowing for homeowners to choose the level of stock they hold and the means by which they adjust their current holdings of the housing stock (i.e., moving to a new home, improving the existing home, or doing nothing).

Boehm and Ihlanfeldt (1986)[1], Galster (1987)[1], Plaut and Plaut (2010)[1], Fisher and Williams (2011)[1], and more recently, Bian (2017) study the determinants of home improvement expenditure. Boehm and Ihlanfeldt (1986) state that home improvement expenditure is positively related to consumption and the financial value of the home improvement. They further suggest that the financial value of home improvements depends on the resale price prevailing at that time, which is a function of neighborhood quality. Empirically, they identify neighborhood quality variables such as the crime rate in the area and the quality of schools, roads, and sidewalks as explanatory variables of home improvement expenditure, but they do not estimate the financial value of home improvements. Galster (1987) studies the determinants of home improvement expenditure and finds that in addition to the dwelling, owner, and neighborhood characteristics, variables concerning community interaction and the household's perception of the future of the neighborhood are important factors that affect home improvement behavior. Galster (1987) suggests that the combination of cohesive neighborhoods and households that strongly identify with such neighborhoods results in higher home improvement investment. Plaut and Plaut (2010) study the financial, household and geographic factors that affect household's decisions to renovate and which sort of renovations to undertake. They conduct separate analyses on the decision to undertake "major structural renovations" as opposed to remodeling the kitchen or bathroom, and also on the decision to conduct renovations that increase floor space. Fisher and Williams (2011) explore the micro as well as macro level determinants of home improvement decisions, such as before-tax income, family-size, age

[1] In addition to home improvement expenditure, these studies also include maintenance spending in their analysis.

of respondents, 30-year fixed mortgage interest rate, change in housing market, and state employment rate. Bian (2017), on the other hand, examines the effect of housing equity position, as measured using loan-to-value ratio, on the probability of home improvements. The author finds that higher loan-to-value (LTV) ratio (i.e., lower home equity) reduces the likelihood of home improvement. The author also finds that the probability of home improvement decreases by a greater amount when a high LTV ratio is the result of falling house values than when it is due to equity extraction.

Gyourko and Saiz (2004) describes the role of construction costs in the housing decline in the United States. They find that home improvements cease when the value of a home is low relative to the cost of construction, suggesting a rational investment motive. Guthrie (2010) argues that new house prices are considerably above direct construction costs and that a premium can be attributed to the option value of delaying the development of the marginal piece of land. When homeowners sell their unimproved homes, they permanently transfer the option to the buyer and therefore receive a premium attributed to the option value of delaying their development to the future buyer. By contrast, homeowners who improve have exercised their option[2] and instead receive value for the development works, but with significant outlay in the form of construction costs that offset the returns.

Womack (2015) studies the value of urban land and its effect on investments in physical building structures. The author examines the estimation of the redevelopment option and explores the relationship between real options and land values. Womack (2015) also examines the determinants of the decision to redevelop physical capital either in whole (rebuilds) or in part (renovations). Yao and Pretorius (2014) value a redevelopment option

[2] Although the buyer can demolish the previous addition and redevelop, this is costly and therefore an improvement can be thought of as an irreversible option.

for builders that involves purchase, holding, converting and developing a leasehold land, using an American call option pricing model. Their empirical results confirm presence of a positive and non-trivial option premium of 5.274%, on average. They also show that their real option model accurately predicts the exercise point of the redevelopment option.

Mendelsohn (1977) develops a theoretical framework of home improvements that balances the cost between hired help and self-labor and suggests that homeowners do not undertake works on their homes unless the rewards from that work equals the value of their leisure time. The author focuses on improvement works that include both alterations and repairs and involve self-labor (i.e., do-it-yourself projects), unlike in the present study, where I examine only the major remodeling works that require certification.

Despite the significance of home improvement investments, little has been written about their profitability. Among the few such studies are those by Choi et al. (2014) and Simons et al. (2009) which examine the return on home improvements and whether they are profitable investments. Choi et al. (2014) theoretically show that as house prices increase, the recoup values of home improvements also increase; however, for homeowners with a consumption-cum-financial motive, rising house prices loosen the financial constraints that lead to lower recoup ratios. Their empirical results are based solely on internal activities such as the addition or remodeling of bedrooms, bathrooms, and kitchens. Additionally, the resale value (or value-added) of home improvements, used in their empirical test, is based on the professional judgment of members of the National Association of Realtors. By contrast, the identification of home improvement value in our method comes from estimating and comparing the realized house price return of homeowners who improve compared with those who do not.

My empirical work also contributes to the literature on household finance (e.g., Campbell (2006), Plaut and Plaut (2010), Barber and Odean (2011), and Fisher and Williams (2011)). Much of this literature focuses on the financial decisions of households and whether they are profitable or identifying homeowners who are likely to renovate. A consensus exists that financially unsound and insufficiently educated households do not make appropriate decisions (Choi et al., 2014). This is also true in our study, where investors who like to speculate are generally more educated about house prices, construction costs, and general market trends, and therefore they make positive returns from home improvements, as opposed to non-speculators who have a consumption motive. Overall, the household finance literature is limited in relation to home improvement decisions and whether the right level of home improvement activity is undertaken. Our study adds to the home improvement literature by informing the economic decisions of homeowners and suggests that home improvement activities in Australia are overcapitalized at the aggregate level.

2.2.1 Testable Hypothesis - Home Improvement

Based on the present research reviewed, I put forth a set of testable hypotheses, and the tests of these are detailed in Chapter 3 on Home Improvement.

$H_{3,1}$: *Homeowners overcapitalize on home improvements.*

$H_{3,2}$: *Speculators earn higher returns from home improvements relative to those who do not undertake any improvements.*

$H_{3,3}$: *Consumers-cum-speculators make lower returns from home improvements relative to non-speculators who do not undertake any improvements.*

2.3 Studies Related to Persistence, Predictability and Market Efficiency

The understanding and analysis of persistence of house price index returns is typically discussed in the context of the validity of market efficiency or inefficiency (Schindler, 2014). The topic of market efficiency was first systematically discussed by Malkiel and Fama (1970) in application to the financial markets. The authors presented both a thorough discussion of theoretical issues and empirical tests of efficient market hypothesis. A number of studies on market efficiency emerged thereafter: for example, Grossman and Stiglitz (1976); Basu (1977); Chiras and Manaster (1978); Jensen (1978); Pesando (1979); Ho (1985); Fama and French (1988); French (1988); Poterba and Summers (1988); Chaudhuri and Wu (2003); Bali et al. (2008); Fama (1991); Dockery and Kavussanos (1996); Timmermann and Granger (2004); Malkiel (2005); Aga and Kocaman (2008); Lee and Lee (2009), among others, which covered a wide range of markets and assets and applied various methodological approaches.

2.3.1 Real Estate Markets

In terms of property or real estate markets, the empirical literature has overwhelmingly been concerned with assessing persistence in the capital component of housing market returns, while the rental component of housing market appreciation has received no attention whatsoever. Further, published research has been highly concentrated on the evaluation of the U.S. real estate markets, followed by Canada, the UK, and other international markets, while the literature's coverage and analysis of persistence offered in Australia is largely ignored.

2.3.1.1 Multifamily Housing: Units

Gau (1984) conducted one of the first studies to analyze weak-form efficiency in the capital component of housing returns for multifamily housing (i.e., units) for Vancouver, Canada, and finds no evidence of significant autocorrelation in the returns. In a subsequent study of testing for a semi-strong form of market efficiency for units by Gau (1985), the author applies the asset pricing model to estimate the abnormal returns resulting from two public information sources: major changes in government tax shelter and rent control policies as well as unanticipated changes in the mortgage interest rates. The author concludes that the investors do not earn significant abnormal or economic profits around these two sources of public information and therefore the market must be semi-strong form efficient.

For the same local market, Clayton (1998) studies efficiency using quarterly appraisal-based data from the Royal Lepage Survey of Canadian House Price for the period 1982 to 1994 and finds opposite results to Gau (1985), with strong evidence against market efficiency. Clayton (1998) shows that lagged annual capital returns and a measure of deviation of house price from its fundamental value, such as price-to-rent ratio, to some extent predict future capital returns. These results suggest there are mixed findings for persistence in the case of multi-family units. Further, a study by Londerville (1998) also looks into the real estate market for apartments in Vancouver, Canada, using data from 1971 to 1985. Londerville (1998) estimates the value of homes using a hedonic model for repeat sales, finding that undervalued properties have higher appreciation rates, suggesting economic profits based on this trading rule—however, once these are adjusted for risk by using Sharpe ratio, the differences in returns are insignificant. A similar result was found by Linneman (1986) and Rayburn et al. (1987), but they report that the excess profits were not sufficient enough to cover the high transaction cost associated with transacting residential real estate and that no significant arbitrage opportunities exist. Rayburn et al. (1987) tests the weak-form efficiency for the city of Memphis, Tennessee, using data from 1970 to 1984 and finds that seven of the ten sub-markets depict patterns in time series; however, after adjusting for transaction costs, all ten sub-markets were determined weak-form efficient, suggesting no time pattern, consistent with the results of Linneman (1986). Rayburn et al. (1987), however, finds this was not the case for homeowners over shorter holding periods, 1970 to 1975.

2.3.1.2 Single-family Housing: Houses

Literature on market efficiency or persistence in single-family housing is further divided into different paradigms of market efficiency. One of the most classical forms of market efficiency is the temporal form which tests the predictability based on past information. The second is the spatial form of market efficiency where the predictability of market returns is based on neighboring geographic areas.

2.3.1.2.1 Temporal

Karl et al. (1989) extend the research on market efficiency for single-family homes (i.e. houses) by examining four geographical areas in the United States for the period 1970 to

1986, using 39,210 repeat-sale homes for which there were no apparent quality changes and for which conventional[3] mortgages applied. They also apply an improved methodology over that used in Gau (1985): they regress the index change on lagged index change, which is robust to spurious serial correlation. Karl et al. (1989) conclude that the housing markets in all of the four geographical areas (Atlanta, Chicago, Dallas, and San Francisco/Oakland) exhibit substantial persistence. However, they add a caveat to their results due to the difficulties associated with measuring imputed rents for owner-occupied housing. Further, they show that a profitable trading strategy persists, since details from real interest rates are not being completely incorporated into house prices. Further, using the same data set, Case and Shiller (1990) apply a multivariate approach to forecast price changes in single-family housing market and test the predictability of price changes and excess returns using certain independent variables. They find that annual price changes tend to continue for more than one year in the same direction, indicating persistence in annual capital returns. Further, they also find that the price changes over the subsequent year and excess returns are both forecastable using these identified variables, hence providing further evidence of inefficient markets.

Glaeser and Nathanson (2017) build an extrapolative model of house price dynamics and identify momentum at one-year horizons, mean reversion at five-year horizons, and excess longer-term volatility relative to fundamentals. When a home buyer makes a modest approximation about the expected price, it leads house price to increase in the market value after recent increases.

[3]A conventional mortgage refers to a home loan that is not insured or guaranteed by the federal government, but instead is available through or guaranteed by a private lender, such as banks, credit unions, mortgage companies or the two government-sponsored enterprises: the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage Corporation (Freddie Mac) (Investopedia, 2019).

Case and Shiller (1989) show that the housing market for single-family homes is not efficient and that the year-on-year index changes are followed by changes in the same direction, suggesting a profitable trading rule is exploitable for individuals who are free to time the market. Hosios and Pesando (1991) construct a single quarterly price index represented by detached homes, semi-detached homes and townhouses for the city of Toronto, Canada using the Bailey et al. (1963) methodology on repeat-sale observations of quality-constant or unimproved homes for the period 1974 to 1989, and test its efficiency. To prevent spurious serial correlation in the index returns from biasing the forecastability of future changes in an estimated index based on prior changes in this same index, the authors follow the method of Case and Shiller (1989). They divide the sample in half and estimate two separate indices and then regress the current change in one index on the lagged change in the other, thus eliminating the bias. Hosios and Pesando (1991) find that their estimated index returns exhibit a serially correlated structural relationship across lags indicating strong persistence, and hence do not reconcile with the efficient market hypothesis.

Meese and Wallace (1994) apply a different methodology to test the efficiency of residential housing markets between 1970 to 1988 for the two counties: Alameda and San Fransisco in Northern California. According to Meese and Wallace (1994), the present value relationship implies that the house prices and capitalized rents have a common trend i.e. they are co-integrated. Therefore, any deviations of the net present value of all future rents (i.e. fundamental value) from the house value would imply inefficient markets. In using a present value relation model, they show that the house values deviate from the fundamental values in the short run, indicating inefficient markets, but are consistent in the long run when they adjust the discount factor for changes in both, tax rates and borrowing cost, suggesting that the markets are efficient. They attribute these results to the high transaction costs that characterize the housing market. Clayton (1996) applies an extended version of the present value relation model for quarterly house prices for the single-family housing market in the city of Vancouver, British Columbia from 1979–1991. The author uses a novel approach to proxying the imputed rents of owner-occupied housing, as a function of observable housing market fundamentals. Clayton (1996) finds that the present value relation model fails to fully capture the observed house prices during two real estate booms, but is able to track real house prices well in the less volatile market, suggesting that the housing market is efficient in the less volatile market, and vice versa.

Elder and Villupuram (2012) examine the return and volatility of the S&P Case and Shiller real estate index and find evidence of long memory in the form of fractional difference. They find evidence of very persistent long memory in both the return and volatility of real estate index. They suggest that long memory in real estate returns implies future asset return are predictable at long horizons, potentially violating weak form of efficiency.

Gatzlaff (1994) extends the results of Case and Shiller (1989) by identifying the relationship between expected inflation and excess returns. Using two alternative models of expected inflation: rational expectations model and adaptive expectations model, the author shows that both estimates of expected inflation are positively correlated with excess returns, suggesting predictability in house price returns. As the important extension, Gatzlaff (1994) suggests that this predictability of excess returns using historical information from past excess returns may depend on market's ability to forecasts inflation rates, and that, in the adaptive expectation model of expected inflation, the trading rules are less likely to be profitable during the low to moderate inflation.

Gu (2002) analyze the predictability of U.S. housing market using quarterly indices published by CMHPI for all 50 states in the U.S., District of Columbia, separate indices for nine Census Divisions and a national level index for the U.S., from 1975 to 1999. The author finds that for shorter periods, the autocorrelation in returns is negative, suggesting mean reversion, and for longer time between periods, the autocorrelation is positive, indicating persistent returns. Applying heteroskedacity-consistent variance ratio tests, Gu (2002) show that the ratios for all states are less than one, indicating negative autocorrelation or mean reverting process. However, at higher lags, the results differed across states with more regions exhibiting greater than one variance ratios, indicating positive autocorrelation or persistence in returns. Using a trading strategy that is based on estimated autocorrelation, the author also shows that it is possible to obtain excess return.

Schindler (2013, 2014) test the persistence in house price index returns and predictability in the U.S. and UK regional as well as nationwide housing market, respectively. While, Schindler (2013) examines the monthly and quarterly returns in the U.S. S&P/Case–Shiller house price indices for the period 1987 to 2009, Schindler (2014) looks at only quarterly returns in the UK Nationwide Building Society Indices from 1974–2009. Using both univariate variance ratio test and non-parametric independent runs test, the author finds evidence of strong persistence in the house price index returns. Schindler (2013, 2014) also test the technical trading strategies and find that moving average-based strategies perform significantly better than a simple buy-and-hold strategy in regions with persistent returns. This suggests that with prior knowledge of persistence in a given local market, the investors can make excess real profits from using moving average-based strategies.

Meen (2000) constructs a model of the UK housing market by simulating housing cycles that are created by interactions between economic variables, such as house prices, construction costs and interest rates. The author finds that house prices and transactions are correlated, and that the transactions are forward indicators of house price changes, hence suggesting that the UK housing market is inefficient, with persistent returns.

Barkham and Geltner (1996) examine the informational efficiency of the housing market in the UK by assessing the extent to which the house price movements can be predicted or discovered on the basis of movements observed in another market. Barkham and Geltner (1996) refer to this as the "price discovery" approach to market efficiency. They find that the returns in the housing market can be predicted by returns to certain securities on the UK stock market up to two years in advance, concluding that the UK markets are not semi-strong form efficient. Further, Case et al. (2000) look into international real estate markets and find significantly high correlation across geographies. This suggests that the house price movements in one country are influenced by the changes in the house prices in another country. Hence, this provides more evidence of "price discovery", and thus, of semi-strong form of market inefficiency.

For housing markets in other parts of the world, studies report persistence and predictability in house price index returns. A study by Larsen and Weum (2008) examines the efficiency of a Norwegian housing market in the capital city of Oslo by employing the methodology of Case and Shiller (1989) on repeat sales house price index and its returns. For the period 1991 to 2002, they conclude that both time series exhibit time patterns and that the housing market is inefficient. Englund et al. (1999) test the random walk hypothesis against the alternative of serial correlation using transactions of quality-constant properties in the eight metropolitan regions in Sweden for the period 1981 to 1993. They find evidence of strong serial correlation in the asset returns. Yajie (2016) tests weak-form efficiency of the residential real estate market in China using autocorrelation and unit root test. The author finds that housing returns are auto-correlated and hence the real estate market in China is also weak-form inefficient.

2.3.1.2.2 Spatial

According to Shiller (1990), people use a broad set of models to form their expectations in an economy. In addition to the rational expectations models, Tirtiroğlu (1992) points out that one such popular model in the housing markets for current and potential homeowners is the spatial diffusion model of housing price changes. Tirtiroğlu (1992) identifies this gap and extends the previous research on temporal housing market efficiency by considering a spatial dimension. The author assesses both contemporaneous and lagged price changes in the neighboring regions. Using data from the Hartford, Connecticut, metropolitan area, Tirtiroğlu (1992) finds that there is no evidence of contemporaneous spatial diffusion. However, there occurs a spatial interaction with lagged house price changes in neighboring jurisdictions, supporting the hypothesis for inefficient markets.

Clapp and Tirtiroglu (1994) also examines the housing market efficiency from a spatial angle, where information diffuses across regions—as part of the representative heuristics framework—for a single metropolitan area Hartford, Connecticut. The author tests the form of positive feedback hypothesis, where good news gives rise to positive attitudes, and vice versa. As such, recent house price movements must contain important information for decision makers, and if this hypothesis were true, then the house price changes would tend to diffuse to the entire local area. The author finds evidence in support of this spatial form of housing market efficiency. Similarly, Clapp et al. (1995) find evidence of diffusion of housing price changes. The diffusion is both temporal, within individual towns, and spatial, between neighboring towns. The authors argue that this spatial diffusion appears to represent reactions to information flows rather than systematic autocorrelation—irrational feedback trading. For example, Clapp et al. (1995) show that only past abnormal price changes from neighboring towns affect current abnormal price changes; those from non-neighboring towns do not. Further, Dolde and Tirtiroglu (1997) also examines both temporal and spatial diffusion of information (or price changes), but in both mean and variance, for the towns in Connecticut and near San Francisco. The authors find, contrary to previous research, evidence of negative serial correlation within towns, and, consistent with Clapp and Tirtiroglu (1994); Clapp et al. (1995), significantly positive spatial information diffusion in the neighboring towns, but none in non-neighboring towns.

2.3.1.2.3 Novel Paradigms

Rosenthal (1999) provides a new paradigm for testing the efficiency of housing markets based on building prices. According to Rosenthal (1999), for the housing market to be efficient, a necessary condition is that the new building prices must adjust to movements in construction costs more quickly than the time required for construction, so as to eliminate any excess profits for the builders. Based on the results from the error correction model, the author shows that the implicit market for residential buildings is efficient and hence the inefficiencies in the housing market must lie in the market for the land itself. However, because the physical location of the land is fixed, the inefficiency in the land market must be attributed to the idiosyncratic characteristics of the location of the land, which also contributes to the heterogeneity of housing as an asset class. Given that the spatial attributes of the land are responsible for its efficiency (or inefficiency) in the pricing process, it also shows further relevance to carrying out research covering smaller geographical areas, using regional-level indices.

Hjalmarsson and Hjalmarsson (2009) provide an alternative test of efficiency in the Swedish housing market by taking advantage of its co-operative housing setting. In this market, the purchaser of the unit in the co-operative housing market buys a share in the co-operative with a time-unrestricted right to occupy the unit. As such, the purchaser pays the sale price at the outset and a monthly rent to the co-operative to cover the capital cost for the co-operative's debt. Essentially, the sale price of the dwelling is one part of the total cost of occupying the unit which is paid upfront, and rent is the other part paid on ongoing basis. Thus, if the housing market were efficient, there should be an inverse one-to-one relationship between the present value of future rents and the sale price as the total cost of obtaining unrestricted right to occupy the dwelling must be fixed. The authors, however, show that for every 100 Kroner increase in the rent (in present value terms), the sale price decreased by 75 Kroners, suggesting that the Swedish co-op housing markets must be inefficient.

2.3.1.2.4 Securitized Real Estate Markets

In addition to underlying/spot real estate market, academics have also examined securitized real estate markets. Schindler et al. (2010) test the weak-form market efficiency of fourteen public real estate securitized markets using weekly returns from January 1990 to December 2006. Except for Australia, the major securitized real estate markets do not follow a random walk and hence exhibit persistent returns. The authors find that the

Australian securitized real estate market shows significant signs of mean reversion process with variance ratios significantly below one. Stevenson (2002) examine the international real estate securities using variance ratios on monthly returns of REITs from 1977 to 2000 for eleven countries, including Australia, and find mean aversion in most of the securities returns, suggesting persistent return patterns across most international real estate securities, with the exception of Australia, Hong Kong, Japan, Singapore, and the UK for intervals greater than one year.

Serrano and Hoesli (2010) also find persistence and predictability in the real estate returns, showing that arbitrage using a trading strategy is possible. They also compare the securitized real estate market with the stock market and show that there is more predictability in the former than latter. Liu and Mei (1992); Mei and Liu (1994) also find similar results. On the contrary, Li and Wang (1995) find no evidence that the predictability of REIT return is any better than the returns in stock market. Meanwhile, Mei and Gao (1995); Nelling and Gyourko (1998) find limited evidence of persistence in REIT returns and caution that returns may no longer be persistent in the presence of transaction costs.

Graff and Young (1997) find that the monthly and yearly REIT returns exhibit serial correlation in contrast to quarterly data. Hence, they conclude that linear multi-factor models do not explain the behavior of REIT returns. Mei and Gao (1995) also report that U.S. REIT markets show specific persistence in returns and thus reject the RWH in its theoretical form. However, they ascertain that no trading strategies can be derived that generate excess returns considering transaction costs.

Furthermore, Gatzlaff and Tirtiroğlu (1995) and Maier and Herath (2009) provide a comprehensive overall survey of studies on the topics of market efficiency, and closely related, persistence and predictability in the housing market. Overall, most of the existing literature demonstrates predictability and persistent returns in the capital component of the housing market appreciations, while the tests for persistence or market efficiency in the rental component of market returns have been ignored. Further, the extant literature has focused mainly on the U.S. housing markets with some coverage for Canada, the UK, and other international markets, and little attention paid to Australian housing markets. In addition, most previous studies have evaluated persistence or market efficiency using a low-frequency quarterly data, rather than monthly data, except in case of securitized real estate markets where both low- and high-frequency returns are well-covered.

2.3.2 Testable Hypothesis - Efficiency

In view of the research reviewed, I put forth a set of testable hypotheses related to persistence or weak-form efficiency in the housing market. The tests of these are detailed in Chapter 4 on persistence testing.

$H_{4,1}$: *The capital component of inflation-adjusted housing market returns exhibit persistence.*

$H_{4,2}$: *The rental component of inflation-adjusted housing market returns exhibit persistence.*

2.4 Studies Related to Underquoting

The understanding of housing search models, with respect to the role of list prices (e.g. Yavas and Yang (1995); Chen and Rosenthal (1996); Arnold (1999); Knight (2002); Han and Strange (2015, 2016); Merlo et al. (2015); Albrecht et al. (2016); Taylor (1999); Haurin et al. (2013); Lester et al. (2017)), the role of real estate agents (e.g., Baryla and Ztanpano (1995); Turnbull and Dombrow (2007); Palm (1976); Rutherford et al. (2005); Levitt and Syverson (2008); Jud and Frew (1986)), bidding behavior (e.g. Kagel and Levin (2002); Compte (2004); Ahlee and Malmendier (2005); Malmendier and Lee (2011); Han and Strange (2014)), underpricing in auction versus private treaties (Ashenfelter and Genesove (1992); Lusht (1996); Quan (2002); Bender et al. (2008)), and welfare costs (e.g. Lehmann (2016); Anglin (1997); Österling (2017); Shimizu et al. (2004)) have been the key topics discussed in the literature, with strong implications for underquoting. I review the literature related to each of these topics in the corresponding sections below.

2.4.1 Search Models and the Role of List Prices

Behavioral theories can explain that a decrease in the list price will either decrease the sale price or increase the sale price. Underpricing assumes that decreasing the list price increases demand and ultimately increases the sale price. In contrast, the anchoring theory by Tversky and Kahneman (1986) argues that a higher list price will increase peoples' perception of the value of the home, and hence will increase the sale price. Therefore, most search models use list price as a ceiling at which the seller cannot reject the offer. Underpricing in these models is impossible (e.g. Horowitz (1992); Yavas and Yang (1995);

Chen and Rosenthal (1996); Arnold (1999); Taylor (1999); Knight (2002); Han and Strange (2015); Lester et al. (2017). Meanwhile, others do allow for underpricing specifically (e.g. Han and Strange (2016); Merlo et al. (2015); Albrecht et al. (2016); Haurin et al. (2013)).

The empirical literature on housing search models has largely focused on the case wherein the list price is a ceiling and buyers arrive one at a time. Chen and Rosenthal (1996) consider the impact of list price on buyer search. The author suggests that buyers are more willing to incur the costs of visiting a particular house if the seller has committed to a low ceiling price. (Lester et al., 2017) construct an efficient equilibrium and revenue-maximizing model wherein the seller advertises the good for a price at which (s)he will be willing to trade immediately. Hence, the model uses asking price as a ceiling and allows for offers below the asking price, but not above. Knight (2002) examine the factors affecting the list price changes. The author shows that homes most likely to undergo price revisions are those with high initial markups and vacant homes, while homes with unique features are the least likely to experience a price change. The author further suggests that mispricing the home in the initial listing is costly to the seller in both time and money. In fact, they find that homes with large percentage changes in list price take longer to sell and ultimately sell at lower prices. This result implies that the author considers list price as an upper range, and as such does not seem to acknowledge that downward mispricing (or underquoting) is possible. Arnold (1999) also specifies a model where the list price impacts the arrival rate of buyers and hence time-on-market and the sales price. Yavas and Yang (1995) add brokerage to this type of model. See Haurin (1988), Wheaton (1990), and Horowitz (1992) for early models of housing search that consider list prices as a ceiling.

Taylor (1999) proposes a two-period model whereby it may be optimal for the seller to post an excessively high initial listing price in order to complicate the inference problem faced by uninformed potential buyers. Hence, the sellers may choose to overprice their property when entering the market and then revise the listing price downward in the second period if the property is still unsold.

Haurin et al. (2013) investigate the relationship between the list and sale prices of residential properties over the housing cycle. The authors point out that the list prices may not always act as a ceiling as in the most standard search models. In down or normal markets, they note that the list price generally exceeds the sales price; however, in the rising market, homes sell for more than their list price. As an alternative, Haurin et al. (2013) develop a model in which sellers set the list prices based on their expectations of future changes in sales prices and the buyer arrivals; however, they also allow for demand shocks. This model failed to explain the list to sales price ratio during a housing boom. In response, they develop a model where sellers can endogenously select their search mechanism conditioned on the strength of the housing market. The authors find support for the claim that sellers switch to auctions in rising markets. They also find evidence that list prices are sticky in a declining market. However, according to these models, underpricing is only possible in a rising market.

By contrast, Han and Strange (2016); Merlo et al. (2015); Albrecht et al. (2016) recognize underquoting and do not treat asking price as a ceiling. Han and Strange (2016) develop a search model in which the home will sell at the list price only if there is exactly one buyer. In that case, the vendor is committed to sell at the list price. However, if there are more buyers, the home will sell at an auction and the seller is not bound to sell at the list price but can sell above or below the list price. The list price directs the search because of the possibility of getting the home at discount (at the list price). Buyers visit the home if it is optimal to do so. Han and Strange (2016) also show that increasing the list price reduces the buyer arrivals. Merlo et al. (2015) solve the home selling problem theoretically. They find that buyer arrivals (demand) is sensitive to the list price, and therefore, it would be optimal for the seller to underprice. Both Han and Strange (2016) and Merlo et al. (2015) use the number of bidders as a proxy for buyer arrivals.

Albrecht et al. (2016) solve a general equilibrium search model where sellers compete for buyers using the list price and buyers compete against each other using bids. The authors allow for the receipt of multiple simultaneous offers as in an auction setting. Initially, the authors start with a model that rules out the scope of list prices to effect a housing transaction, either in price or timing. In this model, all sellers have the same reservation price. Hence, as long as the list prices are marginally above their reservation price, the equivalent payoffs for sellers must be risk-neutral in list prices, i.e. any list price gives the seller the same probability of making a sale and also gives the same price conditional on the sale. Hence, list prices would play no role in influencing the price or timing of a sale. In this setting, Albrecht et al. (2016) show that the expected sale prices are then simply a function of the intensity of market demand (the ratio of buyers to sellers in the market), which is consistent with expectations that an increase in demand increases house prices. Albrecht et al. (2016) then extend this analysis to a situation where sellers now differ in their reservation prices. Those with low reservation prices are more motivated and willing to sell and vice versa. In this case, list price indicates the seller's motivation. A motivated seller sets lower list prices than less motivated sellers. Since buyers can infer reservation price from list price, this situation will yield motivated sellers having a higher probability of sale and receiving a lower price than less motivated sellers. While Albrecht et al. (2016) allow for sale prices below, above, or at the asking price, their model does not seem consistent with the motivation for underquoting. In case of an underpricing regime, the more motivated the seller is, the more underpricing occurs, as higher underpricing increases the buyer arrival rate which ultimately leads to a higher sale price.

Han and Strange (2016) considers the role of the asking price in housing transactions both theoretically and empirically. The author develops a model where asking price is neither a binding commitment nor a ceiling, yet it still directs buyer search and impacts sales price. The author provides empirical evidence consistent with asking price playing a directing role in buyer search. The author also suggests that this effect is stronger for more atypical houses and in bust markets.

Another interesting study is conducted by Guren (2018) and models list price as the expected price of the market value of the property, rather than binding or ceiling. Guren (2018) notes that sellers do not set a unilaterally high or low list price because they face a concave demand curve: increasing the price of an above-average-priced house rapidly reduces its sale probability, but decreasing the price of a below-average-priced house only slightly improves its sale probability. The resulting strategic complementarity amplifies frictions because sellers gradually adjust their price to stay near average. The author provides empirical evidence for concave demand using a quantitative search model. However, the author's model fails to explain underpricing regimes prevalent in the residential housing market.

There has been considerable attention paid to the relationship between list price and time-on-market in Yavas and Yang (1995); Knight (2002); Anglin et al. (2003); Merlo and Ortalo-Magne (2004), and others. Anglin et al. (2003) studies the role of list prices in marketability of the property. More specifically, they assess the trade-off between selling at a higher price and selling in less time, showing that an increase in the list price increases expected time on the market. Merlo and Ortalo-Magne (2004) use 780 transactions in their sample data from the period 1995–1998, which includes all offers a house receives, and show how listing price influences the arrival of offers and ultimately determines the timing of the sale. As time on the market increases, buyer arrivals decrease, and the probability of listing price revision increases. The longer the time on the market, the lower the level of offers relative to the listing price, the higher the probability a match is found, and the lower the sale price is relative to listing price. The authors do include some above-list sales. However, the frequency of such sales is small at 4% of transactions in the sample. Their empirical evidence supports the assumptions that the seller faces a trade-off between the rate of arrival of buyers and the sale price: a low listing price increases the arrival rate of buyers but makes it impossible for a sale at high price. Merlo and Ortalo-Magne (2004) also provide evidence that shows that a sizeable fraction of sellers revise their listing price at least once, and those who do typically reduce it by a substantial amount after waiting a substantial period of time without receiving any offer.

Most existing theoretical models, however, imply that in equilibrium, either the seller never revises the listing price (e.g., Arnold (1999); Chen and Rosenthal (1996); Horowitz (1992); Yavas and Yang (1995)), or gradually lowers the listing price over time in a continuous fashion (e.g., Coles (1998)).Some papers have considered how time-on-market, in turn, relates to issues such as the heterogeneity of housing (e.g., Haurin (1988); Glower et al. (1998); Haurin et al. (2010)). Others have considered how time-on-market influences the probability of a successful match with a buyer (e.g., Zuehlke (1987)) and the decision to revise the list price (e.g., Sass (1988)). Carrillo (2012, 2013) develop a structural approach to model this issue. Further, Bender et al. (2008); Han and Strange (2014) also identify the determinants of underquoting.

2.4.2 Role of Real Estate Agents

Baryla and Ztanpano (1995) examine buyer search duration using transactions conducted with and without the assistance of real estate brokers. Their results indicate that information asymmetries are present in the residential real estate market with agents being in the advantageous positions. Baryla and Ztanpano (1995) show that real estate brokers are able to reduce search costs in terms of the buyer search time for all classes of buyers, whether first-time, experienced, or out-of-town buyer. Turnbull and Dombrow (2007) study the role of individual agents and how they affect house selling prices and time on the market while controlling for brokerage firm-specific effects as well as supply and demand conditions that vary by neighborhood. Turnbull and Dombrow (2007) find that agents who specialize in listing properties are able to obtain higher prices for their sellers while those who specialize in selling obtain lower prices for their buyers.

Palm (1976) study the role of real estate agents in the U.S. and find spatial bias in the recommendations they made to prospective home buyers. They suggest that any such bias constraints the information field and consequently the search space of such households. Palm (1976) conclude that, in general, households that are dependent on estate agents for information on neighborhood characteristics are making use of a highly structured and spatially limited information source. This further adds to information asymmetry in the real estate sector.

Rutherford et al. (2005) study the "principal–agent" problem (or "agency problem") between the seller (Principal) and the real estate agent (Agent). Rutherford et al. (2005)

suggest that agents have more information on the market price than the sellers, and they investigate whether the agents are able to exploit this information asymmetry to their advantage by selling their own property either faster or for a higher price than their clients' properties. Their empirical results confirm the existence of the "agency problem". Rutherford et al. (2005) find that agent-owned homes sell no faster than client-owned homes, but they do sell at a price premium of around 4.5%. A similar study is conducted by Levitt and Syverson (2008). The authors suggest that agents are often better informed than the clients. They have an incentive to exploit this informational advantage and convince their clients to sell too cheaply and too quickly. Levitt and Syverson (2008) tests these hypotheses by comparing home sales in which real estate agents are hired when an agent sells his own home. The authors find that homes owned by estate agents sell for 3.7% more than other houses and stay on the market for 9.5 days longer after controlling for observables. They further conclude that greater information asymmetry leads to larger distortions.

Jud and Frew (1986) examine the role of real estate brokers in the market for residential housing. They show that buyers who search the housing market with the assistance of a real estate broker have a higher demand for housing than buyers who shop the housing market without the help of a broker. They also find that brokers obtain higher prices for the homes they sell and implicitly shift part of the brokerage-commission burden to the buyer.

2.4.3 Bidding Behaviors in Auction Setting

Han and Strange (2014) study the time series and cross-sectional patterns of overoptimistic bidding behaviors for houses—transactions where sale price exceeds the list price, referred to as “bidding wars’. The author suggests that bidding wars, or, conversely, underpricing, were once rare, comprising only 3–4% of total transactions, which led to the treatment of list price as a ceiling in empirical and theoretical research on housing (see, e.g., Yavas and Yang (1995); Chen and Rosenthal (1996); Arnold (1999); Knight (2002); Han and Strange (2015), as discussed above). The authors find that the bidding war share roughly tripled between 1995 and 2005, rising to more than 30% in some markets. Further, Han and Strange (2014) show bidding wars' incidence to be greater during macroeconomic and housing booms, and the share falls during subsequent busts. Han and Strange (2014) also attribute the bidding wars to other potential contributing factors, including buyer irrationality, the use of the internet in home purchases, and land use regulations.

Several studies have proven the existence of overbidding in an auction setting. For example, Malmendier and Lee (2011) show that bidders pay too much relative to how much they would be willing to pay outside the auction setting, suggesting that the observed bidding behavior in auctions is inconsistent with rational behavior. Malmendier and Lee (2011) examine online auctions in which the same item is also continuously available for immediate purchase on the same website. In a broad cross-section of auctions, they find 48% overbidding with average overpayment of around 10%. They even account for the uncertainty about prices and switching costs as the expected auction price also exceeds the fixed price. Ahlee and Malmendier (2005) show that in 51% of all auctions, the final price is on average 7% higher than the “buy-it-now” price for the same good. This is despite the fact that these markets have less information asymmetry as compared to real estate markets—the same items can be easily be located elsewhere on the internet for less than the buy-it-now price[4]. (Ahlee and Malmendier, 2005) suggest that buyers in online auction neglect cheaper prices once they have started bidding.

Further, Malmendier and Lee (2011) find that only a small fraction—17% of bidders—are enough to spark a large fraction of auctions with overbidding. Malmendier and Lee (2011) suggest that overbidding is slow at first but feeds on itself if these participants make up more than 10–15% of total auction bidders. Hence, from a seller's perspective, it becomes important to create conditions that will attract this segment of bidders to the auction, or at least let in as many people as possible. This explains why underpricing is so widely used by real estate agents. Given that bidders are able to collect even the most basic, readily-available information, the market must be efficient. Therefore, the buy-it-now price, in these auctions, should be an upper bound to bidding. However, in contrast, Malmendier and Lee (2011) document the prevalence of an ill-informed and economically-indifferent group of overbidders who end up determining many auction results. These studies also question the validity of the law of one price, even in low-transaction-cost environments. Therefore, this further validates the argument that irrational overbidding behavior could be even more pronounced, particularly in the real estate markets that are heavily characterized by information asymmetries[5].

Other explanations for overpriced bidding is given by the large theoretical and empirical literature on the "winner's curse"—extensively discussed in Kagel and Levin (2002). In its simplest form, the idea is that an auction winner has the highest estimate of the value of the item being sold, and no one else believes that the item is worth that much (otherwise,

[4]This result is consistent with Ariely and Simonson (2003) who find that in 98.8% of instances, an item being auctioned on e-Bay can easily be located elsewhere on the internet for less than the buy-it-now price.

[5]For example, (Baryla and Ztanpano, 1995) find the presence of significant information asymmetries in the residential real estate market.

they would continue to bid higher), and therefore there is a good chance that the winner has overpaid. Compte (2004) provides an alternative explanation for "winner's curse". Compte (2004) suggests that bidders make estimation errors and competition induces the selection of overoptimistic bidders, resulting in a higher sale price.

2.4.4 Auctions versus Private Treaties

Several studies compare the prices in auctions with those in private treaty sales and show that auctions yield higher sale prices relative to private treaty sales for comparable properties (see, for example, Ashenfelter and Genesove (1992); Mayer (1998); Lusht (1996); Quan (2002); Bender et al. (2008)).

Ashenfelter and Genesove (1992) study auction sales of 83 condominium apartment units in New Jersey and find that 40% of all auction sales that were finalized fell through. Meanwhile, prices in the subsequent sale of condominium units in face-to-face negotiations resulted in identical units selling for 13% less than they fetched at auction. Ashenfelter and Genesove (1992) attribute this declining price anomaly to information asymmetry that exists between bidders and sellers, and point out that bidders may have been the subject of a "winner's curse". Lusht (1996) compares sales prices brought by auction to prices brought by private treaty in a Melbourne housing market in Australia from January 1988–March 1989. After controlling for selection bias, Lusht (1996) finds that average price from auctions was about 8% higher than from private negotiations. Quan (2002) propose a model for disposition of real estate assets with two alternatives: a search market that incurs search costs for buyers and holding cost for sellers and an auction where the seller pays a commission upon sale. Quan (2002) finds that the auction mechanism yields higher prices for the asset than the search market. Their model, however, does not consider the buyer's search costs in the auction markets.

Mayer (1998) investigates the performance of real estate auctions relative to negotiated sales. The author uses a repeat-sales methodology to control quality differences. Properties auctioned in Los Angeles during the 1980s boom sold at an estimated discount of up to 9%, while sales in Dallas following the oil bust obtained discounts of 9–21%. Mayer (1998), however, finds no evidence of the declining price anomaly.

One of the most comprehensive studies establishing prevalence of underquoting in Australia is conducted by Bender et al. (2008). Bender et al. (2008) investigate the problem of underquoting in 16 Melbourne suburbs in Victoria. The authors examine the accuracy of advertised pricing compared to the eventual selling price of residential property and determine the relative accuracy of advertised price for the two methods of sale: "Auction" and "Private Treaty". Based on 3,000 sales and associated listings between April 01, 2005 to March 31, 2007, the authors find considerable disparity between the listing and actual sale price, particularly in relation to the Auction sales. Bender et al. (2008) report such disparities were not typically evident in Private sales, with listing price for Private sales more accurately corresponding to the sale prices. Their results show that over 45% of price range advertisements for auctions led to sales above the top of the advertised range, compared to 13% of that of private sales. Further, Bender et al. (2008) find that where "price plus" was the advertised phrase for auction sales, the average sale price was 11.3% above the advertised price, contrasting strongly with private sales, where the average sale price was just 4.8% above the advertised price plus figure.

2.4.5 Welfare Costs

Search costs are major form of welfare costs to society that arise out of underquoting. Real Estate Monitor Worldwide (2014); Lehmann (2016); Consumer Affairs Victoria (2017) highlight the substantial costs associated with underquoting for the potential buyers in terms of time and effort invested in inspecting properties, acquiring building, strata, and pest reports, attending auctions, and even obtaining pre-auction legal advice. Lehmann (2016) further suggests that the prohibition on underquoting amendment could potentially result in indirect cost savings. (Anglin, 1997) model the search costs in the form of duration of housing search, estimated in terms of time and the number of houses seen. The author identifies several significant factors, including prior information and the quality of information provided by a newspaper or a real estate agent, dealing with the provision of information. The type of agency that employs the agent and the characteristics of the buyers have little effect.

Österling (2017) estimates the annual search cost of underpricing in Stockholm and Gothenberg in Sweden, finding that it amounts to 950 million Swedish Kroners, corresponding to 0.71% of the value of homes sold. Shimizu et al. (2004) estimate the buyer search cost given the imperfect information environment, such as an underquoted listing, in the real estate market of resale condominiums in central Tokyo. Their results suggest that, on average, 1.042 million yen are spent on search activities for one transaction, equivalent to 13.2% of buyers' average annual income.

Morse and Crawford (2018) draw attention to the costs of underquoting to real estate agents in fines and penalties, which is part of the welfare costs associated with underquoting[6]. (REINSW, 2018) further highlights the costs of underquoting practices to agents, which include injunctions, severe monetary penalties and legal costs, not including the reputational damage suffered. Additionally, underquoting also has other welfare costs with consequences to buyers, vendors and their agents. According to Murphy, quoted in REINSW (2018), the practice of underquoting may significantly inconvenience, disappoint and deceive prospective buyers. The practice of underquoting also affects the interests of other vendors and real estate agents who comply with the law and do not engage in underquoting (REINSW, 2018). They suffer unfair and improper competition and may miss out on getting prospective buyers to purchase their properties as a result.

Overall, the practice of underquoting in residential real estate has been recognized in the literature, and there is extensive research on related topics, as discussed above. However, studies on the laws that regulate these underquoting practices in the real estate sector have received no formal attention in the academic literature. The underquoting reforms in New South Wales and Victoria, thus, provide a natural experiment case study to examine the effectiveness of these laws in Australian housing markets. This study contributes to the literature in several ways. First, it extends the literature on underquoting regulations and property underpricing by testing whether property listings in New South Wales and Victoria were affected by increased information disclosure and transparency brought about

[6] Morse and Crawford (2018) reports a case of record fine of \$880,000 paid by an estate agent after the federal court found its marketing strategies unacceptable. This was considerably larger than the previous record of a \$330,000 penalty imposed by Director of Consumer Affairs in 2015. In November 2018, another agency in Victoria was imposed with a \$720,000 fine, which is currently the second-highest penalty (Leaman, 2018). These fines are a reminder of the significant costs to agents for engaging in underquoting practices, and ultimately to the society.

by the enforcement of underquoting regulations. My results show that reducing pre-auction uncertainty and information asymmetry between sellers and prospective buyers leads to less underpricing of homes. Second, given the fact that underpricing declined significantly as early as immediately after the enactment of the laws, it establishes that the underquoting practices were deliberate on the part of the agents. Third, by having a control sample afforded by the existence of states that have not adopted the regulation, I am able to significantly reduce the contemporaneous effects of other unobservable market forces that affect underpricing in auctions during our sample period. This allows me to make stronger inferences about the effects that government regulations have had on property underpricing in New South Wales and Victoria.

2.4.6 Testable Hypotheses - Underquoting Regulation

In the light of the present research reviewed, I put forth the following hypothesis in relation to the underquoting regulations, and the tests of which are detailed in Chapter 5.

$H_{5,1}$: *The regulation impacts the underquoting behavior of real estate agents.*

2.5 Summary

This chapter reviews the literature on three key facets of housing market performance and identifies gaps in the literature; and correspondingly puts forth a number of testable hypotheses. Tests of these hypotheses are presented in the following chapters. Chapter 3 examines the financial performance of home improvement investments. Chapter 4 assesses the persistence (or weak-form) efficiency of the capital and rental components of housing market returns across several geographic demarcations in Australia. Chapter 5 investigates the impact of underquoting reforms in New South Wales and Victoria before and after enactment and commencement of the laws.

Chapter 3

Do Homeowners Overcapitalize?

3.1 Introduction

The first study in this dissertation examines the financial returns derived by homeowners who carry out significant home improvements relative to owners who do not make any alterations to their homes. The extant literature on home improvements discussed in Section 2.2 reveals that the research is mainly focused on topics such as, modeling consumption demand (e.g., Potepan (1989) and Montgomery (1992)), identification of determinants (e.g., Boehm and Ihlanfeldt (1986); Galster (1987); Bian (2017)), and the role of construction costs (e.g., Gyourko and Saiz (2004); Guthrie (2010); Mendelsohn (1977)). Despite the significance of home improvement investments, little has been studied about their returns. Among the few such studies are those by Choi et al. (2014) and Simons et al. (2009) that examine the return on home improvement investments. Specifically, Choi et al. (2014) develop a theoretical model and show that, for homeowners with a consumption-cum-financial motive, rising house prices lead to lower recoup ratios on home improvement investments. This chapter extends their analysis empirically and provides evidence of lower returns for homeowners who improve their homes relative to those who do not.

The remainder of the chapter is organized as follows. Section 3.2 reviews the institutional settings surrounding the development application process. Section 3.3 develops a model of house price returns and Section 3.4 describes the data and sample selection process. In Section 3.5, I describe the estimation methodology and provide summary statistics. Section 3.6 presents the main results of my first hypothesis ($H_{3,1}$) along with a critical discussion, while the results of various robustness tests are presented in Section 3.7. In Section 3.8, I conduct further analyses to examine returns based on investor segmentation, which provides the tests for other two hypotheses, $H_{3,2}$ and $H_{3,3}$. Finally, Section 3.9 concludes.

3.2 Institutional Setting

In Australia, home improvements follow a formal process and require drawings from architects, engineers and quotations from builders. A development application is made by or on behalf of homeowners to local government authorities seeking consent to carry out development activity as part of capital-funded home improvement works. While property transactions are administered at the state level and property taxes are levied at the state and local levels of the government, the local level of government oversees all development and planning controls including building heights, floor space to land size ratios, changes in developing a swimming pool, and being able to add a deck to an existing dwelling.

Thus, homeowners must obtain a building permit/DA and a construction certificate from their local council before commencing the development. There are two categories of development applications: complying and non-complying developments (CDs and NCDs hereafter). CDs are to some extent standardized with a universal set of requirements that apply across the state and cannot be amended to suit the preferences of the individual homeowner. While CDs have limited parameters, this affords homeowners the ability to obtain approved plans in a relatively short period (approximately 10 days) and commence works without input from neighboring properties. In the case a homeowner cannot obtain his or her desired outcome within the regulations of a CD, a larger gambit of opportunities is available via an NCD, which requires consultation, greater administration, and consequently more significant time to achieve approval, in some cases over a year. NCDs are region-specific and can vary between local councils within the state. Depending on the specific requirements, homeowners can apply to their local councils for CD or for more customized NCD[1].

As part of the application process, homeowners submit a proposal providing detailed development plans, compliance tables, costs, and other related documents along with payment of an application fee. Once the application is lodged, it is advertised in local newspapers and notices are sent to the neighbors of the property for comment or feedback, as part of the community consultation process. The application is then allocated to an assessment officer, who assesses the development application in detail, including site inspections where required, and prepares a report. The assessment officer determines if there are any objections and whether the application complies with the policies and codes. The application is then referred to the Development and Building Unit to approve the

[1] I am unable to distinguish between CD and NCDs.

decision. In some cases, if required, the application is further referred to the Development Application Panel. Once the application is approved, the homeowner can apply for the construction certificate to commence the development work.

As part of development applications, information on development cost and the type of development works are collected. I use this reported development cost as the expected value for the actual home improvement expenditure[2]. My study focuses on housing reinvestment in single-family detached houses. Other residential building types such as unit/apartment blocks, townhouses, and villas are not considered in the analysis, as they typically do not involve a single household and are developments of a commercial nature.

The improvement activities are categorized, such as completely demolishing and rebuilding a new house from scratch, adding a bedroom, bathroom, or carport, and adding a veranda or pergola. These types of improvement activities are grouped into six categories of home improvement works: carports/garages/sheds, duplexes, extensions/alterations, houses/single dwellings, swimming pools, and verandas/pergolas. A development application is a real option provided to households that typically expires in one, two, four, or five years depending on the state. There is no obligation to start a development application, but there is a requirement to complete it once commenced to obtain an occupation certificate.

[2] As the development application fees charged by local councils are typically a percentage of the home improvement expenditure, households have an incentive to declare lower costs and thus pay lower fees. Therefore, the development application costs recorded in the development application dataset may underestimate actual home improvement expenditure, and consequently, the negative returns reported in this study.

3.3 A Model of House Price Returns

In this section, I develop a model of house price returns subsequently used in my empirical analysis.

Let T represent a point in time with three dates. Let subscript -1 denote the time of purchase, $+1$ the time of subsequent sale post-development application (resale), and, for improved homes, 0 the time of home improvement[3]. Therefore,

$$T_{-1} < T_0 < T_{+1}$$

The value of a house comprises three components: land value (L), non-durable consumption (B) (i.e., the building value), and durable consumption (H) (i.e., the value of housing as a service) (Flavin and Nakagawa, 2008). Let R be the composite rent to be paid for the collective value of the house at a given time $t = T$. Then, using the model given by Kiel and McClain (1995), the house value V at time $t = T$ can be modeled as

$$V_T = \int_T^{\infty} Re^{\alpha t} e^{-bt} e^{ht} e^{\sum_i \mu_i K_i} e^{-rt} dt \tag{3.1}$$

where α is the appreciation rate of the land, b is the depreciation rate for the non-durable consumption value B, h is the appreciation rate, if any, for the durable consumption value

[3]For the purpose of model exposition, I assume that the time of the home improvement activity is a point in time; however, this point actually represents the interval from the date DA is received until the completion of improvements. To distinguish between the two, I use the notation 0^- and 0^+ to indicate the points of pre-improvement and post-improvement, respectively. The point in time when the improvement is completed is equal to the time when building approval is received plus the average commencement time (C) plus the average construction time (C'). In the empirical analysis, I adjust for this interval accordingly.

H, K_i is the set of control variables, where i indexes different control factors, μ_i is the corresponding effect of the controls on house prices, and r is the discount rate.

Houses in Australia can be on a freehold or a leasehold land title. In a freehold lease, the homeowner has full ownership of the property in perpetuity, while in leasehold, the homeowner can possess the property for up to 99 years. Most residential properties in Australia are freehold. Therefore, the rents to be paid for periods far in the future would be negligible in present value terms. Hence, the integral of the above equation is finite.

Solving the above integral yields,

$$V_T = \frac{Re^{-(r-\alpha+b-h)T}e^{\sum_i \mu_i K_i}}{r-\alpha+b-h} \tag{3.2}$$

Now, for the repeat sales data, I have sale prices observed twice within a specified period. Using equation (3.2), I can calculate the value of the house at the time of purchase as

$$V_{T_{-1}} = \frac{R_{-1}e^{-(r-\alpha+b-h)T_{-1}}e^{\sum_i \mu_i K_i}}{r-\alpha+b-h} \tag{3.3}$$

Similarly, the value of the house at the time of resale can be given as,

$$V_{T_{+1}} = \frac{R_{+1}e^{-(r-\alpha+b-h)T_{+1}}e^{\sum_i \mu_i K_i}}{r-\alpha+b-h} \tag{3.4}$$

Now, the appreciation rates in terms of log-returns is calculated as,

$$ln[V_{T_{+1}}/V_{T_{-1}}] = ln[\frac{R_{+1}e^{-(r-\alpha+b-h)T_{+1}}e^{\sum_i \mu_i K_i}}{r-\alpha+b-h} / \frac{R_{-1}e^{-(r-\alpha+b-h)T_{-1}}e^{\sum_i \mu_i K_i}}{r-\alpha+b-h}] \tag{3.5}$$

Simplifying equation (3.5) and re-arranging gives,

$$ln[V_{T_{+1}}/V_{T_{-1}}] = ln[R_{+1}/R_{-1}] + (\alpha + h - r)(T_{+1} - T_{-1}) - b(T_{+1} - T_{-1}) \tag{3.6}$$

This model is estimated using the log returns of the repeat sale prices of houses over time. Owing to changes in supply and demand at the time of purchase and resale, the gradients of those attributes (e.g., the number of bedrooms, bathrooms, and car parking spaces) affecting house prices may not be constant over time. Therefore, although the equation suggests that these cancel out, these attributes have been found to affect appreciation rates (Kiel and McClain, 1995) and hence are included in the regression. The composite rate $(\alpha + h - r)$ between sales is inseparable but jointly observed in the market index. I explicitly allow for the depreciation rate b to be included in the model to capture the effect of depreciation for improved homes[4]. Equation (3.6) therefore is estimated as

$$ln[V_{+1}/V_{-1}] = a_0 + \beta(MarketReturn) - b(T_{+1} - T_{-1}) + \sum_i \mu_i K_i \tag{3.7}$$

where $a_0 = ln[R_{+1}/R_{-1}]$ is a constant and β is a composite rate of return equal to $(\alpha + h - r)$ attributed to the average market appreciation.

[4]The house price index developed by CoreLogic does not account for the age of the property, and therefore the effects of depreciation may not have been captured entirely. In my model, I explicitly include the age of the home improvement and control for linear as well as quadratic effects of depreciation.

3.4 Data and Summary Statistics

I use a unique database of repeat sales that include house price sales information and DA details. The data are provided by CoreLogic, the leading property data, information, analytics and services provider in Australia and New Zealand. The sale price data are sourced from the Valuer General of each state, which registers and files the population of property transfers in Australia. CoreLogic supplements the transaction data with property attribute data collected from property listings including the number of bedrooms, bathrooms, and car parking spaces at the time of sale[5]. The DA data are obtained via a subsidiary of CoreLogic, Cordell, which obtains the DA materials submitted to local councils. While house price data are available from 1990, DA submission data are available from 2004. The combination of these time-stamped data by unique property ID provides detailed information on sale price, property attributes, improvement costs, date of building approvals, and classification of home improvement works. This allows me to estimate the return on improved homes relative to unimproved homes to identify home improvement values.

To measure the returns of households who undertake home improvements compared with those that do not, I first identify all repeat sales transactions since 1990[6]. I exclude

[5]In Australia, property taxes are levied on the parcel of land, not the improved value of the dwelling; consequently, housing stock attribute data are limited from government sources and sourced from property listing portals.

[6]I exclude two territories of Australia, ACT and Northern Territory as Cordell does not collate DA records for these small territories and therefore I exclude them from the analysis.

condo/apartments sales and property transactions that involve non-arm's length transactions[7] or vacant land transactions, and duplicate/incomplete records[8]. I classify the repeat sales into properties that have DAs (treatment sample) and those that do not (control sample).

My treatment sample includes all repeat sale properties with DAs. Homeowners can choose to carry out multiple DAs during their residency (e.g., add a bedroom as well as construct a swimming pool). In such cases, they can submit their plans for multiple improvements in one or multiple development application(s). The DA data identifies each type of building work and records the respective approval date. Therefore, I have distinct records on all improvements carried out by the homeowner whether part of the same or multiple applications.

In the case of the DA for a duplex, homeowners typically buy a house on one lot of land, demolish the dwelling, subdivide the land into two equal lots, and build two often identical duplexes[9] Owners can then decide to reside in one and rent or let the other, or ultimately sell one or both dwellings. The generation of two dwellings from a single property parcel purchase requires adjustment to both the purchase price and the cost of the DA. The Cordell-sourced DA records include the total construction costs of the duplex. Therefore, to account for this double equity generated from the two duplexes, I double the resale price in my analysis based on the assumption that the other duplex also sells at the same price at that time.

---

[7]Sales where transfers are of the following nine types: gift, court order, family sale, extraordinary circumstances, mortgage in possession, part-sale/consideration represents partial interest in the property, rebated sale/negotiated sale, residential redevelopment, and transfer by death or transfer by bankruptcy). These types of sales represent 3.5% of the population dataset.

[8]I exclude outliers at the 1^{st} and 99^{th} percentiles.

[9]For example, if the original property is on 13 Rainbow Street, then after the split the two duplexes will be addressed 13A and 13B Rainbow Street.

A DA is a real option provided to households that typically expires in one, two, four, or five years depending on the state, and therefore it is essential to distinguish between homes that have exercised their DA option and those that have not. Comparing the attributes of the properties and identifying any changes are contingent on the level of works. For example, if a DA is for a car parking space, I look if there is an increase in the number of car parking spaces between pre- and post-DA, while for a duplex, new house/single dwelling, or extension/alteration, I check if the number of bedrooms or bathrooms has increased. In the case of swimming pools, I confirm if the swimming pool flag is "true" post-DA. In this way, I can identify a robust sample of improved homes[10,11,12,13].

The control sample includes every repeat sale property not approved for remodeling and purchased post-2004, (i.e. non-DA homes). Despite sales data being available from 1990, DA data are only available from 2004 and the inclusion of pre-2004 purchased homes would bias the results by overstating the returns, as the cost of remodeling would not be accounted. Therefore, I exclude all observations with purchases before 2004 to ensure they are not associated with an unreported DA. As such, I include 1,063,686 homes in my control sample.

For the treatment sample, with homes purchased pre-2004, I cannot tell if properties carried out improvements before 2004. If anything, this would bias the results in favor of home improvements providing better returns, as it would not account for the unrecorded

[10] Attribute changes for verandas and pergolas are not available consequently. I assume that considering their relatively small outlay, households would have proceeded these constructions.

[11] For properties in which attributes are missing or remain unchanged between the time of purchase and resale, I cannot ascertain if the DA option is exercised and therefore exclude them from the analysis.

[12] For demonstration purposes, if I assume all properties that applied for DA completed works, my treatment sample increases to 200,207. I find similar results to those reported herein; see Table E in the appendix A.

[13] In our home improvement sample, we cannot distinguish between homeowners who use self-labor or hired help. While owner-builders exist as a group their costs are to be submitted in a DA process, while we cannot ensure these are accurate, if anything it would understate our results.

Table 3.1: Distribution by DA Works and State

	State						
	NSW	QLD	SA	TAS	VIC	WA	Total
Non-DA	245,948	319,273	77,504	35,803	255,412	129,746	1,063,686
Carports/Garages/Sheds	301	307	98	23	194	149	1,072
Duplex	612		1		122		735
Extension/Alteration	4,616	681	726	74	3,412	1,208	10,717
House/Single Dwelling	1,450	584	514	15	2,676	783	6,022
Multiple DA	1,239	1,194	763	10	1,528	4,324	9,058
Swimming Pool	3,891	3,626	1,200	8	2,640	4,966	16,331
Verandahs & Pergolas	1,072	1,976	1,702	103	2,746	4,199	11,798
Total	259,129	327,641	82,508	36,036	268,730	145,375	1,119,419

This table reports the number of observations in the control sample (i.e., properties not associated with DA) and treatment sample, categorized by DA works across six states in Australia. The data includes repeat-sale properties from 1990-2016 for those associated with DA, and 2004-2016 for those without a DA. DAs start from 2004 onward. Duplex refers to a dwelling with occupancy for two separate households, typically identical in dimension and design.

Table 3.2: Summary Statistics – DA Cost (Constant Dollar 2016-Q3)

	Mean (Std. deviation)						
DA Type	NSW	QLD	SA	TAS	VIC	WA	All States
Carports/Garages/Sheds	17,136	14,935	11,061	15,296	14,279	14,586	15,039
	(12,799)	(10,527)	(6,329)	(8,745)	(12,468)	(8,717)	(11,139)
Duplex	491,765		172,374		760,411		535,922
	(233,881)		NA		(278,275)		(261,690)
Extension/Alteration	107,353	65,979	85,077	82,035	138,539	129,736	115,492
	(106,108)	(74,837)	(69,411)	(84,990)	(143,566)	(140,012)	(121,634)
House/Single Dwelling	295,850	288,558	240,484	239,705	377,409	389,903	338,749
	(188,719)	(115,932)	(128,832)	(128,905)	(282,821)	(285,465)	(244,922)
Multiple DA	282,546	251,220	208,279	153,836	375,217	274,928	284,015
	(272,418)	(217,374)	(146,280)	(104,467)	(297,933)	(229,289)	(245,612)
Swimming Pool	27,846	29,349	27,320	38,776	40,657	24,360	29,157
	(16,029)	(13,238)	(18,725)	(36,661)	(32,755)	(100,236)	(58,170)
Verandas/Pergolas	20,188	15,309	12,810	18,859	16,507	10,907	14,135
	(15,041)	(12,909)	(8,954)	(22,191)	(14,186)	(8,018)	(11,958)
All DA Types	129,786	78,234	79,963	59,266	173,012	116,434	123,863
	(182,441)	(133,177)	(115,008)	(86,891)	(240,681)	(199,600)	(194,603)

This table reports the DA costs for the treatment sample by DA works across six states in Australia in constant dollars 2016-Q3. The data include observations from 2004–2016.

development cost[14]. Further, this also helps ensure sufficient degrees of freedom for the treatment sample as it increases the sample from 36,894 (using only post-2004 repeat sales) to 55,733 repeat sales.

[14]To ensure the estimates are stable, I also present the results with post-2004 purchases for the treatment group in the Robustness section.

Table 3.1 and 3.2 report the distribution of DAs and summary statistics of the DA costs, respectively, by DA works and state. Table 3.1 reports the number of repeat sale observations, which are higher in larger states as expected, with significant variation in the types of works approved by councils across states. For example, New South Wales and Victoria have the highest propensity to undertake extensions or alterations, possibly reflecting the limited release of land supply and desire for increased housing, while Western Australia, New South Wales, and Queensland have the greatest penchant for swimming pools, possibly reflecting the higher average temperatures. In the case of homes undertaking more than one development, either at the same time or at different times between a repeat sale, the value produced by each improvement work is inseparable and implicit in the resale price. As such, the return calculated for these homes includes the collective value of all improvement works carried out between a repeat sale, and therefore I must also account for the total cost of improvement works between the repeat sale. Hence, I create an additional category of works called "Multiple DAs." The individual work categories reported in Table 3.1 are unique, namely they are not part of "Multiple DAs" or vice versa.

Table 3.2 shows improvement spending by works and state reported in constant dollars of 2016-Q3. Duplexes have the highest average cost of development, as these are essentially a construction of two dwellings, followed by houses/single dwellings, which require the development of a home from ground level. Across states, the highest spending in constructing a new house/single dwelling is in Western Australia, mainly because the houses in this state are, on average, larger and remote, which adds to the transportation costs. Verandas/pergolas, on the contrary, are the cheapest improvement works, followed by carports/garages/sheds and swimming pools. Swimming pools are the most expensive to build in Victoria with an average cost of $40,657. This may be attributed to the added heating costs due to the colder temperature in the south of Australia. The highest improvement spending is carried out in Victoria, which has an average spend of $173,012, followed by New South Wales and Western Australia with average expenditure of $129,786 and $116,434, respectively, consistent with the location of the major capital cities of Sydney, Melbourne, and Perth.

Figure 3.1 shows the distribution of time between sales (holding term) and the time of sales relative to the DA. The homes in the control sample typically sell within 2–4 years, while treatment homes undertaking DAs are sold after 3–7 years. This is somewhat expected given that the control group only includes data post-2004, while the treatment sample includes post-1990 data. Figure 1a also highlights that approximately 7.5% of homeowners improve their homes and sell them within two years of purchase. Such households could be considered to be speculators/flippers who have undertaken home improvements for speculative purposes solely (Bayer et al., 2011).

I also observe in Figure 3.1c that homeowners tend to carry out improvements as soon as they purchase their homes and therefore have more extended time on average to consume the improvement. This is also evident in Figure 3.1d, which shows a longer time to resale post-improvement. Households who *buy-and-sell* within two years tend to have a speculative motive *a priori* and therefore can be considered to be speculators. On the contrary, households who stay in their homes for longer but sell within two years of undertaking improvements could also be speculating on home improvements. Therefore, they cannot be assumed to have a speculative motive *a priori* but rather a consumption motive on property purchases and possibly a speculative motive on home improvements. Such households can be considered to be consumers for a home purchase but potential speculators on home improvements.

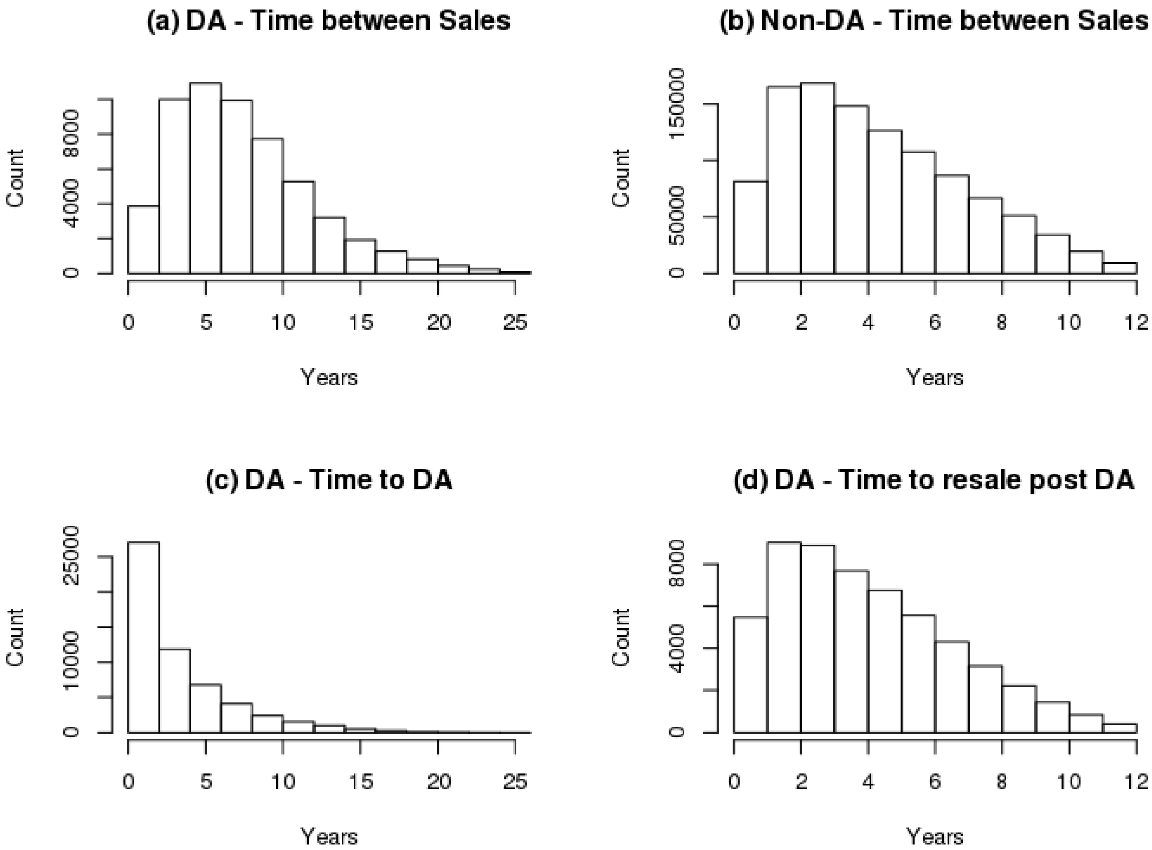


Figure 3.1: Distribution of holding term for improved and unimproved homes and time of sale relative to DA for Improved Homes

Figures (a) and (b) show the distribution of the holding term for DA and non-DA homes, respectively. Figure (c) shows the distribution of time to DA (i.e., after purchasing the home, how long does one wait to carry out home improvements). Figure (d) illustrates the distribution of time to resale post-home improvement (i.e., how long does one stay in their home after improvement).

3.5 Model Estimation and Variable Statistics

To test the returns realized by homeowners who complete home improvements compared with those that undertake no planning and building works after buying a house, I estimate the model in Equation 3.7 using the following general form,

$$Y_i = a_0 + DA_i + \beta MktReturn_{ssd} + \gamma_1 Age_i + \gamma_2 Age_i^2 + Year_i + Location_i + \mu K_i + \epsilon_i \quad (3.8)$$

where Y_i is the log return of the resale price divided by the notional purchase price of property i. Two sets of notional prices are used depending on whether the home is affected by a DA. The notional purchase price for unimproved homes, or non-DA homes, is the purchase price on the purchase date, whereas the notional purchase price for improved homes, or DA homes, is the market-adjusted indexed price at the time of the DA plus the total spending on DA works. This reflects the equivalent cost that a homeowner would have had to pay if he or she were to buy the house at the time of DA and then spend on improvement works.

The expected price at the time of the DA is calculated as the purchase price of property i indexed to the point of DA[15] using the Statistical Subdivision (SSD)[16,17] region-specific hedonic house price indices (HPI) provided by CoreLogic. Specifically, the log returns on unimproved and improved homes are calculated as,

$$Y_i = \begin{cases} ln[P_{i,+1}/(E(P_{i,0}) + DACost_{i,0})] & \text{Improved Homes} \\ ln[P_{i,+1}/P_{i,-1}] & \text{Unimproved Homes} \end{cases} \tag{3.9}$$

[15]Since the DA costs are reported as of the DA date and not as of the time of completion, I calculate the expected (market-adjusted indexed) house price at the point of DA, as this allows the expected value of a home to be expressed in the same dollar terms as the DA cost and therefore directly addable to arrive at the notional purchase price.

[16]The SSD is an Australian Standard Geographical Classification (ASGC) (2011 Census) defined area that represents an intermediate level, general purpose, regional-type geographic unit. SSDs are socially and economically homogeneous regions characterized by identifiable links between the inhabitants. They consist of one or more Statistical Local Areas and cover, in aggregate, the whole of Australia without gaps or overlaps (Australian Bureau of Statistics, 2001). The structure of ASGC (2011) is provided in Appendix A and the maps of Statistical Division and Subdivisions for Sydney, as an example, are provided in Appendix B

[17]To validate if the SSD House Price Index is an appropriate predictor of expected house prices, I leverage the repeat sales information on non-DA homes. I find the expected house price at the time of resale and then compare it with the actual resale price. Explicitly, I calculate the percentage prediction errors as $(E(P_{+1})/P_{+1} - 1) * 100$ and plot the distribution in Figure G in the appendix B. I find that the error distribution is normally distributed and centered on the zero mean. The empirical densities are similar to the theoretical densities.

where $E(\cdot)$ is the expectation and the expected house price at time $T = 0$ is given by,

$$E(P_{i,0}) = P_{i,-1} * (HPI_{ssd,0}/HPI_{ssd,-1}) \tag{3.10}$$

Once the development is completed, an additional value is generated from the improvement works, which is unobserved at that time but implicitly observed in the resale price. Unimproved homes do not have this added value and therefore comparing the return on improved homes with that on unimproved homes, after controlling for variation due to the other factors, provides an identification strategy for estimating the returns attributable to home improvements.

Further, since the additional housing value is generated at the time of the DA and identified only at resale, the return from the time of purchase to the point of the DA must be attributed to market appreciation alone. Therefore, any variations in returns between those times are regardless captured in the indexed purchase price at the point of the DA and consequently in the notional purchase price. Hence, indexing the purchase price should not affect the identification of home improvement value[18]. On the contrary, this prevents me from having to index the DA costs over time, which benefits the model to be free of any assumption of using an appropriate cost-of-funds rate.

Depending on the model specification, DA is a binary dummy variable coded 1 for improved homes and 0 for unimproved homes or a categorical variable representing the different home improvement types. $MktReturn_{ssd}$ is the log return on the market index and this captures the return attributed to market appreciation between the notional

[18]Given that most households improve immediately after purchasing the home (see Figure 1c), indexing the purchase price up to the point of the DA allows me to have minimal prediction bias on average.

purchase date and resale date. $MktReturn$ is calculated using the SSD-specific hedonic House Price Index (HPI) as

$$Mkt_i = \begin{cases} ln[HPI_{ssd,+1}/HPI_{ssd,0}] & \text{Improved Homes} \\ ln[HPI_{ssd,+1}/HPI_{ssd,-1}] & \text{Unimproved Homes} \end{cases} \tag{3.11}$$

For improved homes, Age refers to the age of home improvement component. It is measured by the number of months between development completion and resale date, while for unimproved homes, it is the number of months between purchase and resale[19]. Age captures the monthly depreciation effect of non-durable consumption (i.e., the building value) (Kiel and McClain, 1995). For improved homes, the time of development completion is calculated as the time when building approval is received plus the average commencement time plus the average construction time by the different improvement types[20]. Figure H in the appendix C shows the average commencement and construction times in days. Hence, Age, calculated in months, is given as

$$Age_i = \begin{cases} T_{i,+1} - (T_{i,0} + C_q + C'_q) & \text{Improved Homes} \\ T_{i,+1} - T_{i,-1} & \text{Unimproved Homes} \end{cases} \tag{3.12}$$

where $T_{i,+1}$ is the time of resale for property i, $T_{i,-1}$ is the time of purchase for property i, and $T_{i,0}$ is the time of DA for improved property i. C_q and C'_q represent the average commencement and construction times for the different improvement types, respectively.

[19]Since every observation is a repeat sale, the age of the house at the point of notional purchase cancels out. Further, I also include the year fixed effects. Therefore, the only variation that remains to be accounted for is the time between notional purchase and resale, and not the absolute age of the property.

[20]Australian Bureau of Statistics (2017b) and Australian Bureau of Statistics (2008) provide the average commencement and construction times for new houses. The average construction time for swimming pools is available from (Home Improvement Pages, Australia, 2014). The average commencement and construction times for other improvement works are calculated on a pro-rata basis depending on the average cost of the home improvements.

Some of the model specifications also include Age_i^2, which captures quadratic depreciation. Since, in my model design, the age for unimproved homes is the time between purchase (t_{-1}) and resale (t_{+1}), the depreciation effect is controlled only for the existing building value of the house at the time of purchase (B_{-1}). For improved homes, on the contrary, age is taken from the time of notional purchase (t_0). This allows for the depreciation effect to be accounted not only for the existing building value of the house (i.e., the pre-improvement value at t_{0^-}) but also for the building value component added by the improvement works at the time of the DA (t_{0^+}).

$Years$ is the year fixed effects at the notional purchase date[21]. The year fixed effects control for the macroeconomic shocks at the time of notional purchase, such as the changes in the interest rates over time and the volatility attributed to the 2008-09 global financial crisis. *Location* is the location fixed effects at the state level which controls for the interstate variations in returns[22]. K_i is a set of control factors, such as the number of bedrooms, bathrooms, and car parking spaces. a_0 is the constant term and ϵ_t is the error term.

The identification of the home improvement value comes from controlling for the common sources of variation in the improved and unimproved house prices that affect returns. A significant source of variation in house price returns is attributed to market appreciation between the notional purchase date and resale date. Another source of variation is the length of time between notional purchase and resale. For unimproved homes, this variable controls for the depreciation effect due to the aging of the existing building, whereas,

[21] I also test the model with year fixed effects at the time of resale. The results are consistent and can be provided upon request.

[22] As within-state variation in house prices may affect returns, I also test the results by controlling for location fixed effects at the SSD level. Similar results are found. See Table A2 in the appendix A.

for improved homes, it captures the depreciation effect of both the existing and the additional building value created from the home improvements. After controlling for these common sources of variations, the difference in returns between improved and unimproved homes, as captured by the dummy variable DA_i, would then be attributable to the home improvements.

According to Rosenthal (1999), the implicit market for residential buildings is efficient and inefficiencies in the housing market must thus lie in the market for the land itself. Therefore, the prices of houses (including the building component in the house price index) should adjust themselves sufficiently fast to eliminate any excess profit opportunities for builders. Hence, since the building component in the house price index is efficient and the land, in the repeat sales model, between the time of purchase and resale does not change with home improvements, my model should be free from any market inefficiency bias.

Table 3.3 shows the summary statistics for the main variables used in the model. Of the 1.1 million records used in my model, 55,733 improved homes serve as my treatment sample and 1.06 million unimproved homes are the control sample. The average purchase prices for improved and unimproved homes are \$436,829 with a standard deviation of \$410,073 and \$377,666 with a standard deviation of \$315,797, respectively. The expected purchase price at the time of the DA, for improved homes, is \$554,532 with an average improvement cost of \$104,345; the average notional purchase price is \$658,879 with a standard deviation of \$536,042. The notional purchase price for unimproved homes is the same as the purchase price. The average resale prices for improved and unimproved homes are \$887,089 with a standard deviation of \$723,141 and \$485,573 with a standard

Table 3.3: Variable Descriptions and Sample Statistics (2004-2016)

Name	Description	Overall	Improved	Unimproved
		Mean (Std. Deviation)	Mean (Std. Deviation)	Mean (Std. Deviation)
Purchase Price	House price at first sale	380,612 (321,403)	436,829 (410,073)	377,666 (315,797)
Purchase Price indexed to DA			554,532 (478,355)	
DA cost	Cost of developments as reported in development applications		104,345 (165,288)	
Purchase price (notional)	Purchase price for Non-DA homes; Indexed purchase price plus cost of development for DA homes	391,667 (335,871)	658,879 (536,042)	377,666 (315,797)
Resale Price	House price at second sale	505,564 (414,304)	887,089 (723,141)	485,573 (381,072)
HPI growth rate	Annual average growth rate of SSD specific hedonic HPI for period 1990 - 2016	0.073 (0.048)		
Log Returns	Ln(Resale price/Purchase price (notional))	0.278 (0.407)	0.304 (0.422)	0.276 (0.406)
Age	No. of months between sales for Non-DA homes; No. of months between notional purchase and resale for DA homes	50.3 (31.5)	47.7 (30.9)	50.4 (31.5)
Observations		1,119,419	55,733	1,063,686
Attributes at Purchase	No. of Bedrooms	3.3 (0.8)	3.2 (0.8)	3.3 (0.8)
	No. of Bathrooms	1.5 (0.6)	1.5 (0.6)	1.5 (0.6)
	No. of Car Spaces	1.8 (0.9)	1.8 (0.9)	1.8 (0.9)
Attributes at Resale	No. of Bedrooms	3.4 (0.8)	3.8 (0.8)	3.3 (0.8)
	No. of Bathrooms	1.6 (0.7)	2.1 (0.8)	1.5 (0.6)
	No. of Car Spaces	1.9 (1.1)	2.2 (1.1)	1.9 (0.9)

deviation of \$381,072, respectively. The large standard deviation for improved homes is mainly due to the different types of improvement works, as some improvements (e.g., verandas/pergolas) add little value to homes, while others (e.g., duplexes) add more value.

The average annual growth rate of the Hedonic House Price Indices (HPI) at SSD level is 7.3%. The average log return of the resale price to the notional purchase price (i.e., after accounting for the cost of improvements) for improved homes is 30.4% with a standard deviation of 42.2%. While for unimproved homes, the average log return is 27.6% with a standard deviation of 40.6%. In terms of the univariate results, this suggests that the return on improved homes is, on average, 2.8% higher than that on unimproved homes. However, the univariate results do not control for the time of purchase and resale, depreciation, and property attributes, which is possible in a regression model. The average time between sales for improved homes is 47.7 months, while for unimproved homes, the average time between notional purchase and resale (i.e., the time between the point of the DA and resale) is 50.4 months. These times represent those during which households have consumed the housing service and allow me to capture the depreciation effect of the property.

3.6 Results

Table 3.4 reports the coefficient estimates for the various model specifications of Equation (3.8)[23]. All the models control for the year and location effects[24]. Model 1 is the basic model comparing improved homes with unimproved homes by construction works, after controlling for market trends. Table 3.4 reports mixed results on the effects of the types of DA works on house price returns. For example, Model 1 suggests that homeowners benefit from all works except for additions of carports and new home builds. However,

[23]Since the returns are expressed in log form, the coefficients are interpreted as $(e^{\hat{\beta}} - 1)$ for small values of β.

[24]Table A2 in the appendix A presents the model results with the location fixed effects at the SSD level. They are in line with the main results across all the model specifications.

the specification of Model 1 does not control for property attributes; it assumes that all properties that are bought and sold have the same number of bedrooms, bathrooms, and car parking spaces. Model 2 includes the property attributes at the time of resale, while in Model 3, I control for the property attributes at the time of both resale and purchase. Based on this specification, the sign of many of the DA works is negative. The coefficients of both resale and purchase attributes are significant, with values for the number of bedrooms, bathrooms, and car parking spaces as 2.6%, 5.8%, and 0.4% and -3.2%, -6.9%, and -1.5%, respectively. This finding suggests that other factors being constant, the average return is higher if one buys a smaller house and sells a bigger one and vice versa.

In Model 4, I include age (in months) as a linear term, while Model 5 allows for quadratic age. The coefficient of *Age* in the linear form indicates that the return on property decreases by 0.1% every month due to depreciation. In the quadratic model, the coefficient of *Age* is -0.2% and the coefficient of *Age_squared* is positive. These estimates are also consistent with (Kiel and McClain, 1995). House values generally decline with age and then increase, reflecting that homes in Australia are typically desirable for their historical characteristics. Since age is measured in months, the coefficient of the quadratic term (the curvature) is small but statistically significant and therefore I include the squared term in all full model specifications (Models 5 to 8) for precision. The coefficients of the attributes in Model 5 at the time of resale and purchase are consistent with those of the previous models. In Model 5, attributes at both time of purchase and resale could be correlated. Therefore, to avoid multicollinearity, I also run an alternative model specification (Model 6) in which I include the change in the corresponding attributes as the independent variable. Models 7 and 8 (alternative model) are full model specifications by improvement works corresponding to Models 5 and 6, respectively.

The results show that the returns on carports are negative and mostly insignificant across all the model specifications. The coefficient of duplexes in Model 5 suggests that the return on a duplex is 9.8% higher than that on unimproved homes. Across all the models, the coefficient of duplexes is consistently positive and significant, ranging from 9.7% to 18%. For extensions/alterations, returns are insignificant across the full models. For houses/single dwellings, returns are consistently negative and strongly significant in all the model specifications. The Model 5 coefficient of houses/single dwellings is -0.10, indicating that returns on this category are around 10% lower than those on unimproved homes.

For multiple DAs, on average, the results are negative and significant across the models. In Model 5, the return on multiple DAs is 1.1% lower than that on unimproved homes. In the case of swimming pools, returns are not significantly different from those on unimproved homes. The insignificant returns can be attributed to the perceived recurring cost in operating swimming pools; therefore, they do not offer a high resale value. For verandas/pergolas, returns are mostly negative and strongly significant. In the full model, the return on verandas/pergolas is 3.8% lower than that on unimproved homes. At the aggregate level, I find that the return on improved homes is 1.9% lower than that on unimproved homes (see Model 7).

The finding in Model 6 (the alternative specification) is also consistent with the results in Model 5. In Model 6, the returns on carports/garages/sheds and verandas/pergolas are 2.5% and 4.2% lower than those on unimproved homes, respectively. For duplexes, the return is 10.1% higher than that on unimproved homes. For extensions/alterations and

Table 3.4: Main Model Results

	Log(Resale Price/Purchase Price (Notional))							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DA							−0.019***	−0.024***
							(0.002)	(0.002)
Carports/Garages/Sheds	−0.090***	−0.090***	−0.022***	−0.021***	−0.021***	−0.025***		
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)		
Duplex	0.181***	0.135***	0.094***	0.097***	0.098***	0.101***		
	(0.012)	(0.012)	(0.013)	(0.013)	(0.013)	(0.013)		
Extension/Alteration	0.028***	−0.014***	0.001	0.001	0.000	−0.001		
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)		
House/Single Dwelling	−0.080***	−0.129***	−0.105***	−0.101***	−0.100***	−0.102***		
	(0.005)	(0.004)	(0.007)	(0.007)	(0.007)	(0.007)		
Multiple DA	0.021***	−0.020***	−0.018***	−0.012*	−0.011*	−0.017***		
	(0.003)	(0.003)	(0.006)	(0.006)	(0.006)	(0.006)		
Swimming Pool	0.179***	0.143***	−0.001	0.004	0.004	−0.005		
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)		
Verandahs/Pergolas	0.009**	−0.001	−0.039***	−0.037***	−0.038***	−0.042***		
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)		
MktReturn	0.750***	0.764***	0.804***	0.923***	0.922***	0.924***	0.923***	0.925***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Months between sales				−0.001***	−0.002***	−0.002***	−0.002***	−0.002***
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Months between sales squared					0.000***	0.000***	0.000***	0.000***
					(0.000)	(0.000)	(0.000)	(0.000)
No. of beds (resale)		0.018***	0.026***	0.027***	0.026***		0.026***	
		(0.001)	(0.001)	(0.001)	(0.001)		(0.001)	
No. of baths (resale)		0.050***	0.058***	0.059***	0.059***		0.059***	
		(0.001)	(0.001)	(0.001)	(0.001)		(0.001)	
No. of cars (resale)		0.001**	0.004***	0.006***	0.006***		0.006***	
		(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	
No. of beds (purchase)			−0.032***	−0.033***	−0.033***		−0.032***	
			(0.001)	(0.001)	(0.001)		(0.001)	
No. of baths (purchase)			−0.069***	−0.069***	−0.069***		−0.068***	
			(0.001)	(0.001)	(0.001)		(0.001)	
No. of cars (purchase)			−0.015***	−0.016***	−0.016***		−0.016***	
			(0.000)	(0.000)	(0.000)		(0.000)	
Change in # of beds						0.029***		0.029***
						(0.001)		(0.001)
Change in # of baths						0.063***		0.062***
						(0.001)		(0.001)
Change in # of cars						0.010***		0.010***
						(0.000)		(0.000)
Constant	0.059***	−0.082***	0.088***	0.114***	0.129***	0.078***	0.129***	0.078***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)
Year Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Location Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	1,119,293	1,012,436	517,011	517,011	517,011	517,011	517,011	517,011
Adjusted R^2	0.125	0.149	0.281	0.289	0.290	0.287	0.289	0.287
F Statistic	6,390.998***	6,325.029***	6,528.365***	6,580.655***	6,398.490***	6,954.690***	7,793.277***	8,663.804***
	(df = 25; 1119267)	(df = 28; 1012407)	(df = 31; 516979)	(df = 32; 516978)	(df = 33; 516977)	(df = 30; 516980)	(df = 27; 516983)	(df = 24; 516986)

Notes: Robust standard errors are reported in parentheses; significance of variables is adjusted accordingly. *** 0.1% significance ** 1% significance * 5% significance. I have 1,119,419 (55,733 in the treatment sample and 1,063,686 in the control sample) possible observations with deviations accounted for by missing data which are excluded from the regression.

swimming pools, returns are not significantly different from those on unimproved homes. For houses/single dwellings, the return is strongly negative by 10.2% compared with that on unimproved homes. Lastly, for multiple DAs, average returns are 1.7% below those on unimproved homes. The coefficient of $MktReturn$ is 92.4%. The coefficient of the change in the number of bedrooms, bathrooms, and car parking spaces are all positive, indicating that the greater the difference between the size of the house pre- and post-improvement, the higher are the returns, as expected. Finally, at the aggregate level, Model 7 and its alternative specification (Model 8) suggest that returns on improved homes are, on average, 1.9% and 2.4% lower than those on unimproved homes, respectively. Therefore, homeowners who do nothing are relatively better off than those who improve their homes.

Overall, once I have controlled for property attributes, these model specifications paint a consistent picture. Returns on carports/garages/sheds, multiple DAs, and verandas/pergolas are negative relative to those on unimproved homes. The return on houses/single dwellings is strongly negative, while the returns on extensions/alterations and swimming pools are found to be insignificantly different from those on unimproved homes. By contrast, the return on duplexes is strongly positive.

One factor that may explain why the return on houses/single dwellings is strongly negative is the stamp duty. Stamp duty rates in Australia are quite high (usually 4-5% of the sale price). Hence, they provide a strong disincentive to move vis-à-vis home improvement. This means that people may be 'forced' to renovate their house rather selling and moving to a more appropriate home. Another factor is the lost value of the remaining non-durable consumption (i.e., the building value). In building a new house, unlike extensions/alterations where the homeowner produces additional housing by developing on top of the existing building, the homeowner demolishes the existing building and therefore, in the process, loses the residual value of the building component at the time of the DA (B_0). The homeowner then builds the house from scratch and has to pay for the whole building value again. Moreover, homeowners also have the opportunity to overcapitalize on the entire new build rather than just a subsection as with an alteration. This is pure indulgence as there are no restraints. Therefore, the returns on a house/single dwelling are found to be strongly negative despite the efficiency gains from the lack of technological constraints. This is consistent with the consumption-based argument that home improvements are overcapitalized.

Like for a new house, duplexes also require demolishing the old property and building from a blank canvas. Therefore, they also lose value in the form of non-durable consumption. However, duplexes maximize the utility of the available land by subdividing it into two lots of equal sizes for two single-family dwellings. As such, the return on duplexes is highly positive, although this is partly offset by the losses due to the lost residual building value.

When homeowners carry out improvements, the necessary cost should be the cost of construction at the time of improvement i.e. price of the building materials plus labor. As such, the expected value of that improvement would be the necessary cost of construction plus the value-added produced from the improvement. However, according to rational expectations theory, developers may be inclined to price some proportion of this expected value-added into the construction cost of home improvement, raising this cost and potentially contributing to the lower return on home improvements.

3.7 Robustness

3.7.1 Correcting Sample Selection Bias

Homes that choose to improve may be different from those that do not. Moreover, confounding factors that predict the exposure under study might also be independently related to the outcome of interest (i.e., the house price return), potentially introducing self-selection bias. Therefore, to correct for any self-selection bias, I apply propensity score (PS) matching as formalized by Rosenbaum and Rubin (1983) to identify a modified treatment and a control sample of DA and non-DA homes. According to Brookhart et al. (2006), all variables related to the outcome regardless of whether they are related to the exposure should be included in the PS model. They find that the inclusion of these variables increases the precision of the estimated exposure effect without increasing bias. By contrast, including variables related to the exposure but not the outcome decreases the precision of the estimated exposure effect without decreasing bias. Therefore, in the PS model, I use all available variables thought to be risk factors in explaining house price returns (i.e., the outcome) regardless of whether they affect the likelihood of being treated or improved (i.e., the exposure).

The logistic regression model used to calculate the PS is given below:

$$\begin{aligned} DA_i = \alpha + \beta P_{i,-1} + \phi_1 Mkt\_Index_{i,-1} + \phi_2 Mkt\_Index_{i,+1} + \gamma_1 Age_i \\ + \gamma_2 Age_i^2 + \mu K_{i,j} + State + \epsilon_i \end{aligned} \tag{3.13}$$

where DA_i is the dummy variable is coded 1 for improved homes (treatment group) and 0 for unimproved homes (control group), P_{-1} is the purchase price of the house, $Mkt\_Index_{i,-1}$ and $Mkt\_Index_{i,+1}$ are SSD-specific house price index values at the time of notional purchase and resale, respectively. Age_i is the time between the actual purchase and resale in months. $K_{i,j}$ is the set of property attributes such as the number of bedrooms, bathrooms, and car parking spaces, j indexes the different attributes and i indexes individual property, $State$ is the state fixed effects, and ϵ_i is the random error term.

Using the estimates from the model in Equation 3.13, I predict the PSs for all observations in both treatment and control groups. Based on the calculated PSs, I match each observation in the treatment group of improved homes with the control group of unimproved homes using the nearest-neighbor method. I identify a sample of 20,366 matched pairs of treatment and control group observations. The standardized mean difference in the PSs is 0.07, which is well below the standardized mean difference of 0.2, as recommended by Austin (2011) and Wang et al. (2013).

Table 3.5 presents the results after correcting for any self-selection bias in the sample. The results are consistent at the aggregate level with the primary model results in Table 3.4. The results for the full model specifications (Models 7 and 8) at the aggregate level show that returns are 2.4% and 2.3% (respectively) lower than those on unimproved homes, after correcting for any potential self-selection bias. Across home improvement types in Models 5 and 6, houses/single dwellings have the lowest return of around -14% and -13%, respectively followed by extensions/alterations (-2.7% and -1.9%, respectively) and verandas/pergolas (-0.9% and -1%, respectively). Swimming pools have returns of 2.1% and 1.2%, while carports/garages/sheds show insignificant returns of -1.1% and -1%,

Table 3.5: Self Selection Bias Correction

	Log(Resale Price/Purchase Price (Notional))							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DA							−0.024***	−0.023***
							(0.003)	(0.003)
Carports/Garages/Sheds	−0.065***	−0.030***	−0.007	−0.011	−0.011	−0.010		
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)		
Duplex	0.129***	0.126***	0.058***	0.060***	0.060***	0.075***		
	(0.014)	(0.013)	(0.014)	(0.014)	(0.014)	(0.014)		
Extension/Alteration	0.017***	0.016***	−0.023***	−0.027***	−0.027***	−0.019***		
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)		
House/Single Dwelling	−0.056***	−0.073***	−0.144***	−0.142***	−0.142***	−0.133***		
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)		
Multiple DA	0.016**	−0.001	−0.032***	−0.030***	−0.029***	−0.030***		
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)		
Swimming Pool	−0.042***	−0.035***	0.024***	0.021***	0.021***	0.012***		
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)		
Verandahs/Pergolas	−0.065***	−0.047***	−0.004	−0.009**	−0.009**	−0.010**		
	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)		
MktReturn	0.761***	0.761***	0.758***	0.866***	0.866***	0.869***	0.870***	0.873***
	(0.010)	(0.010)	(0.010)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Months between sales				−0.001***	−0.001***	−0.001***	−0.001***	−0.002***
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Months between sales squared					0.000	0.000	0.000	0.000*
					(0.000)	(0.000)	(0.000)	(0.000)
No. of beds (resale)		0.004**	0.034***	0.033***	0.033***		0.030***	
		(0.002)	(0.002)	(0.002)	(0.002)		(0.002)	
No. of baths (resale)		0.051***	0.090***	0.090***	0.090***		0.082***	
		(0.002)	(0.002)	(0.002)	(0.002)		(0.002)	
No. of cars (resale)		−0.005***	0.009***	0.011***	0.011***		0.011***	
		(0.001)	(0.001)	(0.001)	(0.001)		(0.001)	
No. of beds (purchase)			−0.049***	−0.049***	−0.049***		−0.042***	
			(0.003)	(0.003)	(0.003)		(0.002)	
No. of baths (purchase)			−0.102***	−0.101***	−0.101***		−0.093***	
			(0.003)	(0.003)	(0.003)		(0.003)	
No. of cars (purchase)			−0.030***	−0.030***	−0.030***		−0.028***	
			(0.002)	(0.002)	(0.002)		(0.002)	
Change in # of beds						0.039***		0.035***
						(0.002)		(0.002)
Change in # of baths						0.092***		0.085***
						(0.002)		(0.002)
Change in # of cars						0.016***		0.016***
						(0.001)		(0.001)
Constant	0.137***	0.009	0.160***	0.197***	0.200***	0.093***	0.196***	0.104***
	(0.008)	(0.010)	(0.010)	(0.010)	(0.011)	(0.008)	(0.011)	(0.008)
Year Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Location Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	40,732	40,732	40,732	40,732	40,732	40,732	40,732	40,732
Adjusted R^2	0.294	0.311	0.377	0.382	0.382	0.376	0.373	0.368
F Statistic	680.395***	657.758***	796.219***	787.249***	763.472***	819.946***	896.923***	989.584***
	(df = 25; 40706)	(df = 28; 40703)	(df = 31; 40700)	(df = 32; 40699)	(df = 33; 40698)	(df = 30; 40701)	(df = 27; 40704)	(df = 24; 40707)

Notes: Robust standard errors are reported in parentheses; significance of variables is adjusted accordingly. *** 0.1% significance ** 1% significance * 5% significance. I have 40,732 (20,366 in the treatment sample and 20,366 in the control sample) possible observations with deviations accounted for by missing data which are excluded from the regression.

respectively. Duplexes have the highest return of 6% and 7.5%, respectively compared with unimproved homes.

3.7.2 Including Improved Homes Purchased Post-2004

As aforementioned, Cordell only has data on DAs from 2004, I cannot identify whether the properties were improved before 2004. Therefore, for the control group of unimproved homes, I take homes purchased after 2004 only. For the treatment group, however, I take properties purchased after 1990. In addition, since these are classified as improved homes, a relatively small proportion of properties may have carried out additional improvements before 2004. Any value attributed to improvements before 2004 will be implicit in the resale price. However, the improvement cost before 2004 would not have been accounted for and therefore the total cost of development for improved homes would be underestimated for such properties, making the coefficients even more negative. Hence, this does not affect the main analysis adversely.

Nonetheless, as a robustness check, I re-estimate all the models after excluding all improved and unimproved homes purchased before 2004. Table 3.6 presents the results, showing that they are all consistent with the main results.

In Models 7 and 8, the returns on improved homes are 1.7% and 2.1% lower than those on unimproved homes, respectively. By the different improvement types, according to Models 1 to 6, returns are generally consistent with the results in Table 3.4. In Models 5 and 6, the coefficients of carports/garages/sheds are -1.9% and -2.3%, respectively. Returns on duplexes are around 9% higher than those on unimproved homes. For extensions/alterations, returns are weakly significant or insignificant. For houses/single dwellings, returns are around 10% lower than those on unimproved homes. For multiple DAs and swimming pools, they are not significantly different from those on unimproved homes (Model 5) and weakly significant at -1.3% and -0.7% (Model 6), respectively. For verandas/pergolas, returns are around 3% lower than those on unimproved homes.

3.7.3 Construction of Repeat Sales Index

To evaluate the performance of control and treatment homes over time, I take advantage of the repeat sales index method, which models returns to estimate an index at the monthly level for both improved and unimproved properties. Specifically, I apply the Bailey et al. (1963) methodology and extend the sample period to 2004–2016. In their repeat sales index model, the specification takes the following general form:

$$R_{itt'} = \sum_{j=1}^{T} b_j x_j + \epsilon_{itt'} \tag{3.14}$$

or in matrix notation:

$$r = xb + \epsilon$$

where, R is the log returns of resale price over notional purchase price. x_j is the monthly dummy coded is '-1' only if the property was purchased in period $j = t$ (year, month), +1, only if the property was sold in the period $j = t'$ (year, month) and zero otherwise. j is from 2004-03 to 2016-07.

The coefficients b_j of each of the dummies correspond to the log value of the index. Therefore, I take the anti-log of the regression estimates to obtain the raw index values and re-base the index for the starting point in March 2004. ϵ is the random error term in log

Table 3.6: Including Improved Homes Purchased Post 2004

	Log(Resale Price/Purchase Price (Notional))							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DA							−0.017***	−0.021***
							(0.002)	(0.002)
Carports/Garages/Sheds	−0.088***	−0.088***	−0.020***	−0.019***	−0.019***	−0.023***		
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)		
Duplex	0.165***	0.119***	0.091***	0.092***	0.094***	0.096***		
	(0.013)	(0.013)	(0.014)	(0.014)	(0.014)	(0.014)		
Extension/Alteration	0.039***	−0.002	0.009**	0.006*	0.006*	0.005		
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)		
House/Single Dwelling	−0.085***	−0.131***	−0.105***	−0.101***	−0.100***	−0.102***		
	(0.005)	(0.005)	(0.007)	(0.007)	(0.007)	(0.007)		
Multiple DA	0.010***	−0.031***	−0.013*	−0.008	−0.007	−0.013*		
	(0.003)	(0.003)	(0.007)	(0.007)	(0.007)	(0.007)		
Swimming Pool	0.089***	0.054***	−0.003	0.002	0.002	−0.007**		
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)		
Verandahs/Pergolas	−0.028***	−0.037***	−0.032***	−0.030***	−0.031***	−0.036***		
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)		
MktReturn	0.747***	0.762***	0.805***	0.924***	0.923***	0.925***	0.924***	0.926***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Months between sales				−0.001***	−0.002***	−0.002***	−0.002***	−0.002***
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Months between sales squared					0.000***	0.000***	0.000***	0.000***
					(0.000)	(0.000)	(0.000)	(0.000)
No. of beds (resale)		0.017***	0.026***	0.026***	0.026***		0.026***	
		(0.001)	(0.001)	(0.001)	(0.001)		(0.001)	
No. of baths (resale)		0.050***	0.058***	0.059***	0.059***		0.059***	
		(0.001)	(0.001)	(0.001)	(0.001)		(0.001)	
No. of cars (resale)		0.001	0.004***	0.006***	0.006***		0.006***	
		(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	
No. of beds (purchase)			−0.032***	−0.033***	−0.032***		−0.032***	
			(0.001)	(0.001)	(0.001)		(0.001)	
No. of baths (purchase)			−0.068***	−0.068***	−0.068***		−0.068***	
			(0.001)	(0.001)	(0.001)		(0.001)	
No. of cars (purchase)			−0.015***	−0.016***	−0.016***		−0.016***	
			(0.000)	(0.000)	(0.000)		(0.000)	
Change in # of beds						0.029***		0.028***
						(0.001)		(0.001)
Change in # of baths						0.063***		0.062***
						(0.001)		(0.001)
Change in # of cars						0.010***		0.010***
						(0.000)		(0.000)
Constant	0.057***	−0.081***	0.087***	0.113***	0.127***	0.077***	0.128***	0.077***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)
Year Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Location Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	1,100,455	994,874	514,079	514,079	514,079	514,079	514,079	514,079
Adjusted R^2	0.121	0.145	0.280	0.288	0.289	0.286	0.288	0.286
F Statistic	6,053.299***	6,006.500***	6,448.556***	6,502.870***	6,323.274***	6,872.608***	7,704.113***	8,563.969***
	(df = 25; 1100429)	(df = 28; 994845)	(df = 31; 514047)	(df = 32; 514046)	(df = 33; 514045)	(df = 30; 514048)	(df = 27; 514051)	(df = 24; 514054)

Notes: Robust standard errors are reported in parentheses, significance of variables is adjusted accordingly. *** 0.1% significance ** 1% significance * 5% significance. I have 1,100,580 (36,894 in the treatment sample and 1,063,686 in the control sample) possible observation with deviations accounted for by missing data which are excluded from the regression.

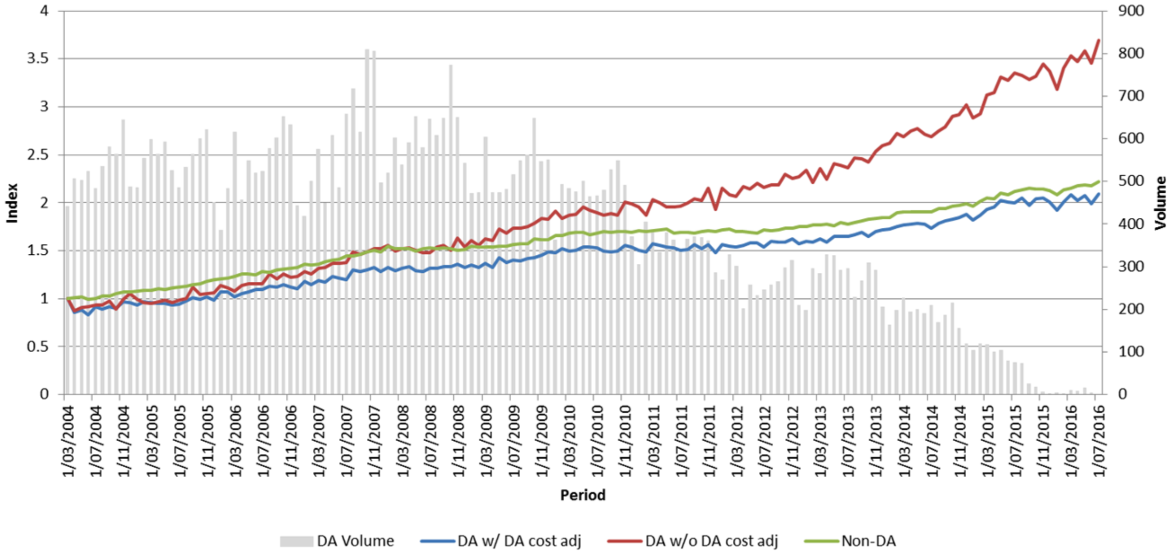


Figure 3.2: Repeat Sales Index (2004–2016): DA vs Non-DA

form with zero mean and constant variance. The notional purchase price for unimproved homes is the actual purchase price, while that for modified homes is the expected price at the time of the DA plus the development cost.

Figure 3.2 shows three repeat sales indices: (1) for unimproved properties, (2) for improved properties before cost adjustments, and (3) for improved properties after cost adjustments to the notional purchase price. The results show that house prices for improved properties, without controlling for costs, have appreciated over time much more than for unimproved properties. This is expected since part of the value in the resale price is attributed to the home improvements. However, when I account for the improvement costs, house price appreciation is lower than that for unimproved homes. For instance, if an improved and an unimproved property were bought in 2004 and sold any time before 2016, the cost-adjusted house price return on improved homes would remain below that on unimproved homes. Therefore, over time, returns on improved homes are on average lower than those on unimproved homes. This is consistent with my main findings.

3.8 Further Analyses: Investor Segmentation

Helms (2003) suggest that households invariably take account of the asset value of their property when they make renovation decisions, indicating a speculative motive. I therefore conduct further analyses to examine how returns for homeowners with a speculative motive perform for improved homes compared with unimproved homes. The home and home improvements are distinct asset classes. Homeowners can choose to have either a speculative or a consumption motive toward one or both of them.

For unimproved homes, people who *"buy-and-sell"* a property in the short term are likely to have a speculative motive on the home at the time of purchase and are referred to as speculators (a.k.a. flippers Bayer et al. (2011)). Meanwhile, those who *"buy-live-sell"* the property in the longer term can be thought of as consumers[25,26]. In the case of improved homes, homeowners who *"buy-improve-sell"* in the short term are likely to be speculators on home improvements[27,28] (a.k.a. flippers). Meanwhile, homeowners who *"buy-live-improve-sell"* with a longer holding term but a shorter home improvement term are those who most probably had a consumption motive on the home at the time of purchase, but were likely optimistic about the future value of home improvements at the time of improvement, and therefore decided to improve shortly before selling (*"consumers-cum-speculators"*). Finally, those who *"buy-improve-live-sell"* in the long term are consumers

[25] I take two years as the amount of time between sales required to identify homebuyers with the intent to buy a property with a speculative motive Bayer et al. (2011).

[26] The time of two years is calculated from the date of the DA and not the completion of the home improvement, as this time closely represents the time of homeowners' decision to improve and most probably their intent to sell post-improvement.

[27] These homeowners could also be speculating on the home value at the same time.

[28] Homeowners who buy with an investment motive of renting the property and selling in more than two years from buying are treated as consumers because this can be thought of as equivalent to someone else consuming the property on the owner's behalf.

of both the home and the home improvement and are a major part of the population data, and hence the focus of my main results. In this section, I examine the returns on home improvements for speculators and consumers-cum-speculators compared with speculators who do not undertake any major improvements.

3.8.1 Speculators (Buy - Improve - Sell Homes)

To examine the aggregate-level return for speculators on improved homes compared with unimproved homes, I run the following model specification with an interaction between DA and $Speculators$.

$$\begin{aligned} Y_i = a_0 + DA_i + Speculator_i + DA_i * Speculator_i + \beta MktReturn_{ssd} \\ + \gamma_1 Age_i + \gamma_2 Age_i^2 + Year_i + Location_i + \mu K_i + \epsilon_i \end{aligned} \tag{3.15}$$

where DA_i is the dummy variable equal to 1 for improved homes and 0 for unimproved homes. $Speculator_i$ is also a dummy variable indicating a speculator; this equals 1 if the time between the actual purchase and resale is less than two years and 0 otherwise. $DA_i * Speculator_i$ is the interaction term. Table 3.7 shows the interaction results for speculators (Buy-Improve-Sell Homes). Models 1 and 2 are the full model specifications at the aggregate level with interaction terms. The coefficients of the other model variables are all consistent with the main model results.

In Models 1 and 2, for homeowners who are consumers, the results confirm my main findings. Returns on improved homes are 2.1% and 2.5% lower than those on unimproved homes, respectively. However, for speculators, returns on improved homes, on aggregate, are significant and higher than those on unimproved homes by 0.4% (-0.021 + 0.025) and 0.1% (-0.025 + 0.026), respectively.

For unimproved homes, if I compare the speculator and non-speculator groups, the return for the speculator group is 0.7% higher than that for the non-speculator group in Models 1 and 2. For improved homes, returns for speculators are 3.2% (0.007 + 0.025) and 3.3% (0.007 + 0.026) higher than those for non-speculators, respectively.

Homeowners who do not improve their homes and buy and sell within two years have higher returns than those who buy and sell in more than two years. Therefore, the gap between the returns of speculators and non-speculators is much higher for improved homes than for unimproved homes. This finding suggests that in contrast to the results in Table 3.4, speculators who improve their homes are better off than speculators who do not.

Table 3.8 presents the results based on Equation (3.8). I examine the results by improvement works and focus on the speculator group only. Models 1 to 6 show the findings that correspond to the model specifications (1) to (6) in Table 3.4. The results show that the return for carports/garages/sheds has improved from significantly negative in the main results to be not significantly different from unimproved homes. Returns on duplexes—around 8% higher than those on unimproved homes—are similar to the main result, around 10% higher than those for unimproved homes.

The most notable result is found for extensions/alterations, where returns are 5% higher than those for unimproved homes in contrast to the negative or insignificant returns reported in Table 3.4. Homeowners who buy with a speculative motive typically extend the number of bedrooms or bathrooms. Therefore, the results meet my expectations and explain why most homeowners (flippers) with a speculative motive typically carry

Table 3.7: Results for Speculators

	Log(Resale Price/Purchase Price (Notional))	
	(1)	(2)
DA	-0.021^{***}	-0.025^{***}
	(0.002)	(0.002)
Speculator	0.007^{***}	0.007^{***}
	(0.001)	(0.001)
DA:Speculator	0.025^{***}	0.026^{***}
	(0.006)	(0.006)
MktReturn	0.923^{***}	0.925^{***}
	(0.003)	(0.003)
Age (months between sales)	-0.002^{***}	-0.002^{***}
	(0.000)	(0.000)
Age (months between sales) squared	0.000^{***}	0.000^{***}
	(0.000)	(0.000)
No. of beds (resale)	0.026^{***}	
	(0.001)	
No. of baths (resale)	0.059^{***}	
	(0.001)	
No. of cars (resale)	0.006^{***}	
	(0.000)	
No. of beds (purchase)	-0.032^{***}	
	(0.001)	
No. of baths (purchase)	-0.068^{***}	
	(0.001)	
No. of cars (purchase)	-0.016^{***}	
	(0.000)	
Change in # of beds		0.028^{***}
		(0.001)
Change in # of baths		0.062^{***}
		(0.001)
Change in # of cars		0.010^{***}
		(0.000)
Constant	0.121^{***}	0.070^{***}
	(0.003)	(0.003)
Year Fixed Effects	Yes	Yes
Location Fixed Effects	Yes	Yes
Observations	517,011	517,011
Adjusted R^2	0.289	0.287
F Statistic	$7,258.251^{***}$	$8,000.221^{***}$
	(df = 29; 516981)	(df = 26; 516984)

Notes: Robust standard errors are reported in parentheses, significance of variables is adjusted accordingly. *** 0.1% significance ** 1% significance * 5% significance. I have 1,119,419 (4,196 (DA and Speculator), 51,537 (DA and Non-Speculator), 261,302 (Non-DA and Speculator) and 802,384 (Non-DA and Non-Speculator) possible observation with deviations accounted for by missing data which are excluded from the regression.

out extensions/alterations as part of their home improvements and then sell their homes quickly, thereby making positive returns. This is also consistent with the fact that in Models 3, 4, and 5, the coefficients of the number of bedrooms, bathrooms, and car parking spaces at the time of purchase (resale) are negative (positive), suggesting that returns increase with the purchase of a smaller house and the sale of a bigger house.

Returns on houses/single dwellings in the investor group are still found to be significantly negative (ranging from -10% to -15%). This finding also aligns with one of the justifications provided in the main results that in building a new house/single dwelling, homeowners lose the residual value of the building and therefore returns are negative. This also explains why speculators would typically not buy a property and build a new house/single dwelling. Most homeowners build a new house with a long-term view for their consumption purposes. Buying a house to demolish and build a new one only to sell in the short term is a poor strategy to make financial gains.

For multiple DAs, the return has improved from being significantly negative to no different from that on unimproved homes. A significant improvement in returns can be attributed to the positive returns from extensions/alterations. For swimming pools, the results show that the return on improved homes is mostly insignificant across the models, consistent with the main findings, since homeowners with a speculative motive typically do not invest in a swimming pool. Finally, the return on verandas/pergolas has improved from being significantly lower to being not significantly different from that on unimproved homes. Overall, the results suggest that for homeowners with a speculative motive, extensions/alterations are a critical instrument for making significantly higher returns compared with unimproved homes.

Table 3.8: Results for Speculators by Improvement works

	Log(Resale Price/Purchase Price (Notional))					
	(1)	(2)	(3)	(4)	(5)	(6)
Carports/Garages/Sheds	−0.063***	−0.049**	0.019	0.013	0.014	0.009
	(0.023)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Duplex	0.139***	0.088***	0.066***	0.087***	0.080***	0.082***
	(0.014)	(0.014)	(0.017)	(0.017)	(0.017)	(0.017)
Extension/Alteration	0.082***	0.048***	0.058***	0.053***	0.054***	0.054***
	(0.008)	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)
House/Single Dwelling	−0.111***	−0.158***	−0.122***	−0.109***	−0.110***	−0.113***
	(0.012)	(0.011)	(0.017)	(0.017)	(0.017)	(0.017)
Multiple DA	0.022	−0.027*	0.016	0.023	0.024	0.018
	(0.015)	(0.015)	(0.020)	(0.021)	(0.021)	(0.020)
Swimming Pool	0.041***	0.021	0.012	0.012	0.013	0.005
	(0.014)	(0.014)	(0.009)	(0.009)	(0.009)	(0.009)
Verandahs/Pergolas	−0.049***	−0.041***	0.005	−0.003	−0.003	−0.006
	(0.012)	(0.013)	(0.012)	(0.012)	(0.012)	(0.012)
MktReturn	0.800***	0.833***	0.870***	0.934***	0.936***	0.941***
	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)
Months between sales				−0.003***	−0.006***	−0.006***
				(0.000)	(0.001)	(0.001)
Months between sales squared					0.000***	0.000***
					(0.000)	(0.000)
No. of beds (resale)		0.020***	0.031***	0.031***	0.031***	
		(0.001)	(0.002)	(0.002)	(0.002)	
No. of baths (resale)		0.050***	0.059***	0.059***	0.059***	
		(0.002)	(0.002)	(0.002)	(0.002)	
No. of cars (resale)		−0.009***	0.004***	0.004***	0.004***	
		(0.001)	(0.001)	(0.001)	(0.001)	
No. of beds (purchase)			−0.035***	−0.035***	−0.035***	
			(0.002)	(0.002)	(0.002)	
No. of baths (purchase)			−0.068***	−0.068***	−0.068***	
			(0.002)	(0.002)	(0.002)	
No. of cars (purchase)			−0.015***	−0.015***	−0.015***	
			(0.001)	(0.001)	(0.001)	
Change in # of beds						0.033***
						(0.002)
Change in # of baths						0.063***
						(0.002)
Change in # of cars						0.009***
						(0.001)
Constant	0.062***	−0.066***	0.078***	0.110***	0.127***	0.083***
	(0.003)	(0.005)	(0.005)	(0.006)	(0.007)	(0.007)
Year Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Location Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	265,470	229,805	117,605	117,605	117,605	117,605
Adjusted R^2	0.046	0.062	0.123	0.126	0.126	0.124
F Statistic	518.052***	546.342***	533.669***	529.388***	514.377***	554.262***
	(df = 25; 265444)	(df = 28; 229776)	(df = 31; 117573)	(df = 32; 117572)	(df = 33; 117571)	(df = 30; 117574)

Notes: Robust standard errors are reported in parentheses, significance of variables is adjusted accordingly. *** 0.1% significance ** 1% significance * 5% significance. I have 265,498 (4,196 in the treatment sample and 261,302 in the control sample) possible observation with deviations accounted for by missing data which are excluded from the regression.

In the above analysis of speculators/flippers, I assumed two years as the length of time between sales to identify homeowners with a speculative motive at the onset. Therefore, to examine how the estimates change with different speculator selection criteria (i.e., classification based on different lengths of time between purchase and resale), I present a holding term structure of estimates. I run multiple regressions with speculators classified based on the time between sales, from less than two years to less than 24 years. As such, in the first regression, I take only those observations where the time between purchase and resale is less than two years and then for each subsequent regression, I successively increase the number of years between purchase and resale. Figure 3.3 plots the estimate profiles of returns on improved homes compared with unimproved homes by the number of years between sales (holding terms).

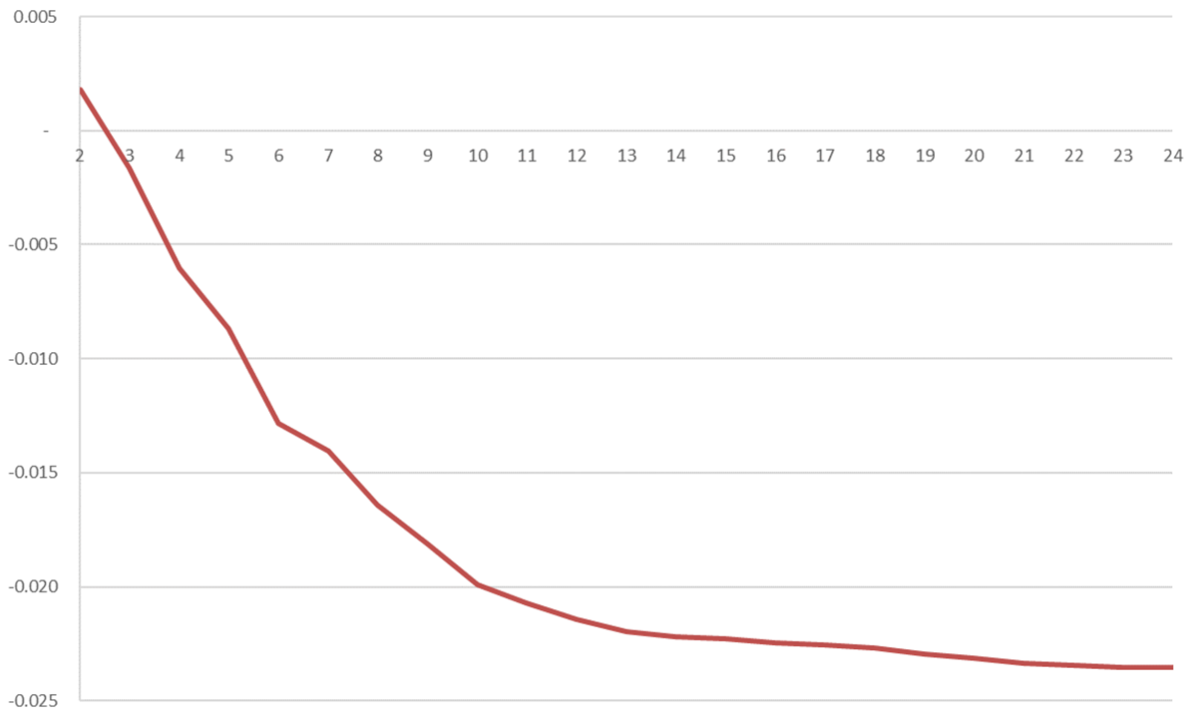


Figure 3.3: Estimates Profile by Holding-Term

We see that for holding periods of less than two years, returns for speculators (flippers) are positive (although small). Further, as I increase the time between purchase and resale, returns indeed start to drop and become negative relative to those on unimproved homes.

As I increase the number of years between sales further, the estimates become almost constant and converge to the overall mean.

3.8.2 Consumers-cum-Speculators (Non-Flippers) (Buy - Live - Improve - Sell Homes)

To examine the aggregate-level return for consumers-cum-speculators on improved homes relative to unimproved homes, I run the following model specification with the interaction between DA and consumers-cum-speculators.

$$\begin{aligned} Y_i = a_0 + DA_i + Cons\_Spec_i + DA_i * Cons\_Spec_i + \beta MktReturn_{ssd} \\ +\gamma_1 Age_i + \gamma_2 Age_i^2 + Year_i + Location_i + \mu K_i + \epsilon_i \end{aligned} \tag{3.16}$$

where DA_i is the dummy variable equal to 1 for improved homes and 0 for unimproved homes. $Cons\_Spec_i$ is also a dummy variable indicating consumers-cum-speculators; this equals 1 if the time between actual purchase and resale is more than two years and the time between DA and resale is less than two years, and 0 otherwise. $DA_i * Cons\_Spec_i$ is the interaction term.

Table 3.9 presents the aggregate-level interaction results for the full model specifications (Models 1 and 2). For the consumers-cum-speculators group, the returns on improved homes are 5.6% (-0.012 + -0.042) and 5.7% (-0.017 + -0.040) lower than those on unimproved homes. All the other variable coefficients are consistent with those in Table 3.4.

Across the consumers-cum-speculators group, for unimproved homes, the return is 0.4% higher than that for non-speculators. This finding is consistent with the speculator results

(0.7%). Since the speculator group for unimproved homes in both cases is identified in the same way (i.e., the time between purchase and resale is within two years), this is expected. Now, in the case of improved homes, returns for consumers-cum-speculators are 3.8% (0.004 + -0.042) and 3.6% (0.004 + -0.040) lower than those for non-speculators in Models 1 and 2, respectively.

Table 3.10 presents the results by improvement works for Models 1 to 6 for the consumers-cum-speculators group. The results for carports in the full model specifications (Models 5 and 6) are 2.4% (insignificant) and 2.8% lower than those for unimproved homes, respectively. The results for duplexes are positive, 5.5% and 5.9% higher than those for unimproved homes but lower than the positive return in Table 3.4 and the speculator results. For extensions/alterations, returns are lower by around 3% than those on unimproved homes, a much lower return than the results in Table 3.4. For a house/single dwelling, the return on improved homes is also below that on unimproved homes by around 22%, far lower than the main results in Table 3.4 where returns were lower by around 10%.

For multiple DAs, returns are around 5% lower than the primary results where returns were around 1% lower. In the case of swimming pools, the return is 1.6% lower (weakly significant) than the primary results, where returns are insignificantly different from those on unimproved homes. Finally, for verandas/pergolas, returns are 7% lower compared with around 4% lower in the primary results. Overall, I find that returns for consumers-cum-speculators are not only worse than those for speculators but also worse than the results in Table 3.4.

Table 3.9: Results for Consumption-cum-Speculators

	Log(Resale Price/Purchase Price (Notional))	
	(1)	(2)
DA	-0.012^{***}	-0.017^{***}
	(0.002)	(0.002)
Cons_Spec	0.004^{***}	0.004^{***}
	(0.001)	(0.001)
DA:Cons_Spec	-0.042^{***}	-0.040^{***}
	(0.005)	(0.005)
MktReturn	0.923^{***}	0.925^{***}
	(0.003)	(0.003)
Age (months between sales)	-0.002^{***}	-0.002^{***}
	(0.000)	(0.000)
Age (months between sales) squared	0.000^{***}	0.000^{***}
	(0.000)	(0.000)
No. of beds (resale)	0.026^{***}	
	(0.001)	
No. of baths (resale)	0.058^{***}	
	(0.001)	
No. of cars (resale)	0.006^{***}	
	(0.000)	
No. of beds (purchase)	-0.032^{***}	
	(0.001)	
No. of baths (purchase)	-0.068^{***}	
	(0.001)	
No. of cars (purchase)	-0.016^{***}	
	(0.000)	
Change in # of beds		0.029^{***}
		(0.001)
Change in # of baths		0.062^{***}
		(0.001)
Change in # of cars		0.010^{***}
		(0.000)
Constant	0.125^{***}	0.074^{***}
	(0.003)	(0.003)
Year Fixed Effects	*Yes*	*Yes*
Location Fixed Effects	*Yes*	*Yes*
Observations	514,693	514,693
Adjusted R^2	0.290	0.288
F Statistic	$7{,}254.168^{***}$	$7{,}993.790^{***}$
	(df = 29; 514663)	(df = 26; 514666)

Notes: Robust standard errors are reported in parentheses, significance of variables is adjusted accordingly. *** 0.1% significance ** 1% significance * 5% significance. I have 1,115,223 (11,046 (DAs and Consumption-cum-Speculators), 40,491 (DA and Non-Speculators), 261,302 (Non-DA and Consumption-cum-Speculators) and 802,384 (Non-DA and Non-Speculators) possible observation with deviations accounted for by missing data which are excluded from the regression.

According to Choi et al. (2014), the rising house prices under the consumption-cum-financial motive loosen financial constraints and lead to lower recoup values. My results are consistent with this premise. Since these homeowners have owned their homes for a longer term, they may have already made significant capital gains from house price appreciation. This relaxes the financial constraints on homeowners, encouraging overindulgence and thus leading to lower returns. Sometimes, the homeowners are naïve: while they think they are trying to beat the market, they are unaware of the potential losses caused by their overcapitalized improvement works.

Another possible reason for the poor performance is that since these homeowners have a consumption motive at the time of purchase, they might also have carried out improvements with a consumption motive in the first place and never had a speculative view on home improvements at all. However, the fact that they still end up selling shortly after improvement could be because the improvement work either did not turn out as desired or no longer serves their expected needs and therefore they had to sell in distress. However, in either case (i.e., whether homeowners sell with a speculative motive on improvement or in distress), they would have likely made capital gains from house price appreciation, which relaxes the financial constraints, leading to a lower return on home improvements compared with doing nothing.

Table 3.10: Results for Consumption-cum-Speculators by Improvement Works

	Log(Resale Price/Purchase Price (Notional))					
	(1)	(2)	(3)	(4)	(5)	(6)
Carports/Garages/Sheds	−0.099*** (0.016)	−0.078*** (0.015)	−0.027* (0.016)	−0.023 (0.016)	−0.024 (0.016)	−0.028* (0.016)
Duplex	0.130*** (0.026)	0.076*** (0.026)	0.055** (0.027)	0.087*** (0.028)	0.055** (0.028)	0.059** (0.028)
Extension/Alteration	−0.015** (0.007)	−0.050*** (0.007)	−0.034*** (0.009)	−0.028*** (0.009)	−0.030*** (0.009)	−0.031*** (0.009)
House/Single Dwelling	−0.193*** (0.013)	−0.239*** (0.013)	−0.229*** (0.017)	−0.206*** (0.017)	−0.223*** (0.017)	−0.223*** (0.017)
Multiple DA	−0.017** (0.007)	−0.047*** (0.008)	−0.061*** (0.012)	−0.043*** (0.012)	−0.053*** (0.012)	−0.057*** (0.012)
Swimming Pool	0.181*** (0.010)	0.152*** (0.010)	−0.023** (0.009)	−0.012 (0.009)	−0.016* (0.009)	−0.022** (0.009)
Verandahs/Pergolas	−0.015** (0.008)	−0.017** (0.008)	−0.070*** (0.007)	−0.069*** (0.007)	−0.070*** (0.007)	−0.072*** (0.007)
MktReturn	0.807*** (0.009)	0.840*** (0.009)	0.875*** (0.009)	0.934*** (0.010)	0.936*** (0.010)	0.941*** (0.010)
Age (months between sales)				−0.002*** (0.000)	−0.006*** (0.001)	−0.006*** (0.001)
Age (months between sales) squared					0.000*** (0.000)	0.000*** (0.000)
No. of beds (resale)		0.020*** (0.001)	0.032*** (0.002)	0.032*** (0.002)	0.032*** (0.002)	
No. of baths (resale)		0.052*** (0.002)	0.061*** (0.002)	0.061*** (0.002)	0.061*** (0.002)	
No. of cars (resale)		−0.008*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	
No. of beds (purchase)			−0.037*** (0.002)	−0.037*** (0.002)	−0.037*** (0.002)	
No. of baths (purchase)			−0.068*** (0.002)	−0.069*** (0.002)	−0.069*** (0.002)	
No. of cars (purchase)			−0.015*** (0.001)	−0.015*** (0.001)	−0.015*** (0.001)	
Change in # of beds						0.034*** (0.002)
Change in # of baths						0.064*** (0.002)
Change in # of cars						0.009*** (0.001)
Constant	0.063*** (0.003)	−0.069*** (0.005)	0.082*** (0.005)	0.111*** (0.006)	0.134*** (0.007)	0.088*** (0.007)
Year Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Location Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	272,319	236,195	119,639	119,639	119,639	119,639
Adjusted R^2	0.049	0.066	0.125	0.127	0.128	0.125
F Statistic	563.607*** (df = 25; 272293)	594.204*** (df = 28; 236166)	551.779*** (df = 31; 119607)	545.483*** (df = 32; 119606)	530.886*** (df = 33; 119605)	572.333*** (df = 30; 119608)

Notes: Robust standard errors are reported in parentheses, significance of variables is adjusted accordingly. *** 0.1% significance ** 1% significance * 5% significance. I have 272,348 (11,046 in treatment sample and 261,302 in control sample) possible observation with deviations accounted for by missing data which are excluded from the regression.

3.9 Conclusion

This study examines a crucial economic decision faced by homeowners on the return on improved homes compared with unimproved homes. Using a novel dataset of house prices and DAs, I test if returns on improved homes are better than those on unimproved homes. I find that cost-adjusted returns on improved homes, overall, are lower than those on unimproved homes by around 2.4%. The highest loss is in building a new house/single dwelling, with around 10% lower returns than on unimproved homes because of overindulgence as well as the lost value of non-durable consumption (i.e., the building value). Carports/garages/sheds have around 2.5% lower returns, while verandas/pergolas have a 4.2% lower return. The returns on extensions/alterations and swimming pools are insignificantly different from those on unimproved homes. By contrast, duplexes provide the highest returns, around 10% more than on unimproved homes, owing to land utility maximization. I also perform a set of robustness tests to correct sample selection bias, including purchase/sales post-2004 and the construction of repeat sales indices, finding that all the robustness test results are consistent with my primary results.

In further analysis, I compare the returns for speculators and consumers-cum-speculators. Speculators are classified as homeowners who *"buy-improve-sell"* their homes in less than two years and consumers-cum-speculators as those homeowners with a *"buy-live-improve-sell"* strategy who have a holding term of more than two years but improve and sell their homes in less than two years. In the case of speculators, I find that returns on improved homes are higher than those on unimproved homes by around 0.4%. The most notable result is found for extensions/alterations, which is around 5.4% higher than that for unimproved homes compared with the insignificant returns in the primary results. This finding explains why speculators/flippers typically include extensions and alterations as part of their improve-and-flip strategy. Returns on carports and verandas/pergolas also improve from negative to being insignificant.

By contrast, for consumers-cum-speculators, at the aggregate level, returns on improved homes are lower than those on unimproved homes by around 5.4%. In particular, returns across improvement works have reduced compared with the primary results because the reference category (unimproved homes) in both analyses (speculators and consumers-cum-speculators) is conditioned by the time between purchase and resale as less than two years. Therefore, since the return for the speculator group in the reference category, on average, is higher than that for the non-speculator group, returns on improved homes are even lower. The return on duplexes reduces from around 10% to 5.5%. The return on extensions/alterations goes from being insignificant to -3%. The return on a new house build reduces further to around 22%. Verandas/pergolas also reduce to 7% lower returns.

Overall, this finding suggests that homeowners with a speculative motive who buy and sell their homes in less than two years have higher returns on home improvements, whereas homeowners who live in the property for more than two years but sell their homes within two years of carrying out improvements perform worse. This further suggests that the time between sales is a key variable that enables the identification of homeowners with a speculative motive. Quick turnaround time may not necessarily imply a higher return. Moreover, homeowners who have a speculative motive make positive returns, while non-speculators with a consumption motive make negative returns which is probably the price they pay for hedonism.

Chapter 4

Testing for Persistence in the Capital and Rental Components of Housing Market Returns in Australia

4.1 Introduction

The research reviewed in Section 2.3 identifies two important gaps in the literature on the persistence (or weak-form efficiency) of housing market returns. First, the studies related to persistence (or weak-form efficiency) have invariably analyzed the capital component of housing market returns, while studies examining the persistence in the rental component of housing market returns in the extant literature are limited. Second, to the best of my knowledge, there are no studies that have investigated persistence in the capital component of housing market returns in the Australian context.

In this chapter, I examine persistence in inflation-adjusted capital and rental components of housing market returns across multiple geographic demarcations including national, capital city and regional areas, both for houses and units across Australia. Specifically, this chapter addresses two hypothesis tests: $H_{4,1}$ and $H_{4,2}$. $H_{4,1}$ tests the hypothesis that the capital component of inflation-adjusted housing market returns exhibit persistence; while, $H_{4,2}$ tests the hypothesis that the rental component of housing market returns exhibit persistence.

The remainder of this chapter is structured as follows. Section 4.2 presents the methodology. In Section 4.3, I describe the data and provide the summary statistics of index returns. Section 4.4 presents and discusses the empirical results. Finally, Section 4.5 concludes.

4.2 Methodology

In this study, I analyze the persistence in real house price index returns under the null hypothesis that price changes are unpredictable, i.e. that there is no time structure in the index returns. If price changes were correlated with the past, future returns could be predicted based on the past returns (Schindler, 2014). By examining whether or not prices follow a random walk, I test the null hypothesis of no persistence. Under the random walk hypothesis, a non-predictable random process generates the price change series such that, in its simplest form, the current index I_t equals the previous index I_{t-1} plus the realization of a random term ϵ_t as:

$$I_t = I_{t-1} + \epsilon_t, \tag{4.1}$$

where I_t is the natural logarithm of the index and ϵ_t is a random disturbance term at time t such that $E[\epsilon_t] = 0$ and $E[\epsilon_t \epsilon_{t-h}] = 0$, $h \neq 0$ for all t. If the expected index changes are given by $E[\Delta I_t] = E[\epsilon_t] = 0$, the best linear estimator for index I_t is the previous period's index value I_{t-1}. Under the assumption that the expected index change μ is constant over time, the random walk model expands to a random walk with drift:

$$\begin{gathered} I_t = I_{t-1} + \mu + \epsilon_t \\ or \\ \Delta I_t = \mu + \epsilon_t. \end{gathered} \tag{4.2}$$

The random walk implies uncorrelated residuals and hence uncorrelated price changes; ΔI_t; $\epsilon_t \sim i.i.d.\ (0, \sigma^2)$ denotes that the increments ϵ_t are independently and identically distributed (i.i.d) with $E[\epsilon_t] = 0$ and $E[\epsilon_t^2] = \sigma_\epsilon^2$.

In this study, two approaches are utilized to test for random walks—variance ratio and independent runs tests, which are described in the following sections.

4.2.1 Variance Ratio Test of Random Walk

The variance ratio test of persistence has clear advantages over classical present value relationship studies or traditional serial correlation-based methods. According to Schindler (2014), the variance ratio test, unlike present value relationship studies, does not rely on the unobservable fundamental value or any exogenous variable. It simply tests the efficiency using the property that the variance of random walk increments increase proportionally with the length of the interval between the increments. Meanwhile, traditional random walk tests based on serial correlation and unit roots are vulnerable to errors due to autocorrelation induced by non-synchronous and infrequent trading[1]. To resolve this shortcoming for financial time series, Lo and MacKinlay (1988) and Lo and MacKinlay (1989) developed tests for random walks based on variance ratio estimators. According to Serrano and Hoesli (2010), univariate variance ratio test models are also preferable to multivariate models, which are used in most previous studies. Moreover, variance ratio tests are also particularly useful for examining housing market index return, which are typically not normally distributed (Schindler et al., 2010).

The variance of the increments of a random walk is linearly time-dependent. Thus, if the natural logarithm of an index (I_t) follows a pure random walk with drift (Eqn. (4.2)), the variance of index returns should increase proportionally to the interval q. Suppose a series of $nq + 1$ price observations ($P_0, P_1, P_2, ..., P_{nq}$) measured at uniform intervals is available. If this time series follows a random walk, the variance of the qth difference will correspond to q times the variance of the first difference. Following the models of Eqs. (4.1) and (4.2), the variance of the first difference, denoted as $\hat{\sigma}^2[I_t - I_{t-1}]$ and $\hat{\sigma}^2[r_t]$, respectively, grows linearly over time so that the variance of the qth difference is:

$$\begin{gathered} \hat{\sigma}^2[I_t - I_{t-q}] = q\hat{\sigma}^2[I_t - I_{t-1}] \\ or \\ \hat{\sigma}^2[r_t(q)] = q\hat{\sigma}^2[r_t]. \end{gathered} \tag{4.3}$$

[1]Concerning house price indices, further discussions on the topic with small sample sizes can be found in Karl et al. (1989) and Kuo (1996), respectively.

For the qth lag in I_t, where q is any integer greater than one, the variance ratio, VR(q), is defined as

$$VR(q) = \frac{\hat{\sigma^2}[r_t(q)]}{q\hat{\sigma^2}[r_t]} = 1 + 2\sum_{i=1}^{q-1}(1 - \frac{i}{q})\hat{\rho}(i), \tag{4.4}$$

where $\hat{\sigma^2}[\cdot]$ is an unbiased estimator of the variance. The expected value of VR(q) is one under the null hypothesis of a random walk for all values of q. Since I_t describes the logarithmic price process, $r_t(q)$ is a q period continuously compounded return with $r_t(q) \equiv r_t + r_{t-1} + ... + r_{t-q+1} = I_t - I_{t-q}$. $\hat{\rho(i)}$ is the estimator of the i^{th} serial correlation coefficient. Alternatively, values for VR(q) greater than one imply mean aversion while values smaller than one imply mean reversion. Equation (4.4) shows that VR(q) is a particular linear combination of the first $i-1$ autocorrelation coefficients with linearly declining weights. If the index I_t behaves like a random walk, then the autocorrelation coefficients will be zero for all $i \geq 1$, hence, VR(q) = 1.

Under the null hypothesis of a homoscedastic increments random walk, Lo and MacKinlay (1988) derive an asymptotic standard normal test statistic for the VR in which the sampling distribution is approximated by its limiting distribution. The standard z-test statistic is

$$Z_1(q) = \frac{VR(q) - 1}{\sqrt{\hat{\theta}_1(q)}} = \frac{M_r(q)}{\sqrt{\hat{\theta}_1(q)}} \overset{a}{\sim} N(0,1), \tag{4.5}$$

where $\hat{\theta}_1(q) = \frac{2(2q-1)(q-1)}{3q(nq)}$, and $\overset{a}{\sim}$ denotes that the distributional equivalence is asymptotic.

Time series typically have time-varying volatilites, with returns deviating from normality. When index changes are conditionally heteroscedastic over time, there may not exist a linear relation across the observation intervals. Hence, Lo and MacKinlay (1988) suggest a second test statistic $Z_2(q)$ with a heteroscedasticity-consistent variance estimator $\hat{\theta}_2(q)$:

$$Z_2(q) = \frac{VR(q) - 1}{\sqrt{\hat{\theta}_2(q)}} = \frac{M_r(q)}{\sqrt{\hat{\theta}_2(q)}} \overset{a}{\sim} N(0, 1), \tag{4.6}$$

with

$$\hat{\theta}_2(q) = \sum_{j=1}^{q-1} \left[\frac{2(q-j)}{q} \right]^2 \cdot \hat{\delta}(j)$$

and

$$\hat{\delta}(j) = \frac{\sum_{t=j+1}^{nq} (I_t - I_{t-1} - \hat{\mu})^2 (I_{t-j} - I_{t-j-1} - \hat{\mu})^2}{\sum_{t=1}^{nq} (I_t - I_{t-1} - \hat{\mu})^2}$$

If the null hypothesis is true, the modified heteroscedasticity-consistent test statistic in Eqn. (4.6) has an asymptotic standard normal distribution (Liu and He, 1991). The $Z_2(q)$-statistic is robust to heteroscedasticity as well as to non-normal error terms.

The variance ratio test of Lo and MacKinlay (1988) considers one VR for a single aggregation interval q by comparing the test statistics $Z_1(q)$ and $Z_2(q)$ with critical values of a standard normal distribution. To implement the test, a choice of holding periods q should be made; for example, in financial markets, a popular choice for daily returns is 2, 5, 10, 20, or 40; while for weekly returns often q is chosen to equal to 2, 4, 8, 16, or 32. However, these choices are arbitrary and made with little statistical justification. In response to this concern, Choi (1999) proposed an Automatic Variance Ratio (AVR) test, in which the optimal value of q is determined automatically, using a completely data-dependent procedure.

If Y_t is an asset return at time $t(t = 1, ..., T)$, the AVR test of Choi (1999) is based on the statistic of the form

$$VR(q) = 1 + 2\sum_{i=1}^{T-1} m(i/k)\hat{\rho}(i), \tag{4.7}$$

where

$$\hat{\rho}(i) = \frac{\sum_{t=1}^{T-i}(Y_t - \hat{\mu})(Y_{t+i} - \hat{\mu})}{\sum_{t=1}^{T}(Y_t - \hat{\mu})^2} \quad \text{and} \quad \hat{\mu} = \frac{1}{T}\sum_{t=1}^{T} Y_t,$$

while $m(x) = \frac{25}{12\pi^2 x^2}\left[\frac{sin(6\pi x/5)}{6\pi x/5} - cos(6\pi x/5)\right]$ is the quadratic spectral kernel. In order to choose the value of lag truncation point (or holding period) q optimally, Choi (1999) adopted a data-dependent method of Andrews (1991) for spectral density at zero frequency. The AVR test statistic with the optimally chosen lag truncation point is denoted as $AVR(\hat{q})$.

For empirical applications it is important to note that the $AVR(\hat{q})$ test is an asymptotic test which may show deficient small sample properties. Choi (1999) reported small sample properties for the proposed AVR test when the returns follow an $i.i.d.$ process, while its properties under conditional heteroskedasticity are unknown. To overcome this problem, Kim (2009) recommends that the AVR test should be combined with wild[2] bootstrapping to correct for small sample size. According to Kim (2009), the wild bootstrap AVR test has been found to have high power also in small samples. Further, in the presence of conditional heteroskedacity, Mammen (1993) successfully applied the wild bootstrap AVR test using the two-point distribution to improve the small sample properties of the test. Kim (2006) applied the wild bootstrap to the Lo–Mackinlay and Chow–Denning

[2]The so-called 'Wild' bootstrap has been suggested for situations when the applied model exhibits heteroskedasticity. The idea is then to resample the response variable by multiplying it with a random variable with zero mean and variance 1. Note that while the literature has suggested different forms of distributions (e.g. Mammen's or Rademacher's) in the empirical application of this study, I decided to use the most commonly applied approach, i.e. the standard normal distribution.

tests and found improved results. In the case of real estate market transactions, data are finite due to infrequent trading. Hence, the wild bootstrap AVR test is particularly well-suited for testing the null hypothesis of a random walk against the alternate hypothesis of persistence in the house price indices considered in this study, where far less observations than for other financial markets are available.

In this paper, I employ the wild bootstrap methodology using a 'Normal' distribution for $AVR(\hat{q})$ as proposed by Kim (2006). The wild ('Normal') bootstrap $AVR(\hat{q})$ is conducted, using the following three steps:

i I form a bootstrap sample of T observations $Y_t^* = \eta_t Y_t (t = 1, ..., T)$ where η_t is a random sequence with $E(\eta_t) = 0$ and $E(\eta_t^2) = 1$

ii I calculate $AVR^*(\hat{q}^*)$, the AVR statistic obtained from $\{Y_t^*\}_{t=1}^T$; and

iii I repeat (i) and (ii) B = 500 times to form a bootstrap distribution of AVR statistics $\{AVR^*(\hat{k}^*; j)\}_{j=1}^{B=500}$

The above procedure is applied to an asymptotically pivotal statistic: AVR. According to Kim (2009), since Y_t^* is a serially uncorrelated sequence conditionally on Y_t, this procedure approximates its sampling distribution under H_0, which is a desirable property for a bootstrap test. As such, the p-value for the test is the proportion of cases in which the variance ratio lies between the 95% confidence interval of the bootstrapped distribution of variance ratios. The application of the AVR test in combination with the wild bootstrapping approach to the examination of persistence in house price indices is an innovative contribution of this study.

4.2.2 Independent Runs Test

The Variance Ratio tests and auto-correlation methods are based on the assumption of a linear process and both approaches thus test for linear dependence by definition, when testing the random walk hypothesis. Hence, it might be important to apply an alternative direct test that does not require the specification of a model. The non-parametric runs test examines the independence of successive price returns and does not require normality or a linear process. These characteristics of testing methods are particularly useful for investigating price movements of house price indices which are mostly non-normally distributed.

A runs test determines whether the total number of runs in the sample is consistent with the hypothesis that price changes are independent. If the series of price changes shows a greater tendency of change in one direction, the average run will be longer, and consequently, the number of runs will be lower than when generated by a random process. In the Bernoulli case, the total number of runs is referred to as N_{Runs}, and the total expected number of runs, under the hypothesis that price changes are independent, is given by

$$E[N_{Runs}] = 2np(1-p) + p^2 + (1-p)^2, \tag{4.8}$$

where $p = P(r_t > 0) = \phi\left(\frac{\mu}{\sigma}\right)$, r_t is the single period return, μ is the expected index single period return, and σ is the standard deviation of index returns. For large sample sizes ($N > 30$), the sampling distribution of $E[N_{Runs}]$ is approximately normal and a continuity correction is produced.

When the actual number of runs exceeds the expected number, this suggests that the length of the runs are shorter and therefore returns oscillate more than they would in case of independence. On the other hand, when the actual number of runs is less than the expected number of runs, this indicates that the length of the run is longer. In the former case, a positive Z-value is obtained indicating negative serial correlation, and in the latter, a negative z-value indicates a positive serial correlation (i.e. a trend or persistence) in the series of index returns.

4.3 Data and Region Summary Statistics

The data set employed in this study is based on CoreLogic's quality-constant capital and rental daily hedonic-imputation-based house price indices in Australia for the period 2005 to 2017, spanning the global financial crisis cycle. CoreLogic's hedonic-imputation methodology for capital indices uses transaction sales to value the properties, and correspondingly, the property value indices measure the daily movement in imputed values. The hedonic index requires that the actual prices of all properties are known in order to calculate the movement in values. However, in each period, not all properties are sold, and therefore their values must be imputed based on sales that were observed for a given Statistical Area, property type, and period (CoreLogic, 2018)[3].

The hedonic-imputation method is used to estimate the values of all properties for each period. If the value of a property cannot be imputed—for example, if there are not enough

[3]When estimating the hedonic regression model, CoreLogic uses past 360 days of data at the time of valuation. One issue that may be raised here is that since the imputation values are based on the historical data, the index may exhibit some persistence by construction. To overcome this issue, CoreLogic controls for the fraction of time elapsed within that 360 day period in the hedonic imputation regression using time-fraction variable calculated as $F_i^t = \frac{date(p_i^t)-date(t_{start})}{date(t_{end})-date(t_{start})}$, where p_i^t is date of sale of property i in period t, $date(t_{start})$ is the start date of period t and $date(t_{end})$ is the end date of period t. Hence, the series should be free of persistence by construction, and any persistence identified in the index series must therefore be attributed to weak-form of market inefficiency.

sales in the Statistical Area for that period—the value of the property is imputed from the sample based on the higher-level Statistical Area (CoreLogic, 2018). For example, the hedonic data for the Statistical Area 4 region will be used to impute the value of each property to estimate the index for the Statistical Area 3 region (CoreLogic, 2018).

Corelogic's index is based on a rich data set, as it records approximately 98% of total housing sales in Australia (CoreLogic, 2018). There is a high degree of accuracy in sales data, as 60% of sales are captured before being communicated by the Valuer General within each state[4]. These features make the data repository the timeliest in Australia, thus allowing for an equally timely daily hedonic index[5]. Further, CoreLogic's hedonic indices help overcome some of the disadvantages associated with the repeat-sales indices, such as bias from the inherent ripple effects (Sommervoll, 2006), sample selection and compositional bias from aggregating sub-indices (Dombrow et al., 1997)[6], and correlation bias (Case and Shiller, 1989; Kuo, 1996). Further, since the hedonic-imputation methodology allows for the use of population of properties in the database for the construction of the index, it eliminates any sample selection bias, such as is common in transaction-only or repeat-sale indices.

The capital index accounts for both, and does not differentiate between, owner-occupied and investment property[7], and excludes outliers at the top and bottom 2.5 percentiles (CoreLogic, 2018). In order to avoid any distortions in the index calculation, the indices exclude arms-length transactions, and the portfolio is re-balanced monthly to account for

[4]In addition to Valuer-General data, CoreLogic also sources property sales data from agents, property listings, and mortgage banks.

[5]CoreLogic's index was specifically developed as a benchmark asset for the settlement of derivative contracts on property (CoreLogic, 2018).

[6]The hedonic methodology is recognized as robust by Valadkhani et al. (2017) at varying levels of disaggregation across both time and space.

[7]Regardless of whether the home sale is carried out with a motive of owner-occupation, rental income, or speculation, the transactions are not differentiated on the basis of the motives, and hence all transactions are included in the capital index.

addition or removal of stock from the residential property portfolio over the preceding month. Changes in property attributes, for example, a change in the recorded number of bedrooms for a property, are handled daily to ensure consistent quality inter-day (CoreLogic, 2018). CoreLogic (2018) employs the same methodology in estimating both capital and rental house price indices, except that the capital index is based on the transactions data, while CoreLogic's rental price index is built using the listings data, which is the best estimate of rental prices in the market.

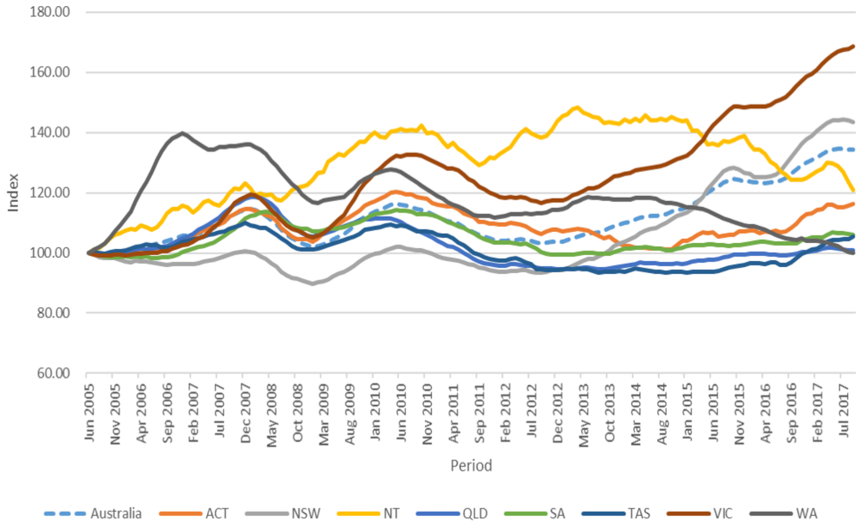
The methodology is consistently applied across all geographic regions and built using transaction price data that are provided by the Valuer-General[8] after the completion of property transaction. Along with additional attribute data, CoreLogic receives most of the transaction price data upfront from banks, mortgage lenders, real estate agents and property listings, and data are further validated as the Valuer-General's data are received. This makes CoreLogic's indices the most accurate and timely[9].

While most previous studies carry out analysis using quarterly returns, CoreLogic's rich data set allows me to conduct the empirical analysis for both monthly and quarterly frequencies. I use monthly and quarterly closing prices to calculate the corresponding period's log returns. Further, I also perform the analysis separately for each property type[10], 'Houses' and 'Units', for the following geographic levels: National, State, Greater Capital City, Statistical Area 4 and Statistical Area 3.

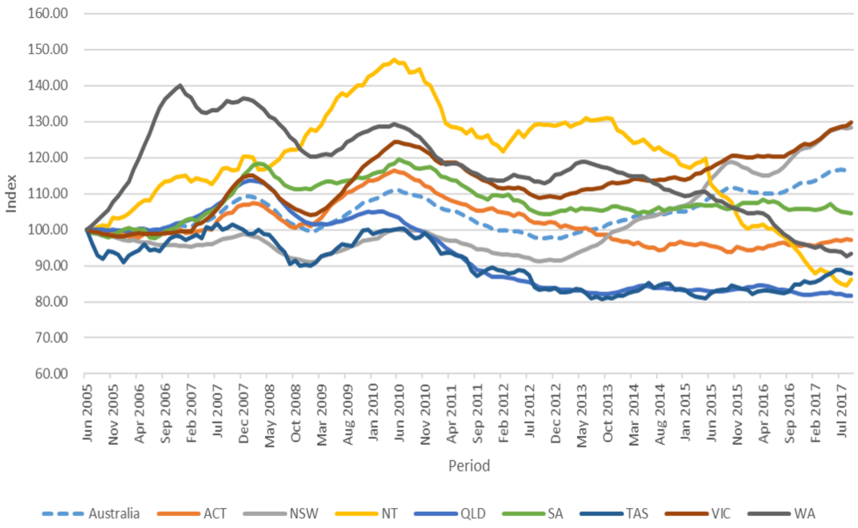
[8]A Valuer-General, in Australia, is a state official, or an independent statutory officer, appointed by the state governor, who oversees the state's land valuation and taxes. The office of Valuer-General provides a registry system for the population of real property transfers in Australia (Valuer General, 2017).

[9]The Corelogic's indices have also been cross validated for robustness by Valadkhani et al. (2017), who compare the quarterly log returns of CoreLogic indices with that sourced from the Australian Bureau of Statistics, and find strong positive correlation. They also carry out the tests for equality of means and variances and find that the two are comparable.

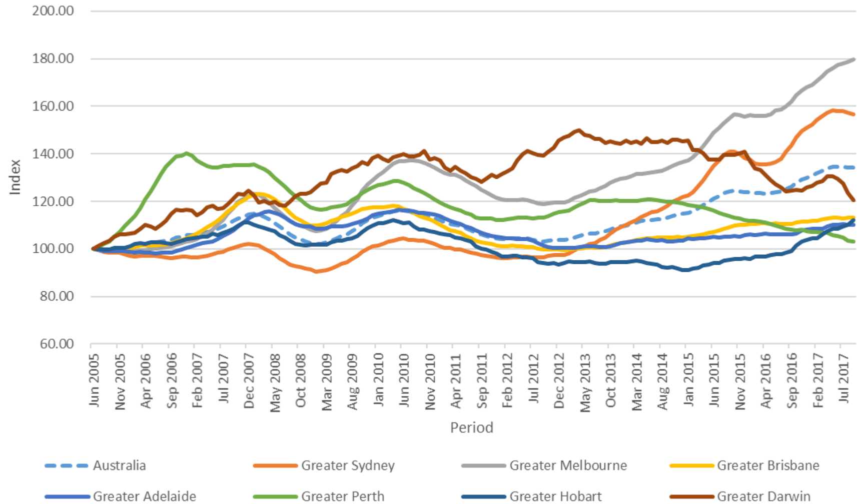
[10]All tables presented in this study are also provided for 'All dwellings' that represent the index aggregated for both property types, 'Houses' and 'Units', in Appendices I through Q.



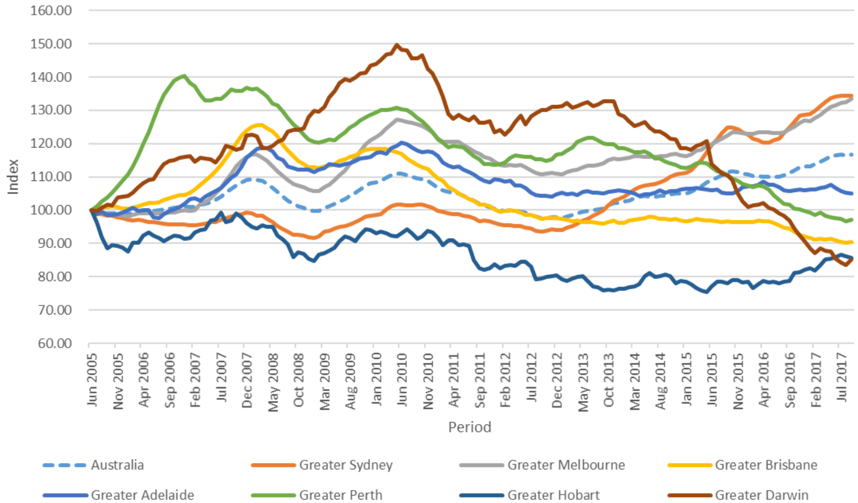
(a) Real Capital Price Index (Houses) for Australia and by States



(b) Real Capital Price Index (Units) for Australia and by States



(c) Real Capital Price Index (Houses): Australia and GCC



(d) Real Capital Price Index (Units): Australia and GCC

Figure 4.1: Real Capital Price Indices for Houses and Units

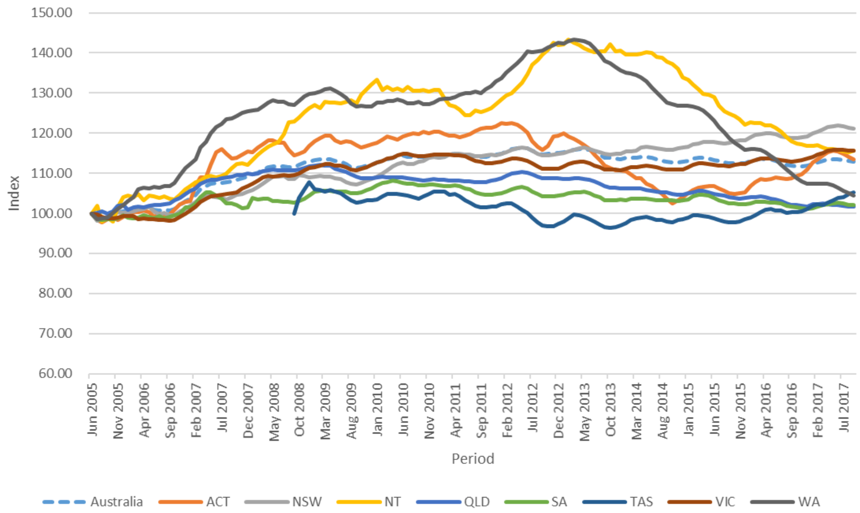
The study calculates the log returns for all regions and nationwide indices, using real house price indices, that is, after adjusting for inflation. Real house price indices are calculated by deflating nominal house price indices with the national level consumer price index (CPI) published by the Australian Bureau of Statistics[11]. Since CPI is available at the quarterly frequency, the monthly CPI values are calculated by linear interpolation of quarterly CPI values. The analyzed data set includes monthly and quarterly house price indices for all regions and at the national level from June 2005 till September 2017, which is equivalent to 148 monthly and 50 quarterly observations.

Figure 4.1a and 4.1b show the real capital house price indices for Australia and all eight states from June 2005 to September 2017 for houses and units, respectively[12]. The house prices, on average, have increased by around 38% since June 2005 with a compound annual growth rate (CAGR) of 2.47%. The house prices in Victoria have seen the highest increase since 2005 of around 68% with a CAGR of 4.32%. The New South Wales index has a similar trend but with lower price levels than Victoria of around 42% with a CAGR of 2.9%. The units, on average, have lower real price increases than houses, on average. The price index for units in Australia increased by around 18% in September 2017 since June 2005 with a CAGR of 1.35%. The price increase for units for Victoria and New South Wales was similar: around 30% with a CAGR of 2.1%. The units price index for all other states closed at below 100 in September 2017 in real terms.

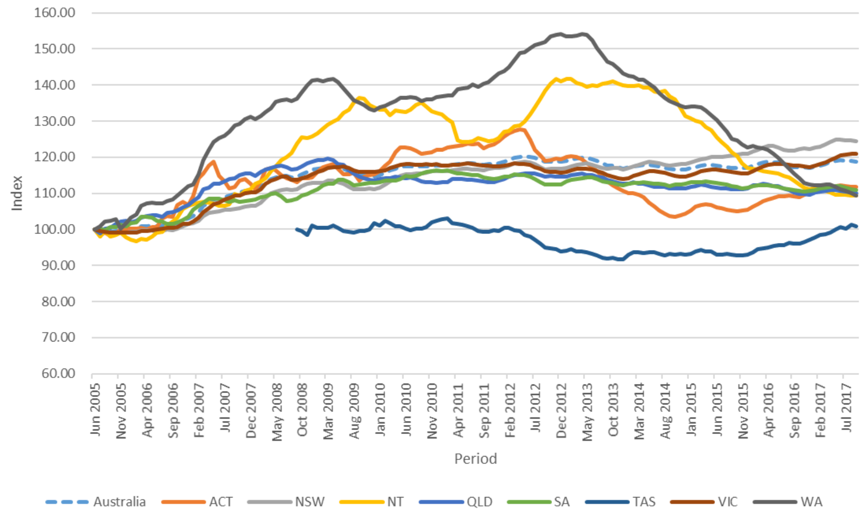
Figure 4.2a and 4.2b show the real rental price index for Australia and all eight States

[11]The Australian Bureau of Statistics does not publish CPI for states or statistical areas, but instead provides CPI for the capital cities (Australian Bureau of Statistics, 2018). Since using the capital cities' CPI indices for regional areas will induce greater variation and may produce biased results compared to the national-level aggregate CPI index, I use the latter for all regions. This is also consistent with Schindler (2013, 2014).

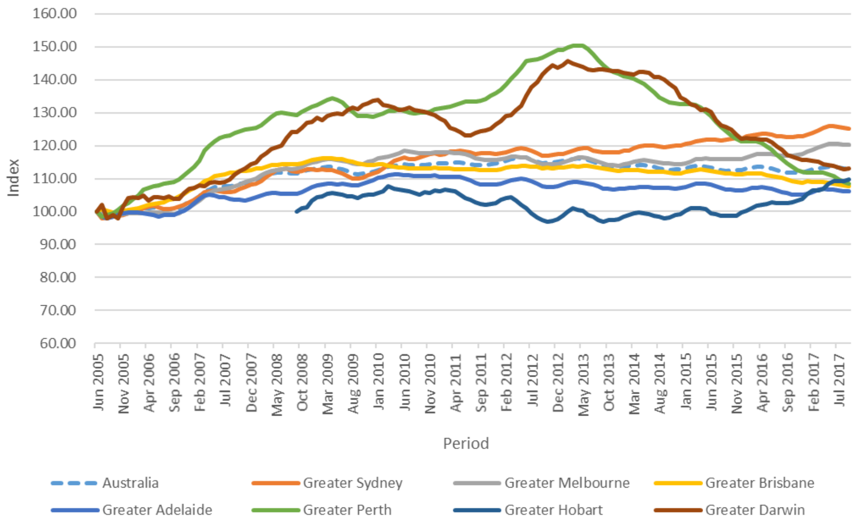
[12]A figure representing the corresponding house price indices for 'All dwellings' by States is provided in Appendix Ia.



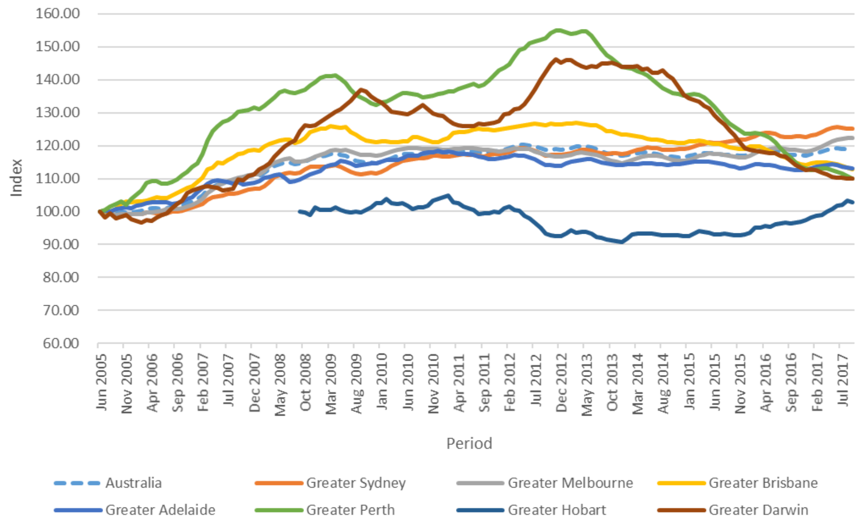
(a) Real Rental Price Index (Houses) for Australia and by States



(b) Real Rental Price Index (Units) for Australia and by States



(c) Real Rental Price Index (Houses): Australia and GCC



(d) Real Rental Price Index (Units): Australia and GCC

Figure 4.2: Real Rental Price Indices for Houses and Units

from June 2005 to September 2017 for houses and units, respectively[13]. For the period, the Australian real rental price index for houses on average has increased by around 12% with a CAGR of 0.9%. For New South Wales, the house rental price index (real) has increased by 20% with a CAGR of 1.49%, while Victoria's house rental price index (real) has increased by 15% with a CAGR of 1.14%. The unit rental price index (real) for Australia has increased by 20% with a CAGR of 1.49%, which is similar to that of Victoria. Meanwhile, for New South Wales, the units rental price index (real) has increased by 24% with a CAGR of 1.77%. The rental price index for Tasmania is available from October 2008, which is re-based to 100, and the rental price has remained constant as of September 2017.

In aggregate, the real capital return for the period from June 2005 until September 2017 has been higher (on average) than the rental market. When we look at it by property type, in the capital component, the real return for houses is more significant than for units, whereas in the rental market there are higher returns for units than houses. This finding is in line with the expectations, as many homeowners purchase units as part of the investment and rent out the property, whereas people who buy houses are mainly owner–occupiers, and therefore there is a higher return for houses in the capital component of housing market returns.

Tables 4.1 and 4.2 present the summary statistics for the levels Nationwide, States, Greater Capital Cities and corresponding Rest of States for the period June 2005 to September 2017 by property type at monthly and quarterly frequencies for real capital and rental index returns, respectively. There are a total of 148 monthly and 50 quarterly observations

[13] A figure representing the corresponding rental price indices for'All dwellings' by States is provided in Appendix Ic.

Table 4.1: Summary Statistics: Real Capital Log Returns (2005–2017)

Region	Sub Region	Houses				Units			
		Monthly		Quarterly		Monthly		Quarterly	
		Mean (%)	Std. Dev. (%)	Mean (%)	Std. Dev. (%)	Mean (%)	Std. Dev. (%)	Mean (%)	Std. Dev. (%)
Australia	Australia	0.4	0.6	1.2	1.8	0.3	0.5	0.9	1.5
ACT	ACT	0.3	0.7	0.9	1.7	0.2	0.7	0.6	1.6
NSW	NSW	0.4	0.7	1.3	2.1	0.4	0.6	1.1	1.7
	GSYD	0.5	0.8	1.5	2.4	0.4	0.7	1.2	1.8
	RNSW	0.2	0.5	0.7	1.4	0.1	0.6	0.4	1.5
NT	NT	0.3	1.1	1.0	2.5	0.1	1.3	0.3	2.9
	GDAR	0.3	1.2	1.0	2.7	0.1	1.4	0.3	3.1
	RNTE	0.4	2.0	1.0	3.7	0.2	2.6	0.5	4.1
QLD	QLD	0.2	0.6	0.6	1.7	0.1	0.6	0.2	1.7
	GBRI	0.3	0.6	0.9	1.9	0.1	0.7	0.4	2.0
	RQLD	0.1	0.5	0.4	1.5	0.0	0.6	0.1	1.6
SA	SA	0.2	0.5	0.7	1.4	0.2	0.7	0.7	1.7
	GADE	0.3	0.6	0.8	1.5	0.2	0.7	0.7	1.7
	RSAU	0.1	0.7	0.2	1.6	0.2	3.9	0.6	7.5
TAS	TAS	0.2	0.6	0.7	1.5	0.1	1.2	0.4	2.5
	GHOB	0.3	0.7	0.9	1.8	0.1	1.5	0.3	3.1
	RTAS	0.2	0.7	0.6	1.5	0.1	1.8	0.4	3.0
VIC	VIC	0.6	0.8	1.7	2.3	0.4	0.7	1.1	1.9
	GMEL	0.6	0.9	1.8	2.6	0.4	0.7	1.2	2.0
	RVIC	0.3	0.6	0.9	1.4	0.1	0.8	0.3	1.6
WA	WA	0.2	1.0	0.7	2.8	0.2	1.0	0.5	2.9
	GPER	0.2	1.0	0.7	2.9	0.2	1.1	0.6	3.0
	RWAU	0.1	1.2	0.3	3.0	-0.1	2.2	-0.1	4.4

This table reports the summary statistics of real capital monthly (148 observations) and quarterly (50 observations) index log returns for both Houses and Units at the Nationwide, States, Greater Capital Cities (GCC) and Rest of State levels for the period 2005–2017.

for all regions. Regarding property type, the real capital return for houses is higher than for units, with an average return at a national level for monthly (quarterly) frequency for houses being 0.4% (1.2%) and that for units being 0.3% (0.9%). The only region where units had a higher average return than houses is the rest of South Australia, where the average monthly (quarterly) return on houses is 0.1% (0.2%), and that for units is 0.2% (0.6%).

For the rental market, there are 148 observations for all regions at the monthly level, except for Rest of Northern Territory houses and units which have 135 and 107 observations, respectively; Rest of South Australia has 146 for Units; Tasmania and Greater Hobart

Table 4.2: Summary Statistics: Real Rental Log Returns (2005–2017)

Region	Sub Region	Houses				Units			
		Monthly		Quarterly		Monthly		Quarterly	
		Mean (%)	Std. Dev. (%)	Mean (%)	Std. Dev. (%)	Mean (%)	Std. Dev. (%)	Mean (%)	Std. Dev. (%)
Australia	Australia	0.3	0.3	0.8	1.1	0.3	0.3	1.0	0.9
ACT	ACT	0.3	0.8	0.9	2.0	0.3	1.0	0.8	2.1
NSW	NSW	0.3	0.4	0.9	1.3	0.4	0.4	1.1	0.9
	GSYD	0.4	0.4	0.9	1.3	0.4	0.4	1.1	1.0
	RNSW	0.2	0.7	0.6	1.6	0.3	0.5	1.0	1.0
NT	NT	0.3	0.9	-0.1	7.7	0.3	1.1	-2.0	20.2
	GDAR	0.3	1.0	-0.2	7.7	0.3	1.1	-2.0	20.2
	RNTE	0.3	2.2	1.0	3.8	0.2	3.2	1.1	2.7
QLD	QLD	0.2	0.4	0.6	0.8	0.3	0.5	0.6	1.7
	GBRI	0.3	0.3	0.8	0.9	0.3	0.5	0.7	1.8
	RQLD	0.1	0.6	0.5	1.0	0.2	0.6	0.7	1.1
SA	SA	0.2	0.4	0.5	1.3	0.3	0.4	0.8	0.9
	GADE	0.2	0.4	0.7	0.9	0.3	0.4	0.9	0.9
	RSAU	0.1	1.8	0.2	2.3	0.1	2.9	0.3	5.5
TAS	TAS	0.2	0.6	0.7	1.7	0.2	0.6	0.5	1.1
	GHOB	0.3	0.6	0.8	1.6	0.2	0.7	0.6	1.4
	RTAS	0.2	0.9	0.5	2.2	0.2	0.8	0.4	1.1
VIC	VIC	0.3	0.3	0.9	0.9	0.3	0.4	1.0	1.0
	GMEL	0.3	0.3	1.0	1.0	0.3	0.4	1.0	1.1
	RVIC	0.2	0.6	0.5	1.4	0.2	1.1	0.5	1.8
WA	WA	0.2	0.7	0.7	2.1	0.3	0.9	0.8	2.4
	GPER	0.3	0.7	0.8	2.1	0.3	0.9	0.8	2.4
	RWAU	0.1	1.3	0.4	2.7	0.2	3.8	0.6	7.8

This table reports the summary statistics of real rental monthly* and quarterly** index log returns for both Houses and Units at the Nationwide, States, Greater Capital Cities (GCC) and Rest of State levels for the period 2005–2017. (*There are 148 observations for all regions except for Rest of Northern Territory, with 135 for Houses and 107 for Units, Rest of South Australia with 146 for Units, Tasmania and Greater Hobart with 109 and Rest of Tasmania with 108 observations; **There are 50 observations for all regions except for Rest of Northern Territory, with 45 for Houses and 36 for Units; Rest of South Australia with 49 for Units; Tasmania and Greater Hobart with 37; and Rest of Tasmania with 36 observations.)

have 109; and Rest of Tasmania has 108 observations. For quarterly frequency, there are 50 observations for all regions except for Rest of Northern Territory houses and units, which have 45 and 36 observations respectively; Rest of South Australia has 49 for Units; Tasmania and Greater Hobart have 37; and Rest of Tasmania has 36 observations. By property type, the real rental average return at the national level for houses for monthly frequency is the same as that of units at 0.3%. However, at the quarterly level, the return for units (1%) is higher than that for houses (0.8%). By different regions, we see that most of the regions have equal or higher average rental return for units than houses, at both monthly and quarterly levels.

4.4 Empirical Results

4.4.1 Results for Different Regions

This section presents the summary of results from wild bootstrapped AVR and independent runs tests for the period 2005 to 2017 at different regional levels: National, State, GCC, SA4 and SA3 at monthly and quarterly frequencies for both houses and units in capital as well as rental markets. Results are reported for tests conducted at the 1% and 5% level of significance. Tables 4.3 and 4.4 report the number of non-overlapping geographic regions analyzed and the percentage of regions that exhibit persistence based on the conducted automatic variance ratio and independent runs test. Results are provided for houses and units, at monthly and quarterly frequencies, as well as for capital and rental housing markets.

In the capital return component of home price appreciation (Table 4.3), for houses at monthly frequency, this study finds that at the national, state and GCC levels, all regions have significant variance ratios at the 1% significance level, suggesting strong persistence in returns. At the SA4 and SA3 level, this study finds that 83% (84%) and 67% (72%) of the regions have significant variance ratios at the 1% (5%) level of significance, respectively. For quarterly returns, at the national level, this study finds significant variance ratios at the 1% level, whereas for the state, GCC, SA4 and SA3 levels, 38% (88%), 40% (80%),

Table 4.3: % Distribution of Regions with Persistence in the Capital Component of Housing Market Returns (2005–2017)

			Houses				Units			
Type	Level	No. of Regions	VR Sig. 1%	VR Sig. 5%	Runs Sig. 1%	Runs Sig. 5%	VR Sig. 1%	VR Sig. 5%	Runs Sig 1%	Runs Sig 5%
Monthly	Nation	1	100	100	100	100	100	100	100	100
	State	8	100	100	88	88	88	100	75	88
	GCC	15	100	100	93	100	67	80	47	60
	SA4	88	83	84	77	83	53	59	39	50
	SA3	334	67	72	49	58	42	51	25	36
Quarterly	Nation	1	100	100	100	100	0	0	100	100
	State	8	38	88	75	100	50	75	63	63
	GCC	15	40	80	60	67	33	53	47	53
	SA4	88	55	74	53	67	34	51	25	38
	SA3	334*	44	60	33	47	21	39	14	25

This table reports % distribution of the number of regions with persistence in capital index returns for houses and units across various regional levels at monthly and quarterly frequencies based on the Variance Ratio and Independent Runs tests. *For units, we have 331 regions.

Table 4.4: % Distribution of Regions with Persistence in the Rental Component of Housing Market Returns (2005–2017)

			Houses				Units			
Type	Level	No. of Regions	VR Sig. 1%	VR Sig. 5%	Runs Sig. 1%	Runs Sig. 5%	VR Sig. 1%	VR Sig. 5%	Runs Sig 1%	Runs Sig 5%
Monthly	Nation	1	100	100	100	100	100	100	100	100
	State	8	88	88	100	100	100	100	100	100
	GCC	15	67	73	73	80	67	73	80	80
	SA4	88	41	44	47	56	60	66	64	70
	SA3	332	26	35	27	43	52	58	42	55
Quarterly	Nation	1	100	100	0	0	0	100	0	0
	State	8	63	63	25	25	50	63	25	25
	GCC	15	33	40	13	27	33	40	27	27
	SA4	88	23	31	9	14	27	33	10	19
	SA3	332*	10	16	5	13	21	29	8	15

This table reports % distribution of the number of regions with persistence in rental index returns for houses and units across various regional levels at monthly and quarterly frequencies based on the Variance Ratio and Independent Runs tests. *For units, we have 333 regions.

55% (74%) and 44% (60%) of the regions have highly significant variance ratios at 1% (5%) significance level, respectively.

In the capital return component of unit prices, when considering monthly returns this study finds significant evidence for persistence for the national market at the 1% level of significance. At the state level, all regions have significant variance ratios at the 5% level, while 88% of states have a significant variance ratio at the 1% level. For GCC, SA4 and SA3, 67% (80%), 53% (59%) and 42% (51%) of regions have significant variance ratios at the 1% (5%) level of significance. For quarterly frequency, at national level, this study finds that the variance ratio is insignificant, even at the 5% level, and therefore I cannot reject the null hypothesis of a random walk. This result suggests that quarterly returns for units at the national level are more likely to revert to the long run mean. However, for state, GCC, SA4 and SA3 levels, I find that 50% (75), 33% (53%), 34% (51%) and 21% (39%) of the regions have significant variance ratios at the 1% (5%) level, respectively.

Let us now consider the rental return component of home price appreciation, where results are reported in Table 4.4. At the monthly frequency, this study finds that, for houses at the national level, conducted variance ratio tests indicate significance at the 1% level, suggesting highly persistent returns. For state, GCC, SA4 and SA3 regions, the study finds that 88% (88%), 67% (73%), 41% (44%) and 26% (35%) of the regions have significant variance ratios at the 1% (5%) level. For quarterly returns, I confirm these results at the national level: conducted tests indicate that the variance ratio is significantly greater than one at the 1% level of significance, suggesting strong persistence in quarterly returns. For state, GCC, SA4 and SA3 levels, I find that 63% (63%), 33% (40%), 23% (31%) and 10% (16%) of the conducted tests suggest significant variance ratios at the 1% (5%) level, respectively.

Considering the rental return component of units, for monthly returns I find that, at the national level, the variance ratio is significant at the 1% level, suggesting highly persistent returns. At the state level, all states have significant variance ratios at the 1% level of significance. For GCC, SA4 and SA3 regions, 67% (73%), 60% (66%) and 52% (58%) of regions have significant variance ratios at the 1% (5%) level of significance. For quarterly frequency, this study finds that at the national level, the variance ratio is significant at the 5% level, providing some evidence for persistence. For GCC, SA4 and SA3 levels, I find that the conducted tests suggest for 50% (63%), 33% (40%), 27% (33%) and 21% (29%) of the regions variance ratios greater than one at the 1% (5%) level, respectively.

The significant variance ratios for most regions imply that there is excess volatility for several regions with variance ratios greater than one, i.e., the variance of house price returns for longer horizons is typically significantly greater than the product of the number of monthly (quarterly) periods and the monthly (quarterly) variance of returns. Hence, these results suggest a violation of the random walk hypothesis, implying persistent returns (or weak-form inefficiency). These results are also consistent with the findings from the extrapolative model of Glaeser and Nathanson (2017), suggesting that short-term momentum and longer-term mean reversion lead to persistent returns.

Tables 4.3 and 4.4 also report results for conducted independent runs test at the 1% and 5% level of significance. I find that these are typically consistent with the results reported for the AVR tests.[14] Based on the variance ratio and independent runs test results, the results suggests that overall there is strong evidence for persistence in housing index returns, with a higher share of regions with persistence in houses than units. Meanwhile, in

[14]Summary results for implemented independent runs tests are not discussed here in detail, but are reported for each geographic region, for monthly and quarterly data, as well as for houses and units in table 4.3 and 4.4 next to the results for AVR tests.

the rental return component of home price appreciation, the study finds higher persistence in units than houses. This result is in line with the expectations, since owner–occupiers typically buy houses for their own consumption and also houses perform well in terms of capital gains. By contrast, speculators and investors typically invest into units for rental purposes, as units perform better in terms of rental income. Note that this is also consistent with the average returns reported in the summary statistics in Table 4.1 and 4.2.

In both capital and rental components of housing market returns, conducted independent runs test also suggest more regions with persistence at the monthly frequency than at the quarterly frequency. One potential reason that explains higher persistence in monthly than quarterly frequency is that the housing market is typically less volatile in the shorter horizon (e.g. month-on-month basis) than in the longer term (See Tables 4.1 and 4.2 for monthly and quarterly volatilities). This means that a positive index return over a quarter, for example, is more likely to show three successive positive returns at monthly frequency in that quarter. Hence, there is a greater tendency for index to display significant persistence at a higher frequency than at lower frequency, consistent with the findings of the extrapolative model of Glaeser and Nathanson (2017), and also Panait and Slavescu (2012) who show using GARCH-in-Mean model that there is greater persistence at higher (daily) frequency than lower (weekly/monthly) frequency. A possible implication of these results is that regions with persistent quarterly returns are riskier than regions with persistent monthly returns from a market efficiency point of view, and also from the perspective of banks/mortgage lenders and policy decision-makers. Persistence in returns indicates that housing values in the identified regions will tend to move in a given direction for a longer time, such that prices in those regions are more likely to deviate from their fundamental value before reverting back to the mean. This effect can be expected to last even longer when significant evidence for persistence for a region is found with quarterly observations.

As this study analyzes indices from SA3 regional levels up to the national level, it finds that the proportion of regions with persistent returns systematically increases. An implication of this result is that regions with highly persistent returns at lower levels must have at least a strong degree of persistence to influence the outcome of persistence in index returns at a higher level of aggregation. This suggests that while the persistence results at state or national levels—which has been the focus of most previous studies—are helpful in policy making at a macro-level, the results are not necessarily representative for lower-level regions. Under these circumstances, state- or nationwide studies might not be particularly useful for banks/mortgage lenders or speculators who want to hedge their exposures for specific regions. Therefore, my results of persistence at the local and regional levels provide a more holistic picture of persistence analysis also at lower levels of aggregation. Further, in regional levels, the study finds that regions with persistence are clustered together and concentrated near greater capital cities. This result could be mainly attributed to the spatial heterogeneity in the regions and the related informational flows, consistent with the literature on spatial diffusion, see, e.g., Clapp and Tirtiroglu (1994); Clapp et al. (1995); Dolde and Tirtiroglu (1997).

Overall, the results of this study show strong evidence for persistence and rejection of the random walk hypothesis at higher national and state levels. However, there are differences across regional area housing markets, where the null hypothesis of a random walk cannot be rejected for some regions, and thus markets are weak-form efficient. In general, given that transactions are irreversible in nature, a prior knowledge of persistence by various risk factors might enable market participants to hedge their property type, horizon, or region-specific exposures accordingly. For example, knowledge of persistence can help banks/mortgage lenders hedge their loan book positions. In a declining market with persistent returns, loan-to-value ratio increases sharply and could potentially become greater than one, increasing default risk. On the other hand, a rising market with persistent returns indicates that banks/mortgage lenders will have a higher collateral value, and consequently lower loan-to value ratios, thus alleviating credit risk. However, the increase in the collateral value does not capitalize into material gain for the banks/mortgage lenders apart from reducing the credit risk. Further, banks/mortgage lenders with exposure to areas with higher house prices also face greater risk of large declines in house values in the event of an economic downturn. Hence, banks/mortgage lenders can hedge their overall loan book positions by lending in regions where house values do not deviate significantly from their fundamental value and thus conform with efficient housing markets. In contrast, regions with persistent returns can be advantageous to speculators, investors, or hedge funds, as they can time the market entry and exit with greater accuracy than in regions with efficient markets, and earn excess economic profits. Therefore, prior knowledge of persistence in returns enables market participants to hedge their level of exposure or make economic profits for their chosen horizon.

4.4.2 Results: Wild Bootstrap AVR Test for Australia and GCC level

This section presents the wild bootstrap AVR test results for Australia, States, Corresponding Rest of States and Greater Capital Cities (GCC)[15]. Tables 4.5 and 4.6 show the wild bootstrap automatic variance ratio test results in capital market for houses and units, respectively[16]. Panels A and B provide results for monthly and quarterly frequencies, respectively.

For houses at monthly frequency (Table 4.5, Panel A), the results suggest that all regions exhibit highly significant variance ratios at the 1% level, suggesting mean aversion and strong persistence in house price index returns. While the highest variance ratios are found for New South Wales followed by Greater Sydney, Rest of New South Wales and then Australia, the Rest of Northern Territory, Greater Darwin and Northern Territory show the lowest variance ratios. This suggests that while New South Wales is the most lucrative region from speculators' perspective, it is also the region with the highest risk for banks and mortgage lenders in terms of lending. For quarterly data (Table 4.5, Panel B), I find that at the national level as well as for New South Wales, Greater Sydney, Rest of New South Wales, Tasmania, Greater Hobart, Victoria, Greater Melbourne, Rest of Victoria, Rest of Western Australia variance ratios are significant at the 1% level. Most other regions have significant variance ratios at the 5% level, further suggesting

[15] For brevity, results at the regional level for monthly and quarterly frequencies are presented as a heat map in Appendices L and M, respectively.

[16] The tables report the automatic variance ratio (AVR), test statistics and the p-value, which is calculated from the boostrapped sample distribution of the variance ratios and represents the proportion of cases in which the test statistic lies between the corresponding 95% confidence interval. The confidence intervals lower and upper represent the 2.5 percentile and 97.5 percentile of the bootstrapped distribution, respectively.

evidence for persistence in quarterly returns in the capital component of home price appreciation. Exceptions include the following regions: Rest of Northern Territory, Rest of South Australia, Western Australia (significant at 10%) and Greater Perth (significant at 10%), where I find no evidence for persistent returns. Overall, these findings indicate stronger persistence at monthly than that at quarterly frequency.

For capital index returns for units at monthly frequency (Table 4.6, Panel A), I find that most regions have highly significant variance ratios at the 1% level, except Tasmania, Greater Hobart and Rest of Western Australia which are significant at the 5% level. These results indicate persistence in the capital component of housing returns also for units. Rest of Northern Territory, Rest of South Australia and Rest of Tasmania have insignificant variance ratios, indicating no evidence of persistent returns in these regions. In Table 4.6, Panel A, I find that for quarterly frequency, many regions have insignificant variance ratios. For example, for the national level, Rest of Northern Territory, Rest of South Australia, Tasmania, Greater Hobart, Rest of Tasmania, Victoria, Greater Melbourne, Rest of Victoria, and Rest of Western Australia estimated variance ratios are insignificant. This suggests that at quarterly frequency most regions in the capital housing market for units do not exhibit significantly persistent returns, what might indicate an efficient housing market for these regions. Thus, these markets will typically also be less risky from the perspective of banks and mortgage lenders, as prices are more likely to follow a random walk and therefore do not significantly deviate from their fundamental value. At the same time, these markets may also be less profitable from an investor's point of view, as these markets may not present opportunities for excess returns.

Overall the trend in the capital component of housing market returns shows that there is stronger evidence for persistence for houses compared to units, as also documented by

Table 4.5: Wild Bootstrap AVR Test: Capital Index Return for Houses

Panel A: Monthly

Region	Sub Region	VR	test.stat	pval	CI.VR lower	CI.VR upper	CI.stat lower	CI.stat upper
Australia	Australia	7.5732	9.5748	0^a	0.6874	1.5762	-1.7731	2.7765
ACT	ACT	4.8164	11.5001	0^a	0.7610	1.4145	-1.4540	2.0588
NSW	NSW	11.0538	16.2134	0^a	0.6507	1.5040	-2.0199	2.5018
	GSYD	10.6643	15.8555	0^a	0.6482	1.4957	-2.0110	2.4173
	RNSW	8.1062	15.8613	0^a	0.6874	1.4287	-1.8162	2.1511
NT	NT	2.3601	5.4039	0^a	0.7608	1.2616	-1.4662	1.4616
	GDAR	2.1011	4.5482	0^a	0.7577	1.2811	-1.4524	1.5369
	RNT	1.3800	1.9316	0.002^a	0.8487	1.1718	-0.9534	1.0186
QLD	QLD	7.0333	9.6301	0^a	0.5980	1.6764	-2.2752	3.0698
	GBRI	7.8483	10.5657	0^a	0.6144	1.6437	-2.2052	3.0179
	RQLD	6.2972	10.5463	0^a	0.6062	1.7271	-2.2045	3.2937
SA	SA	6.4904	12.6775	0^a	0.6524	1.5782	-1.9947	2.5974
	GADE	7.0630	13.6593	0^a	0.6487	1.6312	-1.9750	2.7610
	RSAU	2.0322	4.0910	0^a	0.7979	1.3035	-1.2186	1.6047
TAS	TAS	5.5165	12.0312	0^a	0.6681	1.4826	-1.9077	2.3630
	GHOB	4.5509	11.1564	0^a	0.7338	1.3325	-1.5971	1.7319
	RTAS	2.8728	6.7096	0^a	0.7108	1.4443	-1.6730	2.2143
VIC	VIC	8.4228	11.5824	0^a	0.6435	1.5793	-2.0225	2.8416
	GMEL	8.6559	11.9034	0^a	0.6521	1.5739	-2.0181	2.7861
	RVIC	3.4985	8.2755	0^a	0.7612	1.3582	-1.4290	1.8116
WA	WA	8.1115	10.8656	0^a	0.5952	1.6819	-2.3237	3.2297
	GPER	7.4011	9.4932	0^a	0.6100	1.7103	-2.2526	3.3067
	RWAU	3.5252	9.2192	0^a	0.7543	1.3107	-1.4561	1.6586

Panel B: Quarterly

Region	Sub Region	VR	test.stat	pval	CI.VR lower	CI.VR upper	CI.stat lower	CI.stat upper
Australia	Australia	2.7864	2.5752	0.008^a	0.5633	1.6583	-1.5587	1.7878
ACT	ACT	1.8492	1.6681	0.042^b	0.5955	1.6908	-1.4431	1.8103
NSW	NSW	4.5410	5.2111	0^a	0.5431	1.7522	-1.6121	2.0001
	GSYD	4.4604	5.1689	0^a	0.5422	1.6838	-1.6260	1.8667
	RNSW	3.3354	4.4695	0^a	0.6283	1.6048	-1.3341	1.7113
NT	NT	1.5821	1.5171	0.024^b	0.6742	1.4250	-1.2050	1.2628
	GDAR	1.4828	1.2959	0.028^b	0.6920	1.3844	-1.1408	1.1853
	RNT	1.1964	0.7036	0.264	0.6654	1.5405	-1.2172	1.5787
QLD	QLD	2.6074	2.4723	0.014^b	0.5088	1.7687	-1.7290	2.0215
	GBRI	2.8713	2.7043	0.014^b	0.4983	1.8327	-1.7501	2.1284
	RQLD	2.3694	2.3666	0.016^b	0.5407	1.7680	-1.6130	2.0935
SA	SA	2.2714	2.4031	0.012^b	0.5880	1.6410	-1.4705	1.7188
	GADE	2.4072	2.4738	0.012^b	0.5549	1.6479	-1.5729	1.8553
	RSAU	1.1504	0.6259	0.292	0.6374	1.5629	-1.3012	1.5950
TAS	TAS	2.5008	2.9117	0.002^a	0.6003	1.6286	-1.4104	1.7049
	GHOB	2.7137	3.2509	0.002^a	0.6534	1.5564	-1.2449	1.5901
	RTAS	1.6789	1.6268	0.038^b	0.5976	1.5818	-1.4409	1.6151
VIC	VIC	3.5509	3.3753	0.002^a	0.4946	1.7255	-1.7614	1.9958
	GMEL	3.6534	3.5392	0^a	0.5163	1.6649	-1.6882	1.9056
	RVIC	2.0025	2.3873	0.002^a	0.6501	1.5614	-1.2580	1.5802
WA	WA	2.7669	2.3911	0.056^c	0.4236	2.1458	-1.9934	2.8056
	GPER	2.5681	2.1721	0.086^c	0.4322	2.1171	-1.9935	2.7233
	RWAU	3.5589	4.6970	0.002^a	0.5160	1.7692	-1.7192	2.0490

Within Table 4.5, Panels A and B report the Wild Bootstrap Automatic Variance Ratio (AVR) test results for capital index return for houses at the GCC level (Australia, States, Corresponding Rest of States and Greater Capital Cities) for monthly and quarterly frequencies, respectively. VR is the variance ratio. CI stands for Confidence Interval; a, b and c represent significance levels at 1%, 5% and 10%, respectively.

Gatzlaff and Tirtiroğlu (1995). This study also finds that persistence is generally higher in monthly than in quarterly returns. Further, there is evidence of systematically higher persistence in greater capital cities than in the rest of Australia's states. This also shows that the regions that have higher index returns, on average, also have higher persistence in their index returns, and hence higher returns are found to be correlated with persistence or weak-form market inefficiency.

Let us now consider the results for rental markets in Australia. Tables 4.7 and 4.8 present the wild bootstrap AVR test results in the rental markets for houses and units as well as for monthly (Panel A) and quarterly (Panel B) returns.

For houses, when monthly returns are considered (Table 4.7, Panel A), this study finds that apart from Rest of New South Wales, Rest of Northern Territory, Rest of South Australia, and Rest of Tasmania, all regions have significant variance ratios at the 1% level, except for Rest of Queensland, Greater Adelaide and Tasmania where the ratios are significant at the 5% level. Overall, these results suggest high persistence for the index returns in the rental component of houses. For quarterly index returns (Table 4.7, Panel B), the results are quite different. The study finds that for most regions, the null hypothesis of a random walk cannot be rejected at the 5% significance level, except for Northern Territory, Greater Darwin, Queensland, Greater Brisbane, Greater Melbourne, Western Australia and Greater Perth, where the variance ratios are significant even at the 1% level, and for Victoria and Greater Sydney, where the variance ratios are significant at the 5% level.

In the rental component of housing market appreciation for units at monthly frequency (Table 4.8), this study finds that the variance ratios are significant in most regions at the

Table 4.6: Wild Bootstrap AVR Test: Capital Index Return for Units

Panel A: Monthly

Region	Sub Region	VR	test.stat	pval	CI.VR lower	CI.VR upper	CI.stat lower	CI.stat upper
Australia	Australia	5.2856	8.0250	0^a	0.6900	1.5221	-1.7946	2.5096
ACT	ACT	2.3223	5.6465	0^a	0.7604	1.3449	-1.4362	1.8179
NSW	NSW	7.8786	14.5462	0^a	0.6823	1.4755	-1.8569	2.2562
	GSYD	7.5855	14.2665	0^a	0.6779	1.4582	-1.8647	2.2334
	RNSW	4.5897	11.4863	0^a	0.6826	1.3785	-1.8376	1.9366
NT	NT	2.4934	5.8759	0^a	0.7822	1.2192	-1.2939	1.2415
	GDAR	2.2715	5.1903	0^a	0.7657	1.2154	-1.3984	1.1880
	RNT	0.8596	-0.9094	0.176	0.7679	1.2574	-1.3968	1.4163
QLD	QLD	7.8703	13.0989	0^a	0.6236	1.6310	-2.1550	2.8441
	GBRI	7.2298	12.7908	0^a	0.6171	1.6637	-2.2034	3.0948
	RQLD	6.7252	14.8956	0^a	0.6848	1.5169	-1.8281	2.5827
SA	SA	2.9926	7.0827	0^a	0.7227	1.4545	-1.6102	2.2125
	GADE	2.9303	7.0850	0^a	0.7183	1.3997	-1.6589	1.9915
	RSAU	1.0124	0.1011	0.716	0.7617	1.2758	-1.4416	1.5002
TAS	TAS	1.3533	1.7167	0.044^b	0.7305	1.3279	-1.5876	1.7632
	GHOB	1.3659	1.7141	0.048^b	0.7254	1.3793	-1.6010	1.9234
	RTAS	1.0799	0.5236	0.454	0.7628	1.2945	-1.4279	1.5243
VIC	VIC	5.5933	9.5143	0^a	0.6469	1.6456	-2.0466	2.9424
	GMEL	5.5735	9.2868	0^a	0.6315	1.6461	-2.1229	2.9420
	RVIC	1.4897	2.3954	0.004^a	0.7486	1.3449	-1.4963	1.7927
WA	WA	8.5607	15.5996	0^a	0.6718	1.5322	-1.8908	2.5808
	GPER	8.1724	14.9775	0^a	0.6589	1.5700	-1.9734	2.7501
	RWAU	1.4042	2.0458	0.018^b	0.7735	1.2852	-1.3629	1.5946

Panel B: Quarterly

Region	Sub Region	VR	test.stat	pval	CI.VR lower	CI.VR upper	CI.stat lower	CI.stat upper
Australia	Australia	1.8897	1.4148	0.086^c	0.5628	1.6341	-1.5490	1.7943
ACT	ACT	1.9482	2.1265	0.014^b	0.6150	1.6792	-1.3895	1.9153
NSW	NSW	3.9325	4.5531	0^a	0.5580	1.6524	-1.5603	1.8150
	GSYD	3.9387	4.6406	0^a	0.5668	1.6514	-1.5459	1.7381
	RNSW	3.7069	4.7676	0^a	0.5893	1.6257	-1.4576	1.7590
NT	NT	3.5253	5.2349	0^a	0.6967	1.5706	-1.1048	1.6630
	GDAR	3.3273	5.0102	0^a	0.7051	1.4687	-1.0876	1.4230
	RNT	1.1357	0.4706	0.43	0.6346	1.5717	-1.3074	1.6118
QLD	QLD	3.5488	3.9288	0^a	0.5386	1.7722	-1.6395	2.1380
	GBRI	3.2458	3.4372	0.006^a	0.4897	1.7790	-1.7841	2.0143
	RQLD	3.7986	4.6722	0^a	0.5531	1.8432	-1.5728	2.1867
SA	SA	1.7454	1.9155	0.03^b	0.5761	1.6946	-1.5295	1.9043
	GADE	2.0297	2.5018	0.012^b	0.5976	1.7027	-1.4318	1.8636
	RSAU	0.9576	-0.1734	0.7	0.5894	1.6417	-1.4844	1.7791
TAS	TAS	1.0448	0.1847	0.51	0.7765	1.3506	-0.8491	1.0992
	GHOB	1.1119	0.4445	0.204	0.8021	1.2763	-0.7563	0.9343
	RTAS	1.1362	0.4943	0.424	0.6085	1.5265	-1.3936	1.5615
VIC	VIC	1.9501	1.4701	0.116	0.5529	1.7943	-1.5774	2.1235
	GMEL	2.1099	1.6843	0.078^c	0.5423	1.8008	-1.5994	2.1406
	RVIC	1.1033	0.4194	0.53	0.6092	1.4906	-1.4046	1.4625
WA	WA	3.1784	3.5357	0.004^a	0.4456	2.0256	-1.9457	2.6875
	GPER	2.9072	3.1223	0.014^b	0.4143	2.0797	-2.0340	2.8230
	RWAU	1.3396	1.0365	0.16	0.5666	1.5250	-1.5303	1.5430

Table 4.6 Panels A and B report the Wild Bootstrap Automatic Variance Ratio (AVR) test results for capital index return for houses at the GCC level (Australia, States, Corresponding Rest of States and Greater Capital Cities) for monthly and quarterly frequencies, respectively; VR is the variance ratio; CI stands for Confidence Interval; a, b and c represent significance levels at 1%, 5% and 10%, respectively.

1% level. Exceptions include the Rest of Tasmania (significance at the 5% level), the Rest of Northern Territory, Rest of South Australia, Tasmania, Rest of Victoria, and Rest of Western Australia, where conducted AVR tests are insignificant, and therefore, the null hypothesis of random walk cannot be rejected. At quarterly frequency, this study finds that there is persistence in index returns in Australia, New South Wales, Greater Sydney, Northern Territory, Greater Darwin, Queensland, Greater Brisbane, Victoria, Greater Melbourne, Western Australia and Greater Perth, with variance ratios significant at the 1% level, while the Rest of Queensland has a variance ratio significant at the 5% level. All other regions have insignificant variance ratios, suggesting that these regions must conform with weak-form efficiency in the rental component of housing returns.

Regions that exhibit persistence in rental returns are typically riskier for banks/mortgage lenders as there is more volatility in rental income returns that affects the bank's estimation of affordability measures of the borrower. From the perspective of investors, persistence in rental returns is beneficial as they can use this information to inform their capital investment decisions. Further, regions that have persistent returns at quarterly frequency are even riskier as the effects at quarterly frequency are further accentuated. One observes that there are consistently more regions with persistence in monthly returns than in quarterly returns. Therefore, this finding suggests that there are more regions with lesser risks where banks/mortgage lenders can provide loans. For investors, this finding implies that there are less opportunities for generating higher rental income.

Based on the variance ratio analysis, I also observe that, in the capital component of housing market return, there is higher persistence in houses than in units vis-a-vis in rental markets, where persistence in units is typically higher than in houses. Further, I also find that there is higher persistence in greater capital cities as compared to the rest of states in both capital and rental markets. This result suggests that banks and mortgage lenders might want to provide more lending in regional areas as opposed to greater capital cities, while investors and speculators will likely find profit opportunities by investing in greater capital cities as opposed to regional areas.

4.4.3 Results: Independent Runs Test for Australia and GCC level

Tables 4.9 presents the results from independent runs test for houses and units in the capital component of housing market returns. Overall, the results based on the independent runs test are consistent with the results for the conducted AVR tests. For houses, runs test in monthly returns are statistically significant and negative for all regions except for the Northern Territory. The number of runs is less than expected, suggesting that house price index returns are mean averting and thus persistent in nature. Results based on quarterly returns for single dwelling homes are negative and statistically significant at the 5% level for most regions, suggesting persistent returns, except for Greater Darwin, Rest of Northern Territory, Rest of South Australia, Rest of Tasmania, and Rest of Victoria, where the test is insignificant at the 5% level.

In the case of monthly returns for units, this study finds persistent returns for most regions—except for Rest of Northern Territory, Rest of South Australia, Tasmania, Greater Hobart, Rest of Tasmania, Rest of Victoria and Rest of Western Australia. For quarterly returns, I find that most regions have persistence in the rental component of index returns, with the exception of the Australian Capital Territory, Rest of Northern Territory, South

Table 4.7: Wild Bootstrap AVR Test: Rental Index Return for Houses

Panel A: Monthly

Region	Sub Region	VR	test.stat	pval	CI.VR lower	CI.VR upper	CI.stat lower	CI.stat upper
Australia	Australia	4.4108	8.2501	0^a	0.6686	1.5557	-1.8887	2.7229
ACT	ACT	2.6758	5.7160	0^a	0.6885	1.3816	-1.8289	1.9092
NSW	NSW	2.5675	5.5952	0^a	0.7266	1.4085	-1.6378	2.0334
	GSYD	2.9493	5.8931	0^a	0.7126	1.5676	-1.6876	2.5305
	RNSW	0.9984	-0.0125	0.958	0.6333	1.5660	-2.0937	2.6413
NT	NT	1.7508	3.6333	0.002^a	0.6273	1.4051	-2.1237	1.9286
	GDAR	2.4120	5.9656	0^a	0.6399	1.3582	-2.0837	1.8639
	RNT	0.8167	-1.0700	0.256	0.6849	1.4420	-1.7741	2.0231
QLD	QLD	3.1980	7.5930	0^a	0.6862	1.5046	-1.8575	2.4507
	GBRI	7.2183	16.4706	0^a	0.6668	1.6320	-1.9287	2.9583
	RQLD	1.5282	2.5964	0.032^b	0.6499	1.5066	-2.0445	2.5501
SA	SA	2.0919	4.2707	0^a	0.7461	1.3001	-1.4978	1.5853
	GADE	1.9017	2.5427	0.024^b	0.6868	1.4824	-1.8141	2.2724
	RSAU	1.0012	0.0091	0.966	0.6298	1.5855	-2.1093	2.6396
TAS	TAS	2.1730	3.4420	0.024^b	0.5910	1.9047	-2.0098	3.3679
	GHOB	2.1725	3.2782	0^a	0.6969	1.4041	-1.5581	1.7455
	RTAS	1.5378	1.8488	0.19	0.5333	1.8689	-2.3123	3.2453
VIC	VIC	5.1335	9.6436	0^a	0.6933	1.4582	-1.7743	2.2367
	GMEL	7.5874	13.4841	0^a	0.6631	1.5824	-1.9695	2.7158
	RVIC	1.7659	3.4344	0^a	0.8353	1.2377	-1.0291	1.2971
WA	WA	8.9590	18.5944	0^a	0.6957	1.3762	-1.7538	1.8909
	GPER	11.9471	21.6379	0^a	0.6948	1.4333	-1.8060	2.0830
	RWAU	1.4804	2.4850	0.008^a	0.7064	1.3596	-1.7368	1.8280

Panel B: Quarterly

Region	Sub Region	VR	test.stat	pval	CI.VR lower	CI.VR upper	CI.stat lower	CI.stat upper
Australia	Australia	1.5610	1.4635	0.08^c	0.5858	1.7120	-1.4732	1.9181
ACT	ACT	1.5239	1.4316	0.106	0.5498	1.7689	-1.6031	2.0649
NSW	NSW	1.3514	0.9559	0.178	0.6315	1.6177	-1.3459	1.7233
	GSYD	1.6908	1.7507	0.028^b	0.6197	1.5652	-1.3730	1.6958
	RNSW	1.0840	0.2465	0.636	0.6007	1.6864	-1.4283	1.9367
NT	NT	3.2108	4.7154	0^a	0.6554	1.5732	-1.2593	1.6558
	GDAR	4.0455	5.8495	0^a	0.6414	1.6001	-1.2914	1.6842
	RNT	0.9935	-0.0430	0.83	0.6200	1.7025	-1.3250	1.7947
QLD	QLD	1.9795	2.4754	0.006^a	0.5959	1.6688	-1.4480	1.8072
	GBRI	5.1357	7.1562	0^a	0.4414	2.0451	-1.9374	2.5136
	RQLD	1.1955	0.6998	0.344	0.5759	1.5227	-1.5136	1.4833
SA	SA	1.0989	0.3466	0.504	0.7228	1.4970	-1.0252	1.4292
	GADE	1.0484	0.1624	0.67	0.6763	1.4797	-1.1760	1.4325
	RSAU	0.6803	-1.1786	0.26	0.5251	2.1714	-1.6719	2.8510
TAS	TAS	1.0031	0.0133	0.902	0.6912	1.5450	-0.9843	1.3600
	GHOB	0.9528	-0.1326	0.698	0.6199	1.5865	-1.2024	1.4679
	RTAS	0.7250	-0.8828	0.336	0.4908	1.8511	-1.5790	1.8833
VIC	VIC	1.7607	1.9475	0.018^b	0.6268	1.6367	-1.3440	1.7789
	GMEL	2.4243	3.2802	0.002^a	0.5537	1.7148	-1.5738	1.9416
	RVIC	1.0106	0.0658	0.738	0.6801	1.4949	-1.1648	1.4018
WA	WA	4.9097	7.0506	0^a	0.6210	1.6719	-1.3649	1.8650
	GPER	5.1474	7.2981	0^a	0.6598	1.6113	-1.2398	1.7024
	RWAU	1.5089	1.5185	0.054^c	0.6203	1.6662	-1.3541	1.8952

Table 4.7 Panels A and B report the Wild Bootstrap Automatic Variance Ratio (AVR) test results for rental index return for houses at the GCC level (Australia, States, Corresponding Rest of States and Greater Capital Cities) for monthly and quarterly frequencies, respectively; VR is the variance ratio; CI stands for Confidence Interval; a, b and c represent significance levels at 1%, 5% and 10%, respectively.

Table 4.8: Wild Bootstrap AVR Test - Rental Index Return for Units

Panel A: Monthly

Region	Sub Region	VR	test.stat	pval	CI.VR lower	CI.VR upper	CI.stat lower	CI.stat upper
Australia	Australia	5.8899	11.6442	0^a	0.6322	1.6078	-2.0948	2.8498
ACT	ACT	2.2612	4.6083	0.002^a	0.6822	1.4398	-1.8491	2.1306
NSW	NSW	3.9598	8.1719	0^a	0.6559	1.5630	-1.9481	2.6218
	GSYD	3.9914	8.3007	0^a	0.6467	1.5514	-2.0167	2.5785
	RNSW	2.0403	4.2076	0^a	0.8033	1.2846	-1.2073	1.4888
NT	NT	3.9088	10.1558	0^a	0.7518	1.3527	-1.4962	1.8031
	GDAR	4.9372	12.3095	0^a	0.7221	1.4059	-1.6352	2.0338
	RNT	0.7171	-1.4032	0.382	0.3416	2.0015	-3.1335	3.5385
QLD	QLD	3.3560	8.1889	0^a	0.7081	1.4882	-1.7012	2.3868
	GBRI	3.8443	9.4378	0^a	0.7175	1.4695	-1.6447	2.3398
	RQLD	1.9395	4.3403	0^a	0.6884	1.4429	-1.8274	2.1673
SA	SA	2.4118	4.8463	0^a	0.7056	1.4541	-1.7609	2.2727
	GADE	2.5130	4.9380	0^a	0.7090	1.5028	-1.7532	2.3829
	RSAU	1.3200	1.4791	0.18	0.6022	1.5512	-2.3196	2.6220
TAS	TAS	1.1997	1.0112	0.208	0.7198	1.4284	-1.4611	1.8390
	GHOB	1.8930	3.5679	0^a	0.6995	1.4536	-1.5275	1.9228
	RTAS	0.6110	-1.9398	0.024^b	0.7065	1.4169	-1.5222	1.8161
VIC	VIC	6.0566	12.1443	0^a	0.6532	1.5982	-2.0154	2.7229
	GMEL	7.0652	13.4116	0^a	0.6284	1.6476	-2.0675	2.8731
	RVIC	0.7321	-1.5566	0.314	0.4601	1.7465	-2.9433	3.1080
WA	WA	6.9974	15.4358	0^a	0.6656	1.4910	-1.9388	2.3429
	GPER	9.0517	17.9923	0^a	0.6445	1.5278	-2.0565	2.4752
	RWAU	1.3295	1.5710	0.212	0.5925	1.7143	-2.2887	3.1405

Panel B: Quarterly

Region	Sub Region	VR	test.stat	pval	CI.VR lower	CI.VR upper	CI.stat lower	CI.stat upper
Australia	Australia	2.6827	3.7147	0^a	0.5674	1.6745	-1.5340	1.9195
ACT	ACT	1.2534	0.7299	0.27	0.6356	1.5414	-1.3278	1.5561
NSW	NSW	2.1333	2.6460	0^a	0.6461	1.5278	-1.2842	1.5580
	GSYD	2.2168	2.8067	0^a	0.6519	1.5295	-1.2574	1.6036
	RNSW	0.9518	-0.1563	0.692	0.6581	1.5756	-1.2284	1.7280
NT	NT	3.9190	5.5917	0^a	0.6400	1.6131	-1.2981	1.7763
	GDAR	4.1766	5.9837	0^a	0.5911	1.6134	-1.4617	1.7103
	RNT	0.7703	-0.7532	0.392	0.4839	1.7455	-1.5683	1.7031
QLD	QLD	2.5734	3.5872	0^a	0.5514	1.7105	-1.5932	1.9702
	GBRI	3.1306	4.7423	0^a	0.5910	1.6443	-1.4526	1.8635
	RQLD	1.6948	1.7847	0.024^b	0.6011	1.5837	-1.4335	1.6906
SA	SA	1.0761	0.2219	0.686	0.6188	1.7342	-1.3743	1.9553
	GADE	1.3342	0.8995	0.224	0.6344	1.5882	-1.3144	1.7295
	RSAU	0.7098	-1.0701	0.426	0.3058	2.3755	-2.3556	2.9755
TAS	TAS	1.3141	0.7688	0.158	0.6661	1.4811	-1.0679	1.2433
	GHOB	1.0655	0.1736	0.63	0.6267	1.5217	-1.1641	1.3029
	RTAS	1.3686	0.8853	0.144	0.6292	1.5688	-1.1629	1.4711
VIC	VIC	2.7318	3.8487	0.002^a	0.5693	1.7329	-1.5244	2.0274
	GMEL	2.7614	3.9066	0.002^a	0.5630	1.7649	-1.5241	2.0806
	RVIC	1.0028	0.0139	0.906	0.6586	1.4662	-1.2549	1.3749
WA	WA	4.8665	7.1101	0^a	0.6196	1.6479	-1.3527	1.7994
	GPER	4.8704	6.9495	0^a	0.5965	1.6070	-1.4500	1.6975
	RWAU	0.7789	-0.8368	0.342	0.5252	1.6985	-1.6753	1.8274

Table 4.8 Panels A and B report the Wild Bootstrap Automatic Variance Ratio (AVR) test results for rental index return for houses at the GCC level (Australia, States, Corresponding Rest of States and Greater Capital Cities) for monthly and quarterly frequencies, respectively; VR is the variance ratio; CI stands for Confidence Interval; a, b and c represent significance levels at 1%, 5% and 10%, respectively.

Australia, Rest of South Australia, Tasmania, Greater Hobart, Rest of Tasmania, Rest of Victoria, and Rest of Western Australia.

For rental markets, the conducted runs test also widely confirm the results of the AVR tests. For houses at monthly frequency, I find the test statistic to be negative and significant, suggesting persistence in rental index returns for all regions, except for Rest of Northern Territory, Rest of South Australia, and Rest of Western Australia, where the test statistic is insignificant. In contrast, at quarterly frequency, the study cannot reject the null of a random walk for all regions, except for Northern Territory, Greater Darwin, Greater Brisbane, Western Australia and Greater Perth, where the test statistics are negative and significant at the 5% level, indicating persistence in rental index returns for single-family dwellings.

For monthly unit returns, with the exception of Rest of South Australia, Rest of Tasmania, and Rest of Western Australia, this study finds persistence in all other regions. At a quarterly level, the null of a random walk cannot be rejected for all regions, except for Northern Territory, Greater Darwin, Greater Brisbane, Rest of Tasmania, Western Australia and Greater Perth where the test statistics are negative and significant at the 5% level, suggesting persistent rental index returns for multi-family dwellings.

Overall, I find consistent pattern for the results of conducted variance ratio and independent runs test. There is a higher level of persistence in monthly than in quarterly returns. Consistent with the variance ratio tests results, I also find a higher level of persistence for single-family houses than for multi-family units in the capital component of housing market returns. On the other hand, for the rental component of housing market appreciation, units have greater persistence than houses. Finally, I also observe that, overall, there is higher persistence in capital component of housing market return as compared with rental market returns. This study also finds that persistence in returns tends to exist more in the greater capital cities than in the rest of states.

Table 4.9: Independent Runs Test: Capital Index Return

Region	Sub Region	Houses				Units			
		Monthly		Quarterly		Monthly		Quarterly	
		stat	pval	stat	pval	stat	pval	stat	pval
Australia	Australia	-9.25	0.0000	-4.54	0.0000	-8.16	0.0000	-4.91	0.0000
ACT	ACT	-4.95	0.0000	-2.74	0.0061	-2.20	0.0280	-1.87	0.0608
NSW	NSW	-8.80	0.0000	-4.04	0.0001	-8.33	0.0000	-5.01	0.0000
	GSYD	-8.45	0.0000	-4.09	0.0000	-7.91	0.0000	-5.01	0.0000
	RNSW	-7.84	0.0000	-3.79	0.0002	-4.71	0.0000	-4.47	0.0000
NT	NT	-1.60	0.1103	-2.11	0.0345	-4.39	0.0000	-3.57	0.0004
	GDAR	-2.49	0.0126	-0.95	0.3436	-4.01	0.0001	-3.90	0.0001
	RNT	-2.70	0.0069	-0.36	0.7164	0.42	0.6752	-0.43	0.6669
QLD	QLD	-8.16	0.0000	-2.82	0.0048	-7.20	0.0000	-3.49	0.0005
	GBRI	-7.75	0.0000	-4.04	0.0001	-5.77	0.0000	-3.19	0.0014
	RQLD	-6.85	0.0000	-2.45	0.0142	-5.59	0.0000	-3.35	0.0008
SA	SA	-5.77	0.0000	-2.44	0.0148	-4.21	0.0000	-0.50	0.6168
	GADE	-5.51	0.0000	-3.03	0.0024	-2.54	0.0110	-2.41	0.0161
	RSAU	-2.73	0.0064	-0.59	0.5553	-1.22	0.2237	0.22	0.8256
TAS	TAS	-5.77	0.0000	-2.59	0.0095	-1.57	0.1160	-0.50	0.6168
	GHOB	-4.62	0.0000	-3.83	0.0001	-1.89	0.0585	-0.72	0.4720
	RTAS	-3.01	0.0026	-1.24	0.2154	0.28	0.7822	-0.07	0.9430
VIC	VIC	-7.85	0.0000	-5.25	0.0000	-5.60	0.0000	-3.66	0.0002
	GMEL	-8.87	0.0000	-5.25	0.0000	-6.28	0.0000	-4.22	0.0000
	RVIC	-4.73	0.0000	-1.86	0.0633	-1.29	0.1957	-0.41	0.6832
WA	WA	-8.23	0.0000	-3.73	0.0002	-7.66	0.0000	-3.73	0.0002
	GPER	-7.32	0.0000	-3.79	0.0002	-7.00	0.0000	-3.73	0.0002
	RWAU	-4.16	0.0000	-2.59	0.0095	-1.73	0.0837	-1.02	0.3063

Table 4.9 presents the Independent Runs test results for capital index return for houses and units at national and state levels for monthly and quarterly frequencies.

Table 4.10: Independent Runs Test for Houses: Rental Index Return

Region	Sub Region	Houses				Units			
		Monthly		Quarterly		Monthly		Quarterly	
		stat	pval	stat	pval	stat	pval	stat	pval
Australia	Australia	-9.57	0.0000	-0.50	0.6168	-7.00	0.0000	-1.1000	0.2720
ACT	ACT	-3.60	0.0000	-0.99	0.3202	-4.81	0.0000	-1.1800	0.2382
NSW	NSW	-6.69	0.0000	0.00	1.0000	-4.67	0.0000	-0.4400	0.6569
	GSYD	-7.04	0.0000	-0.28	0.7807	-4.09	0.0000	0.0400	0.9707
	RNSW	-4.57	0.0002	0.07	0.9443	-3.04	0.0024	0.5300	0.5975
NT	NT	-0.72	0.0038	-2.44	0.0148	-5.70	0.0000	-3.6000	0.0003
	GDAR	-0.73	0.0000	-4.19	0.0000	-6.04	0.0000	-3.5700	0.0004
	RNT	0.22	0.8643	-0.31	0.7603	-2.56	0.0106	-1.8000	0.0714
QLD	QLD	-6.38	0.0000	-0.66	0.5124	-6.20	0.0000	-1.5900	0.1128
	GBRI	-6.82	0.0000	-2.45	0.0142	-4.88	0.0000	-2.1100	0.0345
	RQLD	-4.50	0.0003	-1.34	0.1795	-3.87	0.0001	-1.7000	0.0898
SA	SA	-3.80	0.0000	-0.07	0.9430	-6.02	0.0000	-0.9900	0.3232
	GADE	-5.96	0.0000	-0.14	0.8875	-5.21	0.0000	-0.9900	0.3232
	RSAU	-1.38	0.8612	0.88	0.3763	-0.38	0.7021	0.0100	0.9903
TAS	TAS	-3.60	0.0000	-0.61	0.5425	-2.71	0.0068	-1.9100	0.0555
	GHOB	-3.92	0.0000	-0.61	0.5425	-3.83	0.0001	-1.3500	0.1761
	RTAS	-2.34	0.0023	0.02	0.9850	1.26	0.2063	-2.5700	0.0101
VIC	VIC	-8.38	0.0000	-1.30	0.1947	-5.83	0.0000	-0.8800	0.3763
	GMEL	-8.08	0.0000	-0.99	0.3202	-6.86	0.0000	-0.8000	0.4240
	RVIC	-1.94	0.0000	-0.12	0.9058	-2.70	0.0070	0.1000	0.9222
WA	WA	-7.71	0.0000	-4.19	0.0000	-7.34	0.0000	-4.4700	0.0000
	GPER	-8.36	0.0000	-4.18	0.0000	-8.02	0.0000	-2.7000	0.0070
	RWAU	-0.65	0.8940	-0.50	0.6168	-1.43	0.1530	-1.0100	0.3134

Table 4.10 presents the Independent Runs test results for rental index return for houses and units at national and state levels for monthly and quarterly frequencies.

4.5 Conclusion

Overall, this study provides a comprehensive analysis of persistence in inflation-adjusted Australian housing market returns from several perspectives. First, I examine persistence in the capital and rental return components of house price appreciation. Second, I test for persistence not only at the broader nationwide and state level, but also across all non-overlapping geographic areas at three regional levels: Greater Capital Cities (GCC), Statistical Area Level 4 (SA4) and Statistical Area Level 3 (SA3). Third, this study tests for persistence in returns of both single- and multi-family-dwelling separately. Finally, the study also analyzes persistence not only at a quarterly but also at a higher (monthly) frequency. Thus, this study further extends and enhances the methodology applied by Schindler (2013, 2014) for testing persistence in the housing market index returns in two important ways: first, by employing an automatic data-dependent lag selection procedure from Choi (1999), thus making the model free from an arbitrary choice of the applied lag term. Second, by applying a wild bootstrapping approach to the automatic variance ratio test with desirable finite sample properties as compared to the traditional variance ratio test (Kim, 2006).

Based on wild bootstrapped automatic variance ratio and non-parametric—independent runs tests of the random walk hypothesis, the key findings show that both regional- and national-level inflation-adjusted house price indices in Australia exhibit strong persistence in returns. Overall, there is higher persistence in the capital component of housing market returns compared to the rental component of housing market appreciation; further, houses have more persistence than units, in general. However, when considering capital and rental housing markets separately, this study finds that, in the capital component of housing market returns, single-family dwellings (houses) exhibit stronger persistence than multi-family dwellings (units). Conversely, in the rental component of housing market returns, units have higher persistence than houses. This result is consistent with the investment motives of speculators. Owner–occupiers typically buy houses for their consumption and also expect houses to perform well in terms of capital gains. Speculators and investors, on the other hand, typically own units for rental purposes, as units perform well in terms of rental income, which explains why there is more persistence in returns for houses in the capital component of housing market returns than for units in rental markets.

Additionally, I find that there is significant variation in the persistence at regional SA3 and SA4 levels, and that persistence in housing market returns is clustered together and mostly concentrated near greater capital cities. This finding could mainly be attributed to the spatial heterogeneity in the regions and the related informational flows. This result is strongly consistent with the literature on spatial diffusion or the spatial form of market inefficiency, see, e.g., Clapp and Tirtiroglu (1994); Clapp et al. (1995); Dolde and Tirtiroglu (1997). Further, through examination of persistence from regional-level indices up to broader national-level indices, the study finds that the fraction of regions with persistence in housing market returns systematically increases. This suggests that smaller regions with persistence must have at least a strong enough degree of persistence to influence indices at a higher level of aggregation. Finally, this study also finds higher persistence in monthly returns as opposed to quarterly returns.

Overall, I find that the regions that have higher index returns as reported in summary statistics in Table 4.1, on average, also have higher persistence in their index returns, suggesting strong correlation between higher returns and persistent returns. This finding is also consistent in the segmentation analysis by capital and rental components of housing market returns for houses and units. The presence of strong persistence in returns in Australian housing market suggests that it may be possible for speculators to make excess profits in the housing market. However, from the perspective of policy makers, it represents a significant challenge to the notion of residential housing market efficiency in Australia. Moreover, these persistent returns may be the main cause of ongoing volatility in the housing returns, short-term local market conditions, and expectations primarily driving changes rather than the fundamentals.

While the focus of this chapter is solely to test the presence of persistence and not its economic significance – although this has been examined and confirmed by Schindler (2013, 2014) who test a moving average based trading strategy in regions with persistent returns against a simple buy-and-hold strategy and finds profitable returns – it does not, however, preclude testing for the Australian market as part of future research.

Chapter 5

The Impact of Underquoting Regulation: A Case Study of the Housing Market in New South Wales and Victoria

5.1 Introduction

Section 2.4 identifies several studies seeking to understand underquoting behavior with respect to search models and the role of list prices (e.g. Yavas and Yang (1995); Chen and Rosenthal (1996); Arnold (1999); Knight (2002); Han and Strange (2016, 2015); Merlo et al. (2015); Albrecht et al. (2016); Haurin et al. (2013); Lester et al. (2017)), the role of real estate agents (e.g. Baryla and Ztanpano (1995); Turnbull and Dombrow (2007); Palm (1976); Rutherford et al. (2005); Levitt and Syverson (2008); Jud and Frew (1986)), bidding strategies in auctions (e.g. Kagel and Levin (2002); Compte (2004); Ahlee and Malmendier (2005); Malmendier and Lee (2011); Han and Strange (2014)), differences across sale mechanisims—auctions vis-a-vis private treaty (e.g., Ashenfelter and Genesove (1992); Lusht (1996); Quan (2002); Bender et al. (2008)), and welfare costs (e.g., Anglin et al. (2003); Österling (2017); Lehmann (2016)). In this chapter, I investigate the impact of regulation, seeking to reduce information asymmetry in the real estate markets, on underquoting behavior of real estate agents, corresponding to hypotheses $H_{5,1}$.

The remainder of this chapter is structured as follows: Section 5.2 presents the institutional details of the reforms introduced in New South Wales and Victoria. In section 5.3, I describe the data and provide the univariate statistics. Section 5.4 describes the empirical methodology, while Sections 5.5 and 5.6 present the main results and an alternate specification's test results, respectively. Section 5.7 concludes.

5.2 Institutional Details: The Underquoting Law

The underquoting regulations introduced in New South Wales and Victoria are part of the *Property, Stock and Business Agents Amendment (Underquoting Prohibition) Act 2015* and the *Estate Agents (EA) Amendment Act 2016*, respectively. These bills were passed by the parliament in New South Wales and Victoria on October 22, 2015 and November 02, 2016, respectively (referred to as the enactment date), and they have come into effect from January 01, 2016 and May 01, 2017, respectively (referred to as the commencement or effective date) (NSW Fair Trading, 2017b; Consumers Affairs Victoria, 2018a).

Under these underquoting laws, estate agents and agents' representatives have obligations relating to the indicative selling price[1], calculation of estimated selling price of the property based on comparable sales, how and when these estimates are to be revised if they become inaccurate, and advertising prices, terms and symbols[2]. The indicative selling price for the property may be a single price or a price range with the difference between the upper and lower amounts not more than 10% of the lower amount. It must not be less than the agent's estimated selling price[3], the seller's asking price (or reserve price), or a price in a written offer that has already been rejected by the seller (NSW Fair Trading, 2017b; Consumers Affairs Victoria, 2018a).

The law also enforces estate agents to update the indicative selling price on a continuing basis as the conditions change—for example, when the estimated selling price in the suburb has increased or the seller rejects a higher written offer. In Victoria, if the agent's estimated selling price changes, the agent must retract or update the online advertising within one business day, and must update all other advertising as soon as practicable, whereas in New South Wales, this requirement is slightly relaxed, with updates required on a weekly basis (NSW Fair Trading, 2017b; Consumers Affairs Victoria, 2018a). Further, when marketing a property for sale, the agents are banned from use of any references in their advertising that qualify a price or have the effect of modifying the price by the use

[1]In NSW, an agent has the option not to provide a price guide at all, while in Victoria, agents must provide an indicative selling price (NSW Fair Trading, 2017b; Consumers Affairs Victoria, 2018a).

[2]These laws do not apply to individuals and developers selling their own property without the assistance of an agent; however, these parties must comply with the Sale of Land Act 1962 and the Australian Consumer Law, which prohibit false and misleading representations about the price of property for sale (Consumers Affairs Victoria, 2018a).

[3]The estimated selling price must be reasonable and agents must be able to substantiate with any sales of comparable properties in the location, any current or relevant valuations provided in respect of the property, any feedback from potential purchasers, and features of the property, including the existence of any material facts (NSW Fair Trading, 2017b). It must be included in the sales authority as either a single price or a price range where the difference between upper and lower amount is not more than 10%. The estimated selling price represents the local market and therefore is required to be updated as soon as it is known that it ceases to be reasonable or representative for that market. For example, this may occur when the agent becomes aware of a new comparable property.

of words or symbols, such as 'offers above', 'from', 'starting at' or '+'. A key requirement is that agents must not give consumers understated or vague property prices. for instance promoting a property price as 'offers above $400,000'.

In addition to the reforms carried out in New South Wales, the Victorian underquoting law also requires the agents to prepare a Statement of Information (SOI) in an approved form for each residential property they are engaged to sell, regardless of whether the property is advertised for sale. The SOI must be provided to prospective buyers within two business days of request and displayed at all openings for inspection of the property for sale. The SOI must include an indicative selling price for the property with the criteria as mentioned earlier, and it is required to be updated if it increases. The SOI must also provide the median house price for the suburb of the subject property and for a period between three and twelve months (Consumers Affairs Victoria, 2018a). Further, the SOI must also provide details of three comparable properties[4], including the address of the property, sale date and sale price—or, if the agent did not take into account three comparable properties for estimating the selling price, they need to provide a statement outlining that they reasonably believe there are fewer than three comparable sales in the prescribed period. The comparable property must be sold in the last six months and be within two kilometres of the property for sale if the property for sale is in the Melbourne Metropolitan area, or it must be sold in the last 18 months and be within five kilometres of the property for sale if the property for sale is outside the Melbourne Metropolitan area[5] (Consumers Affairs Victoria, 2018b).

[4]To select the most comparable properties, the agents have to take into account the standard, condition, location, and the date of sale of the properties. Agents must use all data and information they have about recently-sold properties, regardless of any confidentiality or non-disclosure agreements (Consumers Affairs Victoria, 2018b).

[5]The Act requires the Director of Consumer Affairs Victoria to determine the geography of "Melbourne Metropolitan Area" which is required for selecting appropriate comparable sales for a subject property (Chief Parliamentary Counsel, Victoria, 2016).

Underquoting is illegal because it gives buyers a false impression about the price a seller will accept for a property. The measures are designed to stop property agents from engaging in misleading or deceptive conduct, or making false or misleading representations to prospective buyers or sellers, with serious consequences for agents who do not comply with the underquoting laws. Agents who commit an underquoting offence can be fined for breach of each item described under the 'underquoting" act by up to $22,000 (200 penalty units) and more than $31,000 (200 penalty units) in New South Wales and Victoria, respectively. Further, they could also lose their commission and fees earned from the sale of an underquoted property[6] (NSW Fair Trading, 2017b; Chief Parliamentary Counsel, Victoria, 2016).

While the recent underquoting legislation in New South Wales and Victoria were specifically designed with clarity and structure for the residential housing market, there also exists a more general form of regulation: False and Misleading Representation Provisions (s65A) of the Trade Practices Act 1974 (TPA), which is now found in two separate provisions, s19 and s38, of the Australian Consumer Law (ACL)[7] (Australian Government Solicitors, 2011). The underquoting laws complement the False and Misleading Representation provisions of the ACL and are applicable for any type of residential property, including new and established homes, off-the-plan sales, and house and land packages,

[6]Morse and Crawford (2018); Lehmann (2016) report a case of record fine of $880,000 paid by an estate agent after the federal court found its marketing strategies were unacceptable. This was considerably larger than the previous record of $330,000 penalty imposed by Director of Consumer Affairs in 2015. In November 2018, one agency in Victoria was imposed with a $720,000 fine which is currently the second-highest penalty (Leaman, 2018), followed by another agency in 2016, which was penalized $330,000 for underquoting, in addition to the incurred $90,000 in legal costs (Bleby, 2016). These fines are a reminder of the significant costs to agents that result from engaging in underquoting practices. (REINSW, 2018) also highlights the costs of underquoting practices to agents in the form of injunctions, severe monetary penalties and legal costs, not including the reputational damage suffered.

[7]The ACL has replaced the consumer protection provisions in 17 pieces of State and Territory legislation and in the Trade Practices Act 1974 (TPA). Limited parts of the ACL commenced on 14 April 2010 and 1 July 2010, with the remaining provisions finally coming into effect on 1 January 2011 (Australian Government Solicitors, 2011).

as well as residential property anywhere in New South Wales and Victoria, including the rural areas. They do not apply to the sale of rural property—that is, property used for primary production, such as farming and mining, and commercial and industrial property, such as offices, shops, warehouses and factories. However, agents selling these kinds of properties are required to continue to comply with provisions under the Australian Consumer Law (NSW Fair Trading, 2017b; Consumers Affairs Victoria, 2018b), which carries a maximum penalty of $500,000 for individuals and $10 million for corporations.

A number of studies, dealing with survey data, have reported evidence on the prevalence of underquoting or its impact, prior to the introduction of new regulation. For example, in terms of complaints statistics, a report by (Castle, 2017) suggests that, in Victoria, there was a marked increase in complaints relating to underquoting a year before the new laws were introduced, in 2015–16, with 339 complaints—up 114% from 158 in 2014–15—indicating that the underquoting practice was still rampant among estate agents. Such increases were even steeper in New South Wales, jumping 280% from 84 in 2014 to 236 in 2015 (Castle, 2017). Real Estate Monitor Worldwide (2014) study finds that all houses they inspected and tracked from original offer to auction sold for more than 10% above the asking price, with most selling for more than 25% of the initial asking price. Further, Consumer Affairs Victoria (the consumer regulatory body), who exercised their power to access sale agreements, investigated the issue of underquoting by looking at a sample of 200[8] properties on the market between 2015 and 2016. They found that 27% of the 176 properties that sold during the investigation sold within the agent's estimated selling price, 30% sold by up to 10% more than the estimated selling price, and 33% sold for more than 10% of the estimated selling price (Consumer Affairs Victoria, 2016).

[8]Rowe, quoted in (Consumer Affairs Victoria, 2016), however, argues that an investigation based on a small sample of 200 properties is not representative, and therefore immaterial.

In a study conducted by a leading consumer advocacy group, *Choice*, for 52 properties in the suburbs of Sydney and Melbourne, researchers found that 52% sold for more than the maximum quoted price given by the agent, with 25% sold by over 10% more than the maximum quoted price and 27% sold up to 10% more than the maximum quoted price, while 8% sold for either less than, or within the quoted price range, and 40% did not sell or disclose the sale price Choice (2017). The 'Choice' report also highlighted one of the most flagrant discrepancies for a property in Sydney's inner west with a price guide of $1.6 million, which subsequently sold for $2.2 million—38% more than the listed price (Castle, 2017). Further evidence on the prevalence of underquoting is also provided by Wallace (2015).

5.3 Data

The data for this study are provided by CoreLogic. They collate information, including unique identifiers, on each listing, sale transaction, and property. The listing data include the date of the listing and list price, among others, while the sale transaction and the property data include sale price, contract sale date, whether the property is a 'House' or 'Unit', and other property attributes, including number of bedrooms, bathrooms, and car spaces. The sale price data are sourced from the Valuer-General of each state, while the listings and attribute data are collected from the property listings on public portals, newspaper advertisements, and real estate agents.

The combination of these time-stamped data provide detailed information to identify all listings and their corresponding sale. By using unique identifiers, I am able to marry each listing to its corresponding property. However, since agents can have multiple updates in listings before the property is sold and there can be multiple sale transactions for each property, I cannot readily identify which listing corresponds to a particular sale. As such, I take listings that are within one year prior to the sale date as the listing corresponding to that sale transaction. Any listing that appears after the sale is considered to correspond to the subsequent sale, provided it is within one year prior to the subsequent sale date. I use the maximum period of one year as a reasonably long amount of time to identify a listing corresponding to a sale because any longer time would indicate that the listing likely must have been a failed listing, and that there was no corresponding sale to it[9].

This information set permits measurement of the underquoting ratio for properties in states affected by new regulations, New South Wales and Victoria, during enactment and post-commencement periods relative to the pre-enactment period. Similarly, I measure underquoting in the control states where there is no change in underquoting regulation during the period 2014 to 2018. The control sample of homes allows me to significantly reduce the confounding effects of contemporaneous factors that affect underpricing during the sample period. This also allows me to make stronger inferences about the effects that underquoting regulations had on underpricing in New South Wales and Victoria. I use the population of house sale transactions data, combined with the corresponding listings data for all eight states between 01 January 2014 to 30 November 2018, classified into three periods: pre-enactment, enactment and post-commencement. I exclude from the sample vacant land sales, commercial property transactions, and other sales that involve non-arm's-length transactions[10]. I further exclude outliers at bottom and top, 1 and 99

[9] A failed listing, otherwise known as an expired, canceled, and/or terminated listing, could occur either when homeowners decide that they no longer want to sell their property and abandon the listing, or the property does not sell after being exposed to the market for a prolonged period of time.

[10] Sales where transfers are of the types 'gift', 'court order', 'family sale', 'extraordinary circumstances', 'mortgage in possession', 'part-sale/consideration represents partial interest in the property', 'rebated-sale/negotiated sale', 'residential-redevelopment', transfer by death or transfer by bankruptcy

Table 5.1: Data Distribution: New South Wales (Treatment Group)

Group	State	Auction				Private Sale			
		Period			Total	Period			Total
		Pre-enactment	Enactment	Commencement		Pre-enactment	Enactment	Commencement	
Treatment	NSW	50,894	37,478	4,200	92,572	207,081	268,637	22,211	497,929
Control		23,695	20,107	2,571	46,373	435,081	625,636	46,272	1,106,989
	ACT	1,805	1,532	239	3,576	9,592	16,487	1,072	27,151
	NT	335	478	20	833	5,578	5,943	456	11,977
	QLD	12,325	5,685	1,124	19,134	204,538	290,928	21,146	516,612
	SA	7,729	9,602	990	18,321	69,276	103,064	7,925	180,265
	TAS	453	293	50	796	27,743	46,870	3,746	78,359
	WA	1,048	2,517	148	3,713	118,354	162,344	11,927	292,625
Total		74,589	57,585	6,771	138,945	642,162	894,273	68,483	1,604,918

This table reports the number of observations for treatment sample (NSW) and control sample (all other states except VIC) by period—pre-enactment, enactment and commencement of regulation enforcement—for NSW. The data include transactions from 2014–2018.

Table 5.2: Data Distribution: Victoria (Treatment Group)

Group	State	Auction				Private Sale			
		Period			Total	Period			Total
		Pre-enactment	Enactment	Commencement		Pre-enactment	Enactment	Commencement	
Treatment	VIC	68,185	32,551	8,716	109,452	229,547	114,760	36,510	380,817
Control		33,498	9,686	3,189	46,373	679,542	314,445	113,002	1,106,989
	ACT	2,573	750	253	3,576	15,437	8,885	2,829	27,151
	NT	501	266	66	833	7,940	3,004	1,033	11,977
	QLD	16,026	2,302	806	19,134	318,733	146,371	51,508	516,612
	SA	12,045	4,495	1,781	18,321	109,779	51,845	18,641	180,265
	TAS	627	115	54	796	45,178	23,789	9,392	78,359
	WA	1,726	1,758	229	3,713	182,475	80,551	29,599	292,625
Total		101,683	42,237	11,905	155,825	909,089	429,205	149,512	1,487,806

This table reports the number of observations for treatment sample (VIC) and control sample (all other states except NSW) by period—pre-enactment, enactment and commencement of regulation enforcement—for VIC. The data include transactions from 2014–2018.

percentiles, respectively.

Since the timing of introduction of regulation differs across New South Wales and Victoria, I carry out the analyses independently and report the results separately. Tables 5.1 and 5.2 report the distribution of observations for 'Auction' and 'Private Treaty' sales by group (treatment and control) and period of regulation enforcement (i.e. pre-enactment, enactment and commencement) for New South Wales and Victoria, respectively. Table 5.1 reports that in the case of 'Auction' sales for New South Wales, there are a total of 138,945 observations with 99,572 for treatment and 46,373 for control group. Meanwhile, for 'Private Treaty' sale, there are a total of 1,604,918 observations, with 497,929 for the treatment and 1,106,989 for the control group. Table 5.2 reports that for 'Auction' sales in Victoria, there are a total of 155,825 observations, with 109,452 for the treatment and 46,373 for the control group. For 'Private Treaty' sales, there are 1,487,806 total observations, with 380,817 for the treatment and 1,106,989 for the control group.

5.4 Model Estimation and Summary Statistics

To investigate the impact of regulation on the underquoting practices in New South Wales and Victoria, I estimate the following difference-in-differences regression model,

$$\begin{aligned} UQ_{i,s,l} = a_0 + \beta_0 Reg_i + \beta_1 Period_{i,s,l} + \beta_2 Reg_i * Period_{i,s,l} + \phi_1 MktIndex_{SA2,c,t} \\ + \psi Last\_pub_{i,s} + \theta Days\_bet\_pubs_{i,s} + \phi Property\_type + \gamma_1 Age_i \\ + \gamma_2 Age_i^2 + \mu K_i + Year_{i,s,l} + Location_{l,SA4} + \epsilon_i \end{aligned} \tag{5.1}$$

where, $UQ_{i,s,l}$ is a measure of underquoting and calculated as the natural log ratio of the listing price[11] to the sale price for each listing l, sale transaction s, and property i. The logarithmic form of underquoting ratio provides the percentage effect in the regression model. Reg_i is a dummy variable coded as 1 for New South Wales and Victoria, where the respective state governments have recently passed the regulation to stop underquoting practices in the sale of residential dwellings. The dummy variable is coded as 0 for all other states.

$Period_{i,s,l}$ is a categorical variable that represents three periods, namely the pre-enactment period, enactment period and post-commencement (or effective) period. Because the regulations in New South Wales and Victoria were introduced separately with different dates of enactment and commencement, I run separate regressions for New South Wales and Victoria to identify the impact of the underquoting regulation in the respective states, with control sample being the same for both regressions. As such, $Period_{i,s,l}$ equals "pre-enact", representing the pre-enactment period, if the date of publication of the listing is before 22 October 2015 and 02 November 2016 for New South Wales and Victoria, respectively. $Period_{i,s,l}$ equals "enact", referring to the post enactment and pre- commencement period, if the date of publication of the listing is on or after 22 October 2015 and 02 November 2016, and before 01 January 2016 and 01 May 2017 for New South Wales and Victoria, respectively. Finally, $Period_{i,s,l}$ equals "Commence", referring to the post commencement or the effective period, if the date of publication of the listing is on or after 01 January 2016 and 01 May 2017 for New South Wales and Victoria, respectively.

[11]The listing price is sometimes quoted as a range—'price from' to 'price to'—instead of a single price. Since the regulation applies to any listing – single price or price range, the use of minimum in the calculation of underquoting ratio is justified.

$Reg_i * Period_{i,s,l}$ is the interaction term between the corresponding regulation dummy and the period categorical variables: pre-enactment, enactment, and post-commencement. Therefore, the interaction terms—$Reg_i * Period(Enact)$ and $Reg_i * Period(Commence)$—measure the impact of regulation on the underquoting ratio by capturing the change in the underquoting ratio in the enactment and commencement period relative to the pre-enactment period, respectively, after controlling for changes between these periods in the control states that cannot be attributed to the event under study.

According to Bender et al. (2008) and Han and Strange (2014), underquoting is correlated with market conditions. Therefore, I include a market index variable—$MktIndex_{SA2,c,t}$—to account for variations attributed to the market changes. $MktIndex_{SA2,c,t}$ represents the natural logarithm of the estimated market index value at the Statistical Area 2 (SA2) level, corresponding to the property type, 'House' or 'Unit', at the time of publication of the listing. Further, Bender et al. (2008) find that the price of the property has a significant effect on the relative percentage difference between the advertised price and the sale price, which suggests that the underquoting ratio will display a scale effect. Therefore, I use log of both the underquoting ratio (dependent variable) and the market index estimate (explanatory variable) that accounts for this scale effect. The market index variable $MktIndex_{SA2,c,t}$ also corrects for the joint hypothesis problem, as discussed earlier, by controlling for the unobserved market value of a given property at the SA2 area level[12]. Therefore, the $MktIndex_{SA2,c,t}$ as an explanatory variable not only controls for any variation in the underquoting ratio directly attributable to the housing market

[12] Given that the housing market transactions are not frequent, the home value indices at the SA2 geographic level calculated by CoreLogic are the most robust market index estimates for the smallest geographical Statistical Areas SA2, and therefore the best approximation of the property value at the time of listing.

movements but also accounts for the joint hypothesis problem. These effects captured by the market index coefficient ϕ_1 are, however, indistinguishable.

The agents may have to publish multiple updates to a listing before a property is sold, and the degree of underquoting in different publications may vary. However, Merlo and Ortalo-Magne (2004) observe that price revisions are "sticky", i.e., both infrequent and sizeable[13]. Therefore, it is likely that majority of sales have only one price revision with two list prices—first and last[14]. As such, I include the first and last publications in my analyses, which provides a good overall representation of the agent's underquoting behavior in the data set. Further, by using a binary variable for first and last publications, I am able to capture the coefficient on average change in the level of underquoting between first and last listings[15]. $Last\_pub_{i,s}$ is coded as 1 for last publication and 0 otherwise. If a sale occurs with only one publication, then the variable is set to 1 representing the last publication. Typically, one would expect the agents to underquote by a lesser amount when they first list the property for sale, and then increase the degree of underquoting over subsequent listings as the 'time on market' for the listing increases.

$Days\_bet\_list\_sale_{i,s}$ indicates the number of days between publication of the listing and the sale date. This variable controls for changes in the underquoting ratio that are attributed to how long it takes before the property is sold post the listing.

[13] Merlo and Ortalo-Magne (2004) provide evidence to show that a sizeable fraction of sellers revise their listing price at least once, and those who do typically reduce it by a substantial amount after waiting a substantial period of time without receiving any offer.

[14] While agents can be convicted for the breach of regulations for any previous listings, in practice, the identification of underquoting based on market estimates is a grey area as agents find ways to evade regulations (e.g., Redman (2018); Wakelin (2016); Schlesinger (2016)). By contrast, the identification of underquoting (observed) after the sale of a property is more obvious, and hence it can be argued that the last listing plays the most important role in the identification of underquoting, as it has effected the sale of the property.

[15] This is based on the assumption that the list price changes are linear over time.

$Property\_type$ is a categorical variable that controls for whether the property is of the type 'House' or 'Unit'. Age_i and Age_i^2 control for the age of the property (in years) in quadratic form. K_i is a set of property attributes such as the number of bedrooms, bathrooms, and car spaces. $Year_{i,s,l}$ controls for the year fixed effects at the time publication of listing. $Location_{SA4,l}$ is the location fixed effects at the SA4 level[16,17]. a_0 is the constant term and ϵ is the random error term.

Tables 5.3 and 5.4 report the summary statistics of the underquoting ratio (calculated as the ratio of the listing price to the sale price of the property) for 'Auction' and 'Private Treaty' sale transactions by group (treatment and control) and period of regulation enforcement (pre-enactment, enactment, and commencement) for New South Wales and Victoria, respectively.

Table 5.3 shows the mean and standard deviation of underquoting ratio for New South Wales. Based on these univariate statistics, I find there was a significant amount of underquoting prevalent in New South Wales and Victoria during the pre-enactment period, particularly for 'Auction' sales, with underquoting ratios of 0.89 and 0.88, respectively. For control states, the average ratio was much higher: 0.949 and 0.948 for New South Wales and Victoria, respectively. For 'Private Treaty' sales there is no evidence of significant underquoting—the listing price (ex-ante) almost matches the sale price (ex-post) of the property with ratios of 0.9947 and 1.01 in New South Wales and Victoria, respectively.

[16]SA4s are the largest sub-state regions based on the Australian Statistical Geography Standards (ASGS) framework (2016 Census), and are specifically designed for the output of Labour Force Survey data. In regional areas, SA4s tend to have populations in the range of 100,000 to 300,000 persons; in metropolitan areas, the SA4s tend to have larger populations of 300,000 to 500,000 persons. SA4s are aggregations of whole SA3s, without crossing state borders, gaps or overlaps (Australian Bureau of Statistics, 2016b).

[17]I also control for the location fixed effects at a lower geographic level (SA2) in the specification test section, where I test an alternate specification that allows me to capture variations in underquoting ratio at a more local and precise market area, and therefore more accurately represent the market value of the subject property.

These results are also consistent with Ashenfelter and Genesove (1992); Mayer (1998); Lusht (1996); Quan (2002); Bender et al. (2008), who find evidence of underquoting in 'Auction' sales and not as much in relation to 'Private Treaty' sales.

Comparing average underquoting ratios during the enactment and post-commencement periods with the pre-enactment period, I find significant reductions in the underquoting activity in both states, New South Wales and Victoria. In the case of 'Auction' sales in New South Wales, the underquoting ratio improved from 0.89 before the law was passed to 0.94 during the enactment period, and further to 0.95 after the commencement of the law, while the ratio for control states was relatively constant through out these periods in the range of 0.94 to 0.95. For 'Auction' sales in Victoria, the underquoting ratio improved from 0.88 in the pre-enactment period to 0.9 and further to 0.95 during the enactment and commencement period, respectively. The average ratio for control states remained stable in the range of 0.94–0.95.

Overall, the ratios for 'Private Treaty' sale remained close to one with no significant evidence of underquoting activity. This result is also consistent with the findings of (Bender et al., 2008). A potential explanation for this finding is that in the 'Auction' format of sale, the underquoting artificially stimulates demand by bringing in more potential buyers at the point of sale. Meanwhile, in the 'Private Treaty' sale, the potential buyers are at distributed points of sale—both spatial and temporal—and therefore underquoting the property price does not have the same effect of stimulating artificial demand as in the case of 'Auction' sale. In 'Private Treaty' sales for New South Wales, the ratio before the enactment of the law was 0.9947, and during the enactment period and after the commencement of the law, the ratio increased marginally to 1.01 and 1.03, respectively. For the control states, the ratio was relatively stable in the range of 1.03 and 1.04. For

Table 5.3: Summary Statistics: Underquoting Ratio (New South Wales)

		Auction Mean (Std. deviation)			Private Sale Mean (Std. deviation)		
Group	State	Pre-enactment	Enactment	Commencement	Pre-enactment	Enactment	Commencement
Treatment	NSW	0.8995	0.9405	0.9547	0.9947	1.0131	1.0329
		(0.0893)	(0.0916)	(0.0858)	(0.0892)	(0.0864)	(0.0737)
Control	All	0.9490	0.9492	0.9527	1.0368	1.0424	1.0371
		(0.1052)	(0.1079)	(0.1014)	(0.0975)	(0.1127)	(0.0984)
	ACT	0.9382	0.9564	0.9463	1.0160	1.0122	1.0039
		(0.0949)	(0.1342)	(0.0814)	(0.0927)	(0.0717)	(0.0765)
	NT	0.9950	0.9716	0.9630	1.0510	1.0753	1.0655
		(0.1080)	(0.0891)	(0.0946)	(0.0801)	(0.1183)	(0.0961)
	QLD	0.9468	0.9372	0.9578	1.0325	1.0343	1.0333
		(0.1074)	(0.1032)	(0.1076)	(0.0959)	(0.1159)	(0.0896)
	SA	0.9524	0.9590	0.9463	1.0364	1.0457	1.0435
		(0.0987)	(0.0965)	(0.0869)	(0.0884)	(0.1010)	(0.0840)
	TAS	0.9512	0.9411	0.9379	1.0464	1.0367	1.0142
		(0.1217)	(0.1054)	(0.1285)	(0.0903)	(0.0840)	(0.0844)
	WA	0.9537	0.9622	0.9691	1.0433	1.0578	1.0489
		(0.1279)	(0.1539)	(0.1380)	(0.1070)	(0.1224)	(0.1224)

This table reports the mean and standard deviation of the underquoting ratio (calculated as the ratio of listing price to sale price for each transaction) for the treatment sample (NSW) and control sample (all other states except VIC) by period of regulation enforcement for New South Wales: pre-enactment (before 22/10/2015), enactment (from 22/10/2015 to 31/12/2015) and commencement (01/01/2016 onward). The data include transactions from 2014–2018.

Table 5.4: Summary Statistics: Underquoting Ratio (Victoria)

		Auction Mean (Std. deviation)			Private Sale Mean (Std. deviation)		
Group	State	Pre-enactment	Enactment	Commencement	Pre-enactment	Enactment	Commencement
Treatment	VIC	0.8852	0.9048	0.9584	1.0116	1.0051	1.0203
		(0.0901)	(0.0906)	(0.0866)	(0.1305)	(0.1038)	(0.0804)
Control	All	0.9488	0.9464	0.9583	1.0400	1.0436	1.0291
		(0.1045)	(0.0970)	(0.1031)	(0.1023)	(0.1033)	(0.0881)
	ACT	0.9395	0.9360	0.9566	1.0142	1.0046	0.9999
		(0.0961)	(0.0903)	(0.0797)	(0.0891)	(0.0901)	(0.0659)
	NT	0.9851	0.9452	0.9668	1.0574	1.0691	1.0603
		(0.1074)	(0.0898)	(0.0890)	(0.0877)	(0.0978)	(0.0943)
	QLD	0.9468	0.9561	0.9659	1.0340	1.0362	1.0297
		(0.1070)	(0.1019)	(0.1102)	(0.0996)	(0.0916)	(0.0787)
	SA	0.9510	0.9412	0.9492	1.0410	1.0464	1.0387
		(0.0960)	(0.0855)	(0.0858)	(0.0915)	(0.0903)	(0.0736)
	TAS	0.9500	0.9259	0.9310	1.0422	1.0187	1.0004
		(0.1224)	(0.1102)	(0.1329)	(0.0894)	(0.0855)	(0.0787)
	WA	0.9551	0.9694	0.9731	1.0506	1.0652	1.0323
		(0.1346)	(0.1492)	(0.1351)	(0.1157)	(0.1291)	(0.1116)

This table reports the mean and standard deviation of the underquoting ratio (calculated as the ratio of listing price to sale price for each transaction) for the treatment sample (VIC) and control sample (all other states except NSW) by period of regulation enforcement for Victoria: pre-enactment (before 02/11/2016), enactment (from 02/11/2016 to 30/04/2017) and commencement (01/05/2017 onward). The data include transactions from 2014–2018.

'Private Treaty' sale in Victoria, however, I find that the ratio increased marginally from 1.01 in the pre-enactment period to around 1.02 post-commencement of the regulation, with a slight decline during the enactment period. For control states, the average ratio remained stable in the enactment period at around 1.04 and then declined to 1.02 after the commencement of the law.

These univariate results provide preliminary evidence of reduction in the underquoting just after the enactment of underquoting law. However, these results do not account for variations that may be attributed to factors such as market trends and property and listing attributes. Therefore, I implement a difference-in-differences regression framework, which allows me to contrast the change in underquoting ratio in treatment states during the enactment and commencement periods relative to the pre-enactment period with the control states, while also simultaneously controlling for variations due to other relevant factors.

5.5 Results

Table 5.5 reports the coefficient estimates of the difference-in-differences model of quoting ratio as shown in the equation 5.1 for both 'Auction' and 'Private Treaty' sales in New South Wales and Victoria[18]. All models control for the market trend, final publication, number of days between the listing and sale, property type, quadratic age, property

[18] In case of underquoting, the ratio of listing price to sale price is less than one, and vice versa. Since the quoting ratio is in logarithmic form, its value will be negative for underquoting (and positive for overquoting). As such, a larger negative value corresponds to a greater degree of underquoting, and a smaller negative value corresponds to lesser underquoting. Consequently, a positive change in the log of the underquoting ratio from a higher negative to a smaller negative value indicates a reduction in the extent of underquoting.

attributes such as number of bedrooms, bathrooms, and car spaces, and year and location fixed effects[19].

The coefficient on the market index is in the range of -1.9% and -2.9%, indicating that the underquoting ratio decreases as the market rises, which implies that in a given Statistical Area, the higher the price level, greater is the amount of underquoting. This is consistent with the findings of Bender et al. (2008). The coefficient of final publication dummy variable is negative, suggesting that agents revise their listing downward and hence that there is more underquoting in the final listings relative to the first[20]. This effect is more prominent in Auction sales, where the coefficient values are -1.2% and -2.0% for New South Wales and Victoria. The coefficient on days between listing and sale is positive, indicating there is less underquoting as the number of days on market increases. This result is consistent with the coefficient sign on final publication dummy variable, which suggests that for the final publication (which also implies there will be relatively less number of days on market), there is more underquoting. The coefficients on property type suggest that there is 0.6% and 1.3% less underquoting for units relative to houses for Auction sales in New South Wales and Victoria, respectively. Meanwhile, for Private Treaty sales, there is 0.3% and 0.4% more underquoting in units relative to houses.

The quadratic age controls for the variations in the underquoting ratio due to the age of the property. The coefficients of the quadratic age (i.e. age and age squared variables) are significant for 'Auction' sales and insignificant for 'Private Treaty' sales. The coefficient on the number of bathrooms is significant and positive, indicating a reduction in underquoting

[19] I also provide the results at a more granular location fixed effect at SA2 level in the specification test section.

[20] This is also consistent with Coles (1998), who develop a stock-flow matching model in which a seller first invites offers above an endogenously determined reserve price in an auction setting, and if no bids are received, the seller then gradually lowers their asking price over time.

with an increase in the number of bathrooms. Number of bedrooms and car spaces is mostly significant and negative, indicating an increase in underquoting as the number of bedrooms and car spaces increase, with exceptions for 'Auction' sales for New South Wales and Victoria.

The results show that there is a reduction in the underquoting practices immediately after the enactment of the regulation (i.e. just after the law was passed in the parliament), and more so after the law was commenced (or effective). I do not find a similar reduction in underquoting practices in control states. This effect is more prominent in 'Auction' sales, as there is greater prevalence of underquoting in an 'Auction' setting than in 'Private Treaty' sale. This is also evident in the univariate results reported in Tables 5.3 and 5.4 for New South Wales and Victoria, respectively. Consistently, Ashenfelter and Genesove (1992); Lusht (1996); Quan (2002); Bender et al. (2008) also find underquoting to be correlated with the method of sale—'Auction' or 'Private Treaty' sales—with significantly higher underquoting in the former. Hence, the reduction in underquoting is more significant in the 'Auction' than in 'Private Treaty' sale.

Table 5.5: Underquoting Difference-in-difference Model Results

	Log(Listing Price/Sale Price)			
	NSW		VIC	
	Auction	Private	Auction	Private
Reg	-0.007**	0.008***	0.018***	0.023***
	(0.004)	(0.001)	(0.007)	(0.001)
Commence (NSW)	0.026***	0.004***		
	(0.001)	(0.000)		
Enact (NSW)	0.004**	0.004***		
	(0.002)	(0.000)		
Commence (VIC)			-0.019***	-0.009***
			(0.002)	(0.001)
Enact (VIC)			-0.015***	-0.002***
			(0.002)	(0.000)
Reg * Commence (NSW)	0.057***	0.038***		
	(0.001)	(0.000)		
Reg * Enact (NSW)	0.041***	0.012***		
	(0.002)	(0.001)		
Reg * Commence (VIC)			0.073***	0.027***
			(0.001)	(0.000)
Reg * Enact (VIC)			0.023***	-0.005***
			(0.002)	(0.001)
Mkt_Index	-0.023***	-0.022***	-0.019***	-0.029***
	(0.003)	(0.001)	(0.003)	(0.001)
Final_publication_dummy	-0.012***	-0.000*	-0.020***	0.001***
	(0.001)	(0.000)	(0.001)	(0.000)
Days_bet_list_sale	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Property_type	0.006***	-0.003***	0.013***	-0.004***
	(0.001)	(0.000)	(0.001)	(0.000)
Age	-0.000***	0.000	-0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Age squared	0.000***	0.000	-0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
No. of bedrooms	0.000	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
No. of bathrooms	0.001*	0.002***	0.004***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
No. of car spaces	-0.001*	-0.000**	0.000	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.030**	0.085***	0.019	0.109***
	(0.015)	(0.003)	(0.013)	(0.003)
Year Fixed Effects	Yes	Yes	Yes	Yes
Location Fixed Effects	Yes	Yes	Yes	Yes
Observations	138,945	1,604,918	155,825	1,487,806
Obs. Treatment	92,572	497,929	109,452	380,817
Obs. Control	46,373	1,106,989	46,373	1,106,989
Adjusted R2	0.146	0.182	0.187	0.173
F Statistic	276.959***	4,148.356***	473.643***	4,083.689***
df	86; 138858	86; 1604831	76; 155748	76; 1487729

Notes: Robust standard errors are reported in parentheses; significance of variables is adjusted accordingly. *** 0.1% significance ** 1% significance * 5% significance. Records with missing values are excluded.

For 'Auction' sales in New South Wales, I find that there is a 5.7% reduction in underquoting after the law was enforced, and a 4.1% reduction in underquoting during the enactment period. For 'Auction' sales in Victoria, the results show that there is a 7.3% and 2.3% reduction in underquoting post-commencement of the law and during the enactment period, respectively. In the case of 'Private Treaty' sales in New South Wales, I find that there is a 3.8% reduction in underquoting after the law was enforced, and a 1.2% decrease in underquoting during the enactment period. In Victoria, I find that the underquoting reduced by 2.7% after the law was enforced. However, there is a 0.5% increase in underquoting during the enactment period. Overall, the findings support the view that elevating governance standards for real estate agents increases transparency and reduces information asymmetries that affect the underquoting practices influencing property transactions and sale prices.

5.6 Specification Test: SA2 Level Location Fixed Effects

Some areas tend to have more underquoting than others, which results in high variations across local geographic areas[21]. As noted earlier, this is also confirmed in an investigation carried out by NSW Fair Trading which finds large variations in underquoting levels across different suburbs (Burke, 2018). Hence, to test the robustness of the model in Eqn. 5.1 to location specific factors, I run the analysis at a more granular level with SA2 level fixed effects. I find that, overall, the results are consistent with the main model results,

[21] In addition to other location-specific factors, this could also be attributed to certain agents who have a higher tendency to underquote operating in those areas. Moreover, this may further result in other agents in those areas being left with no choice but to engage in underquoting practices to remain competitive. This, therefore, makes the differences in underquoting levels across local areas even larger.

suggesting reductions in underquoting. For 'Auction' sales in New South Wales, I find that the underquoting has reduced by 5.4% after the law was enforced, and 3.8% during the enactment period.

For 'Auction' sales in Victoria, the findings suggest that there is a 6.9% decrease in underquoting after the enforcement of the law, and a 2% reduction in underquoting during the enactment period.

In case of 'Private Treaty' sales in New South Wales, there is a 3.4% decrease in underquoting after the commencement of the law, and a 1% reduction in underquoting during the enactment period. For 'Private Treaty' sales in Victoria, the results suggest that the underquoting reduced by 2% after the law was enforced. There was a 1% increase in underquoting during the enactment period.

Table 5.6: Specification Test: Results with Location Effect at SA2 Level

	Log(Listing Price/Sale Price)			
	NSW		VIC	
	Auction	Private	Auction	Private
Reg	-0.006	-0.008	-0.073	0.001
	(0.030)	(0.025)	(0.050)	(0.027)
Commence (NSW)	0.023***	0.002***		
	(0.001)	(0.000)		
Enact (NSW)	0.005***	0.004***		
	(0.002)	(0.000)		
Commence (VIC)			-0.019***	-0.008***
			(0.002)	(0.001)
Enact (VIC)			-0.014***	-0.001*
			(0.002)	(0.000)
Reg * Commence (NSW)	0.054***	0.034***		
	(0.001)	(0.000)		
Reg * Enact (NSW)	0.038***	0.010***		
	(0.002)	(0.001)		
Reg * Commence (VIC)			0.069***	0.020***
			(0.001)	(0.000)
Reg * Enact (VIC)			0.020***	-0.010***
			(0.002)	(0.001)
Mkt_Index	0.002	0.002**	0.002	0.001
	(0.004)	(0.001)	(0.003)	(0.001)
Final_publication_dummy	-0.012***	-0.002***	-0.020***	-0.001***
	(0.001)	(0.000)	(0.001)	(0.000)
Days_bet_list_sale	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Property_type	0.011***	0.002***	0.016***	0.002***
	(0.001)	(0.000)	(0.001)	(0.000)
Age	-0.000***	0.000	-0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Age squared	0.000***	0.000	-0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
No. of bedrooms	0.000	-0.002***	-0.002***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
No. of bathrooms	0.001	0.002***	0.003***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
No. of car spaces	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-0.059*	-0.007	-0.052	-0.004
	(0.033)	(0.025)	(0.032)	(0.027)
Year Fixed Effects	Yes	Yes	Yes	Yes
Location Fixed Effects	Yes	Yes	Yes	Yes
Observations	138,945	1,604,918	155,825	1,487,806
Obs. Treatment	92,572	497,929	109,452	380,817
Obs. Control	46,373	1,106,989	46,373	1,106,989
Adjusted R2	0.175	0.206	0.219	0.205
F Statistic	19.619***	243.075***	30.260***	238.011***
df	1588; 137356	1720; 1603197	1491; 154333	1619; 1486186

Notes: Robust standard errors are reported in parentheses; significance of variables is adjusted accordingly. *** 0.1% significance ** 1% significance * 5% significance. Records with missing values are excluded.

5.7 Conclusion

This study investigates the impact of government intervention in the form of regulation seeking to reduce information asymmetry on underquoting practices in New South Wales and Victoria for both ‘Auction’ and ‘Private Treaty’ modes of sale. By using population of home sales and listings data from 2014 to 2017 and employing a difference-in-differences methodology, the study provides evidence that the new regulations introduced by the state governments have been effective in significantly reducing underquoting practices in New South Wales and Victoria just after the laws were enacted. The study shows that for ‘Auction’ sales in New South Wales, there is a 4.1% and 5.7% reduction in underquoting during the enactment period and after the commencement of the law, respectively. Meanwhile, for ‘Private Treaty’ sales, the study finds a 1.2% and 3.8% reduction in underquoting, respectively. In case of Victoria, the study shows that for ‘Auction’ sales, there is a 2.3% and 7.3% decrease in underquoting during the enactment and post-commencement periods, respectively. However, in ’Private Treaty’ sales, the study finds that the decrease in the underquoting practice is evident only after the regulation became effective, with a 2.7% reduction in underquoting, while there is a marginal increase in the underquoting ratio of 0.5% during the enactment period.

The reduction in underquoting was largely found in the case of ‘Auction’ sales, where underquoting was prevalent before the introduction of the laws. Regardless of the housing market trend, age of the property, whether first or last publication, or type of the property (houses or units), the study finds that, on average, underquoting has significantly reduced in New South Wales and Victoria. Given the heterogeneity in degree of underquoting across local areas, the study also tests the alternative specification of location fixed effects at a more local area/SA2 level to probe the robustness of this conclusion. The study finds that the results are consistent with the original finding.

Overall, the findings suggest that the government intervention in the form of regulation to information asymmetry has been highly effective in curbing the underquoting practices both in New South Wales and in Victoria. The study also contributes to the literature on regulations in underquoting, the role of list prices, and how real estate agents exploit information asymmetry to their advantage. The study demonstrates that good intervention policies by governments can curb such malpractices and improve the fairness of the housing market.

Chapter 6

Conclusion

Housing markets have been of particular interests for firms, individual households, investors, government institutions, and academics. This dissertation studies the performance of housing markets in Australia from three unique perspectives: first, returns derived from home improvements; second, persistence (or weak-form efficiency) in capital and rental components of housing market returns; and third, impacts of the introduction of regulation by the state governments to stamp out underquoting practice in New South Wales and Victoria.

Each of the studies in this dissertation contributes to and extends the literature in their respective streams. Chapter 3 focuses on the returns derived by homeowners who undertake significant home improvements relative to owners who make no alterations to their homes. Chapter 3 extends the work on financial analysis of home improvements by Choi et al. (2014) and also adds to the literature on household finance (see, for example, Barber and Odean (2011); Campbell (2006)), which is largely consistent with the view that typical households are insufficiently educated and do not make profitable decisions.

Chapter 4 contributes to the academic literature on persistence (or weak-form efficiency) in both the capital and rental components of housing market return. While previous studies of persistence, predictability, or weak-form market efficiency have focused on the capital components of housing returns from various perspectives (temporal (Clayton, 1998; Londerville, 1998; Elder and Villupuram, 2012; Schindler, 2013, 2014; Glaeser and Nathanson, 2017); spatial (Clapp and Tirtiroglu, 1994; Clapp et al., 1995; Dolde and Tirtiroglu, 1997); Novel Paradigms (Rosenthal, 1999; Hjalmarsson and Hjalmarsson, 2009); and Securitized Real Estate Markets (Stevenson, 2002; Schindler et al., 2010; Serrano and Hoesli, 2010), tests of persistence (or weak-form efficiency) in the rental component have been completely ignored.

Further, this study also contributes to the state of knowledge by enhancing the methodology of Schindler (2013, 2014) in two important ways: first, by employing an automatic data-dependent lag selection procedure from Choi (1999), thereby making the model free from lag selection procedure, and second, by applying the wild bootstrapping approach to the automatic variance ratio test which has superior finite sample properties as compared to the traditional variance ratio tests (Kim, 2006). Chapter 4 also contributes to the literature by providing a comprehensive characterization of persistence in housing returns across regional levels (SA3, SA4, GCC, State, and National levels), by dwelling types ('Houses' and 'Units'), and for monthly and quarterly frequencies.

Chapter 5 engages with the literature on information asymmetry in relation to how it is exploited by real estate agents to inflate house sale prices. Chapter 5 then examines the impact of the introduction of reforms to prevent underquoting practices in New South Wales and Victoria.

Chapter 3 finds that the cost-adjusted return for homeowners who make significant home improvements is -2.4% relative to those who make no alteration, consistent with the consumption-based views detailed in (Choi et al., 2014). This finding implies that individuals who undertake major improvement works perform significantly worse than homeowners who do not undertake any remodeling expenditure. One reason this may be the case is because of stamp duty, which are quite high in Australia, and therefore provide a strong disincentive to move. As a result, homeowners may be 'forced' to renovate their house rather than selling and moving to a more appropriate home. Further, the lower returns can also be attributed to the consumption benefits derived from improved homes for homeowners. A major implication of this results is that many of the homeowners who improve their homes are either unaware of or undeterred by the possibility that they may be overcapitalizing on their improvements. Thus, owners can now be more educated about the potential returns on home improvement investments, and can therefore indulge in home improvement activities based on their own utility.

The chapter reports significant variation in the degree of returns/losses on different improvement works. Return on construction of a new single dwelling is well below unimproved homes—around -10%—while the addition of verandas, pergolas, and decks provides -4% returns, and for carports, the figure is around -2.5%. Returns earned by undertaking extensions or the addition of a swimming pool are not significantly different from those earned by owners who do not improve their homes. In contrast, the returns on duplexes, which maximize the use of the available parcel of land to increase the number of dwellings, is approximately 10% higher than households that do not improve. These results are consistent after controlling for property attributes and temporal or spatial factors.

The results documented in Chapter 3 are robust to a number of additional tests, such as segmentation by holding term to identify speculators (or flippers) and consumers-cum-speculators, estimation and comparison of repeat sales indices for improved and unimproved home, and sample selection bias. In segmentation analysis, the speculators (or flippers) are found to perform better than homeowners who resell in the same investment horizon but do not undertake any improvements. While this study identifies speculators conditional on the holding term of less than two years, it does not imply that buying and selling in the short term yields higher returns. The holding terms merely acts as a key variable that helps in the selection of speculators but does not directly affect the outcome i.e. higher returns. The most economically significant change is identified in the extensions/alterations improvement category with 5.4% higher returns than unimproved homes. For consumers-cum-speculators, the study finds returns are -5.6% relative to owners who buy and sell quickly but do not improve their homes. These findings are consistent with the speculation-based results reported by (Choi et al., 2014). In addition, the construction and comparison of repeat sales indices for improved and unimproved homes further confirms my results. Based on the estimated indices, the study finds that the cost-adjusted returns on improved homes over time are consistently lower than those for unimproved homes. The test results from sample selection bias correction are also consistent with the original results.

Chapter 3 contributes to our understanding of home improvements in terms of the trade-off between financial rewards and consumption benefits at aggregate level. However, home improvement also needs to be studied further, as part of future research, in the context of a more broader topic, such as rational choice theory. Households that need additional housing face a binary choice of whether to improve or move to a more appropriate home. As such, one can examine whether their economic behavior or decision to improve homes conforms with rational choice theory. Are the homeowners' preferences consistent with the rational choice theory? Further, as discussed in Chapter 3, the stamp duty on new homes provides a strong disincentive to move, but to what extent are these taken into account in the household's cost benefits analysis. These questions need to be addressed at the individual household level rather than at aggregate level which can form part of future research.

Chapter 4 examines persistence in the capital and rental components of housing returns across different regional levels, by dwelling type, and for both monthly and quarterly frequencies. Using both parametric (wild bootstrap automatic variance ratio) and non-parametric (independent runs) tests of random walk on transaction-based imputed inflation-adjusted house price indices, this study finds, overall, strong persistence in housing market returns. The enhanced variance ratio methodology is also free from arbitrary lag selection procedure and benefits from superior small sample properties. Overall, this study documents higher persistence in the capital component of housing market returns than in the rental component.

Further, the study also generally finds more persistence in houses than units. However, when observed separately for capital and rental components of housing market returns, I find that in the capital component of housing market return, houses exhibit stronger persistence than units, and conversely, in the rental component of housing market return, units have higher persistence than houses, consistent with the investment behaviors of speculators/owner-occupiers. The findings can also have implications on lending decisions for banks/mortgage lenders as the proportion of loan for houses and units can be conditioned depending on whether the property being purchased is for owner-occupation or rental purposes.

Spatially, the study documents significant amount of variation in persistence across regional levels—mainly in SA3 and SA4 levels—and that the persistence in housing market returns is clustered together and most concentrated near greater capital cities. The results are in line with the literature on spatial diffusion or spatial form of market inefficiency (for example, (Clapp and Tirtiroglu, 1994; Clapp et al., 1995; Dolde and Tirtiroglu, 1997)). Additionally, from examination of persistence from smaller regional level indices up to broader (national-level) indices, the study finds the number of regions with persistence in housing market returns systematically increases. Finally, the study also records higher persistence in monthly as compared to quarterly returns.

Overall, these findings have implications for banks/financial institutions, and other mortgage lenders, policy makers, and investors. While it is in the interest of banks/mortgage lenders and policy makers to have non-persistent markets so that house prices do not deviate from their fundamental value, the investors, on the contrary, would prefer persistent returns as they present opportunities for arbitrage, and consequently, excess returns. While this study provides a comprehensive analysis of persistence in both capital and rental components of housing market index returns, there are several areas that could be studied as part of future research. For example, one could examine whether there is persistence in different price bands/ quantiles, look into different sub-periods, such as pre- and post-GFC, and also test whether persistence is economically significant with respect to the Australian housing market.

Chapter 5 presents a case study of the underquoting reforms introduced in New South Wales and Victoria to stamp out underquoting practices by real estate agents. Despite opposition from the real estate industry, which believed that the regulation was unnecessary, the state government passed the reforms on October 22, 2015, and November 02, 2016, which subsequently were effective from January 01, 2016, and May 01, 2017, in New South Wales and Victoria, respectively.

I utilize the population of listings and home sales data from 2014 to 2018 classified into pre-enactment, enactment, and commencement periods to test the hypothesis that regulations have reduced underquoting in New South Wales and Victoria. By comparing the change in underquoting during enactment and commencement periods relative to the pre-enactment period in New South Wales and Victoria with respect to control states, I provide evidence of widespread prevalence of the underquoting practice in the states, and a reduction in underquoting practices just after the law was passed.

The empirical findings for New South Wales show that, for 'Auction' sales, there is 4.1% and 5.7% reduction in underquoting during the enactment period and after the commencement of the law, respectively. Meanwhile, for 'Private' sales, the study finds 1.2% and 3.8% reductions in underquoting, respectively. Comparison of the change in the underquoting ratio of listings in Victoria relative to control states shows that, in the case of 'Auction' sales, there is a 2.3% and 7.3% decrease in underquoting during the enactment period and post-commencement period, respectively. However, in 'Private' sales, the study finds the decrease in the underquoting practice is evident only after the law entered into force, with 2.7% reduction in underquoting, while there is a marginal increase in the underquoting ratio of 0.5% during the enactment period. These findings are robust to location fixed effects at the local geographic area level and controlled for market index estimates, various property and listing characteristics, and other location and temporal factors.

While, the results in this study are of interest to the various agencies in NSW and Victoria who are in charge of enforcing underquoting legislation and to the general public, there is a limitation. The study focuses on the average degree of underquoting, which could be the result of a small number of agents massively underquoting or a large number of agents all underquoting by a bit. This difference can be quite significant both in terms of the welfare costs and enforcement of the regulation. Therefore, the prevalence of underquoting is of interest as well as the average degree of underquoting. This can be studied as part of future research, perhaps by creating a binary variable indicating whether underquoting is clearly present or not and then examining the statistics before and after the changes. One could also run a regression using this binary variable as the dependent variable.

Overall, the housing market plays an important role in the financial and economic stability of a nation, and as such, assessing the performance of housing markets is critically important. This dissertation underlines the importance of rational decision-making regarding additional housing, the weak-form inefficiency of the housing market, and the responsiveness of the housing market to regulatory interventions. The findings of the thesis will be of interest to market practitioners and regulators alike. Households should be able to make more informed home improvement decisions depending on utility and not merely on speculation; market participants can hedge their exposures with knowledge of persistence in returns. Finally, regulations are integral components of housing market infrastructure, and if well-designed and -executed, they can improve the performance of markets and enhance social welfare.

Appendices

Appendix A

Australian Standard Geographic Classification Structure

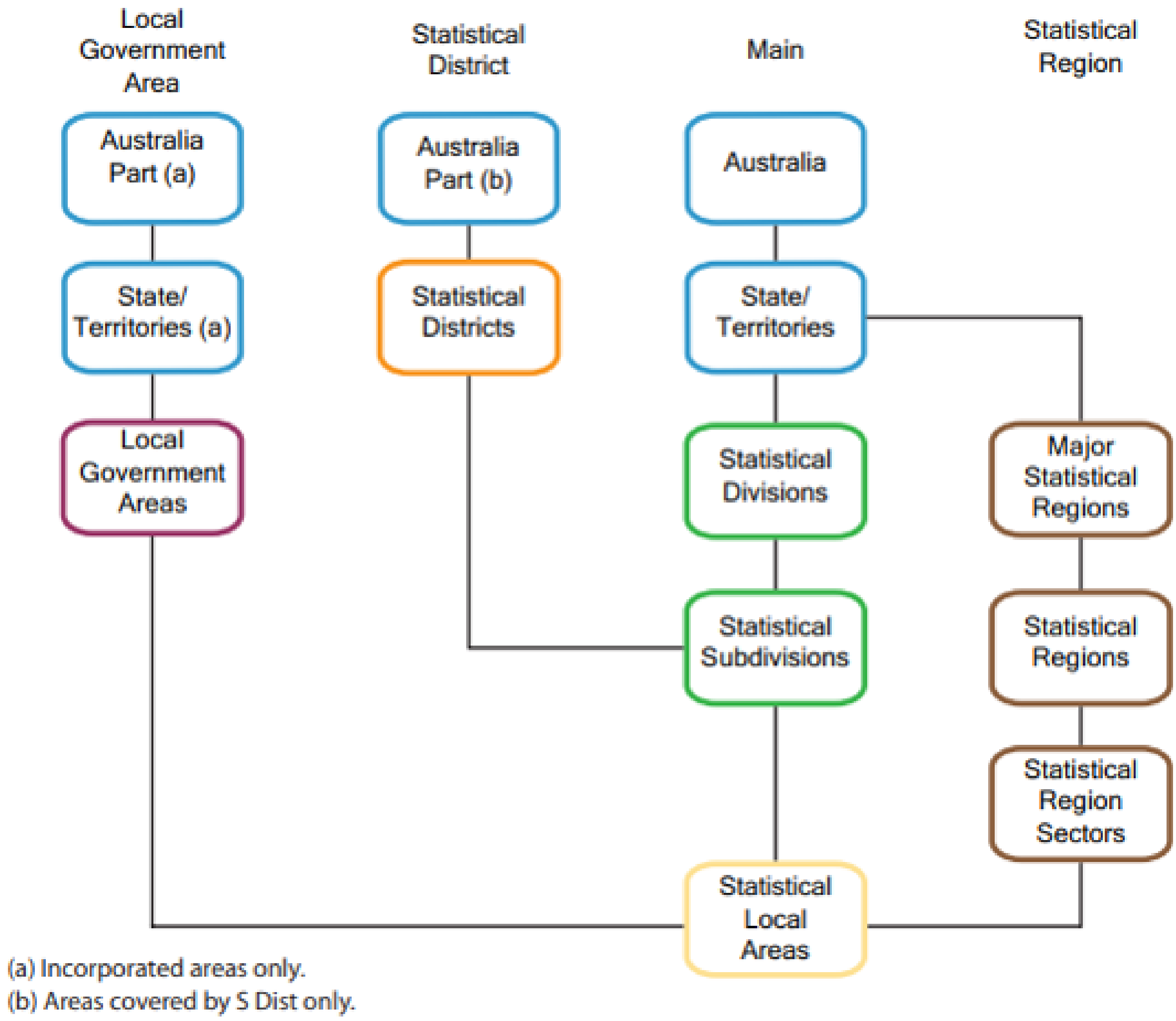
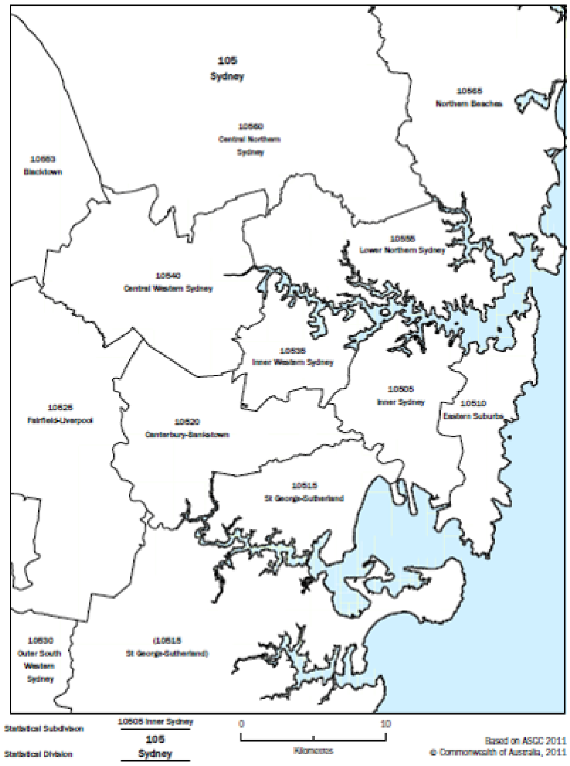


Figure A: Australian Standard Geographic Classification 2011 Structure
Source: Australian Bureau of Statistics (2011b)

Appendix B

Statistical Division and Statistical Subdivision Maps

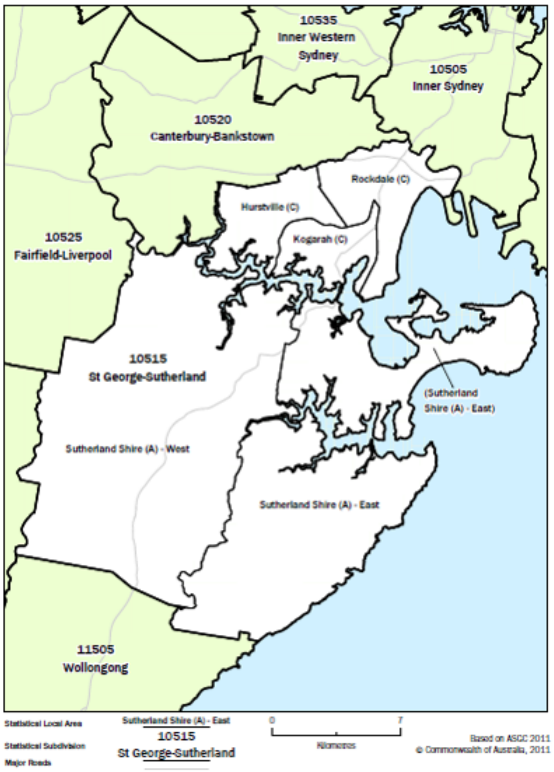
Figure B1: Statistical Division and Statistical Subdivision Map - 105 Sydney
Source: Australian Bureau of Statistics (2011a)



(a) Statistical Subdivision Map - 105 Sydney Inset

(b) Statistical Subdivision Map - 10510 Eastern Suburbs Sydney

(c) Statistical Subdivision Map - 10505 Inner Sydney



(d) Statistical Subdivision Map - 10505 St. George Sutherland

Figure B2: Statistical Subdivision Maps - Sydney
Source: Australian Bureau of Statistics (2011a)

Appendix C

Recent trends in Household Wealth

Household wealth is measured as the household sector's assets less its liabilities. Household assets comprise financial assets, which include bank deposits, direct equity holdings and superannuation balances, and non-financial assets, which include housing and durable items such as motor vehicles. The household sector's liabilities are largely made up of residential mortgages, but also include items such as credit card debt and personal loans (Reserve Bank of Australia, 2019).

Household wealth has grown much faster than household income over recent decades (Graph 1). This is largely because of increases in the value of household assets, which have grown from around six times household disposable income in the early 1990s to around eleven times currently. Household liabilities have also grown faster than household income, although by less than household assets. The rate of growth of household wealth varies greatly from year to year and on several occasions, such as during the Global Financial Crisis, the value of household wealth has declined. After increasing by around 60 per cent

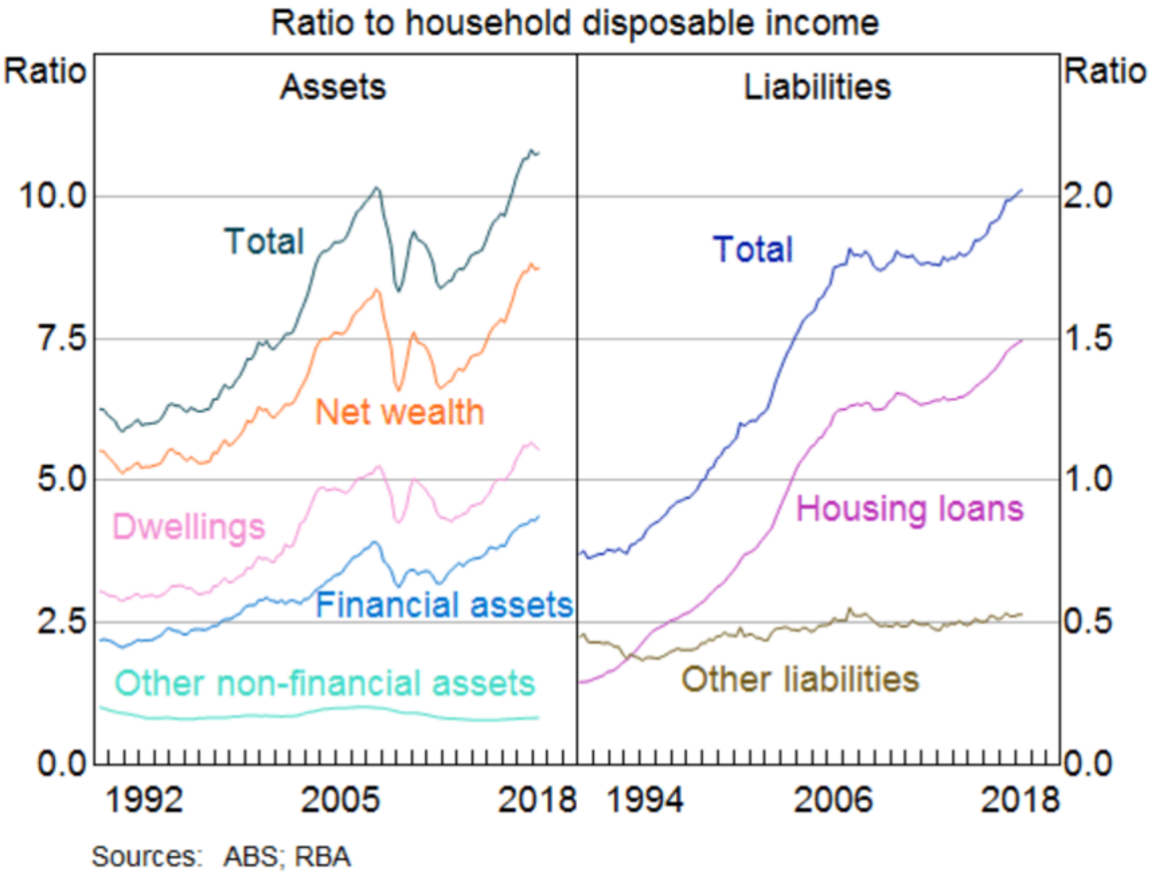


Figure C: Household Assets and Liabilities

between 2013 and 2017, growth in household wealth has slowed recently because of falling housing prices (Reserve Bank of Australia, 2019).

Appendix D

Recent trends in Household Consumption

Household consumption growth has been much more stable than wealth from year to year. After averaging around 5 per cent in year-ended terms between the early 1990s and mid 2000s, the pace of household consumption growth has eased to a bit above two and half per cent in recent years (Graph 2). Modest growth in consumption alongside fast growth in wealth could be taken to mean that changes in wealth have little effect on consumption. In making that judgement, however, it is important to account for other factors that influence consumption growth, such as household income. As the top panel of Graph 2 shows, consumption and income tend to grow at similar rates over time, although income growth is more volatile. Between 2013 and 2017, when household wealth was increasing rapidly, household income growth was low (Reserve Bank of Australia, 2019).

The difference between household consumption and income is reflected in the household saving ratio.[1] Changes in the saving ratio point to a positive relationship between

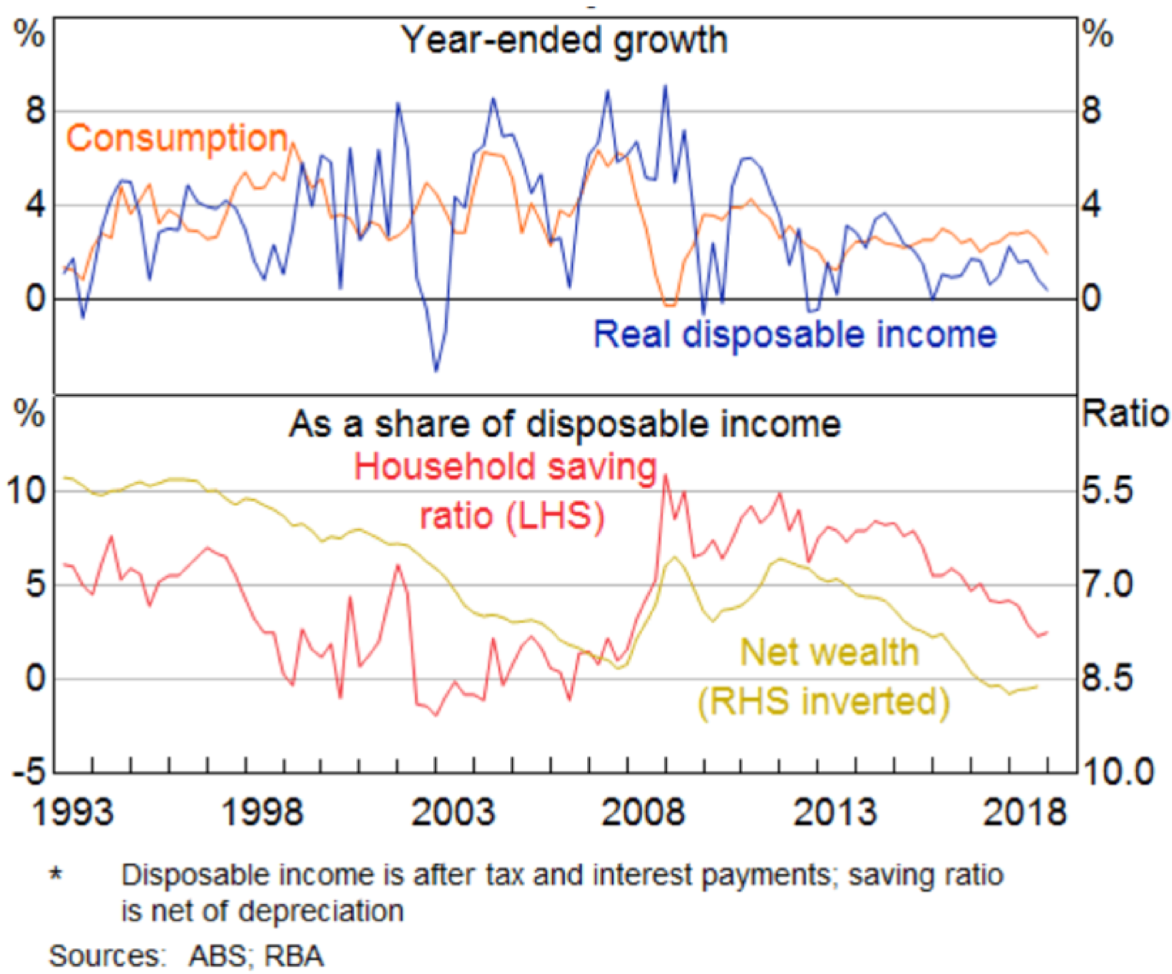


Figure D: Household Consumption and Income

household wealth and consumption. When household wealth grows strongly, consumption typically grows faster than household income and the saving ratio tends to decline. For example, between the 1990s and early 2000s, and again between 2013 and 2017, when household wealth was increasing rapidly, the household saving ratio fell. The opposite typically occurs when household wealth falls. For instance, during the Global Financial Crisis, when household wealth declined, the saving ratio increased (although this had already started some years earlier for other reasons) (Reserve Bank of Australia, 2019).

The patterns highlighted in Graph 2 are consistent with the idea that strong growth in household wealth supported consumption growth in recent years, while, at the same time, weak growth in household income meant that consumption grew more slowly than it did in the 1990s and early 2000s. These relationships may not be causal, however, as other factors influencing both wealth and consumption may drive the correlation between the two variables. In addition, aggregate trends do not tell us how large the effects of changes in household wealth on consumption are. We address these issues in the analysis below by studying the relationship between household wealth and consumption in each Australian state (Reserve Bank of Australia, 2019).

Appendix E

Main Results with Full DA Sample

Table E: Main Result Robustness: Full DA Sample

	Log(Resale Price/Purchase Price (Notional))							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DA							−0.051***	−0.054***
							(0.002)	(0.002)
Carports/Garages/Sheds	−0.016***	−0.013***	−0.041***	−0.042***	−0.043***	−0.045***		
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)		
Duplex	0.148***	0.143***	0.074***	0.077***	0.078***	0.082***		
	(0.009)	(0.009)	(0.013)	(0.013)	(0.013)	(0.013)		
Extension/Alteration	−0.022***	−0.039***	−0.026***	−0.027***	−0.028***	−0.029***		
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)		
House/Single Dwelling	−0.100***	−0.122***	−0.173***	−0.169***	−0.169***	−0.170***		
	(0.001)	(0.001)	(0.005)	(0.005)	(0.005)	(0.005)		
Multiple DA	−0.025***	−0.058***	−0.071***	−0.067***	−0.067***	−0.071***		
	(0.003)	(0.003)	(0.005)	(0.005)	(0.005)	(0.005)		
Swimming Pool	0.119***	0.090***	−0.017***	−0.015***	−0.015***	−0.023***		
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)		
Verandas/Pergolas	−0.023***	−0.032***	−0.042***	−0.040***	−0.041***	−0.045***		
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)		
MktReturn	0.757***	0.766***	0.806***	0.923***	0.923***	0.925***	0.924***	0.926***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Age				−0.001***	−0.002***	−0.002***	−0.002***	−0.002***
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age squared					0.000***	0.000***	0.000***	0.000***
					(0.000)	(0.000)	(0.000)	(0.000)
No. of beds (resale)		0.019***	0.028***	0.028***	0.028***		0.028***	
		(0.001)	(0.001)	(0.001)	(0.001)		(0.001)	
No. of baths (resale)		0.051***	0.062***	0.063***	0.063***		0.062***	
		(0.001)	(0.001)	(0.001)	(0.001)		(0.001)	
No. of cars (resale)		0.002***	0.004***	0.006***	0.006***		0.006***	
		(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	
No. of beds (purchase)			−0.033***	−0.034***	−0.034***		−0.033***	
			(0.001)	(0.001)	(0.001)		(0.001)	
No. of baths (purchase)			−0.071***	−0.071***	−0.071***		−0.070***	
			(0.001)	(0.001)	(0.001)		(0.001)	
No. of cars (purchase)			−0.016***	−0.016***	−0.016***		−0.016***	
			(0.000)	(0.000)	(0.000)		(0.000)	
Change in # of beds						0.030***		0.030***
						(0.001)		(0.001)
Change in # of baths						0.066***		0.065***
						(0.001)		(0.001)
Change in # of cars						0.010***		0.010***
						(0.000)		(0.000)
Constant	0.062***	−0.087***	0.084***	0.109***	0.122***	0.075***	0.123***	0.076***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)
Year Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Location Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	1,263,756	1,140,558	529,063	529,063	529,063	529,063	529,063	529,063
Adjusted R^2	0.136	0.160	0.281	0.289	0.289	0.287	0.287	0.285
F Statistic	7,949.399***	7,735.062***	6,677.688***	6,718.845***	6,529.027***	7,108.311***	7,900.302***	8,797.499***
	(df = 25; 1263730)	(df = 28; 1140529)	(df = 31; 529031)	(df = 32; 529030)	(df = 33; 529029)	(df = 30; 529032)	(df = 27; 529035)	(df = 24; 529038)

Notes: Robust standard errors are reported in parentheses; significance of variables is adjusted accordingly. *** 0.1% significance ** 1% significance * 5% significance. We have a total of 1,263,893 (200,207 for treatment and 1,063,686 for control sample) possible observation with deviation accounted for by missing data which are excluded from the regression.

Appendix F

Main Results with SSD Regional Level Fixed Effects

Table F: Model Results: SSD Region level

	Log(Resale Price/Purchase Price (Notional))							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DA							−0.019***	−0.024***
							(0.002)	(0.002)
Carports/Garages/Sheds	−0.070***	−0.074***	−0.002	−0.001	−0.000	−0.005		
	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)	(0.007)		
Duplex	0.160***	0.114***	0.084***	0.094***	0.096***	0.096***		
	(0.012)	(0.012)	(0.013)	(0.013)	(0.013)	(0.013)		
Extension/Alteration	0.029***	−0.009***	−0.009***	−0.010***	−0.010***	−0.012***		
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)		
House/Single Dwelling	−0.080***	−0.125***	−0.117***	−0.110***	−0.109***	−0.111***		
	(0.005)	(0.005)	(0.007)	(0.007)	(0.007)	(0.007)		
Multiple DA	0.034***	−0.005	−0.023***	−0.015**	−0.015**	−0.021***		
	(0.003)	(0.003)	(0.006)	(0.006)	(0.006)	(0.006)		
Swimming Pool	0.189***	0.156***	0.002	0.007**	0.007**	−0.002		
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)		
Verandas/Pergolas	0.024***	0.015***	−0.028***	−0.026***	−0.027***	−0.031***		
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)		
MktReturn	0.766***	0.775***	0.809***	0.955***	0.954***	0.954***	0.955***	0.955***
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Months between sales				−0.001***	−0.002***	−0.002***	−0.002***	−0.002***
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Months between sales squared					0.000***	0.000***	0.000***	0.000***
					(0.000)	(0.000)	(0.000)	(0.000)
No. of beds (resale)		0.016***	0.025***	0.026***	0.026***		0.025***	
		(0.001)	(0.001)	(0.001)	(0.001)		(0.001)	
No. of baths (resale)		0.054***	0.051***	0.052***	0.052***		0.051***	
		(0.001)	(0.001)	(0.001)	(0.001)		(0.001)	
No. of cars (resale)		0.001***	0.006***	0.008***	0.008***		0.008***	
		(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	
No. of beds (purchase)			−0.031***	−0.031***	−0.031***		−0.031***	
			(0.001)	(0.001)	(0.001)		(0.001)	
No. of baths (purchase)			−0.070***	−0.070***	−0.070***		−0.069***	
			(0.001)	(0.001)	(0.001)		(0.001)	
No. of cars (purchase)			−0.013***	−0.014***	−0.014***		−0.014***	
			(0.000)	(0.000)	(0.000)		(0.000)	
Change in # of beds						0.028***		0.027***
						(0.001)		(0.001)
Change in # of baths						0.060***		0.059***
						(0.001)		(0.001)
Change in # of cars						0.010***		0.010***
						(0.000)		(0.000)
Constant	0.148***	0.023***	0.160***	0.179***	0.194***	0.143***	0.193***	0.144***
	(0.004)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Year Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Location Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	1,119,293	1,012,436	517,011	517,011	517,011	517,011	517,011	517,011
Adjusted R^2	0.140	0.165	0.302	0.311	0.312	0.309	0.311	0.308
F Statistic	887.768***	955.373***	1,057.003***	1,098.319***	1,096.034***	1,095.434***	1,123.717***	1,123.728***
	(df = 206; 1119086)	(df = 209; 1012226)	(df = 212; 516798)	(df = 213; 516797)	(df = 214; 516796)	(df = 211; 516799)	(df = 208; 516802)	(df = 205; 516805)

Notes: Robust standard errors are reported in parentheses; significance of variables is adjusted accordingly. *** 0.1% significance ** 1% significance * 5% significance. We have a total of 1,119,419 (55,733 for treatment and 1,063,686 for control sample) possible observation with deviation accounted for by missing data which are excluded from the regression.

Appendix G

House Price Index Prediction Error Distribution

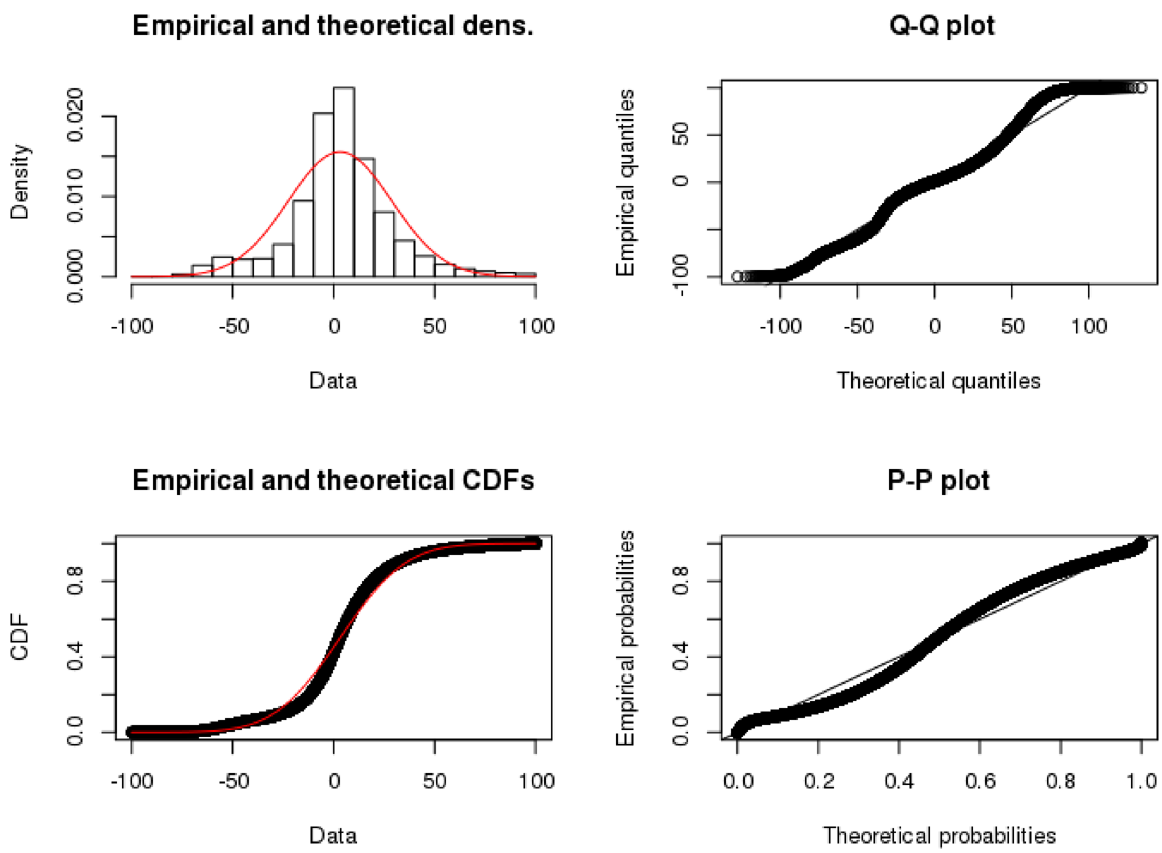


Figure G: House Price Index Prediction Error Distribution

Appendix H

Average Commencement and Construction times (Months)

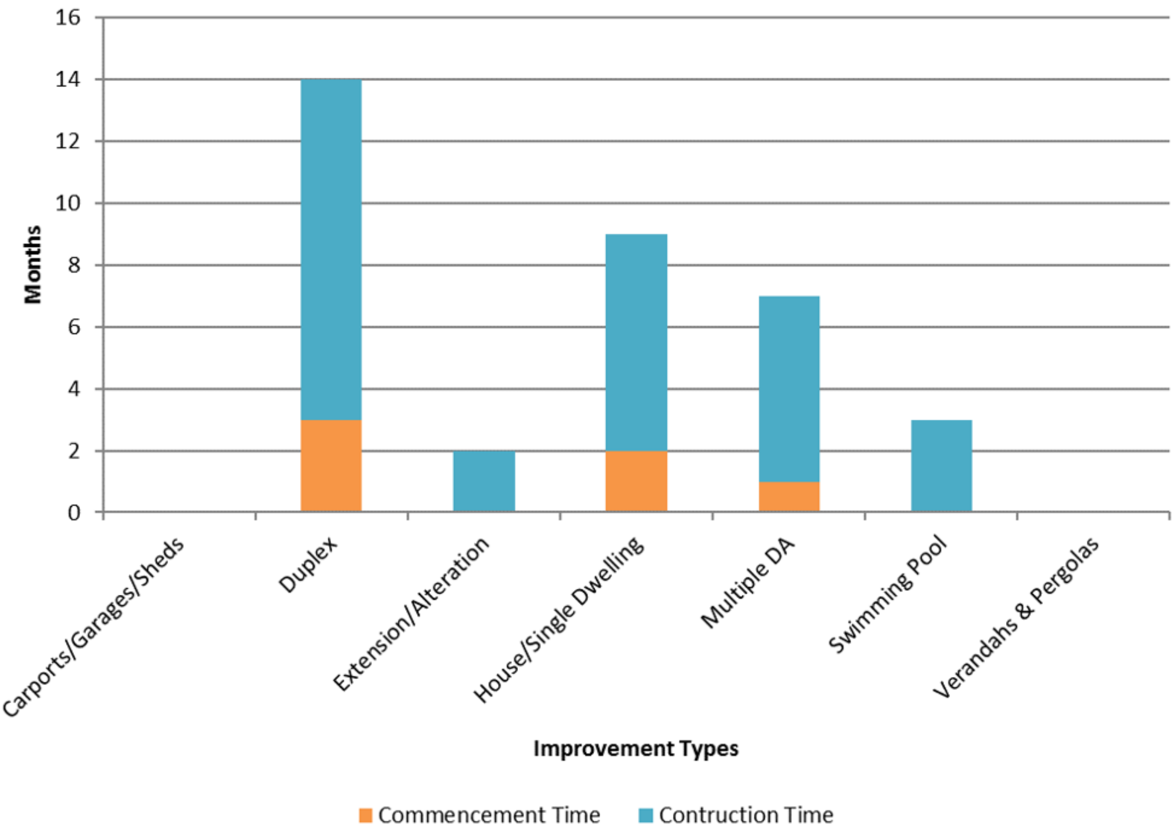
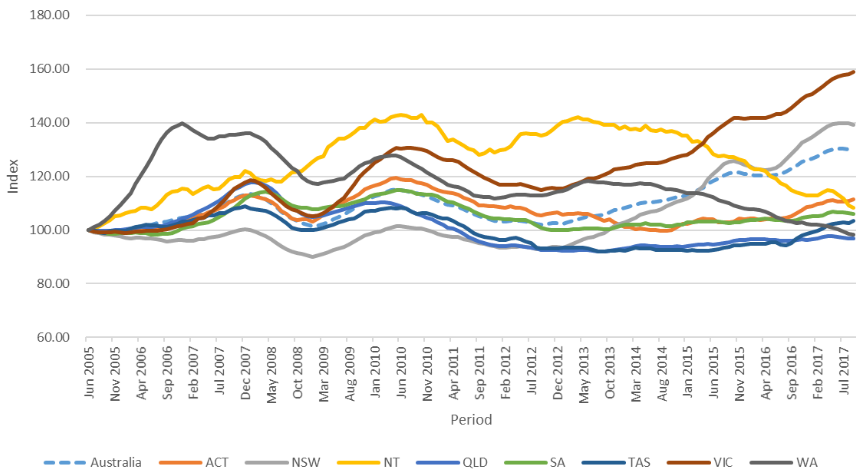


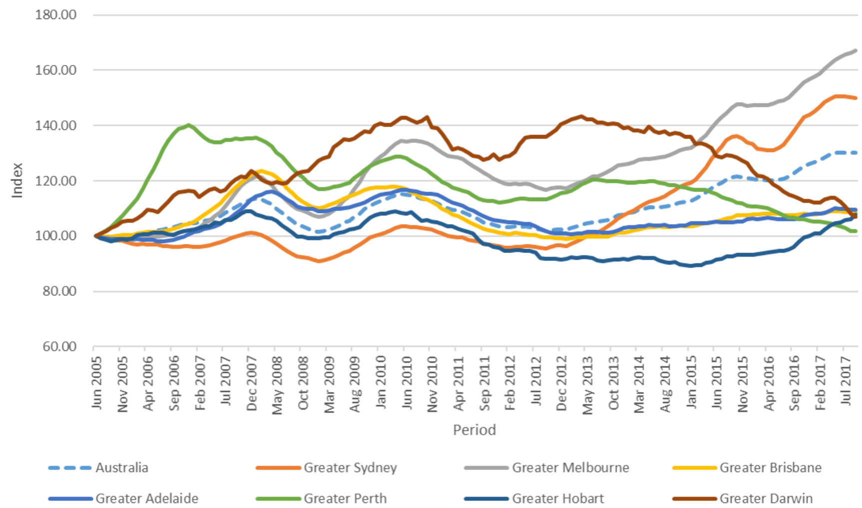
Figure H: Average Commencement and Construction Times (Months)

Appendix I

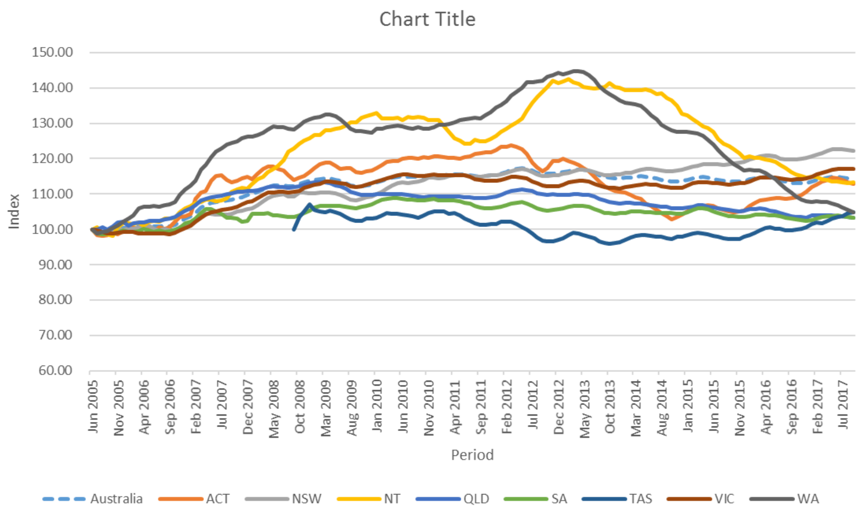
Real Capital and Rental Price Indices: All Dwellings



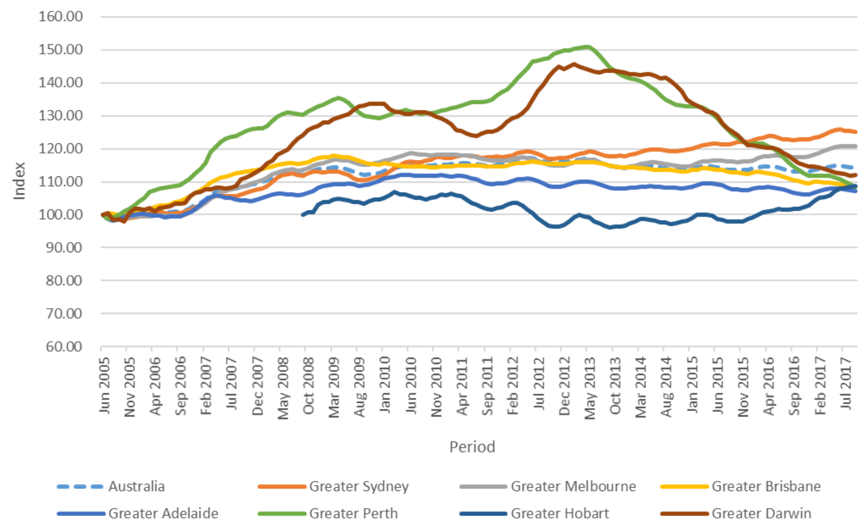
(a) Real Capital Price Index (All Dwellings): Australia and States



(b) Real Capital Price Index (All Dwellings): Australia and GCC



(c) Real Rental Price Index (All Dwellings): Australia and States



(d) Real Rental Price Index (All Dwellings): Australia and GCC

Figure I: Real Capital and Rental Price Indices for All Dwellings

Appendix J

Summary Statistics for All Dwellings

Table J: Summary Statistics: Real Capital Log Returns (2005–2017)

Region	Sub Region	Capital				Rental			
		Monthly		Quarterly		Monthly		Quarterly	
		Mean (%)	Std. Dev. (%)	Mean (%)	Std. Dev. (%)	Mean (%)	Std. Dev. (%)	Mean (%)	Std. Dev. (%)
Australia	Australia	0.4	0.6	1.1	1.7	0.3	0.3	0.8	1.0
ACT	ACT	0.3	0.6	0.8	1.6	0.3	0.8	0.9	1.9
	NSW	0.4	0.7	1.3	2.0	0.3	0.4	1.0	1.0
NSW	GSYD	0.5	0.8	1.4	2.2	0.4	0.4	1.0	1.0
	RNSW	0.2	0.5	0.7	1.4	0.3	0.6	0.6	1.5
	NT	0.3	1.0	0.8	2.3	0.3	0.8	-0.3	8.8
NT	GDAR	0.2	1.0	0.7	2.5	0.3	0.9	-0.4	8.8
	RNTE	0.3	1.7	0.9	3.2	0.3	1.9	1.0	3.6
	QLD	0.2	0.6	0.6	1.7	0.2	0.4	0.7	0.9
QLD	GBRI	0.3	0.6	0.8	1.9	0.3	0.3	0.8	0.9
	RQLD	0.1	0.5	0.3	1.5	0.2	0.6	0.6	1.0
	SA	0.2	0.5	0.7	1.4	0.2	0.4	0.5	1.3
SA	GADE	0.3	0.5	0.8	1.5	0.2	0.3	0.8	0.9
	RSAU	0.1	0.8	0.3	1.6	0.1	1.7	0.2	2.1
	TAS	0.2	0.6	0.7	1.5	0.2	0.6	0.6	1.5
TAS	GHOB	0.3	0.7	0.8	1.8	0.2	0.6	0.7	1.5
	RTAS	0.2	0.6	0.6	1.4	0.2	0.8	0.5	2.0
	VIC	0.5	0.8	1.6	2.2	0.3	0.3	0.9	0.9
VIC	GMEL	0.6	0.9	1.7	2.4	0.3	0.3	1.0	1.0
	RVIC	0.3	0.5	0.8	1.3	0.2	0.6	0.5	1.4
	WA	0.2	1.0	0.6	2.9	0.2	0.7	0.7	2.1
WA	GPER	0.2	1.0	0.7	2.9	0.3	0.8	0.8	2.2
	RWAU	0.1	1.2	0.3	3.0	0.1	1.2	0.4	2.6

This table reports the summary statistics of real capital and monthly (148 observations) and quarterly (50 observations) rental index log returns for all dwellings at the Nationwide, States, Greater Capital Cities (GCC) and Rest of State levels for the period 2005–2017.

Appendix K

% Distribution of Regions with Persistence: All Dwellings

Table K: Summary Results: % Distribution of Regions with Persistence in Capital Component of Housing Market Returns (2005–2017)

Type	Level	No. of Regions	VR Sig. 1%	VR Sig. 5%	Runs Sig. 1%	Runs Sig. 5%
Monthly	Nation	1	100	100	100	100
	State	8	100	100	100	100
	GCC	15	100	100	93	100
	SA4	88	83	84	77	82
	SA3	334	69	75	53	65
Quarterly	Nation	1	100	100	100	100
	State	8	50	88	88	100
	GCC	15	53	73	53	73
	SA4	88	56	70	57	72
	SA3	334	48	62	38	49

This table reports the % distribution of the number of regions with persistence in capital index returns for all dwellings across various regional levels at monthly and quarterly frequencies based on the Variance Ratio and Independent Runs tests.

Table K: Summary Results: % Distribution of Regions with Persistence in Rental Component of Housing Market Returns (2005–2017)

Type	Level	No. of Regions	VR Sig. 1%	VR Sig. 5%	Runs Sig. 1%	Runs Sig. 5%
Monthly	Nation	1	100	100	100	100
	State	8	88	100	100	100
	GCC	15	60	73	80	80
	SA4	88	57	66	59	75
	SA3	332	42	50	33	49
Quarterly	Nation	1	0	0	0	0
	State	8	38	50	13	25
	GCC	15	27	33	13	20
	SA4	88	26	31	9	17
	SA3	332	16	24	7	14

This table reports % distribution of the number of regions with persistence in rental index returns for all dwellings across various regional levels at monthly and quarterly frequencies based on the Variance Ratio and Independent Runs tests.

Appendix L

Results at SA3 Regional Level for Monthly Frequency

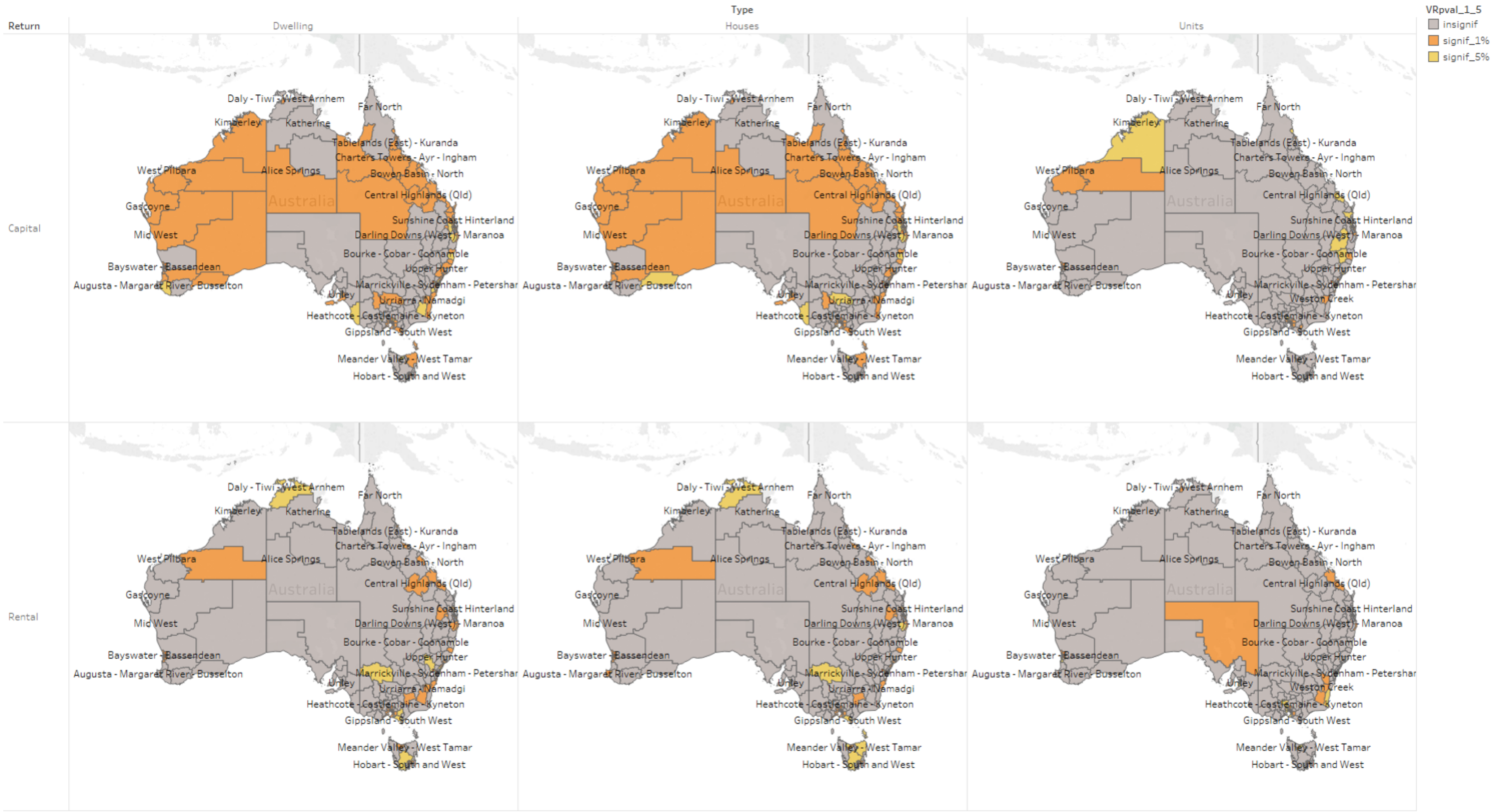


Figure L: Results at SA3 Regional Level for Monthly Frequency

Appendix M

Results at SA3 Regional Level for Quarterly Frequency

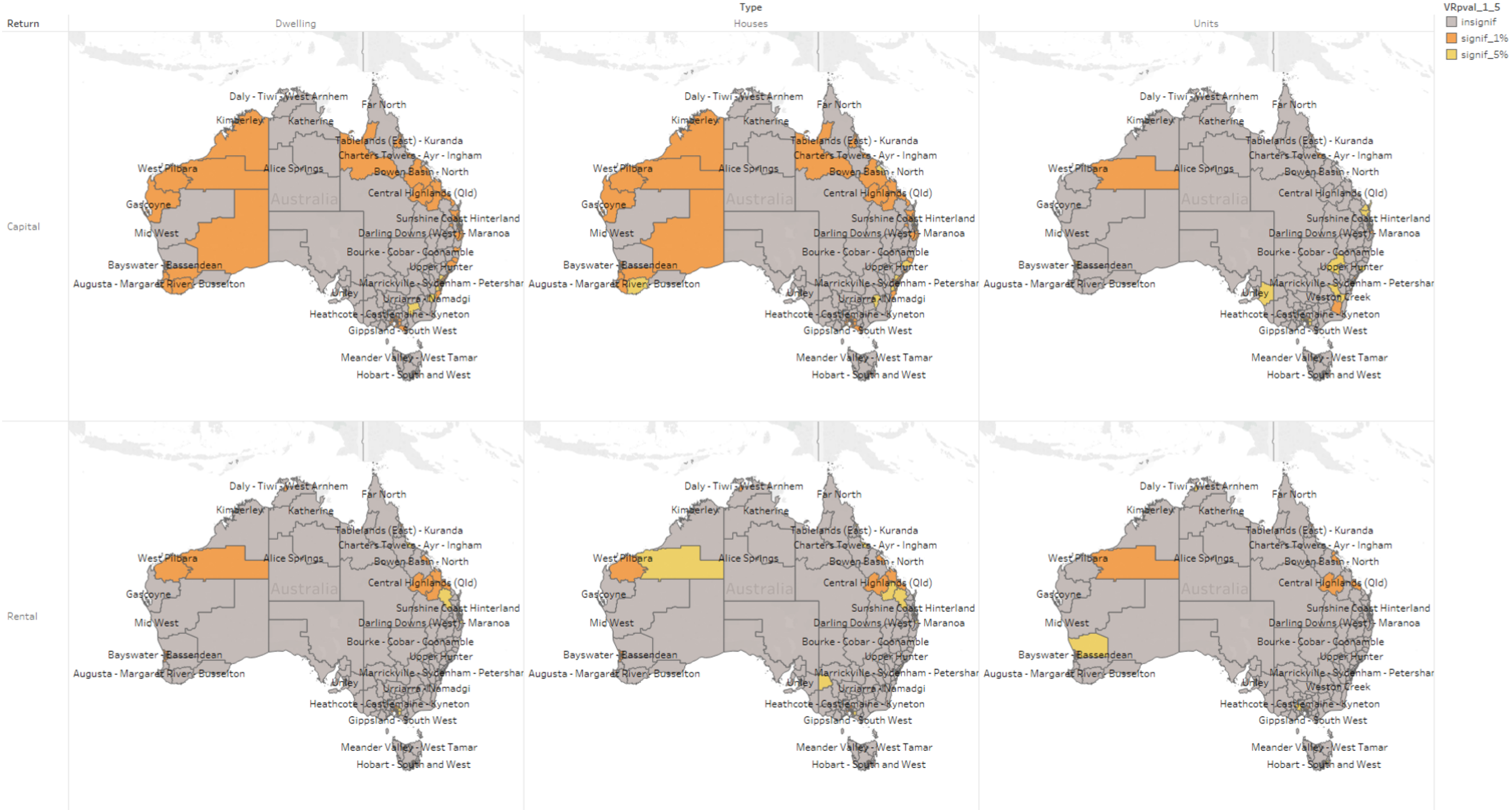


Figure M: Results at SA3 Regional Level for Quarterly Frequency

Appendix N

Wild Bootstrap AVR Test Results for All Dwellings: Capital

Table N: Capital: Wild Bootstrap Automatic Variance Ratio Test Result for All dwellings

Panel A: Monthly

Region	Sub Region	VR	test.stat	pval	CI.VR lower	CI.VR upper	CI.stat lower	CI.stat upper
Australia	Australia	6.9316	8.8230	0	0.6835	1.5810	-1.8472	2.7688
ACT	ACT	5.4752	12.5949	0	0.7350	1.4862	-1.5490	2.2893
	NSW	10.8795	16.0241	0	0.6575	1.4918	-1.9910	2.4128
NSW	GSYD	10.5431	15.7791	0	0.6514	1.5145	-1.9848	2.4041
	RNSW	8.7782	16.5977	0	0.6735	1.4553	-1.8852	2.2190
	NT	3.1648	7.8435	0	0.7767	1.2816	-1.3389	1.4675
NT	GDAR	2.7761	6.6982	0	0.7573	1.2875	-1.4452	1.5106
	RNT	1.3574	1.8292	0	0.8479	1.1703	-0.9575	0.9549
	QLD	7.7572	10.2220	0	0.5923	1.7033	-2.2978	3.1541
QLD	GBRI	7.8993	10.1888	0	0.5952	1.6806	-2.2828	3.1054
	RQLD	6.8993	11.0072	0	0.6152	1.7200	-2.1885	3.3510
	SA	6.4146	12.2984	0	0.6423	1.6283	-2.0580	2.6855
SA	GADE	6.9592	13.1219	0	0.6285	1.6795	-2.1040	2.9718
	RSAU	1.9703	4.0661	0	0.7934	1.3310	-1.2250	1.6827
	TAS	5.2528	11.6764	0	0.6823	1.5421	-1.8626	2.5038
TAS	GHOB	4.1083	10.1835	0	0.7289	1.3821	-1.5879	1.8557
	RTAS	2.9697	6.9695	0	0.7105	1.4230	-1.7025	2.1129
	VIC	7.7297	10.4605	0	0.6474	1.6306	-2.0060	2.8562
VIC	GMEL	7.9585	10.7756	0	0.6580	1.6099	-1.9803	2.8449
	RVIC	3.5136	8.1533	0	0.7675	1.3262	-1.3954	1.7218
	WA	8.3286	10.6523	0	0.6050	1.6663	-2.3010	3.1541
WA	GPER	7.5303	9.3188	0	0.6127	1.7109	-2.2203	3.3194
	RWAU	3.7244	9.7274	0	0.7508	1.3117	-1.4828	1.6397

Panel B: Quarterly

Region	Sub Region	VR	test.stat	pval	CI.VR lower	CI.VR upper	CI.stat lower	CI.stat upper
Australia	Australia	2.5789	2.3105	0.01	0.5598	1.6622	-1.5771	1.7881
ACT	ACT	1.7898	1.5201	0.064	0.5901	1.6808	-1.4608	1.8326
	NSW	4.5072	5.1602	0	0.5458	1.7137	-1.6136	1.9145
NSW	GSYD	4.4702	5.1719	0	0.5428	1.6683	-1.6314	1.8497
	RNSW	3.5662	4.6486	0	0.6044	1.6317	-1.4087	1.8129
	NT	3.0034	4.3291	0	0.6791	1.4894	-1.1713	1.4655
NT	GDAR	2.8535	4.0969	0	0.7244	1.4509	-1.0141	1.3507
	RNT	1.2316	0.7422	0.28	0.6473	1.5977	-1.2745	1.7250
	QLD	2.7606	2.6868	0.014	0.5058	1.7827	-1.7352	2.1270
QLD	GBRI	2.8188	2.6101	0.018	0.4787	1.8777	-1.8142	2.2269
	RQLD	2.7237	2.9201	0.008	0.5138	1.7786	-1.7006	2.0585
	SA	2.2699	2.4208	0.014	0.5692	1.6625	-1.5462	1.8231
SA	GADE	2.4050	2.5059	0.014	0.5441	1.6889	-1.5998	1.8768
	RSAU	1.1634	0.6251	0.282	0.6644	1.5681	-1.2070	1.5659
	TAS	2.4036	2.7703	0.002	0.6056	1.5818	-1.4152	1.6516
TAS	GHOB	2.5663	3.1951	0.002	0.6854	1.5241	-1.1422	1.5409
	RTAS	1.8225	1.8908	0.012	0.6036	1.5643	-1.4137	1.6401
	VIC	3.2048	2.9743	0.004	0.5024	1.7220	-1.7471	2.0399
VIC	GMEL	3.3089	3.1241	0.002	0.5163	1.6756	-1.6874	1.9017
	RVIC	1.8648	2.1196	0.006	0.6645	1.5157	-1.2154	1.5089
	WA	2.9113	2.6326	0.04	0.4097	2.1314	-2.0391	2.8660
WA	GPER	2.6752	2.3614	0.064	0.4136	2.1129	-2.0509	2.7551
	RWAU	3.9682	5.2026	0	0.5045	1.7659	-1.7355	2.0753

Table N Panels A and B report the Wild Bootstrap Automatic Variance Ratio (AVR) test results for capital index return for all dwellings at the GCC level (Australia, States, Corresponding Rest of States and Greater Capital Cities) for monthly and quarterly frequencies, respectively. VR is the variance ratio. CI stands for Confidence Interval.

Appendix O

Wild Bootstrap AVR Test Results for All Dwellings: Rental

Table O: Rental: Wild Bootstrap Automatic Variance Ratio Test Result for All Dwellings

Panel A: Monthly

Region	Sub Region	VR	test.stat	pval	CI.VR lower	CI.VR upper	CI.stat lower	CI.stat upper
Australia	Australia	5.2793	9.9009	0	0.6609	1.5609	-1.9628	2.6247
ACT	ACT	2.8047	5.8190	0	0.6958	1.4241	-1.7705	2.0811
	NSW	2.8248	5.6064	0	0.7039	1.4480	-1.7461	2.1476
NSW	GSYD	4.0102	7.9466	0	0.6610	1.5658	-1.9067	2.6654
	RNSW	0.9975	-0.0282	0.936	0.6427	1.5137	-2.0419	2.4919
	NT	4.4076	11.2613	0	0.7172	1.3223	-1.6664	1.6803
NT	GDAR	5.8305	14.2289	0	0.6712	1.3658	-1.8752	1.8559
	RNT	0.9451	-0.3995	0.614	0.7306	1.4283	-1.5419	2.0913
	QLD	3.5165	8.1860	0	0.6840	1.5131	-1.8259	2.4994
QLD	GBRI	8.0398	17.6920	0	0.6648	1.6590	-1.9710	3.1355
	RQLD	1.7362	3.4655	0.006	0.6551	1.5240	-1.9641	2.5495
	SA	2.1475	4.0905	0	0.7267	1.3265	-1.6200	1.6613
SA	GADE	2.2214	3.1786	0.012	0.6770	1.5037	-1.8510	2.4206
	RSAU	0.9972	-0.0203	0.932	0.6215	1.5927	-2.1618	2.7094
	TAS	2.2706	3.7322	0.01	0.6097	1.8960	-1.9342	3.3491
TAS	GHOB	1.9955	2.6780	0.004	0.7006	1.4259	-1.5410	1.8175
	RTAS	1.5510	1.9245	0.158	0.5267	1.8758	-2.3035	3.2187
	VIC	6.4515	11.9854	0	0.6554	1.5289	-1.9821	2.4730
VIC	GMEL	8.4780	14.8861	0	0.6459	1.6016	-2.0473	2.7782
	RVIC	1.8571	3.7632	0	0.8322	1.2445	-1.0571	1.3320
	WA	10.3629	20.4666	0	0.6755	1.4179	-1.8961	2.0583
WA	GPER	13.2199	22.6434	0	0.6635	1.4339	-1.9575	2.1773
	RWAU	1.5319	2.7102	0.008	0.7005	1.3745	-1.7428	1.8927

Panel B: Quarterly

Region	Sub Region	VR	test.stat	pval	CI.VR lower	CI.VR upper	CI.stat lower	CI.stat upper
Australia	Australia	1.8495	2.0953	0.016	0.5727	1.7137	-1.5153	1.9130
ACT	ACT	1.6448	1.6756	0.072	0.5853	1.7229	-1.4752	1.9555
	NSW	1.5934	1.5252	0.05	0.6368	1.5983	-1.3224	1.6553
NSW	GSYD	1.8956	2.1687	0.004	0.6351	1.5430	-1.3215	1.5989
	RNSW	1.0121	0.0364	0.84	0.6208	1.6388	-1.3531	1.8932
	NT	4.6890	6.5590	0	0.6187	1.7239	-1.3865	2.0173
NT	GDAR	4.9390	6.7563	0	0.6102	1.6907	-1.4100	1.9006
	RNT	1.1945	0.6888	0.22	0.6727	1.5866	-1.1519	1.5933
	QLD	2.2151	2.9253	0.002	0.5744	1.7296	-1.5138	1.9341
QLD	GBRI	5.1426	7.2101	0	0.4854	2.0334	-1.7943	2.5468
	RQLD	1.1766	0.5737	0.402	0.6189	1.4797	-1.3671	1.4059
	SA	0.9610	-0.1282	0.71	0.7103	1.4908	-1.0668	1.4493
SA	GADE	0.9154	-0.2672	0.598	0.6777	1.5034	-1.1763	1.4520
	RSAU	0.6932	-1.1328	0.286	0.5320	2.0844	-1.6477	2.7533
	TAS	0.9719	-0.1335	0.668	0.6933	1.5209	-0.9860	1.2985
TAS	GHOB	0.8852	-0.3140	0.566	0.6318	1.5654	-1.1666	1.4703
	RTAS	0.7298	-0.8693	0.358	0.4843	1.8776	-1.5881	1.9233
	VIC	2.1864	2.8229	0.004	0.5874	1.6240	-1.4565	1.6997
VIC	GMEL	2.7299	3.8289	0	0.5484	1.7367	-1.6107	2.0435
	RVIC	1.0473	0.2265	0.572	0.6769	1.4973	-1.1745	1.4152
	WA	5.2894	7.4103	0	0.6113	1.6654	-1.3855	1.8971
WA	GPER	5.2792	7.4076	0	0.6575	1.6193	-1.2361	1.7427
	RWAU	1.6974	1.9327	0.028	0.6039	1.6778	-1.4114	1.9317

Table O Panels A and B report the Wild Bootstrap Automatic Variance Ratio (AVR) test results for rental index return for all dwellings at the GCC level (Australia, States, Corresponding Rest of States and Greater Capital Cities) for monthly and quarterly frequencies, respectively. VR is the variance ratio. CI stands for Confidence Interval.

Appendix P

Independent Runs Tests Results for All Dwellings: Capital

Table P: Independent Runs Test for All Dwellings: Capital Return

Region	Sub Region	Panel A: Monthly				Panel B: Quarterly			
		Statistic	Runs Test	p.value Runs Test (-)	Runs Test (+)	Statistic	Runs Test	p.value Runs Test (-)	Runs Test (+)
Australia	Australia	-9.41	0.0000	0.0000	1.0000	-4.54	0.0000	0.0000	1.0000
ACT	ACT	-3.99	0.0001	0.0000	1.0000	-3.32	0.0009	0.0005	0.9995
	NSW	-9.14	0.0000	0.0000	1.0000	-4.72	0.0000	0.0000	1.0000
NSW	GSYD	-8.80	0.0000	0.0000	1.0000	-4.09	0.0000	0.0000	1.0000
	RNSW	-7.89	0.0000	0.0000	1.0000	-3.73	0.0002	0.0001	0.9999
	NT	-4.71	0.0000	0.0000	1.0000	-3.89	0.0001	0.0001	0.9999
NT	GDAR	-3.34	0.0008	0.0004	0.9996	-4.47	0.0000	0.0000	1.0000
	RNT	-1.99	0.0471	0.0235	0.9765	0.17	0.8638	0.5681	0.4319
	QLD	-8.51	0.0000	0.0000	1.0000	-2.95	0.0032	0.0016	0.9984
QLD	GBRI	-7.54	0.0000	0.0000	1.0000	-4.04	0.0001	0.0000	1.0000
	RQLD	-6.83	0.0000	0.0000	1.0000	-2.44	0.0148	0.0074	0.9926
	SA	-5.81	0.0000	0.0000	1.0000	-2.45	0.0142	0.0071	0.9929
SA	GADE	-5.85	0.0000	0.0000	1.0000	-2.45	0.0142	0.0071	0.9929
	RSAU	-2.73	0.0063	0.0032	0.9968	-0.50	0.6168	0.3084	0.6916
	TAS	-4.66	0.0000	0.0000	1.0000	-2.70	0.0070	0.0035	0.9965
TAS	GHOB	-3.95	0.0001	0.0000	1.0000	-3.83	0.0001	0.0001	0.9999
	RTAS	-4.05	0.0001	0.0000	1.0000	-1.87	0.0608	0.0304	0.9696
	VIC	-7.56	0.0000	0.0000	1.0000	-5.33	0.0000	0.0000	1.0000
VIC	GMEL	-8.56	0.0000	0.0000	1.0000	-5.33	0.0000	0.0000	1.0000
	RVIC	-4.81	0.0000	0.0000	1.0000	-1.82	0.0684	0.0342	0.9658
	WA	-9.57	0.0000	0.0000	1.0000	-3.66	0.0002	0.0001	0.9999
WA	GPER	-8.59	0.0000	0.0000	1.0000	-3.66	0.0002	0.0001	0.9999
	RWAU	-3.37	0.0007	0.0004	0.9996	-2.52	0.0119	0.0059	0.9941

Appendix Q

Independent Runs Tests Results for All Dwellings: Rental

Table Q: Independent Runs Test for All Dwellings: Rental Return

		Panel A - Monthly				Panel B - Quarterly			
Region	Sub Region	Statistic	Runs Test	p.value Runs Test (-)	Runs Test (+)	Statistic	Runs Test	p.value Runs Test (-)	Runs Test (+)
Australia	Australia	-9.62	0.0000	0.0000	1.0000	-0.66	0.5124	0.2562	0.7438
ACT	ACT	-3.55	0.0004	0.0002	0.9998	-0.59	0.5553	0.2777	0.7223
	NSW	-7.81	0.0000	0.0000	1.0000	-0.41	0.6814	0.3407	0.6593
NSW	GSYD	-7.11	0.0000	0.0000	1.0000	0.39	0.6944	0.6528	0.3472
	RNSW	-4.12	0.0000	0.0000	1.0000	-0.18	0.8561	0.4280	0.5720
	NT	-2.87	0.0041	0.0020	0.9980	-4.76	0.0000	0.0000	1.0000
NT	GDAR	-1.86	0.0630	0.0315	0.9685	-4.76	0.0000	0.0000	1.0000
	RNT	0.18	0.8541	0.5730	0.4270	-0.87	0.3859	0.1929	0.8071
	QLD	-6.38	0.0000	0.0000	1.0000	-0.66	0.5124	0.2562	0.7438
QLD	GBRI	-6.61	0.0000	0.0000	1.0000	-2.74	0.0061	0.0031	0.9969
	RQLD	-5.18	0.0000	0.0000	1.0000	-1.18	0.2382	0.1191	0.8809
	SA	-4.51	0.0000	0.0000	1.0000	-0.07	0.9430	0.4715	0.5285
SA	GADE	-5.65	0.0000	0.0000	1.0000	-0.14	0.8875	0.4437	0.5563
	RSAU	0.04	0.9646	0.5177	0.4823	0.29	0.7681	0.6160	0.3840
	TAS	-2.98	0.0029	0.0014	0.9986	-0.61	0.5425	0.2713	0.7287
TAS	GHOB	-3.03	0.0024	0.0012	0.9988	-1.22	0.2230	0.1115	0.8885
	RTAS	-1.63	0.1028	0.0514	0.9486	0.02	0.9850	0.5075	0.4925
	VIC	-7.52	0.0000	0.0000	1.0000	-0.12	0.9058	0.4529	0.5471
VIC	GMEL	-7.24	0.0000	0.0000	1.0000	-1.10	0.2720	0.1360	0.8640
	RVIC	-1.03	0.3015	0.1508	0.8492	0.51	0.6085	0.6957	0.3043
	WA	-8.08	0.0000	0.0000	1.0000	-4.18	0.0000	0.0000	1.0000
WA	GPER	-9.07	0.0000	0.0000	1.0000	-4.18	0.0000	0.0000	1.0000
	RWAU	-0.62	0.5321	0.2661	0.7339	-3.26	0.0011	0.0006	0.9994

Appendix R

Underquoting Main Results with Market Change Variable

Table R: Underquoting Model Results with Market Change Variable

	Log(Listing Price/Sale Price)			
	NSW		VIC	
	Auction	Private	Auction	Private
Reg	-0.003	0.012***	0.020***	0.024***
	(0.004)	(0.001)	(0.007)	(0.001)
Commence (NSW)	0.018***	0.000**		
	(0.001)	(0.000)		
Enact (NSW)	0.003*	0.004***		
	(0.002)	(0.000)		
Commence (VIC)			-0.019***	-0.007***
			(0.002)	(0.001)
Enact (VIC)			-0.016***	-0.001*
			(0.002)	(0.000)
Reg * Commence (NSW)	0.048***	0.032***		
	(0.001)	(0.000)		
Reg * Enact (NSW)	0.024***	0.003***		
	(0.002)	(0.001)		
Reg * Commence (VIC)			0.064***	0.020***
			(0.001)	(0.000)
Reg * Enact (VIC)			0.026***	-0.005***
			(0.002)	(0.001)
Mkt_change	-0.429***	-0.328***	-0.364***	-0.246***
	(0.010)	(0.002)	(0.010)	(0.003)
Final_publication_dummy	-0.012***	-0.000**	-0.021***	0.001***
	(0.001)	(0.000)	(0.001)	(0.000)
Days_bet_list_sale	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Property_type	0.005***	-0.003***	0.013***	-0.002***
	(0.001)	(0.000)	(0.001)	(0.000)
Age	-0.000***	0.000	-0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Age squared	0.000***	0.000	-0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
No. of bedrooms	0.000	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
No. of bathrooms	0.001***	0.002***	0.004***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
No. of car spaces	0.000	0.000	0.000	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-0.075***	-0.017***	-0.071***	-0.023***
	(0.002)	(0.001)	(0.002)	(0.001)
Year Fixed Effects	Yes	Yes	Yes	Yes
Location Fixed Effects	Yes	Yes	Yes	Yes
Observations	138,945	1,604,918	155,825	1,487,806
Obs. Treatment	92,572	497,929	109,452	380,817
Obs. Control	46,373	1,106,989	46,373	1,106,989
Adjusted R2	0.156	0.19	0.194	0.176
F Statistic	300.058***	4,387.925***	494.919***	4,182.412***
df	86; 138858	86; 1604831	76; 155748	76; 1487729

Notes: Robust standard errors are reported in parentheses, and significance of variables is adjusted accordingly. *** 0.1% significance ** 1% significance * 5% significance. Records with missing values are excluded.

References

Aga, M. and Kocaman, B. (2008). Efficient Market Hypothesis and Emerging Capital Markets: Empirical Evidence from Istanbul Stock Exchange. *International Research Journal of Finance and Economics*, 13(10):131–144.

Agnello, L. and Schuknecht, L. (2011). Booms and Busts in Housing Markets: Determinants and Implications. *Journal of Housing Economics*, 20(3):171–190.

Ahlee, H. and Malmendier, U. (2005). Do Consumers Know Their Willingness to Pay? Evidence from eBay Auctions. http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.320.8962.

Albrecht, J., Gautier, P. A., and Vroman, S. (2016). Directed Search in the Housing Market. *Review of Economic Dynamics*, 19:218–231.

Andrews, D. W. (1991). Heteroskedasticity and Autocorrelation Consistent Covariance Matrix Estimation. *Econometrica: Journal of the Econometric Society*, pages 817–858.

Anglin, P. M. (1997). Determinants of Buyer Search in a Housing Market. *Real estate economics*, 25(4):567–589.

Anglin, P. M., Rutherford, R., and Springer, T. M. (2003). The Trade-off Between the Selling Price of Residential Properties and Time-on-the-market: The Impact of Price Setting. *The Journal of Real Estate Finance and Economics*, 26(1):95–111.

APRA (2018). Statistics: Quarterly ADI Performance (March 2018), Table 1b: ADIs' Financial Position. Technical report, Australian Prudential Regulatory Authority.

Ariely, D. and Simonson, I. (2003). Buying, Bidding, Playing, Or Competing? Value Assessment and Decision Dynamics in Online Auctions. *Journal of Consumer psychology*, 13(1-2):113–123.

Arnold, M. A. (1999). Search, Bargaining and Optimal Asking Prices. *Real estate economics*, 27(3):453–481.

Ashenfelter, O. and Genesove, D. (1992). Testing for Price Anomalies in Real Estate Auctions. *American Economic Review*, 82(2):501–505.

Austin, P. C. (2011). Optimal Caliper Widths for Propensity-score Matching When Estimating Differences in Means and Differences in Proportions in Observational Studies. *Pharmaceutical Statistics*, 10(2):150–161.

Australian Bureau of Statistics (2001). Australian Standard Geographical Areas. http://www.abs.gov.au/websitedbs/d3110124.nsf/f5c7b8fb229cf017ca256973001fecec/53bbe9630b24d6f4ca256c3a000475b8!opendocument#statistical%20subdivision%20(ssd). Accessed: 2017-07-17.

Australian Bureau of Statistics (2008). Average Quarterly Completion Times for New Houses. http://www.abs.gov.au/ausstats/abs@.nsf/Previousproducts/8731.0Feature%20Article1Jul%202008. Accessed: 2017-04-24.

Australian Bureau of Statistics (2011a). Australian Standard Geographical Classification (ASGC) - New South Wales Maps. https://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/2316241CEAE457B0CA25791F000F6398/$File/12160_asgc_2011_nsw_maps.pdf. Accessed: 2020-02-08.

Australian Bureau of Statistics (2011b). Australian Standard Geographical Classification (ASGC) Structure 2011. https://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/32FBEDE1EA4C5800CA25791F000F2E1C/$File/att98dqt.pdf. Accessed: 2020-02-08.

Australian Bureau of Statistics (2016a). Census of Population and Housing: Census Dictionary, 2016. http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2901.0Chapter23002016. Accessed: 2018-11-16.

Australian Bureau of Statistics (2016b). Census of Population and Housing: Census Dictionary, 2016. http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2901.0Chapter23002016. Accessed: 2018-11-16.

Australian Bureau of Statistics (2016c). Statistical Area Level 2 (SA2). http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1270.0.55.001~July%202016~Main%20Features~Statistical%20Area%20Level%202%20(SA2)~10014. Accessed: 2018-12-12.

Australian Bureau of Statistics (2017a). 4130.0 - Housing Occupancy and Costs, 2015-16. https://www.abs.gov.au/ausstats/abs@.nsf/mf/4130.0. Accessed: 2019-06-05.

Australian Bureau of Statistics (2017b). Average Dwelling Commencement Time. http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/8752.0Feature%20Article1Dec%202016. Accessed: 2017-04-24.

Australian Bureau of Statistics (2017c). Building Approvals Australia Series 8731, Table 42, Value of Building Approvals - By Sector, Original. http://www.abs.gov.au/ausstats/abs@.nsf/detailspage/8731.0Feb%202017. Accessed: 2017-04-17.

Australian Bureau of Statistics (2018). Consumer Price Index, Australia, Sep 2018. http://www.abs.gov.au/Ausstats/abs@.nsf/0/CFFA42B90CA68CD2CA25765C0019F281?OpenDocument. Accessed: 2018-11-16.

Australian Bureau of Statistics (2019). Residential Property Price Indexes: Eight Capital Cities, Jun–Dec 2018. https://www.abs.gov.au/ausstats/abs@.nsf/latestProducts/6416.0Media%20Release1Dec%202018. Accessed: 2019-04-05.

Australian Government Solicitors (2011). Fact Sheet Number 12: Australian Consumer Law. https://www.ags.gov.au/publications/fact-sheets/Fact_sheet_No_12.pdf. Accessed: 2018-12-16.

Australian Securities Exchange (2019). Historical Market Statistics, May 2019. https://www.asx.com.au/about/historical-market-statistics.htm. Accessed: 2019-06-09.

Bailey, M. J., Muth, R. F., and Nourse, H. O. (1963). A Regression Method for Real Estate Price Index Construction. *Journal of the American Statistical Association*, 58(304):933–942.

Bali, T. G., Demirtas, K. O., and Levy, H. (2008). Nonlinear Mean Reversion in Stock Prices. *Journal of Banking & Finance*, 32(5):767–782.

Barber, B. M. and Odean, T. (2011). The Behavior of Individual Investors. *SSRN*.

Barkham, R. J. and Geltner, D. M. (1996). Price Discovery and Efficiency in the UK Housing Market. *Journal of Housing Economics*, 5(1):41–63.

Barnes, A. (2017). The Real Estate Year in Review. Copyright (c) 2017 Fairfax Media Publications Pty Limited. www.theage.com.au. Not available for re-distribution; Last updated 2017-12-01.

Baryla, E. and Ztanpano, L. (1995). Buyer Search Duration in the Residential Real Estate Market: The Role of the Real Estate Agent. *Journal of Real Estate Research*, 10(1):1–13.

Basu, S. (1977). Investment Performance of Common Stocks in Relation to their Price-Earnings Ratios: A Test of the Efficient Market Hypothesis. *The Journal of Finance*, 32(3):663–682.

Bayer, P., Geissler, C., Roberts, J. W., et al. (2011). *Speculators and Middlemen: The Role of Flippers in the Housing Market*, volume 16784. Citeseer.

Bender, M., Brown, L. G., and Harris, E. (2008). Residential Property Advertising in Victoria. Report prepared by Monash University for Consumer Affairs Victoria, Department of Justice, Consumer Affairs Victoria, Department of Justice.

Bian, X. (2017). Housing Equity Dynamics and Home Improvements. *Journal of Housing Economics*, 37:29–41.

Bleby, M. (2016). Underquoting Agent Fined $330k. *The Australian Financial Review*.

Boehm, T. P. and Ihlanfeldt, K. R. (1986). The Improvement Expenditures of Urban Homeowners: An Empirical Analysis. *Real Estate Economics*, 14(1):48–60.

Brookhart, M. A., Schneeweiss, S., Rothman, K. J., Glynn, R. J., Avorn, J., and Stürmer, T. (2006). Variable Selection for Propensity Score Models. *American Journal of Epidemiology*, 163(12):1149–1156.

Burke, K. (2018). More than 50 NSW Real Estate Agencies Caught Underquoting in Fair Trading Crackdown. https://www.domain.com.au/news/50-real-estate-agencies-caught-underquoting-fair-trading-crackdown-770317/. Accessed: 2019-03-21.

Campbell, J. Y. (2006). Household Finance. *The Journal of Finance*, 61(4):1553–1604.

Cardeira, H. (2007). UK Property Derivatives. https://heldercardeira.com/0703D.pdf. Accessed: 2019-06-12.

Carrillo, P. E. (2012). An empirical stationary equilibrium search model of the housing market. *International Economic Review*, 53(1):203–234.

Carrillo, P. E. (2013). To sell or not to sell: Measuring the heat of the housing market. *Real estate economics*, 41(2):310–346.

Case, B., Goetzmann, W. N., and Rouwenhorst, K. G. (2000). Global Real Estate Markets: Cycles and Fundamentals. Technical report, National Bureau of Economic Research.

Case, K. and Shiller, R. (1989). The Efficiency of the Market for Single-family Homes. *American Economic Review*, 79(1):125–137. cited By 771.

Case, K. E. and Shiller, R. J. (1990). Forecasting Prices and Excess Returns in the Housing Market. *Real Estate Economics*, 18(3):253–273.

Castle, J. (2017). Real Estate Price Underquoting. https://www.choice.com.au/money/property/buying/articles/real-estate-price-underquoting. Accessed: 2018-12-03.

Chaudhuri, K. and Wu, Y. (2003). Random Walk Versus Breaking Trend in Stock Prices: Evidence from Emerging Markets. *Journal of Banking & Finance*, 27(4):575–592.

Chen, Y. and Rosenthal, R. W. (1996). Asking Prices as Commitment Devices. *International Economic Review*, pages 129–155.

Chief Parliamentary Counsel, Victoria (2016). Estate Agents Amendment (Underquoting) Act 2016, No. 58 of 2016. http://www.legislation.vic.gov.au/Domino/Web_Notes/LDMS/PubStatbook.nsf/f932b66241ecf1b7ca256e92000e23be/D596822335BAF48ACA25805F00081F48/$FILE/16-058aa%20authorised.pdf. Accessed: 2018-12-02.

Chiras, D. P. and Manaster, S. (1978). The Information Content of Option Prices and a Test of Market Efficiency. *Journal of Financial Economics*, 6(2-3):213–234.

Choi, H.-S., Hong, H., and Scheinkman, J. (2014). Speculating on Home Improvements. *Journal of Financial Economics*, 111(3):609–624.

Choi, I. (1999). Testing the Random Walk Hypothesis for Real Exchange Rates. *Journal of Applied Econometrics*, pages 293–308.

Choice (2017). Real estate price underquoting. https://www.choice.com.au/money/property/buying/articles/real-estate-price-underquoting. Accessed: 2018-12-03.

Clapp, J. M., Dolde, W., and Tirtiroglu, D. (1995). Imperfect Information and Investor Inferences from Housing Price Dynamics. *Real estate economics*, 23(3):239–269.

Clapp, J. M. and Tirtiroglu, D. (1994). Positive Feedback Trading and Diffusion of Asset Price Changes: Evidence from Housing Transactions. *Journal of Economic Behavior & Organization*, 24(3):337–355.

Clayton, J. (1996). Rational Expectations, Market Fundamentals and Housing Price Volatility. *Real Estate Economics*, 24(4):441–470.

Clayton, J. (1998). Further Evidence on Real Estate Market Efficiency. *Journal of Real Estate Research*, 15(1):41–57.

CME (2006). CME Housing Futures & Options. http://web.mnstate.edu/sahin/FINC_354_REF/CmeCsiHousing.pdf. Accessed: 2019-06-15.

Coles, M. G. (1998). Stock-flow Matching. *University of Essex, mimeo.*

Compte, O. (2004). Prediction Errors and the Winner's Curse. http://www.enpc.fr/ceras/compte/prediction2004.pdf. Accessed: 2019-07-15.

Consumer Affairs Victoria (2016). Underquoting: Consumer Affairs Criticized Over "inconsequential" Investigation. https://www.domain.com.au/news/underquoting-consumer-affairs-criticised-over-its-investigation-20161104-gshy9v/. Accessed: 2019-03-13.

Consumer Affairs Victoria (2017). Consumer Affairs Victoria Annual Report 2016–17. https://www.parliament.vic.gov.au/file_uploads/Consumer_Affairs_Victoria_-_Annual_Report_2016-17_991FWNCB.pdf. Accessed: 2019-03-13.

Consumers Affairs Victoria (2018a). Underquoting Fact Sheet. https://www.consumer.vic.gov.au/licensing-and-registration/estate-agents/running-your-business/advertising-and-representations/understanding-underquoting. Accessed: 2018-12-02.

Consumers Affairs Victoria (2018b). Understanding Underquoting. https://www.consumer.vic.gov.au/licensing-and-registration/estate-agents/running-your-business/advertising-and-representations/understanding-underquoting. Accessed: 2018-12-02.

CoreLogic (2018). CoreLogic's Home Value Index Methodology. https://www.corelogic.com.au/research/rp-data-corelogic-home-value-index-methodology. Accessed: 2018-01-31.

CoreLogic (2018). CoreLogic Hedonic Home Value Index, November 2018 Results. https://www.corelogic.com.au/sites/default/files/2018-12/CoreLogic%20home%20value%20index%20Dec%201%20FINAL.pdf. Accessed: 2019-03-14.

CoreLogic (2019). CoreLogic Hedonic Home Value Index, December 2018 Results. https://www.corelogic.com.au/sites/default/files/2019-01/CoreLogic%20Home%20Value%20Index.pdf. Accessed: 2019-03-14.

CoreLogic (2019). Property Market Chart Pack. https://www.corelogic.com.au/sites/default/files/2019-05/Monthly%20Property%20Market%20and%20Economic%20Update%20May%202019.pdf. Accessed: 2019-06-01.

De Roon, F., Eichholtz, P., and Koedijk, K. C. (2002). The Portfolio Implications of Home Ownership. *Working Paper*.

Demary, M. (2010). The Interplay Between Output, Inflation, Interest Rates and House Prices: International Evidence. *Journal of Property Research*, 27(1):1–17.

Dockery, E. and Kavussanos, M. (1996). Testing the Efficient Market Hypothesis Using Panel Data, With Application to the Athens Stock Market. *Applied Economics Letters*, 3(2):121–123.

Dolde, W. and Tirtiroglu, D. (1997). Temporal and Spatial Information Diffusion in Real Estate Price Changes and Variances. *Real Estate Economics*, 25(4):539–565.

Dombrow, J., Knight, J. R., and Sirmans, C. (1997). Aggregation Bias in Repeat-sales Indices. *The Journal of Real Estate Finance and Economics*, 14(1-2):75–88.

Donald, G., Wingler, T., and Winkler, D. (2006). Single-family Housing and Wealth Portfolios. *Journal of Real Estate Portfolio Management*, 12(1):13–22.

Elder, J. and Villupuram, S. (2012). Persistence in the Return and Volatility of Home Price Indices. *Applied Financial Economics*, 22(22):1855–1868.

Englund, P., Gordon, T. M., and Quigley, J. M. (1999). The Valuation of Real Capital: A Random Walk Down Kungsgatan. *Journal of Housing Economics*, 8(3):205–216.

Fama, E. F. (1991). Efficient Capital Markets: II. *The Journal of Finance*, 46(5):1575–1617.

Fama, E. F. and French, K. R. (1988). Permanent and Temporary Components of Stock Prices. *Journal of Political Economy*, 96(2):246–273.

Federal Reserve Bank of New York (1999). Household Asset Portfolios and the Reform of the Housing Finance Market. https://www.newyorkfed.org/medialibrary/media/research/economists/tracy/rd59.pdf. Accessed: 2018-01-16.

Fisher, J. D. and Williams, E. D. (2011). Home maintenance and investment decisions. *Cityscape*, pages 147–164.

Flavin, M. and Nakagawa, S. (2008). A Model of Housing in the Presence of Adjustment Costs: A Structural Interpretation of Habit Persistence. *The American Economic Review*, 98(1):474–495.

Flavin, M. and Yamashita, T. (2002). Owner-Occupied Housing and the Composition of the Household Portfolio. *American Economic Review*, 92(1):345–362.

French, K. R. (1988). Crash-testing the Efficient Market Hypothesis. *NBER Macroeconomics Annual*, 3:277–285.

Galster, G. C. (1987). *Homeowners and Neighborhood Reinvestment*. Duke University Press.

Garcia, J. and Raya, J. M. (2011). Price and Income Elasticities of Demand for Housing Characteristics in the City of Barcelona. *Regional Studies*, 45(5):597–608.

Gatzlaff, D. and Tirtiroğlu, D. (1995). Real Estate Market Efficiency: Issues and Evidence. *Journal of Real Estate Literature*, 3(2):157–189.

Gatzlaff, D. H. (1994). Excess Returns, Inflation and the Efficiency of the Housing Market. *Real Estate Economics*, 22(4):553–581.

Gau, G. W. (1984). Weak Form Tests of the Efficiency of Real Estate Investment Markets. *Financial Review*, 19(4):301–320.

Gau, G. W. (1985). Public Information and Abnormal Returns in Real Estate Investment. *Real Estate Economics*, 13(1):15–31.

Gil Alaña, L. A., Aye, G. C., and Gupta, R. (2013). Testing for Persistence in South African House Prices. *Journal of Real Estate Literature*, 21(2):293–314.

Glaeser, E. L., Gyourko, J., and Saiz, A. (2008). Housing Supply and Housing Bubbles. *Journal of Urban Economics*, 64(2):198–217.

Glaeser, E. L. and Nathanson, C. G. (2017). An Extrapolative Model of House Price Dynamics. *Journal of Financial Economics*, 126(1):147–170.

Glower, M., Haurin, D. R., and Hendershott, P. H. (1998). Selling time and selling price: The influence of seller motivation. *Real estate economics*, 26(4):719–740.

Goetzmann, W. N. (1993). The Single Family Home in the Investment Portfolio. *The Journal of Real Estate Finance and Economics*, 6(3):201–222.

Graff, R. and Young, M. (1997). Serial Persistence in Equity REIT Returns. *Journal of Real Estate Research*, 14(3):183–214.

Grossman, S. J. and Stiglitz, J. E. (1976). Information and Competitive Price Systems. *The American Economic Review*, 66(2):246–253.

Grossman, S. J. and Stiglitz, J. E. (1980). On the Impossibility of Informationally Efficient Markets. *The American Economic Review*, 70(3):393–408.

Gu, A. (2002). The Predictability of House Prices. *Journal of Real Estate Research*, 24(3):213–234.

Guren, A. M. (2018). House Price Momentum and Strategic Complementarity. *Journal of Political Economy*, 126(3):1172–1218.

Guthrie, G. (2010). House Prices, Development Costs, and the Value of Waiting. *Journal of Urban Economics*, 68(1):56–71.

Gyourko, J. and Saiz, A. (2004). Reinvestment in the Housing Stock: The Role of Construction Costs and the Supply Side. *Journal of Urban Economics*, 55(2):238–256.

Han, L. and Strange, W. C. (2014). Bidding Wars for Houses. *Real Estate Economics*, 42(1):1–32.

Han, L. and Strange, W. C. (2015). The Microstructure of Housing Markets: Search, Bargaining, and Brokerage. In *Handbook of regional and urban economics*, volume 5, pages 813–886. Elsevier.

Han, L. and Strange, W. C. (2016). What Is the Role of the Asking Price for a House? *Journal of Urban Economics*, 93:115–130.

Haurin, D. (1988). The Duration of Marketing Time of Residential Housing. *Real Estate Economics*, 16(4):396–410.

Haurin, D., McGreal, S., Adair, A., Brown, L., and Webb, J. R. (2013). List Price and Sales Prices of Residential Properties During Booms and Busts. *Journal of Housing Economics*, 22(1):1–10.

Haurin, D. R., Haurin, J. L., Nadauld, T., and Sanders, A. (2010). List prices, sale prices and marketing time: an application to us housing markets. *Real Estate Economics*, 38(4):659–685.

Headley, Bruce, Gary Marks and Mark Wooden (2004). The Structure and Distribution of Household Wealth in Australia. http://melbourneinstitute.unimelb.edu.au/assets/documents/hilda-bibliography/working-discussion-research-papers/2001-2004/Headey_etal_The_Structure_and_Distribution_of_Household_Wealth.pdf. Accessed: 2018-01-16.

Helms, A. C. (2003). Understanding Gentrification: An Empirical Analysis of the Determinants of Urban Housing Renovation. *Journal of Urban Economics*, 54(3):474–498.

Hjalmarsson, E. and Hjalmarsson, R. (2009). Efficiency in Housing Markets: Which Home Buyers Know How to Discount? *Journal of Banking & Finance*, 33(11):2150–2163.

Ho, Y.-K. (1985). A Test of the Incrementally Efficient Market Hypothesis for the London Gold Market. *Economics Letters*, 19(1):67–70.

Home Improvement Pages, Australia (2014). How Long Does It Take to Build a Pool? https://www.homeimprovementpages.com.au/article/how_long_does_it_take_to_build_a_pool. Accessed: 2017-04-24.

Horowitz, J. L. (1992). The Role of the List Price in Housing Markets: Theory and An Econometric Model. *Journal of Applied Econometrics*, 7(2):115–129.

Hosios, A. J. and Pesando, J. E. (1991). Measuring Prices in Resale Housing Markets in Canada: Evidence and Implications. *Journal of Housing Economics*, 1(4):303–317.

Iacoviello, M. and Neri, S. (2010). Housing Market Spillovers: Evidence from An Estimated DSGE Model. *American Economic Journal: Macroeconomics*, 2(2):125–64.

Investopedia (2019). Conventional Mortgage or Loan – Definition. https://www.investopedia.com/terms/c/conventionalmortgage.asp. Accessed: 2019-03-20.

Jensen, M. C. (1978). Some Anomalous Evidence Regarding Market Efficiency. *Journal of Financial Economics*, 6(2):95–101.

Joint Centre for Housing Studies (2009). The Remodeling Market in Transition. http://www.jchs.harvard.edu/sites/jchs.harvard.edu/files/r09-1.pdf. Accessed: 2017-07-21.

Jud, G. D. and Frew, J. (1986). Real Estate Brokers, Housing Prices, and the Demand for Housing. *Urban Studies*, 23(1):21–31.

Kagel, J. H. and Levin, D. (2002). *Common Value Auctions and the Winner's Curse.* Princeton University Press.

Karl, E., Shiller, R. J., et al. (1989). The Efficiency of the Market for Single-family Homes. *The American Economic Review*, 79(1):125–137.

Kiel, K. A. and McClain, K. T. (1995). The Effect of An Incinerator Siting on Housing Appreciation Rates. *Journal of Urban Economics*, 37(3):311–323.

Kim, J. H. (2006). Wild Bootstrapping Variance Ratio Tests. *Economics Letters*, 92(1):38–43.

Kim, J. H. (2009). Automatic Variance Ratio Test Under Conditional Heteroskedasticity. *Finance Research Letters*, 6(3):179–185.

Knight, J. R. (2002). Listing Price, Time on Market, and Ultimate Selling Price: Causes and Effects of Listing Price Changes. *Real estate economics*, 30(2):213–237.

Kuo, C.-L. (1996). Serial Correlation and Seasonality in the Real Estate Market. *The Journal of Real Estate Finance and Economics*, 12(2):139–162.

Larsen, E. R. and Weum, S. (2008). Testing the Efficiency of the Norwegian Housing Market. *Journal of Urban Economics*, 64(2):510–517.

Leaman, P. (2018). Underquoting Agent cops $720,000 fine. http://tlfc.com.au/underquoting-agent-cops-fine/. Accessed: 2019-03-21.

Lee, C.-C. and Lee, J.-D. (2009). Energy Prices, Multiple Structural Breaks, and Efficient Market Hypothesis. *Applied Energy*, 86(4):466–479.

Lehmann, H. (2016). Property Law: Real Estate Agents Forced to Play Fair: An End to Underquoting in Residential Property Sales. *LSJ: Law Society of NSW Journal*, 0(19):90–91.

Lester, B., Visschers, L., and Wolthoff, R. (2017). Competing With Asking Prices. *Theoretical Economics*, 12(2):731–770.

Levitt, S. D. and Syverson, C. (2008). Market Distortions When Agents are Better Informed: The Value of Information in Real Estate Transactions. *The Review of Economics and Statistics*, 90(4):599–611.

Li, Y. and Wang, K. (1995). The Predictability of REIT Returns and Market Segmentation. *Journal of Real Estate Research*, 10(4):471–482.

Linneman, P. (1986). An Empirical Test of the Efficiency of the Housing Market. *Journal of Urban Economics*, 20(2):140–154.

Liu, C. and Mei, J. (1992). The Predictability of Returns on Equity REITs and their Co-movement With Other Assets. *The Journal of Real Estate Finance and Economics*, 5(4):401–418.

Liu, C. H., Nowak, A., and Rosenthal, S. S. (2016). Housing Price Bubbles, New Supply, and Within-city Dynamics. *Journal of Urban Economics*.

Liu, C. Y. and He, J. (1991). A Variance-Ratio Test of Random Walks in Foreign Exchange Rates. *The Journal of Finance*, 46(2):773–785.

Lo, A. W. and MacKinlay, A. C. (1988). Stock Market Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test. *The Review of Financial Studies*, 1(1):41–66.

Lo, A. W. and MacKinlay, A. C. (1989). The Size and Power of the Variance Ratio Test in Finite Samples: A Monte Carlo Investigation. *Journal of Econometrics*, 40(2):203–238.

Londerville, J. (1998). A Test of a Buying Rule for "underpriced" Apartment Buildings. *Real Estate Economics*, 26(3):537–553.

Lusht, K. M. (1996). A Comparison of Prices Brought By English Auctions and Private Negotiations. *Real Estate Economics*, 24(4):517–530.

Maier, G. and Herath, S. (2009). Real Estate Market Efficiency: A Survey of Literature. *SRE - Discussion Papers, 2009/07.*

Malkiel, B. G. (2005). Reflections on the Efficient Market Hypothesis: 30 Years Later. *Financial Review*, 40(1):1–9.

Malkiel, B. G. and Fama, E. F. (1970). Efficient Capital Markets: A Review of Theory and Empirical Work. *The Journal of Finance*, 25(2):383–417.

Malmendier, U. and Lee, Y. H. (2011). The Bidder's Curse. *American Economic Review*, 101(2):749–87.

Mammen, E. (1993). Bootstrap and Wild Bootstrap for High Dimensional Linear Models. *The Annals of Statistics*, pages 255–285.

Mayer, C. J. (1998). Assessing the Performance of Real Estate Auctions. *Real Estate Economics*, 26(1):41–66.

McCarthy (2004). Household Portfolio Allocation: A Review of the Literature. http://www.esri.go.jp/jp/prj/int_prj/prj-rc/macro/macro15/01-2-R.pdf. Accessed: 2018-01-16.

Meen, G. (2000). Housing Cycles and Efficiency. *Scottish Journal of Political Economy*, 47(2):114–140.

Meese, R. and Wallace, N. (1994). Testing the Present Value Relation for Housing Prices: Should I Leave My House in San Francisco? *Journal of Urban Economics*, 35(3):245–266.

Mei, J. and Gao, B. (1995). Price Reversal, Transaction Costs, and Arbitrage Profits in the Real Estate Securities Market. *The Journal of Real Estate Finance and Economics*, 11(2):153–165.

Mei, J. and Liu, C. (1994). The Predictability of Real Estate Returns and Market Timing. *The Journal of Real Estate Finance and Economics*, 8(2):115–135.

Melser, D. and Hill, R. J. (2019). Residential Real Estate, Risk, Return and Diversification: Some Empirical Evidence. *The Journal of Real Estate Finance and Economics*, 59(1):111–146.

Mena Report (2016). Australia: Home Improvement Scheme to Keep Work Flowing. http://go.galegroup.com.simsrad.net.ocs.mq.edu.au/ps/i.do?p=EAIM&sw=w&u=macquarie&v=2.1&it=r&id=GALE%7CA453375099&asid=dc5154be36a61de08115b5e035ae1aa7. Accessed: 2017-07-27.

Mendelsohn, R. (1977). Empirical Evidence on Home Improvements. *Journal of Urban Economics*, 4(4):459–468.

Merlo, A. and Ortalo-Magne, F. (2004). Bargaining Over Residential Real Estate: Evidence from England. *Journal of urban economics*, 56(2):192–216.

Merlo, A., Ortalo-Magné, F., and Rust, J. (2015). The Home Selling Problem: Theory and Evidence. *International Economic Review*, 56(2):457–484.

Meyer, C. J. (1987). Stress: There's No Place Like a First Home. *Family Relations*, pages 198–203.

Miles, D. (1992). Housing and the Wider Economy in the Short and Long Run. *National Institute Economic Review*, 139(1):64–78.

Milgrom, P. R. and Weber, R. J. (1982). A Theory of Auctions and Competitive Bidding. *Econometrica: Journal of the Econometric Society*, pages 1089–1122.

Montgomery, C. (1992). Explaining Home Improvement in the Context of Household Investment in Residential Housing. *Journal of Urban Economics*, 32(3):326–350.

Moran, A. (2006). *The Tragedy of Planning: Losing the Great Australian Dream*. Pinnacle Print Group.

Morse, J. and Crawford, A. (2018). How Low Can You Go? The Cost of Underquoting. https://www.dlapiper.com/~/media/files/insights/publications/2018/03/56-61_anzpj_march17_legalnb.pdf. Accessed: 2019-03-04.

Moschis, G. P. (2007). Stress and Consumer Behavior. *Journal of the Academy of Marketing Science*, 35(3):430–444.

National Association of Home Builders (2015). The Economic Impact of Home Building in a Typical Local Area. https://www.nahb.org/~/media/Sites/NAHB/Economic%20studies/1-REPORT_local_20150318115955.ashx?la=en. Accessed: 2018-03-26.

Nationwide Building Society (2019). Nationwide House Price Index. https://www.nationwide.co.uk/-/media/MainSite/documents/about/house-price-index/2019/Feb_2019.pdf. Accessed: 2019-06-09.

Nelling, E. and Gyourko, J. (1998). The Predictability of Equity REIT Returns. *Journal of Real Estate Research*, 16(3):251–268.

NSW Fair Trading (2017a). Real Estate Price Underquoting. https://www.choice.com.au/money/property/buying/articles/real-estate-price-underquoting. Accessed: 2019-03-02.

NSW Fair Trading (2017b). Underquoting Guidelines for Residential Property, NSW. https://www.fairtrading.nsw.gov.au/__data/assets/pdf_file/0010/367975/Underquoting_guidelines_for_residential_property.pdf. Accessed: 2018-12-03.

NSW Government (2018). Fair trading. http://www.fairtrading.nsw.gov.au/ftw/Tenants_and_home_owners/Home_building_and_renovating/Preparing_for_building_and_renovating/Approvals.page. Accessed: 2018-01-16.

OECD (2018). Focus on House Prices. http://www.oecd.org/eco/outlook/focusonhouseprices.htm. Accessed: 2019-04-10.

OECD (2019). Household Debt. https://data.oecd.org/hha/household-debt.htm. Accessed: 2019-06-05.

Österling, A. (2017). Housing Markets and Mortgage Finance. PhD Thesis, Department of Economics, Stockholm University.

Palm, R. (1976). The Role of Real Estate Agents as Information Mediators in Two American Cities. *Geografiska Annaler: Series B, Human Geography*, 58(1):28–41.

Panait, I. and Slavescu, E. O. (2012). Using garch-in-mean model to investigate volatility and persistence at different frequencies for bucharest stock exchange during 1997-2012. *Theoretical & Applied Economics*, 19(5).

Pesando, J. E. (1979). On the Random Walk Characteristics of Short-and Long-term Interest Rates in An Efficient Market. *Journal of Money, Credit and Banking*, 11(4):457–466.

Piazzesi, M. and Schneider, M. (2009). Momentum Traders in the Housing Market: Survey Evidence and a Search Model. *American Economic Review*, 99(2):406–11.

Piazzesi, M., Schneider, M., and Stroebel, J. (2015). Segmented Housing Search. Technical report, National Bureau of Economic Research.

Plaut, P. and Plaut, S. (2010). Decisions to renovate and to move. *Journal of Real Estate Research*, 32(4):461–484.

Potepan, M. J. (1989). Interest Rates, Income, and Home Improvement Decisions. *Journal of Urban Economics*, 25(3):282–294.

Poterba, J. M. and Summers, L. H. (1988). Mean Reversion in Stock Prices: Evidence and Implications. *Journal of Financial Economics*, 22(1):27–59.

Quan, D. C. (2002). Market Mechanism Choice and Real Estate Disposition: Search Versus Auction. *Real Estate Economics*, 30(3):365–384.

Rae, A. and Sener, E. (2016). How Website Users Segment a City: The Geography of Housing Search in London. *Cities*, 52:140–147.

Rayburn, W., Devaney, M., and Evans, R. (1987). A Test of Weak-Form Efficiency in Residential Real Estate Returns. *Real Estate Economics*, 15(3):220–233.

Razaghi, T. (2018). Real Estate Agents Caught in Crackdown. (News). *The Sydney Morning Herald (Sydney, Australia)*.

Real Estate Monitor Worldwide (2014). 25pc Underquoting by Real Estate Agents 'The New Norm'. *Real Estate Monitor Worldwide*. http://go.galegroup.com/ps/i.do?p=ITOF&u=macquarie&id=GALE|A389160970&v=2.1&it=r&sid=ITOF&asid=6c2c718b. Accessed: 2019-03-06.

Redman, E. (2018). New Laws Fail to Stop Housing Underquoting. Copyright (c) News Limited Australia. All rights reserved; Last updated 2018-01-01.

REINSW (2016). Underquoting Laws: 6 Months On. *Journal of Real Estate Institute of New South Wales*, 67(4).

REINSW (2018). Harsh Consequences for Underquoting. https://www.reinsw.com.au/Web/Posts/Latest_News/201812/harsh_consequences_for_underquoting.aspx. Accessed: 2019-03-14.

Reserve Bank of Australia (2019). Wealth and Consumption. https://www.rba.gov.au/publications/bulletin/2019/mar/wealth-and-consumption.html. Accessed: 2020-02-09.

Rosenbaum, P. R. and Rubin, D. B. (1983). The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika*, 70(1):41–55.

Rosenthal, S. S. (1999). Residential Buildings and the Cost of Construction: New Evidence on the Efficiency of the Housing Market. *The Review of Economics and Statistics*, 81(2):288–302.

Rutherford, R. C., Springer, T. M., and Yavas, A. (2005). Conflicts Between Principals and Agents: Evidence from Residential Brokerage. *Journal of financial Economics*, 76(3):627–665.

Sanders, N. (2017). Real Estate Price Underquoting. https://www.choice.com.au/money/property/buying/articles/real-estate-price-underquoting. Accessed: 2019-03-02.

Sargent, T. J. (2011). Rational Expectations. https://www.econlib.org/library/Enc/RationalExpectations.html. Accessed: 2020-02-09.

Sass, T. R. (1988). A note on optimal price cutting behavior under demand uncertainty. *The review of economics and statistics*, pages 336–339.

Schindler, F. (2013). Predictability and Persistence of the Price Movements of the S&P/Case-Shiller House Price Indices. *The Journal of Real Estate Finance and Economics*, 46(1):44–90.

Schindler, F. (2014). Persistence and Predictability in UK House Price Movements. *The Journal of Real Estate Finance and Economics*, 48(1):132–163.

Schindler, F., Rottke, N., and Füss, R. (2010). Testing the Predictability and Efficiency of Securitized Real Estate Markets. *Journal of Real Estate Portfolio Management*, 16(2):171–191.

Schlesinger, L. (2016). Underquoting Agents Face $30,000 Fine. *The Australian Financial Review*.

Schneiders, B. (2007). Real Estate Agents Revolt Over Underquoting. https://www.theage.com.au/national/real-estate-agents-revolt-over-underquoting-20071122-ge6d40.html. Accessed: 2019-03-10.

Seek Estate (2014). Australia's Property Derivatives Market. https://web.archive.org/web/20150609131154/https://seek.estate/articles/australias-property-derivatives-market/. Accessed: 2019-04-05.

Seek Estate (2017). Royal Commission into Misconduct in the Banking, Superannuation and Financial Services Industry. https://financialservices.royalcommission.gov.au/Pages/default.aspx. Accessed: 2019-04-05.

Serrano, C. and Hoesli, M. (2010). Are Securitized Real Estate Returns More Predictable Than Stock Returns? *The Journal of Real Estate Finance and Economics*, 41(2):170–192.

Shiller, R. J. (1990). Speculative prices and popular models. *Journal of Economic perspectives*, 4(2):55–65.

Shiller, R. J. (2008). Derivatives Markets for Home Prices. Technical report, National Bureau of Economic Research.

Shimizu, C., Nishimura, K. G., and Asami, Y. (2004). Search and Vacancy Costs in the Tokyo Housing Market: Attempt to Measure Social Costs of Imperfect Information. *Review of Urban & Regional Development Studies*, 16(3):210–230.

Simons, R., Magner, A., and Baku, E. (2009). Do Housing Rehabs Pay their Way? A National Case Study. *Journal of Real Estate Research*.

Sinai, T. and Souleles, N. S. (2005). Owner-occupied Housing as a Hedge Against Rent Risk. *The Quarterly Journal of Economics*, 120(2):763–789.

Sommervoll, D. E. (2006). Temporal Aggregation in Repeated Sales Models. *The Journal of Real Estate Finance and Economics*, 33(2):151–165.

Statistica (2019). Home Ownership Rate in Selected European Countries in 2017. https://www.statista.com/statistics/246355/home-ownership-rate-in-europe/. Accessed: 2019-06-07.

Stevenson, S. (2002). Momentum Effects and Mean Reversion in Real Estate Securities. *Journal of Real Estate Research*, 23(1-2):47–64.

Syndey Morning Herald (2018). Real Estate Agents Caught in Crackdown. (News). *The Sydney Morning Herald (Sydney, Australia)*.

Tardi, C. (2019). Rational Expectations Theory. https://www.investopedia.com/terms/r/rationaltheoryofexpectations.asp. Accessed: 2020-02-09.

Taylor, C. R. (1999). Time-on-the-market as a Sign of Quality. *The Review of Economic Studies*, 66(3):555–578.

The Association of Superannuation Funds of Australia (2019). Superannuation Statistics, May 2019. https://www.superannuation.asn.au/ArticleDocuments/269/SuperStats-May2019.pdf.aspx?Embed=Y. Accessed: 2019-06-09.

The US Census Bureau (2019). Quarterly Residential Vacancies and Homeownership, First Quarter 2019. https://www.census.gov/housing/hvs/files/currenthvspress.pdf. Accessed: 2019-06-05.

Timmermann, A. and Granger, C. W. (2004). Efficient Market Hypothesis and Forecasting. *International Journal of Forecasting*, 20(1):15–27.

Tirtiroğlu, D. (1992). Efficiency in Housing Markets: Temporal and Spatial Dimensions. *Journal of Housing Economics*, 2(3):276–292.

Turnbull, G. K. and Dombrow, J. (2007). Individual Agents, Firms, and the Real Estate Brokerage Process. *The Journal of Real Estate Finance and Economics*, 35(1):57–76.

Turner, N. and Thomas, M. (2001). Property Market Indices and Lease Structures–the Impact on Investment Return Delivery in the UK and Germany: Part I. *Journal of Property Investment & Finance*, 19(2):175–194.

Tversky, A. and Kahneman, D. (1986). Judgment Under Uncertainty: Heuristics and Biases. *Judgment and decision making: An interdisciplinary reader*, pages 38–55.

Valadkhani, A., Smyth, R., and Worthington, A. (2017). Regional Seasonality in Australian House and Apartment Price Returns. *Regional Studies*, 51(10):1553–1567.

Valuer General (2017). NSW Valuer General Annual Report 2016–17. https://www.valuergeneral.nsw.gov.au/__data/assets/pdf_file/0008/217754/Valuer_General_annual_report_2016-17.pdf. Accessed: 2018-07-15.

Wakelin, R. (2016). Underquoting Could Soon Become a Thing of the Past. *The Australian Financial Review*.

Wallace, R. (2015). Underquoting Still Prevalent. *The Australian (National, Australia)*.

Wang, Y., Cai, H., Li, C., Jiang, Z., Wang, L., Song, J., and Xia, J. (2013). Optimal Caliper Width for Propensity Score Matching of Three Treatment Groups: A Monte Carlo Study. *PloS One*, 8(12):e81045.

Wheaton, W. C. (1990). Vacancy, Search, and Prices in a Housing Market Matching Model. *Journal of political Economy*, 98(6):1270–1292.

Windsor, C., La Cava, G., and Hansen, J. (2015). Home Price Beliefs: Evidence from Australia. *Journal of Housing Economics*, 29:41–58.

Womack, K. S. (2015). Real options and urban land values: a review of the literature. *Journal of Real Estate Literature*, 23(1):53–64.

Worrall, A. (2017). Complaints Over Underquoting Soar. (News). *The Age (Melbourne, Australia)*.

Yajie, S. (2016). *Market Efficiency and House Price Dynamics in Residential Real Estate Markets of China*. PhD thesis, National University of Singapore.

Yao, H. and Pretorius, F. (2014). Demand uncertainty, development timing and leasehold land valuation: empirical testing of real options in residential real estate development. *Real Estate Economics*, 42(4):829–868.

Yavas, A. and Yang, S. (1995). The Strategic Role of Listing Price in Marketing Real Estate: Theory and Evidence. *Real Estate Economics*, 23(3):347–368.

Zuehlke, T. W. (1987). Duration dependence in the housing market. *The Review of Economics and Statistics*, pages 701–704.