Essays on the housing market, foreign investment, and the stock market: Evidence in the UK, Canada, and China

by

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The thesis is submitted in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy of the University of Portsmouth.

December 2019

Abstract

In the global context of a soaring real estate market, many developed and developing countries have encountered tremendously fast growth in real estate prices. Historical data, however, shows many examples of countries suffering from severe market turbulence and economic loss after undergoing a sharp real estate price surge, followed by a slump. Accordingly, this study aims to provide three essays on the topic of the real estate market and two related sectors, namely, foreign investment and the stock market, within the context of the United Kingdom (UK), Canada, and China. The presence of housing bubbles, as well as the subsequent discussion of potential determinants of housing prices, foreign investment, and stock market movements, are analysed using various empirical models with the evidence from these three countries.

The first chapter examines the presence of a housing bubble using a combination of two empirical models, namely, the co-explosive VAR model and the recursive unit root tests, focussing on explosiveness in the asset bubble. We find clear evidence of housing bubbles in the UK and Canada and of one bubble in China until 2010, the end of the sample period. Therefore, it is of essential importance to discuss the determinants of housing price booms in the following two chapters. Chapter 2 investigates the topic of whether foreign direct investment (FDI) has a vital effect on the fluctuation of housing prices in the market by applying a structural VAR model. The main findings are that housing prices in the UK cannot be affected by FDI, although building construction in the UK has attracted substantial FDI inflow. Meanwhile, both housing prices and the housing supply in Canada have been positively affected by FDI. Comparably, in China, housing prices are negatively affected by FDI and positively affected by the housing supply, whereas the housing supply is positively affected by FDI. Finally, the last empirical chapter explores the sector of the stock real estate market, the real estate investment trust (REIT), and its relationship with the actual housing market using a structural VAR model. We do not find significant explanatory power of REITs on

housing price fluctuations in the three countries, but REITs in the UK and Canada are positively affected by actual housing market movements, and REITs and the real estate market in China are positively affected by interest rate. Meanwhile, the general stock market price is one important explanatory factor for both housing price and REITs in the UK. Canadian housing prices have been dramatically negatively affected by monetary policy, while the Canadian REITs are also closely positively connected to the general stock market.

Overall, the findings suggest that housing markets in the UK, Canada, and China are highly prosperous, and the housing price growth trend considerably deviates from the fundamentals. In the UK, housing supply has been highly attractive to foreign investment, although housing prices have not yet been affected by FDI. Both the actual housing sector and REITs in the UK are closely and positively related to the general stock market, and in the UK, REITs reflect both housing and stock markets movements. In Canada, the housing and housing construction sectors are dramatically boosted by foreign investment, although REITs do not greatly influence the housing market. Similar to the UK, housing and general stock market activities have promoted the development of the REITs sector in Canada. Moreover, adjusting the interest rate is a powerful tool in controlling housing prices in Canada. In China, foreign investment has temporarily contributed to the housing supply via investments in real estate companies, causing a negative pressure on housing price. At the same time, since REITs are an emerging industry in China, no vital impact has yet been seen on the real estate market. In addition, REIT returns are not noticeably affected by housing price change, although interest rate adjustment in China can explain their movements significantly. Housing prices in China are positively affected by housing supply and interest rate, indicating a greater increase in demand than in supply in China. This is particularly the case in major cities, which have seen irrational and speculative investor behaviour in the purchase of properties.

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List of Abbreviations

ADF	Augmented Dickey–Fuller
AIC	Akaike Information Criterion
BP	Building permits
BSADF	Backward SADF
BTL	Buy to Let
CAD	Canadian Dollar
CB	Building completed
CPI	Consumer price index
CV	Coefficient of Variation
FDI	Foreign Direct Investment
FREI	Foreign real estate investment
GDP	Gross Domestic Product
GSADF	Generalised SADF
HP/HI	Housing price (index)
HQIC	Hannan and Quinn information criterion
IP	Industrial production
IR	Interest rate
IRF	Impulse response function
JB	Jarque-Bera
LTV	loan-to-value
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary least squares
ONS	Office for National Statistics
PRR	Price-to-rent
REIT	Real Estate Investment Trust
RMB	Renminbi
RP	Rental price
SADF	Supremum ADF
SBIC	Schwarz' Bayesian Information Criterion
SVAR	Structural VAR
UK	United Kingdom
UNCTAD	United Nations Conference on Trade and Development
US	United States
USD	United States Dollar
VAR	Vector Autoregression
VECM	Vector error correction model
WTO	World Trade Organisation
ZA	Zivot–Andrews

RBP	Real building permits
RFDI	Real FDI
RGDP	Real GDP
RHP/HI	Real housing price (index)
RIP	Real industrial production
RIR	Real interest rate
RREIT	Real REIT
RRP	Real rental price
RSP	Real stock price
LCB	Logged building completed
LRBP	Logged real building permits
LRFDI	Logged real FDI
LRGDP	Logged real GDP
LRHP/HI	Logged real housing price (index)
LRIP	Logged real industrial production
LRREIT	Logged real REIT
LRRP	Logged real rental price
LRSP	Logged real stock price
DLCB	Differenced logged building completed
DPRR	Differenced price-to-rent ratio
DLRBP	Differenced logged real building permits
DLRFDI	Differenced logged real FDI
DLRGDP	Differenced logged real GDP
DLRHP/HI	Differenced log real housing price (index)
DLRIP	Differenced logged real industrial production
DLRREIT	Differenced logged real REIT
DLRRP	Differenced logged real rental price
DLRSP	Differenced logged real stock price

Declaration

Whilst registered as a candidate for the above degree, I have not been registered for any other research award. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award.

Word count: 67,525

Xi Zhang

December 2019

Acknowledgements

Foremost, I am extremely grateful to my supervisors, Dr Renatas Kizys and Dr Ioannis Chatziantoniou, for their patience, motivation, enthusiasm and insightful comments and suggestions. Their persistent help has provided invaluable guidance through each stage of my PhD study. They have inspired me in conducting my research and writing my thesis. Moreover, I would like to take this opportunity to thank my examiners, Professor Don Webber, Dr Aaron Tan and Dr Georgios Magkonis, for their insightful suggestions, guidance and feedback. The time and effort they devoted to my work is greatly appreciated.

I am extending my heartfelt thanks to Portsmouth Business School, the Economics and Finance subject group, the Graduate School and the University of Portsmouth for providing essential and helpful trainings, workshops and seminars to extend my academic skills.

I would like to express my special thanks to my parents for their love, support and encouragement. I cannot express enough thanks to my caring husband, Mr Kun Zhu, who gives me continuous advice and care over the years. Also, big thanks to my loving son, Mr Maverick Zhu, who has been extremely sensible whenever I am busy. My completion of the PhD study could not have been accomplished without the support of them.

I am overwhelmed in all humbleness and gratefulness to acknowledge my depth to all those who have helped me throughout the whole process of my PhD study.

Chapter 1 Introduction

For centuries, the topic of housing prices and real estate sector development has been a controversy among social science researchers. The real estate sector has long been a pillar industry in the national economy, acting as a support for social welfare and the livelihood of citizens. The unabated development of the housing market has contributed to an enormous expansion in demand in other industries, such as construction and building materials (Ren, Xiong, & Yuan, 2012). Moreover, the financial sector is linked in theory to movements in the real estate sector through such factors as stock market fluctuations and foreign investment flow (Gholipour, 2013; Lean & Smyth, 2014). All these influences generate a strong pulling effect on economic growth; however, the swift increase in real estate prices may also cause considerable adverse effects on an economy. For one, as real estate is an essential consumer necessity, the rapid increase in housing prices leads to a significant living cost burden on households (Glaeser, Huang, Ma, & Shleifer, 2017). In addition, historical data shows many examples of countries suffering from severe market turbulence and economic loss after undergoing a sharp increase real estate prices followed by a slump; this can be seen in the 2007 financial crisis in the United States (US) (Martin, 2011). In this context, the rapid growth of the housing market and the potential negative impact it might have in various economies has been subject to much debate (Bloomberg, 2016).

In the general context of a soaring housing sector around the global market, researchers have identified many economies within both developed and developing countries that have grown extremely rapidly. In particular, the United Kingdom (UK) housing industry has been one of the top overvalued housing markets globally, resulting in unsustainable development in the real estate sector (Rees & Isaac, 2018). In terms of the price-to-rent ratio (the profitability of owning a property) and the price-to-income ratio (the affordability of purchasing properties), UK housing prices were overvalued by around 30% in 2017, which places UK real estate prices in the top six globally ("Focus on house prices - OECD", n.d.). The UK housing sector is one of the real estate markets in which overpriced housing stock demonstrates a continuous growing price. More importantly, London has been the top city for international capital flows and direct commercial real estate investment in recent years (CBRE, 2015), and the UK in general has also been the second most popular destination for overseas commercial real estate investment, after the US. As a result, it is highly necessary to study the UK housing market. Economists have also drawn attention to the real estate markets of other developed economies, such as Canada, whose real estate market is a rapidly growing sector that has received limited attention. The housing markets of Canada and the US, as two neighbouring countries, both experienced a steady and dramatic surge before 2006. Nevertheless, continuous growth has been witnessed in Canada even after the financial crisis in the US (Macgee, 2009). Literature has seen much discussion about the US housing market dynamics, while surging housing prices in Canada have received little consideration. However, Canada is becoming increasingly important as an object of study in the context of statistics that show that overvalued housing prices and the price-to-rent ratio in Canada are the second highest in the world ("Focus on house prices - OECD", n.d.). Moreover, given the growth in overseas property investment sector, the UK and Canada have been two of the most attractive destinations for investments in recent decades (Gholipour, Al-mulali, & Mohammed, 2014; Karl, 2006). This flow of investment has also provided influential capital for the development of the property market and raised public expectations of increasing property values. Therefore, studying housing price performance in the UK and Canada, as two major economies, is highly necessary. In addition, the developing economy of China has come into the spotlight due to the extraordinary development seen not only in its economy but also in its housing sector. As the world's second largest economy, China has developed a substantial dependence on the real estate industry, which has served as a massive support for the whole economy. In this context, the dramatic boost of the housing sector is based on the fact that 75% of China's national savings have been invested in housing sectors (Sito & Liu, 2018). With such substantial capital support, China's price-to-rent ratio has been the second highest among Asian countries, which led to tremendous overvaluation of Chinese housing prices. Regarding the crucial role that China's housing market plays in the Chinese, and indeed in the global, economy, it is of central importance to study the healthiness of the China real estate sector. Accordingly, this thesis addresses the topic of the real estate industry and its connection with foreign investment and the stock market in the UK, Canada, and China. It is noteworthy that the level of analysis conducted in this chapter is focussed at the country-level rather than the regional areas. This setting follows several reasons. Primarily, the choice of the three countries is supported by their noticeable development in their real estate markets. The UK housing market reveals significant unbalance between limited housing supply and excessive demand (Wilson et al., 2017); Canada, being a neighbour country, presents a continuous real estate price surge despite its housing sector showing a highly similar trend with the US housing market before 2008 crisis (**Figure 1-6**); the Chinese households have also experienced unprecedented pressure of buying properties facing an overheating housing market (Deloitte, 2019). These three countries have therefore been under the spotlight for the discussion on housing bubbles, and they act as good representatives for property markets in developing and developed economies. Secondly, although earlier studies such as Gholipour Fereidouni and Ariffin Masron (2013) and Shih et al. (2014) on individual countries may suggest regional and spatial diversities of housing price behaviour within a nation, the main discussion in this thesis is on whether certain economies receive particularly great attention from investors. The differences among countries will be revealed in this study to give specific indications to each country, although a regional approach may be considered for future studies. In addition, considering previous empirical studies on housing bubbles in the UK and China with their sample covering periods no later than 2007 in the UK and 2012 in China, this chapter has extended the time span to include the most updated sample period until 2019 aiming at giving latest implications to the industry. In the context of the booming real estate sector, the aim of this study is to examine the soundness of the property sector and discuss the determinants of the rising housing prices in these three essential economies. This approach can then provide implications for not only the individual markets but also the general stability of the broader global market. This topic is deserving of analysis given the crises that have historically been caused by booming housing price globally and the dramatic development in the real estate markets of the three target countries.

1.1 Background and Motivation

1.1.1 The UK housing market

After the 2008 financial crisis, the real estate market in the UK rebounded and has seen an enormous boost since the 2008 financial crisis, and this momentum has reached its peak in the past several years. Statistics collected and analysed by the Office for National Statistics reveals a dramatic percentage rise in the average housing price index, which increased by 16.7% between January 2008 and June 2015, from 180 to 208.2 (ONS, 2015b). According to Savills, the world's leading real estate firm, the total value of property in the UK climbed to a record of £6.79 trillion in 2016, more than 3.6 times the UK's GDP (Laming & Cook, 2017).

I. Historical housing price development

A significant real estate market burst has occurred twice in the UK, once from the late 1980s to the beginning of 1990s, and again after the 2008 global crisis. Past experience shows that each crash has followed prosperous growth in the real estate market and is in turn followed by an instantaneous dramatic drop in market growth and a shrinkage in trading volume.

<u>1988–1989</u>

From the beginning of the 1980s, the UK economy began to recover from its 1970s depression. This period coincided with the end of the downturn of the property industry, and within around ten years, housing prices continued to boom and achieved their peak in 1988. Two factors help explain this. First, the Baby Boomer generation of the 1960s grew arrived at a family-building age, raising the demand for properties enormously (Ball, 1994). Second, in 1988, Nigel Lawson ended Multiple Mortgage Tax Relief, which had provided unmarried couples with benefits when taking joint mortgages (John Muellbauer & Murphy, 1997). This forthcoming adjustment in regulation led to a panic-buying situation, rapidly increasing housing price appreciation and leading to growth rates as high as 40%. In the meantime, the UK benchmark interest rate rocketed from 7.38%, in May 1988, to 14.88%, in October 1989 (**Figure 1-1**), dramatically expanding housing and mortgage prices beyond what purchasers could afford (Steward, 2008). This was followed by a substantial shrinking in house prices until the rebound in 1994.

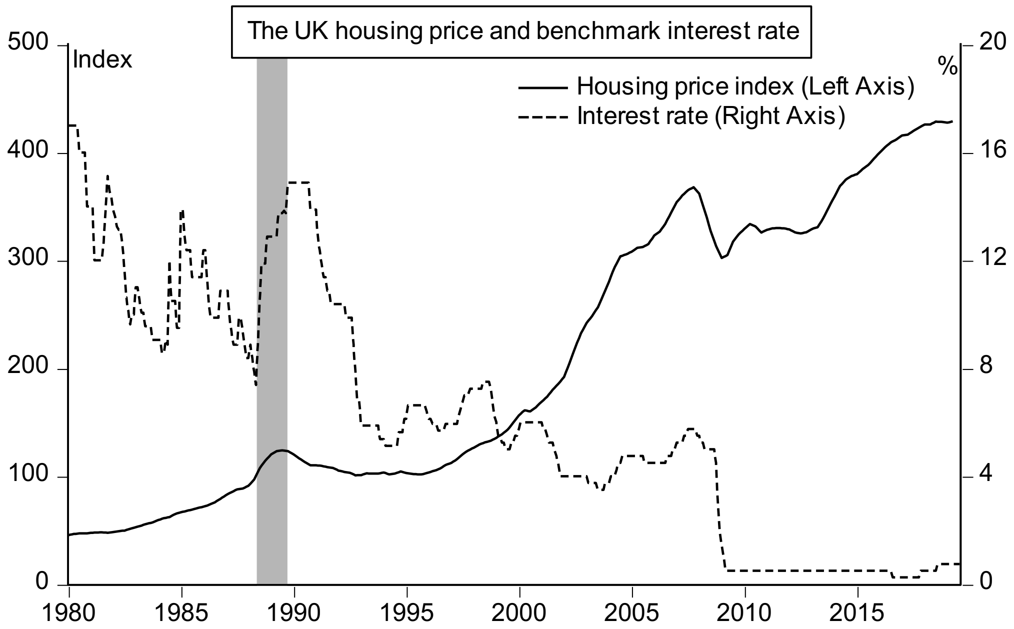

Figure 1-1 *The UK housing price and interest rate*

Notes:

- Data source: DataStream
- The grey area shows the surging period for the UK benchmark interest rate from 1988 to 1989

<u>2008 global crisis</u>

The emergence of Buy to Let (BTL) and related mortgage products from 1996 Q3 contributed to a boost in housing prices in the UK (Dyson, 2014). Buy-to-Let lending encourages residents to purchase property to rent in the market and to repay loans using rental income. A survey conducted by the National Housing and Planning Advice Unit in February 2008 indicates that BTL stimulated roughly 13% more gross mortgage advances and indirectly contributed to a 7% addition increase in real estate prices before 2007 (Taylor, 2008). However, accompanied by the absence of supervision and by the presence of high credit liquidity, some banks, investment companies, and mortgage providers raised capital by securitising mortgage products, resulting in further reduction in the cost of lending. Just before the financial crisis, the loan-to-value (LTV) ratio of some lenders in the market surpassed 100%, offering borrowers the chance to borrow more than the value of the property. This fact finally contributed to a severe drop in the UK mortgage market, similar to the collapse seen in the US (Kathleen Scanlon & Whitehead, 2011). Buy-to-Let investors experienced a tremendous shock, with the gross BTL mortgage slumping from £27.2 billion, in 2008, to £8.5 billion, in 2009 (CML, 2010). Thereafter, the new BTL LTV ratio after 2008 was by the UK government to below 70%. **Figure 1-2** presents the trend of residential mortgage LTV and BTL LTV ratios in the UK, which demonstrated a remarkable drop after the 2008 crisis.

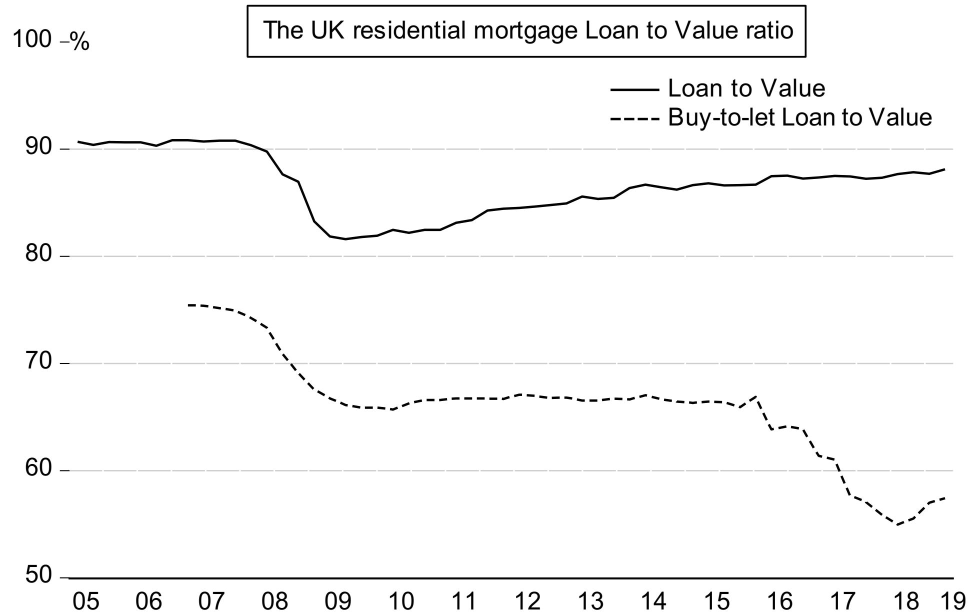

Figure 1-2 *The UK residential mortgage Loan to Value ratio*

(Data source: Bank of England)

The government policy of allowing or even encouraging high-ratio BTL mortgage policy is claimed to have contributed to the boom in housing prices in this period, and loose mortgage policy from banks before the crisis led house buyers to pay more for houses. Meanwhile, with the tightening of policies after the financial crisis, a dramatic burst in the property market was witnessed, notably reducing housing prices to lower than the average price level after 2008 (Miles, 2015). This experience in the real estate market justified subsequent government policy, which has played a vital role in increasing housing prices. The issue of housing price has always been a central focus of the public and the government because it is closely connected to household welfare and cost of living, as well as being an area of investment area that is critical in regulating the property market in the UK economy. Although the government rarely enacts policies that directly intervene in housing prices, the regulating market-based policies it does enact sometimes lead to an unexpected market response, which then leads to unpredictable market trends.

II. London housing market

As London is a global financial centre, not only its regional economic activities have contributed enormously to the UK, the performance of London housing price also has a substantial spillover effect on the whole UK property industry. Primarily, property stock in London accounts for a large portion of the whole UK housing stock. In 2016, the value of London properties was worth £1,709 billion, which makes up ¼ of the total UK housing value (Savills, 2017). Also, the fluctuations and trending of London real estate price can dramatically affect the direction of the overall national housing price movement. After the European debt crisis in 2011, the London real estate market encountered an immediate gloom, which engendered an extensive declining in the UK housing price from the previous increase (Michael, 2014).

A key determinant of the flourishing London property industry is the inflow of international capital and speculative housing investment. In 2017, London became the number-one city in the world in terms of international real estate investment, increasing from second place in 2015 and 2016, according to statistics from the JLL real estate company (Kantro, 2018). Foreign purchases have become a vital element of the London residential market, especially with respect to new buildings. An investigation in 2013 proposed by the British Property Federation shows that, among the newly built properties in London, 61% were purchased by investors, of which 48% were BTL. Only 39% of the purchase of the newly built properties were to be owner-occupied (Building construction design, 2014). In particular, overseas buyers purchased 75–85% of the newly built properties in London. Although most of them are long-term UK residents and non-resident international buyers only account for around 15% of purchases, these foreign investors have still contributed significantly to the development of the London property industry (Building construction design, 2014). Knight Frank has provided a similar figure, indicating that between 2011 and 2013, foreign buyers bought 69% of the newly built houses in central London, of which only 49% were residents (Knight Frank, 2013). In the meantime, however, the percentage of investment in newly built properties by non-residential overseas purchasers has been increasing, with this figure rising to around one-third between 2014 and 2016 (Kath Scanlon, Whitehead, Blanc, & Moreno-Tabarez, 2017). Statistics from the Hamptons International, shown in **Figure 1-3**, indicate that overseas buyers purchased 57% overall homes in prime central London in the second half 2018; this accounts for the highest level since 2012 (Hamptons, 2019). An uptrend interest from foreign investors can be seen in the London property market in recent years. Overseas buyers generally tend to invest more in luxury properties, and a research report from Knight Frank reveals that from June 2012 to June 2013, 49% of the luxury real estate worth over £1 million in prime central London was made by international buyers (Knight Frank, 2013). Most of these overseas property purchases were made with the aim of investment and renting out, providing sufficient funds for further real estate development (Barton & Wilson, 2017).

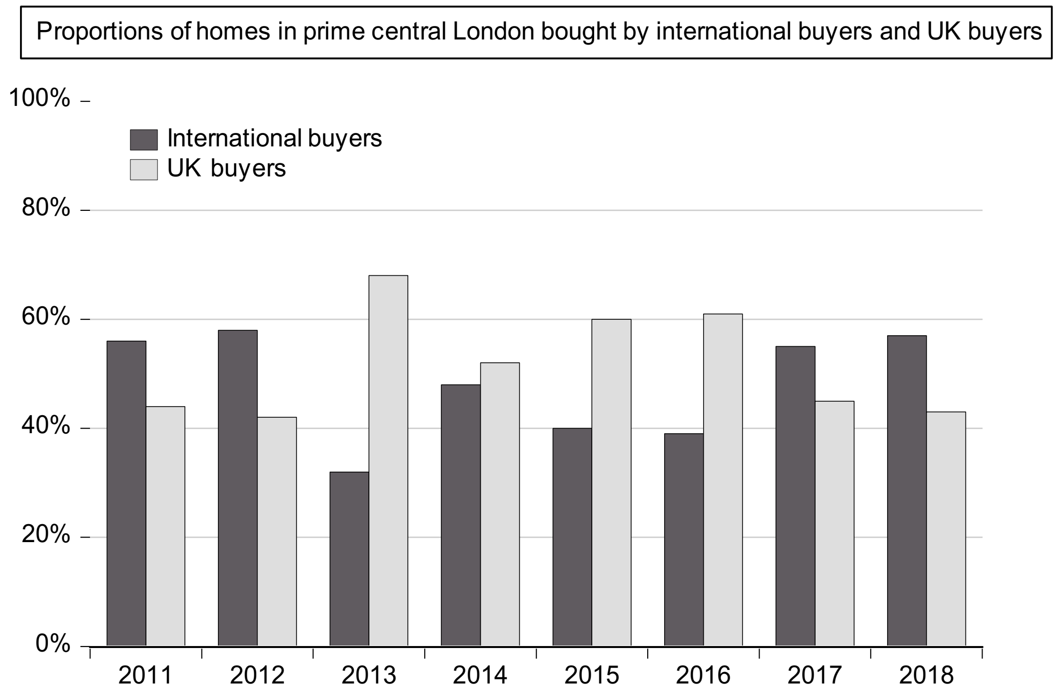

Figure 1-3 *Proportions of homes in prime central London bought by international buyers and UK buyers*

(Data source: Hamptons International (Hamptons, 2019))

III. Housing price development since 2008

Real estate prices in the UK saw a short-term decline after the 2008 crisis but soon recovered with the support of favourable policy, a low interest rate, and high external capital inflow. The overall upward trending in the housing market has remained unchanged. The potential determinants for the increase in housing prices can be summarised as follow:

Policy support

First, the Bank of England has been implementing a low benchmark interest rate of 0.5% for nearly ten years, generating a low mortgage cost to reduce the burden of house buyers. Second, the government has been adopting reforms of Stamp Duty Land Tax policy to encourage property purchase; for example, relief from the tax was offered for properties between £125,000 and £250,000 in 2011 and 2012. Third, the government proposed a Help-to-Buy scheme to improve the homeownership rate and living quality from 2013 by allowing people to deposit as little as 5% for a house whose value is less than £600,000 by providing an equity loan (GOV.UK, n.d.). Finally, the Bank and the Treasury launched the Funding for Lending Scheme, in 2012, to stimulate lending to individuals and businesses from building societies and banks (Bank of England, n.d.). The estimate from the Bank of England shows that, from the second half of 2012, this scheme lowered the mortgage rate by 1%.

Demand and supply

The imbalance between demand and supply has been a critical determinant for the boom in housing prices over the past decade. The expansion of the housing supply in the past few years has slowed, influenced by economic downturn. In particular, in 2010–2011, the number of new buildings completed annually was around 138,000 units, the lowest housing supply figure in the past several decades (Wilson, Barton, & Smith, 2017). More importantly, recent research from the National Housing Federation in 2018 shows that the UK is currently in its most significant shortfall. The figure in this research indicates that there is a total backlog of 3.91 million homes in England, suggesting that the market should construct 340,000 new homes per year until 2031. However, the current target of the government is only 300,000 homes per year (Bulman, 2018). The construction of residential property in the UK has, since the 1980s, relied primarily on private developers, with local government only being responsible for a small portion of welfare housing. Meanwhile, private property developers have shown a delayed reaction to movements in real estate market prices and demand, resulting in a considerable slump in the housing supply. **Figure 1-4** compares data on the number of new dwellings with the demand, showing a sufficient gap between the market need and the actual housing supply in the UK. From the demand side, the UK property market has witnessed rigid demand, exacerbated by a population increase. The data on the age structure of mortgage-holding adults in the UK reveals that housing buyers aged 25–54 years comprise the majority of mortgage buyers, especially the age group of 25–34 (Financial Conduct Authority, n.d.). At the same time, this age group has grown at the highest rate over the past ten years, given the contribution of immigration (Office for National Statistics, n.d.). Notable demand has thus been created, boosting real estate prices given the limited housing supply. The imbalance between housing supply and demand in the UK has also promoted the attractiveness of the property market as a way of investment, generating a cycle of further demand from domestic and foreign markets (Heywood & Hackett, 2013).

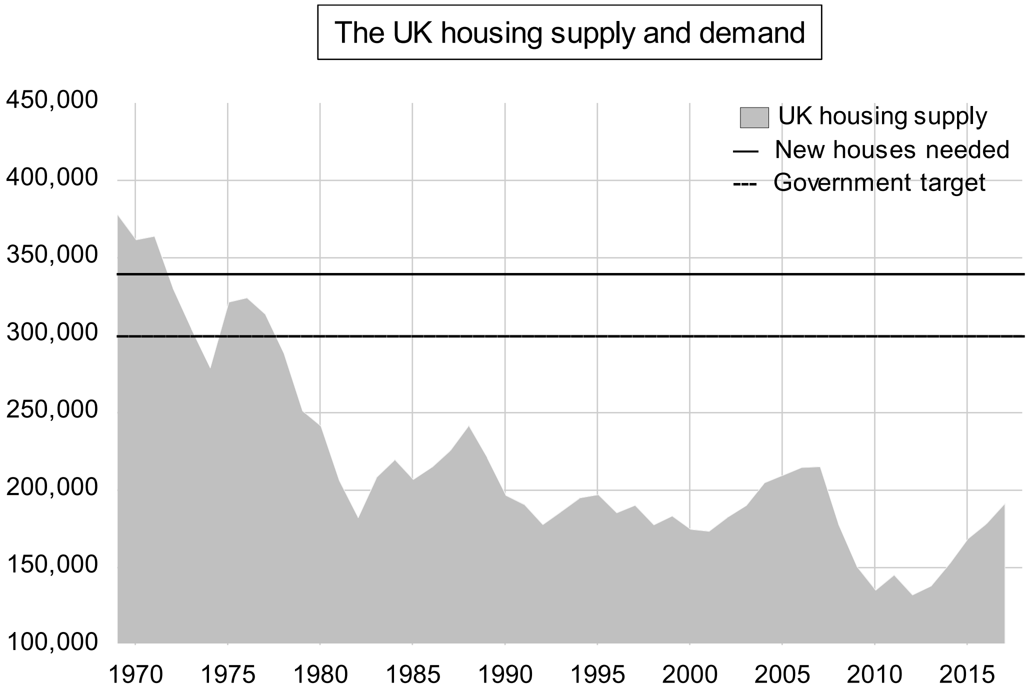

***Figure 1-4** The UK housing supply and demand*

(Data source: Ministry of Housing, Communities & Local Government)

A bubble is the result of excessive investment demand, resulting in a substantial divergence of the asset price from its actual value and profitability and a boost in prices to an unsustainable and unaffordable state. The essence of an asset bubble is the discrepancy between prices and actual demand. A good illustration of housing performance is the rental market. From the historical data on the price-to-rent ratio in the UK, the rate of housing price increase far outstripped the growth of rental prices until the 2008 crisis, and this ratio began to increase again soon after the depression (OECD, n.d.). A recent figure of 112.8 for this ratio is just below the peak of 117 from before the bubble burst in 2008, indicating a tremendous divergence of housing prices from its fundamental. In the meantime, the ability of households to afford housing is decreasing, indicating a dangerous rise in housing prices beyond household capability. **Figure 1-5** shows the price-to-income trends of the national average and the most and least affordable regions, respectively, the north and the Greater London Area. This figure reveals that housing buyers in the UK see houses to be as unaffordable in recent years as they were during their peak level before the 2008 crisis. Especially in London, the cost of first-time housing reached more than ten times the average salary in 2016. Similar figures of median house price to gross annual residence earnings, collected and summarised by the Office of National Statistics, are even higher, with 7.77 times for England and Wales, and 13.24 times in London in 2017 (Chu, 2018). All these signs indicate a potential national housing crisis in the UK.

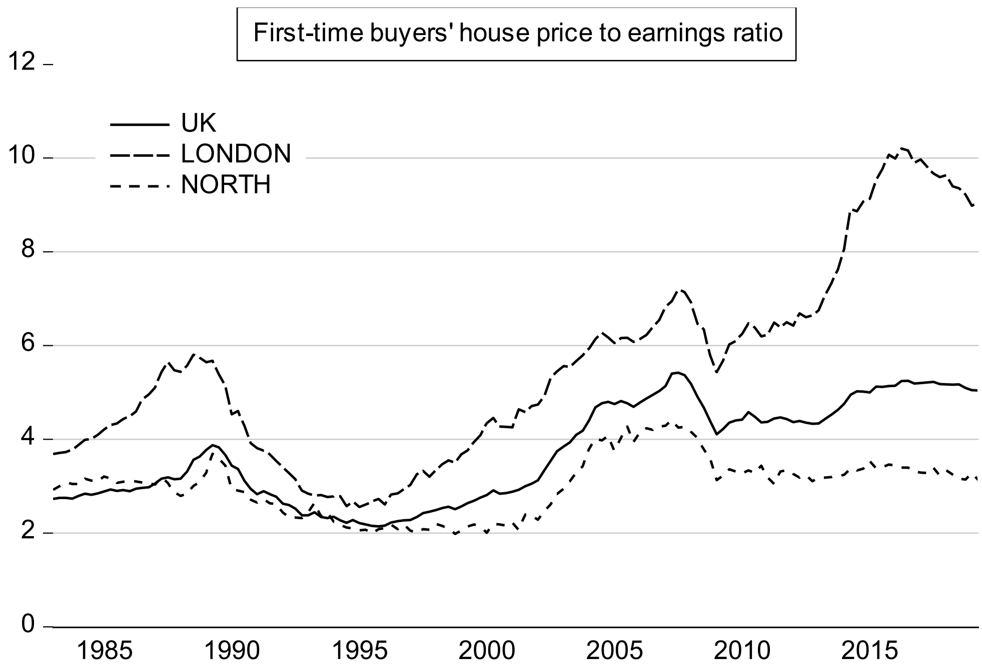

Figure 1-5 *First time buyers' house price to earnings ratio*

Notes:

- Data source: Nationwide Building Society website (Nationwide, n.d.)
- Calculated as the ratio of Nationwide first time buyer house price to mean gross earnings in each region
- This figure includes the national average ratio, the highest (London) and the lowest (North) ratios among regions.

1.1.2 The Canadian housing market

The Canadian real estate sector has been experiencing steady growth throughout the past decades, with only a few, minor slumps. From 2000 to 2013, the Canadian housing sector witnessed an average compound annual growth rate of around 7.4%. In April 2014, the average housing prices surpassed CAD 409,000, which is 7.6% higher than the previous year, and this growth rate jumped as high as 25% in Vancouver (Evans, 2014). Notably, several heated areas with particularly high growth rates, including Toronto and Vancouver, have been the primary drivers of this upward trend (Karl, 2006). Excluding these two areas, the national average housing price is only CAD 336,000, which is 5.3% higher than the preceding year (Evans, 2014). The growth of the real estate market can also be revealed in the expanded building permissions, with a monthly growth rate of 16.7% and 8.7% in June and July 2015, respectively. In the meantime, capital flows from overseas have mainly fuelled this hot real estate market. No constraint had been placed on overseas investors making purchases in the Canadian property market, and such investment has been the key trigger of the boom in housing prices. Hence, the problem of foreign investment in the Canadian housing market tends to be a prominent issue under such a favourable investment environment and a large group of overseas buyers in the past years. Only in 2016 did British Columbia announce a 15% tax on foreign real estate buyers (Proctor, 2018).

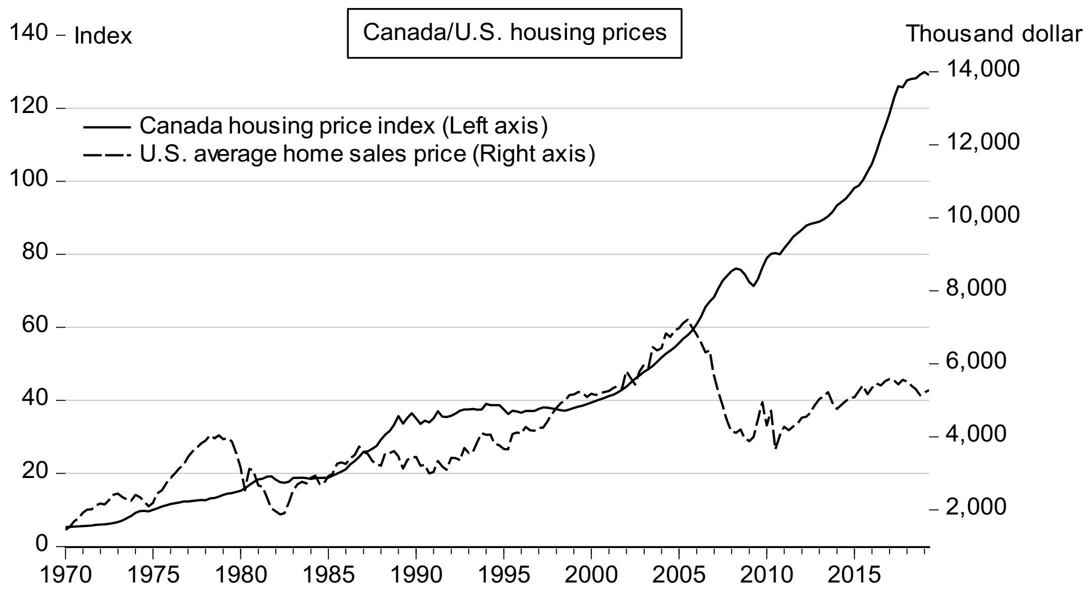

Figure 1-6 *Canada/U.S. housing prices*

(Data source: DataStream)

Despite being a neighbouring country of the United States with a substantial financial market, Canada suffered much less from the 2008 US subprime crisis. From **Figure 1-6**, the housing prices of Canada and the United States displayed similar trends before 2005, although average home sales in the United States fell sharply afterwards, while Canadian housing prices continued to rise steadily. With the rapid development of the housing market, the Canadian government adopted a series of measures to control the real estate market, such as placing stringent requirements on mortgages and deposit percentages and reducing the maximum mortgage repayment length from 30 years to 25 years (Crawford, Meh, & Zhou, 2013). The government has published several tightening criteria to provide sound mortgage lending to the market over the years. For instance, in October 2017, the Canadian Office of the Superintendent of Financial Institutions issued guideline B-20 to regulate real estate mortgage sectors (Bilyk & teNyenhuis, 2018). The government has also released rules to examine the resident conditions when applying for mortgages and to test the ability of lenders to pay higher interest rates. Moreover, interest rate was increased twice, starting in 2017, to regulate the mortgage sector and curb the overheated market (Bilyk & teNyenhuis, 2018). The steady growth of the Canadian housing market thus appears to be the consequence of a sound financial system, prudent regulation, and relatively cautious risk management. Some key characteristics of the Canadian subprime mortgage securities market are closely related to this steady growth.

I. Scale and asset quality factor

Statistics show that the sum of Alt-A and subprime mortgages account for less than 5% of the total amount of market mortgage debt in Canada (Macgee, 2009). Meanwhile, the government also retains a stable low percentage of outstanding mortgages in the total debt. According to figures from the Canadian Bankers Association, the rate of mortgages in arrears was as low as 0.24% in 2006 before the financial crisis, while the latest statistics from 2018 show a similar level. In January, the number of mortgages in arrears in Canadian banks was only around 11,600 (Better Dwelling, 2018). The Canadian mortgage default rate is considerably lower than that of the United States. Statistics reveal that Canada non-prime mortgage default rate was around 1.5% and the subprime mortgage default rate over 1.9% in 2007. These figures are dramatically lower compared to those in the United States, with its overall non-prime mortgage default rate at more than 8.8% (Crawford et al., 2013).

II. Interest rate policy in Canada

Every economy displays an economic cycle, which refers to the process of regular expansion and contraction in economic activities along in the course of the economy's development. Generally, one economic cycle can be divided into four stages, namely, recovery, boom, recession, and depression (Harrison, 2010). At the late phase of recovery, the economy upturns into a prosperous stage and the central bank raises interest rates to restrain overexuberant investment and extend growth. The country then enters the interest rate hike cycle. In the second half of a recession, by contrast, the policy from the central bank is to cut rates to stimulate the economy's slowing growth.

Historical data present an interest rate rise before the 2007 economic depression, followed by a dramatic and consistent reduction to encourage economic recovery. In the meantime, housing investment showed a strong interest-sensitive pattern and is a cyclical element of output (Berger-Thomson & Ellis, 2004). Correspondingly, housing prices in Canada faced a temporary recession during the global crisis, followed by a quick boost back to their long-term increasing trend with the incentive of a low interest rate. However, Canadian interest rates have declined tremendously over the past three decades, which has contributed to the growing capacity of household borrowing together with increasing income and ultimately to soaring property prices over the entire period (Karl, 2006).

III. Collateral factor and relative law

As the collateral of mortgage, a stable housing price supports the Canadian mortgage market without severe fluctuations (MacBeth, 2018). In the context of healthy economic development and high employment in recent years, Canadian real estate prices have been on the rise, with the index continuously increasing since 1998. The result has been a comparatively sound housing industry in Canada. At the same time, Canada banking system has applied a strict approval system with respect to providing collateral loans. For instance, the minimum deposit for a property mortgage is set at 25%, while insurance is required from the buyers, who are incapable of depositing to this level (Crawford et al., 2013).

Overall, the healthy and systematic financial market and regulation strategies have been suggested to be the strong support for the consistent swift growth of real estate prices in Canada. Nevertheless, recent evidence has proposed a continuous unsustainable development in the Canadian real estate market. For instance, Canada has been one of the most vulnerable countries to the correction in housing prices, represented in an extremely high and abnormal price-to-rent ratio. **Figure 1-7** shows that Canada has the third highest ratio in the global market, which represents dramatic growth in Canadian housing prices relative to how much renters pay. This ratio in the other target country, the UK, was in 16th place in 2018. With respect to the ability of households to buy homes in Canada, **Figure 1-8** displays a continually growing in recent years, indicating a continuous worse level of affordability. An increasing amount of household income is required to own a property, so it is increasingly difficult for families to buy houses, and Canadian property owners face more burdens in paying back real estate mortgages (RBC, 2018). Consequently, all the above evidence has shown unsustainable trends in the Canadian housing market in the long term.

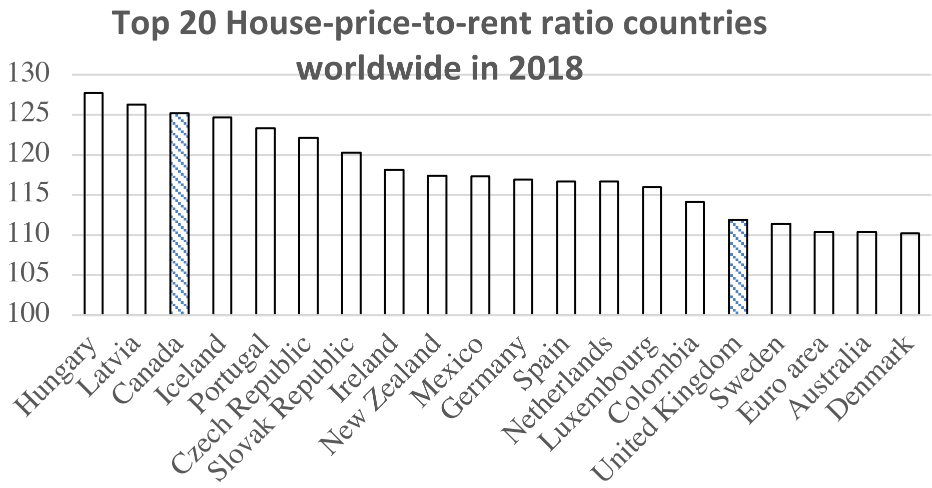

Figure 1-7 *Top 20 House-price-to-rent ratio countries worldwide in 2018*

Note:

- Data source: OECD website (OECD, n.d.)
- The figures have been normalised with 100 equalling the 2015 ratio
- The data of this ratio in China is not available, since the rental price data is limited to until 2010.

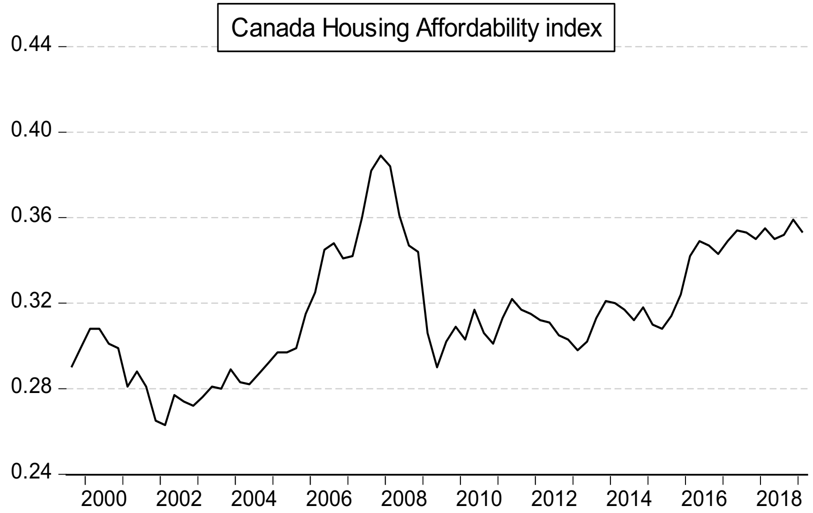

Figure 1-8 *Canada housing affordability index*

Notes:

- Data source: Bank of Canada
- This index measures the ownership costs of median household income; it is an estimate of the share of disposable income that a representative household would put toward housing-related expenses.
- The higher the level, the more difficult it is to afford a home.

1.1.3 The Chinese housing market

As a developing country that is experiencing an unprecedented rate of rapid growth, the Chinese market has several particularities and complexities. Since the policy of reformation and opening, the Chinese real estate market has developed through four phases: the initial stage, the commissioning stage, the accelerated growth stage, and the prosperous stage.

I. 1987–1997: Initial stage

Before 1987, because of China's policy of public property ownership, land could not be traded, and the concepts underlying a commercial housing market and the financial mortgage sector did not exist (Fung, Guoming Huang, and Shen, 2006). It was only in August 1987 when the regulations surrounding the construction of the commodity real estate market were issued, and the first land auction took place in Shenzhen. This led to the commercial reformation of the Chinese real estate market. In the meantime, the process of real estate–related mortgage market development remained in its initial stage until 1997. Exceedingly few banks offered individual loans to buy residential houses with strict requirements and a high interest rate (Deng, Shen, & Wang, 2011).

II. 1998–2002: Commissioning stage

In 1998, the government issued a series of real estate market policies aiming at putting more effort into the development of the housing credit loan sector and supporting the construction and commercial real estate industries (Xu & Chen, 2012). This regulation saw an ever-increasing scale of household mortgage loans to residents, granted by the banking system in the market. At the same time, however, regulations placed several limitations on loan conditions, so the process remained in an immature phase (Fung et al., 2006). For instance, an individual housing loan was limited to the purchase of residential properties or to urban residents to build houses, but not luxury homes. Moreover, stringent requirement meant that individuals were unable to gain any concessionary term on mortgage interest rates. Even for mortgage loans over ten years, there was no interest rate deduction, and the interest rate was set follow the upward market fluctuation (Ding, Huang, Jin, & Lam, 2017). Under this context, even though residents were allowed to take real estate loans and there was a tremendous breakthrough in the restricted payment method when buying properties, households were still suffering from high interest rates with no preferential term (Deng, Shen, and Wang, 2011). Growth in the real estate loan market was still relatively moderate during that period. Nevertheless, commercial housing sales continued to enlarge dramatically between 1998 and 2002, resulting in a massive achievement of growth by a factor of 2.4 (Xu & Chen, 2012).

III. 2003–2007: Rapid growth stage

Intending to regulate and further promote the real estate credit sector, the Chinese government promulgated a state document in 2003, that first proposed the idea that the real estate market had become the pillar industry of the national economy (Ye & Wu, 2008). Since then, the residential housing mortgage loan industry began to adopt a low-entry barrier, which gave rise to a climax of speculative investment in residences on the real estate market using mortgage loans over many cities around China (Xu & Chen, 2012). Between 2003 and 2008, the bank mortgage lending business escalated by nearly 1.8 times, to RMB 4.9 trillion. **Figure 1-9** also reveals a steep surge in the individual property mortgage loan sector, which suggests a flourishing real estate market and expanding public interest in purchasing houses, represented in the dramatic growth in income from commercial property sales (Zhang, Hua, and Zhao, 2012). In this context, the real estate industry has contributed dramatically to the Chinese economy, showing an ever-increasing high percentage of contribution to GDP growth, seen in **Figure 1-10**.

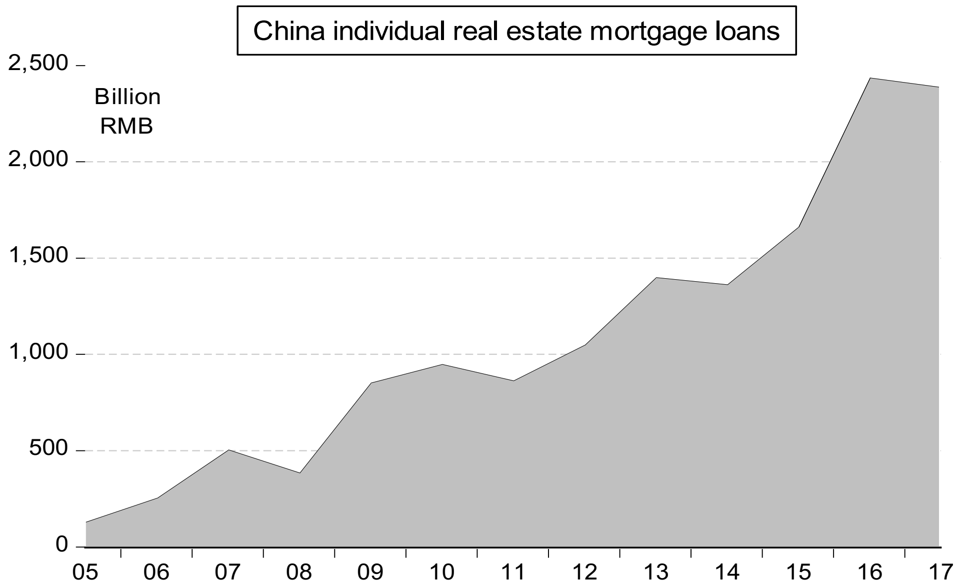

Figure 1-9 *China individual real estate mortgage loan*

(Data source: the China Real Estate Yearbook)

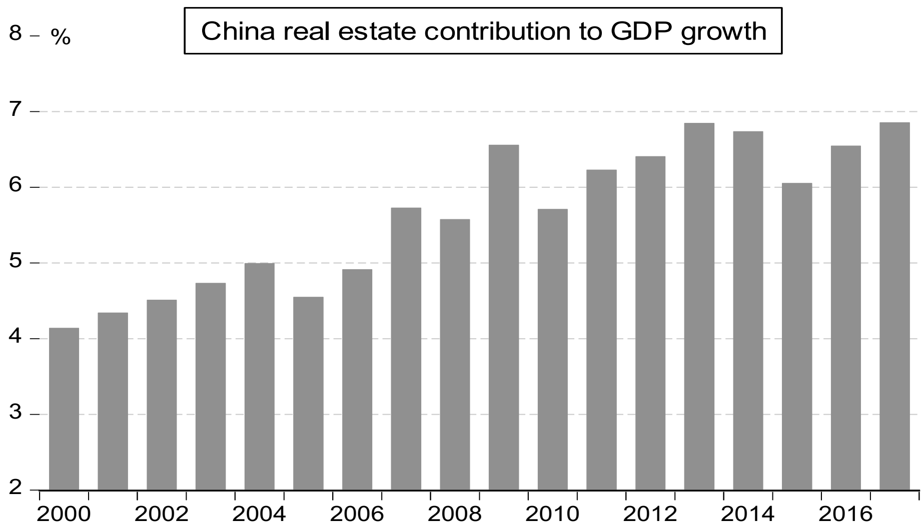

Figure 1-10 *China real estate contribution to GDP growth*

(Data source: the National Bureau of Statistics)

IV. 2007–present: Prosperous stage

In the context of unabated growth in the real estate market and concern over housing bubbles, the China central bank has issued regulations about differentiated credit policy in the market. In particular, the down payment rate has been lowered and a favourable mortgage rate is offered to first-time buyers, with these rates being raised starting from the second property (Deng et al., 2011). However, these policies were interrupted by the US financial crisis in 2008. In response to the crisis to the economy, the state council issued a series of economic stimulus plans, and the central bank implemented a substantially loose monetary policy. The one-year loan benchmark interest rate was cut sharply, from 7.47% before September 2008 to 5.31% in December 2008 (Yueh, 2010; see **Figure 1-11**). Meanwhile, the state council also issued a document announcing the introduction of relevant credit policies to support residents in purchasing general houses for the first time and in upgrading. Under the guidance of loose monetary policy, the market benchmark rate dropped to its lowest level since 1978, and commercial banks even offered a 30%-off discount based on the benchmark rate when offering mortgage loans (Yang & Chen, 2014). The government held a positive attitude in encouraging residents to buy houses, and both first-time buyers and upgraders were eligible to enjoy the preferential conditions.

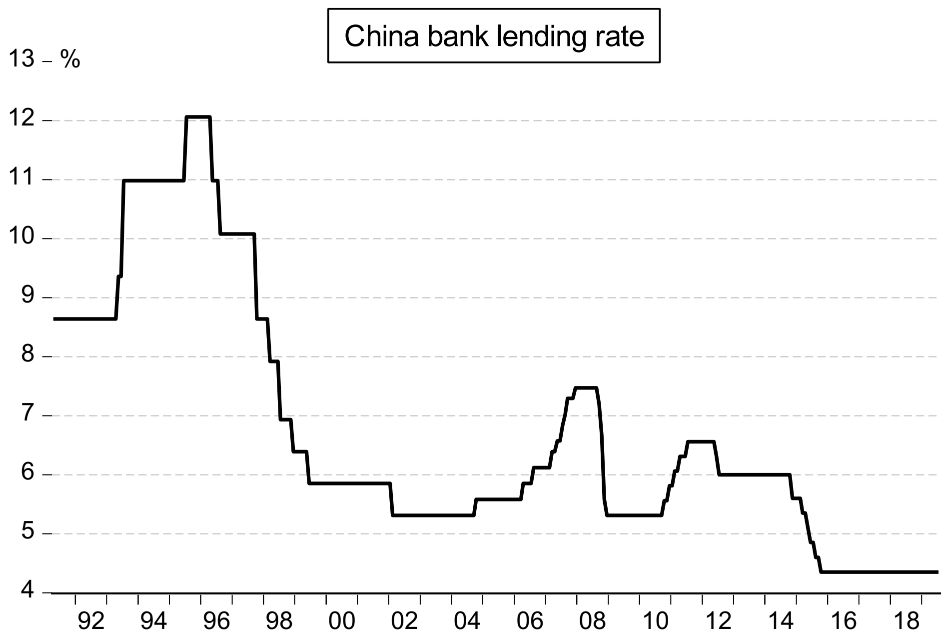

Figure 1-11 *China bank lending rate*

(Data source: The peoples Bank of China)

Accompanied by the stimulation of the excess loose monetary policies, a sharp increase in the amount of both social financing and commercial bank credit loans was witnessed during that period (Muto, Matsunaga, Ueyama, & Fukumoto, 2010). Due to the large amount of capital inflow to the real estate market, housing sales appeared to have soared rapidly, and income from sales totalled to trillions during this period (Ding et al., 2017). The Chinese real estate market entered a stage of dramatic growth and colossal boom, and this industry has become the main dynamic driver of economic growth. In the context of rapid growth in the real estate market, the loose governmental policy was extended in 2015 with the aim of boosting economic growth. The lending rate in 2015 was adjusted downward five times, dropping from 5.6% to 4.35% (Inman, 2015; see **Figure 1-11**). Moreover, other favourable policies had also been issued in central bank documents to provide a reduced down-payment rate and mortgage rate (Bloomberg, 2016). Commercial banks were also allowed to offer second-time buyers who had paid off their first mortgage the same preferential conditions. This series of loose policies lasted until the beginning of 2016 and contributed to tremendous prosperity and a speculative investment boom in the market (Dong, 2018). The overheated real estate market developed through loose policies in China has gradually raised concerns over housing bubbles, and since late 2016, a series of rigorous measures have been implemented by the government in 30 major cities to curb the property market. Several major overheated cities have established new real estate policies, such as restricted purchasing, tightening of loans and sales, and limited auctions, to cool down the housing sector (Koss & Shi, 2018). In particular, this new round of rigid regulations was implemented with unprecedented intensity in 2017, with hundreds of regulations placed on more than 100 cities, and the regulations have only become more specific and stronger (Deloitte, 2019). However, these regulations have had unexpected effects, and the housing market has only surged at a more rapid rate. 2016 and 2017 saw a new round of record-breaking prosperity, with a surge in property sales, incomes, and housing prices. In 2016, real estate loans took around half a percent of the total credit loans in the market, while property sales income in the first six months of 2016 faced a rise of 42%, to RMB 4,868.2 billion (Dong, 2018). These figures have all achieved their highest levels in history, and they continued to attain new peaks in 2017 and 2018. Almost all of China's 70 largest cities have experienced fast-than-ever development (Deloitte, 2019), and the phenomenon only intensified in 2018, with many cities across the country encountering panic buying (Wang, 2019). However, the macro regulations that the government applied to the Chinese property market in 2018 have nearly doubled (Deloitte, 2019). The effects of governmental regulation are severely limited or are even the opposite of what was intended. This outcome is closely related to public expectations and the degree of dependence of the Chinese national economy on the real estate industry.

The past 40 years have seen the extraordinary growth and prosperity of the Chinese real estate market as China's financial policies have evolved. Several favourable policies have reduced the purchase cost and stimulated the entry of households into estate market. These policies lowered the entrance barrier, ensured favourable mortgage rates, and provided a more extensive preferential entitlement for residents to purchase properties. The market has also established the expectation of higher housing prices, which has driven this sector into both high prosperity and enormous risk.

1.1.4 Housing bubble

Many clear examples of the housing boom and bust can be found in the history of major economies. **Figure 1-12** illustrates several examples of big bubble bursts. For example, the Japanese housing market soared briskly in the late 1980s, with the year-on-year growth rate of the residential-used urban land price index in six major cities reaching 33%, in 1990. However, this growth was accompanied by a dramatic decline in the growth rate, to -18% in 1993, and this trend continued until after 2000 (Malkiel, 2010). Throughout these ten years of housing bubble burst in Japan, the macroeconomy also suffered from a slump. Another example is the US real estate market at the beginning of the 2000s, when an enormous incline in housing prices resulted in the growth rate of the Standard and Poor's (S&P) Case-Shiller monthly index of the ten large and medium-sized cities in the US to its peak of 20%, in 2004 (Tse, Rodgers, & Niklewski, 2014). Similarly, it was also followed by a continuous sharp decrease, especially in 2008–2009 when the US housing market confronted a steady decline of over 10% for twenty months. Consequently, this housing bubble burst directly resulted in the subprime crisis and global financial crisis, leading to a severe impact on the global economy.

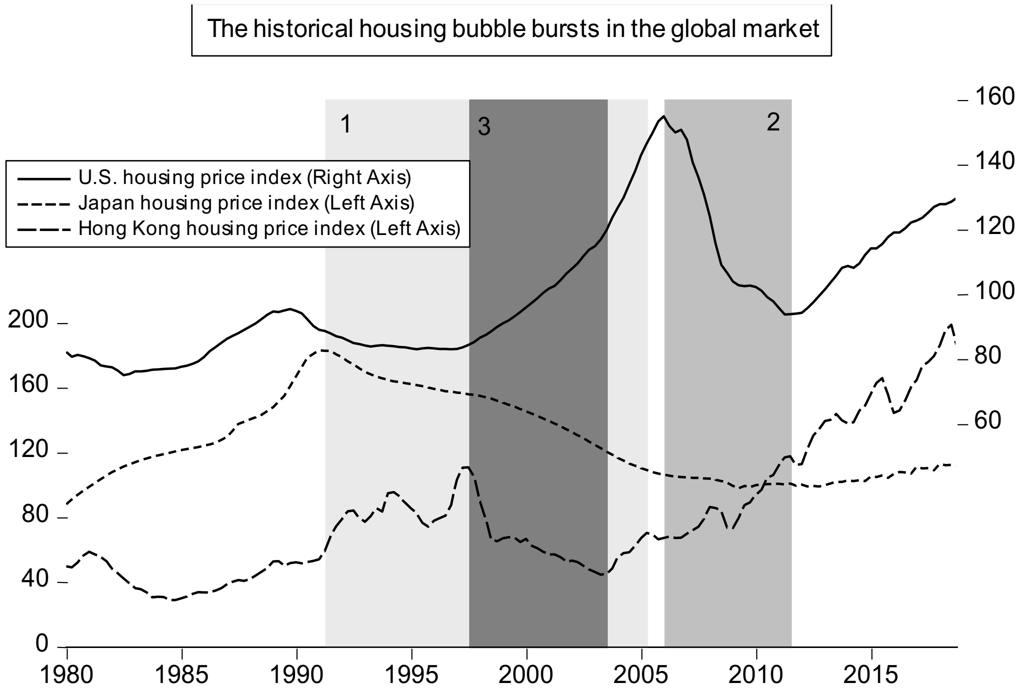

***Figure 1-12** The historical housing bubble bursts in the global market*

Notes:

- Data source: The Federal Reserve Bank of St. Louis
- The shades represent the real estate bubble burst periods in three countries
- Light grey shade (1) is the bubble burst period for Japan in 1991-2005; grey shade (2) is the bubble burst period for the U.S. in 2006-2011; dark grey shade (3) is the bubble burst period for Hong Kong in 1997-2003.

Existing studies have summarised and analysed the historical problem of the housing bubble in the context of many economies that have presented evidence of banking and financial system crisis after a bubble boom and bust. Herring and Wachter (1999) illustrated the historical findings of the link between the housing bubble and the weakening banking and financial system using evidence from five different economies, namely, the United States, Sweden, Japan, Boston, and Thailand. Although under different settings, real estate booms in different cases all ended in the busts in the financial system, in turn leading to devastating effects on the economy. Hilbers, Lei, and Zacho (2001) provided a comparative analysis of the housing bubbles and financial system failure of 11 historical cases. Consistent with the previous study, this study also stated that the surge and dramatic fall in housing prices is associated with financial crisis in an economy. The sharp fluctuations in property prices have substantially increased the probability of the occurrence of financial crisis. The study from Koetter and Poghosyan (2010) indicates that during the process of housing price increase might foster a higher risk of moral hazard and adverse selection when banks aim to expand their loans. This credit expansion results in a more significant failure risk and bank instability.

When the banking system experiences instability as a consequence of housing price surge and bubble burst, the result is a substantial negative influence on the entire market, because the banking system occupies a vital role in monetary policy and the macroeconomy. Bernanke (1990) stated that in one economy, most small and medium-sized enterprises rely mainly on bank credit financing. As a result, when the banking sector is in crisis, companies encounter a severe credit crunch and are forced to cut investment, making the aggregate demand fall and real economic growth decrease. Reinhart and Rogoff (2013), examining cases such as Denmark's financial panic and the 2008 global crisis, discovered a similarity among both advanced and developing economies facing the historical experiences of systemic financial system crisis. Similar research has been done by Honohan and Klingebiel (2003). A banking crisis generated by asset price bubbles causes a burden in particular on government debt position, as the government is forced to rescue the banking sector with financial support, placing more pressure on the economy.

The explanations of how real estate bubbles emerge are closely linked to the characteristics of the housing market. The first explanation relates to the housing supply side. Glaeser, Gyourko, and Saiz (2008) found that high transaction costs and house supply elasticity can largely explain property bubbles in a market. There is a negative relationship between the elasticity level of the housing supply and the probability of the housing bubble and its duration. The primary means of creating housing bubbles under the supply side is the possibility of oversupply during the housing boom period. Specifically, in a place in which supply elasticity is more modest than in other areas, housing prices usually increase more notably and the bubble is longer lasting, whereas in places with more elastic supply, the housing bubble is generally shorter (Ihlanfeldt & Mayock, 2014). Other studies addressed the generation of housing bubbles from the demand side. For example, after examining the history of the US market, Mankiw and Weil (1989) attributed the US housing price boom in the 1970s to the high demand of the Baby Boomer generation. Moreover, the study from Fernández-Kranz and Hon (2006) on Spanish housing prices revealed the importance of income elasticity of demand in determining real estate price enlargement. Furthermore, another suggested determinant is the monetary factor. Both Taylor (2007) and McDonald and Stokes (2013) conducted their research on the US housing sector and on monetary policy in the United States between in the early 2000s. They both found that the continuous low interest rate, cut by the Federal Reserve during this time, contributed dramatically to the next housing price boom and bubble burst. Finally, studies have also provided evidence of the critical role that speculative financial liquidity has played in increasing the creation of housing bubbles. During the period of dramatic real estate sector development in the United States from 2004 to 2006, nearly half of all the properties that were purchased under the housing boom were bought not for self-occupation but for investment purposes (Haughwout, Lee, Tracy, & van der Klaauw, 2011). A similar study, conducted by Bayer, Geissler, Mangum, and Roberts (2011) and focussing on Los Angeles over the same sample period, has also demonstrated the substantial contribution of speculative investors to house purchases. Fuelled by the capital inflow under a loose financial regulation, the real estate market accumulated sufficient speculative money to facilitate the emergence of housing bubbles. Overall, the combinations of various property market and macroeconomic factors explain an overheating housing market and housing bubble in an economy.

1.1.5 Housing price and capital inflow

Together with housing market prosperity, determinants of the boom in housing prices have been a prevalent topic over decades. Existing research has discussed one of the elements, namely, capital inflow, when the public has played an increasingly vital role in the global real estate market. The past several decades have seen enormous growth in the gross capital inflows from advanced economies towards emerging Asian countries. Conditions of excess global liquidity have made a prominent contribution, and the loose regulations of these emerging countries have been another notable factor (Kim & Yang, 2009). The amount of gross capital inflow in emerging economies reached $216 billion in 2005, compared to $140 billion in 1996 (Kim & Yang, 2011). Furthermore, net capital inflow among emerging countries was around 4% of GDP in 2008, decreasing to about -2.5% during the financial crisis, and then rapidly rising again to exceed the previous level in the beginning of 2010 (Tillmann, 2013). Among the capital inflows, FDI is one of the leading sectors in which foreign investors participate in the activities in one economy. The FDI inflow to both developed and developing countries has grown rapidly in the past three decades, with several booms and drops in FDI to developed countries due to crises in the target countries (see **Figure 1-13**). Notably, in recent years, accompanied by the rising importance of the service industry in the global economy, FDI inflow in the service industry is ascendant, especially the real estate sector. According to the global investment report, the service industry has stimulated two-thirds of total FDI inflow, occupying a dominant position (UNCTAD, 2014). The Organisation for Economic Co-Operation and Development (OECD) countries of advanced economies have been frequently discussed in this topic. Statistics show that OECD countries have experienced surging activity in the real estate sector, with an increasing demand for houses (Sá, Towbin, & Wieladek, 2014). In the wake of a revolution of internationalisation in the housing market, foreign investments have flowed into the real estate sector with the aim of profit-seeking. For instance, this part of investment has accounted for almost half of the total foreign direct investment in Spain, while the total amount of foreign investment in the OECD real estate sector reached USD 20,932 million in 2008 (Gholipour et al., 2014). Similarly, in Spain, foreign investment into the housing market accounted for nearly half of total FDI, accounting for the primary demand to motivate housing prices and serving as the prime driver of economic boom (Rodríguez & Bustillo, 2010). Evidence has also been found in Australia, with foreign investment in real estate jumping 75% in 2015, and the US cross-border capital in the US commercial real estate sector more than doubled in 2015 (Costello, 2016; Janda, 2016).

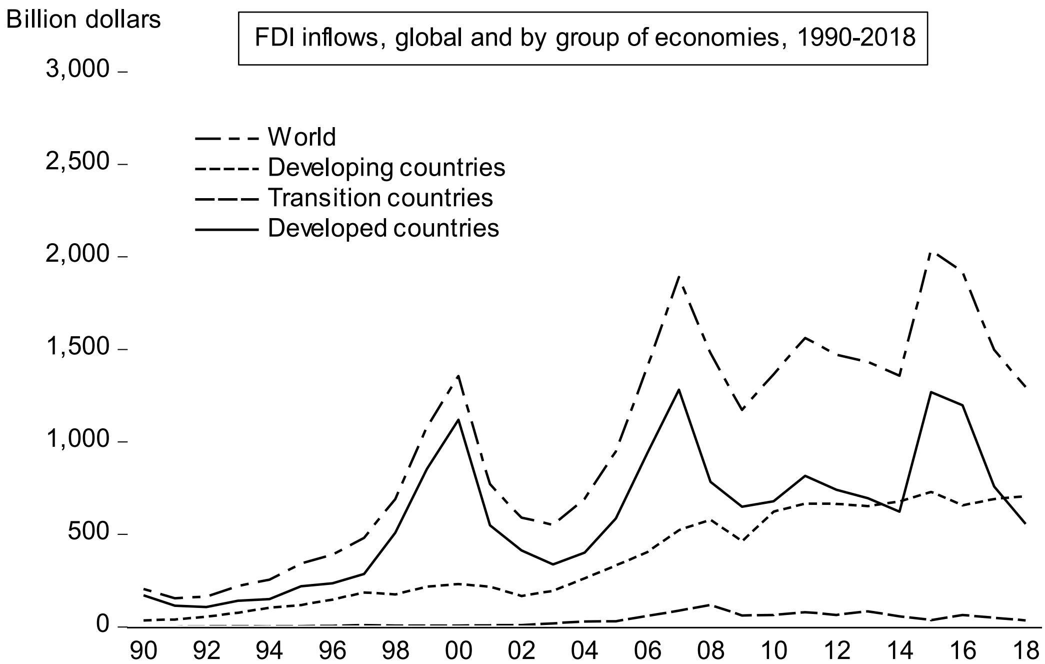

Figure 1-13 *FDI inflows, global and by group of economies, 1990-2018*

Data source: United Nations Conference on Trade and Development

Evidence from the last decade has indeed proven the vital role capital inflow played in the soaring real estate market. For instance, Tillmann (2013) discovered unambiguous evidence of the effect of capital inflows on the surge in house and stock prices in emerging economies. Loose monetary policies in advanced economies lead to the risk of financial instability in the recipient countries. The study also asserts that cross-country differences in terms of sensitivity to capital inflows mainly determine the outcome of a surge in housing prices, and this difference is due to macro policies rather than to features of the real estate market (Tillmann, 2013). He found that a rise in capital inflow of 1% of GDP resulted in a 0.5% upward change in house prices in emerging

Asian countries (Tillmann, 2013, p.718). Nguyen (2011) stated that the unforeseen growth of global capital inflow in Vietnam from 2007 to 2008 contributed to a boom in the real estate sector and that the housing bubble generated by these investments might result in an economic burst as bad loans from banks increase and demand and capital outflow decrease. In the meantime, research on advanced countries has also justified the importance of capital inflow on the housing market. In one study concerning the situation in OECD countries, capital inflow was found to explain approximately 8% of fluctuations in house prices (Sa et al., 2011, p.11). More importantly, in a country in which the mortgage market has developed to be stronger and more mature, this effect appears to be higher. A further study by Sá et al. (2014) found a significant and positive influence of capital inflow on housing prices in OECD countries, and it indicates that this link relies strictly on the degree of development of the mortgage market in the economy. In an economy with a highly developed mortgage market, buyers are capable of mortgaging a more substantial portion of a house's value into collateral. Thus, households tend to be more sensitive to fluctuations in the collateral value when they are primarily indebted (Sá et al., 2014). Similarly, the study of Brixiova et al. (2010) shows that the inflow of external funds led to the real estate boom in Estonia from 2000 to 2007. It functions by fuelling domestic credit expansion and pushing up the demand to purchase houses among local citizens. Although the growth in Estonia appears to be rapid and robust, its pattern shows obvious unbalance. Excessive capital inflow has financed the overdeveloped non-tradable market, and the real estate sector is facilitated with increasing private debt from external financing. Subsequently, the economic burst was also amplified and had effects on the domestic market due to the global financial crisis (Brixiova et al., 2010). The study by Reinhart and Reinhart (2008) incorporated both emerging and developed countries and argued that significant foreign capital is associated with the appreciation in both equity and real estate industry. An inflow of global capital reflects higher demand for assets in the receiving country, which then drives up the asset price.

Capital inflow has been examined in several different contexts. The two most vital inflow channels of foreign investment into the real estate sector is through FDI and speculative capital (Song & Gao, 2007). Speculative capital inflow, or hot money, is believed in particular to have fuelled price levels and have driven up the funds accumulated in housing transactions (Guo & Huang, 2010). It is a short term capital movement that holds the features of high sensitivity and high risk and return. To use China as an example, since China has gradually liberalised its capital accounts, global investors have shifted their attention to this profitable market with a large amount of speculative funds (Zhang et al., 2012). Simultaneously, these capital inflows are claimed to be partly responsible for accelerating price volatilities in the property market (Guo & Huang, 2010). Furthermore, FDI, or, more accurately, foreign real estate investment (FREI), has also been selected in several literatures when discussing the effects of capital inflow. Foreign direct investment can be engaged in in several ways, including Greenfield investment and buying shares of major local real estate companies; the latter is targeted predominantly in the construction sector. Foreign direct investment enters the housing industry through foreign enterprises such as real estate developers, and these enterprises run as entirely foreign-owned enterprises, equity joint ventures, cooperative joint ventures, or joint development ventures (Hui & Chan, 2014). To be more precise, real estate investment flow refers to investment that grants the investor ownership, partial ownership, or some control over the property. The category of real estate investment can be broken down into real estate development investment and real estate property investment (Hui & Chan, 2014). The former focusses on the development, construction, and management of land and buildings in the long term, encompassing a series of activities such as land developing, constructing, renting, or selling. Consequently, while the uncertainty is higher, the profit is higher as well. The second type of investment involves the purchase or construction of houses with the intention of holding properties from which to gain renting returns or value-added investment (Hui & Chan, 2014). This investing process is relatively short, beginning with the purchase of existing houses to sell or rent, instead of entailing the acquisition of non-performed properties and the packaging, securitisation and asset realisation, or recapitalisation of these assets to gain renting income. Compared to the first approach, property investment has a relatively lower risk.

1.1.6 Housing and stock markets

Apart from capital flow from overseas, the stock market has been suggested as another vital determinant of a booming housing market (Su, Chang, & Zhu, 2011). The stock and housing markets have historically experienced many fluctuations together in a diverse array of economies, leading to discussion among economists of the potential connections between the two markets (Kakes & Van Den End, 2004; McMillan, 2011). **Figure 1-14** shows the trends of the housing and stock markets in many economies such as the US and the UK and displays several potential correlations between the two, although lags exist as well. Most previous financial crises are rooted in fluctuation in the real estate and stock sectors (Kapopoulos & Siokis, 2005), which are both of specific interest because of the influence of fluctuations in asset markets on consumption (Sim & Chang, 2006). In particular, to understand the advantage of diversification in wealth portfolios, it is essential to understand the relationship between these two essential asset markets. Equity and real estate prices have historically appeared to move together, and research has accordingly shown interest in the critical argument of whether there exist any short-term correlations or long-term trends, or a non-linear relationship between the two markets. The stock and property sectors are known to be influenced individually by many market activities (Tsai, Lee, & Chiang, 2012). As two distinctive investment tools, stocks have high liquidity and low transaction costs, while houses have lower liquidity but higher transaction cost. They are thus potential choices for risk diversification (Lin & Fuerst, 2014). These characteristics of distinction may cause segmentation between the two asset markets. Nevertheless, macroeconomic elements such as economic growth, interest rates, and financial crisis may conversely cause the correlation between housing and stock prices (Lin & Fuerst, 2014).

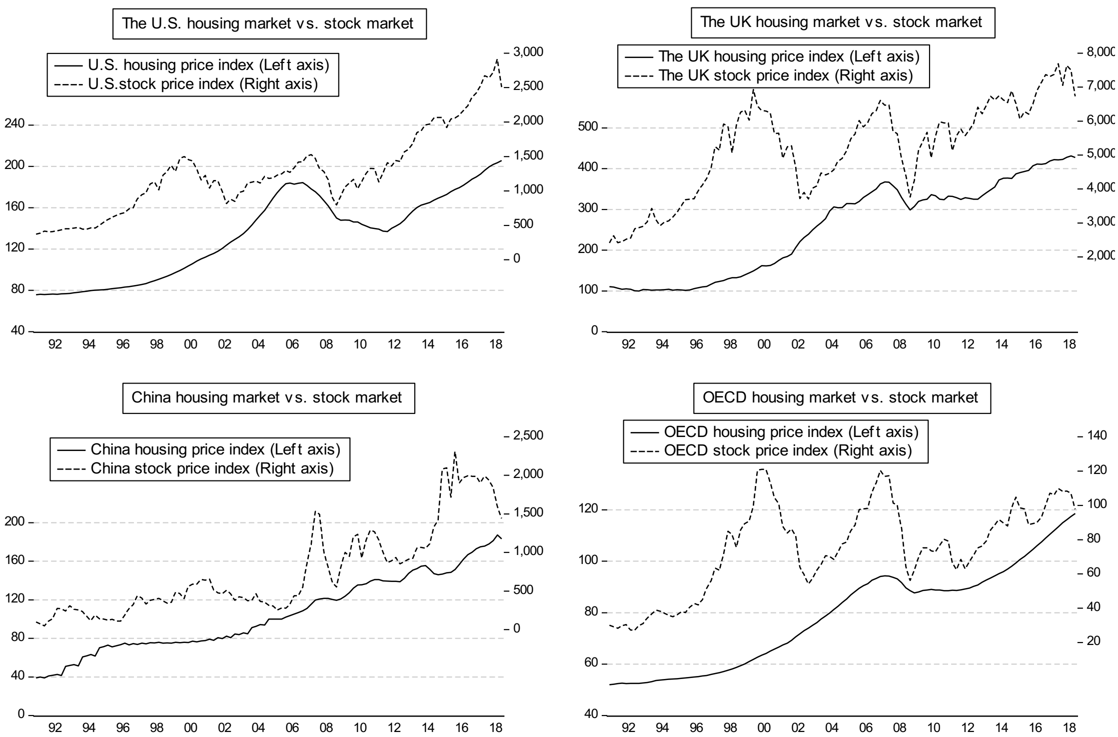

Figure 1-14 *The housing market vs stock market in major economies and areas.*

(Data sources: DataStream and OECD Data)

Consequently, the questions are whether stock prices are merely a leading indicator based on their forward-looking nature or whether a causal relationship exists between stock and housing prices. It is essential to investigate this topic, as together, the real estate and stock markets constitute a major portion of an economy's wealth; any movements in these two markets can generate dramatic shocks on a country's economic situation (Li, Chang, Miller, Balcilar, & Gupta, 2015). Real estate–related investments generally occupy the largest segment of household wealth portfolios for most of the population, and changes in these markets can have a large influence on economic wellbeing (Anderson & Beracha, 2012). This fact would ultimately influence decision-making regarding stock investment in an economy. In particular, if the two assets tend to be moving together, a higher level of asset substitution can be expected; if housing and stock prices are proved to not be integrated, however, then the implications for wise portfolio selection to diversify risks would be positive (Okunev & Wilson, 1997). The outcome would thus be an essential factor affecting investors' asset allocation strategy (Liow & Yang, 2005). Moreover, since volatile financial or property markets would lead to high risks in the market, it is vital to examine this issue (Yang, 2005). An answer would also be indispensable for policymakers when addressing the price bubble issue (McMillan, 2011).

Apart from the general stock market, a specific sector in the stock market, REIT, targets the real estate industry in particular. A REIT is a company that runs the business of owning and operating income-generating real estate (Li & Lei, 2011). This comparatively new model of financial funds follows the operations of mutual funds, which offer the opportunity for individual investors to access real estate assets and earn dividends. Following the same channel of buying shares or funds to invest in other industries, this manner of investment achieves its purpose without requiring the purchase and management of properties (Nareit, n.d.-b). There are four types of REITs in the market, namely, equity REITs, mortgage REITs, public non-listed REITs, and private REITs. The most common type in the market is equity REITs, which are publicly traded and whose properties are income-generating real estate (Howe & Shilling, 1990). Meanwhile, mortgage REITs function by providing financing through the purchase and generation of mortgages and mortgage-related securities and by generating income from interests. Public non-listed REITs are not traded in the market but are registered with the Securities and Exchange Commission. Finally, private REITs are not traded on stock exchanges and are exempt from the regulations on the market.

As equity REITs are the most traded REITs in the market, they incorporate the majority studies of REITs sector. The daily activities of these companies involve operating, owning, and managing properties such as residential apartments, office buildings, and shopping centres. The incomes from these investments are then distributed to shareholders as the form of dividends (Howe & Shilling, 1990). Equity REITs represent the most common REITs in the public understanding, and they constitute the predominant part of the REIT market. According to the pay-out requirement that REITs pay at least 90% of income to shareholders, these are a wise way to invest and earn more income compared to other shares (Nareit, n.d.-b). In addition, they are associated with comparatively a lower correlation between real estates and other assets such as stocks, which offers investors the benefits of diversification and reduced volatility in a portfolio. Moreover, this form of investment in real estate has dramatically heightened the liquidity of property assets, which makes the entry and exit of the investment straightforward. Originating from such a fundamental feature, REITs have been appreciated by the market since their introduction. In the United States, for example, the general performance of REITs has been stable, reliable, and rapidly growing over the past 45 years. The professionally managed portfolios in REIT companies have made this investment outperform the broader stock market or other assets (Stratton & Fein, 2017).

1.2 Research Objectives and Aims

The aims and objectives of this thesis are built on the background of booming real estate markets in the UK, Canada, and China and the context of the close connections between the housing market and capital inflows and between the real estate and stock markets. The three objectives of this thesis thus stem from the problem of soaring housing prices in the UK, Canada, and China and intend to help understand housing bubbles and the determinants of housing prices. The three objectives and aims are presented in detail in this section.

I. Testing for housing bubbles

The primary objective of this thesis is to test for housing bubbles in the UK, Canada, and China. Although situated in the context of distinctive macroeconomic conditions and policies, the housing markets in the three target countries have all encountered similar levels of prosperity over the past decades. The importance of the real estate sector in supporting the economy as a whole has made it vital to monitor the soundness of the housing market and provide pertinent regulations for its healthy development. The previous section discussed the close links between housing bubbles and banking system failure and, ultimately, financial system crisis. This further justifies the necessity of studying housing bubbles. Consequently, Chapter 2 of this thesis examines the presence of housing bubbles in the UK, Canada, and China by using the combination of two empirical models and focussing on explosive bubbles. Modelling the co-explosive vector autoregression (VAR) to test housing and rental prices does not prove the explosiveness of housing prices in the three countries, but recursive unit root tests have detected several housing bubble periods and ongoing bubbles in the UK, Canada and China.

II. Housing price and foreign investment

The second objective of this thesis is to examine the effect of FDI on housing price movement in the UK, Canada, and China. After housing bubbles and overheated housing prices are detected, it is essential to investigate in the possible determinants of booming housing prices so that targeted solutions can be applied. Capital inflow has been suggested to contribute greatly to the development of the housing market in many economies. In the meantime, as one of the key channels for capital inflow to invest in the real estate sector, FDI is one of the determinants to which research must pay attention. To this end, Chapter 3 aims to study the effect of FDI on housing prices in the three economies in question using the structural VAR (SVAR) approach. As suggested by the literature, the variables in this model are housing price, FDI, housing supply, rental price, interest rate, and GDP. The result of the SVAR model suggests that the insignificant impact of FDI in the UK has caused changes in housing prices. Meanwhile, Canadian housing prices have been positively affected by FDI inflow, while Chinese housing prices have been negatively affected by FDI.

III. Housing price and REITs

The third objective is to study the connection between housing prices and REITs in the UK, Canada, and China. As alternative ways of investing in a household portfolio, the stock market and the housing market are closely connected through diverse channels. Therefore, when analysing the dynamics in the real estate market, it is vital to gain knowledge of the relationship between the two. In particular, REITs is one sector in the stock market closely linked to the activities of the real estate market, a connection which requires research to discover its influences on real housing market activities. To this end, Chapter 4 investigates the relationship between housing and REIT prices in the UK, Canada, and China by using the SVAR model. The result is that REIT prices are considerably affected by activities in the housing market as well as those of the broader stock market in the UK and Canada. However, housing prices are not notably affected by REIT price fluctuations.

1.3 Research Gaps and Contributions

I. Housing bubbles

The topic of asset bubbles has long been controversial, and the existence of housing bubbles has often been discussed in the context of many economies. Bone and O'Reilly (2010), Clark et al. (2010), Garino and Sarno (2004), and Zhou and Sornette (2003) have examined the UK housing market to discover topics related to housing bubbles. The dynamic of the causes and consequences of housing bubbles has been discussed by Bone and O'Reilly (2010), Zhou and Sornette (2003), and Garino and Sarno (2004). Black, Fraser, and Hoesli (2006), however, investigated whether the UK housing market is experiencing a housing bubble, and their research has provided evidence for housing bubbles in the UK in different sample period. Furthermore, Dreger and Zhang (2013), Hou (2010), Hui and Yue (2006), Ren et al. (2012), and Shih et al. (2014) tested for bubbles in the Chinese housing market, focussing on a wide range of provinces among the studies, which did detect bubbles in different areas. However, a lack of literature has investigated Canada in this regard, with several exceptions, including Macdonald (2010), Courchane and Holmes (2014), and Clark et al. (2010). These studies have focussed on comparing the housing markets of Canada and the United States with the intension of identifying the differences between them and the possibility of housing bubbles in Canada.

Chapter 2 contributes to this field by providing both a new concept and a new methodological approach. First, previous research has not empirically examined the housing price boom in the specific case of Canada, despite the fact that the soaring property prices in Canada must be discussed for the soundness of the real estate sector. The most related literature examines the comparison between the US and Canada housing markets (Courchane & Holmes, 2014). Hence, this study fills this gap by exploring the presence of housing bubbles in the Canadian real estate market. The study of the Chinese real estate sector has also been seldom examined on a national scale to provide more information for other areas, except for Gabrieli, Pilbeam, and Wang (2018). Next, this study examines both the cointegration and explosiveness in housing prices, a topic which has seldom been studied in previous research. Existing research provided empirical estimation on housing bubble by means of detecting bubble-like price pattern (Ren et al., 2012), cointegration (Courchane & Holmes, 2014; Dreger & Zhang, 2013) or explosive price (McMillan & Speight, 2010). However, no previous approach allows for the combination of both unit root and explosive root in the model. More specifically, Chapter 2 applies two explosive models, co-explosive VAR and the recursive unit root test, to gather more detailed and supportive evidence on the housing bubble problem in the UK, Canada, and China. Co-explosive VAR is a relatively new model in spotting real estate bubbles, as it was introduced to test stock bubbles (Engsted & Nielsen, 2012). Only several recent studies by Engsted, Hviid, & Pedersen (2016) and Kivedal (2013) have applied it to test housing bubbles. Additionally, because of the drawbacks of co-explosive VAR, including the reliance on simple present value model and not allowing for structural breaks, another bubble model – Supremum ADF

(SADF) and Generalised SADF (GSADF) is employed to provide understanding at a different aspect.

II. Housing price and FDI

When exploring the causal relationship between high house prices and foreign investment, the spotlight of most of the existing literature has placed on emerging economies, particularly emerging Asian countries such as China. Kim and Yang (2011), for instance, analysed how the surge in capital inflow contributes to growth in asset prices, the mechanism which underlies this phenomenon, and its effect on the asset market in emerging Asian countries. Existing studies have also shed light on emerging economies in Europe. For instance, in a rapidly growing and severe boom-bust context, Brixiova, Vartia, and Wörgötter (2010) explored the factors that drove Estonia from strong economic performance to deep recession and found that loose capital account and currency policies in Estonia stimulated a vast amount of capital inflow, which then resulted in immensely broadened credit. Their paper aimed to discover whether capital inflow has contributed to such a severe collapse of Estonia economy. Research has also debated FDI and the housing market. According to the study by Nguyen (2011), Vietnam experienced substantial economic growth for two decades due to its attractiveness for foreign capital. Investment which was supposed to flow into manufacturing industries to support the economy has, however, flowed into the real estate sector and realised high profits. Hence, Nguyen (2011) argued that FDI in Vietnam has resulted in instability in the economy and the generation of a housing bubble. By contrast, a lack of research has been conducted on the connection between capital inflow and the real estate industry in developed countries. Korea was a developed country that was studied by Kim and Yang (2009) in their examination of the influence of capital inflow shock on property prices. Moreover, Sa et al. (2011) and Sá et al. (2014) analysed OECD countries to explore how capital inflow affects housing price levels. Moreover, Sa and Wieladek (2010) conducted an exceptional study in the United States to consider capital inflow as the determinant of the housing price boom. In addition to capital inflow, previous studies have also proposed specific types of foreign investments. For example, Gholipour et al. (2014) studied the link between FDI and property prices in OECD countries, while Rodríguez and Bustillo (2010) discussed the impact of foreign real estate investment in Spain.

Of the varieties of capital inflow, FDI into the real estate market has been closely linked to activities in the housing market, as discussed above. However, a comparative lack of research has been conducted on the relationship between FDI and housing prices in the UK, Canada, and China. Studies on FDI and housing markets in developed countries have been conducted by Bonis (2006) and Gholipour et al. (2014). Bonis (2006) concentrated on whether FDI is an essential factor in explaining housing price fluctuations in major US cities, a link which has been revealed to be prominent but adverse. Gholipour et al. (2014), meanwhile, tested the long-term co-movement among FDI, economic growth, and housing prices in OECD countries, although insignificant effects of FDI on housing prices were found in both the short- and the long-term. In the case of developing countries, an earlier study from Jiang, Chen, and Isaac (1998) has proved the remarkable explaining power of FDI on the housing sector boom in one of the major cities in China, Shanghai. Overall, there is a lack of research on the dynamics in the UK and Canada, while the evidence for China has only been limited to a city-specific scale.

Accordingly, the contributions of Chapter 3 are the following: First, this chapter provides a new understanding of the connections between capital inflow and the real estate markets in the UK, Canada, and China. Second, this chapter develops an understanding of whether the FDI level is a vital determinant of booming housing prices in the UK, Canada, and China. Finally, this chapter uses the SVAR model together with the Granger causality test and impulse response function (IRF) to present the short-term explanatory power of FDI on housing price changes.

III. Housing prices and REITs

Many previous studies have contributed to knowledge on the relationship between the stock and housing sectors in various countries. Okunev and Wilson (1997), Tsai et al.

(2012), Anderson and Beracha (2012), Shirvani et al. (2012), and Li et al. (2015) have focussed on the US economy when discussing this topic, incorporating different variables, and some, such as Tsai et al. (2012) and Anderson and Beracha (2012), have indicated notable explanatory power or co-movement of the US stock and housing variables. Studies have also investigated this connection in the European context; these include Kakes and Van Den End (2004), Kapopoulos and Siokis (2005), and Su et al. (2011). The significance of stock price movements to real estate sectors have been justified in many countries, including the Netherlands and Greece. Furthermore, research has also examined Asian countries to conduct similar research on the stock and housing markets. These include Ibrahim (2010), conducting research on the Thai market; Sim and Chang (2006), on the Korean market; and Liow (2006), on the Singapore market. These studies all supported a substantial causal link between stock and housing prices in the economies under examination. In terms of the three countries studied in the present research, Su et al. (2011) discussed the long-term cointegration between the stock and housing industries in the UK. The housing market in the UK was proved to be a prominent explanatory factor of stock movements, although this relationship was indicated to be insignificant by another study, from McMillan (2011). Moreover, some studies have shed light on the stock and housing markets in China. Zhang and Fung (2006) found a negative relation between Chinese stock and housing prices, and the stock price index was found to be influential in explaining housing price fluctuations. Moreover, Liow (2012) tested the housing and stock correlations in China and three other Asian countries and produced similar findings. However, other studies, such as Lin and Fuerst, 2014 and Zeng, Li, and Li (2008), reject the importance of stock prices in affecting the real estate sector in China. Meanwhile, scarce evidence on this topic has been found in Canada.

The discussion of the REIT sector is relatively limited and focussed specifically on the US market when exploring into its relation to the actual housing sector. Bouchouicha and Ftiti (2012); Clayton and MacKinnon (2001); He (2000); Morawski, Rehkugler, and Füss (2008); and Oikarinen, Hoesli, and Serrano (2011) investigated the REIT sector and real estate market in the US, and they all found a significant influence of REIT return movements on the housing market, and they also found the presence of feedback information from actual real estate price changes to REITs. Based on this context, Chapter 4 contributes to the existing literature in several ways. This study primarily contributes to an understanding of the relation between the stock market and the property sector in Canada, providing implications for the Canada regulators. Second, there is limited knowledge on the REIT sector and the connection between REITs and housing prices in the UK, Canada, and China. Therefore, this study discusses this emerging financial sector, closely linked to the housing market.

1.4 Philosophy

This section introduces the research philosophy and the approach, strategy, and techniques derived thence. These reflect the beliefs and assumptions regarding the structure and sources of knowledge which are present in this thesis. Each step of this study makes many assumptions regarding knowledge and reality which shape the understanding derived hence. In particular, the selection on methodologies, research strategy, methods of data collection, and the process of analysis are all underpinned by the foundation of research philosophy. Consequently, only with a coherent and consistent research design, with all the elements in the research responding to each other, can the researcher develop understanding.

1.4.1 Research philosophy

Before engaging in social science research, it is vital that researchers decide how their study can be conducted and what it should entail. To this end, the nature of social science research methods must be explored to determine which method is best in a specific study context. The research method should be closely tied up with how a particular social reality should be investigated, which is in turn closely connected to how researchers envision the link between the viewpoints in terms of the reality and the manner in which the study is conducted (Bryman, 2012). A researcher must consider several factors, including philosophies, approaches, strategies, and techniques, in developing a research strategy (Saunders, Lewis, & Thornhill, 2009).

The starting point of designing research is defining the research philosophy. A research philosophy involves the assumptions of how a researcher views the world. The philosophy then guides the formulation of research approaches, strategies, choices, time horizons, techniques, and procedures. Undoubtedly, philosophy offers a positive support for the research methodology, acting as a fundamental basis for the emergence of research methodologies and avoiding the inappropriate adoption of methodologies (Crossan, 2003; Zikmund, Babin, Carr, & Griffin, 2013). Therefore, it is vital that a research design recognise, learn, and understand the commitments entailed by the research philosophy (Easterby-Smith, Thorpe, & Jackson, 2015; Saunders et al., 2009). In a research philosophy, two crucial branches are epistemology and ontology: The former considers the nature and sources of knowledge, while the latter involves what exists and the nature of existence (Cameron & Price, 2009).

I. Epistemology

The essential problem for anyone who researches in any area of science is the question of "what is knowledge", to which epistemology aims to respond (Goles & Hirschheim, 2000). Epistemology is the discipline concerned with the nature and origin of knowledge of social reality, or, more precisely, what is accepted as valid knowledge (Collis & Hussey, 2013; Grix, 2002; Zikmund et al., 2013). In particular, epistemology focusses on the process of gathering knowledge, which is supposed to develop continuously, as opposed to being static. There are two distinct positions in epistemology, namely, positivism and interpretivism, which designate two distinct perspectives regarding what counts as knowledge in the study of science (Grix, 2002). Positivism involves applying natural-scientific methods to the social sciences and only believes in knowledge which is confirmed by observations, whereas interpretivism focusses on the subjective meaning of social actions (Bryman, 2012). In this thesis, the epistemological position which is adopted is positivism.

The choice of paradigm is generally based on the nature of the research aim. This thesis examines the topic of the relationships among housing prices, foreign investments, and stock prices in the UK, Canada, and China. Rather than focussing on subjective knowledge, which is influenced by individual experience, this research espouses a positivist epistemology (Saunders et al., 2009). The method used in the approach aims to study observable social reality, to this end collecting credible data, testing hypotheses, and developing theory. Positivists suggest that observations about objects must be value neutral. True knowledge according to a positivist epistemology can only be gained through objective measurement and observation, which means that it exists independently of the observer and separate from subjective consciousness (S. Cameron & Price, 2009; Collis & Hussey, 2013; Zikmund et al., 2013). In other words, the only valid knowledge in a positivist frame are those phenomena which can be observed and measured. A formal and rigorous procedure is usually designed to prevent distortion from any personal value or opinions (Collis & Hussey, 2013). Based on observation, the researcher proposes generalisable, rationally adjustable statements to reflect this true fact (S. Cameron & Price, 2009). The goal is thereof to discover theories which can be scientifically verified via experimentation and observation (Collis & Hussey, 2013). In a positivist framework, researchers employ logical reasoning to develop precise and objective theories to explain or predict social reality. Generally, causal laws which bind the social world are produced to explain the causal relationship between or among variables (Collis & Hussey, 2013).

II. Ontology

Social ontology is related to the nature of social entities, that is the way reality works (Saunders et al., 2009). Ontology is not an abstract that is far removed from the intended research project; on the contrary, it is inextricable from the manner in which researchers shape their research and analyse their social-scientific topics (Saunders et al., 2009).

The position of ontology hence supports the assumptions of researchers as to how social entities operate. In a distinction to the positivist and interpretivist positions in epistemology, ontology is often divided into objectivism and subjectivism. Subjectivism holds that social phenomena are created from and fashioned by the interactions and perceptions of social actors (Saunders et al., 2009). By contrast, objectivism refers to the position that social entities exist external to the influence of social actors.

This thesis embraces an objective approach in its investigation of the connections among housing price, foreign investment, and stock price data in the UK, Canada, and China. Similar to positivism, objectivism espouses the objective view of the natural sciences, asserting that things exist independently of how we think of them or our awareness of them. Objectivism therefore conceives of an objective reality independent of our perceptions or behaviour. Social research must be investigated based only on observations of social phenomena, because the world is external and concrete (Easterby-Smith et al., 2015). Through this process, reality and research findings remain detached from any beliefs or values of the researcher.

1.4.2 Research approach

The research philosophy section established the definitions of reality and knowledge. The next step is to select approach based on the philosophy in order to gain knowledge and to study the social action in question. In general, a research project involves the use of theory to support or explain it. In the meantime, the difference lies in the issue of whether the theory is evident at the beginning of the research, and this ultimately defines the research approach that is adopted (Zikmund et al., 2013). If the theory and hypothesis are established prior to conducting the research and a suitable strategy is applied to test the theory, the approach is deductive. However, if the data collection and analysis begins before the theory is developed, the approach is inductive (Saunders et al., 2009). Thus, it is ultimately the emphasis and the nature of the research topic that decides the approach.

A deductive method is more appropriate when many previous studies provide definitions to be used in the theoretical framework. The deductive method in social science resembles the dominant manner of research in natural science, anticipating and predicting events (Collis & Hussey, 2013). The researcher deduces hypotheses on one social action from the foundation of existing knowledge and theoretical considerations and then embeds researchable and operational concepts into the hypotheses for empirical study (Bryman, 2012). Concept and hypothesis take centre stage and guide the process of empirical inquiry, during which the researcher is independent of what is being examined. Through this process, social facts can be tested quantitatively, so that the researcher holds the ideas of how to collect and analyse data, which are finally fed back into the hypothesis of the investigated social action (Saunders et al., 2009). To be able to generalise the outcome into regularities, the deductive method requires a large sample size and a sufficient number of observations. The approach used in this research is deductive: Testable assumptions that generally relate to the relationship between variables are deduced or predicted from current theory, and feasible measurements are designed to test them (Cameron & Price, 2009). In accordance with the philosophy of positivism and objectivism in this thesis, the research approach uses a deductive method that operates by collecting and analysing time-series data of housing prices, foreign investment, and stock prices.

1.4.3 Research strategy

After designing the research approach, the next phase is to select a suitable research strategy and method. This is another vital step, providing strong support for social research design when researchers face methodological issues. The research strategy refers particularly to generalised guidance for social researchers on how to approach their problem (Bryman, 2012). The strategy involves the specific procedures, with in-depth details of methods, analysis, and interpretation, expanded from broader philosophical assumptions. The two research methods discussed here are quantitative and qualitative, which have both been broadly used in social science in relation to both numeric and non-numeric data collection and analysis procedures (Saunders et al., 2009). Qualitative research investigates and understands social topics that have been influenced by social entities. Quantitative research examines existing theories objectively and deductively by statistically testing the connections among measurable factors (Creswell & Creswell, 2018).

The foundations of the epistemology and ontology of these two strategies give them distinct natures, and the strategy should accord with the philosophical framework of the particular research. The focus of the quantitative method is placed on a deductive process of collecting and analysing data to test theories, and it conceives of reality as external and employs practices from natural science. In this method, therefore, there is only a straightforward reality, which exists objectively and independently of consciousness (Zikmund et al., 2013). Quantitative data are "Data in the form of numbers or data that can readily be coded numerically" (Zikmund et al., 2013, p.63). Quantitative data can be either numerical or simple and concise non-numerical data from closed-ended questions that can efficiently be coded into numerical values. Quantitative data have been tested and interpreted to become useful information that can be used to meet research objectives. Moreover, techniques such as statistics and graphs in quantitative strategy assist by analysing, describing, investigating, and demonstrating links and trends among the data (Bryman, 2012). This study, analysing housing bubbles and the impact of foreign investments and stock prices on real estate prices, employs a quantitative method to measure numbers and the relationships among variables using economic models. This study also uses analytical techniques such as tables, diagrams, and statistical modelling.

1.4.4 Data collection

Since the research philosophy, approach, and strategy of this research have been defined, the next step is to outline the techniques used for data collection and analysis, which are based the objectives of the study and their capacity to answer the research questions. This thesis employs secondary data, that is, data that have already been collected for other purposes in other studies or projects. Entities such as governmental institutions and representatives or social scientists collect large amounts of data in both quantitative statistical and qualitative forms for a variety of purposes (Bryman, 2012). These datasets are generally available to the public so that they can also be used as secondary data by social scientists for various research aims. There are several apparent advantages when using secondary data (Dale, Arber, & Procter, 1988; Bryman, 2012; Saunders et al., 2009). For example, using such data saves resources and leaves more time for researchers to analyse data and discuss the results, and the data provided is very high quality compared to self-collected data.

Overall, secondary data analysis enables studies to be conducted which might otherwise have been impossible if primary data had to be collected. Using a positivist, objectivist, deductive approach and a quantitative method, this thesis aims to study the influence on housing market performance of foreign investment and the stock market in the UK, Canada, and China. National time-series data on housing prices, foreign investment, and stock prices, together with other macroeconomic variables such as GDP and interest rate, are necessary to investigate the relationships. These data are national in scale, with a large sample size, and these would be impossible for individuals to collect due to time and expense. Meanwhile, governmental departments or representatives such as national statistics institutions or real estate associations provide professional statistics collected by specialists through well-tested procedures. Although the time-series data were originally collected for specific research purposes, they are easily accessible and can be used to test the hypotheses in this thesis. Thus, the data collection technique used here is secondary data analysis.

1.5 Structure of Thesis

This thesis contains five chapters. First, the introduction chapter presented the background of the research and the motivation, illustrating the historical context of the housing market, the development trends of the real estate market, and the macroeconomic policies relating to the real estate market in the UK, Canada, and China. Moreover, it provided a discussion of the historical evidence of housing bubbles, the connection between housing bubbles and economic development, and the features of the housing market which cause bubbles. In addition, this chapter illustrated the link between capital inflow and the housing market, including the types of housing investment and the channels of foreign investment in the real estate sector. Furthermore, the dynamics of the stock and housing markets and the REIT sector, together with the introduction of REITs, were presented. The research objectives and aims were introduced, as were the gaps to be addressed and the contributions of this thesis. The philosophy section presented the research design, and the beliefs and assumptions regarding knowledge and reality, the approach, and the strategy were outlined, all of which were selected to best address the research questions and objectives of this thesis. Finally, the structure of the thesis was outlined.

Chapter 2 investigates the first research question, detecting housing bubbles in the UK, Canada, and China by conducting two explosive bubble models. It builds upon the background of soaring housing prices and the lack of knowledge on the presence of explosive housing bubbles in the three target countries. The co-explosive VAR model and recursive unit root tests were adapted to this chapter. The results from Chapter 2 suggest several past housing bubbles that are proved by the history, as well as ongoing housing bubbles in the UK, Canadian and Chinese real estate markets.

Chapter 3 addresses the second research objective, of discovering the relationship between foreign investment and housing prices in the UK, Canada, and China. Studies on capital inflow and real estate prices can be found in the literature, although there is limited research on the dynamic between FDI and housing prices in the three countries. Accordingly, an SVAR model is applied to Chapter 3 to discuss the short-term explanatory power of FDI on housing prices. We found a substantial impact of FDI on real estate sector movements in Canada and China, while FDI in the UK is considerably affected by changes in housing supply numbers.

Chapter 4 discusses the third research question, the link between REIT and housing prices in the UK, Canada, and China. The REIT industry has been an emerging industry in the global financial market, and previous focus has been placed on the United States, which has a more extended history of REIT development. Research on the REITs sector in the three countries is insufficient. Therefore, this chapter studies the connection between REITs and housing prices by using a SVAR model. The findings of Chapter 4 have demonstrated the vital effect of housing prices and stock prices on UK and Canadian REITs.

Finally, Chapter 5 concludes the thesis, summarising the context, arguments, and findings of each empirical chapter. This section also provides implications based on the results of the three empirical studies. Chapter 5 also presents the limitations of this thesis, together with suggestions for further research.

Chapter 2 Testing for rational bubbles in the UK, Canadian, and Chinese housing markets

2.1 Introduction

Over the past two decades, global real house prices have seen rapid growth and headed up than ever before, not only in developing economies such as China but also in developed countries, including the UK and Canada (Muellbauer, 2012). Indeed, the average housing price level in the UK has heightened over the past few years, and it continues to grow at an unprecedented rate (Rees & Isaac, 2018). In particular, the annual rate of growth in real estate prices was estimated at 10.1% in March 2016, a new peak level since July 2014 (FT, 2016). Unexceptionally, in Canada, the housing market has confronted stable rapid development, and home prices are stated to be overvalued for many years (Economist, 2011). Correspondingly, in China, especially in metropolitan cities, the property market has faced overheating. The growth rate of real estate prices has been persistently high. Major cities in the Chinese real estate market have seen a remarkable expansion rate, reaching as high as 225% (Ambrose, Deng, & Wu, 2015). The housing market is a critical sector, because it makes vital contributions to economic activity and growth (Cooper, 2004). Therefore, the expeditious development of the real estate market has raised public concerns over the possibility of housing bubbles. Soaring real estate price levels have also become subject to heated debate among academics.[1]

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[1] The most prevalent definition of a housing bubble in academic literature is based on the notion of fundamentals. When house prices cannot be justified merely by underlying fundamentals, the bubble is

Motivated by the above concerns of an overheating global real estate market (Muellbauer, 2012) – and centred on the present value model for house price determination – this chapter seeks to identify the presence of a speculative bubble in the housing markets of the UK, Canada, and China. Specifically, the presence of a housing bubble is worth investigating due to its potential dramatic negative impacts on the economy, the most notable and direct of which is banking system crisis. Historical experiences have proven that the collapse in housing prices will trigger the vulnerable banking system in one country, especially when banks play a dominant role in the housing market (Herring & Wachter, 1999). Financial market fluctuations were emerged thereafter, driving the economic crisis in the entire market. For instance, the risk of a collapse of the house price bubble was at the heart of the subprime mortgage crisis in 2007 in the United States and subsequently of the global financial crisis in 2008. Due to the subprime mortgage financial crisis, housing prices showed enormous movement, affecting the state of the global economy. However, literature has noted that the enlargement in housing prices prior to the 2007 financial crisis was considerable as well. The lesson of the global financial crisis must be used to reshape financial regulation by targeting housing price bubbles (Martin, 2011). Therefore, it is interesting to examine the behaviour of housing prices. According to Kivedal (2013), "an important reason for monitoring housing prices is, therefore, the substantial negative effects affecting households if the housing prices decrease". Iacoviello (2005) explains that a rise in housing prices will cause a positive wealth effect for the households (i.e., it may magnify aggregate demand). However, a drop in household wealth and lower

defined as the difference between the actual market price and the "fundamentals-based" prices (Dreger & Zhang, 2013; B. H. Kim & Min, 2011; Mikhed & Zemčík, 2009; Walks, 2014). The fundamentals-based price is typically characterised as the sum of expected future dividends, discounted to the present (Black et al., 2006). The existence of a bubble builds upon a rational or irrational belief that the future expected housing price will rise and profit can be earned by selling property at a higher price in the future (Dreger & Zhang, 2013; Goodman & Thibodeau, 2008; McCarthy & Peach, 2004). According to Miles (2015), a bubble, by definition, refers to when house prices may have risen to higher levels than could be justified by fundamentals. This chapter examines the problem of rational housing bubbles. Under the concept of rational bubbles, housing investors believe that their decision-making is rational, and they are willing to buy overpriced houses with a bubble component growing at an expected rate. They can ultimately receive returns from the price increase at this growth rate (Homm & Breitung, 2012).

market demand may be the result of decreased housing prices, which indicates the potential severe negative impacts of a bubble in the housing market. The presence of housing bubbles is a crucial topic for any country and even the global market to prevent possible damage on economies and the outbreak of financial crisis. Apart from the uncertainty associated with price increases, housing bubbles are also proved in history to be highly costly. In most markets, typical residential houses, as well as other property types, are financed primarily by borrowing from banks (Jurgilas & Lansing, 2013). Household leverage is thus strongly linked to the real estate boom and bust, and it tremendously magnifies the negative impacts of drops in property prices (Fisher, 1930). Notably, a recession due to the burst of a housing bubble also tends to be more prolonged than that from other types of asset bubbles.

The recent financial crisis produced significant shocks in the UK housing market, and UK house prices experienced several large swings (Miles, 2015; Tse et al., 2014). However, the dynamics of the UK housing market are complex (Antonakakis & Floros, 2016). House prices react immediately and strongly to monetary policy shock, while house price movements change for several reasons. For example, the 2007 financial crisis showed regional differences in London, as a world financial centre. The UK also saw dramatic financial innovations in the last decade (Miles, 2015). Comparable circumstances can be seen in China, with globalisation and international liquidity from foreign speculators playing a vital role in boosting the property market (Wang, Yang, & Liu, 2011). As China more tightly integrated into the worldwide market, global volatility has made a crucial contribution to the changes in the Chinese housing sector. the Canadian housing sector has also been proved to react to a combination of factors in the market. Monetary policy and inflation, for instance, are claimed to constitute vital contributions to aggregate housing price variation in Canada (Tsatsaronis & Zhu, 2004). Overall, changes in housing in the UK, Canada, and China can lead to booms, busts, and breaks. The last 20 years have seen much volatility in global housing prices. The boom and bust had consequences in the housing sector, as the drop in house prices and building was associated with an economy-wide recession which was, by some measures, the most severe since the Great Depression. Accordingly, for indispensable financial markets such as those of the UK, Canada, and China, not being aware of bubbles tends to have enormous negative consequences on not only the soundness of their economies, but on worldwide economic development. In the view of policymakers, this study could contribute to establishing practical policy approaches (Liang & Cao, 2007).

A comprehensive range of literature has examined the real estate sector around the world. Many studies have focussed on house price behaviour, the ripple effect in house prices, and the price-volume relationship (Jim Clayton, Miller, & Peng, 2010; Cook & Thomas, 2003; Tsai, 2014). According to Tsai (2014), a prominent gap usually exists between buying and selling prices in the UK. He reported that the 2000 dot com bubble and the 2008 global financial crisis caused by the bankruptcy of Lehman Brothers in the United States resulted in house price convergence correction or adjustment behaviour. Other studies have aimed to determine whether bubbles exist in the housing market. For instance, Dreger and Zhang (2013); Hou (2010); Hui and Yue (2006); Ren, Xiong, and Yuan (2012); and Shih, Li, and Qin (2014) have found insight into the real estate market in China, while Goodman and Thibodeau (2008), Mikhed and Zemčík (2009), and McCarthy and Peach (2004) have examined the house price bubble in the United States. Previous literature such as Bone and O'Reilly (2010); Clark, Duran-Fernandez, and Strauss (2010); Garino and Sarno (2004); and Zhou and Sornette (2003) has also focussed on the UK. Some studies report a bubble in the UK housing market (Barrell, Kirby, & Riley, 2004; Zhou & Sornette, 2003), while others report no evidence (Cameron, Muellbauer, & Murphy, 2006; Nickell, 2006). It is generally accepted that the UK housing industry has become a faster-growing sector around the world, and this context of worldwide real estate reinforces the importance of identifying potential housing bubbles (Muellbauer, 2012). However, there is a debate in existing literature on whether there is a bubble in the real estate market. Moreover, in the literature review, the housing bubble problem has gradually become a momentous issue for global researchers to prevent economic crisis. To test the existence of real estate bubbles, diverse methods and models have been proposed in previous literature. For example, unit root and cointegration methodology using panel data was applied by Mikhed and Zemčík (2009); Chan, Lee, and Woo (2001); and Dreger and Zhang (2013). In the meantime, Roche (2001) and Kim and Min (2011) proposed a regime-switching regression model. However, little discussion has centred on the co-explosive behaviour of housing prices, considering them to be a powerful instrument in detecting explosive asset bubbles despite the lack of a common trend between asset price and its fundamentals, though in this regard, Kivedal (2013) is an exception.[2] Against this background, the aim of this study is to investigate the existence of real estate bubbles in the UK, Canada, and China by means of a co-explosive VAR model and recursive unit root tests. To this end, we use data from the UK, Canada, and China data over the period from 1955Q1 to 2018Q3, 1970Q1 to 2018Q3, and 1980Q1 to 2019Q1 on, respectively, real estate price, actual rental price, and price-to-rent ratio. These three countries have encountered episodes of strong escalation in real house prices, as well as in price-income and price-to-rent ratios (Giglio, Maggiori, & Stroebel, 2016; Reuters, 2007; Sizemore, 2015). Accordingly, between 1995 and 2005, the price-to-rent ratio in the UK more than doubled; this ratio in China has been soaring for decades and is well above the international warning line indicating a property bubble; Canadian housing prices have also climbed faster than the pace of rental price growth, making the price-to-rent ratio reach 1 to 200. Our research findings shed light on the presence of explosive bubbles in the UK, Canada and China from recursive unit root tests.

The rest of this chapter presents the methodology, the research findings, as well as summarising the main finding of other studies and providing relevant implications.

[2] Kivedal (2013) uses a co-explosive VAR model to study the presence of speculative bubbles in the US housing market.

2.2 Literature Review

2.2.1 Background

Recent years have seen much debate regarding housing bubbles (Giglio et al., 2016). In the past decade, the remarkable upward trend in housing prices and the concern over the presence of bubbles has been subject to considerable critical attention on the part of the public and scholars. The total value of residential property in developed economies has expanded by nearly $40 trillion between 2000 and 2005, reached the level of the combined GDP of these countries (The Economist, 2005). After the 2007 US financial crisis and the successive global financial crisis, this controversy has led to great academic interest. It is noteworthy that the UK, Canada, and China have experienced analogous cases of housing price levels heating up. In particular, in the UK, the real estate sector confronted an unprecedented appreciation, with prices tripling during the decade from 1997 to 2007, over and above the long-term trend (Bone & O'Reilly, 2010). The upward trend was then reversed in 2007, following the outbreak of the US subprime mortgage crisis and the global financial crisis (Clark et al., 2010). However, in 2014, housing prices 7.8% higher than in the preceding year in the UK, the highest annual rate of growth since 2007 (News, 2014). Moreover, this price level was just below the peak of the last burst and showed no signs of slowing (Blackmore, 2014). Similar to the growth pattern in the United States, Canada has faced a continuous increase in house price level from 1994 onward (Courchane & Holmes, 2014). Data on the house price index showing that the average price level has doubled dates from the year 2000 (Walks, 2014). House prices in the period from 1980 to 2000 in Canada remain stead, whereas just after 2001, the level of prices in the leading real estate markets soared, shooting to $100,000 and doubling the historical price level (Macdonald, 2010). This growth is much faster in particular compared to the rise in rents for many years, which have gradually driven the price-to-rent ratio to 175.9, one of the largest in the world (Sizemore, 2015). Under the measurement of this indicator, house prices in Canada are proposed to be overvalued by around 25%, more than they were in the US before the burst of the bubble (Economist, 2011). Furthermore, in China, real estate prices soared, with a rising rate that has continuously risen in the past 20 years and reached 25% in major cities by 2001 (Dreger & Zhang, 2013). In particular from 2003 to 2007, the national growth rate was as high as 14% per year on average (Ren et al., 2012). A dramatic increase in housing sector prices was faced especially by metropolitan areas between 2005 and 2007 (Hou, 2010).

The issue of the housing bubble has become a prevalent topic because there is, in theory, a precise mechanism according to which a house price bubble would cause disadvantageous influences. Primarily, the gross value of real estate in most economies is much greater than the value of financial assets invested by households, and the share occupied by the house in the whole of household wealth is crucial (Černy, Miles, & Schmidt, 2010). Indeed, a collapse in the house price bubble can have adverse effects on the economy (Dreger & Zhang, 2013; Kim & Min, 2011; McCarthy & Peach, 2004; Mikhed & Zemčík, 2009). For instance, the housing bubble is generally viewed as a critical element of the recent global financial crisis (Galí, 2014). When a bubble exists, economic growth is retarded even in the long term (Grossman & Yanagawa, 1993), because the bubble is equivalent to an unproductive asset, and the trading of real estate generally absorbs capital away from productive area. Housing bubbles can also affect the economy through inefficient wealth allocation and by influencing the stability of the financial sector (Kim & Min, 2011). If the bubble is neglected, national or even global crisis can be the ultimate consequence (Hou, 2010; Kim & Min, 2011; Zhou & Sornette, 2003).

2.2.2 Conceptual framework

Given this background, the housing industry is generally accepted to have become a faster-growing sector around the world, and these global serious real estate conditions have further emphasised the significance of solving the problem of potential housing bubbles (Muellbauer, 2012). However, there is a debate in existing literature on whether a bubble does in fact exist in the real estate market.

Many studies in this regard have been published to analyse the controversy over the existence of housing bubbles in the UK, Canada, and China. For example, Bone and O'Reilly (2010), Clark et al. (2010), Garino and Sarno (2004), and Zhou and Sornette (2003) conducted their research in the UK market concerning housing bubbles. Bone and O'Reilly (2010) focussed mainly on the principal causes and social effects of the housing bubble in the UK, aiming to provide key findings on this hot issue to promote the moderating of some social ills. By analysing different sources such as interviews, emails, and weblogs, their study suggested that affordable housing is the foundation of a stable society. The analysis of Clark et al. (2010) is based on the backdrop of the latest burst of house price bubbles in 2007, and they demonstrate a bubble in the difference between the paths of house price and the pattern of real income and stock market movement. By proposing the idea of tacit knowledge, their hypothesis is that those who are experienced in the financial market are the most capable of a making reasonable judgement to identify a bubble and boom using tacit knowledge (Clark et al., 2010). Contrary to Bone and O'Reilly (2010) and Clark et al. (2010), Zhou and Sornette (2003) focussed primarily on the existence of real estate bubbles in both the US and the UK. In the context of loose monetary policy in the market as part of an attempt to stimulate the economy after the bursting of the 2000 stock market bubble, they examined the possibility of a new bubble being generated in the real estate industry in the US and the UK (Zhou & Sornette, 2003). Similar to the research direction of Zhou and Sornette (2003), Garino and Sarno (2004) and Black, Fraser, and Hoesli (2006) also explore the claim that a bubble has been present in the UK real estate sector. However, since the housing industry seems to be experiencing a boom again, there is a lack of up-to-date studies on this topic.

Meanwhile, Gabrieli et al. (2018), Dreger and Zhang (2013), Hou (2010), Hui and Yue (2006), Ren et al. (2012), and Shih et al. (2014) have provided insight into the real estate market in China. It is worth noting that most of these papers have been conducted in selected provinces in China. Among these, Hou (2010) and Hui and Yue (2006) focussed on the cities with the largest economies, namely, Beijing and Shanghai, as their objects to test whether there are housing price bubbles. By contrast, Dreger and Zhang (2013) and Ren et al. (2012) both focus on 35 major provinces in China and analyse the same topic using panel techniques; Shih et al. (2014) does the same but with only 28 provinces. Dreger and Zhang (2013) also investigated the impact of house prices on the inflation of CPI and the growth of GDP. Among these studies, Gabrieli et al. (2018) have exceptionally discussed the presence of real estate bubble in China at a national scale.

Limited literature has drawn attention to the Canadian real estate industry, except Macdonald (2010), Courchane and Holmes (2014), and Clark et al. (2010). Since the Canadian housing market follows a similar growth pattern to the US, Macdonald (2010) aimed to estimate the problem of a housing bubble and risk in the housing market in Canada by comparing essential scores in Canada and the US. The study also examines the size of the bubble and the cities in which it is apparent under three historical scenarios. Similarly, Courchane and Holmes (2014) built two panel data sets for Canada and the US, aiming to search for links between house prices and fundamentals and exploring whether fundamentals direct the index of price level. Furthermore, Clark et al. (2010) indicate that Canadian house prices have better reflected fundamentals such as income and population than those in the US prices. They then built a house price model for both countries to determine which is linked more closely to fundamental-based prices.

2.2.3 Theoretical framework

In theory, the fundamental factors link to house prices through specific mechanisms. Interest rate, for example, is closely connected to the changes in house price level through two channels. A lower interest rate can primarily be seen in a lower mortgage rate, which raises the public demand for houses and therefore house prices because of the lower cost of purchasing houses (Basco, 2014; Courchane & Holmes, 2014). It is easier to get access to credit based on low mortgage rate, which drives purchasers into some markets such as the real estate industry, in which they are not able to compete

(Macdonald, 2010). Once there is a lagged decrease in mortgage rate, borrowers can enlarge their repayment transactions in the short term to finish the house purchase process earlier, before the cost increases. This also motivates the upward trend in real estate prices (Courchane & Holmes, 2014). Conversely, if the cost of a mortgage becomes a heavy burden as a result of higher rates, buyers may be pushed away from the market (Macdonald, 2010). Second, in conditions of lower interest rates, the return of other assets with fixed incomes, such as bonds, is decreased compared to the return of houses. This circumstance can amplify the need for real estate and thus raise real estate prices (Courchane & Holmes, 2014). Moreover, when interest rates are low, creditors explore substitute investment tools rather than lending. Speculative housing investment, which is not ideal at higher interest rates, could then be an optimal choice (Arce & López-Salido, 2011). In addition, excess liquidity in the market resulting from the low interest rates is an essential channel through which house prices increase (Kim & Min, 2011).

Rent, regarded as the future dividend or return of investment in houses, is also closely linked to house price (Courchane & Holmes, 2014); in fact, the theory regards it as the main component of formulating the fundamental housing price. Fundamentals-based property prices should reflect the present value of future dividend flows, that is, rental income (Black et al., 2006). However, since the housing stock cannot react to changes directly, heightened rent leads more people to purchase houses rather than renting, which would cause higher real estate price (Gholipour, 2013). A lower user cost of housing than of market renting implies that it is cheaper to buy than to rent. Growth in the demand to buy a house can thus be witnessed, leading to an increase in housing prices (Dreger & Zhang, 2013). Moreover, real estate prices can in return have an impact on rent price. Higher house prices indicate a higher return of constructing houses, generating a more extensive house stock and lower rents in the future. Thus, the result of lower discounted present value implies that fundamentals-based prices are lower compared to the market price, thereby resulting in a bubble (Blanchard & Watson, 1982).

Finally, some economic factors are expected to contribute to changes in house prices. For instance, economic activities such as employment affect household income, and GDP is used as an indication of economic activities. These are all key elements related to the demand for real estate and thus to real estate price levels (Gholipour, 2013). When the unemployment rate in one city is lower, it brings a rapid population inflow and leads to people searching for jobs in the city (Macdonald, 2010). Since this inflow of people increases the demand for houses, real estate prices increase.

2.2.4 Methodological framework

Diverse methods and models have been proposed to test for the existence of real estate bubbles. Unit root and cointegration methodology using panel data applied by Mikhed and Zemčík (2009), Chan et al. (2001), and Dreger and Zhang (2013) has been a popular approach to test for real estate bubbles in many countries and cities. For instance, regarding the house as an investment instrument, Mikhed and Zemčík (2009) construct a present-value model to illustrate the relationship between house price and cash flows in the United States. The notion that changes in rents should predict changes in house prices motivated the cointegration and Granger causality tests between house price and rent. Adopting a similar viewpoint, the study of Chan et al. (2001) in Hong Kong used rental income as the independent variable. In particular, it constructed a fundamentals-based model with misspecification errors and rational bubbles, and it analysed this topic using the flow and stock approaches. Black et al. (2006) also conducted a comparable study in the UK, incorporating quarterly data on real disposable income, discount rates, and the retail price index from 1973 to 2004. However, one disadvantage of the present-value approach is that it may return an unreliable estimate of the fundamentals-based price due to (i) model-dependent expectations of future cash flows and (ii) model-dependent discount (Ren et al., 2012). Dreger and Zhang (2013) is one example of research which employs cointegration analysis in China's real estate market. It establishes a set of fundamental factors, rather than a single arbitrary factor, that can be used to identify the fundamentals-based price within the panel cointegration test. Most convincing subsets of variables are incorporated into the model, which consist of real land prices, real per capita income, population, real interest rates, construction costs, and stock market wealth. The dataset of Dreger and Zhang (2013) is comparatively small, with annual data from 35 Chinese cities observed throughout the period 1998–2010. Likewise, Shih et al. (2014) collected the quarterly data from 28 central provinces in China between 2000 and 2012 in the cointegration model. The fundamental factors in the model consist of average disposable income, total new commercial housing, and total new commercial housing sales. It is noteworthy that Hui and Yue (2006) combine a cointegration test and a generalised impulse response analysis in exploring housing price bubbles in Hong Kong, Beijing, and Shanghai from 1997 to 2003. The economic fundamentals in this study are reflected by the disposable income of urban households, GDP, and Shanghai stock price index. Meanwhile, studies have also concentrated on the Canadian case using the cointegration methodology. Clark et al. (2010) adopted this method for both Canada and the United States and generate two cases for analysis. Case 1 uses quarterly data on population, personal income, rents, consumer prices, stock market index, and mortgage interest rate during the period 1980–1990, while case 2 includes additional variables such as wages, steel prices, and construction material prices, which are argued to be linked to house prices from 1984 to 2009. Courchane and Holmes (2014) also assembled two analogous datasets with quarterly data for Canada and the United States for the vector error correction model to better compare the dynamics in both countries. They proposed the fundamentals inflation, mortgage rates, personal income, population, rental index, and stock market index.

A model based on regime-switching is also prevalent in previous research on the house price bubble problem in various economies. By using a regime-switching regression model, Roche (2001) examined the dynamics of house prices in Dublin, whereas Kim and Min (2011) estimated the housing bubbles in Korea from a national scale. The model builds upon the observation of two states of nature, identified as low-variance and high-variance states. Both studies assumed the existence of fads and stochastic bubbles as non-fundamental components of house price. Thus, researchers can both measure the nonlinearity of the asset prices and compare the performance of both fads and stochastic bubble components (Kim & Min, 2011). A regime-switching model is also said to have better finite sample properties than the cointegration method (Roche, 2001). Roche (2001) and Kim and Min (2011) both used interest rate as one of their variables, though the studies had different objectives, and the other variables are different. Roche (2001) chose real disposable income and the percentage of the population between 25 and 44 years old as a demographic variable to be the dependent variables using quarterly data over the period 1976 to 1999 in Dublin, whereas Kim and Min (2011) use production index, price level, and bank loans as the fundamentals with monthly data for Korea covering the period from 1987 to 2003.

Unlike the two approaches mentioned above, Zhou and Sornette (2003) applied a log-periodic power-law model throughout 1992–2003 in the UK to identify the presence of a housing bubble. He described the symptom of the housing bubble as a faster-than-exponential growth rate. His research findings suggest that "the log-periodic oscillations have been found to be reliable indicators of endogenous bubbles signalling a coming instability or change of regime" (Zhou & Sornette, 2003, p251). Six different UK house price indices from 1992 to 2003 were taken into account to detect the symbolic growth. By contrast, Hou (2010) concentrated on a composite of indicators encompassing (i) a comparison between market house prices and the market's rational expectation price, presented using a present value model; (ii) a comparison of the market price with mortgage loans; (iii) the price-to-income ratio; (iv) the price-to-rent ratio; and (vi) a control chart. Hou (2010) collected the five datasets in Beijing and Shanghai for the period beginning between 1992 and 2001 and ending in 2007. Furthermore, the research of Ren et al. (2012) in China adopts the theory suggested by Blanchard and Watson (1982) about rational expectation bubbles. This method was initially applied in the stock market, whereas Ren et al. (2012) applied it to the analysis of house-price bubbles in China. The condition for a speculative bubble is characterised as a decline in the possibility of negative abnormal return rates of assets in the period during which there are positive rates of abnormal returns and, thus, house return is chosen as the dependent variable (Ren et al., 2012). The independent variables in this study are the price-to-rent ratio, growth rate of GDP, real deposit rate, real stock return, population growth rate, and unemployment rate, and the data is yearly data from the 35 leading cities during the period 1999–2009. Another study in China at state level by Gabrieli et al. (2018) applies a state-space model to obtain the calculated fundamentals through demand and supply in housing market. Additionally, in the study of Lai and van Order (2017), the dividend discount model is adopted in the housing markets of the United States to test for the long-term and short-term relationships between house prices and price-to-rent ratios. Unlike other studies, the investigation of the Canadian house bubble in the study of Macdonald (2010) compares several key scores in Canada and the United States based on the accessible experience of the US financial crisis. In the first part, the Case-Shiller home price index between 1997 and 2007 is adopted to compare the average changing paces of house prices in both countries (Macdonald, 2010). Other relative factors such as mortgage rates, access to easy credit, the number of new houses, populations, and incomes are also taken into account for the analysis. Meanwhile, three historical scenarios are generated to measure the size of the bubble and where it might occur.

More recently, previous studies such as Homm and Breitung (2012) and Phillips, Shi, and Yu (2015) have investigated the explosive feature in a bubble model. A recursive right-tailed unit root test, the supremum augmented Dickey-Fuller (SADF) test, was introduced by Phillips, Wu, and Yu (2011) and by Phillips and Yu (2011) as a new strategy to detect and date multiple explosive asset bubbles. By distinguishing the explosive character of the housing bubble from a random walk, this recursive methodology has been proposed to capture an explosive unit root as an indication of bubbles. The null hypothesis of this rolling right-sided ADF test is of a unit root against a mildly explosive root. This methodology can contain both bubble and non-bubble sub-periods in a sample period. Moreover, the SADF test is more powerful than the traditional unit root and cointegration tests and can date the origination and termination of a bubble episode. Furthermore, this method was generalised by Phillips, Shi, and Yu

(2015) as the generalised SADF (GSADF) test to solve the problem of reducing power and inconsistency in the SADF test. Several recent studies have applied the recursive unit root in detecting housing bubbles, such as de Oliveira and Almeida (2014) and Engsted, Hviid, and Pedersen (2016). De Oliveira and Almeida (2014) adopted this approach to test for speculative bubbles in the residential real estate market in the main cities of Brazil, and the result confirmed the existence of bubbles. Similarly, Engsted et al. (2016) conducted this analysis in the OECD housing market and provided evidence of explosiveness in many housing markets. Homm and Breitung (2012) proposed a comparison among several tests, such as the Chow-type DF, the Busetti–Taylor, and the SADF tests to examine explosive rational bubbles.

2.2.5 Analytical framework

More recently, housing bubbles were identified at national level in China by Gabrieli et al. (2018) and in major cities by Dreger and Zhang (2013) and Hou (2010). The study of Dreger and Zhang (2013) found substantial evidence of huge bubbles in the south-east coastal areas and economic zones. However, it stated that even if real estate bubbles burst, the impact on key economic elements such as GDP and inflation would not be severe. The results from Hou (2010), who concentrated only on Beijing and Shanghai, indicated that there appear to have been three bubbles in Beijing, in 1993, 1997, and 2007, and a real estate bubble appear to have developed in Shanghai between 2003 and 2004. Hou (2010) stated that many important indicators emerged to support this result along with the formation of the bubbles. These factors comprise the unusual divergence of market prices from rational expectation price levels, the loan boom, and a high price-to-rent ratio. Another updated study in China, from Shih et al. (2014), examined the period 2000–2012 and also stated that most of the provinces in the research sample displayed bubble and affordability problems. Moreover, the house prices of many provinces are cointegrated, and a spillover effect can be seen among different provinces (Shih et al., 2014). For instance, the house prices in Beijing and Shanghai can become exogenous variables to show their impact on the long-term equilibrium price level of the neighbour provinces. The most recent research by Gabrieli et al. (2018) discovered strong evidence of a housing bubble in China, especially after 2010. However, the above evidence disagrees with Ren et al. (2012), who found no sign of a housing bubble in China between 1999 and 2009, though they did acknowledge the interaction of house prices among different regions. They proposed that the failure rate of positive returns was found not to be a decreasing function of duration, which indicates no growing bubbles during this period. One interesting result is that the local economy, represented by GDP, unemployment, and population, did not have a vital influence on house prices (Ren et al., 2012). This finding is because capital flows freely across regions, especially from rich to poor regions, to boost house prices regardless of any economic changes. Hui and Yue (2006) also support this view, asserting that, despite some evidence of housing bubbles in Shanghai, Beijing did not demonstrate a bubble during that time.

As for the UK, Zhou and Sornette (2003), Black et al. (2006), and Garino and Sarno (2004) found unambiguous evidence of bubble-type behaviour in the real estate market. From a comparison of the US and the UK during the same period, Zhou and Sornette (2003) stated that the seeming boom in the United States is due to economic growth. By contrast, they asserted that the real estate bubble in the UK was gradually created from 2000 to 2003 and would cause a negative influence on the recovery of the economy. In addition, Garino and Sarno (2004) stated that two bubbles are present in the UK real estate market that cannot be justified by fundamentals during the sample period. One bubble was found at the end of the 1980s, according with the historical record. The other continued from the late 1990s to the end of the period, in 2002. McMillan and Speight (2010) also suggest clear and considerable evidence supporting a non-fundamental part with explosive features in UK real estate prices. The fact of nonlinear non-stationarity among the discussed series further sustained the existence of a bubble generated by non-fundamental behaviours from housing sector participants. Moreover, changes in house prices appears to display downward stickiness (McMillan & Speight, 2010). Since the traders face many transaction fees and high information asymmetry, it shows that prices will change more slowly when they are higher than the fundamental-based prices and adjust more quickly when lower. These findings contrast with the conclusion proposed by Black et al. (2006), who exclude the possibility of an explosive rational housing bubble created by non-fundamental factors from 1973 to 2004. Instead, they propose a non-negligible role played by an intrinsic bubble in generating market house prices (Black et al., 2006). The overvalued portion in real estate prices can be explained evenly by the intrinsic part and price dynamics. Bone and O'Reilly (2010) claim that the straightforward explanation of rising demand outstripping supply is no longer satisfactory in analysing the house bubble issue, and the driving factor of house prices must be something else. Several of the core elements they mentioned are factors controlled by the financial and banking sectors, such as interest rates and the availability of credit; the inadequate response of housebuilders to increasing demand; and the government housing policy and tax concession which generates property speculation (Bone & O'Reilly, 2010). Clark et al. (2010) not only stated that there are signs of bubbles in the path of real estate prices from 2000 to 2007, but also raised the view that people who are in the market obtain tacit knowledge about whether to invest in properties. Bubbles would then not be generated by these savvy investors who do not allocate property as a critical component in their retirement investment plan and do not make decisions based on any irrational boom (Clark et al., 2010).

Some empirical evidence also supports the presence of house price bubbles in Canada. Comparing the growth paths of the average percentage change in house price levels in some of the main cities in the United States and Canada, Macdonald (2010) proposed that Canada is experiencing a housing bubble in six major real estate markets for the first time during the last thirty years. Furthermore, the study simulated three historical scenarios to analyse the possibility of a bubble burst. In different cases, the bubble was corrected by the market, burst with a steep decline, or crashed intensely for an extended period (Macdonald, 2010). The study also asserted that rather than real GDP, mortgage rates and unemployment play prominent roles in deciding housing bubbles. On the supply side, the historical experiences of excess housing stocks due to the difficulty of unloading existing homes when prices collapse make builders unwilling to build too many houses anymore. This fact leads to the decline in new house completion even when house prices soar (Macdonald, 2010). Finding a similar outcome, Clark et al. (2010) and Courchane and Holmes (2014) indicated that Canadian house prices are more weakly linked to the fundamentals than US house prices and that Canadian prices have deviated even more from the fundamentals than US prices. Because the United States encountered a severe housing bubble in 2007 even though its price level adhered to the fundamentals, and Courchane and Holmes (2014) stated that price crashes are due to a shock in the market structure such as the subprime rise or capital investment flow looking for higher returns. However, they stated that their study detected no signs of these structural shocks in the Canadian real estate sector to the extent that they affect US house prices.

Arce and López-Salido (2011) suggested a positive relationship between the provided funding in the market and house bubbles. They argued that a shock of increasing funding, which affects the available credit that can flow into the market, would have a positive effect on the demand for assets due to the mechanism of a low interest rate. In particular, they found that more financially advanced economies with easy collateral policies seem to be less likely to generate house bubbles, though their bubbles are more vulnerable to any credit shocks (Arce & López-Salido, 2011). Basco (2014) further proves the argument that only financially undeveloped economies can generate rational housing bubbles under an overlapping generation model. The mechanism under this is that middle-age individuals intend to save more so that their consumption is guaranteed when they are old, whereas there are not enough assets available in the economy since the younger generation is financially restrained (Basco, 2014). Thus, the result of the asset shortage is the gradual production of bubbles. The study of Kim and Min (2011) suggested the existence of dominant links between house bubbles and bank lending, market production, and interest rates. When household lending used to purchase houses grows, the price level increases, and an enlargement in industrial production, which drives up the economy and living standard, also raises the demand for houses. However, house prices decline when the interest rate grows, because the costs of buying a house are increased (Kim & Min, 2011). However, among these influencing factors, the effect of the interest rate is comparatively weak, suggesting that interest-rate policy is less effective at managing house bubble problems. The study of Ren et al. (2012) found that the deposit rate can cause an influential negative impact on the expected real estate returns and, thus, on house prices. Since this acts as the opportunity cost, the underlying mechanism affects the expectation of the future price level.

Grossman and Yanagawa (1993) pointed out that if the growth rate of rent equals the economic growth rate and the price of rent-based assets ultimately reflects all the consequent dividends, then the possibility of bubbles is ruled out, because a bubble would affect the economy negatively towards its steady state. Moreover, bubbles cannot exist in cumulable assets, because new assets can quickly be produced at a fixed cost to fulfil demand expansion and prevent any growth in the prices (Grossman & Yanagawa, 1993). Roche (2001) also suggests that if the supply of houses remains at a lower level than the demand, house prices rise further. A bubble would exacerbate conditions, leading to a higher possibility of crash. By contrast, McCarthy and Peach (2004) insisted that even if in a market in which the supply of houses appears to be sticky and inelastic, which leads to the instability of the price level, the market can only consider it to be an adjustment in fundamentals rather than in bubble components.

2.2.6 Gaps in the literature

In the literature review, the housing bubble problem has gradually become a dominant issue for global researchers, with the aim of preventing economic crisis. However, studies presented here have focussed little on the housing bubble problem in Canada, because its house price level is believed to grow steadily. Furthermore, literature seldom concentrates on the circumstances in China at a national scale. While a few provinces have seen the most discussion, the majority of other areas in China have encountered the same house price issue, and this has not yet been explored. To test the existence of real estate bubbles, diverse methods and models have been proposed in previous literature. Unit root and cointegration methodology using panel data has been a popular way of testing for real estate bubbles (Chan et al., 2001; Dreger & Zhang, 2013; Mikhed & Zemčík, 2009). Roche (2001) and Kim and Min (2011) conducted their research to examine the dynamics of house prices using a regime-switching regression model. However, none of the previous models are capable of analysing both cointegration and explosiveness concurrently (Engsted, Hviid & Pedersen, 2016). To this end, the co-explosive VAR model, an approach that was originally intended to be used to test bubbles in the stock market, has been introduced; one example of its use is by Engsted and Nielsen (2012). It is rarely applied to the real estate sector, although the rental income for housing is similar to the dividends for stock. One exception is Kivedal (2013), who adopted this method in the housing market in the United States. The advantage of this co-explosive approach is to allow for both a unit root and explosive root in the time series, as the housing price and rental price do not necessarily have a common trend (Engsted et al., 2016). Apart from the non-stationary cointegration between housing price and fundamentals, this model also allows for an explosive component representing the bubble part. This is a vital character for bubble detection that has not been addressed in previous research (Engsted et al., 2016). In addition, the methodology in this chapter is enhanced by combining the co-explosive VAR with the recursive unit root tests, which have also concentrated on the explosive roots in asset prices. As a result, the primary aim of this research is to conduct an empirical test for house price bubbles in the UK, Canada, and China by combining the co-explosive VAR and recursive unit root approaches.

2.2.7 Contributions

The study of the housing bubbles is of tremendous importance, as excessive growth in real estate prices may cause considerable consequences for the whole economy (Jurgilas & Lansing, 2013). The dramatic uptrend in the housing sector not only causes investors to respond to the signals of price increase, resulting in a misallocation of resources, but can also lead to a major crisis. In general, this study can provide new knowledge and perspectives on the existence of real estate bubbles in the UK, Canada, and China. In addition to the statements that indicate the presence of housing bubbles in the UK and China from many past studies, such as McMillan and Speight (2010), Clark et al. (2010), and Dreger and Zhang (2013), this study raises the new consideration of explosiveness in both real estate and rental prices. By applying the co-explosive VAR model and recursive unit root tests, this study proposes the possibility of bubble behaviour in explosive housing prices when an explosive pattern is apparent in rental prices as well. A comparatively new focus is used to test for housing bubbles to provide new concepts for regulators when monitoring and regulating the development of the real estate sector. It is especially important to construct a well-considered and well-suited analysis to test the housing bubble for the UK, Canada, and China, as these are vital financial markets around the world, to support effective policy approaches. These findings might also be a useful reference for profit-seeking investors in these three countries to reshape their knowledge in setting up their investment portfolios to avoid the risk of bubble burst.

2.3 Methodology

2.3.1 Data

2.3.1.1 Data description

I. Co-explosive VAR

This method examines the house price bubble, assuming that the rental price represents the fundamentals-based price based on a present value model. Therefore, the real house prices index and the actual rental prices for housing in each country are the time-series data included in this test. Both of the two data series are seasonally adjusted quarterly data from 1968Q2 to 2018Q2 for the UK and 1970Q1 to 2018Q3 for Canada. These two time series data for the two countries are taken from the *Organisation for Economic Co-operation and Development (OECD) website*. The sub-sample for the UK chosen in this test is from 1968Q2 to 2005Q1 since the house price experienced a structural break after 2005Q1 contributed by the happening of the global crisis. Since this method applies the idea of an explosive component in the house price, it is a practical way to diagnose bubbles before they burst (Kivedal, 2013). It shows that both of these two variables have a considerable escalation path over the period. Similarly, in China case, the time series of the house price index is collected from *Oxford Economics* website, and the rental price index is from the *National Bureau of Statistics of China* website. According to data availability, the sample period for China is 1998 Q1 to 2010 Q4. Both price levels have been seasonally adjusted and adjusted by the Consumer Price Index (CPI) to remove inflation and transform into the real price levels.

II. Recursive unit root test

In contrast to the study of Phillips et al. (2015), quarterly housing price, rental price, and the price-to-rent ratio are included in the analysis. Due to data availability, the models obtain different sample sizes. For housing price, it is 1955Q1-2018Q3 for the UK, 1970Q1-2018Q3 for Canada, and 1980Q1-2019Q1 for China. The rental price sample size is 1962Q1-2018Q3 for the UK, 1959Q1-2018Q3 for Canada and 1998Q1-2010Q4 for China due to data availability. Meanwhile, there is a smaller data sample size for the price-to-rent ratio, and therefore this is 1968Q2-2018Q3 for the UK, 1970Q1-2018Q3 for Canada, and 1998Q1-2010Q4 for China. Prior to implementing the recursive SADF and GSADF tests, a minimum window size r_0 is selected following the rule of deciding optimal window size from Phillips, $r_0 = 0.01 + 1.8/\sqrt{T}$. Initial window sizes of 31, 29 and 28 for the UK, 27, 30 and 27 for Canada are chosen for the housing price, rental price and price-to-rent ratio time series respectively. The initial window size in China is chosen as 24, 13 and 13 for housing price, rental price and price-to-rent ratio data based on the above principle.

2.3.1.2 Time-series performance

To deal with the relationship among variables, the dominating software being utilised in this chapter is OxMetrix and EViews. Quantitative statistics are inputted into these software to build economic models and conduct analysis of the data set. **Table 2-1** demonstrates the performance of the housing price index and rental price index for the co-explosive VAR model and the statistical specifications for the housing price and price-to-rent ratio time-series data for recursive unit root test. Despite the positive movements from positive skewness figures in housing prices, the rental prices in the UK and China have presented more negative fluctuations. In the meantime, sharp upward fluctuations in the price-to-rent ratio data can be seen from the positive Skewness levels. Meanwhile, large Jarque-Bera (JB) statistics suggest that the time series is substantially different from normal distribution. **Figure 2-1**, **Figure 2-2**, and **Figure 2-3** show the line chats for the house prices, rental prices, and price-to-rent ratios in each country, presenting the movement trends. For the UK and Canada, the trend of the house price level appears to include explosiveness on the surface, except for the break in 2007 due to the global financial crisis, whereas that of rental prices appears smooth. In the meantime, both of the variables have shown a smooth upward trend in China. The price-to-rent ratio has also demonstrated dramatic growth over the period, apart from the price-to-rent ratio in the UK, which encountered several noticeable fluctuations. The large surging and declining historical movements in the period potentially indicate the presence of bubbles. To be noted that the housing price in China before 1987 has presented an unusual degree of regularity. This may result from the fact that the Chinese properties were seldom traded before 1987 due to their publically owned nature. With a lack of available trading records, the question of how reliable the data is and whether it should be included in the analysis requires a discussion by further research.

Table 2-1 *Descriptive Statistics*

		Average	Maximum	Minimum	Std.Dev.	Skewness	Kurtosis	Jarque-Bera
		Coexplosive VAR model variables						
		Average	**Maximum**	**Minimum**	**Std.Dev.**	**Skewness**	**Kurtosis**	**Jarque-Bera**
UK	**HI**	56.44	112.39	22.72	29.77	0.57	1.72	24.53
	RP	73.17	100.76	41.53	20.99	-0.11	1.38	22.50
Canada	**HI**	58.41	123.50	31.10	22.74	1.16	3.40	44.47
	RP	100.81	146.93	91.18	14.06	2.16	6.56	253.3
China	**HI**	106.69	131.46	88.55	13.84	0.21	1.66	4.26
	RP	104.06	109.24	98.70	3.06	-0.25	1.93	3.05
		Recursive unit root test variables						
		Average	**Maximum**	**Minimum**	**Std.Dev.**	**Skewness**	**Kurtosis**	**Jarque-Bera**
UK	**HP**	102435	213882	41010.1	54051.1	0.84	2.20	36.38
	PRR	94.76	149.42	62.67	26.65	0.55	1.86	21.01
Canada	**HI**	58.76	123.59	31.1666	23.14	1.16	3.40	45.12
	PRR	89.24	199.48	31.36	40.56	0.96	3.16	30.31
China	**HI**	111.09	152.72	87.31	17.29	0.61	2.24	13.45
	PRR	0.95	1.29	0.72	0.19	0.42	1.68	5.31

Notes:

- The top of the table presents the descriptive statistics for the housing price index (HI) and rental price (RP) time series in Cexplosive VAR model. The bottom of the table summarised the descriptive statistics for housing price (HP/HI) and price-to-rent ratio (PRR) in the recursive unit root test.
- The skewness figures show upward fluctuations in most of the time series except for rental prices in the UK and China.
- Large Jarque-Bera figures indicate distributions significantly differ from normal distribution.

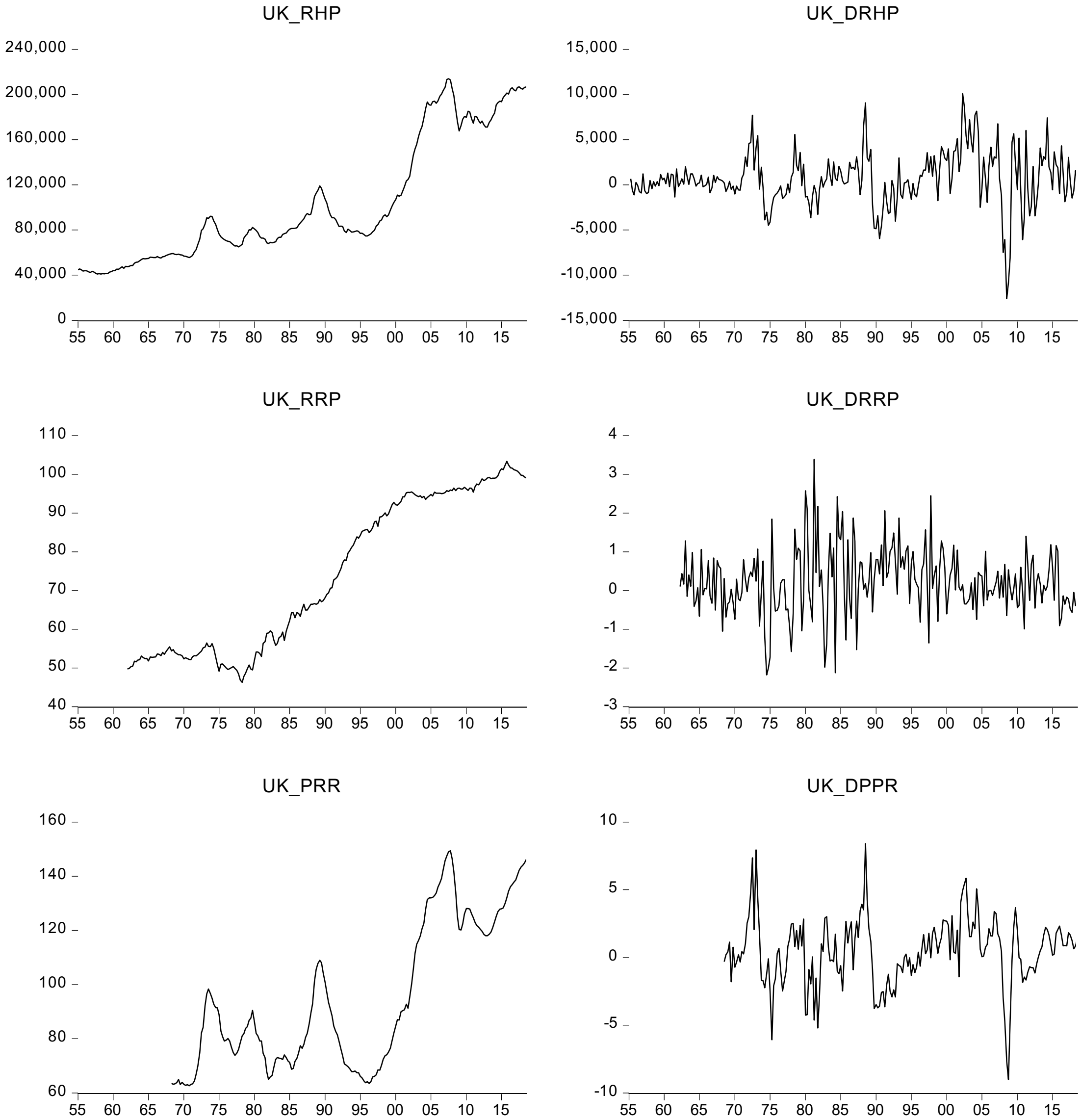


Figure 2-1 *The UK time series*

Note:

- The UK quarterly real house price in level, log and differenced (RHI, LRHI, DLRHI). The UK quarterly real rental price index in level, log and differenced (RRP, LRRP, DLRRP). The UK actual price-to-rent ratio in level and differenced (PRR, DPRR).
- Data source: *OECD* website.

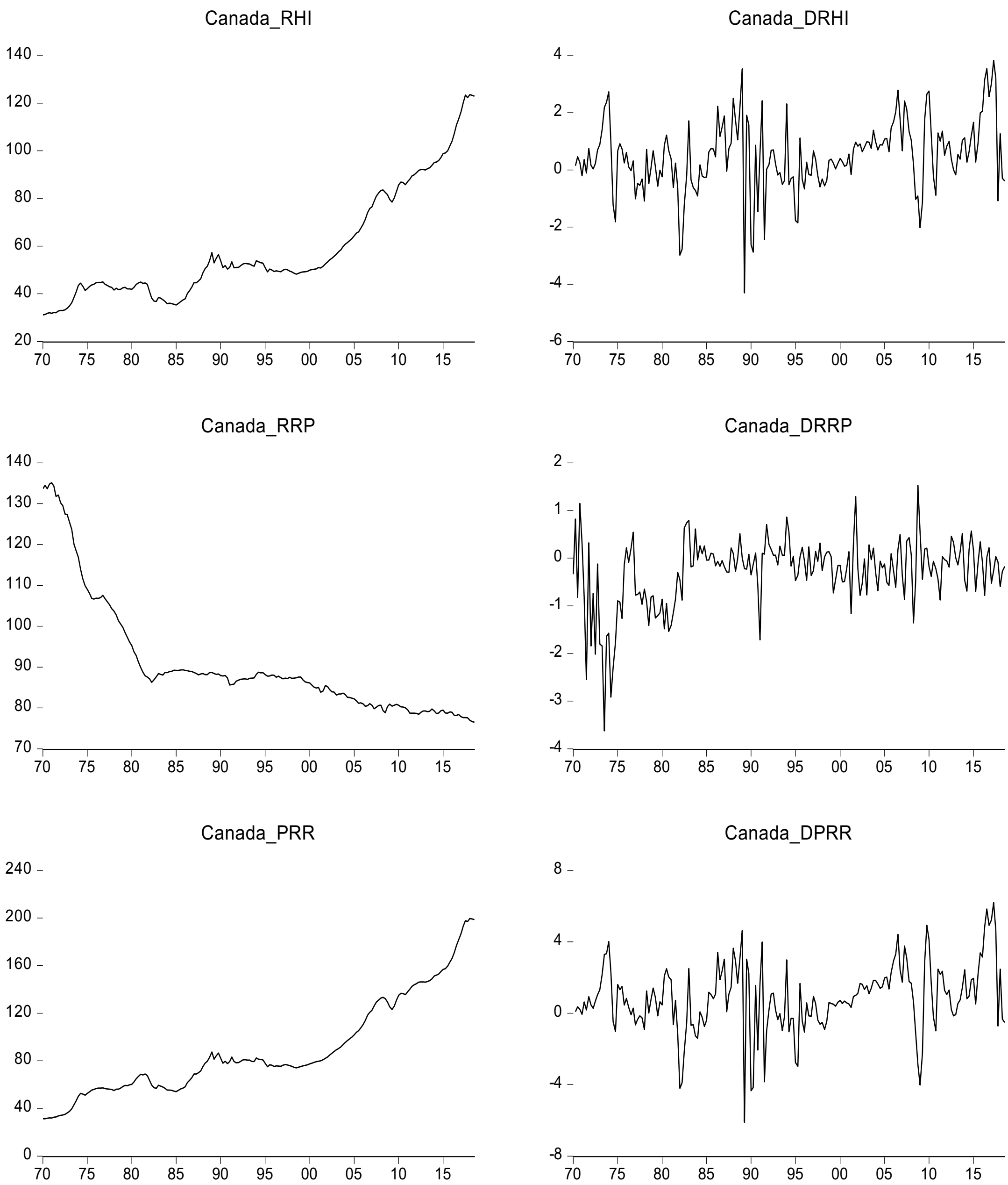


***Figure 2-2** Canada time series*

Note:

- Canada quarterly real house price index in level and differenced (RHI, DRHI). Canada quarterly real rental price index in level and differenced (RRP, DRRP). Canada actual price-to-rent ratio in level and differenced (PRR, DPRR).
- Data source: *OECD* website.

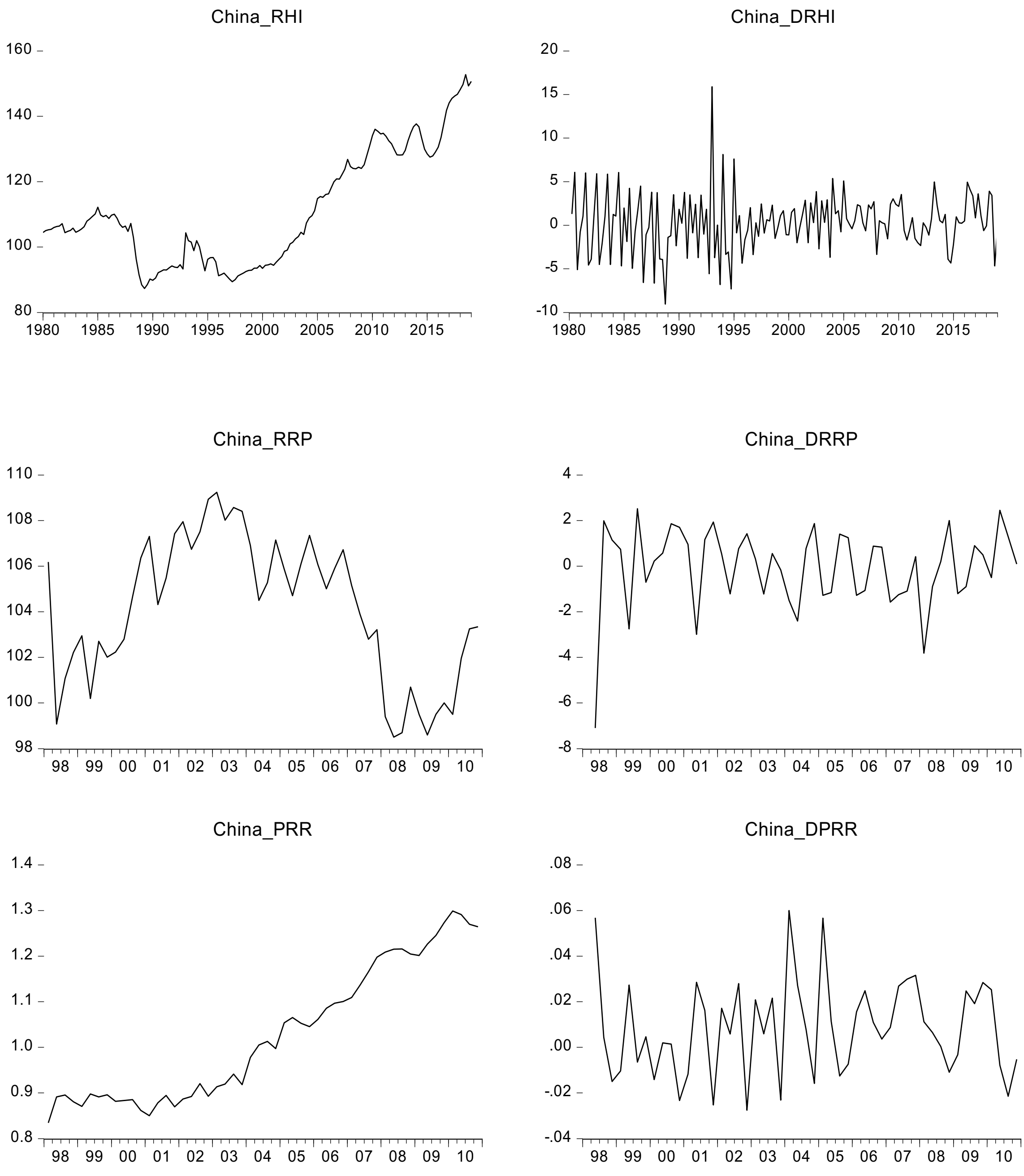


Figure 2-3 *China time series*

Note:

- China quarterly real house price index in level and differenced (RHI, DLRHI). China quarterly real rental price index in level, differenced (RRP, DLRRP). China calculated price-to-rent ratio in level and differenced (PRR, DPRR).
- Data sources: *Oxford Economics* and *National Bureau of Statistics of China*.

2.3.2 The Model

This chapter has used two empirical models – co-explosive VAR and recursive unit root tests – to document the explosive behaviour of asset prices in the housing market. The co-explosive VAR model tests the explosiveness of both housing and rental prices by allowing the prices to contain both explosive root and unit root. By contrast, the appealing feature of the recursive unit root test is to estimate an explosive price behaviour over an I(1) process and date-stamp the bubble periods. In particular, the co-explosive VAR has the advantage of containing both explosive and unit roots, while the recursive unit root tests procedure can measure a sample period with both bubble sub-periods and non-bubble sub-periods. Consequently, although they might lead to distinct conclusions, the two models complement each other in this chapter and provide implications for the presence of housing bubbles from two different aspects.

2.3.2.1 Co-explosive VAR

According to Giglio et al. (2016), the debate over the existence of housing bubbles is an empirical question. The test in this sector is based on the present value model for house price determination, including house prices and house rental prices. The fundamental price of houses is formulated as the present value of all the future cash flows, knowing as the rental incomes. This relation is modelled by:

$$P_t = \frac{1}{1+i} E_t(P_{t+1} + R_{t+1}) \qquad (2\text{-}1)$$

$$M_t = P_t + R_t - (1+i)P_{t-1} \qquad (2\text{-}2)$$

where $E_{t-1}M_t = 0$ is a martingale difference under the hypothesis of efficient market. P_t is the house price, R_t is the rental price, and i represents the discount factor. Besides, the definition of "spread" describes the relationship between house prices and rental prices, correcting for i. This concept is shown as:

$$S_t \equiv P_t - R_t/i \tag{2-3}$$

Therefore, (2-2) could also be written as:

$$M_t = (1+i)\Delta_1 P_t - i \cdot S_t \tag{2-4}$$

where Δ_1 shows the first difference of the variable. For the house price dynamic system, the price can be composed by a fundamental component and a bubble part:

$$P_t = \sum_{j=1}^{\infty}(\frac{1}{1+i})^j E_t R_{t+j} + bB_t, \tag{2-5}$$

Where $B_t = (1+i)^{-1} E_t B_{t+1}$, i.e. $B_{t+1} = (1+i)B_t + \xi_{t+1}$ where ξ_{t+1} is a forecast error. Moreover, in order to make the bubble part explosive to generate an explosive house price pattern, i needs to be larger than zero.

The economic model under to test housing bubble is Vector autoregressive model (VAR). Assuming $X_t = (P_t, R_t)'$, therefore, the unrestricted VAR is primarily conducted.

$$X_t = \sum_{j=1}^{k} A_j X_{t-j} + \mu + \varepsilon_t \tag{2-6}$$

Under an error correction form, it is reformulated as:

$$\Delta_1 X_t = \Pi X_{t-1} + \sum_{j=1}^{k} \Gamma_j \Delta_1 X_{t-j} + \mu + \varepsilon_t \tag{2-7}$$

Where $\Gamma_1 = -(A_{j+1} + A_{j+2} + \cdots + A_k)$ and $\Pi = -(\mathrm{I} - A_1 - \cdots - A_k)$. This is model **M**. Since this is a co-explosive model, the largest root should be explosive, which means larger than unity so that this model can be reached. After verifying the model, Cointegration analysis is conducted to test the rank. In this case, the rank needs to be r=1. Moreover, after imposing this restriction on the model, the largest root still needs to be more than one. This is model $\mathbf{M_1}$

$$\Delta_1 \Delta_\rho X_t = \alpha_1 \beta_1' \Delta_\rho X_{t-1} + \alpha_\rho \beta_\rho' \Delta_1 X_{t-1} + \sum_{j=1}^{k-2} \Phi_j \Delta_1 \Delta_\rho X_{t-j} + \mu + \varepsilon_t \tag{2-8}$$

where $\Delta_\rho X_t = X_t - \rho X_{t-1}$, $\Phi_j = \sum_{l=j+1}^{k-1} \rho^{j-1} \Gamma_1$. β_1 describes the cointegrating vector, whereas β_ρ represents the coexplosive vector. In order to prove the existence of a bubble in the house prices rather than the rental prices, the hypothesis of non-explosive rental price H_R: β_ϱ= (0, 1)' is tested. Thus, we reduce the model to the restricted model $\mathbf{M_{1R}}$

$$\Delta_1\Delta_\rho X_t = \alpha_1\beta_1'\Delta_\rho X_{t-1} + \alpha_\rho\Delta_1 R_{t-1} + \sum_{j=1}^{k-2}\Phi_j \Delta_1\Delta_\rho X_{t-j} + \mu + \varepsilon_t \qquad (2\text{-}9)$$

Moreover, the hypothesis pertaining to the spread in (2-3) needs also to be tested in the model. Furthermore, since i is the discount factor which then linked to the explosive root $\rho = 1 + i$, it reaches the hypothesis H_S: β_1= (1, -1/i). To this end, the bubble model $\mathbf{M_{1RS}}$ is constructed.

$$\Delta_1\Delta_\rho X_t = \alpha_1\Delta_\rho S_{t-1} + \alpha_\rho\Delta_1 R_{t-1} + \sum_{j=1}^{k-2}\Phi_j \Delta_1\Delta_\rho X_{t-j} + \mu + \varepsilon_t \qquad (2\text{-}10)$$

Finally, the housing bubble is tested through the efficient market hypothesis. First of all, the martingale restriction outlined in (2-4) should be applied in the model. The model $\mathbf{M_{1R}}$ (2-9) is then rewritten as

$$\Delta_1\Delta_\rho(P_t + R_t) = \iota'\alpha_1\Delta_\rho S_{t-1} + \iota'\alpha_\rho\Delta_1 R_{t-1} + \iota'\sum_{j=1}^{k-2}\Phi_j \Delta_1\Delta_\rho X_{t-j} + \iota'\alpha_1\zeta_1 + \iota'\varepsilon_t \qquad (2\text{-}11)$$

where $\iota' = (1,1)$. Therefore, it reduces to $M_t = \iota'\varepsilon_t$ which is denoted as ε_M after imposing H_B:

$$H_B: \iota'\alpha_1 = -1,\ \iota'\alpha_\rho = -\frac{(1+i)^2}{i},\ \iota'\Phi_j = 0,\ \zeta_1 = 0$$

With the restriction of H_S and H_B, $\mathbf{M_{1R}}$ can be reparameterised into the model $\mathbf{M_{1RSB}}$ according to the marginal equation for M_t and condition equation for $\Delta_1 R_t$

$$M_t = \varepsilon_{M,t} \qquad (2\text{-}12)$$

$$\Delta_1 R_t = \alpha_{1,R}\Delta_\rho S_{t-1} + (\alpha_{\rho,R} + \rho)\Delta_1 R_{t-1} + \sum_{j=1}^{k-2}\Phi_{j,R}\,\Delta_1\Delta_\rho X_{t-j} + \omega M_t + \varepsilon_{R,M,t} \qquad (2\text{-}13)$$

where $\varepsilon_{R,M,t} = \varepsilon_{R,t} - \omega\varepsilon_{M,t}$ and $\varepsilon_{M,t}$ are not correlated such that given a known i=1-ϱ (2-12) and (2-13) are unrelated. Therefore, this model is estimated with the restrictions above to test the bubble issue.

First, the unrestricted VAR is estimated, after which this model is specified for the following tests via the specification tests. The tests for autocorrelation, normality, and autoregressional conditional heteroskedasticity are incorporated to guarantee the validity of the model. Among them, residual autocorrelation is the main factor to be focussed on. Accordingly, the optimal lag length is decided as the minimum lag length to fulfil no autocorrelation in residuals. Under this unrestricted VAR, since this is a co-explosive model, the largest root should be explosive in the characteristic roots test, which means larger than unity. After verifying the model, cointegration analysis is conducted to test the rank. In this model, with only two variables, the rank r should be equal to 1 in order to make the cointegration test valid, and the largest root should still be explosive after imposing this condition. Afterwards, diverse hypotheses targeting at the housing bubble issue, summarised in **Table 2-2** according to the model framework, are tested to explore the relationship between house and rental prices.

Table 2-2 *Testable hypotheses*

Model	Hypothesis	Description
M_1	$H_{1,}$ r=1	Rank r=1
M_{1R}	H_1, H_R	Test for non-explosive rental price
M_{1RS}	H_1, H_R, H_S	Spread $S_t = P_t - R_t/i$ as a cointegrating relation
M_{1RSB}	H_1, H_R, H_S, H_B	Efficient market hypothesis

Notes:

- The four hypotheses are generated from the model M_1 to M_{1RSB} under equation (2-6 to 2-13) with the aim of testing bubbles.
- The description demonstrates the hypothesis being tested.

Firstly, the cointegration vector error correction model is estimated from model **M** (2-7) through imposing the rank r=1. This gives the coexplosive model $\mathbf{M_1}$ (2-8). Secondly, this model assumes that the explosive behaviour exists in real estate price, not in rental price. Accordingly, H_R: $\beta_\varrho = (0, 1)'$ is tested to guarantee the non-explosive rental price given r=1 and $\varrho>1$. This generates model $\mathbf{M_{1R}}$. Estimate this model with a given ϱ from the largest root, and in this reduced rank regression, it maximised the likelihood. Then a profile argument over the root ϱ is conducted to maximise the likelihood. Next, as regards the hypothesis for spread in (2-3), H_S: $\beta_1 = (1, -1/i)$ is imposed on the reduced model. Furthermore, based on the linkage between the discount factor and explosive root $\varrho=1+i$, the bubble model $\mathbf{M_{1RS}}$ (2-10) is built. Estimate $\mathbf{M_{1RS}}$ imposing general restrictions, and the likelihood is also maximised over ϱ with a profile argument. Finally, the housing bubble is tested through the efficient market hypothesis H_B. This model is estimated with the restrictions, and a profile argument over *i* maximises the likelihood.

2.3.2.2 Recursive unit root tests

One problem with co-explosive VAR model in the previous section is that it does not allow for structural breaks during the sample period of the kind that may happen when there are bubble bursts. More importantly, this method is based on the hypothesis of a present value model, which assumes the present value of housing price to be purely decided by future rental incomes. This assumption might not be the case in a real-life context. Under this premise, the recursive unit root tests are applied to the time series as well. This section adopts the recursive unit root test methodology proposed by Phillips to capture evidence of explosive features. Different unit root tests have been applied in previous studies to estimate time series bubbles, while this recursive approach is well suited for this study. This choice is supported by the persuasive power that this methodology has in revealing multiple bubble episodes, as well as the technique of presenting date-stamping bubble periods with the origination and termination of explosive bubbles within the sample period. In this methodology, the bubble is considered to be explosive as shown in Equation (2-14):

$$E[B_{t+1}|I_t] = (1+r)B_t \qquad r > 0 \tag{2-14}$$

I_t represents all the information about the price, and B_t represents the bubble part. Established from this basis, this model proposes the right-tailed ADF test with the following hypothesis:

H_0: $\varrho=1$, no bubble

H_1: $\varrho>1$, bubble existed

However, bubbles in real context involves cycles with repetitive boom and bust. These periodical bubble bursts tend to give the time-series patterns of unit root or even stationary feature, not explosiveness. Therefore, the ADF test would be unavailable in capturing explosive time-series pattern. Pioneered by Phillips et al. (2011) and Phillips et al. (2015), a multiple bubble identification approach has been generated from the traditional left-tailed stationary unit root test procedure to contain explosive root that exceeds unity. In this methodology of Supremum Augmented Dickey-Fuller (SADF) t-statistics, the right-sided unit root test is conducted recursively to capture explosive feature. In other words, it is to capture the time periods when explosive bubble component dominates the asset pricing process from testing a group of subsamples with right-tailed ADF test.

I. SADF Test

Suggested by Phillip, the SADF test is the process of recursive calculation of the right-tailed ADF test. There is a fixed starting point and initial set size of the window, with the window size expanding with the calculation. The starting point of the estimation window r_1 (in fraction terms) is set to be the first observation of the sample, i.e.,$r_1 = 0$, and the endpoint of the initial window r_2 is decided by the minimal window size r_0 being chosen, i.e., window size $r_w = r_2$. Afterwards, this estimation is recursively calculated, with the window size being expanding, $r_0 < r_2 < 1$, and with one observation at each time. In other words, the test of observations from the initial subsample is extended until all the observations in the sample are involved in the tests. ADF_{r_2} denotes the ADF statistic yielded from each estimation. Moreover, the supremum value of this sequence is defined as the SADF statistic:

$$SADF(r_0) = \sup_{r_2 \in [r_0,1]} \{ADF_{r_2}\} \tag{2-15}$$

II. GSADF Test

One feature in the SADF model is to fix the starting point r_1 to be 0, which means along with the continued recursive estimation, the subsample is closer to the whole sample. This feature makes SADF less advantageous in testing multiple bubbles with accurate bubble starting and bursting points.

Unlike the SADF test, GSADF proposed by Phillips includes flexible estimation windows without fixing the starting point r_1. r_1 can now vary within the range of [0, $r_2 - r_0$]:

$$GSADF(r_0) = \sup_{\substack{r_2 \in [r_0,1] \\ r_1 \in [0, r_2 - r_0]}} \left\{ADF_{r_1}^{r_2}\right\} \tag{2-16}$$

Finally, the SADF and GSADF statistics are compared with the right-tailed critical values, and the bubble is identified to exist initiating at T_{r_2} if the null hypothesis is rejected.

III. Date-stamping strategy

After the null hypothesis is rejected, indicating the presence of explosive bubbles, the sample dating technique is implemented to describe multiple bubble episodes. Since the GSADF test outperforms SADF by covering more subsamples and providing substantial flexibility on calculating windows, it gains extra power in detecting explosive multiple bubble episodes (Chang, Gil-Alana, Aye, Gupta, & Ranjbar, 2016).

According to the date-stamping strategy for bubble periods in this recursive unit root test by (Phillips et al., 2015), the origin of a bubble period is presented as the first time point when the ADF t statistics exceeds the corresponding right-tailed unit root test critical value. Define the starting date in fraction term as T_{r_e}, and it is at which the backward SADF (BSADF) becomes higher than the critical value shown in equation (2-17). Meanwhile, the termination of a bubble period is decided as the first time point when the t statistic becomes lower than the critical value. This endpoint is presented in equation (2-18) as the first observation at which BSADF statistic cross its critical value from above:

$$\widehat{r_e} = \inf_{r_2 \in [r_0, 1]} \{r_2 : BSADF_{r_2}(r_0) > cv_{r_2}^{\beta_T}\}. \tag{2-17}$$

$$\widehat{r_f} = \inf_{r_2 \in [\widehat{r_e}, 1]} \{r_2 : BSADF_{r_2}(r_0) < cv_{r_2}^{\beta_T}\}. \tag{2-18}$$

where $cv_{r_2}^{\beta_T}$ denotes the 100(1-β_T)% critical value of the SADF statistic depending on (T_{r_2}) observations, and the BSADF statistic B$SADF_{r_2}(r_0)$ is associated with GSADF statistic with the following equation:

$$GSADF(r_0) = \sup_{r_2 \in [r_0, 1]} \{BSADF(r_0)\} \tag{2-19}$$

2.4 Empirical Results

The processes of conducting the two models in this chapter has been introduced in detail in the previous section. The models examine the explosiveness in asset prices from distinctive approaches, and since both are advantageous in some respects, the estimated results are presented below to investigate the possible implications.

2.4.1 Co-explosive VAR

In this section, the co-explosive VAR model is demonstrated to capture explosiveness in the real estate markets. Assuming a fixed interest rate, the results of this test are shown below. The optimal lag lengths for the initial unrestricted VAR model are set to 2, 4, and 1 for the UK, Canada, and China, respectively, since these are the minimum numbers of lags that could prevent residual autocorrelation. One lag length is selected for China in addition because of the small sample size and limited availability of data. **Table 2-3** lists the misspecification tests and shows that the model does not contain residual autocorrelation.

Table 2-3 *Specification tests for the unrestricted VAR model*

	UK	Canada	China
Residual autocorrelation AR 1-2	F (20, 260) =1.4285(0.1087)	F (20, 340) =1.5585(0.0607)	F (16, 78) =1.7174(0.0605)
Test for normality	$\chi^2(4) = 31.249(0.0000)$	$\chi^2(4) = 50.131(0.0000)$	$\chi^2(4) = 6.2068(0.1842)$

Also, the characteristic roots for the unrestricted model are presented in **Table 2-4**, which shows that the characteristic roots are for the UK: 1.003, 0.9706, 0.7670 and 0.1646; Canada: 1.014, 0.9521, 0.7169 and 0.7169; China: 1.008 and 0.8738. The largest root for each country is 1.003, 1.014 and 1.008 respectively, which identify one explosive root in each model. This outcome coincides with the hypothesis of explosiveness. Moreover, **Table 2-5** displays the cointegration rank test result, and the hypothesis of rank 1 for the three models cannot be rejected in the test.

Table 2-4 *Characteristic root test for unrestricted VAR model*

UK			Canada			China		
real	Imag	modulus	real	Imag	modulus	real	Imag	modulus
1.003	0.0000	1.003	**1.014**	0.0000	1.014	**1.008**	0.0000	1.008
0.9706	0.0000	0.9706	0.9521	0.0000	0.9521	0.8738	0.0000	0.8738
0.7670	-0.9206	0.7670	0.7169	-0.0199	0.7172			
0.1646	0.9206	0.1646	0.7169	0.0199	0.7172			
…	…	…	…	…	…			

Notes:

- The table contains the characteristic root result for testing explosive and unit roots. A root larger than 1 is an indication of explosive root.
- This result presents one explosive root in the housing price of each country.

Table 2-5 *Cointegration rank test*

UK			Canada			China		
Hypothesis	Test statistic	p-Value	Hypothesis	Test statistic	p-Value	Hypothesis	Test statistic	p-Value
r≤0	18.564	0.084*	r≤0	38.834	0.000***	r≤0	23.136	0.018**
r≤1	1.5059	0.861	r≤1	6.9606	0.132	r≤1	3.4321	0.514

Notes:

- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.
- The test results indicate rank one under 1% level of significance for the UK and Canada model and under 5% level of significance for the China model.

After imposing a unit root in the model to set the rank to 1, **Table 2-6** lists the updated root results. The largest roots in the UK and Canada models appear to become 1.000, since cointegration is imposed, providing no evidence of explosiveness in UK and

Canadian housing prices, a result which accords with the study by Engsted et al. (2016). In the meantime, the largest root in the China model is still higher than 1, while the second is 1.000 due to the cointegration restriction. This result favours the anticipated outcome in which there is one explosive root and one unit root in the model. Next, the models with different assumptions are estimated in the Chinese case. In each step, different values of the root ϱ are applied to repeat the estimation to obtain the root that maximise the likelihood. In particular, the profile likelihood under model M_{1RS}, provided in **Table 2-7**, suggests a root lower than one, which removes the possibility of an explosive root in the model. Consequently, the co-explosive VAR model reinforces a lack of evidence of a housing bubble in China.

Table 2-6 *Updated characteristic root test*

UK			Canada			China		
real	Imag	modulus	real	Imag	modulus	real	Imag	modulus
1.000	0.0000	1.000	1.000	0.0000	1.000	1.006	0.0000	1.006
0.9979	0.0000	0.9979	0.9503	0.0000	0.9503	1.000	0.0000	1.000
0.7463	0.0000	0.7463	0.7993	0.0000	0.7993			
0.1631	0.0000	0.1631	0.7570	0.0000	0.7570			
			…	…	…			

Notes:

- The table contains the updated characteristic root result for testing explosive and unit roots. A root larger than one is an indication of explosive root.
- In the UK and Canada model, the largest root is unity; in the China model, there is one explosive root of 1.006 and one unit root.

Table 2-7 *Profile likelihood under M_{1RS}*

ϱ	1.019	1.009	1.004	1.002	1.001
Log-likelihood	-175.71681	-175.32069	-175.12359	-175.04499	-175.00576

Note:

- The value of log-likelihood continues to increase with lower ρ value, indicating the actual maximised log-likelihood ρ value to be lower than unity.

The empirical findings from the co-explosive VAR model targeting the housing and rental prices time series in the three countries provided no evidence of housing bubbles in the market. However, the drawbacks of the co-explosive VAR model are worth considering, including that it did not allow a structural break and is based on the present value model. Consequently, a multiple bubble testing technique, the recursive unit root test, is introduced in the next section to overcome this issue.

2.4.2 Recursive unit root test

In the previous section, the conclusion from the co-explosive VAR model regarding the presence of bubbles in the target countries was negative based on the approach of the basic present value model. This finding has added value to the understanding of this topic by stating the cointegration relationship between housing and rental prices in the three countries and rejecting explosive housing prices under the present value model. Additionally, this model does not allow for a structural break in the sample period, which means that the sample period should end at the peak of the housing bubble. Hence, the negative conclusion in this section indicate the need to check for bubble bursts during the sample period. Accordingly, this section conducts the recursive right-tailed unit root tests to shed additional light on the presence of housing bubbles in the three target countries.

The recursive unit root test is a repeated right-tailed ADF test, used to detect multiple explosive features in asset prices. Before the recursive unit root test, a conventional ADF test was conducted on the time series, as presented in **Table 2-8**. The test statistics p-value for all the data in the level are higher than 5%, while those for the first differenced terms are considerably lower than 5%. This indicates non-stationary data for housing price, rental price, and price-to-rent ratio in the three countries. Next, the SADF and GSADF tests are applied to the three time series to detect explosive bubbles in the property market, and **Table 2-9**, **Table 2-10**, and **Table 2-11** display the test statistics. These tests on housing prices produced p-values that are substantially lower than 1% in Canada and China and lower than 5% in the UK. This means that the null hypothesis is rejected and indicates the existence of explosiveness in housing prices in the sample periods in the UK, Canada, and China. When the tests are conducted on rental prices in each market (presented in **Table 2-10**), they both show explosiveness in the UK and Canadian rental sector, while rental prices in China appear to contain explosive pattern in the GSADF test but not in the SADF test. Consequently, further tests are required on the price-to-rent ratio in the UK, Canada, and China to detect the explosiveness of housing price over rental price, as the time series have shown explosive roots. It is worth noting that due to limited data, there is no data for rental prices in China after 2010, which means that evidence of a housing bubble in China after 2010 is missing. However, when applying the tests on the price-to-rent ratio, the result in Canada is a consistent rejection of the null hypothesis, implying evidence of a deviation in housing price from its fundamentals. Meanwhile, although the SADF test in the UK price-to-rent ratio is insignificant, the GSADF test indicates obvious significance under 1% level of significance. Since the SADF test may lose its power along with the testing procedure, we focus mainly on the results of the GSADF test, which suggest the presence of a housing bubble in the UK. At the same time, the tests have also been applied to the Chinese price-to-rent ratio, and the statistics for the Chinese market reject the null hypothesis under a 10% level of significance in both tests, implying the presence of bubbles in the period until 2010. However, further research is required to find evidence after 2010 when available data can be collected.

Table 2-8 *ADF unit root test*

		Level			1st difference		
		Intercept	Trend & Intercept	None	Intercept	Trend & Intercept	None
UK	HP	0.9048	0.4731	0.9336	0.0006	0.0037	0.0001
	RP	0.9345	0.9043	0.9999	0.0000	0.0000	0.0000
	PRR	0.6512	0.3509	0.8482	0.0000	0.0000	0.0000
Canada	HP	0.999	0.9982	1.0000	0.0000	0.0000	0.0000
	RP	0.3248	0.7950	0.0270	0.0070	0.0173	0.0021
	PRR	0.9998	0.9969	1.0000	0.0000	0.0000	0.0053
China	HP	0.9875	0.9055	0.9665	0.0000	0.0000	0.0000
	RP	0.8290	0.5046	0.2066	0.0000	0.0000	0.0000
	PRR	0.9909	0.3069	1.0000	0.0000	0.0001	0.0000

Notes:

- The ADF test is conducted under the three models (with intercept, trend and intercept and none) in both level and first differenced time series.
- The result shows that all the time series accept the existence of unit root in level but become stationary under first differenced.

Table 2-9 *GSADF test and SADF test value and critical value -- housing price*

Housing price						
		t Stat.	**Prob.**	**90% CV**	**95% CV**	**99% CV**
UK	**SADF**	1.726650	0.0190	1.199539	1.458834	1.872161
	GSADF	7.399617	0.0000	1.919937	2.180149	2.710490
Canada	**SADF**	2.943163	0.0000	1.065007	1.401318	1.825373
	GSADF	9.496973	0.0000	1.866682	2.089426	2.562001
China	**SADF**	2.103355	0.0080	1.152254	1.403027	2.018414
	GSADF	4.283939	0.0000	2.745866	2.060587	1.763843

Notes:

- Critical values in the tests are obtained from Monte Carlo simulation with 1000 replications.
- The optimal lag length is selected using the Schwarz information criterion with a maximum of four lags.
- The smallest window has 31, 27 and 24 observations for the UK, Canada and China respectively.

***Table 2-10** GSADF test and SADF test value and critical value -- rental price*

Rental price

		t Stat.	Prob.	90% CV	95% CV	99% CV
UK	**SADF**	4.280455	0.0010	2.383545	2.672507	3.358891
	GSADF	4.152306	0.0000	1.878610	2.101910	2.711131
Canada	**SADF**	3.901510	0.0000	1.089599	1.365005	1.921554
	GSADF	4.335994	0.0000	1.871993	2.099292	2.726694
China	**SADF**	-0.96103	0.8200	2.053642	1.202891	0.908246
	GSADF	2.953845	0.0060	2.777291	1.957140	1.607955

Notes:

- Critical values in the tests are obtained from Monte Carlo simulation with 1000 replications.
- The optimal lag length is selected using the Schwarz information criterion with a maximum of four lags.
- The smallest window has 31, 27 and 13 observations for the UK, Canada and China respectively.

***Table 2-11** GSADF test and SADF test value and critical value -- price-to-rent ratio*

Price to rent ratio

		t Stat.	Prob.	90% CV	95% CV	99% CV
UK	**SADF**	-0.89584	0.8980	1.927414	1.409405	1.152167
	GSADF	5.498942	0.0000	2.516167	2.064583	1.831101
Canada	**SADF**	2.412250	0.0000	1.825373	1.401318	1.065007
	GSADF	10.44465	0.0000	2.562001	2.089426	1.866682
China	**SADF**	1.063457	0.0750	2.053642	1.202891	0.908246
	GSADF	1.638869	0.0950	2.777291	1.957140	1.607955

Notes:

- Critical values in the tests are obtained from Monte Carlo simulation with 1000 replications.
- The optimal lag length is selected using the Schwarz information criterion with a maximum of four lags except for no lag being included in China case due to the small sample size.
- The smallest window has 28, 27 and 13 observations for the UK, Canada and China respectively.

After proving the presence of bubbles in the time frame, the bubble episodes are date-stamped. As proposed in the methodology, the starting point of a bubble period is the first quarter, when the test statistic is larger than its critical value, while, by contrast the endpoint is the first quarter when the statistic becomes lower than its critical value. In particular, the "too-short-lasting" bubble periods have been excluded suggested by Phillips who proposed to identify the ones that last over log(T) units of time measures. In Canada and China case, this time range is $\log(157)\ and\ \log(195) \approx 2\ quarters$. The graphs of the date-stamping are presented from **Figure 2-4** to **Figure 2-10**, while **Table 2-12** summarises the bubble episode information. From economic theory, the possibility of a bubble boom and burst is higher if asset prices increase and decrease sharply. Meanwhile, from the figures, the bubble periods diagnosed using the GSADF method almost coincide with the actual housing price booms, which is consistent with the theory. Accordingly, this study has summarised the following information from the test. In the UK, housing prices have shown an explosive rise in four periods, 1962–1969, 1971–1973, 1988–1990, and 1999–2007. The performance of the price-to-rent ratio indicates that bubbles were not generated in 1962–1969 and 1971–1973 due to the significant fluctuations in the rental price as well. However, the historical housing bubbles in the UK, namely, the crisis from the late 1980s to the early 1990s and the bubble burst in the 2008 financial crisis, were captured correctly (Hay, 2009). Even though rental prices did accumulate into a bubble during the period 1990–2009, the growth of housing prices continued to exceed the pace of its growth and cause divergence over the fundamentals. It is worth noting that a continued bubble has been occurring since 2016 Q4 from the test statistics for price-to-rent ratio, indicating that the UK housing market is experiencing a bubble, starting in late 2016. This is due to the recovery of the housing market and the burst of the rental market bubble at the end of 2016, in turn due to several tax changes such as the stamp duty surcharge and to Brexit (Savills, 2016). Correspondingly, in Canada, the explosive behaviour of the price-to-rent ratio in the period 1980–1982 was due to the dramatic decline in real rental prices and the rental bubble burst. A construction boom in rental housing in Canada in the late 1960s is blamed for causing this depression in the rental market in the 1970s, and massive expansion has been witnessed in the number of rental apartments. Additionally, the Canadian tax structure revision in 1972 has worsened the situation by increasing the relative attractiveness of owning houses rather than renting (Smith, 1983). This model detected the housing bubble burst around 1990 (Macdonald, 2010), and a housing bubble in Canada can be seen since 2002, nearly bursting in the 2008 crisis but continuing to present in the market. In China, several explosive periods in housing prices exist, including 1988 Q3–1989 Q3, 2007 Q2–2014 Q4, and after the end of 2016. These periods cover the real estate market reformation in China at the end of the 1980s, the breakneck growth of Chinese housing price after the financial crisis in 2007, and the rigid housing market policies from around 2014 to 2016. Moreover, the estimation of the price-to-rent ratio indicates one continuous bubble being generated from 2004 Q1 until the end of the sample period. Evidence of a bubble in the Chinese real estate sector can thus be seen until 2010. This result is consistent with previous studies, such as Dreger and Zhang (2013), Hou (2010), and Shih et al. (2014), which also found undeniable evidence of housing bubbles in China. Moreover, it is in line with the research on major cities in China of Su-Ling and Hsien-Hung (2015), which states that China's 2005 exchange rate reform had a significant impact on the generation of housing bubbles. However, the results in the Chinese real estate market in this chapter are limited based on the availability of rental price, so further research is needed to provide evidence after 2010.

Table 2-12 *Bubble episodes*

	Bubble 1	Bubble 2	Bubble 3	Bubble 4
		Housing price		
UK	1962 Q3-1969 Q4	1971 Q3-1973 Q3	1988 Q2-1990 Q1	1999 Q4-2007 Q4
Canada	1988 Q4-1990 Q1	2002 Q1-continued		
China	1988 Q3-1989 Q3	2002 Q1-2012 Q2	2016 Q4- continued	
		Rental price		
UK	1990 Q2-2009 Q4	2012 Q4-2016 Q3		
Canada	1973 Q1-1983 Q1	1991 Q1-1991 Q4	2000 Q3-2001 Q4	2005 Q2-2009 Q3
	2010 Q3-2013 Q3	2016 Q4-continued		
China	2007 Q4-2008 Q4			
		Price-to-rent ratio		
UK	1988 Q3-1989 Q4	1999 Q4-2008 Q1	2016 Q4- continued	
Canada	1980 Q4-1982 Q1	1988 Q4-1990 Q1	2002 Q1-continued	
China	2006 Q3-2010 Q4			

Note:

- The bubble episodes are based on the results from Date-stamping from **Figure 2-6**, **Figure 2-9** and **Figure 2-12**.
- The periods with Price-to-rent ratio GSADF values above critical values are regarded as bubble periods.

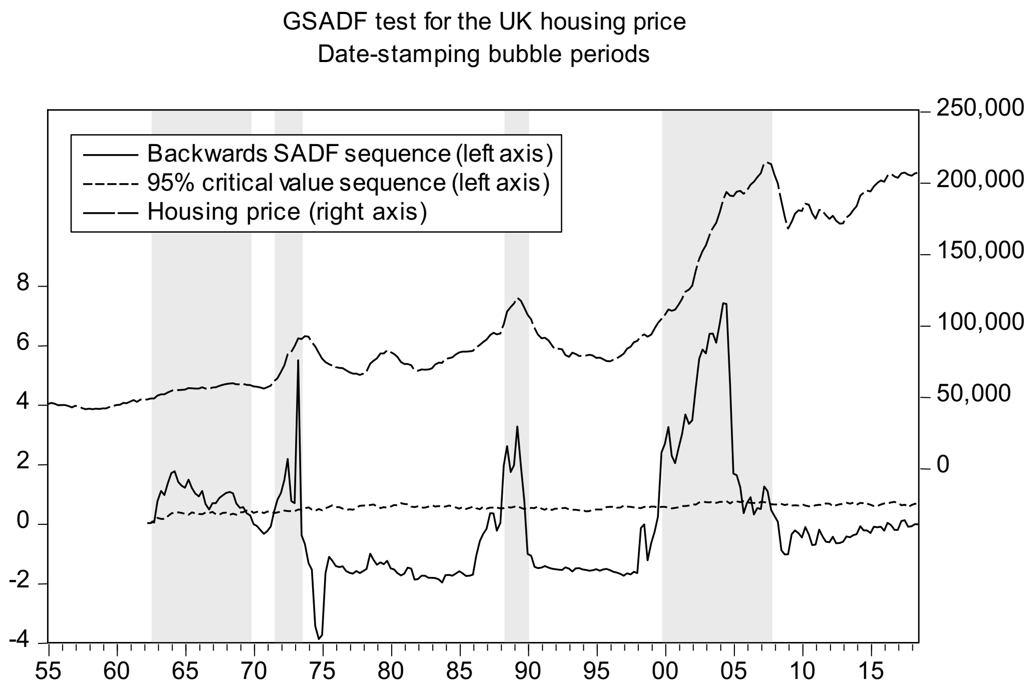


Figure 2-4 *Date-stamping bubble periods – The UK housing price*

Note: the shaded areas show the explosive bubble periods.

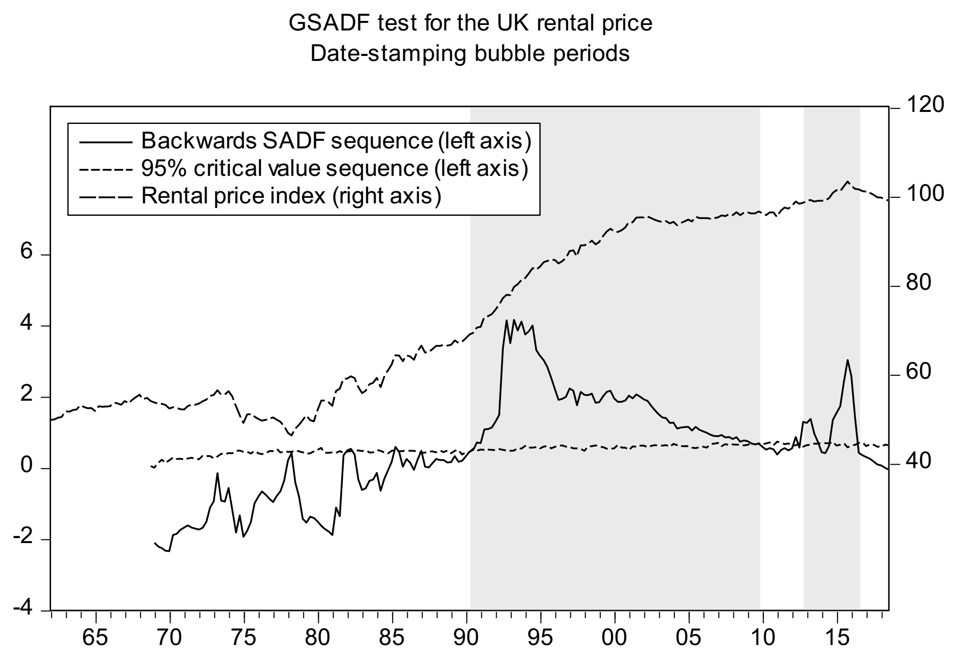


Figure 2-5 *Date-stamping bubble periods – The UK rental price*

Note: the shaded areas show the explosive bubble periods.

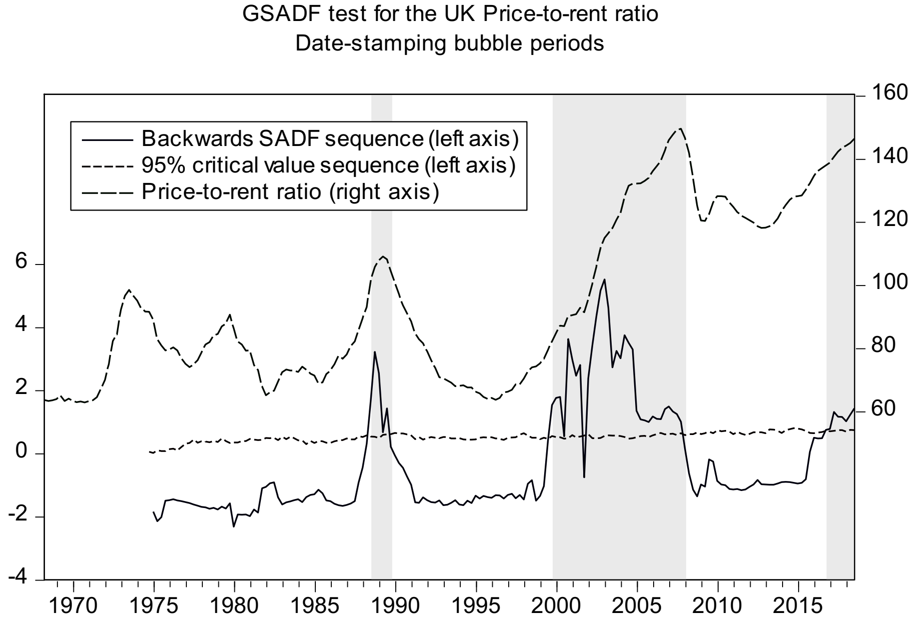


Figure 2-6 *Date-stamping bubble periods – The UK Price-to-rent ratio*

Note: the shaded areas show the explosive bubble periods.

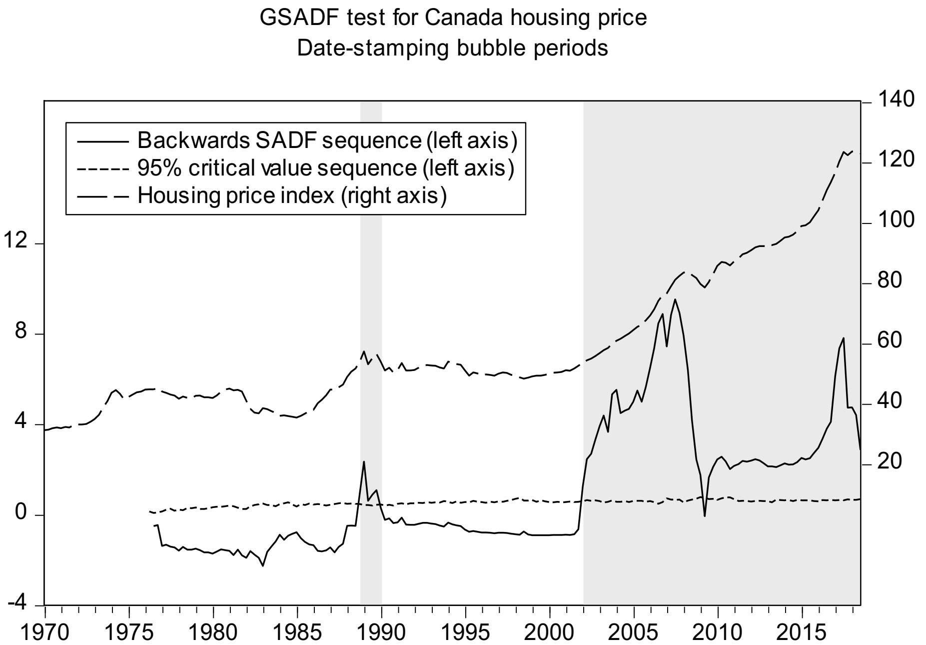


Figure 2-7 *Date-stamping bubble periods -- Canada housing price*

Note: the shaded areas show the explosive bubble periods.

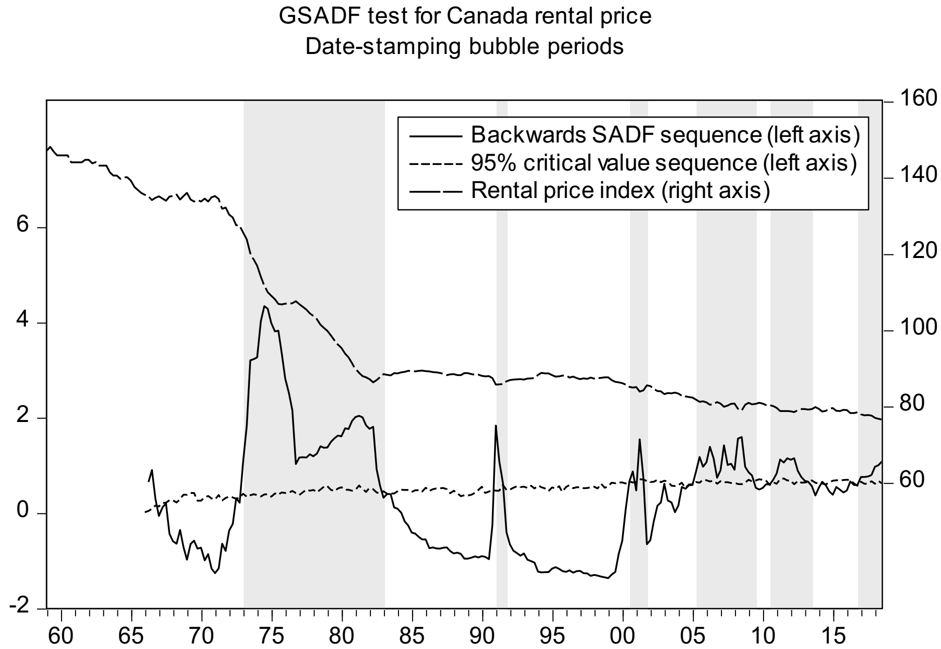


Figure 2-8 *Date-stamping bubble periods -- Canada rental price*

Note: the shaded areas show the explosive bubble periods.

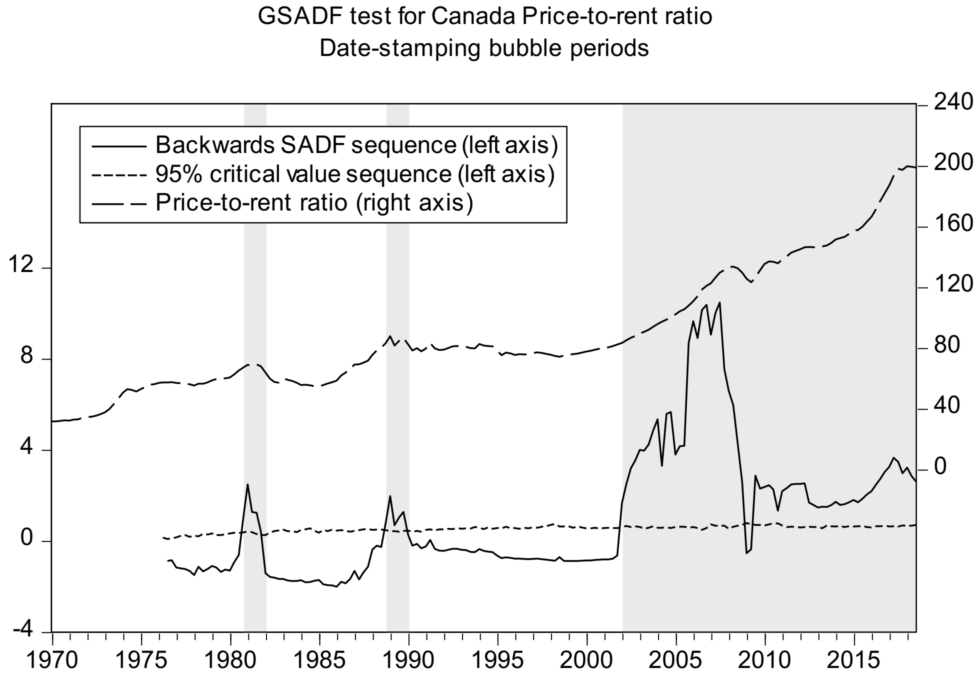


Figure 2-9 *Date-stamping bubble periods -- Canada Price-to-rent ratio*

Note: the shaded areas show the explosive bubble periods.

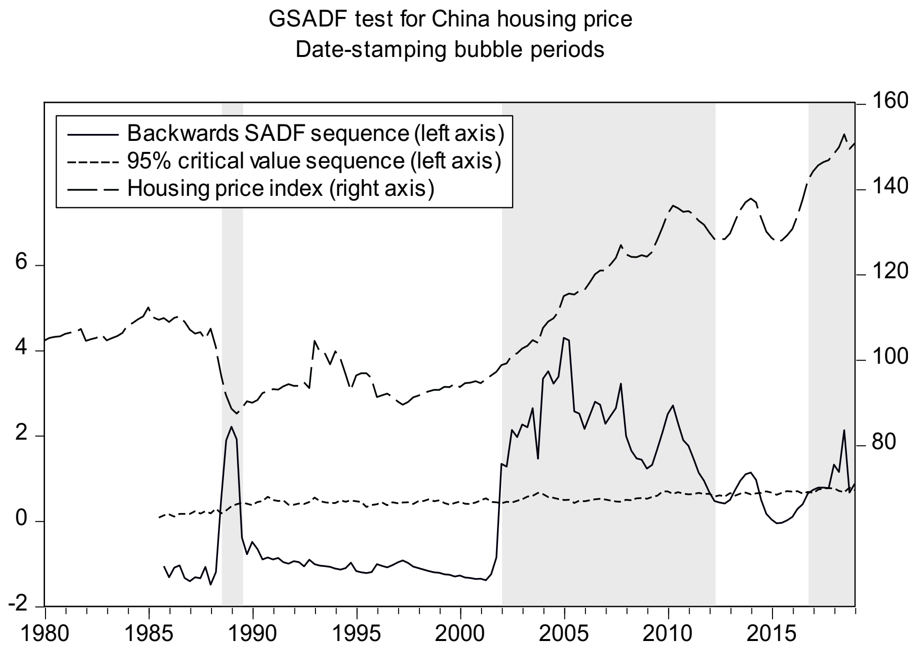


***Figure 2-10** Date-stamping bubble periods – China housing price*

Note: the shaded areas show the explosive bubble periods.

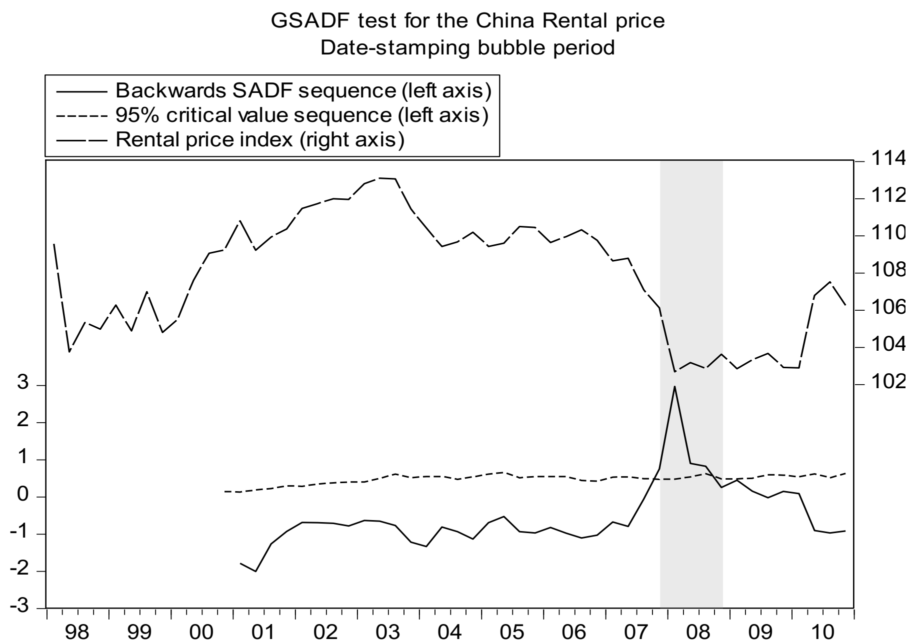


***Figure 2-11** Date-stamping bubble periods – China rental price*

Note: the shaded area shows the explosive bubble period.

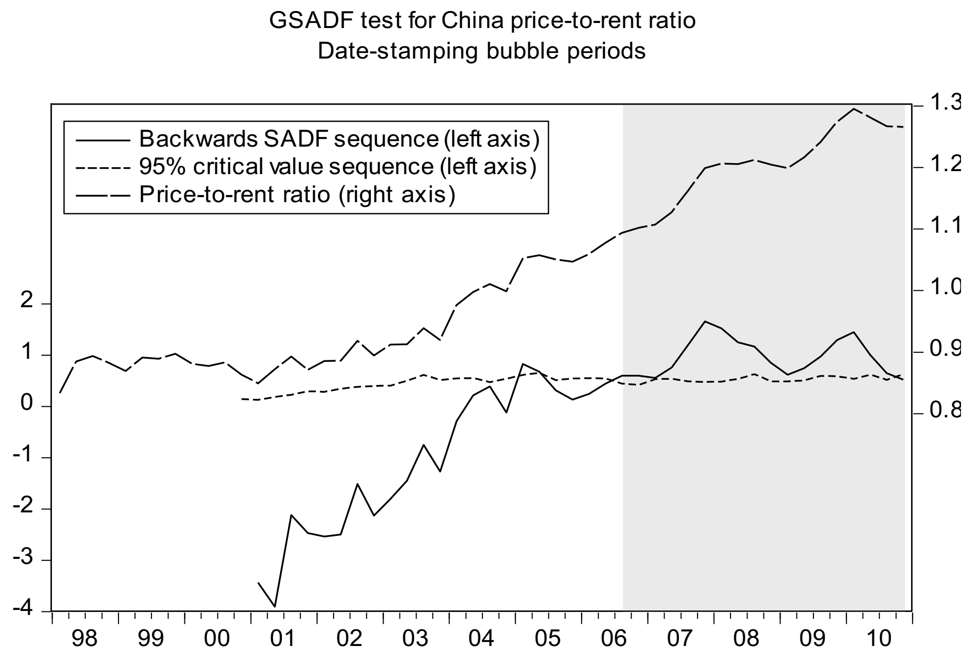


***Figure 2-12** Date-stamping bubble periods – China price-to-rent ratio*

Note: the shaded area shows the explosive bubble period.

In summary, the two methodologies to detect explosive bubbles seen above have shown some differences. For the three target countries, the VAR statistics find a common I(1) trend between housing prices and rent, but the explosive root is eliminated when imposing cointegration restrictions. The uncertainty of whether real estate price is non-explosive or both rental and housing prices are explosive cannot be investigated following this approach. It is noteworthy, though, that the co-explosive VAR model does not allow for bubble burst and structural break during the sample period. This result may be restricted by the assumption of the present value model and the potential structural breaks in the sample periods. Meanwhile, the GSADF test on the price-to-rent ratio suggests an explosive bubble between prices and rents in the UK and Canada, and tests on Chinese housing prices show continuous explosiveness from 2014. Since several bubble bursts have been detected in the GSADF test, a weak hindered power of the co-explosive VAR result according to its limitation is justified. Consequently, from the implications of both models, the estimated results in this study have substantiated the presence of housing bubbles in the UK, Canada, and China.

2.5 Conclusion

This chapter presents an empirical study of the real estate bubble issue for the UK, Canada, and China by applying quarterly time-series data. It contributes to the previous literature by adopting two explosive models – the co-explosive model originally for the stock market bubble and the recently proposed recursive unit root tests for explosive bubbles – to the real estate market. Both the co-explosive VAR method and the recursive unit root tests assume that house prices, which contain a bubble component, present an explosive growth pattern. In this research, the rental price acts as the fundamentals-based price for real estate. Therefore, the co-explosive VAR test is undertaken to evaluate whether rental prices are non-explosive, whereas house prices are confirmed to display explosive behaviour. Meanwhile, the recursive right-sized unit root method is tested on the explosive root of the stationary price-to-rent ratio, and the beginning and termination of a bubble is date-stamped. This chapter contributes to the earlier study by conducting a combined study of two explosive asset bubble detecting models on the real estate markets in the UK, Canada, and China. In addition, the recursive unit root tests are applied to housing prices, rental prices, and the price-to-rent ratio to discover in more detail the dynamics within real estate prices and its fundamentals. These explosive models have both been advantageous in different respects. The co-explosive VAR contains both an explosive root and a unit root, and the recursive unit root tests allow for multiple bubbles in the sample period. Therefore, both models have increased understanding of this topic. The findings of this study justify the presence of explosive bubbles in the UK, Canada, and China. The bubble periods in the UK and Canada are both dated in the 1980s. One bubble from 2002 in Canada was detected, as was one in the UK, ongoing from 2016 to the end of the sample period. The housing bubble burst in 2008 in the UK was captured. One bubble from 2006 that continues to the end of the sample period of 2010 was also found in the Chinese market.

The real estate industry has vast potential in supporting and stimulating economic growth and social improvement, while the potential bubble in housing prices raises the possibility of a burst and financial crisis. Therefore, only by discovering whether a bubble contributes booming house prices and then adopting the corresponding measures to curb the imbalanced enlargement can real estate markets be brought into full play. The evidence provided in this study justifies the presence of real estate bubbles in the UK, Canada, and China, and this is worth critical attention to prevent any future burst. In the meantime, the outcomes of this study must be noted in the context of its limitations, such as the choice of fundamental variables. The limitations of the two models in this chapter are also worth paying attention here. The setting of co-explosive VAR will be invalid if there is a bubble burst during the sample period, which means the sample needs to finish at the peak of a bubble. Although this drawback is solved in the recursive unit root tests, the SADF and GSADF methods do not allow for both cointegration and explosiveness in the model. Since there is no other approach based on the current knowledge to combine both unit root and explosive root, an alternative solution can be testing co-explosive VAR on subsamples that exclude the disturbance of a structural break. Worth noting that this method may provide inferior results if the subsamples are not sufficient.

Despite its exploratory nature, this study provides insight into the implications for policymakers regarding the real estate market in the UK, Canada, and China to guarantee appropriate oversight. In consideration of the explosive nature of house prices, policymakers might with more forethought act to control and supervise the fluctuation of real estate prices. Finally, it remains necessary for policymakers to provide suitable guidance for investors in making investment decisions and to prevent speculative behaviour.

Chapter 3 The effect of foreign investment on housing prices in the UK, Canada, and China

3.1 Introduction

Researchers have raised the topic of capital inflow as an element that potentially affects the real estate market (Sá et al., 2014). This approach to analyse the real estate market is based on the general context of globalisation and international economics. To be more precise, capital inflow, particularly foreign investment growth, which drives the rise of asset prices, is recognised as an essential component of the real estate boom (Gholipour, 2013). Of capital inflow, a significant category is foreign investment, especially foreign direct investment (FDI; Gholipour, 2013; Kim & Yang, 2011)[3]. An important component of capital inflow, FDI refers specifically to investment into a controlling ownership of one company in one economy by a foreign entity. In this study, FDI is applied rather than other forms of capital because we are concerned with the specific mechanism through which FDI affects the real estate market. For example, as the direct investment into corporations, FDI brings advanced technology and knowledge to develop the real estate market, which rapidly boosts housing prices (Kepili & Masron, 2011). A more noticeable flow of FDI in the past several years has been witnessed in many economies as a result of liberalisation policies and globalisation (Gholipour Fereidouni & Ariffin Masron, 2013).

[3] Foreign Direct Investment (FDI) is defined by Rodríguez and Bustillo (2010, p.355) as "a type of international investment with the aim of a long lasting involvement in a business in another country". Many other literatures have applied similar definitions (e.g., Jiang, et al, 1998; Gholipour, 2013; Brixiova et al., 2010).

As a house price bubble is at the root of the subprime crisis in the United States in 2008 and the world financial crisis, the problem that it poses should be evaluated seriously in the wake of such a striking lesson (Martin, 2011). The average house price level in the UK has confronted long periods of high growth, interrupted only by the global financial crisis in 2007/2008. Figures show that the annual real estate price growth rate in March 2016 was 10.1% and reached its highest level in July 2014 (FT, 2016). In the meantime, a trend of rising FDI can be seen in all sectors of the UK, making it the leading country for FDI among European economies (Meakin, 2016). Almost 2,000 projects were received into the UK from 2014 to 2015, a figure 12% higher than the preceding year. A similar situation can be seen in Canada, were the average house price in March 2016 jumped by 15% compared to the same month in 2015 (Evans, 2016). At the same time, international investment, especially in the real estate market have soared enormously. For instance, the number of Chinese buyers for houses in Canada increased by 134% during the same period in 2015 (Sourceable, 2016). Favourable advantages, such as low taxes, have made Canada a profitable location for international investors. More importantly, the UK and Canadian markets are considerably connected in terms of investment. The UK has been the second-largest source of FDI and the second-largest European foreign investor in Canada. Similarly, the UK is also the second largest destination, and the largest European destination, for overseas investment from Canada (Dachis & Jacobs, 2016; Government of Canada, 2018). Canadian corporations invested $93 billion in the UK in 2015, and the peak of investment in the UK from Canada in 2010 formed 5% of the Canada GDP, compared to less than 2% in the 1980s (Dachis & Jacobs, 2016). Due to the increasing investment from Canada to the UK, Luxembourg, and the Netherlands, FDI from Canada in Europe in 2016 grew to nearly $289 billion, with a 7.7% growth rate. In total, more than 1,100 UK companies are either owned or controlled by Canadian entities (Government of Canada, 2018). In the meantime, the reversed flow of investment from the UK to Canada has shown a similar pattern. Figures indicate that over 700 UK corporations have branches operating in Canada (Government of Canada, 2018). Furthermore, as China is an emerging economy, house prices there have grown sharply. Data shows that the average price of new residential property in China in April 2016 was nearly 9% higher than in 2015 (SteelOrbis, 2016). In China, FDI has seen continuous growth as well, with a year-on-year figure of 4.5% in the first quarter of 2016, reaching around RMB 224 billion (Xinhua, 2016). China has been the top developing country to receive FDI since 1995, and the real estate industry has absorbed the second-highest share of investment. Increasing liquidity from foreign investment has raised concerns from economists and investors about the possible existence of a housing bubble in the real estate markets of many economies. Excessive inflow of international capital enabled greater available funds to be operated to boost real estate prices and increase the possibility of inflated house values (Brana et al., 2012). In 2012, the central bank enacted a series of regulations on FDI operations in China, some of which placed restrictions on FDI into properties. The incentive of the regulations is to prevent an overheated real estate market caused by foreign investment. Such speculative capital can easily pursue a high return and flow into the most profitable industries, such as real estate, ultimately bidding the asset price up (Hui & Chan, 2014). Although limitations have been applied on FDI into property purchase, the construction sector of the real estate market has not been affected in China. The deputy minister of information at the China International Economic and Exchange Centre, Wang Xiaohong, stated that FDI inflow to China in 2013 was the second highest globally, with the service sector occupying 70% of foreign investment in 2016. In particular, the construction industry is one of the fields that has received the most foreign investment (Wang, 2018). She stated that FDI is integral to development in China in terms of promoting innovation and technologies. A housing bubble is measured as the divergence of real estate price from fundamental values, and foreign investment inflow might enhance real estate price from a speculative nature. Thus, housing price volatilities and the ultimate housing bubble could be generated from the inflow and outflow of foreign investment (Kuang, et al., 2011).

Given the global and domestic context of FDI and the housing sector, the primary objective of this study is to examine whether foreign investment acts as a critical factor in promoting high house prices in the UK, Canada, and China. While the above evidence may suggest that inward FDI can manifest in a bull real estate market, research into the effects of inward FDI has been scarce. The soundness of the property market is one of the vital elements underlying the stability and development of the economy, especially in the UK, Canada, and China, which all occupy central positions in the global market. Hence, preventing irrational boost in the real estate industry by speculation activities along with capital inflow is a topic of great importance. To fill in this gap in research, we aim to test the causal relationship between inward FDI and house and rental prices in these countries. The findings of this chapter indicate no significant connection between FDI and housing prices in the UK, with UK housing prices responding more to other variable shocks, such as in GDP and rental price. Conversely, the relation between FDI and housing prices in Canada and China are prominent, as assessed in the chapter, signifying a vital role of FDI in the Canadian and Chinese real estate sectors.

A comprehensive range of literature has examined the impacts of capital inflow on high real estate prices, and the interactions between these two factors have also been studied. For instance, Gholipour (2013), Tillmann (2013), and Kim and Yang (2011) have explored the effect of capital inflow on house prices in emerging economies, and Jiang et al. (1998), Song and Gao (2007), Guo and Huang (2010), and Kuang et al. (2011) focussed specifically on the Chinese market. However, a limited amount of literature has concentrated on the developed market, with Gholipour et al. (2014) and Sa et al. (2011) constituting exception who examined the interaction between foreign investment and real estate prices in OECD countries.

3.2 Literature Review

3.2.1 Background

International interaction in the real estate market has experienced a phenomenal development, and an increase in FDI in the real estate sector is associated with a higher demand for housing, as more resources become available for investment. This services industry has internationalised at an unprecedented pace, involving an increasing number of multinational real estate corporations (He & Zhu, 2010). Encouraged by the fact that there is a shortage of global real estate trade, other substitute activities, such as cross-border housing investment, global projects, and international ventures, have expanded. For instance, a total sum of USD 40,640 million has been seen in cross-border merger and acquisition sales in the area of global housing during the period 2001–2003. A series of promotional policies and the maturity of the real estate market have jointly contributed to the increase of foreign investment in the housing industry (Gholipour Fereidouni & Ariffin Masron, 2013). More importantly, these activities occur not only in developing economies, which are seen as traditionally hospitable to international capital, but also in developed economies that possess highly mature real estate industries (He & Zhu, 2010). Through bringing advanced technology and knowledge to receiving countries, FDI has been commonly believed to be positive to boost housing prices (Kepili & Masron, 2011). However, it should be emphasised that despite the advantageous nature of foreign investment, foreign corporations can acquire potential monopoly power with advanced technology and management expertise and therefore edge out the low-performance domestic real estate companies (Boakye-Gyasi & Li, 2016). Consequently, the potential benefits of FDI inflow are only achievable by adopting adequate environmental policies in the recipient country.

The previous focus in this field, by studies such as Song and Gao (2007), Kim and Yang (2009), and Tillmann (2013), has been placed predominantly on emerging economies, since they have shown significant economic booms, real estate price increases, and foreign capital inflow surges. More specifically, a dramatic growth in foreign real estate investment (FREI) has been witnessed in most emerging countries in the past several years. For instance, the portion of FDI that flow into the real estate industry in China comprised more than one-third of investing enterprises in the 1980s and 1990s, and this figure reached a more stable level of near 15% between 1990 and 2009 (Gholipour, 2013, p.32; He, Wang, & Cheng, 2011, p.268). In Vietnam, nearly 40% of the total USD 72 billion in FDI was into the development of real estate and construction projects until the end of 2008 (Nguyen, 2011). Because of the speculative nature of profit-seeking, foreign capital is invested in sectors with high returns (Nguyen, 2011). In addition, because of the comparatively unbalanced development of the capital market in emerging countries, FDI becomes the primary channel for foreigners who hope to conduct profit-orientated trades in the housing industry (Jiang et al., 1998; S. Kim & Yang, 2011).

Researchers have shed light specifically on China, a rapidly developing economy, to analyse this topic. As an emerging market, China has seen a substantial improvement in economic fundamentals and a sufficient loosening of regulatory restrictions (Kim & Yang, 2011), in which context both domestic investors and global speculators have been blamed for the surge in housing prices (Chan, 2007). From as early as the late 1980s, when the real estate industry in China began to develop and created remarkable revenue, soaring expectations drove the attention of speculators to this leading industry. Moreover, since China's openness policies were adopted in the 1980s with its accession to the World Trade Organisation (WTO) in 2002, speculation has become more prevalent among foreign investors in the real estate sector, with enormously inflated housing prices as the result (Kuang et al., 2011). In 2002, China surpassed the United States to become the top FDI receiver in the world (Chan, 2007). China's transition from a developing country into one with a prosperous and robust economy offered a massive opportunity for businesses to attract the attention of housing investors to chase for profit. Therefore, as strongly expected, China became the leading destination of foreign investment in 1993. China has witnessed a rapid foreign exchange storage expansion, which has be the first in the world (Song & Gao, 2007). Increased speculation among foreign investors led to the injection of a large amount of money into the Chinese market, especially in the real estate sector, which accelerated inflating housing prices (Kuang et al., 2011). The percentage of foreign investment in China among all Asian foreign investment destinations has been tremendously high, soaring to 73% in 2005 (Kim & Yang, 2011). From 1992 to 2008, the amount of aggregate FDI in China increased from around USD 10 billion to nearly USD 100 billion at an average rate of 14% per year (He & Zhu, 2010). In the meantime, a noteworthy portion of this international capital flows into the housing market, for example, one-third from as early as 1985 (He & Zhu, 2010; Jiang et al., 1998). From as early as the 1980s, more than one-third of aggregate FDI is assigned to real estate development (He & Zhu, 2010). In the 1990s, the annual rate of increase of investment into the housing market was around 125% (Jiang et al., 1998). More recent evidence shows that FDI into the Chinese real estate sector has absorbed has occupied almost 15% of total FDI in the last 20 years (Gholipour, 2013). For instance, in contrast with around USD 8 billion in 2006, the aggregate amount of FDI into real estate in 2007 approached USD 17 billion, and this trend has persisted thereafter (KPMG, 2007). In recent years, the real estate industry has even become the second largest industry in China, further attracting overseas investments (Song & Gao, 2007). The appreciation of the RMB is also an essential factor leading overseas investors to expand their investment into China. In addition to major cities such as Beijing and Shanghai, the demand for real estate asset investment also appears to be active in many second-tier cities (KPMG, 2007).

However, in the current context, many developing countries such as China are sending considerable savings into advanced countries (Gordon, 2011; see **Figure 3-1**), and significant growth in the investment flow both to and from developing countries can be seen (Forfas, 2014). In contrast to historical trends in the international finance, many emerging markets, such as China, Hong Kong, and Russia, are now in the position of capital exporter. Despite the rapid growth of FDI in some emerging economies, it is undeniable that most of the top FDI inflow countries remain advanced economies. In particular, in one report in 2015 which measured the global FDI rank using the A. T. Kearney FDI Confidence Index, China, the UK, and Canada occupied the second to the fourth positions (Thirlwell, 2015). This index is interpreted as a forward-looking index showing the expectation of FDI performances in the coming year. The UK and Canada have experienced large FDI flows, and with high expectations of future flows as well. Moreover, a large portion of this FDI inflow has been received from emerging economies. For example, India became the third largest FDI source in the UK in 2015 (PTI, 2016). The FDI inflow from India increased by 65%, and the number of Indian corporations in the UK almost doubled, from 36 to more than 60. In these circumstances, however, the causal relation between FDI and housing price in advanced economies, especially the UK and Canada, has received little attention. The trend of overseas investment in the UK is worth attention apart from its soaring housing price. With more focus being attracted to the UK property sector, overseas investment has confronted steady growth in recent years. The statistics show that even if under the global climate of an 18% decline in foreign investment in the period 2012–2013, the public witnessed a rise of 22% foreign investment inflow in the UK (Perria, 2013). Until last decade, economic development in Canada was characterised by a typical capital flow pattern, in which capital runs from advanced countries with higher savings standards to emerging markets (Gordon, 2011). However, Canada has also become one of the advanced countries on the receiving end of investment. Indeed, the real estate industry of metropolitan cities in many developed countries has experienced massive capital inflows from wealthy investors in emerging economies, such as those of Latin America and the Middle East. This has massively driven up housing prices and caused a construction boom (Surowiecki, 2014). A large portion of these foreign buyers have purchased houses as speculative investments rather than for the purposes of living or renting (Marlow & Jane, 2014). Vancouver, a representative city in Canada, has gradually become a global real estate market due to immigration and foreign investment. A large real estate agent has reported that buyers from China account for approximately one-third of buyers, while roughly half of luxury-house sales went to international buyers between January and June 2013 (Marlow & Jane, 2014;

Surowiecki, 2014). This influence is advantageous if the inflow ends of the capital are beneficial investment projects; however, it might cause concern if the housing or stock prices are stimulated and hence yield bubbles (Gordon, 2011).

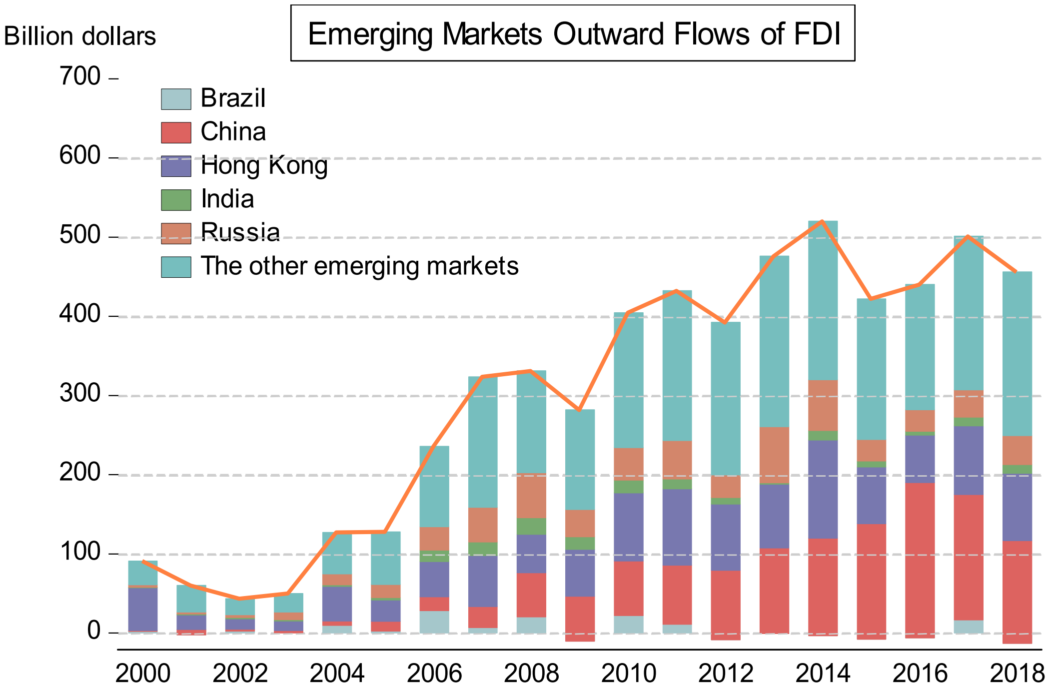


Figure 3-1 *Emerging markets outward flows of FDI*

Notes:

- Data source: United Nations Conference on Trade and Development
- The line chart presents the total outward FDI level from emerging markets

3.2.2 Conceptual Framework

Based on the assumption, previous research has explored the performance of foreign investment and housing prices in the UK, Canada, and China. China, as an emerging economy, has been drawn much attention. Guo and Huang (2010) investigated the effect of another kind of capital inflow, speculative hot money inflow, on the real estate and stock markets in China. Hot money here refers to speculative capital received from foreign countries that seek short-term profit, interest rate differences, or exchange rate fluctuation. According to its nature, this paper examines whether hot money fuels the market and promotes a real estate bubble. Kuang et al. (2011) and Song and Gao (2007) also examine the link between capital inflow and the housing prices in China. Given the rapid growth of both foreign exchange storage and the real estate industry, Song and Gao (2007) reinforced the importance of investigating the effects of international capital on real estate price levels. Similarly, inspired by soaring house prices and massive foreign investment, together with a theoretical model indicating capital inflow as a vital factor, Kuang et al. (2011) discovered the impact of foreign investment on Chinese housing prices from the demand and supply sides in 31 major cities in China. Furthermore, He et al. (2011) illuminated the location pattern of foreign investment in provinces in China. By controlling for spatial autocorrelation effects, this paper aimed to discover the relationship between foreign investment and housing prices and to examine the investment distribution issue, examining how investments are distributed among provinces with diverse real estate price levels and labour costs. Comparably, He and Zhu (2010) also drew attention to local market conditions and regional institutions in China in the context of the development of foreign capital inflow. In the context of foreign real estate investment as a contributor to an extreme increase in house prices in China, Chan (2007) provided an overview of the development of foreign investment in China and how it results in high real estate prices. The study also examines the effects of government control on foreign investment on investors. Given the dynamic of surging housing prices in China, Zhang et al. (2012) built a model to investigate vital determinants that affect housing prices. Of the variables, hot money as one type of capital inflow was also a factor pushing the real estate market. Due to the expectation of the appreciation of the RMB, global speculative investors have been sending money into the Chinese stock and housing market (Zhang et al., 2012), and Zhang et al. stated that this inflow contributed to stimulating stock prices and the real estate bubble.

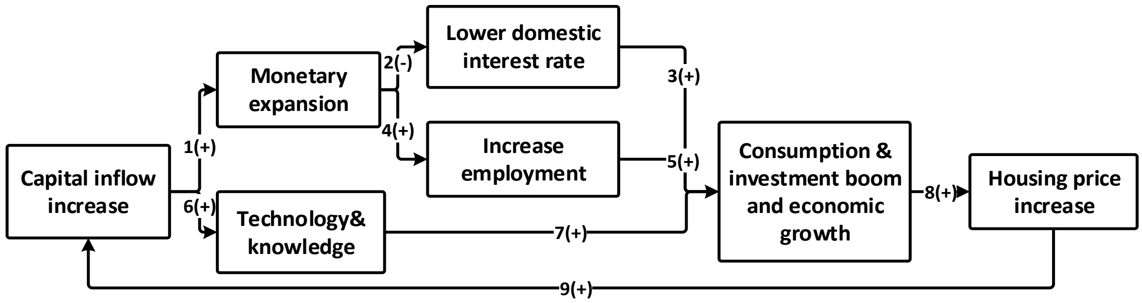
Relatively less focus has been placed on developed countries. It is undeniable that a huge surge of capital has flowed into emerging markets, and this has received much attention in literature in the past several years. However, capital has also been transmitted gradually from emerging economies to advanced markets. Statistics indicate that the lowest level of capital inflow since 2009 occurred among emerging countries in 2015 due to the slowdown of economic growth in many emerging markets. The total amount of capital inflow dropped from USD 1,048 billion in 2014 to USD 981 billion in 2015 (Wheatley, 2015). Moreover, a large absolute outflow of capital has been seen to emerging markets, with USD 735 billion of capital flowing out in 2015 (Shaffer, 2016). Advanced economies number among the destinations of this capital, but research focussing on the link between housing prices and capital inflow for advanced economies is scarce. Given that the mature real estate sectors in these countries attract a large amount of foreign investment, it is vitally important to understand this topic. A comparatively early study by Bonis (2006) noted the link between foreign investors and hiking real estate prices in the United States. The study claimed that the United States has been attractive because its property market is relatively more stable and secured with strict laws. Foreign direct investment has accounted for a measurable portion of demand for houses in the United States, and Bonis (2006) thus attempted to explore whether FDI has a vital influence on real estate price fluctuations and commercial real estate prices in particular. South Korea is another exceptionally developed country that has been studied in this context. Kim and Yang (2009) analysed the impact of capital inflow shocks on both equity prices and property prices in Korea to determine whether foreign capital causes surging asset prices. Their study asserted that, comparable to other Asian countries, Korea is a popular destination for capital, and the discussion of this issue is vital for economies that suffer from crisis and to attempt to avoid the boom-bust cycle (Kim & Yang, 2009). In recent years, the OECD countries as a group have also become the subject of the debate regarding the existence of a link between foreign capital and housing prices. The evolution of capital inflow and the real estate industry can be seen not only in developing economies but also, more importantly, in developed countries, and this has been gradually been noticed in the literature. For example, 18 of the OECD countries are studied in the paper by Sá et al. (2011) and their later research Sá et al. (2014) to investigate whether capital inflow played an important role in motivating real estate booms before the 2008 global crisis. Sá et al. (2011) concentrated on shocks in two areas, monetary policy and capital inflow, because many OECD economies have encountered low interest rates, high levels of foreign capital, and soaring housing markets. Their work aimed to identify how real estate variables respond to these shocks and to determine how the results change with different development levels of the mortgage market and mortgage-based securities (Sa et al., 2011). In their updated study, Sá et al. (2014) specified to examine only shocks to capital inflow to discover how these affect the housing market and how the mortgage market structure and securitisation level shift with changes in capital inflow, thereby identifying the channels by which shocks affect the housing market price level Sá et al. (2014). Comparably, Gholipour et al. (2014) also selected OECD countries to explore the interrelation between FDI in the housing area and property prices. Since the economy, property price, and foreign investment in these OECD countries have been growing together expeditiously, proposals have been made that economic growth might be influenced by foreign capital as well. In addition, one study, about foreign real estate investment in Spain, by Rodríguez and Bustillo (2010), concentrated on this topic in an advanced country. In the context of large foreign real estate investment inflow in Spain, as well as the housing bubble and current account deficit that this causes, the object of this paper was to discover which elements determine changes in foreign investment in real estate sector (Rodríguez & Bustillo, 2010). As Spain is an attractive tourism destination, the study assumed that an indispensable part of capital inflow might be derived from investment from global tourists. Consequently, this study models FREI from the perspective of the demand and financial focus of tourism services. The 2007 US financial crisis and the successive global crisis have been a prevalent topic in academic discussion, and a series of hypotheses have been raised to explain the house price surge in the United States prior to the crisis. Among these studies, Sa and Wieladek (2010) is one of the exceptions that considers the mechanisms underlying the large amount of capital inflow. This study proposed two suggested determinants, namely, the loosening of monetary policy and capital inflow. Excess liquidity in the global environment might negatively influence long-term interest rates, and the Federal Reserve had been operating under a loose monetary policy to keep interest rates low during early 2000s (Sa & Wieladek, 2010). Given this context, this study selected monetary policy and capital inflow as its independent variables to explore which hypothesis can best justify the housing price boom in the United States.

In summary, when discussing the causal link between FDI and real estate prices, scarce attention has been paid to the UK and Canada. Several studies have analysed this topic in other advanced economies, such as the United States and France, and these studies justify the importance of discussing this topic in developed countries such as the UK and Canada. However, no substantive studies have chosen FDI as the primary variable to thoroughly investigate foreign investment and housing price. Other indicators, such as capital inflow, hot money, and FREI, have instead been selected by previous literature in this area. Moreover, many studies place their interest mainly on asset prices, incorporating not only real estate but also stock prices. Other factors such as monetary policy and location distribution have also been involved in consideration by some research when analysing the relation between capital inflow and housing prices.

3.2.3 Theoretical framework

There are several mechanisms through which foreign investment could affect real estate prices, namely, aggregate demand–driven, demand for property–driven, and liquidity-based mechanisms (Gholipour, 2013; Kim & Yang, 2011).

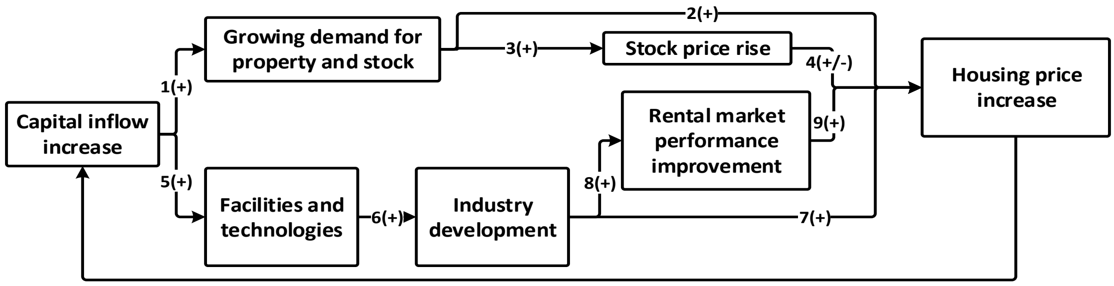
I. Aggregate demand–driven mechanism



Mechanism 3-1 *Aggregate demand-driven mechanism (Source: Author based on literature)*

The aggregate demand–driven channel involves the inflow of capital or FDI fuelling basic economic growth, and this channel works through two aspects: monetary expansion and the introduction of technology. 1. The influx of capital primarily generates monetary expansion, which stimulates the growth of the economy by receiving finance for domestic investment (Kim & Yang, 2011). 2. Induced by a low world interest rate, the growth of the money supply produces downward pressure on the domestic interest rate. 3. A lower interest rate in domestic market encourages people to consume rather than save, with borrowing and mortgage interest both being cheaper. Similarly, investment in assets is more attractive under lower interest rate conditions. Thus, a heightened level of consumption and investment creates an economic boom and improves living standards (Gholipour, 2013; Kim & Yang, 2009; Tillmann, 2013). 4. Foreign direct investment can increase the level of employment in the host country, as investment into companies can increase the demand for labour (Jenkins, 2006). 5. Employment and labour demand have been asserted to be closely linked to economic growth, property prices, and rental prices in theory, since workers must buy or rent houses to live (Chakrabarti & Zhang, 2015). 6. However, rather than the simple capital accumulation, one aspect of FDI is that it can lead to economic growth through the importation of technology and knowledge. Multinational corporations are one major group that engage in FDI and transmit technologies (Borensztein, De Gregorio, & Lee, 1998). 7. A higher GDP level and larger market size can be the result of new technologies, which can also boom the domestic economy. 8. Notably, appreciation for houses tends to be inelastic, which means that growth in housing and rental prices do not lower this demand in the short term. Given this circumstance, changes in the domestic economy would therefore affect the housing market. 9. In the meantime, a feedback mechanism can be identified between capital inflow and property price. When the real estate market encounters a boom and housing prices surge significantly, the profitable market will absorb more investment, such as foreign capital inflow, especially for speculative purposes.

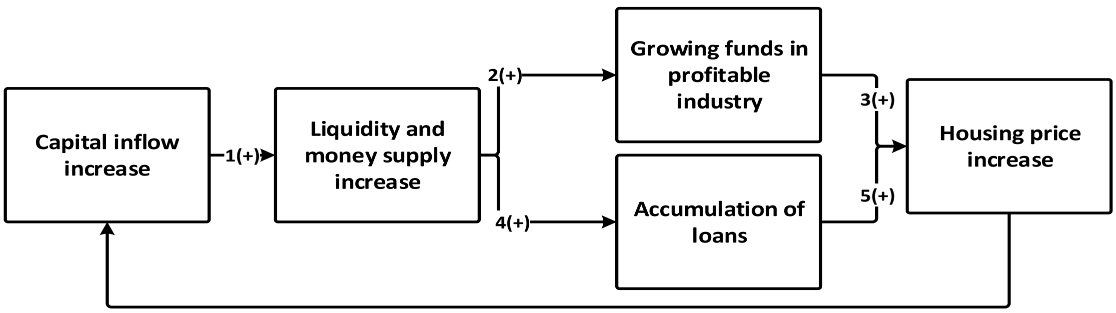
II. Demand for property–driven mechanism



Mechanism 3-2 *Demand for property–driven mechanism (Source: Author based on literature)*

In a demand for property–driven channel, foreign investment can directly cause a housing price boom. 1. In this channel, the increase in foreign capital in the market generally increases the demand for property, placing upward pressure on the property price (Gholipour, 2013; Kim & Yang, 2011). 2. When the speculative housing demand is enlarged due to foreign capital inflow chasing for profit, the real estate market and housing business is boosted as a whole (Song & Gao, 2007). This cycle begins with credit expansion, is followed by investment and the rise in asset prices, and ends up with the burst of the bubble (Gholipour, 2013). 3. Moreover, different markets are also closely linked. For instance, more capital inflow towards the stock market can stimulate higher stock prices. 4. When the expected return of the stock market increases, investors transfer their money away from the real estate industry as a substitute investment alternative, which causes a negative influence on housing prices (Kim & Yang, 2011; Shiller, 2014). However, in terms of the theoretical mechanisms in Chapter 4, there is also a positive effect from stock prices in the housing market under the information, wealth effect, credit effect, and composition risk mechanisms. Stock return contains information on future housing activity, enhances household wealth, and provides credit for housing consumption (Binswanger, 2000; Lean & Smyth, 2014; McMillan, 2011). Accordingly, housing prices could be affected either positively or negatively through the influences of the stock market. 5. In the meantime, the inflow of this international capital also brings advanced facilities, technologies, and strategies to the real estate market. 6. For those countries which lack and have a high demand for advanced technology for real estate development such as house-building, the inflow of FDI and expertise rapidly boosts the housing market (Kepili & Masron, 2011). 7. Foreign direct investment is a way for the real estate industry to access technology. As a result of this inflow, the housing industry encounter advanced development and thus a higher price level (Song & Gao, 2007), which provides an opportunity for the domestic housing market to develop. 8. From the rental market side, an expansion of foreign capital in the housing industry, such as real estate agents might also improve the performance of the rental market. 9. This channel, in turn, drives the real estate price up, since the present value of future rental cash flows decides housing prices, in theory.

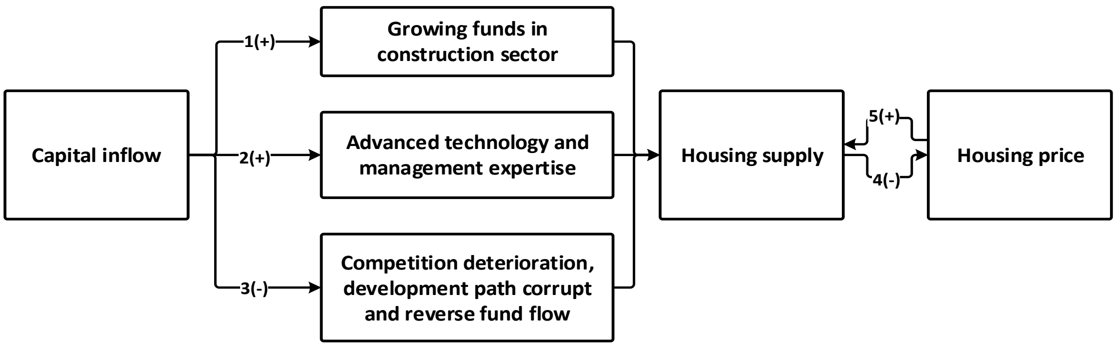
III. Liquidity-based channel



Mechanism 3-3 *Liquidity-based channel (Source: Author based on literature)*

In the liquidity-based channel, with excess liquidity from the global market flowing in, the money supply and domestic liquidity increase. 1. Generally speaking, capital inflow leads to nominal and real exchange rate appreciation (Kim & Yang, 2011; Tillmann, 2013). Thus, the intervention from authorities to stabilise the domestic currency results in the purchase of foreign currencies and the release of the domestic money supply. 2. A continuous inflow of foreign capital can cause currency appreciation and an imbalance in foreign income and payment. A rigorous monetary policy by the government in response might encounter a weaker actual effect on the market due to the speculative expectation of the inflow funds (Song & Gao, 2007). This is followed by short-term speculative international investment and price level fluctuation with high profits, which further raise domestic liquidity. 3. A growing liquidity flow into the asset market tends to promote asset prices (Kim & Yang, 2011). 4. Simultaneously, higher liquidity transferring into the market would ultimately generate more loans in the housing market than can be repaid. 5. This might cause house prices to escalate sharply and lead to the creation of an unstable bubble (Brana et al., 2012). More importantly, this can lead to the accumulation in banks of subprime loans, which contain a large risk of non-repayment and which caused the US financial crisis of 2008.

IV. Capital inflow and housing supply



***Mechanism 3-4** Capital inflow and housing supply (Source: Author based on literature)*

Capital inflow has, in theory, also presented a close connection with the supply side of the real estate industry. 1. The possibility of domestic investment deviation from the national saving level is theoretically reasonable with the existence of additional funds from FDI, which improves disposable income and saving (Saka & Lowe, 2010). This ultimately contributes to higher investment in the construction sector and therefore an increased housing supply. 2. In addition, apart from providing an inflow of capital, FDI brings with it technology, entrepreneurial skills, and management practices (Ebekozien, State, Ugochukwu, Chukwudi, & Okoye, 2015; Türkcan, Duman, & Yetkiner, 2008). Foreign direct investment has been identified as the key source not only of funds but also of technology to the hosting country (Boakye-Gyasi & Li, 2016). More advanced technology and better management strategies applied by multinational companies can be introduced to the receiving country by FDI (Babatunde, Awodele, & Adeniyi, 2018). This improvement might result in an improvement in productivity and efficiency in local businesses, including real estate developing companies. In particular, subsequent private investment spending would be encouraged by the increased productivity to promote continuous growth (Ramirez, 2006). 3. However,, there might also be negative influence from FDI on construction growth since competition might be deteriorated, which might obstruct the development path in the receiving country (Türkcan et al., 2008). In addition, resources can be diverted from the host country and after a time generate a reverse flow in the form of the repayment of dividends or profit back to the head corporations (Ramirez, 2006). 4. In the meantime, fluctuations in the supply side of the housing industry can potentially generate impact on housing price changes, as, in theory, a higher housing supply compared to housing causes negative pressure on the price level. 5. Conversely, when housing prices continue to increase, a feedback effect can be produced towards the construction sector and create a higher housing supply, seeking more profit from upward trending prices.

The above mechanisms constitute the summary of the theoretical basis for this chapter. They have been proposed to be the potential key channels through which the variables in the model affect each other. Meanwhile, it is worth noting that the actual effect of individual mechanism may differ and change across countries, especially since countries are facing diverse contexts of economic perfomance. Hence, a more thorough analysis is waited to be examined by future research to disclosure the dominance of mechanisms in each country.

3.2.4 Methodological framework

When measuring the relationship between capital inflow – or, more accurately, foreign investment – and asset price, most of the studies have primarily used a VAR model. Compared to the single-equation model, in which the result depends strictly on model selection, the VAR model tends to be more trustworthy (Song & Gao, 2007). Gholipour (2013), Tillmann (2013), Kim and Yang (2011), and Kim and Yang (2009) choose a VAR methodology using panel data from different emerging economies to conduct their research. Gholipour (2013) applied the annual data of FREI, GDP, output, long-term interest rate, and construction costs in 21 emerging economies. Tillmann (2013) and Kim and Yang (2011), by contrast, only examined five emerging countries, with the aim of discovering the shocks of capital inflow not only on property prices but also on equity prices. Tillmann (2013) included capital inflow, GDP, consumer price index, exchange rate, and interest rate from 2000 to 2011, whereas Kim and Yang (2011) included output, price level, capital inflow, and exchange rate. Many studies that have focussed on the real estate industry in China have also employed the VAR approach. A study conducted by Song and Gao (2007) adopted the vector error correction model (VECM) on international capital inflow, land dealing price, and consumer price index. In addition, the research of Guo and Huang (2010) about the housing market and stock market in China amended the VAR model by using the Markov regime-switching feature. The approach in Zhang et al. (2012) involved vector error correction analysis to investigate influencing factors for housing prices, but the primary estimate they proposed is the nonlinear autoregressive moving average with an exogenous inputs model. Several other, exceptional papers, namely, Sa et al. (2011), Sá et al. (2014), and Gholipour et al. (2014), examined both developing and developed economies, applying a panel VAR model. Sa et al. (2011) and Sá et al. (2014) built a panel VAR model that included 18 OECD economies. Sa et al. (2011) selected both monetary policy, reflected by interest rate, and foreign capital, represented by current account balance, as its key factors, and a total of ten variables were included in the panel VAR model. Sá et al. (2014), by contrast, included 13 variables such as real house prices, real credit available, and residential investment in their methodology. Similarly, the annual data of FDI in the real estate area of 21 OECD countries was incorporated in the cointegration approach by Gholipour et al. (2014). The study on the US case by Sa and Wieladek (2010) also applies a VAR model on short-term and long-term interest rate, current account balance, residential investment, and real house prices, and other variables were GDP, price index, and exchange rate. In addition to the VAR model, previous research has proposed several other methods. Kuang et al. (2011) established a partial equilibrium and adopted the system generalised method of moments estimator to explore the influence of foreign investment on house prices in China. Rodríguez and Bustillo (2010) modelled FREI using three models, a financial, demand for services, and eclectic model, and used the Engle and Granger approach to check for a cointegration relation. An earlier study by Bonis (2006) adopted a relatively more straightforward approach, an aggregated regression model, to analyse the sample data and reveal the degree to which real estate prices change with shifts in FDI.

Above all, much of the previous literature used VECM and VAR models to explore the relation between capital inflow and real estate prices, while some of the studies applied structural VAR. Therefore, this chapter applies a structural VAR model with the aim of revealing the economic response of targeting variables to a structural shock of other variables. Exceptions can be found in Sa and Wieladek (2010) and Kim and Yang (2011), which apply structural VAR. Nevertheless, none consider FDI as the indicator of the capital inflow representative.

3.2.5 Analytical framework

Property bubbles and house prices are linked to capital inflows, and shocks to these inflows have crucial impact on the growing real estate price level. Notably, a strong positive interaction between the size of capital account balance and changes in property prices has been demonstrated in developing as well as in advanced economies (Sa et al., 2011). Especially in emerging economies, in which measures regulating international portfolio investment have been eased through liberalisation, capital inflows have been further promoted (Kim & Yang, 2011, Song & Gao, 2007). Real estate prices attract more profit-chasing foreign capital in the short term, while in the long term, foreign capital boosts housing prices (Song & Gao, 2007). Guo and Huang's (2010), Zhang et al.'s (2012) and He et al.'s (2011) conclusions about Chinese market accords with that of Song and Gao (2007), claiming that international investors and hot money have driven up real estate prices by introducing capital as well as by bringing in advanced practices. Especially in a highly volatile regime with more flows of capital, the explanatory power of hot money is even greater (Guo & Huang, 2010). A case study of performance in Shanghai indicates that FDI is the primary factor boosting the real estate industry regardless of the contrary situation in other markets over the same period (Jiang et al., 1998). In particular, foreign capital appears to have apparent geographical distribution characteristics among provinces. These investments tend to be targeted at coastal areas and cities as well as metropolises in the interior with higher housing prices (He et al., 2011; He & Zhu, 2010). Investors usually follow opportunities with higher profit while avoiding areas with more costs.

There are also evidences of foreign investment in real estate influencing the housing market of advanced economies. Modelling foreign investment, Rodríguez and Bustillo (2010) asserted that housing price levels, in return, had a crucial influence on foreign real estate investment growth in Spain. Analogously, Gholipour Fereidouni and Ariffin Masron (2013) found the same result, that foreign investors in the housing industry generally favoured areas with higher property prices. This study, to certain extend, justified the choice of the three countries studied in this thesis. The UK, Canada and China are particularly economies that drive the attention of foreign investors as all the three markets are undergoing fast housing price growth. It may also provide suggestions to future research to focus on regional diversity in the target countries. It is important to mention that, although Bonis (2006) found a definite causal relation between FDI and property prices in six sample cities in the United States, this link is negative according to the result. Foreign direct investment can indeed be a predictor of housing prices, but with an upward shift in FDI, the real estate prices decrease. This outcome is more prominent in the individual model, which includes only one specific type of property, and is less conspicuous when the overall model is tested (Bonis, 2006). This result, however, is opposite that of Sa and Wieladek (2010), who found an unambiguous positive relation between capital inflow and house prices. Sa and Wieladek (2010) asserted that the influence of capital inflow on US real estate is twice as large and more persistent. This argument does not accord with that of Gholipour (2013), Gholipour et al. (2014) and Kuang et al. (2011), who stated that foreign investments have only a minor role in explaining soaring housing prices. Instead, it is the housing market itself and other macroeconomic factors that contributes to the fluctuation.

3.2.6 Gaps in the literature

3.2.6.1 Conceptual framework

Many analyses of the causal link between foreign investment and asset prices contain other determinants such as monetary policy. Other studies may limit their variable to capital inflow in general, hot money, or to FREI, a specific part of investment. This part of the effect is only one aspect of how FDI might influence domestic housing prices, as it could also raise liquidity and generate economic booms and lead to shifts in the need for housing. Furthermore, while mature real estate sectors in developed countries have absorbed a large amount of foreign investment in recent years, insufficient attention has been paid to the situation in the UK and Canada, with most of debate centring on emerging economies. Several studies in this field have examined advanced economies such as the United States, France, and Korea, and these justify the objective of this study, namely, to analyse the situation in the UK and Canada. As for China, many studies have examined a group of determinants for housing prices or foreign real estate investment. Even if there are exceptions such as Song and Gao (2007) and Kuang et al. (2011), which analyse the influence of foreign investment on housing price in China, only specific provinces have been evaluated in Kuang et al. (2011), and capital inflow index is the selected factor in Song and Gao (2007).

3.2.6.2 Theoretical framework

Under the theoretical framework for the causal relationship between FDI and real estate prices, three channels have been proposed by previous research to explain the mechanism. First, capital inflow could boom the economy in the host country (**Mechanism 3-1**). Second, investment could directly increase the demand for property (**Mechanism 3-2**). Finally, the inflow of capital tends to bring in excess liquidity to the market in the receiving country (**Mechanism 3-3Error! Reference source not found.**). Nevertheless, one vital element – rental price – has not been assessed by existing literature. The basic notion for explaining fundamental housing price is the present value of future rental income flows. Changes in the rental market are closely linked to fluctuations in the real estate market according to **Mechanism 3-3**. Given this context, the question then concerns the relation between FDI and rental prices. Through the rental price channel, FDI could make a further contribution to real estate prices. Accordingly, this study incorporates FDI, housing price, interest rate, rental price, and economic growth as essential variables in building the model to address the causal relationship between foreign investment and real estate price in the UK, Canada, and China.

3.2.6.3 Methodological framework

Regarding the methodology proposed by previous literature in this area, different approaches have been applied, such as a system generalised method of moments and regression. Many articles focussing on the relationship between foreign investment and house prices, however, have applied traditional a VAR approach and the VECM to examine their topics. Exceptional studies include Sa and Wieladek (2010) and Kim and Yang (2011), in which a structural VAR was constructed to analyse the structural response towards economic shocks. However, Sa and Wieladek (2010) placed their primary focus on the interaction among monetary policy, capital inflow, and property prices, and Kim and Yang (2011) focussed primarily on portfolio inflow and asset prices like stock price and land price. Neither used FDI as the independent variable. As a result, this research employs an SVAR model as well as a Granger causality test and IRF as a by-product to explore the link between FDI and housing price.

3.2.7 Contributions

This research, on the whole, has provided new understanding and knowledge of the previous theory on whether FDI affects housing prices. Contrary to the previous view that developed economies such as the UK and Canada have faced capital outflows rather than capital inflows, this study raises a new insight into the real estate price issue. It proposes that capital inflow such as FDI into these developed countries has played an essential role in explaining the surge in housing prices. A new focus has been placed on the relationship between foreign investment and fluctuations in real estate prices to help policymakers by providing new insights from the analysis. These suggestions include monitoring unacceptable behaviours, promoting professionalism and training in construction projects, and avoiding abuse of power in investment agencies (Boakye-Gyasi & Li, 2016). Moreover, accepting rental price to be one key element in housing market, this chapter has also provided new implications for policymakers by constructing a detailed analysis of FDI, rental prices, and housing prices. This study provides countries that experience high capital inflow with information on the implications of this inflow for their domestic economy and real estate market development. It helps the government to impose stringent restrictions to restrain speculative behaviours. Profit-seeking investors will also benefit from this study by reconstructing their understanding of decision-making based on the results to avoid the potential risk of burst after excessive inflation.

3.2.8 Hypotheses

Establishing from the literature, the following hypotheses have been proposed in this chapter.

H_1: FDI has a positive effect on real estate prices in the UK, Canada and China. Under **Mechanism 3-1** aggregate demand–driven, **Mechanism 3-2** demand for property–driven and **Mechanism 3-3** liquid-based mechanisms, FDI can cause a positive impact on the housing price fluctuations. FDI can directly inflate real estate demand and can cause the economy to boom, bringing in excess liquidity to indirectly increase housing prices. The aggregate demand in the market, the specific demand in housing industry and the level of money supply have all been boosted with increasing foreing investment (Gholipour, 2013; Kim & Yang, 2011; Song & Gao, 2007). These result in a higher demand for properties to drive prices up.

H_2: FDI has a negative effect on real estate prices in the UK, Canada and China. In **Mechanism 3-2**, the inflow of capital brings demand for stocks, which may cause a negative effect on housing prices (Kim & Yang, 2011; Shiller, 2014). The stock market is led by capital inflow to absorb the funds from the housing market. Similar effects present in **Mechanism 3-4** the housing supply channel, with a growth in the housing construction sector caused by the growth of funds and technology, in which circumstances negative pressure is exerted on property prices (Saka & Lowe, 2010).

H_3: Real estate prices have a positive effect on FDI in the UK, Canada and China. Suggested by the theory, there is a feedback effect from property price to FDI. A boosted real estate market encourages both local and global market expectation, and thus stimulate foreign investment especially for speculative purposes (Song & Gao, 2007).

3.3 Methodology

3.3.1 Data

3.3.1.1 Variable selection

This study examines the effect of foreign investment on real estate prices, and to this end, specific variables have been chosen. The represented indicator of foreign investment that this model applies is FDI, with direct investment from foreign individuals or companies into production or business in the domestic market being considered. The role that FDI plays through global speculators in the real estate market is vital, and the manner of aggregate demand–driven, demand for property–driven, and liquidity-based mechanisms in which it influences the real estate market supports the choice of FDI. The reason that FREI was not chosen in this study depends on some particular impacts brought by FDI in the real estate market. Despite the direct influence, the shocks of FDI also lead to changes in domestic liquidity and economic booms, which might indirectly affect housing prices (Rodríguez & Bustillo, 2010). These justify the selection of FDI when analysing the impact of foreign investment in real estate prices. This study did not select foreign portfolio investment because this is linked to financial securities, and the relation between the stock market and the housing market is discussed in Chapter 4. Although Kim and Yang (2011) argue that portfolio investments in recent years have developed to occupy a more substantial portion of total capital inflow and thus are preferable for selection, their study concentrates more on equity prices than on house prices. Meanwhile, the real estate price index for the UK, which is a relative number which reflects housing price fluctuations and trends in a given period, and the real estate price level for Canada and China is used as one dependent variable to represent domestic housing prices. The real estate price index defines changes in the national average selling price of commodity houses per square metre. Moreover, as demonstrated in the theoretical framework, the rental price level is also included in the model. The rental price level is closely linked to the property market through the determination of the fundamentals of house prices. In addition, the analysis engages the variables interest rate, GDP, and housing supply. Interest rate is an outstanding variable to indicate causality concerning changes in housing prices and is included in this study for that reason. This study expects the interest rate to be non-negligible in the models to explain housing prices. As a reflection of return for assets, the interest rate could affect not only credit condition but also the price of assets other than real estate (Gholipour, 2013). Government bond rates for the UK and Canada and the lending rate in China have been selected for the analysis. Equivalently, the level of GDP is applied in this study to reflect economic growth, which was suggested in the theoretical framework to connect firmly to housing prices and foreign investment. With respect to supply-side time series, this model selects the variables of the number of newly completed buildings in the UK, the floor space of completed buildings in China, and building permits in Canada. Therefore, six variables are included in this econometric investigation: the real estate price index, FDI, rental price, interest rate, GDP, and housing supply.

3.3.1.2 Data collection

This thesis uses secondary data due to the nature of the research objective. Since government departments generally collect official statistics on social and economics topics, economic data are immediately available through online databases (Bryman & Bell, 2015). Primary data on economic topics can be costly and time-consuming to procure, and nationwide data is almost impossible to collect individually. All time-series data included in this chapter are quarterly, and the sample periods for the three countries depend primarily on the availability of data for each.

Among the UK quarterly time series, FDI is the total inward FDI, including the equity capital and reinvested earnings collected from the *United Nations Conference on Trade and Development (UNCTAD)* website. Government bond interest rate is gathered from the *Bank of England* website. The house price index comes from the *Nationwide Building Society*, and it is seasonally adjusted. The actual rental price is calculated with the total rentals for housing and the dwelling stock being rented in the market. These two time series are collected from the *Office for National Statistics (ONS)* and *Home Office* websites respectively and are seasonally adjusted. This seasonally adjusted GDP data collecting from the *Office for National Statistics (ONS)* measures GDP at market prices. The number of completed buildings in the UK is gathered from the *Ministry of Housing, Communities & Local Government*. The period for the UK is 1989 Q1-2017 Q3. Moreover, for Canada, the source of housing price index, FDI, rental income and GDP data are all collected from the *Statistics Canada* website; government bond interest rate comes from the *Bank of Canada* website; the amount of building permits is gathered from *Statistics Canada*. The time series period for Canada is from 1987 Q1 to 2015 Q2. In China case, the time series of house price index, FDI and GDP are collected from *Oxford Economics* website, the bank lending interest rate is gathered from the *People's Bank of China*, the rental price index is from the *National Bureau of Statistics of China* website, and the floor space of completed buildings is from the OECD website. The sample period for China is 1998 Q1 to 2010 Q4 according to data availability. The following notations throughout the chapter are applied to represent different variables. Given the period of t, real estate price index is denoted as $LRHI_t$, real estate price level as $LRHP_t$, foreign direct investment as $LRFDI_t$, interest rate as RIR_t, rental price as $LRRP_t$, GDP as $LRGDP_t$, building completed for the UK and China as LCB_t and building permit for Canada as $LRBP_t$. All the price levels have been adjusted by the Consumer Price Index (CPI) to remove inflation and transform into the real price levels except. Moreover, all of the six variables have been seasonally adjusted and log-transformed to stabilise the variance of time series.

3.3.1.3 Time-series performance

The software being applied for the econometric analysis in this chapter is EViews and STATA. STATA is regarded as a robust and flexible statistical package, which is an optimal choice for econometric research (Baum, Schaffer, & Stillman, 2011). Moreover, Eviews has also been recognised to be an excellent software for detailed time series data analyses, with various choices of package programs (Agung, 2011). **Table 3-1** presents the descriptive statistics for each time series. **Figure 3-2**, **Figure 3-3**, and **Figure 3-4** display line charts of the fluctuations of the time series during the sample period in the UK, Canada, and China. The behaviours of real estate prices and FDI are demonstrated to follow a similar trend in all three economies, although the real house price index shows a tremendous drop prior to 1996 in Canada. Both the housing indices and FDI demonstrate gradual upward progress, especially over the past two decades, with a similar growth rate immediately apparent. The house price level in the UK shows a continuous growth trend before 2007, with the exception of one significant drop, in 1990. This housing crash with bubble bust followed the overshoot of real estate price in late 1980s (Muellbauer & Murphy, 1997). Housing prices fell by 20% during this period. Additionally, the global financial crisis caused the fall in housing prices in 2007, whereafter prices remained at a comparatively steady state, although the nominal real estate price continued to grow. In the meantime, FDI, real rental price level, and real GDP in the UK also climbed steadily during the period, whereas the trend of government bond rates declined remarkably. Canada shares a comparable fluctuation in the property market and interest rate as the UK market, with constant climbing in FDI, rental price, and GDP during the sample period. Housing supply in the UK saw a dramatic decline after the 2008 crisis, while the Canadian housing supply showed an overall increasing trend with several fluctuations. In the time series for China, real estate prices, FDI, GDP, and housing supply all rose steadily together, except for several fluctuations in FDI, while dramatic fluctuations are apparent for interest rate and rental price. The implications for this study are the generation of a structural VAR model to examine a short-term relationship among crucial variables. The empirical results are presented below.

Table 3-1 *Descriptive statistics*

	HP		FDI		RP		GDP		CB/BP		IR
	UK										
Variables	RHP	LRHP	RFDI	LRFDI	RRP	LRRP	RGDP	LRGDP	LCB		RIR
Mean	144954	5.1323	420318	5.5248	104.37	2.0158	392828	5.5875	4.6514		2.8128
S.D.	50285	0.1635	272815	0.3015	11.234	0.0504	67633	0.0776	0.0619		2.1998
Skewness	-0.0845	-0.284	0.5971	0.0294	-1.159	-1.314	-0.2322	-0.3593	-0.6671		-0.3386
Kurtosis	1.3833	1.4383	2.0508	1.5151	3.2040	3.6463	1.5465	1.5977	2.8047		2.2546
	Canada										
Variables	RHI	LRHI	RFDI	LRFDI	RRP	LRRP	RGDP	LRGDP	RBP	LRBP	RIR
Mean	79.596	1.8982	512939	5.6588	57157	4.7497	1320883	6.1117	12030398	7.0625	3.7669
S.D.	8.8167	0.0484	235487	0.2190	10456	0.0815	268993	0.0903	3368471	0.1267	2.1654
Skewness	-00193	-0.074	0.1797	-0.227	0.0936	-0.307	0.0315	-0.1273	0.0716	-0.207	0.2849
Kurtosis	1.3156	1.3384	1.6122	1.5774	2.4353	2.5371	1.5396	1.5148	1.6275	1.7067	2.3637
	China										
Variables	RHI	LRHI	RFDI	LRFDI	RRP	LRRP	RGDP	LRGDP	LCB		RIR
Mean	106.686	2.0246	25754	4.3355	104.07	2.0172	8888080	5.9182	1.5006		4.3966
S.D.	13.816	0.0560	16077	0.2529	3.0508	0.0128	336725	0.1635	0.2287		2.3247
Skewness	0.2118	0.1016	1.0113	0.4259	-0.284	-0.317	0.5223	0.1361	-0.4942		-0.272
Kurtosis	1.6545	1.5641	2.8754	1.8140	1.8578	1.8631	1.9853	1.7193	2.2075		2.3720

Notes:

- UK: HP (£), FDI(£ million), RP(index), GDP((£ million). Canada: HI (index), FDI(CAD million), RP (CAD), GDP (CAD million), BP (CAD thousand). China: HI (index), FDI (USD million), RP (index), GDP (USD million).
- The skewness figures show that most times series follow symmetrical distributions; rental price in the UK presents negative trend, and FDI in China presents upward trend. The kurtosis statistics indicate relatively heavy-tailed distributions with outliers and large fluctuations. This figures do not affect the later research.

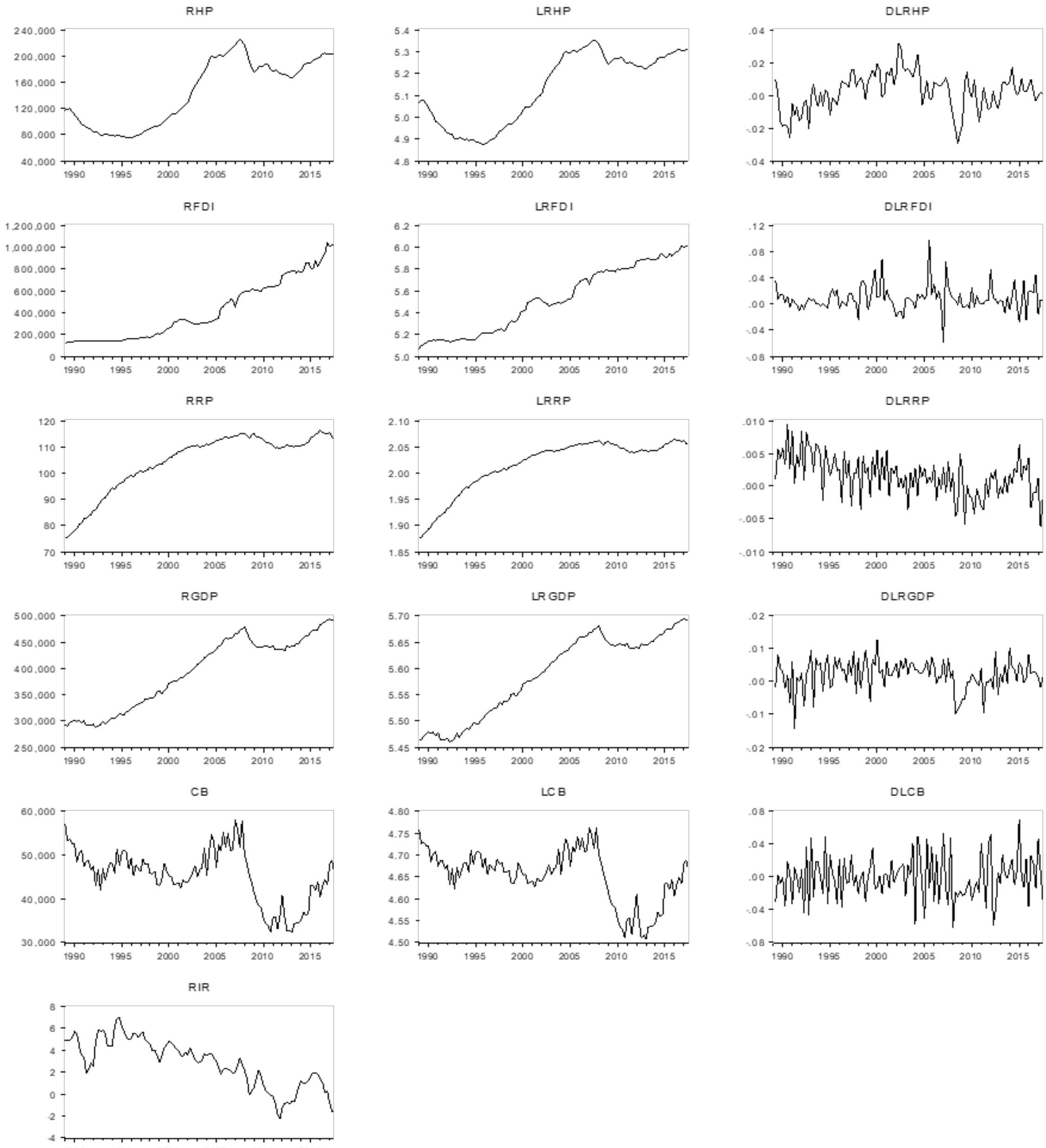


Figure 3-2 *The UK time series*

Note:

- The UK real FDI in level, log and differenced (RFDI, LRFDI, DLRFDI, £ million); the UK real house price in level, log and differenced (RHP, LRHP, DDLRHP, £); The UK real rental price index in level, log and differenced (RRP, LRRP, DDLRRP); the UK real GDP in level, log and differenced (RGDP, LRGDP, DLRGDP £million); the UK building completed in level, log and differenced (CB, LCB,DLCB); the UK real government bond rate (RIR).
- Data sources: *UNCTAD, Bank of England, Nationwide Building Society, ONS, Home Office, Ministry of Housing, Communities & Local Government* websites.

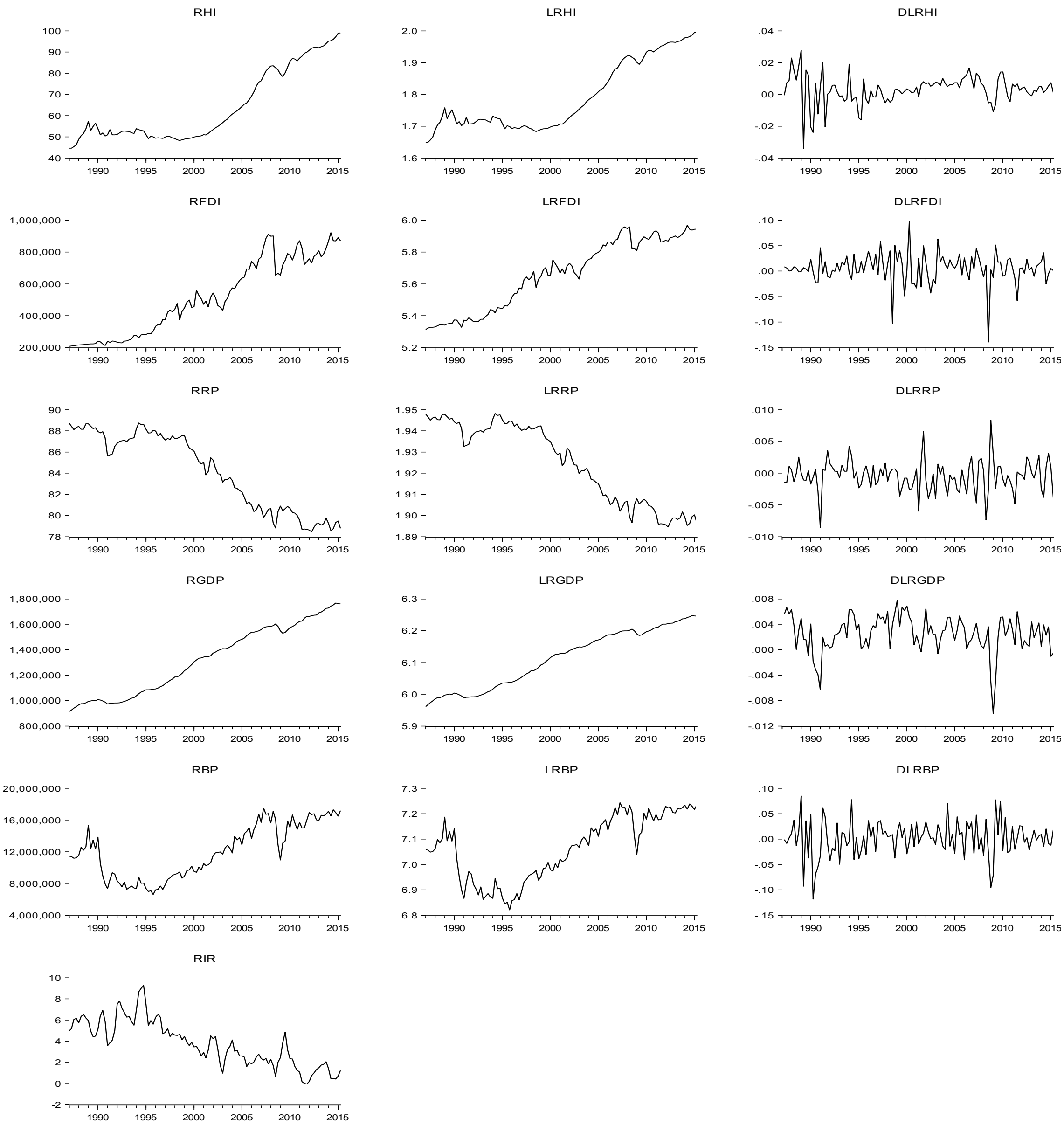


Figure 3-3 *Canada time series*

Note:

- Canada real FDI in level, log and differenced (RFDI, LRFDI, DLRFDI, C$ million); Canada real house price index in level, log and differenced (RHI, LRHI, DLRHI); Canada real rental price in level, log and differenced (RRP, LRRP, DLRRP, C$); Canada real GDP in level, log and differenced (RGDP, LRGDP, DLRGDP, C$ million); Canada real building permit in level, log and differenced (BP, LRBP, DLRBP, C$ thousands); Canada real government bond rate (RIR).
- Data sources: *Statistics Canada and Bank of Canada*.

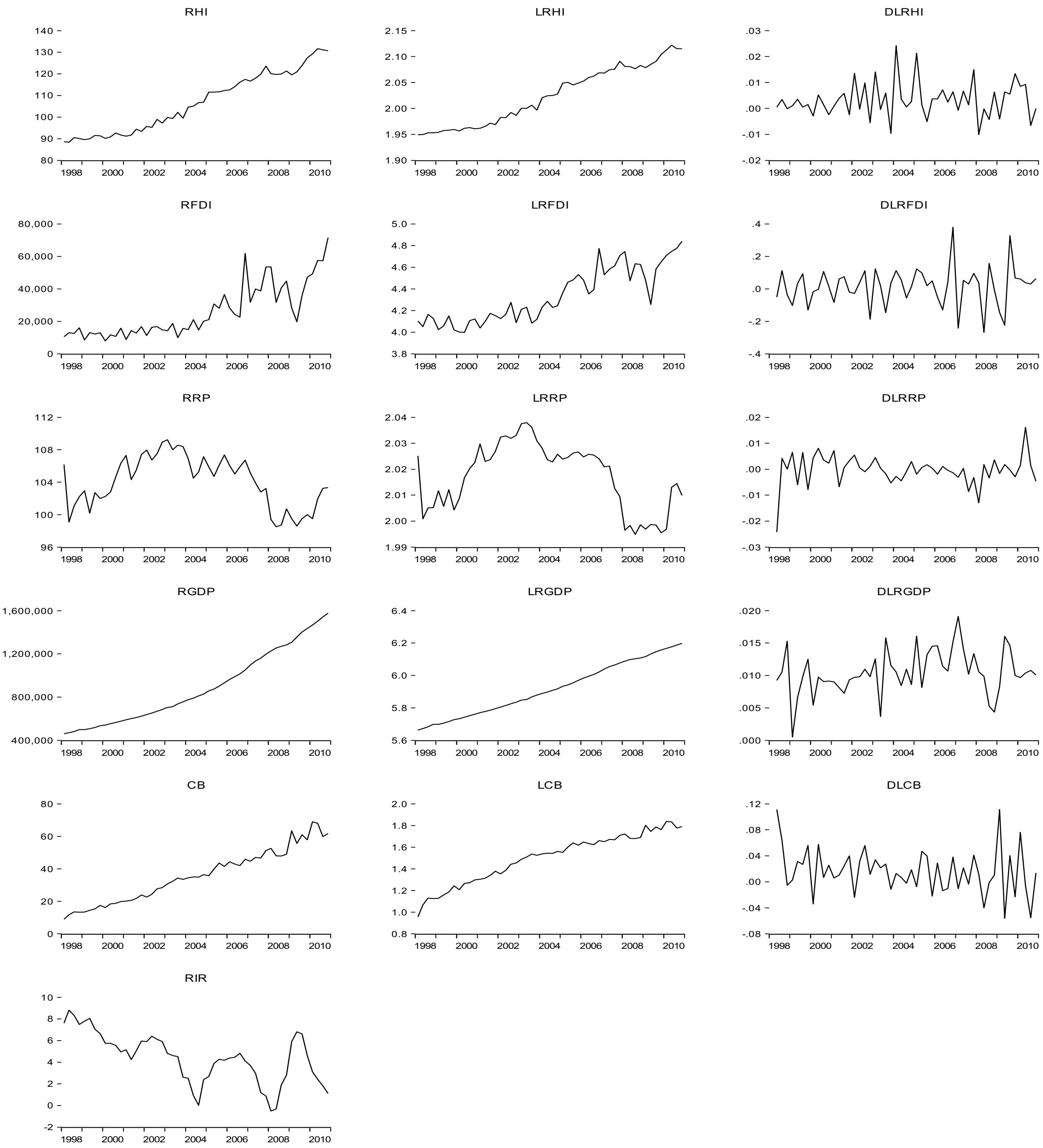


Figure 3-4 *China time series*

Note:

- China real FDI in level, log and differenced (RFDI, LRFDI, DLRFDI, U$ million); China real house price index in level, log and differenced (RHI, LRHI, DLRHI); China real rental price index in level, log and differenced (RRP, LRRP, DLRRP); China real GDP in level, log and differenced (RGDP, LRGDP, DLRGDP, U$ million); China floor space of building completed in level, log and differenced (CB, LCB,DLCB); China real lending rate (RIR).
- Data sources: *Oxford Economics, People's Bank of China, National Bureau of Statistics of China, and OECD.*

3.3.1.4 Stationary test and correlation analysis

First and foremost, the Zivot–Andrews (ZA) unit root test is conducted prior to the model estimation. Generally speaking, time-series data is prone to be non-stationary, as justified with this test. By verifying stationarity, the ZA test allows for unknown structural breaks in the model. In this study, model A, which allows for a break in the level, model B, which permits a break in the slope, and model C, which involves a break in both intercept and trend, are built respectively.

Table 3-2, **Table 3-3**, and **Table 3-4** present the ZA unit root tests for the UK, Canada, and China. Furthermore, the ADF unit root test results in **Table 3-5**, **Table 3-6**, and **Table 3-7** are presented as a guide to support the results of the ZA test. According to the result of the performance of the time-series data for the UK, Canada, and China, the time series of FDI, GDP, and buildings completed in the UK; housing price, FDI, GDP, rental price, and building permits in Canada; and housing price, rental price, and GDP in China tend to show the pattern of I(1), while housing price and rental price in the UK appear to be integrated at order two. In the meantime, the interest rate in the three countries, and FDI and floor space of buildings completed in China, tend to be stationary. When the breakpoints being detected in ZA tests are discussed, it is clear that these breakpoints conform with expectations. The market pattern changes during the 2008 financial crisis in the UK and Canada (Taylor, 2018), the 1990s bubble bust and the subsequent boom in 2000s in Canada (Macdonald, 2010), and a prosperity in Chinese market following the exchange rate reform in 2005 have all been presented (Su-Ling and Hsien-Hung, 2015). Like the premise, the results for the three countries contribute to the further exploration of the SVAR after differencing the non-stationary time-series data to I(0) in all the three cases. To this end, an SVAR model is introduced to examine the interdependencies among variables, and the time series of each country are differenced to adjust to stationarity based on the assumption of a VAR analysis.

Table 3-2 *Zivot Andrews unit root test for the UK*

Variables	Form	Model A Test statistic	Model B Test statistic	Model C Test statistic
HP	LRHP	-4.157	-3.865	-4.433
	Breakpoint	2008 Q2	2004 Q4	2008 Q2
	First difference of LRHP	-4.278	-3.973	-5.069*
	Breakpoint	2004 Q4	1997 Q4	2004 Q4
	Second difference of LRHP	-12.381***	-12.027***	-12.385***
	Breakpoint	2009 Q1	2008 Q3	2009 Q2
FDI	LRFDI	-3.133	-2.729	-3.409
	Breakpoint	2005 Q4	1993 Q3	1998 Q3
	First difference of LRFDI	-10.440***	-10.249***	-10.496***
	Breakpoint	1998 Q3	2000 Q2	2001 Q3
IR	RIR	-4.618*	-4.498**	-4.639
	Breakpoint	1994 Q1	1994 Q4	1994 Q1
	First difference of RIR	-7.666***	-7.497***	-8.412***
	Breakpoint	2012 Q2	1994 Q3	2013 Q2
RP	LRRP	-4.027	-2.583	-3.034
	Breakpoint	2009 Q3	1994 Q1	2009 Q3
	First difference of LRRP	-3.637	-2.811	-3.000
	Breakpoint	2012 Q2	1996 Q4	1994 Q3
	Second difference of LRRP	-7.318***	-7.483***	-7.961***
	Breakpoint	2003 Q4	2013 Q3	2011 Q4
GDP	LRGDP	-5.616***	-3.193	-4.689
	Breakpoint	2008 Q2	2004 Q4	2008 Q2

	First difference of LRGDP	-4.272	-3.693	-5.048*
	Breakpoint	2008 Q1	1994 Q3	2008 Q2
	Second difference of LRGDP	-13.047***	-12.762***	-13.167***
	Breakpoint	2009 Q3	1994 Q3	2009 Q3
CB	LCB	-3.713	-2.130	-3.821
	Breakpoint	2008 Q2	2013 Q3	2009 Q1
	First difference of LCB	-5.185**	-4.888**	-6.595***
	Breakpoint	2007 Q4	2010 Q3	2008 Q2
Critical value	1% Critical value	-5.34	-4.93	-5.57
	5% Critical value	-4.80	-4.42	-5.08
	10% Critical value	-4.58	-4.11	-4.82

Notes:
- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.

Table 3-3 *Zivot Andrews unit root test for Canada*

Variables	Form	Model A Test statistic	Model B Test statistic	Model C Test statistic
HI	LRHI	-3.174	-3.144	-3.078
	Breakpoint	2003 Q2	1991 Q3	1994 Q3
	First difference of LRHI	-6.054***	-5.752***	-6.028***
	Breakpoint	2007 Q4	2006 Q2	2007 Q4
FDI	LRFDI	-4.643*	-4.087	-4.555
	Breakpoint	2008 Q3	2007 Q2	2008 Q3

	First difference of LRFDI	-7.896***	-7.589***	-8.121***
	Breakpoint	2008 Q3	1996 Q2	2008 Q3
IR	RIR	-6.244***	-5.747***	-6.736***
	Breakpoint	1991 Q4	1994 Q2	1996 Q4
	First difference of RIR	-10.854***	-10.364***	-10.926***
	Breakpoint	1995 Q1	1997 Q1	1995 Q1
RP	LRRP	-3.483	-2.530	-2.681
	Breakpoint	2002 Q2	2010 Q2	2002 Q2
	First difference of LRRP	-11.652***	-11.540***	-11.716***
	Breakpoint	2006 Q2	2000 Q4	2006 Q2
GDP	LRGDP	-3.638	-2.629	-3.400
	Breakpoint	1998 Q3	2005 Q3	1998 Q3
	First difference of LRGDP	-6.094***	-5.851***	-6.330***
	Breakpoint	1992 Q3	1999 Q1	1992 Q3
BP	LRBP	-2.622	-4.211*	-3.747
	Breakpoint	2001 Q4	1992 Q2	1992 Q1
	First difference of LRBP	-7.764***	-7.449***	-7.739***
	Breakpoint	1996 Q1	2002 Q1	1996 Q1

Critical value	1% Critical value	-5.34	-4.93	-5.57
	5% Critical value	-4.80	-4.42	-5.08
	10% Critical value	-4.58	-4.11	-4.82

Notes:

- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.

Table 3-4 *Zivot Andrews unit root test for China*

Variables	Form	Model A Test statistic	Model B Test statistic	Model C Test statistic
HI	LRHI	-4.624*	-3.530	-4.672
	Breakpoint	2004 Q1	2000 Q2	2004 Q1
	First difference of LRHI	-6.286***	-6.048***	-6.791***
	Breakpoint	2002 Q1	2004 Q2	2008 Q1
FDI	LRFDI	-5.311**	-4.840**	-5.369**
	Breakpoint	2005 Q1	2000 Q2	2005 Q1
	First difference of LRFDI	-8.564***	-8.310***	-9.422***
	Breakpoint	2008 Q2	2008 Q4	2008 Q2
IR	RIR	-5.439***	-4.813**	-5.104**
	Breakpoint	2008 Q3	2004 Q3	2003 Q4
	First difference of RIR	-5.525***	-5.302***	-6.529***
	Breakpoint	2004 Q4	2008 Q4	2008 Q3
RP	LRRP	-3.588	-4.536**	-4.148
	Breakpoint	2000 Q2	2002 Q2	2001 Q4
	First difference of LRRP	-10.071***	-10.113***	-10.431***
	Breakpoint	2008 Q4	2008 Q2	2007 Q3
GDP	LRGDP	-3.278	-2.745	-2.629
	Breakpoint	2005 Q4	2001 Q4	2000 Q1
	First difference of LRGDP	-7.381***	-6.858***	-7.297***
	Breakpoint	2008 Q1	2007 Q2	2008 Q1
CB	LCB	-3.937	-5.876***	-6.102***
	Breakpoint	2002 Q3	2003 Q4	2003 Q1

	First difference of LCB	-7.286***	-6.844***	-7.173***
	Breakpoint	2003 Q4	2006 Q4	2003 Q4
Critical value	1% Critical value	-5.34	-4.93	-5.57
	5% Critical value	-4.80	-4.42	-5.08
	10% Critical value	-4.58	-4.11	-4.82

Notes:

- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.

Table 3-5 *Augmented Dickey-Fuller Unit Root test for the UK*

	Intercept and trend			Intercept			None	
	Probability							
Variables	Level	1st difference	2nd difference	Level	1st difference	2nd difference	Level	1st difference
LRGDP	0.6430	0.1409	0.0000***	0.8272	0.0385**		0.9767	0.0141**
LRRP	0.3748	0.1376	0.0000***	0.0136**	0.3423	0.0000***	0.8113	0.0425**
LRHP	0.1429	0.3708	0.0003***	0.4415	0.1054	0.0001***	0.8690	0.0250**
LRFDI	0.5069	0.0000***		0.9431	0.0000***		1.0000	0.0000***
RIR	0.0254**			0.4757	0.0000***		0.1094	0.0000***
CB	0.7196	0.0000***		0.3069	0.0000***		0.5528	0.0000***

Notes:

- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.

__Table 3-6__ Augmented Dickey-Fuller Unit Root test for Canada

	Intercept and trend		Intercept		None	
	Probability					
Variables	Level	1st difference	Level	1st difference	Level	1st difference
LRGDP	0.7577	0.0000***	0.8470	0.0000***	0.9999	0.0001***
LRRP	0.9811	0.0147**	0.9441	0.0248**	0.9993	0.2619
LRHI	0.5065	0.0001***	0.6026	0.0000***	0.6454	0.0000***
LRFDI	0.2330	0.0000***	0.7549	0.0000***	0.9894	0.0000***
RIR	0.2413	0.0000***	0.8427	0.0000***	0.1824	0.0000****
BP	0.3411	0.0000***	0.6972	0.0000***	0.8117	0.0000***

Notes:

- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.

__Table 3-7__ Augmented Dickey-Fuller Unit Root test for China

	Intercept and trend			Intercept		None		
	Probability							
Variables	Level	1st difference	2nd difference	Level	1st difference	Level	1st difference	2nd difference
LRGDP	0.6771	0.0000***		0.9995	0.0000***	1.0000	0.6365	0.0000***
LRRP	0.7340	0.0000***		0.4517	0.0000***	0.5446	0.0000***	
LRHI	0.1933	0.1121	0.0000***	0.9470	0.0297**	0.9939	0.1328	0.0000***
LRFDI	0.0051***			0.9529	0.0000***	0.9663	0.0000***	
RIR	0.0097***			0.0409**		0.0628*	0.0000***	
CB	0.0192**			0.1516	0.0000***	0.9996	0.0000***	

Notes:

- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.

In the next step, the correlation analysis on the variables is presented to show the initial connections among time-series data. As shown in **Table 3-8** Correlation analysis, the p-values indicate a substantial correlating relationship among some variables. In the UK, rental price, GDP, and interest rate are all considerably correlated with each other under a 1% level of significance. Foreign direct investment has linear relationship with housing price and housing supply under a 5% and 10% level of significance. In the Canada model, GDP, housing price, and housing supply are all dramatically correlated with each other under a 1% of significance. Additionally, rental price and GDP have linear relation under a 10% level of significance. In China, housing supply, interest rate, and FDI have a linear relationship with each other under a 1% level of significance, while GDP is substantially correlated with housing supply and FDI under a 5% and 10% level of significance.

***Table 3-8** Correlation analysis*

UK						
Correlation Probability	DLCB	DLRGDP	DLRRP	DDLRHP	DLRFDI	RIR
DLCB	1.000000					

DLRGDP	0.114522	1.000000				
	0.2271	-----				
DLRRP	0.012241	0.446270	1.000000			
	0.8976	0.0000	-----			
DDLRHP	0.105765	0.030323	-0.035368	1.000000		
	0.2649	0.7499	0.7100	-----		
DLRFDI	-0.162717	0.023188	-0.017995	-0.211255	1.000000	
	0.0851	0.8074	0.8500	0.0247	-----	
RIR	-0.001146	0.261561	0.464369	-0.000577	0.001001	1.000000
	0.9904	0.0051	0.0000	0.9952	0.9916	-----

Canada

Correlation Probability	DLRBP	DLRGDP	DLRRP	DLRHI	DLRFDI	RIR
DLRBP	1.000000					

DLRGDP	0.337515	1.000000				
	0.0003	-----				
DLRRP	-0.082868	-0.164245	1.000000			
	0.3829	0.0821	-----			
DLRHI	0.309604	0.438502	0.045738	1.000000		
	0.0008	0.0000	0.6305	-----		
DLRFDI	0.096347	-0.006261	-0.029535	0.002046	1.000000	
	0.3100	0.9475	0.7561	0.9828	-----	
RIR	-0.056179	0.112521	0.176653	-0.203163	0.085886	1.000000
	0.5545	0.2354	0.0612	0.0309	0.3657	-----

China

Correlation Probability	LCB	DLRGDP	DLRRP	DLRHI	RIR	LRFDI
LCB	1.000000					

DLRGDP	0.300869	1.000000				
	0.0319	-----				
DLRRP	0.019548	-0.123098	1.000000			
	0.4751	0.1087	-----			
DLRHI	0.102280	0.227312	0.152693	1.000000		
	0.4751	0.1087	0.2848	-----		
RIR	-0.662998	-0.072401	0.094543	0.002554	1.000000	
	0.0000	0.6136	0.5093	0.9858	-----	
LRFDI	0.856333	0.237571	-0.069868	0.057793	-0.608911	1.000000
	0.0000	0.0932	0.6261	0.6871	0.0000	-----

3.3.2 The Model

The procedure of analysing data is conducted at various stages, organised as follows. After collecting and processing the data for all the variables, the research presents a first step towards obtaining insight into the stationary condition of the variables through the unit root test. The order of each variable, which is the fundamental condition for economic analysis, is tested. In any economic topic, the test for the stationarity of the data is vital to prevent spurious regression (Yan & Chen, 2011). If variables are revealed to be integrated at different orders, a differencing technique can be applied to transform the variables into stationary variables, which are fit into an SVAR model to justify the relationship among the time-series data. Once all the variables have been proved to be stationary, that is, I(0), an SVAR analysis is performed to discover a short-term statistical connection among the stationary variables. Following the SVAR model, the IRF is computed to analyse the responses of one variable towards one positive shock of the other variable in the system. In addition, a Granger causality test is conducted to prove the short-term causality link among variables. Overall, this process of time-series data analysis provides a general deliberation of the impact of one variable on another, in line with the purpose of this research.

3.3.2.1 Stationarity test

I. Zivot Andrews (ZA) test

To engage in testing or an estimation process in a time-series economic model, the typical requirement for the various variables is stationarity, because the dominant theory in econometrics is generated strictly based on this assumption, and non-stationary variables cause spurious regression (Verbeek, 2017). The first step of our data analysis is to perform a unit root test, and all the variables in all levels appear to feature a unit root. One issue with the ADF test is that it does not report the probability of a structural break. The power of rejecting the null hypothesis of the unit root is reduced if the exogenous phenomenon of break is ignored (Perron, 1989). To exclude the possibility of a structural break in the time series, Zivot and Andrews (2002) proposed another unit root test: The ZA test which allows for a structural break in the model. Notably, the original unit root by Perron (1989), which assumes that the breakpoint is already known, has been transformed to allow for an unknown structural break. The reflection of the structural break issue in a macroeconomic time series prevents the possibility of spurious results in the unit root test. At the point where the t-statistic in the ADF test is at its most negative level, this test selects the most unfavourable result for null hypothesis as the break time. In this test, the structural break is estimated, rather than assumed.

$$y_t = \mu + y_{t-1} + e_t \tag{3-1}$$

$$y_t = \mu + \theta DU_t(T_b) + \beta t + \alpha y_{t-1} + \sum_{j=1}^{k} c_j \Delta y_{t-j} + \varepsilon_t \tag{3-2}$$

$$y_t = \mu + \beta t + \gamma DT_t(T_b) + \alpha y_{t-1} + \sum_{j=1}^{k} c_j \Delta y_{t-j} + \varepsilon_t \tag{3-3}$$

$$y_t = \mu + \theta DU_t(T_b) + \beta t + \gamma DT_t(T_b) + \alpha y_{t-1} + \sum_{j=1}^{k} c_j \Delta y_{t-j} + \varepsilon_t \tag{3-4}$$

Equation 3-2, 3-3 and 3-4 are model A, model B and model C. Three parameterisations of break have been built to test for unit root: Model A allows for a break in the level of the series, model B permits a break in the rate of growth and model C involves a break in both intercept and trend. Both DU_t and DT_t are indicator dummy variables. The sustained dummy variable DU_t captures a break in the intercept, and DT_t presents a break in the trend at time T_b. DU_t=1 if t>T_b, and zero otherwise, and DT_t = (t-T_b) if (t>T_b) and zero otherwise. Under the ZA test, T_b is estimated endogenously through building the model in which T_b can be any particular quarter except for the first and last quarters. This method by Zivot and Andrews regards every point as a possible break date. Therefore, a regression is conducted for each potential break date. The time of break T_b is selected at the point where one-tail t-statistic of α=1 in the model is minimised. This selection represents the point that is the least favourable to the null hypothesis. If the coefficient is tested to be influential, the null hypothesis is rejected.

II. Augmented Dickey-Fuller test

In the meantime, the ADF test is also conducted to support the unit root test result. The ADF test allows for the existence of correlation in the error term ε_t and transforms it into a white noise process, while the general ADF specification also encompasses the possibility of a deterministic trend and drift.

$$\Delta y_t = \mu + \gamma y_{t-1} + \delta t + \Sigma\beta\Delta y_{t-i} + \varepsilon_t \tag{3-5}$$

The ADF test is conducted by regressing the first difference of y_t on its one-period lagged value y_{t-1}, drift, deterministic trend, and lagged values of Δy_t, and examining whether the estimated coefficient γ is notably different from zero. To be more specific, the t critical value, particularly for the DF and ADF tests, which follows the τ statistic, has been adopted to estimate the null hypothesis. If the p-value is larger than 0.05, the null hypothesis $\gamma = 0$ is rejected, indicating there is not a unit root. The number of lagged difference terms to be involved is primarily determined by inspecting the t and F values of the max lag to check their significance based on the precondition of white-noise residuals. The number of these terms is decided before the test is conducted. Subsequently, the p-value from the ADF test is selected to estimate whether γ is significantly different from zero to verify unit root. It is necessary to emphasise that the test begins with the most general form, and the presence of drift or a trend is checked by an F-test of joint significance, which aims to confirm the trend to which the time series belongs. Detection the possibilities of the existence of these trends can help to prove the presence of a unit root.

3.3.2.2 Structural VAR

When a group of time-series variables is under analysis, the interactions and co-movements among these observables can be modelled, rather than a simple regression. The SVAR model is a system of equations which confirms all the variables in the model as endogenous. This model is justified as especially useful for explaining the dynamic behaviour of economic factors as well as for structural analysis (Zivot & Wang, 2006). This model explains the links among a group of interrelated time-series variables by analysing their dynamic evolution in their shared history. The causal structure and impacts to specific variable in the model can also be summarised. Isolate estimation of recognised assumptions on individual variable behaviour and influence can be made explicitly under an SVAR model.

Assuming six variables are encompassed in the analysis, which is an (6×1) vector X_t of endogenous variables following an AR(p) process. This multivariate SVAR(p) representation as a linear equation system with six equations can be written as:

$$BX_t = \Gamma_0 + \sum_{i=1}^{p} \Gamma_i X_{t-i} + \varepsilon_t \quad (3\text{-}6)$$

where Γ_0, X_t and ε_t are (6×1) matrices and B and Γ_i are (6×6) matrices. ε_t is serially uncorrelated, white-noise error term. This is a structural VAR model because it demonstrates the structure of the six equations, and the variables inside this model are designed to affect each other, resulting in a feedback inherent incorporated in this framework. This is reflected as the form of both direct contemporaneous effect, which shows as variables directly entering each equation and indirect contemporaneous effect which presents in error terms. Since this model is empirically unattainable with all the variables endogenous existed, a reduced-form VAR model is applied first to achieve a structural VAR.

3.3.2.3 Vector autoregressive model

In terms of the previous SVAR model (3-6), pre multiplication by B^{-1}allows it to generate the standard VAR in the reduced-form:

$$B^{-1}BX_t = B^{-1}\Gamma_0 + B^{-1}\sum_{i=1}^{p} \Gamma_i X_{t-i} + B^{-1}\varepsilon_t$$

or

$$X_t = A_0 + \sum_{i=1}^{p} A_i X_{t-i} + E_t \tag{3-7}$$

where $A_0 = B^{-1}\Gamma_0$; $A_i = B^{-1}\Gamma_i$; $E_t = B^{-1}\varepsilon_t$. Since in the reduced-form representation each equation is just functions of lagged values of all the variables, VAR can be estimated. In particular, $X_t = (x_{1t}, x_{2t}, x_{3t}, x_{4t}, x_{5t}, x_{6t})'$ is (6×1) vector containing the six variables FDI, housing price, interest rate, rental price, housing supply and GDP, A_0 is (6×1) vector of intercept coefficients, A_i is (6×6) coefficient matrix of autoregressive coefficients and E_t is (6×1) unobservable white noise vector of error terms. The standard regressors for each variable contained in the VAR model are its own lagged time series, the lagged terms of other model elements and deterministic terms. Since the right-hand side of the equation contains only predetermined variables and constant variances, and the errors are serially uncorrelated, it can then be estimated using ordinary least squares (OLS). The OLS estimates will be consistent and asymptotically efficient. Moreover, as each equation contains identical explanatory elements, OLS estimation can be adapted to every single equation. Prior to this test, the optimal lag length is selected by choosing the one that minimises model selection criteria while ensuring the residuals are white noise simultaneously. Since long lag length would quickly consume degrees of freedom, lag selection tends to be critical. The specific criteria utilised in this study are the Akaike Information Criterion (AIC), Schwarz' Bayesian Information Criterion (SBIC) and Hannan and Quinn information criterion (HQIC).

After conducting a reduced-form VAR, the parameters for SVAR(p) can be recovered only when the VAR structural equations adopt appropriate restrictions on parameters. When the structural system applies the required number of restrictions and the entries of the matrix have been decomposed using Cholesky decomposition, the result is an exactly identified system. With respect to the above SVAR(p) model, Γ_i must be recovered from the values of A_i, estimated from the VAR model. Under this premise, the structural VAR expects n^2 more parameters than the reduced-form model, which indicates the necessity of n^2restrictions to produce an exactly identified SVAR. Under Cholesky decomposition, the following short-term restrictions of normalisation on contemporaneous covariance between shocks can be applied: 1) Restrict the matrix of coefficients B to be triangular, with diagonal elements normalised to be equal to 1, resulting in $(n^2+n)/2$ restrictions imposed on B; and 2) Restrict the variance-covariance matrix of the structural error term ε_t to be a diagonal matrix, which makes all covariances equal to zero. Another $(n^2-n)/2$ restrictions are then imposed on $Var(\varepsilon_t)$, making the total number of restrictions n^2. When imposing identifying restrictions, the outcome of the Granger causality test and economic theory support the identification of the significance of the regressors in each equation. As a consequence, the structural VAR can be examined and analysed. Under the SVAR model, the results of significance for the coefficients can be interpreted as presenting short-term relationships.

3.3.2.4 Granger causality test

Whether the current and past values of one variable can be used to forecast the future values of another variable can be measured by Granger causality. The Granger causality test captures the short-term causal relationships between variables. Under a VAR framework, the Granger causality estimates whether the lags of one variable enter the equation for another variable. Assuming a VAR model with p lags, the null hypothesis is that all coefficients for all the lags of one variable in the equation for another variable are jointly equal to zero.

3.3.2.5 Impulse Response Function

Usually, a VAR model can be represented as a Vector moving average form:

$$X_t = \bar{X}_t + \sum_{i=1}^{p} \emptyset_i \epsilon_{t-i} \tag{3-8}$$

where $\bar{X}_t$ is (6×1) vector of the long run unconditional means, $\emptyset_i$ is called impact multipliers and ϵ_{t-i} i is (6×1) vector of structural errors. This representation is useful in examining the interaction between two variables. The coefficients $\emptyset_i$ can be used to estimate the effects of structural error shocks of one variable on the entire time paths of another variable. This $\emptyset_i$ vector contains the instantaneous as well as the different period responses of one-unit change on the variable. The plotting of coefficients of $\emptyset_i$ against i is the IRF. This approach is a practical way to visually show the behaviour of different time series in response to various shocks.

3.4 Empirical results

3.4.1 Vector autoregressive model

Before the SVAR model is built to capture feedback relationships among variables in the UK, Canada, and China, the optimal lag length for the model is selected. According to the results in **Table 3-9**, information criteria, and **Figure 3-5**, residuals performance, a lag length of two is chosen for the UK model, while a lag length of one is selected for the Canada and China models, subject to the criteria AIC, SBIC, HQIC, white-noise residuals, and sample size. A reduced-form VAR with a specified lag length is the primary component of the first part of the methodology, and an SVAR model is employed. The results of the VAR model are visualised from **Table 3-10** to **Table 3-12**.

The outputs from **Table 3-10** to **Table 3-12** include autoregressive coefficients for each variable. As the focus have been placed primarily on the house price and FDI equations, the coefficients in this part indicate whether FDI, interest rate, rental price, GDP, and supply-side variables can explain the house prices in the three countries. The p-value after each coefficient presents the significance of each lag. As indicated by the result, FDI in Canada and China are vital explanatory determinants of the housing price level. At this point, a more informative result about the effect from each variable is presented in terms of the output of the Granger causality test.

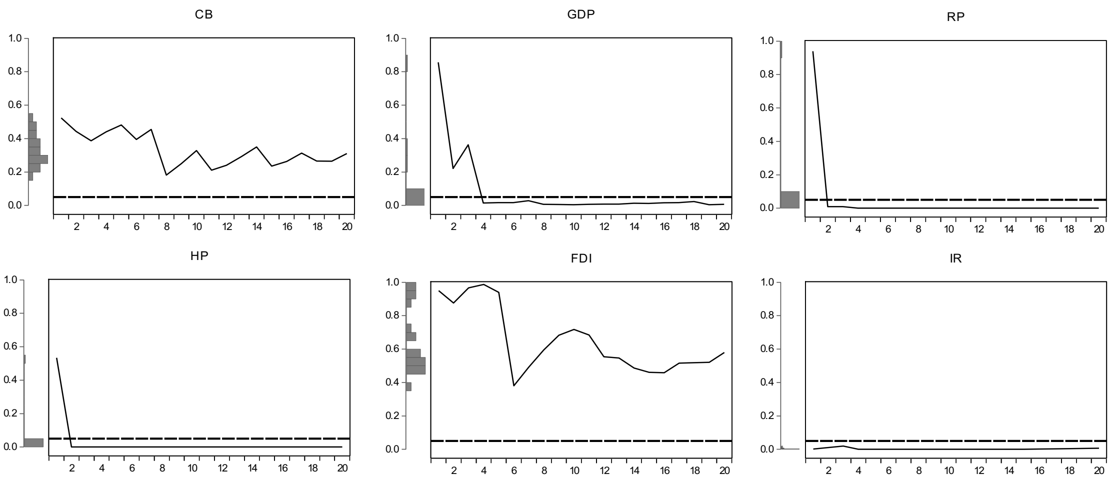
Table 3-9 *Lag length criteria*

Lag		0	1	2	3	4
UK	**AIC**	-28.6720	-31.4420	-31.8107	-31.6549	-32.3271*
	SC	-28.5238	-30.4050*	-29.8848	-28.8401	-28.6234
	HQ	-28.6119	-31.0215	-31.02971*	-30.5134	-30.8251
Canada	**AIC**	-28.6571	-31.896*	-31.8364	-31.7470	-31.8176
	SC	-28.5090	-30.85889*	-29.9105	-28.9322	-28.1140
	HQ	-28.5971	-31.47537*	-31.0554	-30.6055	-30.3157
China	**AIC**	-21.7382	-26.1511	-26.5778	-27.1903	-27.60587*
	SC	-21.5020	-24.49774*	-23.5074	-22.7027	-21.7011
	HQ	-21.6493	-25.52891*	-25.4224	-25.5016	-25.3839

Note:

- * indicates lag order selected by the criterion. Together with the Residual correlogram presented in **Figure 3-5**, a lag length of 2, 1 and 1 is selected for the UK, Canada and China respectively.

Lag 1



Lag 2

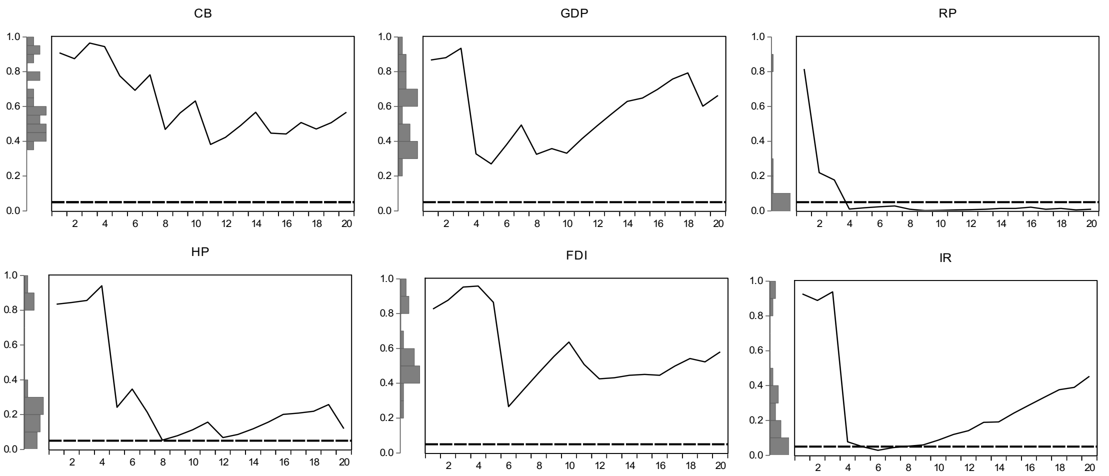


Figure 3-5 *The UK Residual correlogram p values*

Notes:

- CB--building completed to represent housing supply; HP-- housing price; IR--interest rate; RP--rental price.
- The variables being used are logged real term in differenced level according to the unit root test.
- This figure compares the residual correlogram p values for the six variables in the UK, considering both lag one and lag two.
- The horizontal reference line indicates 0.05 p level. Above this level indicates white noise residuals.
- After imposing two lags, the behaviour of residuals has been significantly improved. Therefore, the UK model selects a lag length of two.

***Table 3-10** VAR result for the UK*

		LCB		LRGDP		LRRP		LRHP		LRFDI		RIR	
Variables	Lags	Coef.	t value	Coef.	t value	Coef.	t value	Coef.	t value	Coef.	t value	Coef.	t value
LCB	1	-0.45	-4.45***	0.03	2.192**	0.02	2.70***	-0.01	-0.311	0.16	2.105**	2.96	1.358
	2	-0.19	-1.825*	0.05	2.87***	0.01	1.562	0.00	0.105	0.07	0.943	0.42	0.189
LRGDP	1	1.00	1.550	-0.01	-0.098	-0.26	-4.43***	-0.09	-0.498	0.95	1.963*	-5.99	-0.432
	2	0.96	1.347	0.07	0.615	-0.08	-1.180	-0.29	-1.448	-0.24	-0.446	0.63	0.041
LRRP	1	0.01	0.012	-0.38	-2.204**	0.03	0.254	-0.14	-0.439	-1.26	-1.514	27.68	1.160
	2	-0.09	-0.085	0.12	0.727	0.35	3.70***	1.03	3.42***	0.83	1.048	35.62	1.572
LRHP	1	-0.06	-0.191	-0.10	-2.005**	-0.06	-2.179**	-0.16	-1.751*	0.16	0.685	-4.38	-0.652
	2	0.28	0.945	0.06	1.152	0.02	0.734	-0.41	-4.68***	0.12	0.536	-3.83	-0.585
LRFDI	1	-0.05	-0.392	0.01	0.604	0.01	1.172	-0.02	-0.595	0.09	0.839	-0.85	-0.289
	2	-0.06	-0.452	0.04	2.132**	0.02	1.367	0.01	0.224	0.03	0.255	-4.43	-1.541
RIR	1	0.00	0.509	0.00	3.026***	0.00	3.507***	0.00	0.765	-0.00	-1.274	1.27	13.05***
	2	-0.00	-0.791	-0.00	-2.238**	-0.00	-2.187**	-0.00	-1.213	0.00	1.329	-0.35	-3.58***
C		-0.00	-0.002	0.00	0.505	-0.00	-0.343	0.00	0.985	0.01	1.697*	0.13	1.408

Note:

- The 1% critical value for t test is 2.626; the 5% critical value for t test is 1.984; the 10% critical value for t test is 1.660. *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.
- CB--building completed to represent housing supply; HP--housing price; IR--interest rate; RP--rental price.
- In CB and IR equations, none of the variables are significant; the significant variables in GDP equation are all of the other variables, in RP equation are CB, GDP, HP and IR, in HP equation is RP, and in FDI equation are CB and GDP.

Table 3-11 *VAR result for Canada*

Equations		LRBP		LRGDP		LRRP		LRHI		LRFDI		RIR	
Variables	Lag	Coef.	t value	Coef.	t value	Coef.	t value	Coef.	t value	Coef.	t value	Coef.	t value
LRBP	1	-0.24	-2.364**	0.01	1.706*	-0.03	-2.090**	0.02	1.993**	-0.01	-0.136	-0.99	-0.444
LRGDP	1	0.49	0.359	0.46	4.977***	-0.33	-1.809*	0.16	1.055	0.11	0.094	-50.61	-1.668*
LRRP	1	0.57	0.804	-0.01	-0.223	-0.09	-0.953	-0.11	-1.328	0.48	0.778	10.46	0.657
LRHI	1	0.86	1.268	0.04	0.975	0.23	2.459**	0.54	7.025***	0.61	1.037	25.66	1.689*
LRFDI	1	0.33	3.003***	0.02	2.658***	-0.01	-0.985	0.02	1.682*	-0.12	-1.202	1.21	0.486
RIR	1	-0.00	-1.061	0.00	1.414	0.00	1.801*	-0.00	-2.547**	0.00	0.949	0.96	26.64***
C		0.00	0.465	0.00	1.317	0.00	2.734***	0.00	1.911*	-0.00	-0.110	0.21	1.343

Note:

- The 1% critical value for t test is 2.626; the 5% critical value for t test is 1.984; the 10% critical value for t test is 1.660. *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.
- BP—building permits to represent housing supply; HI—housing price index; IR--interest rate; RP--rental price.
- The significant variables in BP equation is FDI, in GDP equation are BP and FDI, in RP equation are BP, GDP, HI and IR, in HI equation are BP, FDI and IR, and in IR equation are GDP and HI. In FDI equation, none of the variables is significant.

Table 3-12 *VAR result for China*

Equations		LCB		LRGDP		LRRP		LRHI		LRFDI		RIR	
Variables	Lag	Coef.	t value	Coef.	t value	Coef.	t value	Coef.	t value	Coef.	t value	Coef.	t value
LCB	1	0.97	21.76***	0.01	1.953*	0.00	0.444	0.03	2.97***	0.37	2.223**	-0.84	-0.604
LRGDP	1	-2.88	-2.033**	0.04	0.286	-0.18	-0.835	-0.17	-0.587	2.85	0.534	-71.17	-1.601
LRRP	1	-0.88	-1.106	-0.01	-0.149	-0.09	-0.730	-0.20	-1.277	-0.72	-0.240	17.21	0.690
LRHI	1	1.28	1.887*	-0.10	-1.323	-0.09	-0.886	-0.32	-2.39**	1.83	0.721	-23.26	-1.096
LRFDI	1	0.01	0.274	-0.00	-0.039	-0.00	-0.352	-0.02	-2.44**	0.61	4.611***	0.04	0.038
RIR	1	0.00	0.329	0.00	2.105**	0.00	1.370	0.00	1.338	0.00	0.021	0.82	9.803***
C		0.04	0.356	-0.01	-0.453	0.00	0.204	0.04	1.643	1.10	2.545**	2.57	0.712

Note:

- The 1% critical value for t test is 2.678; the 5% critical value for t test is 2.009; the 10% critical value for t test is 1.676. *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.
- CB--building completed to represent housing supply; HI—housing price index; IR--interest rate; RP--rental price.
- The significant variables in the CB equation are GDP and HI, in GDP equation are CB and IR, in HI equation is FDI, and in FDI equation is CB. In RP and IR equations, none of the variables are significant.

3.4.2 Granger causality test

When addressing short term dynamics, the central focus is placed on how FDI, rental price, interest rate, and GDP can affect real estate price. This information can be gained from a more informative post-estimation statistic, the Granger causality test, which tests the joint influence of all lagged value to assess short-term behaviour in VAR outputs. From the result in **Table 3-13**, FDI is seen to prominently explain the short-term behaviour of housing price movement in Canada and China, but not in the UK, while the housing prices in none of the three countries are dominant determinants of FDI. The interpretation from the test states that FDI is a tremendous explanatory factor of the fluctuations in housing prices in Canada and China. Meanwhile, the outcome confirms the effects of rental price on housing price levels in the UK, revealing the close link between the real estate market and its fundamental. In addition, building permits and interest rates in Canada, and the buildings completed in China, play important roles in explaining the real estate market, with buildings completed in China having vital effects on changes in FDI level. This result, therefore, justifies the statement that the housing market boom is an element of FDI expansion in Canada and China in the short term, but not in the UK.

Table 3-13 *Granger Causality Test*

Equations	Variables	Probabilities		
		UK	Canada	China
LCB(LRBP)	LRGDP	0.0715*	0.7192	0.0420**
	LRRP	0.9963	0.4212	0.2686
	LRHP(HI)	0.6160	0.2047	0.0591*
	LRFDI	0.8274	0.0027***	0.7838
	RIR	0.5713	0.2886	0.7421
LRGDP	LCB(LRBP)	0.0076***	0.0880*	0.0508*
	LRRP	0.0835*	0.8233	0.8812
	LRHP(HI)	0.0552*	0.3294	0.1856
	LRFDI	0.0793*	0.0079***	0.9687
	RIR	0.0020***	0.1571	0.0353**

LRRP	LCB(LRBP)	0.0214**	0.0366**	0.6570
	LRGDP	0.0000***	0.0704*	0.4035
	LRHP(HI)	0.0606*	0.0139**	0.3756
	LRFDI	0.1800	0.3244	0.7242
	RIR	0.0000***	0.0716*	0.1705
LRHP(HI)	LCB(LRBP)	0.9269	0.0462**	0.0030***
	LRGDP	0.2531	0.2911	0.5572
	LRRP	0.0029***	0.1839	0.2014
	LRFDI	0.8222	0.0924*	0.0146**
	RIR	0.2554	0.0109**	0.1806
LRFDI	LCB(LRBP)	0.1070	0.8913	0.0262**
	LRGDP	0.1453	0.9244	0.5929
	LRRP	0.2343	0.4364	0.8102
	LRHP(HI)	0.7052	0.2995	0.4707
	RIR	0.4123	0.3424	0.9825
RIR	LCB(LRBP)	0.3766	0.6567	0.5456
	LRGDP	0.9098	0.0953*	0.1093
	LRRP	0.0973*	0.5106	0.4899
	LRHP(HI)	0.7020	0.0912*	0.2727
	LRFDI	0.2841	0.6264	0.9689

Note:

- This table presents short term causality among the variables. *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.
- CB--building completed to represent housing supply; BP—building permits to represent housing supply; HP-- housing price; HI—housing price index; IR--interest rate; RP--rental price.
- In the UK, GDP and CB are important explanatory factors for each other; HP, RP, FDI and IR all have explanatory power on GDP; CB, GDP, HP and IR are all significant in explaining RP; RP is an important determinant for HP; RP substantially explains IR.
- In Canada, FDI is significant in explaining CB and GDP; CB can also considerably explain GDP as well as RP; GDP, HP and IR can also explain RP; For HP, CB, FDI and IR are all critical determinants; GDP and HP are vital determinants for IR.
- In China, GDP and HP are crucial determinants for CB; CB and IR significantly explain GDP; CB and FDI are crucial determinants for HP; CB is important at explaining FDI.

3.4.3 Structural vector autoregressive model

After the standard VAR model, the SVAR model is used to apply short-term restrictions to retrieve the parameters. Specifically, the restrictions are generated on the basis of theory, indicating the relationship among variables. Equation 3-9 and Equation 3-10 summarise the identification structure according to the formula $BE_t = \varepsilon_t$ and the Cholesky decomposition. Before the applying restrictions, it is essential to order the variables in the model under Cholesky decomposition to the result if the residual correlations are high. If the correlation coefficient is low, changing the ordering is unlikely to be essential (Enders, 2015). Accordingly, the correlations of residuals under the VAR model are tested to assist the ordering of variables, and the results indicate that some residuals are correlated in each of the three models. Consequently, the ordering of the variables is examined.

The ordering of the six time-series variables is built on the foundation of economic theory, which indicates the potential endogeneity level of the time series in the system. Within the ordering, it is assumed that the first variables can affect the others immediately, while the other variables can only affect those primarily placed with a lag. Consequently, the relatively less endogenous variables are placed before the relatively more endogenous ones, because the former are more likely to influence the latter, while the reverse is not the case. First, housing supply, the production of a long-lived durable good, is generally believed to be the most sticky time series and does not tend to respond to other variables (Barsky, House, & Kimball, 2007; Grimes & Aitken, 2010). When GDP is concerned, it is generally regarded as a long-term macroeconomic driver of asset markets, and GDP has a compelling effect on housing price movement (Goodhart & Hofmann, 2008; Tze, 2013). Meanwhile, asset price and market movement may only anticipate future changes to economic growth and cause lagged influences on GDP, indicating a slower response of GDP to other variable shocks. Growth in GDP is less volatile than real estate and financial activities (Goodhart & Hofmann, 2008; Huu, Abdlatif, & Nasir, 1999). Housing price is, in theory, decided by the flow of exogenous dividends, presented as rents (Granziera & Kozicki, 2012). Rental price is commonly stated to linked closely to housing stock, which is relatively fixed and stable in a market, with only small changes annually (Rosen & Smith, 1983). There is also a delay in the response of rents to changes in housing market development and other market fluctuations (Leeuw & Ekanem, 1973). Therefore, rental price has shown a comparatively slower adjustment that indicates the lower endogeneity that it holds in this model. As far as the endogeneity of FDI is concerned in this model, it is widely proved to be affected by factors such as GDP, economic performance, and investment climate (Anop, 2010; Botrić & Škuflić, 2006; Saini & Singhania, 2018). Additionally, foreign real estate investment in FDI is multiplying, which helps attract a large amount of FDI inflow in many economies. Consequently, the movements in real estate markets may also affect the FDI level (Anop, 2010). Finally, as part of the monetary policy from regulators, the interest rate is one tool for central banks to react to economic developments. Ample evidence, provided by Cecchetti (2000), Goodhart (2001) and Güney (2016), has justified a robust response of monetary policy on output, inflation, and asset prices such as housing prices. Accordingly, the theoretical basis has formulated the ordering of variables under Cholesky decomposition in this model. Moreover, this section has also tested alternative orderings with changes in order within more endogenous and less endogenous time series, and similar results are achieved. Therefore, the ordering of the six variables are decided as housing supply, GDP, rental price, housing price, FDI, and interest rate. **Table 3-14** reports the resulting coefficients of matrix B, demonstrating housing supply, GDP, and rental price in the UK and Canada all have consequential contemporaneous effects on housing price. In particular, this model captures a contemporaneous effect of housing price on FDI in the UK.

$$\begin{bmatrix} B_{11} & B_{12} & B_{13} & B_{14} & B_{15} & B_{16} \\ B_{21} & B_{22} & B_{23} & B_{24} & B_{25} & B_{26} \\ B_{31} & B_{32} & B_{33} & B_{34} & B_{35} & B_{36} \\ B_{41} & B_{42} & B_{43} & B_{44} & B_{45} & B_{46} \\ B_{51} & B_{52} & B_{53} & B_{54} & B_{55} & B_{56} \\ B_{61} & B_{62} & B_{63} & B_{64} & B_{65} & B_{66} \end{bmatrix} \begin{bmatrix} E_{LCB(LRBP)} \\ E_{LRGDP} \\ E_{LRRP} \\ E_{LRHI(LRHP)} \\ E_{LRFDI} \\ E_{RIR} \end{bmatrix} = \begin{bmatrix} \varepsilon_{LCB(LRBP)} \\ \varepsilon_{LRGDP} \\ \varepsilon_{LRRP} \\ \varepsilon_{RLRHI(LRHP)} \\ \varepsilon_{LRFDI} \\ \varepsilon_{RIR} \end{bmatrix} \quad (3\text{-}9)$$

$$B = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ B_{21} & 1 & 0 & 0 & 0 & 0 \\ B_{31} & B_{32} & 1 & 0 & 0 & 0 \\ B_{41} & B_{42} & B_{43} & 1 & 0 & 0 \\ B_{51} & B_{52} & B_{53} & B_{54} & 1 & 0 \\ B_{61} & B_{62} & B_{63} & B_{64} & B_{65} & 1 \end{bmatrix} \tag{3-10}$$

***Table 3-14** SVAR result*

The UK

	LCB		LRGDP		LRRP		LRHP		LRFDI		RIR	
Equations	Coefficients	Prob.	Coefficients	Prob.	Coefficients	Prob.	Coefficients	Prob.	Coefficients	Prob.	Coefficients	Prob.
LCB	1	-	0	-	0	-	0	-	0	-	0	-
LRGDP	-0.0299	0.040**	1	-	0	-	0	-	0	-	0	-
LRRP	-0.0075	0.3551	-0.1756	0.0008***	1	-	0	-	0	-	0	-
LRHI	-0.0470	0.075*	-0.2929	0.096*	0.7852	0.0101**	1	-	0	-	0	-
LRFDI	0.0655	0.3596	0.0129	0.9784	0.0863	0.9180	0.5230	0.039**	1	-	0	-
RIR	0.5532	0.7864	-7.7641	0.5664	-15.556	0.5142	-19.828	0.007***	-2.1177	0.4327	1	-

Canada

	LRBP		LRGDP		LRRP		LRHI		LRFDI		RIR	
Equations	Coefficients	Prob.	Coefficients	Prob.	Coefficients	Prob.	Coefficients	Prob.	Coefficients	Prob.	Coefficients	Prob.
LRBP	1	-	0	-	0	-	0	-	0	-	0	-
LRGDP	-0.0297	0.0000***	1	-	0	-	0	-	0	-	0	-
LRRP	0.0133	0.3459	0.0941	0.6516	1	-	0	-	0	-	0	-
LRHI	-0.0398	0.0002***	-0.2709	0.0792*	-0.1914	0.0062***	1	-	0	-	0	-

LRFDI	-0.1688	0.0782*	1.2801	0.3395	0.2303	0.7097	0.6133	0.4487	1	-	0	-
RIR	-0.0166	0.9945	35.834	0.2782	-37.800	0.0129**	-44.264	0.0264**	-1.0017	0.6660	1	-

China

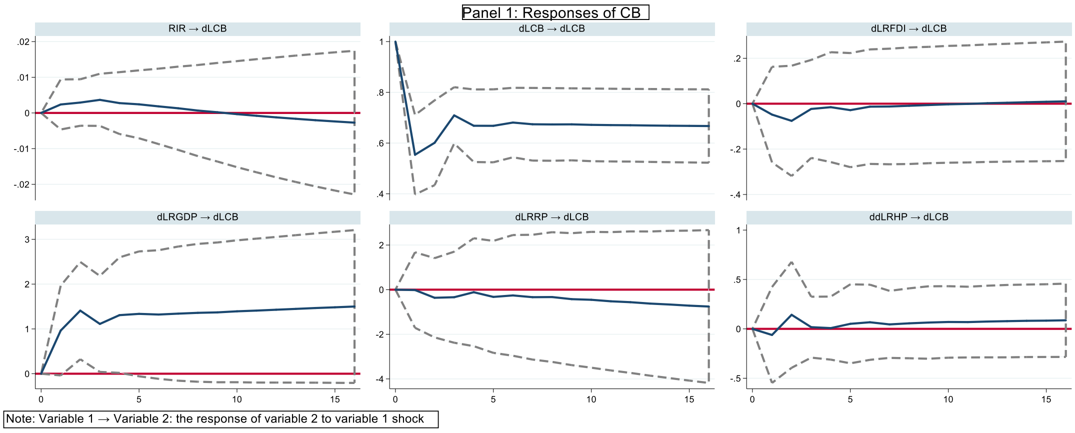
	LCB		LRGDP		LRRP		LRHI		LRFDI		RIR	
Equations	Coefficients	Prob.	Coefficients	Prob.	Coefficients	Prob.	Coefficients	Prob.	Coefficients	Prob.	Coefficients	Prob.
LCB	1	-	0	-	0	-	0	-	0	-	0	-
LRGDP	-0.0069	0.6431	1	-	0	-	0	-	0	-	0	-
LRRP	0.0163	0.4402	0.3492	0.0796*	1	-	0	-	0	-	0	-
LRHI	-0.0281	0.3181	-0.2688	0.3210	-0.1424	0.4453	1	-	0	-	0	-
LRFDI	-1.2012	0.0149**	3.1517	0.5069	1.6282	0.6173	-3.9954	0.1037	1	-	0	-
RIR	-13.149	0.0018***	24.932	0.5176	-46.657	0.0771*	20.451	0.3150	1.7384	0.1281	1	-

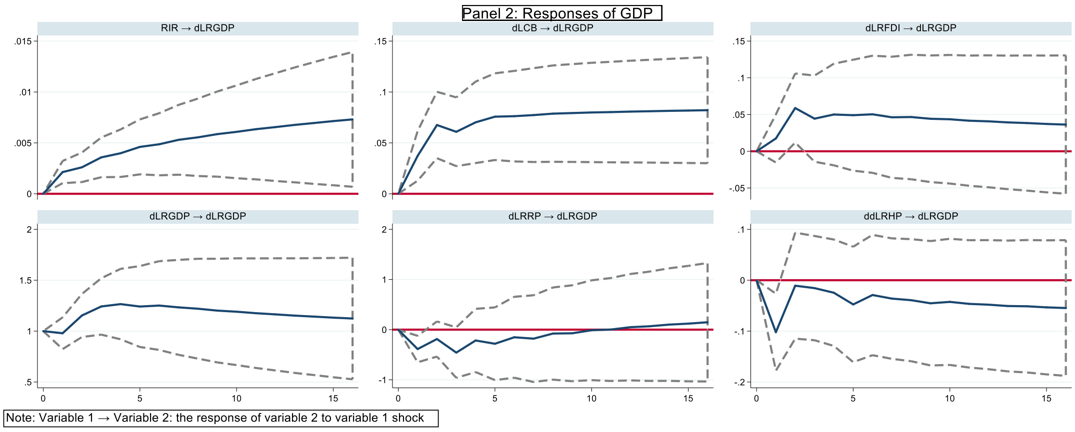
Notes:

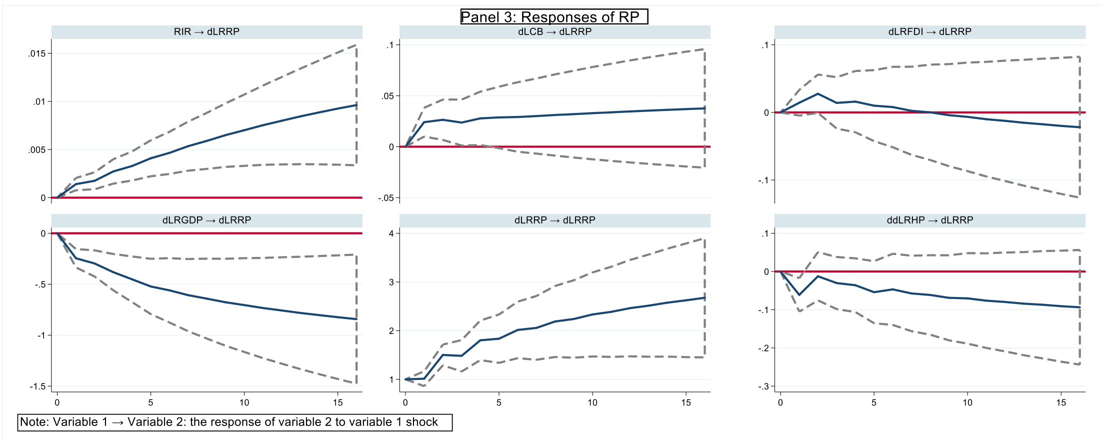
- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.
- CB--building completed to represent housing supply; BP—building permits to represent housing supply; HP-- housing price; HI—housing price index; IR--interest rate; RP--rental price.

3.4.4 Impulse response functions

To reveal the responsiveness of the contemporaneous value of one variable at a time and over subsequent time points towards one deviation shock or impulse in another variable, IRF is conducted. The results are shown from **Figure 3-6** to **Figure 3-8**, which present the responses of each time series towards the shock on the other time series. In the UK, as seen in panel 1, the housing supply level shows a positive reaction in the first five quarters to a shock in GDP. In panel 2, GDP indicates positive responses to interest rate and housing supply shocks throughout the entire period and positively to FDI shock in the second and third quarters. A development in domestic production indeed boosts the property construction in the UK, and housing construction together with FDI investment have contributed significantly to national GDP. Meanwhile, the positive relation between interest rate and GDP was also identified by Simionescu, Popescu, and Firescu (2017), who found that interest rate growth stimulates a heightened GDP in Romania because, after regime change, the interest rate may increase to encourage economic recovery. A growth in interest rate tends to push up the level of future income, stimulate a reduction in current saving, and thus generate a higher national income. A similar positive relation is seen in Bangladesh in the work of Afrin (2017). The interest rate can also affect GDP by changing the appreciation level of domestic currency. With a higher interest rate level, the exchange rate is appreciated in the short term, which can cause expansion on bank credit and increase the national output level (Catão & Pagan, 2010; Wesołowski, 2018). Under the appreciation of currency through foreign capital inflow, a tightening monetary policy may produce a weaker actual effect due to the speculative nature of funds (Song & Gao, 2007). In the UK, the positive relationship between interest rate and economic growth can also be explained as the failure of monetary policy to alter public expectations (Dell'Ariccia & Rabanal, 2018). Simultaneously, negative responses have been found in GDP towards shocks in rental price and housing prices in the first two quarters. Houses sold in the UK are primarily existing rather than newly built homes, and their sales do not directly contribute to GDP (Rottier, 2018). In addition, excess growth in the real estate market may crowd out investment in the productive sector, thereby slowing down economic growth (Andrews, Sánchez, & Johansson, 2011). The study by Caballero, Hoshi, and Kashyap (2008) also indicates a negative connection between housing prices and GDP, stating that the depreciation in housing prices may crowd out low-productive firms from the market and leave bank-lending resources to more productive companies. With respect to the responses of rental price, in panel 3, a constant positive response of rental price on interest rate shock over the time can be seen, and a positive reaction can be found for a shock on the housing supply level. The growing interest rate can result in a reduction in demand for properties purchased because of higher expenses and reduced mortgage affordability. Hence, the demand for property renting would increase, driving the rental price up (Augustyniak, Łaszek, Olszewski, & Waszczuk, 2013). In addition, rental price responded in a constantly negative manner to a shock in GDP and negatively to a housing price shock in the first quarters. A rise in GDP may drive up the wealth level of residents and hence broaden the capability of households to purchase rather than rent (Kim, 2007). Moreover, heightened housing prices might also stimulate purchasing over renting. Previous literature has studied this by providing the evidence of both positive and negative effects of the price-to-rent ratio on rent, which can be explained by the different levels of risk aversion seen in different economies (Engsted & Pedersen, 2015; Gelain & Lansing, 2014). In panel 4, housing prices in the UK can be seen to respond negatively to GDP shock and positively to rental price shock from the third quarter. This is supported by Nyakabawo, Miller, Balcilar, Das, and Gupta (2013), who presents a mixed result of both positive and negative responses of housing price to GDP shock in different subsamples. When focussing on the FDI reactions in panel 5, a positive response to a shock in housing supply can be seen through the whole period, while a positive response to GDP shock is apparent in the first four quarters. Accordingly, the UK construction sector and GDP growth have contributed to stimulate FDI inflow. Finally, a positive reaction of interest rate to rental price shock over the whole sample period can be seen in panel 6.


Panel 1: Responses of CB
RIR → dLCB
dLCB → dLCB
dLRFDI → dLCB
dLRGDP → dLCB
dLRRP → dLCB
ddLRHP → dLCB
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock


Panel 2: Responses of GDP
RIR → dLRGDP
dLCB → dLRGDP
dLRFDI → dLRGDP
dLRGDP → dLRGDP
dLRRP → dLRGDP
ddLRHP → dLRGDP
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock


Panel 3: Responses of RP
RIR → dLRRP
dLCB → dLRRP
dLRFDI → dLRRP
dLRGDP → dLRRP
dLRRP → dLRRP
ddLRHP → dLRRP
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

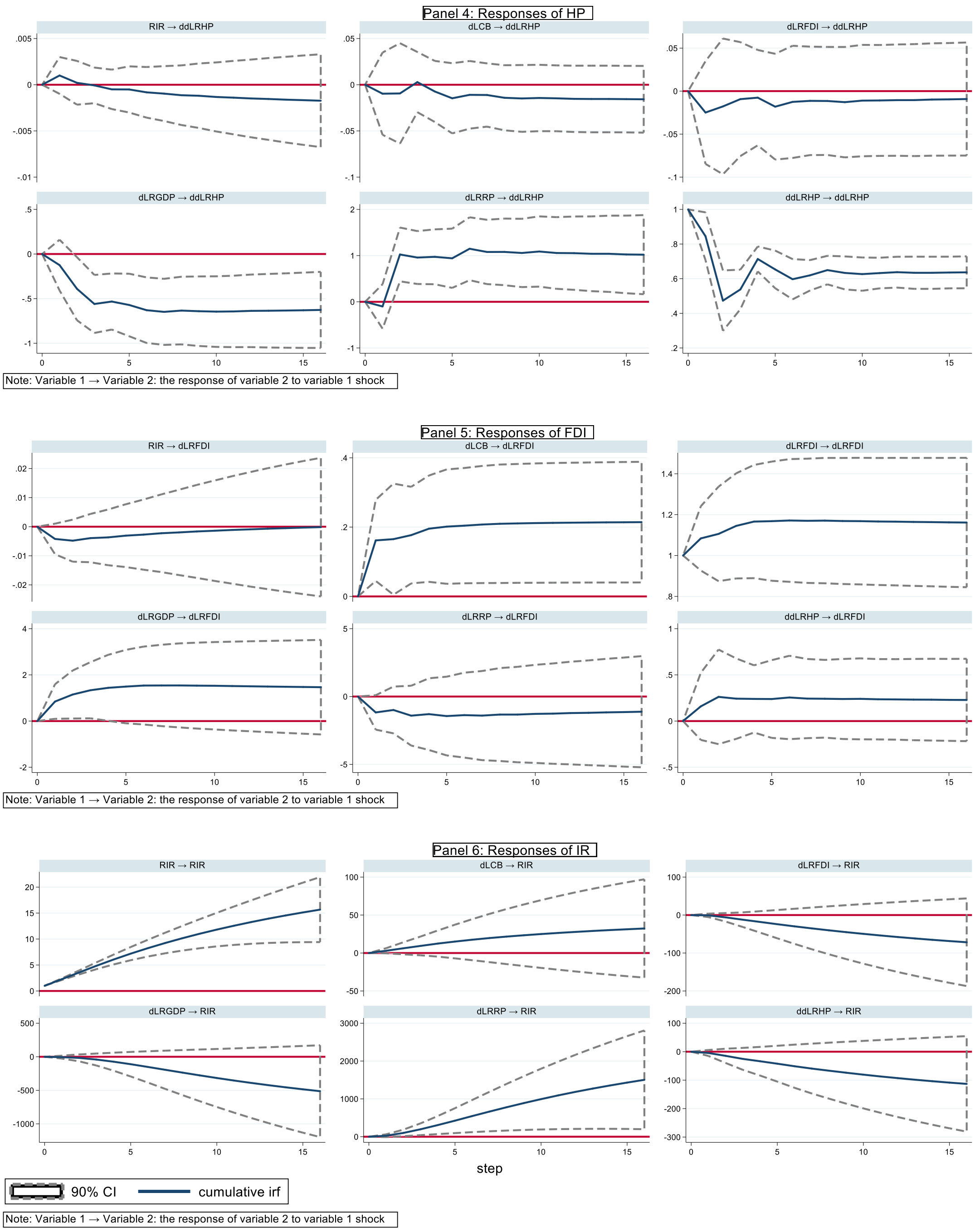


Figure 3-6 Impulse response functions for the UK

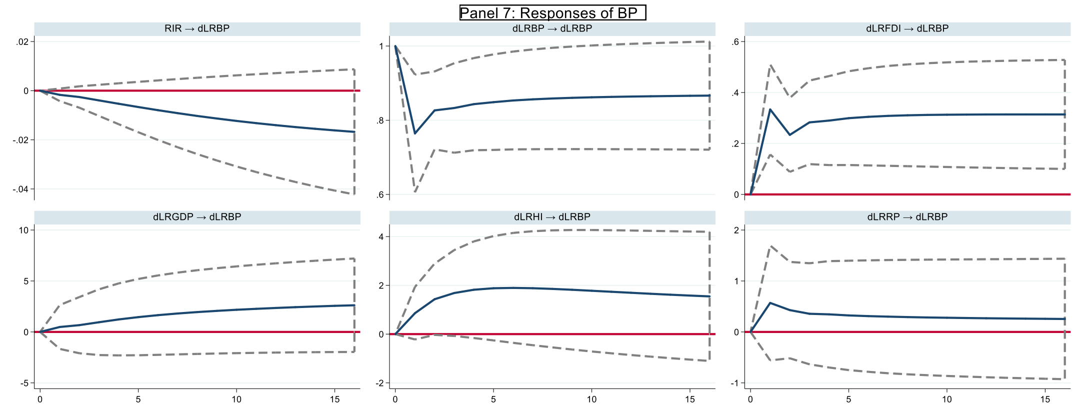
Note:

- This model applies accumulated responses of variables to shocks.
- CB--building completed to represent housing supply; HP-- housing price; IR--interest rate; RP--rental price.

- The model includes 2 lags, and Cholesky decomposition has been applied. The variables are in the following order: CB, GDP, RP, HP, FDI, IR.
- CB and GDP respond to the shocks in each other positively. GDP also reacts positively to a shock in IR. There is also a negative response from GDP in the first two quarters to shocks in RP and HP. RP reacts positively to IR shock while negatively to GDP shock. Also, there is a positive response from GDP to shock in CB in the first three quarters. HP reacts positively to RP shock but negatively to GDP shock from the 3rd quarter. FDI responds positively to CB shock, and positively to GDP shock in the first three quarters. IR reacts positively to a shock in RP.

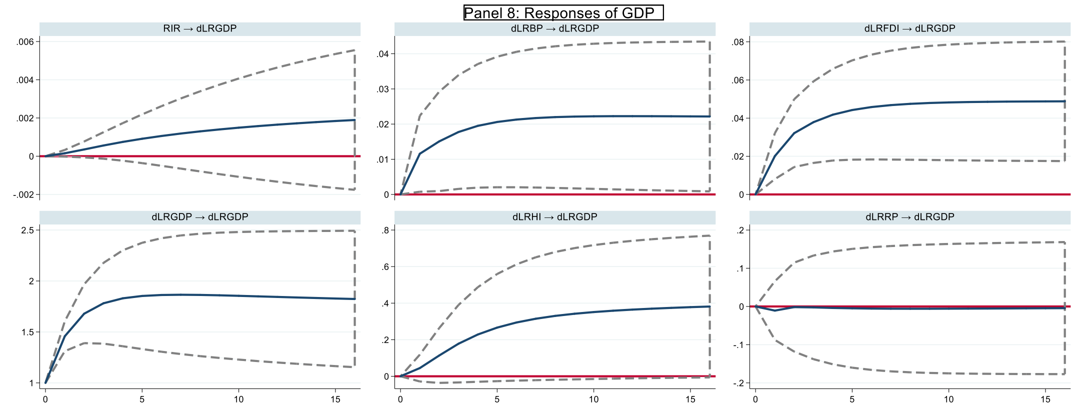
The IRF results for the variables for Canada are presented in panels 7–12. First, panel 7 shows that the reactions of housing supply are only noteworthy in that they respond positively to FDI shock for the entire sample period, as does GDP to FDI shock and housing supply shock, seen in panel 8. Therefore, FDI inflow in Canada indeed supports the construction sector and GDP in Canada. The movement of rental price is continuously positive in relation to housing market shock, whereas this relation is negative in the first two years to housing supply shock and negative in the first year to GDP shock. Similar to the UK, GDP growth in Canada may also support more housing purchases while driving down renting by increasing household wealth (Kim, 2007). Panel 10 shows the responses of housing price to different variable shocks. There is a considerable negative response of housing price to interest rate shock, which indicates the role of monetary policy in controlling the housing market. More importantly, housing price reacts positively to shocks in FDI and housing supply over the entire period and to GDP two years after the shock. Consequently, FDI contributes to the housing price boom in Canada. Meanwhile, the building construction boom may expand the public expectation of prosperity in the real estate sector and lead to the purchase of more houses. Evidence of housing price growth with heightened housing supply can be found in countries such as Canada, Belgium, and Denmark in the working paper by the OECD (Sánchez & Johansson, 2011). The issue of housing supply elasticity may alter the result, and this area is suggested for further research. Panel 11 shows that FDI in Canada does not react substantially to any variable shock. Overall, the relationships among variables are within expectations, and this model captures a crucial relationship between housing price and FDI in Canada. Finally, in panel 12, the response of interest rate to housing price shock is positive in the first four quarters.

Panel 7: Responses of BP



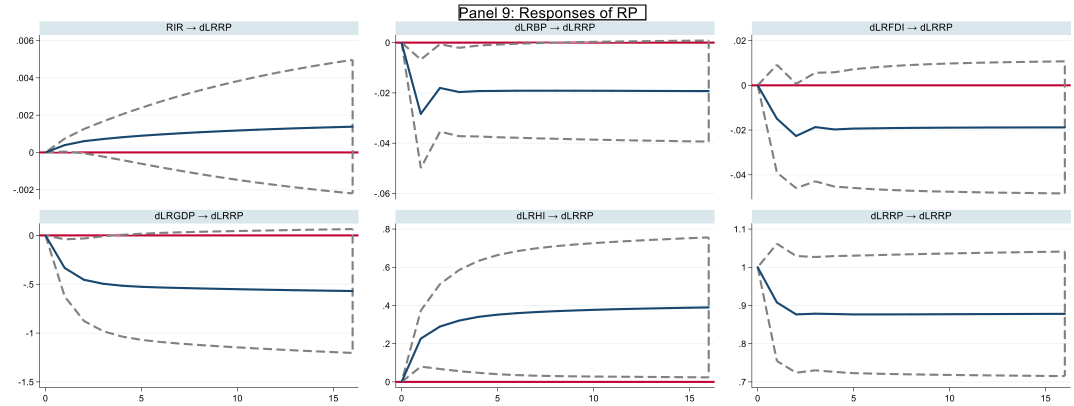
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 8: Responses of GDP



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 9: Responses of RP



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

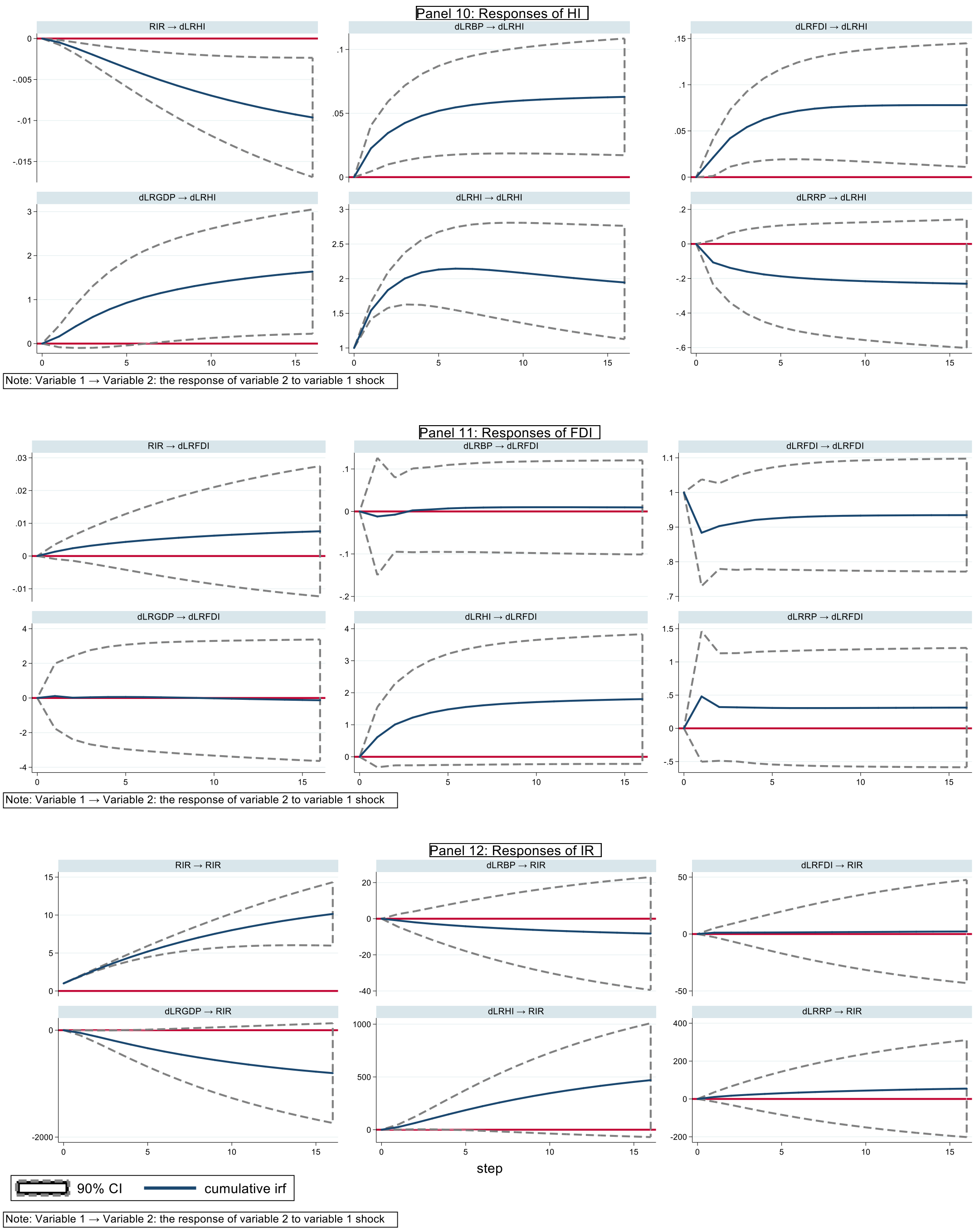


Figure 3-7 Impulse response functions for Canada

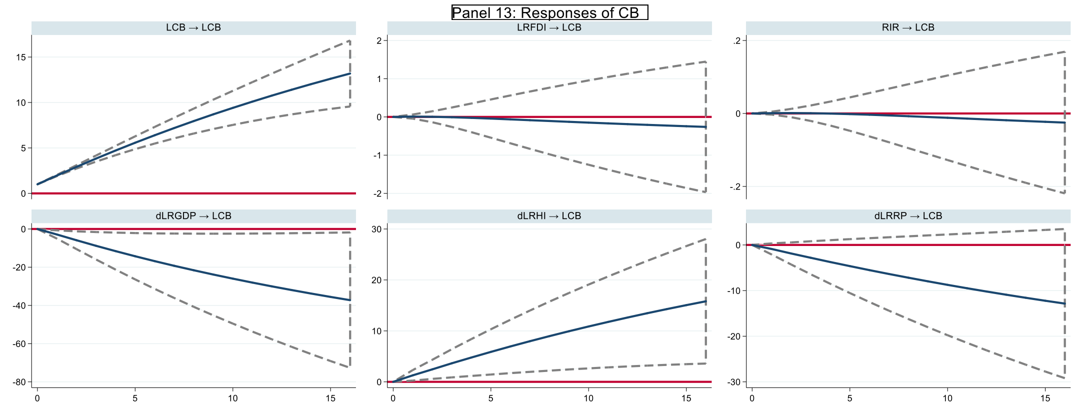
Note:

- This model applies accumulated responses of variables to shocks.
- BP—building permit to represent housing supply; HI-- housing price index; IR--interest rate; RP--rental price.

- The model includes 1 lag, and Cholesky decomposition has been applied. The variables are in the following order: BP, GDP, RP, HI, FDI, IR.
- BP responds positively to a shock in FDI. GDP reacts positively to shocks in FDI and BP. RP reacts negatively to shocks in BP and GDP in the first three quarters, while positively to HI shock. HI respond negatively to IR shock, while positively to BP and FDI shock, and positively to GDP shock from the 7^{th} quarter.

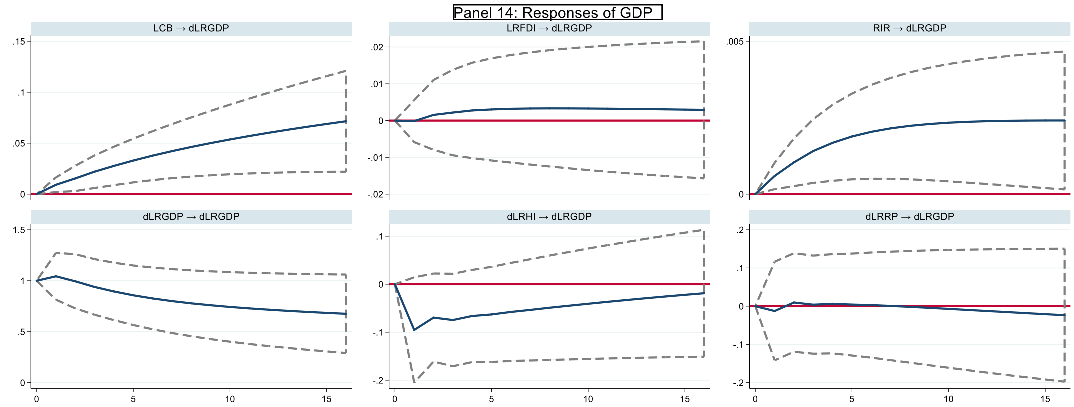
Finally, the case in China is illustrated in panels 13–18. First, the housing completed in China regularly responds negatively to GDP shock and positively to housing price shock. In China, the government controls land supply by colluding with real estate developers rather than allowing them to operate under market mechanisms, distorting the Chinese real estate market (Tian & Ma, 2009; Yao, Luo, & Wang, 2014). Higher housing prices lead to greater housing supply from developers seeking profit. Additionally, the housing market contributes vitally to China's economic growth and national output (Yao et al., 2014). An increase in housing supply from the government may occur after a negative shock in GDP to compensate for the decline. In the meantime, there is considerable diversity across provinces in China, and the real estate market varies enormously among cities. Thus, further research should examine the housing supply and its application to different cities to provide more evidence of this. Similar to the UK model, GDP responds positively to housing supply and interest rate shocks, again supported by the study from Simionescu, Popescu, and Firescu (2017) in the context of a developing country. The explanation offered in their study is that the interest rate in a developing country is higher than in a developed country, and this can be applied to China as well. Economic growth, the increase in the interest rate, and the expansion of consumption can occur together in a rapidly and unsustainably developed economy (Simionescu et al., 2017). Moreover, the pattern of an appreciating exchange rate due to an increase in the interest rate to generate output can also be applied to China (Catão & Pagan, 2010; Wesołowski, 2018). In panel 15, rental price does not exhibit visible reactions to any other variable shock. Meanwhile, in panel 16, housing price in China presents a positive response to housing supply shock and a negative response to FDI shock. Previous research has found evidence of a positive effect of housing supply on housing price level in China in the context of faster growth on the demand side than what supply can keep up with (Chow & Niu, 2015). The limited growth in supply happens particularly in tier 1 and tier 2 cities, which quickly boost the housing price level even though a large amount of housing stock remains in tier 3 and tier 4 cities (Ding et al., 2017). This result is also supported by Kuang (2005), who also demonstrates that the housing supply can positively affect real estate prices when land supply is scarce in China. Meanwhile, with a rise in FDI, the fund inflow generates development in industries other than housing sector, such as manufacturing. In this context, housing prices could drop. This negative effect from FDI to housing price has been supported by the study of Bonis (2006) regarding US cities. Bonis (2006) explains this dynamic through the reverse link of housing price to FDI, that is, higher property prices may diminish their attractiveness for investment. This research also states that in developing countries such as China, industrial facilities absorb much more investment due to low labour costs (Bonis, 2006). Nevertheless, diversified dynamics exist among cities in China, similar to the United States, stated by Bonis (2006), which might also distort the result. Hence, further research could be conducted in this regard at regional level. In panel 17, FDI reacts positively to housing supply shock, while the positive response of FDI to housing price shock only occurs after a period of four years, which indicates the indispensable attractiveness of good economic behaviour in the Chinese housing sector to FDI inflow. Finally, in panel 18, the interest rate is seen to respond negatively to housing supply shock after five quarters, indicating an incentive of rigid monetary policy following the low development in the construction sector with the worry of housing price growth.

Panel 13: Responses of CB



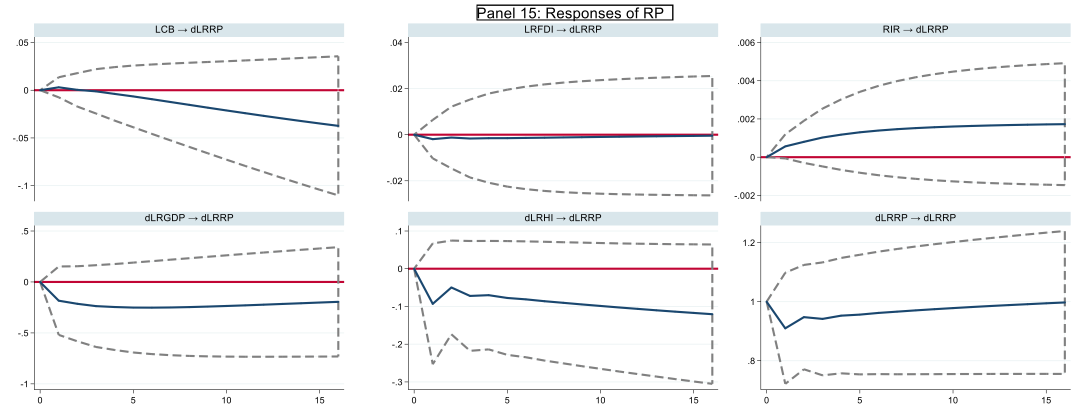
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 14: Responses of GDP



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 15: Responses of RP



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

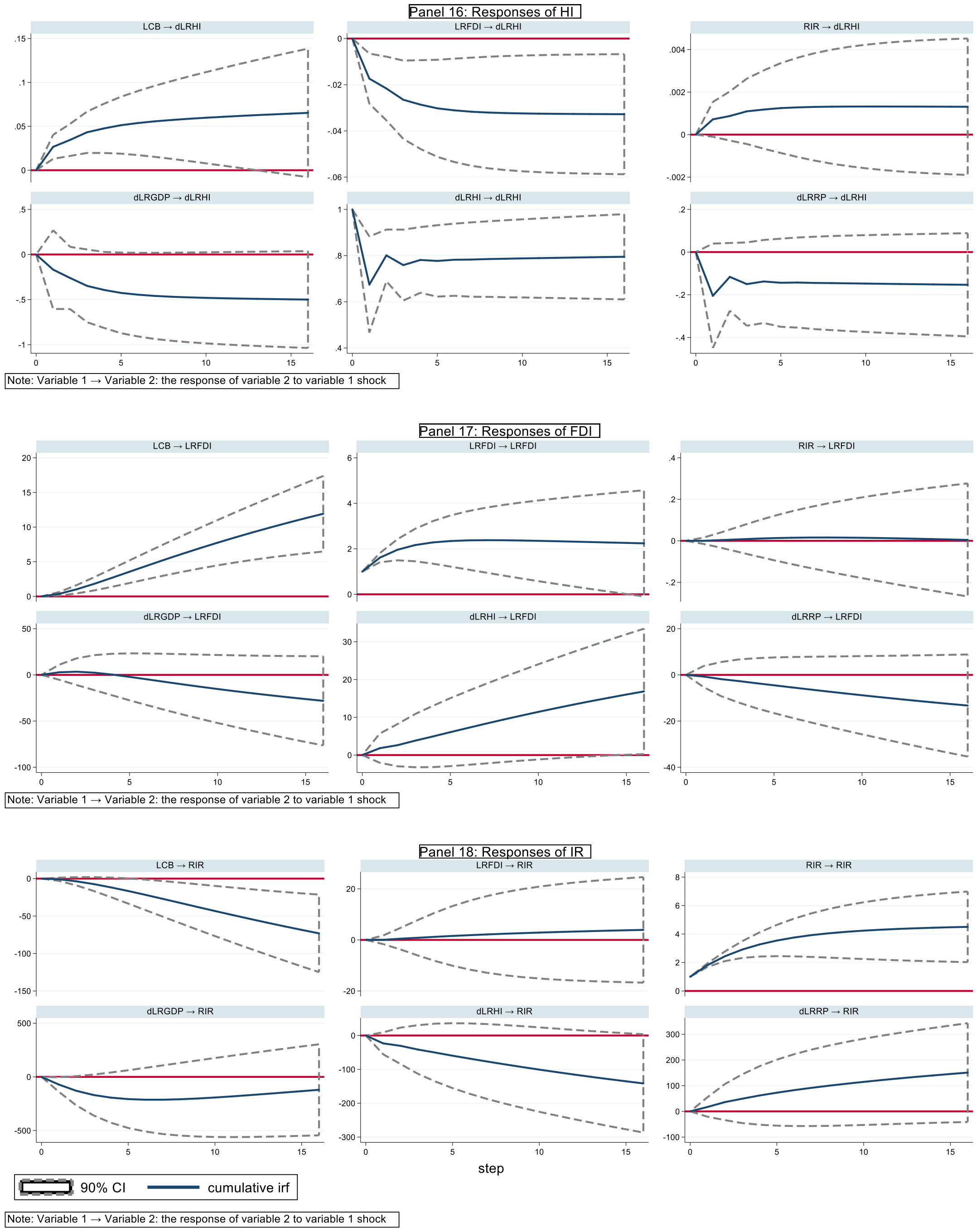


Figure 3-8 Impulse response functions for China

Note:

- This model applies accumulated responses of variables to shocks.
- CB--building completed to represent housing supply; HI-- housing price index; IR--interest rate; RP--rental price.

- The model includes 1 lag, and Cholesky decomposition has been applied. The variables are in the following order: CB, GDP, RP, HI, FDI, IR.
- BP responds positively to a shock in HI and negatively to a GDP shock. GDP reacts positively to shocks in CB and IR. HI responds negatively to FDI shock, while positively to CB shock. FDI reacts positively to CB shock. IR responds negatively to a shock in CB from the 5th quarter.

To summarise the result, the effects of FDI on the housing price level are different among the three economies. Given the relatively low supply of houses in the UK, its high housing prices tend to be better explained by the imbalance between supply and demand, whereas FDI inflow does not have much explanatory power on fluctuations in UK housing prices. By contrast, FDI inflow in Canada not only provides capital to real estate development companies but also direct funds to housing investment. Accordingly, housing price has also been driven up by the excess capital inflow from overseas, exacerbated by the loose regulation of foreign real estate investment in Canada. By comparison, a rise in FDI inflow has resulted in a negative pressure on housing prices in China. Apart from the real estate construction growth under FDI inflow, as it is a developing country, China has seen a greater amount of foreign investment in its manufacturing industry. Both of these impacts may become the reasons for the negative relationship between FDI and housing prices in China. At the same time, there is no significant causal effect from housing price to FDI in the target countries. FDI inflow tends to boost the construction sector of the real estate market based on evidence in Canada as housing supply responds significantly to FDI. Substantial funds from foreign investment have contributed to the supply of buildings and housing in the market. In the meantime, the real estate construction increase has attracted dramatic growth in FDI in the UK and China, which, again, presents a close connection between FDI and the housing market. Future research may work with other models to address a more synthesised analysis on the effect of real estate price on FDI, providing the existed evidence of a link between the two sectors.

3.4.5 Robustness check

As the aim of this chapter was to study the explanatory power of foreign investment on fluctuations in housing prices, an SVAR model was established to analyse the dynamics among the variables. A quality assurance methodology is essential to verify the certainty and accuracy of the results. Since the SVAR model might show sensitivity to the assumptions made during the estimation, several accepted approaches exist to test the robustness, including testing in subsample periods and changing the variable ordering. In this section, we perform a robustness check of the results reported in the previous section to evaluate whether the model functions well under an alternative variable ordering. Since this chapter applies the popular approach of Cholesky decomposition, the variable ordering has a crucial impact on the estimated result. As a consequence, the order of the variables in the robustness check was altered from housing supply, GDP, rental price, housing price, FDI, and interest rate to GDP, housing supply, rental price, housing price, interest rate, and FDI. In particular, concerning the economic plausibility of the ordering, the orders of the less endogenous variables, as well as of the more endogenous variables, was adjusted. Following the new variable ordering, the empirical model was reconstructed accordingly to gather the estimated result, presented in **Table A1**-**A3** in **Appendix A**. Overall, we obtained highly similar results in both attempts, showing a positive effect of FDI on housing prices in Canada and a negative effect of FDI on Chinese housing price movements. Thus, the robustness of the analysis provided in this chapter is confirmed.

3.5 Conclusion

This chapter used the quarterly data of house prices, FDI, housing supply, interest rate, rental prices, and GDP to determine the explanatory power of foreign investment on soaring real estate prices in the UK, Canada, and China. To this end, an SVAR model, as well as the Granger causality test and IRF, were employed. This chapter contributes to the existing literature by including the variables of FDI, rental price, and housing supply in the model. Some key conclusions have been obtained following the test results. Most prominently, no short-term relationship between house prices and FDI inflow in the UK has been found, implying that FDI does not have any effect on the UK real estate price level. Nevertheless, FDI inflow to the UK is closely connected to the housing supply, indicating the significance of the construction area in attracting capital inflow. In the meantime, rental price in the UK has a noteworthy explanatory power on housing price, justifying the relationship between the housing market and its fundamental value in the UK. This might be seen as an indication that there is no housing bubble in the UK real estate market, which can be examined by further research. Comparatively, there is a notable short term causal effect of FDI on housing price in Canada, making it a vital explanatory factor for real estate market fluctuation in Canada. The conclusion from the IRF also indicates a positive response of housing price and housing supply to a shock in FDI in Canada, which reveals the critical effect of FDI on real estate price changes and the support it offers to the construction sector. Regarding the Chinese market, a significant short-term causal effect of FDI on housing prices is clear, indicating that FDI is a crucial determinant of fluctuation in the housing market. In the meantime, the housing supply in China has a considerable explanatory power on FDI inflow. In addition, the conclusion from the IRF implies a negative response of housing price to an FDI shock in China, which reveals the crucial negative effect of on real estate price changes. This result is supported by the study of Bonis (2006), stating that capital flows to developing countries accumulate mainly in manufacturing industries rather than in the housing sector. This negative relation is also proved in the United States in this study, which is explained due to the lesser attractiveness of housing investment when real estate prices are growing (Bonis, 2006). At the same time, negligible links were revealed between housing price and rental price in this study, which could not justify the connection between housing price and its fundamentals. This might indicate a housing bubble in the Chinese housing sector, which should be the subject of future research.

Stabilising and controlling the housing market boom is a key task for the UK, Canadian, and Chinese government, whereas the inflows of foreign investment, by contrast, do not necessarily provide sustainable resources for real estate development. If housing prices are overheated, driven by speculative capital inflow, a possible burst leads to falling demand, bad debt, capital outflow, or even market crisis (Nguyen, 2011). The evidence from this chapter suggests an enormous effect of FDI on the fluctuation of real estate prices in Canada and China. Furthermore, the vital role that housing supply plays in attracting FDI inflow has been justified in the UK and China. With respect to the relation between the rental and house prices, these two time series are closely related in the UK and Canada, but in not China, which might indicate that there is no bubble in the UK and Canadian real estate markets. Nevertheless, the limitations of this study must be clarified so that they can be taken into account for future research. Although a significant effect from FDI to real estate prices in Canada and China has been detected, it is not testable in this thesis which theoretical mechanism is a dominant channel in this relationship. The method proposed in this study only contributes to the understanding of the effects among variables in the model, while the knowledge on the importance of specific theoretical mechanism is limited. It thus produces recommendations to further research to adopt models, including variables such as consumption and mortgage loans to assess this topic. The employed SVAR model in this chapter also needs a discussion on its general limitations. Since the Cholesky decomposition is applied, the ordering of variables is prudently selected following the theoretical basis. Nevertheless, a more comprehensive discussion on the variable ordering or more suited restrictions such as a sign restriction approach could be conducted in future studies. To be noted that the potential alternative selection of restrictions in models is again crucial to avoid inferior results. Furthermore, diverse forms of foreign capital could be examined in the same situation to explore a different source of influence on the real estate market. Furthermore, the variables in the economic model are another limitation that can be addressed in further research. At the same time, this study provides several implications. With wise supervision, the inflow of foreign investment could positively promote and boost the healthiness of the real estate market. Since this study found no causal relationship between inward FDI and housing price changes in the UK, new practice on other factors related to housing industry would be brought into the operation of the real estate market and improvement of housing developers. Accordingly, supervision in Canada and China must concentrate on regulating the FDI sector to guarantee a stable source of funds for the housing industry. Additionally, policymakers in the UK should monitor other potential influencing elements on the real estate industry, while FDI can be deemed as a safe source of funds for the development of the real estate industry. In the meantime, the government should continue to encourage a balanced distribution of foreign capital to ensure even development in different industries.

Chapter 4 Relation between the stock and real estate markets in the UK, Canada, and China

4.1 Introduction

In the previous chapters, the focus has been put on the presence of real estate bubbles, and foreign investment as one determinant for the soaring housing prices in the UK, Canada and China. This chapter has proposed another emerging indicator in the stock market that relates closely to real estate development, REITs, into the analysis. Existing studies have made massive contributions to the relationship between stock and housing markets fluctuations (Li et al., 2015; Louis & Sun, 2013). Several unprecedented fluctuations, that is, booms and busts, in the stock market and housing market have prompted substantial social debate as to the degree to which the two markets interact and the possible relations between stock and house prices (Kakes & Van Den End, 2004; McMillan, 2011). This chapter, instead, investigates a comparatively new area to contribute to the gaps. In particular, the securitisation of property, especially of real estate, which can take the form of REITs, can have a considerable effect on the property market. As a critical traded vehicle for real estate investment, REITs generally operate in a clear and straightforward manner: Rent earnings are collected by REITs companies, which produce income to be paid out to REIT buyers with the pattern of dividends (Li & Lei, 2011). A stable and contractual dividend payment as the income-yield cash flow is provided by REITs asset, and this remains the most crucial component of the return (Sagalyn, 1990). This means of investment offers the individual a chance to own real estate assets by purchasing corporate stock in the same way that one would invest in any other industry, without actually buying and managing property. Real estate investment trusts operate under a structure similar to mutual funds to increase tax transparency compared to a traditional corporate structure (Bredin, O’Reilly, & Stevenson, 2011). These trusts have two requirements, namely, that at least 75% of the REIT’s assets be invested in housing and that a minimum of 90% of taxable income is paid as shareholder dividends, and if these requirements are fulfilled, REIT dividends can be tax exempt. As an alternative tool for property investment, the development of the REIT market has been rapid in recent years (KPMG, 2007). Notably, studies in the US REIT market have found a low correlation between REITs and stock or bond assets, which provides a particular stability feature to the portfolio (Randy, Vivek, & Akash, 2018). Moreover, due to the high dividend level and strong return performance that has been demonstrated by historical statistics, REIT assets have continuously attracted individual and institutional investors (Randy et al., 2018). The relationship between REITs and real estate essentially evaluates how real activities and real stocks react to each other (He, 2000). The mechanism can be understood as indirect real estate investment leading to higher liquidity flows in the market and fewer transaction costs, while more related information is available (Yang, 2005).

It is particularly crucial to understand the nature of the relation between REITs and real housing prices, as REITs are a critical part of the household portfolio. As such, the investment context, such as how sensitive REITs are towards other asset types like real estate and how strongly they can be used as a proxy of the housing market, must be fully grasped in order to allocate assets wisely and stabilise the market (Clayton & MacKinnon, 2001). Regulators can also apply more specified supervision over the financial sector after gaining a more unobstructed view of this relation. In the past decade, during booms in the REIT sector, researchers have noticed a much closer link between the more matured REITs and real estate market rather than stock market (Clayton & MacKinnon, 2001). Consequently, it is of central importance to understand and study the link between housing prices and property stock prices. The aim of this chapter is thus to empirically test for a connection between REIT portfolio prices and housing price levels in the UK, Canada, and China. The methodology adopted to this end is the SVAR model. Although the context of growth in both industries has illuminated a possible connection between REITs and real estate prices in the target countries, limited research on this has been conducted. Consequently, this chapter is designed to estimate the link between REITs and housing prices and to acquire evidence as to whether they are indispensable determinants of each other. The findings of this chapter cannot suggest any obvious explanatory power of REITs on housing prices in the three countries, although REIT returns are dramatically influenced by real estate prices in the UK and Canada.

Economic theory suggests that housing wealth and stock investment could affect each other given their fundamental relation, and a wide range of literature has provided empirical evidence on this subject. Tsai et al. (2012); Anderson and Beracha (2012); Shirvani, Mirshab, and Delcoure (2012); and Li et al. (2015), for instance, researched US stock and real estate market movements, and some of them have found linear or non-linear links between the two sectors. Studies such as Kakes and van den End (2004); Yang (2005); Kapopoulos and Siokis (2005); and Su, Chang, and Zhu (2011) have examined this topic among European countries. In particular, the dynamic in the UK was researched by Su et al. (2011), who studied the cointegration relationship between the stock and housing industries in European countries. Similarly, McMillan (2011) provided some evidence for this relationship in the US and UK. With respect to Asian economies, Sim and Chang (2006); Liow (2012); Lean and Smyth (2014); Lee, Liang, Wu, and You (2013); and Ibrahim (2010) have offered positive or negative findings on the relationship among stock price, housing price, and other economic variables. Notably, Zeng, Li, and Li (2008); Zhang and Fung (2006); and Lin and Fuerst (2014) have examined the causal relationship between the stock and real estate sectors in China. Nevertheless, limited evidence has been found by empirical studies on the relationship between rising house values and real estate sector-related stock investment, such as REIT activities, in the UK, Canada, and China. He (2000) is one exception, applying apartment REIT and unsecuritised real estate prices as the objective variables in the context of the United States. This study explored the causal relationship between REITs and real estate prices in the target countries using SVAR analysis.

The rest of the chapter is organised as follows. Section 4.2 presents a literature review of previous studies on the stock and real estate markets. Section 4.3 describes the methodology and data applied in this chapter. In Section 4.4, the research results are analysed, and, finally, in Section 4.4.5, a conclusion and summary are presented, along with related implications.

4.2 Literature review

4.2.1 Background

With the globalisation of the economy and wealth creation in the real estate market, more investment instruments such as securitised real estate investments have become available to global investors (Liow, 2012). Investment in properties has been transformed from direct to share ownership with securitised real estate by intermediaries such as real estate companies (Morawski et al., 2008). With the evolution of real estate investment in forms such as REITs and property stocks, this area has grown into an increasingly vital investment for property globally. For instance, the portion of securitised real estate in Asia comprised 12% of the overall global figure in 2008, far above the worldwide average, of 6% (Liow, 2012). In particular, REITs have become a leading product for income with high a pay-out in the investor's portfolio in recent years. These trusts were first introduced to the market in 1960 in the United States, and countries around the world have since gradually adopted the REIT regime (Nareit, n.d.). This investment tool has the characteristic of exposure to diversified assets which would otherwise be inaccessible or too expensive for individual investors to gain access. As a result, significant public funds have been consumed in the attempt to gain exposure to the housing asset class (Clayton & MacKinnon, 2001). Statistics show that the amount of capitalisation of REITs in the global market has grown from $579 billion in 2006 to almost $800 billion in 2013 (Hale, 2014). This suggests that REITs has revealed more of the fundamentals in the real estate industry, which represent its nature, rather than the stock market. Conversely, some evidence has found that the correlation between REITs and real estate is low. This might be due to the fact that REITs and direct real estate share different adjustment speeds towards market movements (Oikarinen et al., 2011). The informationally more efficient REITs hold some characteristics, such as more participants, higher liquidity, and lower costs. Consequently, they react more quickly to fundamental shocks than actual property. Besides, lower return in REITs and other influencing factors such as strategic aspects and management quality might also affect the relationship between these two investment tools (Oikarinen et al., 2011). With the trend of investors seeking more liquid access to the real estate assets, the link between REITs and real housing investment has attracted tremendous attention and is worth studying (Clayton & MacKinnon, 2001).

Together with property market development, the UK stock sector has also presented an increasing trend in history. Several boom and bust cycles have been witnessed in the UK stock market, both before and during the 2008 financial crisis. However, the market has seen a continuous surge since the crisis. A leading representative stock index in the UK covering the most prominent companies, the FTSE 100, has shown a strong performance. In March 2015, the FTSE 100 reached 7,000 points for the first time, reaching a new record, higher than the pre-crisis peak (ONS, 2015a). In addition, a return of nearly 20% was delivered by the FTSE 100 in the UK in 2016; this is more than 50 times the rate of savings interest (Jones, 2017). Statistics show that in 2016, the performance of the London stock market soared to become the best year since 2013 (Shapland, 2016). In the meantime, REITs in the UK had a comparatively slow start from their establishment in 2007, but they are flourishing and have become increasingly attractive in recent years. A group of large real estate companies, including some already listed in the UK with higher market capitalisation and higher dividends, have chosen to become REITs (Park, 2016). The market has generated favourable expectations in the UK REIT sector. Furthermore, the changes in the REIT regime brought in by the Finance Act 2012, as well as the 2014 adjustment of rules which allowed foreign REITs to invest in UK REITs tax-free, have further contributed to the boom in this real estate investment sector (Allen, 2014). According to one leading real estate company in the UK, three-quarters of its REIT investment has come from domestic to overseas investors. Since then, the interest in global investment has substantially raised the capital available to the UK market, which makes the REIT market in the UK a worthwhile sector to which to pay attention.

The Canadian stock market has been one of the leading performers among the global markets for the years since the 2008 crash, although several fluctuations have been seen. In 2014, the Canadian stock market outperformed many other major stock markets and was significantly enlarged (Tencer, 2014). In 2015, a decline of around 11% was seen in the S&P/TSX Composite Index, the benchmark index in the Canadian stock market (Evans, 2015). However, despite this slump, the stock market corrected itself and presented the best performance among developed economies in 2016. Stock returns in 2019 reached 21%, the best since 2009 (Advisor, 2017). In the meantime, the Canadian REIT sector has continued to be prevalent and stable and has gained investment superiority, with an average return of nearly 13% compared to the low interest rates in Canada that have prevailed since 2002 (Craig, 2016). In 2016, a total return of 14.8% was produced in the Canadian REIT market, placing it far ahead of its counterparts around the world. This trend reveals the confidence that the public places in the Canadian property market. Moreover, with the expectation of a low interest rate, market valuations, and stable Canadian dollar, global investors continue to transfer capital into the Canadian REIT sector (Ratner, 2016). Therefore, together with the booming real estate sector, the link between REIT and property prices in Canada is also an targeted area to study.

For the past several years in China, a striking imbalance has been apparent between the stock market, which has displayed huge fluctuations, and the real estate market, which has continuously surged (Zhang & Fung, 2006). Despite its booming housing industry, the value of stock indices in China has continued to plunge since the beginning of the twenty-first century. The stock market pattern did not reveal the real performance and fundamental value of the economy (Zhang & Fung, 2006). In general, the financial industry in China remains immature, with limited financial tools and channels available, meaning that investors do not favour this market due to its high risk and potential unprofitability. This imbalance restricted healthy economic development, and China has faced more challenges due to changes in credit growth and significant uncertainty in the property market. In the meantime, as these two commodities have gradually become an essential part of household income, their prices and stability are crucial for the wellbeing of the Chinese asset market (Zeng et al., 2008). Meanwhile, real estate investment in China is a vital and common practice due to factors such as tradition and population density (Lin & Fuerst, 2014). However, as a developing country, the ideas of securitisation and trusts in China remain in an immature stage (KPMG, 2007). Across Asia, the REIT is a relatively new investment instrument, while the rest of the world is building this real estate structure to allow for small or individual investors to participate in the benefits of a boom in the property sector. Only quasi-REIT products have been released in the Chinese financial market. Since 2014, China has issued several similar products, such as the Penghua Qianhai Vanke REIT, which has raised almost USD 2 billion (Fung, 2016). China is still working on establishing a suitable framework and matured securitisation system for the development and operation of REITs. Simultaneously, several REIT assets targeting the Chinese property markets have been listed outside the Chinese stock market. These investment trusts have been traded in Hong Kong and Singapore, with their backed assets as buildings and properties in China (APREA, 2018). The growth of these Chinese REIT assets has been tremendous as well. According to the statistics from 2017 to 2018, these REITs received a return of 16%, ranking them among the top REITs in Asia (APREA, 2018). The topic of how this surging sector affects the real estate market in China must therefore be discussed.

4.2.2 Theoretical framework

The model in this chapter examines the relationship between real activities and stock returns. Since the returns reflect the expectations for future activities, a two-way causality exists between them (He, 2000). The outcome of He (2000) indicates that REIT returns positively Granger-cause actual real estate price, and vice versa. Changes in one asset price can provide relevant information and feedback to affect expectations of the other asset returns. This relationship is based on the following theoretical mechanisms.

I. Information mechanism

Primarily, there is a direct bidirectional link between real estate stock returns and real activities such that current real activities can justify subsequent return behaviours, while lagged stock returns can influence current activities (He, 2000). The return of stocks thus reflects public expectations of changes in future real activities, and stock prices are theoretically discounted future income (Binswanger, 2000; Fama, 1990; Geske & Roll, 1983; Kaul, 1987). Changes in cash flow in real activities can offer vital feedback for the public to revise future expectations (Balvers, Cosimano, & McDonald, 1990). Consequently, this modified expectation is reflected in stock prices. Specifically, the return of real estate-related stocks such as REITs incorporates information about real housing market movements, and the housing sector changes are regarded as fundamental determinants of the value of REIT equity (Fama, 1990). This leads to a positive causality from actual real estate returns to REITs. However, the subsequent real activities can also be explained by stock returns, which display a positive bidirectional relation between actual real estate returns and real estate stock returns. The growth of return on stocks from the above channel will, in turn, stimulate higher capital expenditure, which provides more funds for real output, such as the development of the housing sector (Fama, 1990). In the meantime, stock return growth can also provide capital and information useful for subsequent property investment. It is worth noting that the movement of stock returns from future information usually occurs before the real activities happen. In other words, it is quicker for REIT equity returns to adopt new information than the real housing market returns. Consequently, REIT price level increases have passively provided information about the upward movements of future real housing activities, and this information can lead to higher levels of housing investment (Binswanger, 2000). When stock prices are greater, household personal incomes are higher, which promotes real estate investment and increases housing prices as well (Geske & Roll, 1983). Therefore, a positive causality from REIT to housing prices is apparent based on the above channels.

II. Wealth effect mechanism

A wealth effect can be seen between the two assets (Ibrahim, 2010; Lean & Smyth, 2014; Li et al., 2015; Sim & Chang, 2006). Aggregate consumption is positively related to household wealth, including property and stocks, and real estate and stocks are generally viewed as alternative investment tools (Kapopoulos & Siokis, 2005). A change in the value of stocks in household portfolios such as the REIT price change would stimulate an attempt to rebalance the portfolio by adjusting property ownership. In the meantime, as houses can also be regarded as consumption goods, an unexpected gain from changes in REIT share prices, indicating an expansion in wealth, could stimulate more purchase behaviour in the housing market (He, 2000; Ibrahim, 2010; Lean & Smyth, 2014). Similarly, since stock prices generally reflect the profitability of one firm, rising stock prices also magnify the demand for houses, as either consumption or investment (Lean & Smyth, 2014). This is expressed as a positive causal relationship running from REIT stock returns to housing prices.

III. Credit effect mechanism

At the same time, a credit effect could exist between housing and stock performance (Chen, 2001; Ibrahim, 2010; Lean & Smyth, 2014; McMillan, 2011). Fundamentally, increased housing prices mean that the collateralisable assets that individuals and firms hold gain a higher value, giving borrowers a greater capacity to borrow (Chen, 2001). For REIT firms in which properties act as collaterals, increasing in the value of houses provides the possibility of accessing lower-cost borrowing to conduct further investment. A favourable position on the balance sheet from the capital income and the expected profit from the expanded investment both result in the higher equity price of the REIT firm (Chen, 2001; Kapopoulos & Siokis, 2005). Similarly, consumption is amplified from the households that put properties as collateral, which again drives up the price of REIT stocks due to greater demand. Such effects, inducing higher REIT prices, then in turn boost the wealth effect further and place upward pressure on housing prices (McMillan, 2011).A feedback effect is also apparent in this mechanism, for when the investment expands, the demand for land and property for the new investment pushes up real estate prices (Chen, 2001; McMillan, 2011). Hence, the credit effect mechanism presents a positive causality from housing prices to REITs and from REITs to housing prices.

IV. Composition risk mechanism

The final mechanism, composition risk, is particularly apparent in a recession period. Real estate is illiquid and volatile, and the wealth and risk linked with housing investment can therefore affect the risk level that investors are willing to hold with other investments such as stocks (Anderson & Beracha, 2012). Taking the recent global financial crisis as an example, the original housing bubble that burst in the United States was immediately followed by a remarkable blow-up of the stock bubble, which ultimately gave rise to the general crash of the global economy (Li et al., 2015). Additionally, as the decision-making between consumption and savings by household is affected by both future consumption and the composition of house consumption, investors decide to sell stocks such as REITs to raise current consumption during recessions. This is especially true when the share of property consumption is low (Lean & Smyth, 2014; Piazzesi, Schneider, & Tuzel, 2007). Moreover, when there is a heightened composition risk, represented by a higher volatility of housing shares in the consumption basket, the precautionary saving motive of investors is stronger, placing downward pressure on REIT stock prices (Piazzesi et al., 2007). At the same time, Hui and Chan (2014) proposed a contagion between the stock and real estate markets during the financial crisis. Even though investors usually use diversification to mitigate risk, this diversification can be lightened during recessions, because the same asset in different regions, or different types of assets such as property and stock, tend to descend together. In particular, more volatile movement has been seen in the stock than in the property market in response to a negative shock, while similar levels of volatility are shown in response to a positive shock. Therefore, correlation might be found in a booming economy rather than a down market (Tsai et al., 2012). In theory, both REIT stock and real estate can be sensitive to some common fundamentals, such as interest rates, which can therefore result in simultaneous movements (He, 2000). A lagged reaction on the part of housing market due to its nature of slower adjustment to fundamentals than the stock market is apparent. Overall, these channels indicate a positive contemporaneous causality between housing activity and REIT stock returns.

V. Monetary policy and real estate price

Expansive monetary policy, primarily interest rates, according to past studies, is suggested to be another factor that could influence housing prices. According to the theoretical model, loose monetary policy can stimulate the housing market boom, and the two markets have shown co-movement. This was examined by Zhang (2013) in his research, which states the house prices are partially the result of magnified liquidity from money overflow to the property market. In particular, the loose monetary policy in China was the origin point that provided this money. Lower interest rates have generated more incentive to consume and invest rather than save, which can potentially result in more resources being allocated to the real estate sector (Tillmann, 2013). In the context of stimulating the economy, especially after the financial crisis, large amounts of liquidity might be offered through expansion policy in order to enlarge consumption (Guo & Li, 2011). The policy mentioned in particular by Agnello and Schuknecht (2011) and Liang and Cao (2007) refers to interest rate reduction, which might affect the individual financial conditions of the debt of housing buyers. Interest rates are a vital factor in a model that examines the movements in real estate prices. Empirical evidence from previous research demonstrates that low interest rates tend to boost the ultimate housing price increase, and in China, monetary policy is the critical driving force (Zhang, Hua, & Zhao, 2012). This is because shocks in interest rate affect the debt financing condition if households purchase houses, which could reduce credit and make house purchasing cheaper, following neoclassical theory (Sa et al., 2011). In particular, the liberalisation of capital markets increases the sensitivity of real estate prices to interest rates (Agnello & Schuknecht, 2011).

VI. Macroeconomic variables and REITs

Previous research has revealed the correlation between property market returns and macroeconomic variables. Primarily, the interest rate has prominent explanatory power, explaining two-thirds of the changes in REITs in one study, by McCue and Kling (1994). This study focussed on macroeconomic factors and real estate returns, represented by REITs, using the unrestricted VAR to focus on the channels of influences and examine how REITs responded to the shocks (McCue & Kling, 1994). Using this method the enormous explanatory power of the US nominal interest rate on real estate returns was found (McCue & Kling, 1994). Examining the UK property industry with a VAR model, Brooks and Tsolacos (1999) confirmed a contemporaneous effect of interest rate on property returns, although the most significant influencing factor was the lagged real estate price level, not the interest rate. This study selected the FTSE property total return index as the proxy of real estate return (Brooks & Tsolacos, 1999). Similarly, concentrating on exploring the impact of unanticipated central bank behaviour on REITs, Bredin et al. (2011) applied a baseline regression and a forecast VAR model in the US. According to the outcome, this research justified the notable and consistent negative influences of interest rate shocks on REITs. In particular, the driving force under this mechanism is the dividend pathway (Bredin et al., 2011). A further long-term co-movement relationship among REITs, residential sector prices, and interest rate has been found in the UK and US markets (Bouchouicha & Ftiti, 2012) using the dynamic coherence framework method. In addition, a negative response on the part of the US REITs towards shocks in interest rate as well as economic growth, expressed by the coincident index, was discovered by Ewing and Payne (2005). With a rigorous monetary policy, resulting in higher interest rate or an unexpected real output fall, REIT returns decrease. Examining the determinant factors of REIT pricing using the VAR model, Li and Lei (2011) supported this result, finding strong explanatory power of all general economic factors, including GDP, and the stock market on REITs. As suggested in the result of this study, REITs contain information on economic growth and are thus an advantageous instrument with which to predict at least two quarters of

GDP in the United States (Li & Lei, 2011). Furthermore, a long-term cointegration model used by Loo, Anuar, and Ramakrishnan (2016) discovered a long-term co-movement of the REIT market and macroeconomic factors such as the interest rate and GDP. In particular, emerging REIT sectors were claimed to be more sensitive to these variables compared to developed REIT markets (Loo et al., 2016). The study of Sagalyn (1990) revealed different returns and volatility levels of REITs and real estate companies, though no direct interaction between economic growth and REITs was found. However, the study stated that REITs have lower systematic risk and higher returns during period of high growth in the economy (Sagalyn, 1990), indicating a certain link between the two variables.

VII. Housing supply, housing price, and REITs

In theory, the supply-side factor in the real estate industry is a fundamental determinant of housing price movement. In a simple supply-demand model, a lack of supply indicating a shortage in the market, resulting in an upward pressure on price. Housing supply cost is generally represented as the land on which housing is built, which is a direct capture of the driving force for housing price (Ahuja, Cheung, Han, Porter, & Zhang, 2010). In particular, when the movement pace of housing supply is inelastic and cannot match demand shock in cheap and rapid manner, shocks to the price level are the result (Anundsen & Heebøll, 2016; Paciorek, 2013). In addition, the market is often subject to many supply restrictions due to government regulations or natural geographic limitations (Paciorek, 2013). The government can manually lower the supply elasticity by extending the housing permit process or heightening the cost of supplying new houses. Certain locations also face naturally limited developable land. Thus with restricted housing stock as well as demand shock in the short term, housing prices surge (Anundsen & Heebøll, 2016; Ihlanfeldt & Mayock, 2014). Housing supply can even be seen as a force shaping the process of generating property bubbles (Glaeser et al., 2008). Therefore, the theory suggests a negative causality from housing supply to housing price. However, an increase in housing prices results in an expansion in property supply under the supply-demand model. In particular when there is a higher supply elasticity under the housing market boom, more overbuilding is witnessed, with more new constructions going up (Glaeser et al., 2008; Ihlanfeldt & Mayock, 2014). Hence, a positive causal link exists between housing price and housing supply.

Scarce research has addressed the mechanism underlying the causality between housing supply and REITs, though there is a clear theory underneath. Housing trusts, funds, and specific taxes and fees are gathered by real estate developers and governments to build houses (Anft, 2003). An obvious source of income injected into real estate companies is the housing trust fund, which can therefore be applied to the construction area. Another income source from REITs is the exclusive transfer and sales taxes and fees, which are mainly operated by government real estate agencies and can be used to build houses. In both cases, more capital flows into the construction sector, which leads to a surge in the supply side of houses. There is therefore, in theory, a positive causality from REITs to housing supply.

Noteworthily, it may appear to show a distinctive actual effect of each mechanism across countries. This may be due to the different economic environment, policy varieties, investors' expectations and perceptions. However, the approach employed in this chapter is limited to provide further implications on how mechanisms differ. Future research is then suggested to provide a more comprehensive analysis of this area.

4.2.3 Relevant literature

The interaction between the two closely linked financial markets, the stock market and real estate markets, has been subject to widespread controversy in recent literature. For example, Kakes and Van Den End (2004), Kapopoulos and Siokis (2005), and Su et al. (2011) have engaged with this issue in Europe. Kakes and Van Den End (2004) focussed mainly on this problem in the Netherlands, using a VAR and demonstrating the indispensable impact of stock price movements on different sectors of the housing market. Furthermore, a study on the Greek real estate market by Kapopoulos and Siokis (2005) proposed a Granger causality test to examine the two mechanisms to explain the relationship between housing and stock prices from 1993 to 2003. The results favour the wealth effect as an explanation, and only one-way causality was found, from the stock market to the real estate market, to adjust portfolio. Moreover, from the study by Su (2011) using a threshold cointegration model and non-parametric rank test, the positive outcome indicates a long-term equilibrium between real estate and stock prices in European countries. With respect to the UK market, Su et al. (2011) applied an asymmetric threshold cointegration technique on data on European countries to study the long-term equilibrium between the stock and housing markets based on a sample period of 2000 to 2007. The study indicated a non-linear adjustment of long-term cointegration. The Granger causality test indicates a one-way direction of causality, from housing to the stock market, in the UK and the Netherlands, and opposite direction in Belgium during the sample period. In addition, Su et al. (2011) discovered feedback effects in Spain and France, as did McMillan (2011), who also proved a long-term cointegration connection between stock and house prices in the US and UK from 1974 to 2009. The method proposed in this study is a non-linear error correction model. Nevertheless, this connection disappears in the UK when testing from a linear perspective, although it remains valid in the case of the United States using the non-linear model.

Sim and Chang (2006), Liow (2012), Zhang and Fung (2006), Lean and Smyth (2014), Lee et al. (2013), and Ibrahim (2010) have explored the same topic in Asia. The primary objective of Ibrahim (2010) was to study the wealth effects and credit price effects in the link between house and stock prices in Thailand, and the study demonstrated a unidirectional link, from the stock market to the real estate market. Lee et al. (2013) focussed on stock price, housing price, and monetary policy in Taiwan to analyse the effects of different shocks using a recursive VAR model from 1993 to 2010. The result suggested positive effects from housing price to stock price, and conversely, although the latter relationship was negligible. A study by Sim and Chang (2006) focussing on the Korean real estate and stock markets supported this. The VAR model and IRF have been proposed in the methodology to examine the relationship among the data of housing price, land price, and Korean composite stock price index from 1986 to 2005. Sim and Chang (2006) identified a dramatic causation, from housing and land prices to stock price in most regions, whereas the converse effect was not justified by the evidence from their model. According to the IRF, positive reactions to stock price were shown immediately after the shocks imposed on both housing and land prices, also supporting the relationship between real estate and stock markets. A case study in Singapore by Liow (2006) investigated how the real estate sector affected the stock market, using the sample period 1985 to 2002. Performance benchmarks, including residential and office property price indices as well as the stock exchange index in Singapore, were selected, and the methodology was autoregressive distributed lag cointegration, and a long-term relationship was found between the stock and property sectors. Using different variables, Liow and Yang (2005) also showed the long-term co-movements and short-term links between the stock and housing markets in four Asian economies, namely, Japan, Singapore, Hong Kong, and Malaysia. Securitised real estate, stock indices, and other economic variables such as GDP and CPI were incorporated into the study. The fractional integrated VECM model, which incorporates an extended memory of previous cointegration residuals, was used, and all four economies were proved to have at least one long-term cointegrating relationship among securitised real estate, stock indices, and the macroeconomic variables (Liow & Yang, 2005). The real estate and stock markets in Hong Kong and Singapore were also found to display fractional cointegration, indicating that they are not good choices for asset diversification. Moreover, a study conducted by Abelson et al. (2005), which aimed to explore long-term and short-term determinants for house price in Australia, proposed equity price as a potential variable. Multivariate cointegration, dynamic ordinary least squares, and nonlinear vector error correction models were combined, and equity price was proved to have a negative effect on the real estate sector in Australia. Conversely, the outcome of Lean and Smyth (2014), which concentrates on this connection in Malaysia using the cointegration and Granger causality test, indicated no cointegration among house price, stock price, and interest rate.

Several studies have provided evidence of a connection between the Chinese stock and real estate markets. The research by Zhang and Fung (2006) attempted to analyse the problem of imbalanced stock and housing markets in China. Based on the multivariate regression and Granger causality test, its result indicates that the stock and housing prices are significantly and negatively related. Moreover, the stock composite index is an important explanatory factor in real estate price movements in China (Zhang & Fung, 2006). According to later research by Liow (2012), four more Asian countries, including China were taken into account, and the real estate-stock correlations were explored at the local, regional, and global levels using the GARCH model from 1995 to 2009. The result again support the time-varying and asymmetric correlation, and co-movements were also found between the global and regional real estate-stock correlations in these countries (Liow, 2012). By contrast, a study by Zeng et al. (2008) focussing on monetary policy and asset prices in China produced different findings, namely, that the negative correlation between real estate and stock prices was insignificant, with little contribution. In their simultaneous equations and VAR models, the core variables were interest rate, housing price, and stock price, and the period was 1999 to 2006. Another study, by Lin and Fuerst (2014), found mixed results from nine Asian countries during the sample period from 1980 to 2012 using the model of both linear and non-linear cointegration with data on transaction-based real estate indices. Although linear cointegration and fractional cointegration between housing and stock prices was found separately in Taiwan, Singapore, and Hong Kong, no evidence was found in the rest countries, including China, Japan, and Korea (Lin & Fuerst, 2014). Furthermore, the study stated that the maturity of the financial market in one country cannot be justified as the reason of the segmentation of housing markets from stock markets; instead, economic structure plays an essential role in deciding the level of integration.

In addition, the United States has been examined in terms of this dynamic relation. Li et al. (2015), for instance, adopted the novel wavelet analysis to investigate the co-movement and causal relationship between the US real estate and stock markets from

1890 to 2012. The study found evidence of co-movement between these two time series from either the frequency or time domain approaches, although there was no stable causal link for the whole sample. In addition, when analysing co-movement in the recent financial crisis, Li et al. (2015) indicated that the two markets reflect economic growth more than each other. Moreover, Tsai et al. (2012) conducted a study similar to a previous study in Europe, by Su et al. (2011), in the US property and stock market from 1970 to 2009. With the data of the housing price index and Dow Jones Composite Average Index and using a non-linear threshold autoregression model and asymmetric error correction model, this study indicated a long-term cointegration between the two indices, although with asymmetric adjustments to equilibrium. The wealth effect presented especially when stocks performed better than the housing sector, which drove real estate prices to soar thereafter (Tsai et al., 2012). One specific study from Anderson and Beracha (2012) drew attention to the effect of real estate prices in the headquarters city on one company’s stock price in the US from 1989 to 2004. Under this assumption, the relationship between the stock market movements and the real estate conditions remained vital. Nevertheless, the majority of the literature analysed the relationship between the housing market and the general stock market. Studies have also taken other economic elements into consideration. For instance, inspired by the wealth effect between the stock and house markets, Shirvani et al. (2012) performed a test among stock and house prices as well as private consumption in the United States. To consider structural break, this study adopted a robust bilateral test of Granger causality rather than a conventional Granger causality test. The result did support a bilateral causality relationship between stock and home prices, and especially the critical role that stock prices have played in influencing both house prices and consumption as a consequence of the wealth effect. Notably, the performance of the stock market could also propose a further feedback effect on the real estate market (Shirvani et al., 2012). Okunev and Wilson (1997) concentrated on REIT stock indices and the S&P composite price index (S&P 500) as representatives of the real estate market and stock performances, respectively. Their research examined the relationship between housing and stock prices using a nonlinear model as the basis on which to test the degree of integration.

Studies on this topic on Canada are scarce except for one from Boone and Girouard (2003), which investigated the wealth effect from stock and housing price changes on consumption behaviour in G7 countries, which include Canada.

The existing evidence from the literature shows a lack of coinciding result on the relationship between the general stock market performance and housing sector development, as a mixed of conclusions have been made on whether this link is significant, and if it is positive or negative. This justifies the discussion on REITs and housing prices this chapter proposes.

With regard to the REIT sector and the real housing market, several debates have centred on a direct correlation between REITs as a metric of specific stock performance and housing prices. By raising the concept of securitised real estate index, the study of Liow and Yang (2005) justified the importance of studying REITs in the real estate market in their study on Japan, Singapore, Hong Kong, and Malaysia. He (2000) selected REIT stock as one variable when testing the Granger causality relationship between stock returns and housing returns in the United States. Nonetheless, only a specific part of the REIT stock, apartment REIT stock and unsecuritised residential real estate, was chosen to be the represented time series. In this study, the apartment REIT returns significantly affected housing supply, while the changes in the housing supply and housing price movements provided information for the REIT market. Moreover, real estate prices and apartment REIT returns were causally related. In Clayton and MacKinnon (2001), the relationships among REIT, bond returns, stock returns, and unsecuritised real estate returns in the United States were discussed using a multi-factor regression technique. The link between US REITs and unsecuritised real estate was substantial during the 1990s, though this relation has shown a cyclical nature, with changes over time. Moreover, Morawski et al. (2008) contributed to this topic by examining the correlation and cointegration among direct and indirect real estate sectors and the stock market in the United States from 1978 to 2006 and in the UK from 1983 to 2006. Only in the US study were REITs applied, while in the UK case, the Global Property Research Index was selected to represent the indirect housing index.

Depending on the investment horizon, Morawski et al. (2008) indicate cointegration between direct and indirect real estate in the long term, but not in the short term. A more recent study, by Oikarinen et al. (2011), provided an analysis of long-term cointegration between REITs and property indices as well as stocks in the US market in the sample period of 1977 to 2008. This study justified a positive result, indicating co-movement between the two indices in the United States. Correspondingly, Bouchouicha and Ftiti (2012) discovered a significant collective movement between two real estate markets, namely, the direct real estate and REIT markets, and the macroeconomic environment in the US and the UK through a dynamic coherence framework method. This methodology captured the movement of the correlation between different real estate markets and macroeconomic variables over time, as well as decomposed interactions in both the short term and the long term. Yang (2005) discussed the relationship between the housing market and the property stock market in Sweden in the period 1980 to 1998. Using the VECM, the study identified co-movement between the performances of housing price, property stock price, and government bonds. This study also evaluated the impact of rent on this equilibrium by applying rentals as an exogenous variable in the model. Nevertheless, a limited amount of empirical studies have focussed on the short-term causal dynamics between REITs and direct real estate price levels in the UK, Canada, and China. Hence, scarce information is to be found regarding risk diversification when investors make a decision to inject capital in property and REITs in these countries.

When discussing the methodology in this research area, many studies have applied a VAR model and cointegration approach. However, exceptions do occur. For instance, Louis and Sun (2013) focussed on simple correlations between the housing and stock markets in the United States using a four-factor model which assessed the four-year changes in house prices in the period 1979 to 2002. They presented clear evidence of a negative relationship between abnormal stock returns and growth in housing prices in the place where the headquarters of the firm is located in the long term, although this association appears to be positive in the short term. To investigate the contagion effect between the housing and stock markets in the United States, Hong Kong, and the UK from 2004 to 2012, and particularly during the financial crisis, Hui and Chan (2014) proposed a study using the Forbes–Rigobon, co-skewness and co-kurtosis tests. Contagion was discovered by the co-kurtosis test to occur between the equity and property sectors, and this effect was especially significant in the United States. In the meantime, this research identified contagion across different countries as well, including transmitting directions from the US to the UK and Hong Kong and from the UK to Hong Kong (Hui & Chan, 2014).

4.2.4 Gaps in the literature

Many earlier studies have examined the relationship between the real estate and stock markets. In particular, a variety of researchers have focussed on the US market as well as several European economies such as Sweden (Yang, 2005) and the Netherlands (Kakes & Van Den End, 2004). In addition, studies have produced findings on Asian countries such as Malaysia (Lean & Smyth, 2014), Thailand (Ibrahim, 2010), and China (Zhang & Fung, 2006). However, the current academic understanding has provided limited findings for Canada and the UK. In addition, when addressing the causal relations and mechanism underlying stock and housing prices, the market representative stock index has generally been selected in their model design. Scarce attention has been paid into any specific type of stock performance linked more closely with the housing market, for instance, REITs, to better investigate the relationship between the behaviours of stocks and real estate. Exceptions include Morawski et al. (2008) and Oikarinen et al. (2011), who examined US REITs and direct real estate data to explore short-term and long-term relations. Nevertheless, scarce study has applied this methodology to focus on the UK, Canada, and China, meaning that limited implications have been identified about securitised and the actual real estate in these countries. Therefore, this study aims to investigate the short-term interdependence between REITs and direct real estate prices, using a SVAR model, in the UK, Canadian, and Chinese markets.

4.2.5 Contributions

This chapter has built vital knowledge on the connection between the direct real estate market and indirect housing sectors such as REITs. The implications from this study support the sound development of the real estate industry. The presence of an economically justified leading relationship between the two summarised in this chapter offers valuable information to investors with regard to the forecast power of housing stock returns on direct housing investment returns (Morawski et al., 2008). The result of the link between direct and indirect real estate markets also helps policymakers to undertake practical financial constraints to strengthen the healthy development of the housing sector. Building on the concept generated from this study, REITs can also improve the quality, supply level, and accessibility of the direct property market, benefiting from a reliable, established alternative means of attracting capital. The remarkable development of the REIT market in the target countries is in its early stage and booming with increasing popularity, especially in the UK and China. The UK REIT regime is comparatively new and displays a substantial need for the government to create structures and promote innovation. In the meantime, a proper level of legislation regarding REITs in China is absent, and these financial activities are conducted on a limited scale (KPMG, 2007). However, this presents a massive potential for the REIT market, meaning that the exposure of banks to the housing industry would be reduced and the professional management of property promoted, while more available channels for property investment not only domestically but also globally would be provided.

4.2.6 Hypotheses

To advance the aims of this research, three hypotheses are proposed in this study:

H_1: REIT stock prices have a positive effect on housing prices in the UK, Canada, and China. From information, wealth effect, credit effect, and composition risk mechanisms, REIT performance has a positive causal effect on real estate prices. REIT stock returns contain information on future housing activity, enhance household wealth, and provide credit for housing consumption (Binswanger, 2000; Lean & Smyth, 2014; McMillan, 2011). In addition, during booms and recessions, the stock and real activity movements tend to correlate, and this is presented as stock price Granger causes housing prices due to the slower adjustment of housing market (Hui & Chan, 2014).

H_2: Housing prices have a positive effect on REIT stock prices in the UK, Canada, and China. Similarly, information and credit effect mechanisms justify an opposite effect, from housing to REIT. After lagged stock prices revealing housing activities, housing performance can also give feedback to correct REIT returns (Fama, 1990; Kapopoulos & Siokis, 2005).

In addition, the theoretical explanation of the relations among macroeconomic variables including interest rate and GDP, housing supply, REIT, and housing prices have provided support for the variables in the SVAR model (Agnello & Schuknecht, 2011; Bouchouicha & Ftiti, 2012; Loo et al., 2016). As a result, departing from the theoretical framework and hypothesis, the SVAR model used in this chapter examines the relationship between housing and REIT prices, applying six variables: housing price, REIT price, stock price, housing supply, GDP, and interest rate.

4.3 Methodology

4.3.1 Data

4.3.1.1 Data Description

Quarterly data is applied to the UK and Canada, while monthly data is chosen for China according to a short sample period. Direct real estate price data for the UK, including all house types, is gathered from the *Nationwide Building Society* website. The new housing price index, which measures the selling price of new residential houses from contractors, from the *Statistics Canada* website is collected for the Canada market. In addition, the average house price per square meter for China's 70 medium and large cities is calculated from the total housing sales revenue and housing square metres sold, both from the *National Bureau of Statistics of China*. In terms of the demand-side factors, this model contains REIT, GDP, interest rate, and composite stock index. An REIT is a type of financial company that owns and publicly trades investment-based real estate. Investors are supported with a more efficient way of receiving investment returns through real estate investment (FTSE Russell, 2016). In pursuance of the objective in this chapter, that is, to focus on the relationship between the stock and real estate market, REITs is one of the time series representing stock market performance, since it can represent housing-related real stock returns. DataStream Real Estate Investment Trusts Index, created by *DataStream*, provides an assessment of the UK and Canadian real estate associated investment stock market behaviours. DataStream UK retail real estate investment trusts contains 19 representative constituent REIT indices and property company indices in the UK, listed in **Table 4-1**. DataStream Canada retail real estate investment trusts contains 19 representative constituent REITs indices in Canada, included in **Table 4-2**. Both of the DataStream REITs indices are collected at the closing price. Moreover, since the REIT market is an emerging sector in China, the current data period is comparatively short. In the case of China, seven REITs are listed on the Hong Kong Exchange and the Singapore Exchange, listed in

Table 4-3, which focus purely on properties in China. The data of the seven REITs are collected from *DataStream* and this chapter calculates the Chinese REIT index using the weighted average of these seven REITs. Despite the general increasing paths for both house price and REIT index in the UK, Canada, and China, REITs for these countries also present an overall climbing trend with fluctuations. Suggested by the theory, the model also includes GDP as one vital variable. The UK seasonally adjusted GDP data collecting from the *Office for National Statistics* measures GDP at market prices, while GDP for Canada is collected from the *Statistics Canada* website. In China, monthly data is applied. Consequently, the Industrial Production Index, from the *National Bureau of Statistics of China*, is selected as a substitute for GDP. Another encompassed variable is the interest rate. The long term government bond yield for the UK and Canada is gathered from the *International Monetary Fund* website. For China, this variable is selected as the weighted average lending rate on loans by three major banks, collected from the *People's Bank of China*. In addition, the composite stock index is included for analysis. The FTSE 100 Price Index, S&P TSX Composite Index, and Shanghai Stock Exchange Composite Index are chosen for the UK, Canada, and China to represent stock market performance. Regarding the supply-side exogenous variable, the number of newly completed buildings in the UK and China and building permits in Canada are selected in the model. The UK volume of buildings completed is collected from the *Ministry of Housing, Communities and Local Government*. This data in China is the floor space of completed buildings, which comes from the *OECD* website. Due to data availability, the number of building permits in Canada is selected to reflect the supply-side influencing element. This time-series data is gathered from *Statistics Canada*. It must be mentioned that data on industrial production and buildings completed time-series are missing for January in China. Accordingly, the technique of interpolating missing data from EViews is adopted to calculate the missing values. The sample period for the UK, Canada, and China is 1989 Q1–2018 Q1, 1994 Q1–2017Q1 and 2005M12–2018M3, respectively, due to data availability. All the data are seasonally adjusted and adjusted for inflation to be real terms except for the volume of buildings completed, and all the variables except interest rate are log-transformed to stabilise the variance of time series.

Table 4-1 *Datastream UK Real Estate Investment Trusts*

Components	**Business model**
Hammerson plc REIT	Owning, managing and developing retail destinations across Europe.
Intu Properties REIT	Owning and managing 20 shopping centres in the UK and Spain
Shaftesbury REIT	Investing real estate in London's West End
Capital and Regional REIT	Owning and managing dominant community shopping centres in the UK
NewRiver REIT	Owning and managing shopping centres in the UK
Land Securities Group REIT	Owning and managing the shopping centres and shops, hotels and leisure assets, retail warehouse properties, the London offices and central London shops
British Land Company plc REIT	Owning, managing, developing and financing a portfolio of commercial properties focused on retail locations around the United Kingdom and London offices.
Segro plc REIT	Owning, developing and managing warehouse properties in the United Kingdom and Continental Europe.
Derwent London plc REIT	Owning and managing portfolio including investment property, owner-occupied property and trading property in central London region.
Unite Group plc	A United Kingdom-based developer and operator of student accommodation
Assura plc REIT	Developing, investing and managing a portfolio of primary care medical centres across the United Kingdom.
Big Yellow Group	The provision of self-storage and related services in the United Kingdom.
Great Portland Estates	Owning, managing and developing office, retail and residential properties.
Londonmetric Property REIT	Property investment and development with the segments of Distribution, Offices, Residential and Development.
Safestore Holdings REIT	Providing self-storage facilities to customers throughout the United Kingdom and Paris.
Workspace Group REIT	Property investment in commercial property to let throughout London.

McKay Securities plc REIT	The property investment and development in the United Kingdom.
Primary Health Properties REIT	Investment in primary healthcare property in the United Kingdom and the Republic of Ireland.
RDI REIT	Owning and managing the retail and commercial properties in the UK and Germany.

Notes:

- Source: DataStream
- DataStream constructs the UK REIT index with the portfolio containing the above 19 constituents.
- This table has described the key business model for each component REIT company. The UK REIT index is a market capitalisation weighted index.

Table 4-2 *Datastream Canada Real Estate Investment Trusts*

Components	**Business model**
Canadian Apartment Properties REIT unit	Acting as residential landlords, owning interests in residential units across Canada and The Netherlands.
H&R REIT Staple Unit	Leasing properties in Canada including office, retail, industrial and residential real estates to tenants on a long-term basis.
Riocan REIT	Investing in retail and residential real estates across Canada.
Allied Properties REIT	Owning, managing and developing urban office properties in Canada.
Boardwalk REIT	Providing communities of residential units across Canada to tenants.
Chartwell Retirement Residences REIT	Operating the Canadian senior living sector to provide retirement residence and care.
Choice Properties REIT	Owning, managing and developing retail and commercial real estate across Canada.
Cominar REIT	Owning and managing office, retail and industrial properties in Canada.
Dream Global REIT	Owning, investing and managing commercial properties in Germany, Austria, Belgium and the Netherlands.
Smartcentres REIT	Acquisition, asset management, planning, development, leasing, operations, property management and construction including a variety of urban, mixed-use, residential and industrial developments.

Artis REIT	Investment in and ownership of commercial properties in Canada and the United States.
Crombie REIT units	Owning, operating, and developing commercial, retail, and residential real estate in Canada.
CT REIT	Producing commercial properties and development projects primarily located in Canada
Dream Office REIT unit A	Owning, leasing and operating office properties across Canada
Killam Apartment REIT	Residential landlords owning, operating, managing and developing a portfolio of apartments and manufactured home community properties.
Northview Apartment REIT	Owing and managing multi-family residential property, single-family apartment buildings, ExecuSuites and hotels, as well as a number of commercial properties across Canada.
Northwest Healthcare Properties REIT	Owning and managing medical office buildings, clinics, and hospitals in Canada, Brazil, Germany, Australia, and New Zealand.
Granite REIT units	Acquisition, development, ownership and management of predominantly industrial, warehouse and logistics properties in North America and Europe
Interrent REIT	Acquisition, holding, leasing or managing of multi-unit residential properties and real estate ventures in Canada.

Notes:

- Source: DataStream
- DataStream constructs the Canada REIT index with the portfolio containing the above 19 constituents.
- This table has described the key business model for each component REIT company.
- The Canada REIT index is a market capitalisation weighted index.

Table 4-3 *China Real Estate Investment Trusts index*

Components	**Stock market**	**Business model**
Dasin Retail Trust	Singapore	Invest in, own or develop land, uncompleted developments and income-producing real estate in China. The Trust's portfolio comprises four retail malls.
BHG Retail REIT	Singapore	Owing and managing five retail properties located in major cities in China

CapitaLand Retail China Trust	Singapore	Invest in a portfolio of income-producing real estate used for retail purposes located in China. Its portfolio includes approximately ten shopping malls.
Yuexiu REIT	Hong Kong	Achieve steady rental income through investing in office buildings, retailing malls and hotel and serviced apartments in mainland China, for maintaining and enhancing property value. It currently holds six commercial properties.
Spring REIT	Hong Kong	Owning and investing in income-producing real estate primarily in China, while seeking yield-accretive investment opportunities globally. Its portfolio includes office buildings and car parking spaces.
Hui Xian REIT	Hong Kong	Owning and investing in commercial properties including malls, office buildings, hotels and apartments in China.
New Century REIT	Hong Kong	Investing in retail and commercial properties and hotels or other hospitality-related properties in China.

Notes:

- Source: DataStream
- The China REIT index is constructed with the portfolio containing the above 7 constituents.
- These 7 REITs are offshore REIT targeting at China property market listed in Singapore and Hong Kong stock markets.
- The Asia Pacific Real Estate Association suggests this list.
- This table has described the key business model for each component REIT company.

4.3.1.2 Data performance

The software being applied for the econometric analysis in this chapter is EViews and STATA, as both software have been suggested to be flexible interactive platforms to conduct time series analysis and research (Baum, Schaffer, & Stillman, 2011, Agung, 2011). The line charts in

Figure 4-1, **Figure 4-2**, and **Figure 4-3** present the fluctuations of time series in each country. The overall movement of time series in the structural VAR model in each country express some potential common trends. A more apparent upward movement in housing prices than in REIT is witnessed in the UK, although both have experienced a dramatic deviation during the period of global crisis. Stock prices in the meantime show significant inconsistencies, with booms and busts during the time frame. GDP growth in the UK is relatively constant and rapid, whereas interest rate and buildings completed show some fluctuations and an overall decline. A similar dynamic is apparent in Canada, where housing prices and REITs encountered major fluctuations during the financial crisis, around 2008, despite their expeditious growth throughout the period. In addition, Canadian stock prices presented a more unstable trend, with notable fluctuations. Canadian GDP presents a highly similar trend to housing prices but are several steps ahead along the time frame. At the same time, the interest rate level displays a continuous decrease, with some minor inconsistencies. The China time series begins in 2005 based on data availability. The climbing direction of house prices in China is accompanied by some instabilities, while prominent fluctuations in REITs and interest rate are apparent. The 2007 stock bubble burst, as well as stock prices in China, contribute to the initial slump in REITs. At the same time, stock prices do not present a visible increase, with several large fluctuations instead over the entire sample period. By contrast, there is a steady increase in the Chinese GDP level, with high consistency throughout the entire period. The floor space of completed buildings in China presented seasonal fluctuation, with a general upward trend over the time frame. Generally speaking, the three time series in each country share similar fluctuations and trends over the period. In **Table 4-4** Descriptive Statistics, the descriptive statistics show the performance of the time series variables in the SVAR model. Some downward variations can be seen in the UK and Chinese housing prices, while more upward fluctuations are apparent in the Canadian housing price level. In the meantime, the REITs in the three countries present upward movements during the sample period.

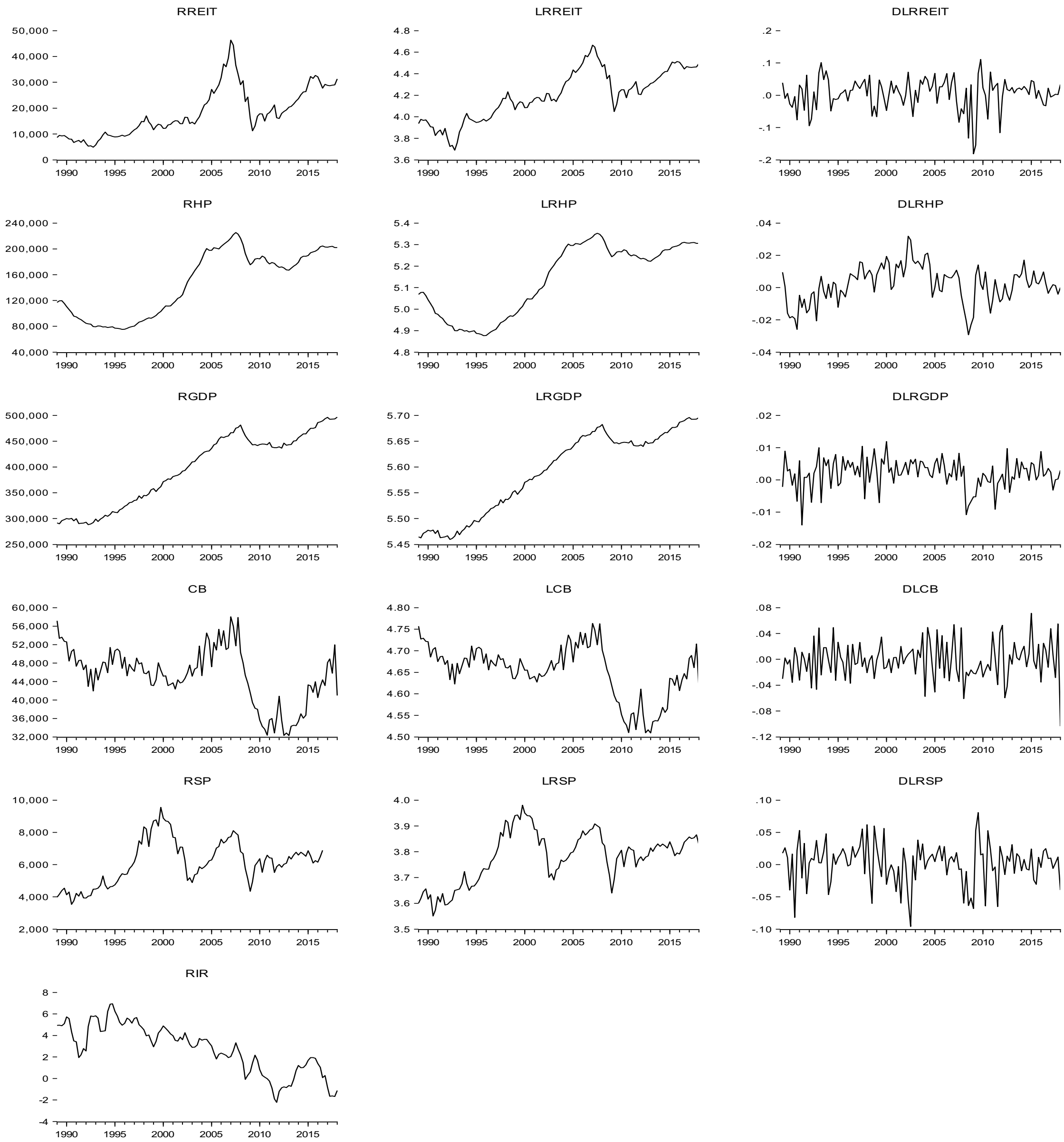


Figure 4-1 *The UK time series*

Notes:

- SVAR model variables: The UK real REIT in level, log and differenced (RREIT, LRREIT, DLRREIT); the UK real house price in level, log and differenced (RHP, LRHP, DLRHP, £); the UK real GDP in level, log and differenced (RGDP, LRGDP, DLRGDP £million); the UK building completed in level, log and differenced (CB, LCB, DLCB); the FTSE 100 real price in level, log and differenced (RSP, LRSP, DLRSP); the UK real government bond rate (RIR)
- Data sources: *Nationwide Building Society, DataStream, Office for National Statistics, International Monetary Fund, Ministry of Housing, Communities and Local Government.*

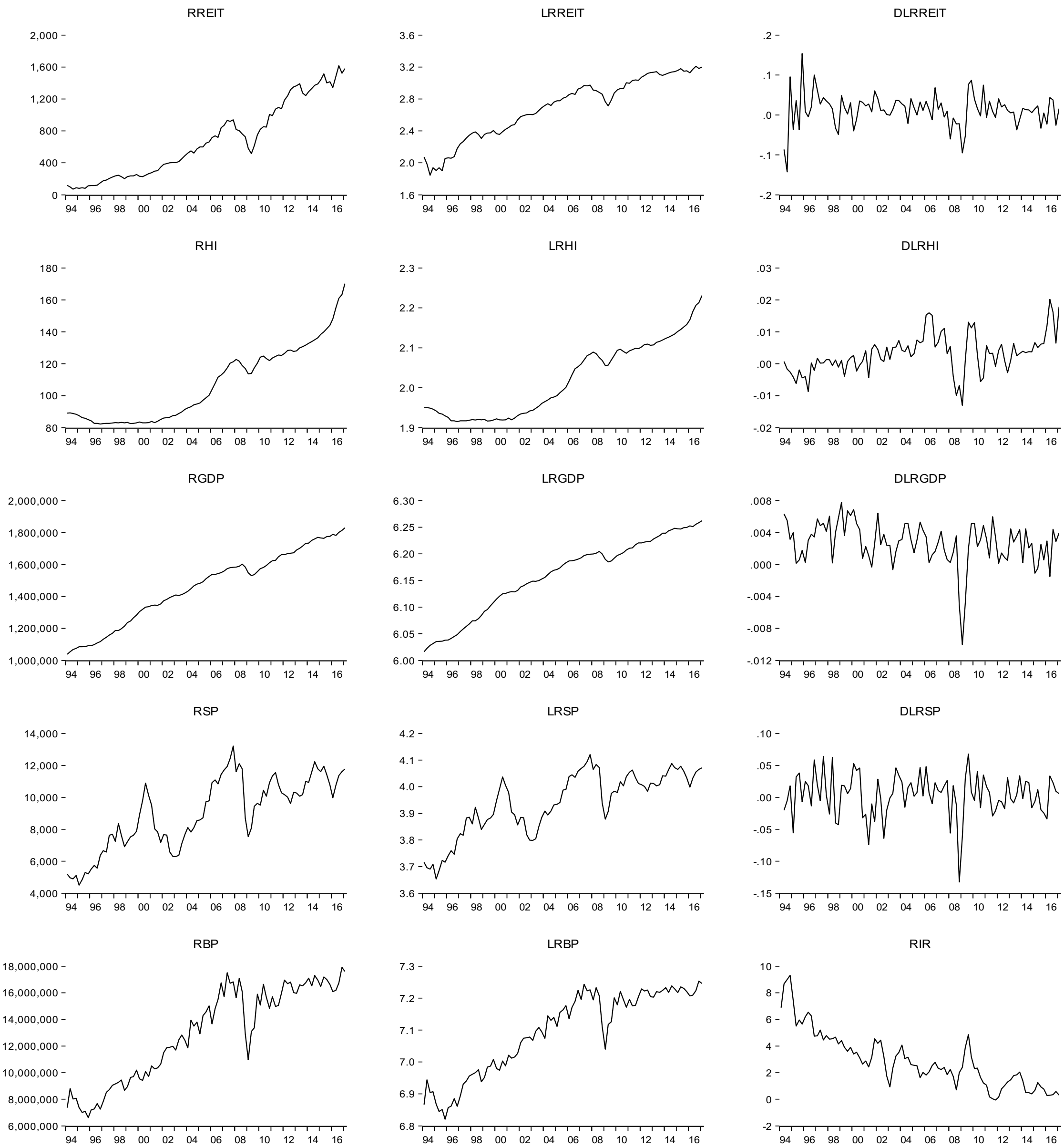


***Figure 4-2** Canada time series*

Notes:

- SVAR model variables: Canada real REITs in level, log and differenced (RREIT, LRREIT, DLRREIT); Canada real house price index in level, log and differenced (RHI, LRHI, DLRHI); Canada real GDP in level, log and differenced (RGDP, LRGDP, DLRGDP, C$ million); S&P TSX composite index real term in level, log and differenced (RSP, LRSP, DLRSP); Canada real building permit in level and log (BP, LRBP, C$ thousands); Canada real government bond rate (RIR).
- Data sources: *Statistics Canada, DataStream, International Monetary Fund.*

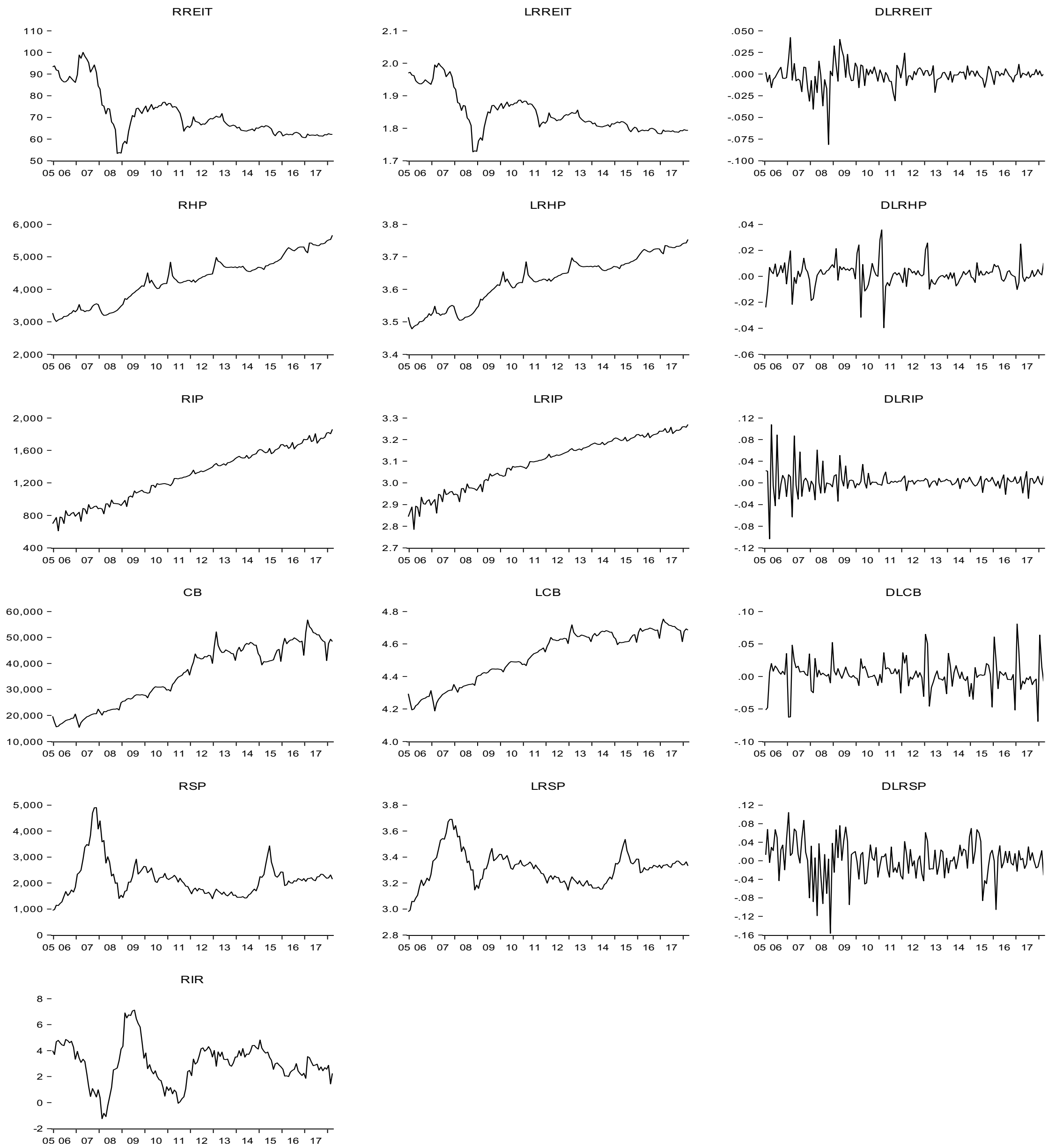


Figure 4-3 *China time series*

Notes:

- SVAR model variables: China real REIT in level, log and differenced (RFDI, LRFDI, DLRFDI, U$ million); China real house price in level, log and differenced (RHP, LRHP, DLRHP, RMB/sq); China real industrial production index in level, log and differenced (RIP, LRIP, DLRIP); China floor space of building completed in level and log (CB, LCB); Shanghai stock exchange composite index real term in level, log and differenced (RSP, LRSP, DLRSP); China real lending rate (RIR).
- Data sources: *National Bureau of Statistics of China, DataStream, People's Bank of China, OECD.*

__Table 4-4__ Descriptive Statistics

SVAR model variables

	HP		REIT		SP		GDP		CB/BP		IR
	UK										
Variables	**RHP**	**LRHP**	**RREIT**	**LRREIT**	**RSP**	**LRSP**	**RGDP**	**LRGDP**	**LCB**		**RIR**
Mean	142866	5.14	18096	4.20	6120.9	3.78	395474	5.59	4.65		2.74
S.D.	49935	0.16	9309.7	0.23	1378.0	0.10	69079	0.08	0.06		2.25
Skewness	-0.02	-0.31	0.78	-0.10	0.21	-0.31	-0.25	-0.38	-0.67		-0.33
Kurtosis	1.39	1.45	2.89	2.18	2.36	2.30	1.56	1.61	2.81		2.20
	Canada										
Variables	**RHI**	**LRHI**	**RREIT**	**LRREIT**	**RSP**	**LRSP**	**RGDP**	**LRGDP**	**RBP**	**LRBP**	**RIR**
Mean	106.95	2.02	679.02	2.69	8992.27	3.94	1458696	6.16	12948697	7.09	2.93
S.D.	23.40	0.09	469.78	0.38	2236.12	0.12	228855	0.07	3498050	0.13	2.08
Skewness	0.61	0.36	0.43	-0.51	-0.25	-0.63	-0.27	-0.47	-0.29	-0.55	0.91
Kurtosis	2.34	1.79	1.86	2.16	1.95	2.41	1.92	2.04	1.62	1.93	3.66
	China										
Variables	**RHP**	**LRHP**	**RREIT**	**LRREIT**	**RSP**	**LRSP**	**RIP**	**LRIP**	**LCB**		**RIR**
Mean	4300	3.63	71.06	1.85	2153.61	3.31	1285.12	3.09	4.52		3.00
S.D.	722.22	0.08	10.68	0.06	702.62	0.13	328.67	0.12	0.16		1.61
Skewness	-0.13	-0.35	1.07	0.81	1.65	0.46	-0.13	-0.46	-0.53		-0.002
Kurtosis	1.94	1.97	3.29	2.92	6.69	3.88	1.78	2.06	1.90		3.44

Notes:

- The descriptive statistics for housing price (HP/HI), REIT, stock price (SP), GDP, housing supply (CB/BP) and interest rate (IR) in SVAR model are presented.
- UK: HP (£), REIT (£), GDP((£ million).
- Canada: HI (index), GDP (CAD million), BP (CAD thousand).
- China: HP (RMB/sq), IP (index).
- The skewness figures show upward fluctuations in REIT in the three countries, the housing prices in Canada and the stock price in China, while other time series follow symmetrical distributions; the kurtosis figures present relatively heavy-tailed distributions with outliers and large fluctuations. These statistics do not affect the later study.

4.3.1.3 Stationary test and correlation analysis

Before constructing the SVAR model, a ZA unit root test, allowing for unknown structural breaks, is applied to test for the order of each variable. Similar to Chapter 3, the unit root test results are displayed in **Table 4-5**, **Table 4-6**, and **Table 4-7**. Furthermore, the ADF unit root test in **Table 4-8**, **Table 4-9**, and **Table 4-10** is also adopted as a guide to support the test result. Based on the two tests and the characteristics of the historical data of each time series, most of the variables contain one unit root, except for housing price in the UK, which shows a pattern of I(2), and interest rate in the three countries, which is stationary. By adopting the ZA unit root test, structural breakpoints during periods such as the 2008 financial crisis, the recovery of Canadian market from 1990s bubble bust, and Chinese stock market crash in 2015 have all been captured following (Macdonald, 2010; Riley & Yan, 2015; Taylor, 2018).

The correlations among variables have also been tested before conducting the model. The linear relationship among the targeting time series can clearly be seen in **Table 4-11** Correlation analysis. In the UK, linear relations are seen only between GDP and interest rate and between GDP and stock price. In the Canadian model, housing price, housing supply, and stock price have an important linear relationship with each other, and other vital correlations can be found between housing supply and GDP, interest rate and GDP, stock price and GDP, housing price and interest rate, and REIT and stock price. In particular, housing price and REIT correlate under a 10% level of significance. In China model, housing price, REIT, and interest rate have a linear relationship with each other, while correlations have also found between the variables stock price, REIT, and interest rate.

Table 4-5 *Zivot Andrews unit root test for the UK*

Variables	Form	Model A Test statistic	Model B Test statistic	Model C Test statistic
HP	LRHP	-4.368	-3.777	-4.306
	Breakpoint	2008 Q1	2004 Q2	2008 Q1
	First difference of LRHP	-4.471	-3.900	-4.938*
	Breakpoint	2004 Q4	1997 Q3	2004 Q4
	Second difference of LRHP	-11.904***	-11.572***	-11.904***
	Breakpoint	2008 Q4	2008 Q2	2009 Q1
REIT	LRREIT	-3.865	-2.868	-3.731
	Breakpoint	2008 Q3	2006 Q2	2008 Q3
	First difference of LRREIT	-10.007***	-9.485***	-10.053***
	Breakpoint	2007 Q2	1993 Q4	2007 Q2
IR	RIR	-4.590*	-4.459**	-4.684
	Breakpoint	1993 Q4	1994 Q3	2009 Q4
	First difference of RIR	-7.951***	-7.562***	-8.193***
	Breakpoint	2012 Q1	1994 Q1	1994 Q3
GDP	GDP	-5.709***	-3.324	-4.183
	Breakpoint	2008 Q2	2005 Q2	2008 Q2
	First difference of LRGDP	-4.249	-3.628	-5.462**
	Breakpoint	2008 Q1	1994 Q2	2008 Q2
	Second difference of LRGDP	-12.903***	-12.598***	-12.926***
	Breakpoint	2009 Q2	1994 Q1	2009 Q2
CB	CB	-3.997	-2.037	-3.616
	Breakpoint	2008 Q1	2004 Q1	2008 Q3
	First difference of CB	-5.105**	-4.787**	-6.627***
	Breakpoint	2007 Q3	2010 Q2	2008 Q1
SP	SP	-3.161	-3.192	-3.789
	Breakpoint	1995 Q2	1997 Q4	2001 Q1
	First difference of SP	-10.976**	-10.517**	-10.959***
	Breakpoint	2000 Q1	2008 Q4	2000 Q1

Critical value	1% Critical value	-5.34	-4.93	-5.57
	5% Critical value	-4.80	-4.42	-5.08
	10% Critical value	-4.58	-4.11	-4.82

Notes:

- Model A allows for a break in the level; model B permits a break in the slope; model C involves a break in both intercept and trend in the SVAR model.
- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.

Table 4-6 *Zivot Andrews unit root test for Canada*

Variables	Form	Model A Test statistic	Model B Test statistic	Model C Test statistic
HI	LRHI	-2.320	-2.720	-2.866
	Breakpoint	1998 Q2	2013 Q3	2013 Q3
	First difference of LRHI	-6.134***	-4.778**	-6.129***
	Breakpoint	2007 Q4	2013 Q3	2007 Q4
REIT	LRREIT	-3.962	-3.970	-4.181
	Breakpoint	2008 Q1	1997 Q4	2008 Q1
	First difference of LRREIT	-8.188***	-7.678***	-8.280***
	Breakpoint	2009 Q3	2009 Q2	2009 Q3
IR	RIR	-5.448***	-5.634***	-5.793***
	Breakpoint	2008 Q4	1999 Q3	2001 Q3
	First difference of RIR	-9.279***	-8.853***	-9.180***
	Breakpoint	2009 Q4	2002 Q1	2009 Q4
GDP	GDP	-3.725	-3.718	-3.806
	Breakpoint	2008 Q2	1999 Q4	1998 Q3
	First difference of GDP	-6.227***	-5.828***	-6.194***
	Breakpoint	2009 Q4	2009 Q1	2000 Q2
BP	BP	-4.142	-4.730**	-6.785***
	Breakpoint	2008 Q4	2006 Q3	2008 Q4
	First difference of BP	-7.552***	-7.538***	-7.760***
	Breakpoint	2007 Q3	1998 Q1	1998 Q1

SP	SP	-4.075	-4.010	-4.264
	Breakpoint	2008 Q4	1998 Q2	2000 Q4
	First difference of SP	-5.461***	-5.270***	-5.715***
	Breakpoint	2000 Q4	2002 Q1	2003 Q2
Critical value	1% Critical value	-5.34	-4.93	-5.57
	5% Critical value	-4.80	-4.42	-5.08
	10% Critical value	-4.58	-4.11	-4.82

Notes:

- Model A allows for a break in the level; model B permits a break in the slope; model C involves a break in both intercept and trend in the SVAR model.
- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.

Table 4-7 *Zivot Andrews unit root test for China*

Variables	**Form**	**Model A** Test statistic	**Model B** Test statistic	**Model C** Test statistic
HP	LRHP	-4.469	-3.757	-4.406
	Breakpoint	2009 M02	2010 M01	2008 M11
	First difference of LRHP	-12.079***	-11.597***	-12.050***
	Breakpoint	2011 M03	2014 M06	2010 M03
REIT	LRREIT	-4.261	-3.960	-4.738
	Breakpoint	2008 M01	2008 M09	2009 M04
	First difference of LRREIT	-11.051***	-10.255***	-11.860***
	Breakpoint	2008 M10	2009 M08	2008 M12
IR	RIR	-3.413	-3.234	-3.877
	Breakpoint	2012 M01	2015 M01	2008 M04
	First difference of RIR	-5.795***	-5.465***	-6.194***
	Breakpoint	2008 M02	2008 M08	2009 M03
IP	IP	-6.329***	-6.556***	-6.532***
	Breakpoint	2009 M04	2012 M09	2012 M08
	First difference of IP	-9.267***	-9.343***	-9.928***
	Breakpoint	2009 M03	2007 M12	2008 M03

CB	CB	-3.395	-4.401*	-4.856*
	Breakpoint	2014 Q12	2012 Q11	2012 Q01
	First difference of CB	-12.220***	-11.944***	-12.158***
	Breakpoint	2013 Q03	2011 Q7	2013 Q03
SP	SP	-3.742	-3.397	-3.869
	Breakpoint	2014 M12	2013 Q5	2008 Q2
	First difference of SP	-4.772*	-4.837**	-5.610***
	Breakpoint	2008 M2	2008 M3	2008 M12
Critical value	1% Critical value	-5.34	-4.93	-5.57
	5% Critical value	-4.80	-4.42	-5.08
	10% Critical value	-4.58	-4.11	-4.82

Notes:

- Model A allows for a break in the level; model B permits a break in the slope; model C involves a break in both intercept and trend in the SVAR model.
- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.

Table 4-8 *Augmented Dickey-Fuller Unit Root test for the UK*

	Intercept and trend			**Intercept**			**None**	
	Probability							
Variables	**Level**	**1st diff**	**2nd diff**	**Level**	**1st diff**	**2nd diff**	**Level**	**1st diff**
LRGDP	0.7315	0.0000***		0.8054	0.0262**		0.9811	0.0104**
LRHP	0.1682	0.1854	0.0000***	0.7203	0.0508*	0.0000***	0.8667	0.0055***
RIR	0.0193**			0.4017	0.0000***		0.0995*	0.0000***
LRREIT	0.3071	0.0000***		0.6798	0.0000***		0.9155	0.0000***
LRCB	0.6261	0.0000***		0.2861	0.0000***		0.5058	0.0000***
LRSP	0.5143	0.0000***		0.2083	0.0000***		0.8449	0.0000***

Notes:

- Three models allowing for intercept and trend, intercept and none are tested in this test.
- The variables are tested at level, first differenced and second differenced.
- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.

Table 4-9 *Augmented Dickey-Fuller Unit Root test for Canada*

	Intercept and trend		Intercept		None	
	Probability					
Variables	**Level**	**1st diff**	**Level**	**1st diff**	**Level**	**1st diff**
LRGDP	0.7776	0.0000***	0.4899	0.0000***	1.0000	0.0003***
LRHI	0.5792	0.0049***	0.9992	0.0085***	0.9895	0.0035***
RIR	0.0842*	0.0000***	0.1947	0.0000***	0.0038***	
LRREIT	0.5651	0.0000***	0.5650	0.0000***	0.9977	0.0000***
LRBP	0.1610	0.0000***	0.5233	0.0001***	0.9518	0.0000***
LRSP	0.1389	0.0000***	0.3779	0.0000***	0.9250	0.0000***

Notes:
- Three models allowing for intercept and trend, intercept and none are tested in this test.
- The variables are tested at level and first differenced.
- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.

Table 4-10 *Augmented Dickey-Fuller Unit Root test for China*

	Intercept and trend			Intercept			None		
	Probability								
Variables	**Level**	**1st diff**	**2nd diff**	**Level**	**1st diff**	**2nd diff**	**Level**	**1st diff**	**2nd diff**
LRIP	0.977	0.018**		0.092*	0.060*	0.000***	0.995	0.143	0.000***
LRHP	0.184	0.000***		0.872*	0.000***		0.991	0.000***	
RIR	0.097*	0.000***		0.024**	0.000***		0.310	0.000***	
LRREIT	0.340	0.000***		0.312	0.000***		0.224	0.000***	
LCB	0.962	0.023**		0.203	0.026**		0.989	0.020**	
LRSP	0.028**	0.000***		0.052*	0.000***		0.848	0.000***	

Notes:
- Three models allowing for intercept and trend, intercept and none are tested in this test.
- The variables are tested at level, first differenced and second differenced.

- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.

Table 4-11 *Correlation analysis*

UK						
Correlation Probability	DLCB	DLRGDP	DDLRHP	RIR	DLRREIT	DLRSP
DLCB	1.000000					

DLRGDP	0.079964	1.000000				
	0.3956	-----				
DDLRHP	0.055867	0.049469	1.000000			
	0.5532	0.5996	-----			
RIR	0.018892	0.267950	0.004378	1.000000		
	0.8412	0.0038	0.9630	-----		
DLRREIT	0.065882	0.114795	0.062265	0.072559	1.000000	
	0.4842	0.2218	0.5086	0.4409	-----	
DLRSP	0.099055	0.162669	-0.047183	0.088607	0.047902	1.000000
	0.2922	0.0824	0.6166	0.3464	0.6112	-----
Canada						
Correlation Probability	DLRBP	DLRGDP	DLRHI	RIR	DLRREIT	DLRSP
DLRBP	1.000000					

DLRGDP	0.226015	1.000000				
	0.0303	-----				
DLRHI	0.238825	0.118525	1.000000			
	0.0219	0.2605	-----			
RIR	0.100728	0.214568	-0.374894	1.000000		
	0.3394	0.0400	0.0002	-----		
DLRREIT	0.162125	0.151193	0.178431	-0.027330	1.000000	
	0.1226	0.1503	0.0888	0.7959	-----	
DLRSP	0.294358	0.240557	0.205740	0.083167	0.335230	1.000000
	0.0044	0.0209	0.0491	0.4306	0.0011	-----

China						
Correlation Probability	DLCB	DLRIP	DLRHP	RIR	DLRREIT	DLRSP
DLCB	1.000000					

DLRIP	-0.096565	1.000000				
	0.2446	-----				
DLRHP	-0.071744	0.042530	1.000000			
	0.3878	0.6090	-----			
RIR	-0.057698	0.038186	0.175391	1.000000		
	0.4876	0.6461	0.0336	-----		
DLRREIT	-0.070581	0.055612	0.187536	0.361908	1.000000	
	0.3956	0.5035	0.0229	0.0000	-----	
DLRSP	0.007540	0.076861	0.107040	0.301015	0.290163	1.000000
	0.9278	0.3548	0.1969	0.0002	0.0004	-----

4.3.2 The Model

4.3.2.1 Stationarity test

As a priority to any of the time-series data analysis, a stationarity test is applied before building the SVAR model. As with the previous chapter, a ZA unit root test, allowing for structural breaks, is conducted for each time-series data. Tests with a structural break under a different assumption are conducted with three models, A, B, and C (Equation 4-1, 4-2, and 4-3):

$$y_t = \mu + \theta DU_t(T_b) + \beta t + \alpha y_{t-1} + \sum_{j=1}^{k} c_j \Delta y_{t-j} + \varepsilon_t \quad (4\text{-}1)$$

$$y_t = \mu + \beta t + \gamma DT_t(T_b) + \alpha y_{t-1} + \sum_{j=1}^{k} c_j \Delta y_{t-j} + \varepsilon_t \quad (4\text{-}2)$$

$$y_t = \mu + \theta DU_t(T_b) + \beta t + \gamma DT_t(T_b) + \alpha y_{t-1} + \sum_{j=1}^{k} c_j \Delta y_{t-j} + \varepsilon_t \quad (4\text{-}3)$$

Model A allows for a break in the level of the series, model B permits a break in the rate of growth, and model C involves a break in both intercept and trend. The breakpoint is decided as the location at which the t-statistic in the ADF test is at its most negative.

In the meantime, the ADF test is also conducted to support the unit root test result. An ADF test allows for the existence of correlation in the error term ε_t and its transformation into a white noise process, while the general ADF specification also encompasses the possibility of deterministic trend and drift.

$$\Delta y_t = \mu + \gamma y_{t-1} + \delta t + \Sigma\beta\Delta y_{t-i} + \varepsilon_t \quad (4\text{-}4)$$

The ADF test is achieved by regressing the first difference of y_t on its one-period lagged value y_{t-1}, drift, deterministic trend, and the lagged values of Δy_t, and examining whether the estimated coefficient γ is significantly different from zero. To be more specific, the t critical value, particularly for the DF and ADF tests, which follow the τ statistic, has been adopted to estimate the null hypothesis. If the p-value is larger than 0.05, the null hypothesis $\gamma = 0$ is rejected, indicating there is no unit root. By inspecting the t and F values of the max lag to check its significance based on the precondition of white noise residuals, the number of lagged difference terms to be incorporated is determined. The number of these terms is decided before conducting the test. Through the following step, the p-value from the ADF test is selected to estimate whether γ is notably different from zero to verify a unit root. It is necessary to emphasise that the test begins with the most general form, and the presence of drift or trend is checked in order by an F-test of joint significance aiming to confirm the trend to which the time series belongs. Detecting these trends can help prove the presence of a unit root.

4.3.2.2 Structural VAR model

When a group of time series variables is under analysis, the interactions and co-movements among these observables, rather than simple regression, can be modelled. An SVAR model is a system of equations which considers all the variables in the model as endogenous. It has been justified as especially practical in explaining the dynamic behaviour of economic factors as well as structural analysis (Zivot & Wang, 2006). This model explains the links among a group of interrelated time series variables by analysing the dynamic evolution of these variables from their shared history. The causal structure and impacts of specific variables in the model can also be summarised. Isolate estimation of recognised assumptions of individual variable behaviour and influence can be made explicitly using an SVAR model.

Assuming this analysis encompasses six variables, which is an (6×1) vector X_t of endogenous variables following an AR(p) process. This multivariate SVAR(p) representation as a linear equation system with four equations can be written as:

$$BX_t = \mathit{\Gamma}_0 + \sum_{i=1}^{p} \mathit{\Gamma}_i X_{t-i} + \varepsilon_t \tag{4-5}$$

where Γ_0, X_t and ε_t are (6×1) matrices and B and Γ_i are (6×6) matrices. ε_t is serially uncorrelated, white-noise error term. This is an SVAR model because it demonstrates the structure of the four equations, and the variables inside this model are designed to affect each other, resulting in feedback that is incorporated in this framework. This is reflected as the form of both direct contemporaneous effect, which shows as variables directly entering each equation, and indirect contemporaneous effect which presents in error terms. Since this model is empirically unattainable with all the variables endogenous existed, a reduced-form VAR model is applied first to achieve a SVAR.

4.3.2.3 Reduced-form VAR model

Considering the previous SVAR model (4-5), premultiplication by B^{-1} allows it to generate the standard VAR in the reduced-form:

$$B^{-1}BX_t = B^{-1}\Gamma_0 + B^{-1}\sum_{i=1}^{p}\Gamma_i X_{t-i} + B^{-1}\varepsilon_t$$

or

$$X_t = A_0 + \sum_{i=1}^{p} A_i X_{t-i} + E_t \quad (4\text{-}6)$$

where $A_0 = B^{-1}\Gamma_0$; $A_i = B^{-1}\Gamma_i$; $E_t = B^{-1}\varepsilon_t$. Since in the reduced-form representation, each equation is just functions of lagged values of all the variables, VAR can be estimated. In particular, $X_t = (x_{1t}, x_{2t}, x_{3t}, x_{4t}, x_{5t}, x_{6t})'$ is (6×1) vector containing the six variables building completed, GDP, housing price, interest rate, REITs and stock price, A_0 is (6×1) vector of intercept coefficients, A_i is (6×6) coefficient matrix of autoregressive coefficients, and E_t is (6×1) unobservable white noise vector of error terms. The standard regressors for each variable contained in the VAR model are their own lagged time series, the lagged terms of other model elements, and deterministic terms. Since the right-hand side of the equation contains only predetermined variables and constant variances, and the errors are serially uncorrelated, the equation can then be estimated using ordinary least squares (OLS). The OLS estimates are consistent and asymptotically efficient. Moreover, as each equation contains identical explanatory elements, OLS estimation can be adapted to every equation. Prior to this test, the optimal lag length is selected by selecting the one that minimises model selection criteria while ensuring that the residuals are simultaneously white noise. Since long lag length would quickly consume degrees of freedom, lag selection tends to be critical. The specific criteria used in this study are the AIC, SBIC, and HQIC. In addition, the Granger causality test and IRF are conducted to reveal the short-term relationship and responses of variables to shocks. The Granger causality estimates whether the lags of one variable significantly enter the equation for another variable, and IRF visually displays the behaviour of different time series in response to various shocks.

After conducting a reduced-form VAR, the parameters for SVAR(p) can be recovered only when the VAR structural equations adopt appropriate restrictions on parameters.

When the structural system applies the required number of restrictions and the entries of the matrix are decomposed using Cholesky decomposition, the result is an exactly identified system. Regarding the above SVAR(p) model, Γ_i must be recovered from the values of A_i, estimated from the VAR model. Under this premise, n^2 more parameters than the reduced-form model are expected in the SVAR, which indicates the necessity of n^2restrictions to obtain an exactly identified SVAR. In accordance with Cholesky decomposition, the following short-term restrictions of normalisation on contemporaneous covariance between shocks can be applied: 1) Restrict the matrix of coefficients B to be triangular with diagonal elements normalised to be equal to one, resulting in $(n^2 + n)/2$ restrictions imposed on B. 2) Restrict the variance-covariance matrix of the structural error term ε_t to be a diagonal matrix, which makes all covariances equal to zero. Other $(n^2 - n)/2$ restrictions are then imposed on $Var(\varepsilon_t)$, making the total number of restrictions n^2. When imposing identifying restrictions, economic theory and the outcome of the Granger causality test support the identification of the significance of the regressors in each equation. As a consequence, the SVAR can be examined and analysed. Under this SVAR model, the results of significance for the coefficients can be interpreted as presenting short term relationships.

4.4 Empirical results

4.4.1 Reduced-form VAR

The first part of the methodology primarily builds a reduced-form VAR from which to conduct the SVAR model. With the premise that the time-series variables involved in the VAR should be stationary and the unit root test should result from the above section, the differenced technique is adopted to transform each element into a stationary one proceeding from its integrated order. In addition, an appropriate lag length for the model is crucial to conduct the VAR. Based on the criteria AIC, SBIC, and HQIC, seen in **Table 4-12**, a lag length of one for the Canada model is consistently proposed by all the three information criteria. Meanwhile, departing from the three information criteria results, lag two is suggested by AIC, while SCIC and HQIC suggest lag one for the UK model. Similarly, lag two from AIC and HQIC and lag one from SCIC is proposed for the China model. Under this premise, since the criteria select different models, the white-noise pattern of residuals in the model must be confirmed, which is achieved in **Figure 4-4** and **Figure 4-5.** The UK model with two lags is better behaved than that with one lag, while the China model with one lag does not improve the residual behaviour. Consequently, according to the lag selection process, lag lengths of two, one, and one are chosen for the UK, Canada, and China, respectively. Correspondingly, this study constructed a standard VAR model with time series observables for each country. The results of the VAR model are provided from **Table 4-13** to **Table 4-15**.

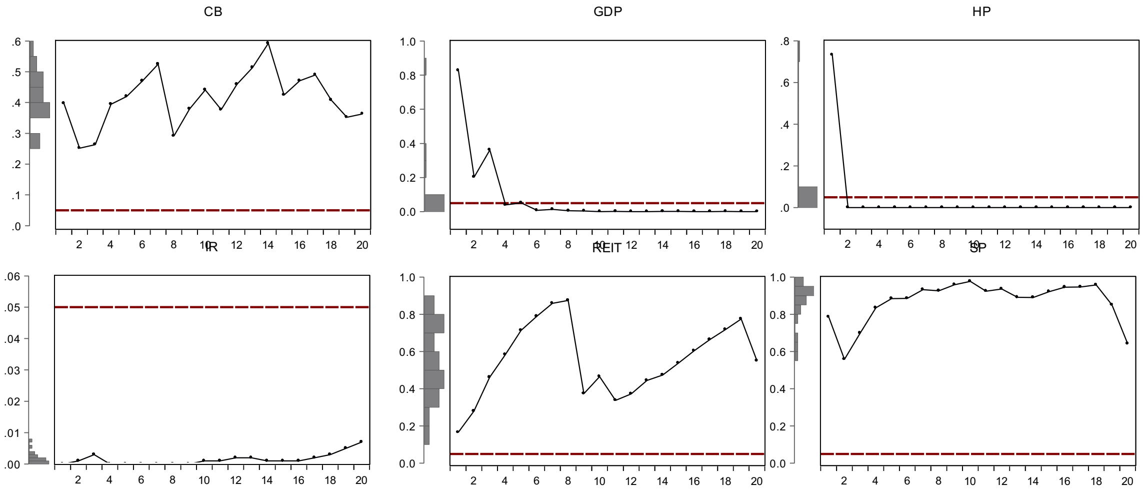
Table 4-12 *Lag length criteria*

Lag		0	1	2	3	4
UK	**AIC**	-21.7509	-24.5925	-24.7886*	-24.7848	-24.7753
	SC	-21.5993	-23.5310*	-22.8171	-21.9033	-20.9840
	HQ	-21.6895	-24.1624*	-23.9897	-23.6172	-23.2390
Canada	**AIC**	-25.3002	-28.0490*	-27.8705	-27.6686	-27.6027
	SC	-25.1313	-26.8666*	-25.6747	-24.4593	-23.3800
	HQ	-25.2321	-27.5726*	-26.9859	-26.3756	-25.9015
China	**AIC**	-22.4256	-24.5303	-24.9190*	-24.8064	-24.7530
	SC	-22.3013	-23.6601*	-23.3029	-22.4444	-21.6452
	HQ	-22.3751	-24.1766	-24.2623*	-23.8466	-23.4902

Notes:

- * indicates lag order selected by the criterion.
- A lag length of 1 is selected for Canada.
- Because of inconsistent result, the residual correlogram p values graphs for different lag lengths are compared in **Figure 4-4** and **Figure 4-5**.

Lag one



Lag two

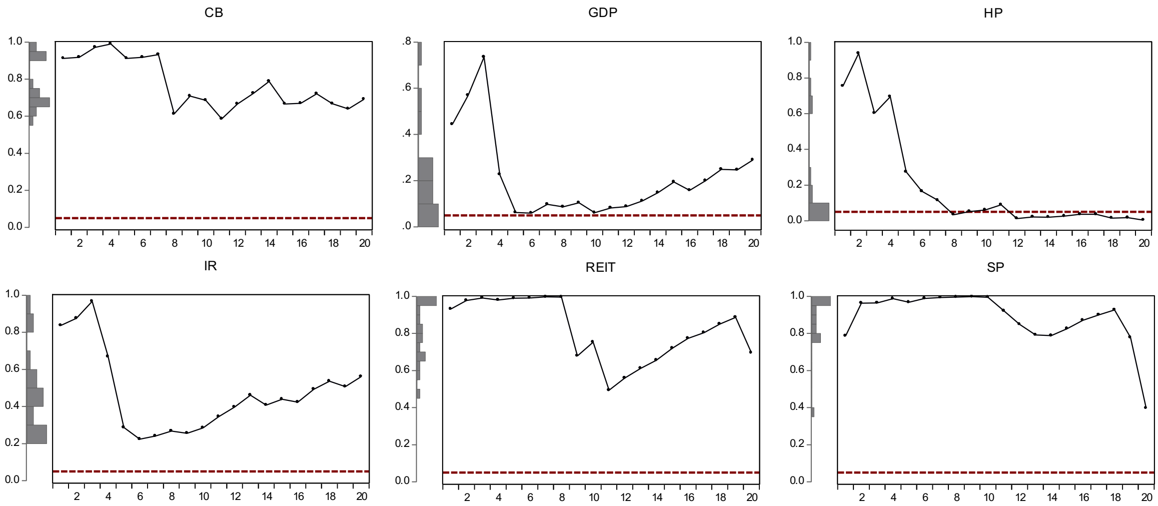
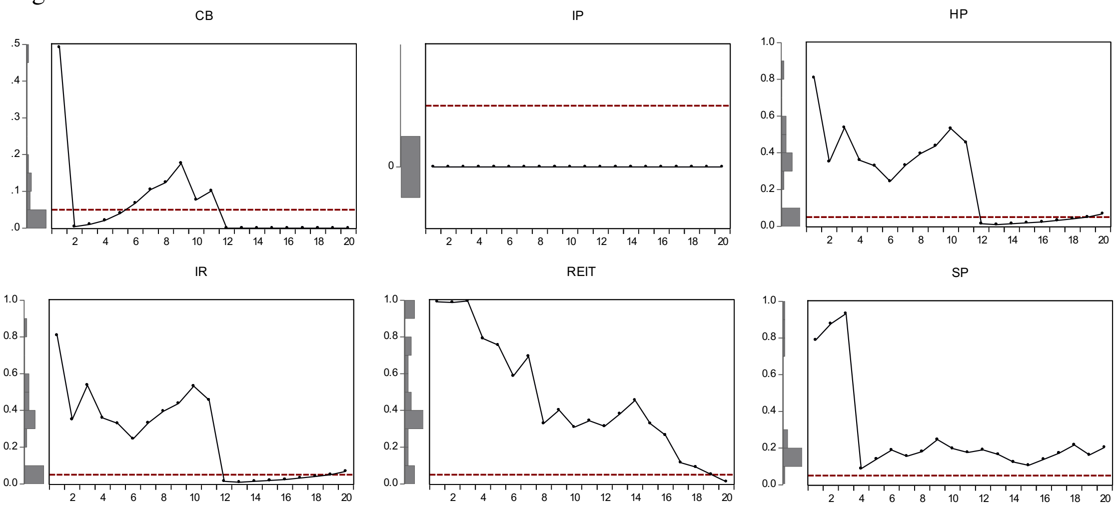


Figure 4-4 *Residual correlogram p values-UK*

Notes:

- CB--building completed to represent housing supply; HP-- housing price; IR--interest rate; SP--stock price.
- The variables are logged real term in differenced level according to the unit root test.
- The residual correlogram p values for the six variables in the UK, considering both lag one and lag two are compared in this figure.
- The horizontal reference line indicates 0.05 p level. Above this level indicates white noise residuals.
- After imposing two lags, the behaviour of residuals has been significantly improved. Therefore, a lag length of two is selected for the UK model.

Lag one



Lag two

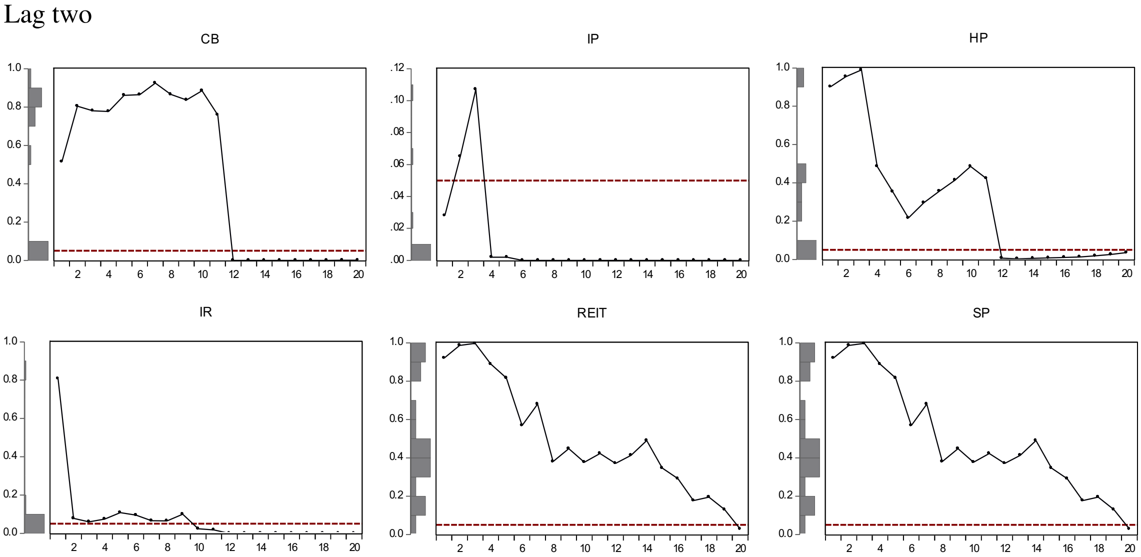


Figure 4-5 *Residual correlogram p values-China*

Notes:

- CB--building completed to represent housing supply; IP—industrial production; HP--housing price; IR--interest rate; SP--stock price.
- The variables are logged real term in differenced level according to the unit root test.
- The residual correlogram p values for the six variables in China, considering both lag one and lag two are compared in this figure.
- The horizontal reference line indicates 0.05 p level. Above this level indicates white noise residuals.
- After imposing two lags, the behaviour of residuals has not been improved. Therefore, a lag length of one is selected for the China model.

Table 4-13 *VAR result for the UK*

Equations		LCB		LRGDP		LRHP		RIR		LRREIT		LRSP	
Variables	**Lag**	**Coefficients**	**t value**	**Coefficients**	**t value**	**Coefficients**	**t value**	**Coefficients**	**t value**	**Coefficients**	**t value**	**Coefficients**	**t value**
LCB	1	-0.5262	-5.05***	0.0233	1.4851	-0.0093	-0.322	3.4714	1.694*	0.2187	1.403	0.041	0.347
	2	-0.2045	-1.921*	0.0296	1.840**	-0.0147	-0.499	1.5157	0.723	0.2493	1.564	-0.0929	-0.759
LRGDP	1	0.7986	1.275	-0.1484	-1.566	-0.376	-2.164**	-9.7522	-0.791	0.3955	0.422	0.4439	0.616
	2	0.5739	0.946	0.148	1.620	-0.0228	-0.135	-1.1673	-0.097	-0.1093	-0.120	-0.6676	-0.957
LRHP	1	-0.031	-0.096	-0.0869	-1.764*	-0.1054	-1.163	-3.4599	-0.539	0.5732	1.175	-0.1009	-0.269
	2	0.2349	0.746	0.030	0.631	-0.416	-4.75***	-0.8274	-0.133	0.0781	0.165	0.9534	2.63***
RIR	1	0.0035	0.735	0.0022	3.13***	0.0020	1.524	1.3493	14.2***	-0.0013	-0.184	0.004	0.801
	2	-0.004	-0.921	-0.0019	-2.60**	-0.0020	-1.521	-0.3837	-4.01***	0.0019	0.275	-0.0035	-0.629
LRREIT	1	0.0567	0.872	0.0125	1.279	-0.0200	-1.108	-4.5017	-3.51***	-0.0389	-0.400	-0.1812	-2.42**
	2	0.0489	0.837	0.0170	1.928*	0.0274	1.689*	2.2694	1.973*	0.0853	0.975	0.0656	0.975

LRSP	1	0.0420	0.492	0.0177	1.374	0.0473	1.994**	-0.0163	-0.009	0.8441	6.60***	0.0138	0.141
	2	0.0270	0.272	-0.0144	-0.959	0.0034	0.123	3.6503	1.869*	0.2903	1.954*	0.1956	1.714*
C		-0.0016	-0.396	0.0009	1.476	0.0009	0.781	0.0858	1.036	-0.0001	-0.016	-0.0001	-0.040

Notes:

- The 1% critical value for t test is 2.626; the 5% critical value for t test is 1.984; the 10% critical value for t test is 1.660.
- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.
- CB--building completed to represent housing supply; HP-- housing price; IR--interest rate; SP--stock price.
- In CB equation, none of the variables are significant; The significant variables in GDP equation are REITs and IR, in HP equation are GDP and SP, in IR equation are SP and REITs, in REIT equation is SP, and in SP equation are HP and REITs.

Table 4-14 *VAR result for Canada*

Equations		**LRBP**		**LRGDP**		**LRHI**		**RIR**		**LRREIT**		**LRSP**	
Variables	**Lag**	**Coef.**	**t value**	**Coef.**	**t value**	**Coef.**	**t value**	**Coef.**	**t value**	**Coef.**	**t value**	**Coef.**	**t value**
LRBP	1	-0.3120	-2.954***	0.0197	2.403**	0.0151	0.87688	-1.0565	-0.43162	-0.1150	-0.74580	-0.0298	-0.23287
LRGDP	1	-0.9612	-0.84861	0.3282	3.734***	-0.2554	-1.38604	-53.117	-2.022**	0.3720	0.22497	0.4039	0.29393
LRHI	1	1.3677	2.423**	0.0437	0.99819	0.6006	6.543***	-18.209	-1.39202	1.2528	1.52084	1.2952	1.891*
RIR	1	0.0018	1.11958	0.0003	2.257**	-0.0006	-2.166**	0.9047	24.72***	0.0028	1.22924	0.0029	1.50135
LRREIT	1	0.0714	0.96378	0.0010	0.17636	-0.0010	-0.08048	-2.2238	-1.29580	-0.0208	-0.19208	-0.0810	-0.90200
LRSP	1	0.1503	1.55400	0.0190	2.526**	0.0187	1.19035	2.3377	1.04273	0.2555	1.809*	0.1124	0.95832
C		-0.0034	-0.54395	0.0007	1.37878	0.0035	3.505***	0.4022	2.811***	0.0002	0.02386	-0.0084	-1.12045

Note:

- The 1% critical value for t test is 2.632; the 5% critical value for t test is 1.987; the 10% critical value for t test is 1.662.
- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.
- BP—building permits to represent housing supply; HI—housing price index; IR--interest rate; SP--stock price.
- The significant variables in BP equation is HI, in GDP equation are BP, IR and SP, in HI equation is IR, in IR equation is GDP, in REIT equation is SP, and in SP equation is HI.

Table 4-15 *VAR result for China*

Equations		LCB		LRIP		LRHP		RIR		LRREIT		LRSP	
Variables	**Lag**	**Coef.**	**t value**	**Coef.**	**t value**	**Coef.**	**t value**	**Coef.**	**t value**	**Coef.**	**t value**	**Coef.**	**t value**
LCB	1	-0.050718	-0.615	0.195425	2.931***	0.053111	1.580	1.130954	0.534	0.047127	0.329	0.060331	1.281
LRIP	1	0.031694	0.371	-0.518228	-7.509***	-0.017203	-0.494	0.487378	0.222	0.040528	0.273	0.016735	0.343
LRHP	1	0.279930	1.371	-0.260785	-1.579	0.028374	0.340	-3.159416	-0.602	-0.348392	-0.982	-0.082474	-0.707
RIR	1	-0.000399	-0.312	0.000315	0.305	0.000741	1.424	0.954129	29.11***	0.005491	2.477**	0.002236	3.069***
LRREIT	1	-0.011346	-0.073	0.135688	1.082	0.035889	0.568	1.919563	0.482	0.600782	2.231**	0.054259	0.613
LRSP	1	-0.081094	-1.628	0.004682	0.116	0.004724	0.232	-2.882782	-2.252**	-0.074528	-0.861	0.023647	0.831
C		0.004041	0.943	0.003306	0.954	-0.00053	-0.303	0.138010	1.253	-0.012905	-1.733*	-0.008007	-3.272***

Note:

- The 1% critical value for t test is 2.648; the 5% critical value for t test is 1.994; the 10% critical value for t test is 1.667.
- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.
- CB--building completed to represent housing supply; IP—industrial production; HP—housing price; IR--interest rate; SP--stock price.
- In CB and HP equations, none of the variables are significant; the significant variables in IP equation is CB, in IR equation is REIT, in REIT equation are IR and SP, and in SP equation is IR.

Starting with the VAR model, the significance of the coefficient for individual explaining element is revealed from the resulting tables. **Table 4-13** provides the standard VAR model result for the UK model. Among the variables, only the lagged value of housing supply (CB) itself is statistically essential in the housing supply equation. In the GDP equation, the lagged value of housing supply, housing price, interest rate (IR), and REIT are all vital determinants, with housing price and REIT at 10% significance. In particular, the result of the housing price (HP) equation indicates that GDP, REIT, stock price (SP), and the lagged value of housing price itself are all statistically important, although REIT is only at a 10% level of significance. Moreover, the lagged value of housing supply, REIT, stock price (at a 10% level of significance), and interest rate itself enter considerably into the interest rate equation. Stock price lagged value is the only outstanding value in the REIT equation, while both housing price and REIT are statistically vital in the stock price equation.

Table 4-14 demonstrates the explanatory power of the lagged value of variables in Canada. Housing price (HI) is the only variable apart from housing supply (BP) itself that enters dramatically in the housing supply equation. In the meantime, the lagged values of housing supply, interest rate, and stock price are all statistically significant in the GDP equation. The housing equation suggests critical explanatory factors of lagged value of interest rate and housing price itself. Meanwhile, GDP lagged value is vital in the interest rate equation in addition to interest rate itself. Stock price is the only variable that is prominent in the REIT equation, and housing price is the only influential lagged variable in the stock price equation.

The China VAR model result is presented in **Table 4-15**, which shows that none of the lagged values are prominent in the housing supply and housing price equations. In the industrial production (IP) equation, the lagged value of housing supply and industrial production itself are considerable factors. Moreover, the interest rate equation can be largely explained by stock price lagged value and its own lagged value. The interest rate lagged values are essential in both the REIT and stock price equations, while the REIT lagged value itself is also vital in the REIT equation.

At this point, the Granger causality test is conducted following the empirical analysis to help to provide more information on the short-term explanatory power of the joint lag terms. The significance of the determinants for each variable are exhibited clearly under the causality test, indicating the nature of the real market relationship.

4.4.2 Granger causality test

The aim of the Granger causality test is to discover the joint effect of the lag terms of one variable on another. With the support of the significance of the lagged value, this test can justify the forecast power of one time series on another. This technique is useful and practical in analysing the causal relationship between economic terms and explaining economic phenomena. From **Table 4-16**, the short term causalities among the targeting variables in the three countries are clearly exhibited. Similar to what is proposed in the standard VAR model, the UK market suggests that interest rate and REIT are vital factors in influencing GDP, and GDP can causally explain housing price under a 10% level of significance. In addition, the interest rate can be considerably affected by REIT in a short time frame. Stock price is an important determinant for REIT, while stock price can be explained by housing price and REIT in the UK. In Canada, GDP and interest rate can prominently explain each other, and GDP can also be explained by building permits and stock price, while housing price can noteworthily explain building permits and stock price. In addition, the interest rate is an essential determinant for housing price, while stock price can dramatically explain REIT price. Correspondingly, in China, buildings completed is a non-negligible explanatory factor for GDP, and interest rate and REIT can explain each other. Finally, interest rate and REIT are vital determinants for general stock price in China.

The preliminary result from the standard VAR and Granger causality tests provides some insight into the inherent nature of the relations among the focussing variables in the real market. In the UK market, the movement of the UK government bond, GDP, and stock price is shown to be affected by REIT price level, indicating a vital connection between the REIT market and macroeconomic factors in the UK. With respect to UK housing prices, there is no direct causality between real estate price and REIT, as only GDP can affect housing price. Housing supply in the UK tends to be inelastic, as no variable causes compelling movement in the real estate supply. However, housing price level can Granger-cause stock price level, which justifies the relationship between housing and stock markets proposed in the theoretical framework. Moreover, there is a considerable link between REIT and representative stock composite index, as they can Granger-cause each other in the UK. Canadian housing prices escalation can stimulate an upward shift in the supply side, while surges in housing price can be explained by a decrease in interest rate. Meanwhile, comparable with the result in the UK, there is no apparent causality between housing and REIT prices. Conversely, REIT connects closely with the stock market, as stock prices can affect REIT prices, while the stock market can be explained by housing prices, again agreeing with the economic theory. The Granger causality test also presents such a relationship among the key factors in China. The housing supply in China also tends to be inelastic when acknowledging non-causality from the rest of the variables on housing supply. However, the status of real estate supply has massively contributed to China’s GDP. The housing price in China is not affected by other variables, whereas China’s REIT fluctuations can be explained by the interest rate level. Meanwhile, REIT in China can significantly influence the interest rate and stock market. In summary, the Granger causality test is not able to justify the short-term link between real estate prices and REITs in the three countries.

Table 4-16 *Granger Causality Test*

Equations	Variables	Probabilities		
		UK	Canada	China
LCB	LRGDP(IP)	0.3312	0.3961	0.7102
	LRHP(HI)	0.7495	0.0154**	0.1702
	RIR	0.5534	0.2629	0.7545
	LRREIT	0.4428	0.3352	0.1035
	LRSP	0.8602	0.1202	0.9416
LRGDP(IP)	LCB	0.1321	0.0162**	0.0034***
	LRHI (HP)	0.1613	0.3182	0.1142
	RIR	0.0020***	0.0240**	0.7602
	LRREIT	0.0516*	0.8600	0.9075
	LRSP	0.2245	0.0115**	0.2790
LRHI (HP)	LCB	0.8752	0.3806	0.1140
	LRGDP(IP)	0.0943*	0.1657	0.6209
	RIR	0.3071	0.0302**	0.1542
	LRREIT	0.1543	0.9359	0.8161
	LRSP	0.1368	0.2339	0.5699
RIR	LCB	0.2377	0.6660	0.5933
	LRGDP(IP)	0.7308	0.0431**	0.8240
	LRHI (HP)	0.8599	0.1639	0.5469
	LRREIT	0.0006***	0.1950	0.0243**
	LRSP	0.1728	0.2971	0.6297
LRREIT	LCB	0.2059	0.4558	0.2000
	LRGDP(IP)	0.8990	0.8220	0.7313
	LRHI (HP)	0.4987	0.1283	0.4793
	RIR	0.9186	0.2190	0.0021***
	LRSP	0.0000***	0.0703*	0.4059
LRSP	LCB	0.5811	0.8159	0.7421
	LRGDP(IP)	0.4703	0.7688	0.7845
	LRHI (HP)	0.0285**	0.0585*	0.3259
	RIR	0.6255	0.1333	0.0132**
	LRREIT	0.0407**	0.3671	0.0256**

Note:

- This table presents short term causality among the variables. *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.
- CB--building completed to represent housing supply; BP—building permits to represent housing supply; IP—industrial production; HP-- housing price; HI—housing price index; IR--interest rate; SP--stock price.
- In the UK, IR and REIT significantly explain GDP; REIT is a vital explaining factor for IR; SP can substantially explain REIT, while HP is an essential determinant for SP.
- In Canada, HI dramatically explains CB; CB, IR and SP are important explanatory factors for GDP; IR considerably explains HI, while GDP significantly explains IR; SP is vital in explaining REIT; HI and REIT are important determinants for SP.
- In China, CB prominently explains GDP; IR and REIT are important determinants for each other; IR and REIT are important explanatory factors for SP.

4.4.3 Structural VAR

Based on the standard VAR and Cholesky decomposition, short-term restrictions on contemporaneous covariance are imposed on the matrix of structural parameters. Equations (4-7) and (4-8) summarise the identification structure according to the formula $BE_t = \varepsilon_t$ as well as the applied restrictions on matrix B. Before applying restrictions to the model, the correlation level between residuals in the VAR model are estimated to decide whether variable ordering is vital under the Cholesky decomposition restrictions. Enders (2014) stated that ordering is not likely to be important if residuals are not correlated. After testing for the residual correlation, some of the high correlation statistics indicate a linear relationship among some of the variables in the three models. As a consequence, the ordering of variables is discussed through economic theory. Based on the economic theory, the relatively less endogenous time series, such as housing supply and GDP, are placed first, because they are less likely to be influenced and they move more slowly. The relatively more endogenous time series, such as REIT and stock prices, are placed after, because they are more likely to be influenced. The stock market movement is the newly added variable in this chapter and is tightly related to various changes in the real economy, such as monetary policy, national output, and the real estate market (Dieci, Schmitt, & Westerhoff, 2018; Kurov, 2012; Prantik & Vina, 2012; Singh, 2010). The adjustment of stock prices towards information and news is instantaneous (Kayal, Maheswaran, 2018). Moreover, inside the endogeneity groups, different orders of variables have been tested, with similar result gained. Accordingly, the final variable ordering is selected to be housing supply, GDP, housing price, interest rate, REIT, and stock price. **Table 4-17** reports the resulting coefficients of matrix B under this identification, explaining the contemporaneous relationship among the variables.

Some information regarding the link among variables is presented. In the UK, REIT price is contemporaneously affected by housing supply, negatively and under a 10% level of significance; this was not captured in the Granger causality test. This means if the housing supply is broadened, REIT prices are reduced in the same period. Meanwhile, the interest rate is influenced by contemporaneous housing prices. A negative contemporaneous effect of housing supply on all of the other variables, including REIT, is detected in Canada. In addition, the Canadian stock market is crucially affected by contemporaneous REIT prices. Similarly, in China, contemporaneous housing prices can explain interest rate changes, while REIT is substantially affected by the interest rate in the same period. Meanwhile, the Chinese stock market is also influenced by contemporaneous REIT movements.

$$\begin{bmatrix} B_{11} & B_{12} & B_{13} & B_{14} & B_{15} & B_{16} \\ B_{21} & B_{22} & B_{23} & B_{24} & B_{25} & B_{26} \\ B_{31} & B_{32} & B_{33} & B_{34} & B_{35} & B_{36} \\ B_{41} & B_{42} & B_{43} & B_{44} & B_{45} & B_{46} \\ B_{51} & B_{52} & B_{53} & B_{54} & B_{55} & B_{56} \\ B_{61} & B_{62} & B_{63} & B_{64} & B_{65} & B_{66} \end{bmatrix} \begin{bmatrix} E_{LCB(LRBP)} \\ E_{LRGDP} \\ E_{LRHI(LRHP)} \\ E_{RIR} \\ E_{LRREIT} \\ E_{LRSP} \end{bmatrix} = \begin{bmatrix} \varepsilon_{LCB(LRBP)} \\ \varepsilon_{LRGDP} \\ \varepsilon_{LRHI(LRHP)} \\ \varepsilon_{RIR} \\ \varepsilon_{LRREIT} \\ \varepsilon_{LRSP} \end{bmatrix} \tag{4-7}$$

$$B = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ B_{21} & 1 & 0 & 0 & 0 & 0 \\ B_{31} & B_{32} & 1 & 0 & 0 & 0 \\ B_{41} & B_{42} & B_{43} & 1 & 0 & 0 \\ B_{51} & B_{52} & B_{53} & B_{54} & 1 & 0 \\ B_{61} & B_{62} & B_{63} & B_{64} & B_{65} & 1 \end{bmatrix} \tag{4-8}$$

Table 4-17 *SVAR result*

The UK

	LCB		**LRGDP**		**LRHP**		**RIR**		**LRREIT**		**LRSP**	
Equations	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**
LCB	1	-	0	-	0	-	0	-	0	-	0	-
LRGDP	-0.0229	0.1424	1	-	0	-	0	-	0	-	0	-
LRHP	-0.0389	0.1803	-0.1271	0.4745	1	-	0	-	0	-	0	-
RIR	-1.3365	0.4947	-5.597	0.6387	-16.168	0.012**	1	-	0	-	0	-
LRREIT	-0.2620	0.0954*	0.0478	0.9601	-0.1668	0.7543	0.0067	0.3849	1	-	0	-
LRSP	-0.0333	0.7817	-1.5251	0.0348**	-0.0463	0.9085	-0.0005	0.9385	-0.0452	0.5359	1	-

Canada

	LRBP		**LRGDP**		**LRHI**		**RIR**		**LRREIT**		**LRSP**	
Equations	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**
LRBP	1	-	0	-	0	-	0	-	0	-	0	-
LRGDP	-0.0223	0.004***	1	-	0	-	0	-	0	-	0	-
LRHI	-0.0306	0.0783*	-0.1636	0.4644	1	-	0	-	0	-	0	-
RIR	-4.4428	0.0681*	83.578	0.007***	-21.965	0.129	1	-	0	-	0	-
LRREIT	-0.2760	0.0848*	0.2767	0.894	-1.0435	0.27	0.0089	0.187	1	-	0	-

LRSP	-0.2685	0.036**	-1.5468	0.3427	-0.5974	0.4238	-0.0025	0.63	-0.1830	0.026**	1	-

China

	LCB		**LRIP**		**LRHP**		**RIR**		**LRREIT**		**LRSP**	
Equations	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**
LCB	1	-	0	-	0	-	0	-	0	-	0	-
LRIP	0.0418	0.5317	1	-	0	-	0	-	0	-	0	-
LRHP	0.0442	0.1882	-0.0019	0.9635	1	-	0	-	0	-	0	-
RIR	0.3387	0.8725	-3.1562	0.2236	-8.5740	0.097*	1	-	0	-	0	-
LRREIT	0.0069	0.8798	-0.0131	0.8163	-0.1599	0.1564	-0.0054	0.003***	1	-	0	-
LRSP	-0.0823	0.5556	-0.1389	0.4205	-0.1527	0.6604	-0.0074	0.1871	-0.5826	0.021**	1	-

Note:

- *, ** and *** indicate significance under 10%, 5% and 1% levels of significance.
- CB--building completed to represent housing supply; BP—building permits to represent housing supply; IP—industrial production; HP-- housing price; HI—housing price index; IR--interest rate; SP--stock price.

4.4.4 Impulse response functions

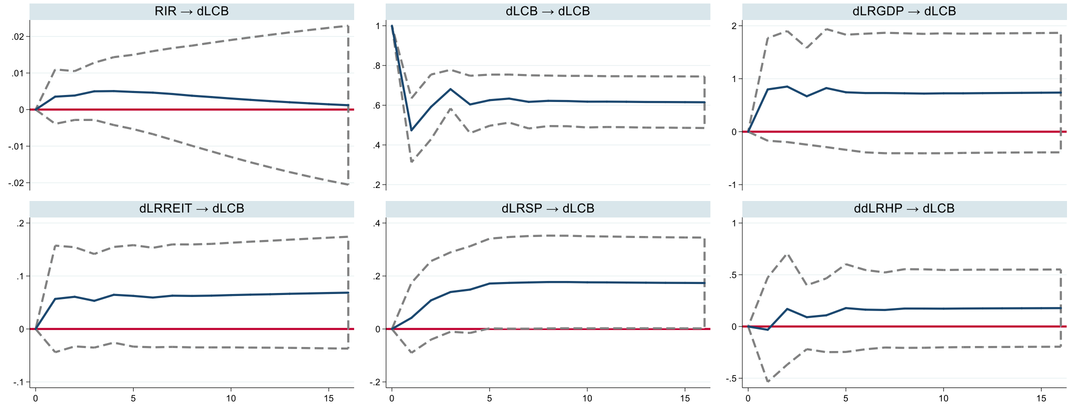
A typical operation of SVAR analysis is to perform a series of shocks and observe the influence of one deviation shock simulation to every single time series in this system. This illustration is accomplished through IRFs, the result of which is contained from **Figure 4-6** to **Figure 4-8**. Distinct from the Granger causality test, which justifies the statistical significance of variables, the IRF model explains the economic significance of time series.

The information about shocks and responses in the UK time series is demonstrated in **Figure 4-6**. Following a positive stock price shock, in panel 1, housing supply in the UK does not change immediately but rises after five quarters. At the same time, there is an immediate expansion in GDP level, with a positive shock on interest rate, a finding also captured in the previous chapter. Meanwhile, the positive response in GDP happens after half a year and one year with housing supply and stock price shocks, respectively. In addition, panel 2 shows that GDP reacts negatively to a housing price shock in the first two quarters, and in panel 3, a negative response for the whole period of housing price on GDP shock can be seen. These results were both found in the previous chapter. Similar to housing supply, housing price in panel 3 also reacts positively to a stock price shock, although this is an immediate response in the first two quarters, which coincides with the theory of a solid link between the housing and stock markets. In panel 4, the interest rate in the UK presents an immediate decline in response to a REIT shock, and this effect lasts for three years. Previous research has shown a notable response of monetary policy to REITs changes in economies such as the US and Asian ones, although this relationship is positive (Loo et al., 2016; Lu & So, 2001). Nevertheless, one working paper from Furlanetto (2008) discovered a negligible response of monetary policy to REIT prices in the UK. Accordingly, future study can be conducted to acquire more evidence. Regarding REIT responses in panel 5, a rise in REIT in the third quarter is seen, due to a housing supply shock, and an immediate positive movement after a stock price shock is seen for the entire time frame.

A positive relation between housing supply and real estate price has also been captured by Chow and Niu (2015). Moreover, this result is found in the context of a shortage of housing supply in the UK, resulting in a lower-than-demanded supply growth and a boom in real estate prices and housing-related assets (Griffith & Jefferys, 2013). Supply constraints and elasticity have played an important role in affecting housing price changes in the UK (Hilber & Vermeulen, 2010), which can be a suggestion for future studies. Importantly, an upward shift in REIT prices has been captured from the fourth quarter, lasting for one year after the housing price shock. Finally, in panel 6, the stock market in the UK shows an immediate negative response to a REIT shock, while a positive reaction of the stock price in the third quarter has been found after a housing price shock. Both positive and negative responses of the general stock market to REIT shocks have been captured in previous studies, such as Laopodis (2009) and Subrahmanyam (2007). In particular, Subrahmanyam (2007) found an inevitable adverse reaction of the stock market to REITs changes. REIT is regarded as an alternative investment tool for stock investment, generating downward pressure when more capital flows into the housing market. Meanwhile, the interrelationship between the stock and housing markets are also proved by this result.

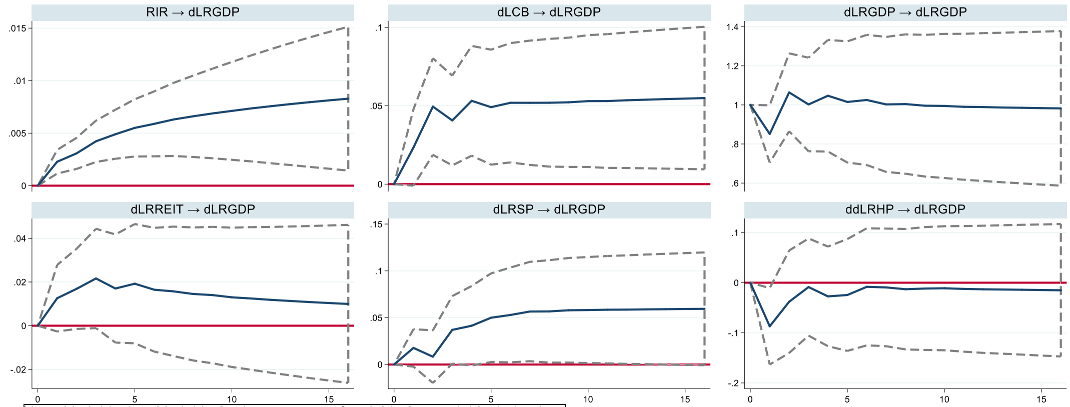
This result demonstrates the importance of the real estate construction industry in the UK, as it can cause influential movements in the national GDP and stock market. In addition, UK housing prices are affected by not only GDP but also by stock price level, which justifies the theoretical relation between the real estate and stock markets. It is noticeable that the escalation of the REIT price in the UK is caused by both housing price and stock price enlargement, and this provides hypothesis H_2. In the meantime, the stock composite index reflecting the overall stock performance is affected by REIT movements, indicating an important role played by REIT in the UK financial market.

Panel 1: Responses of CB



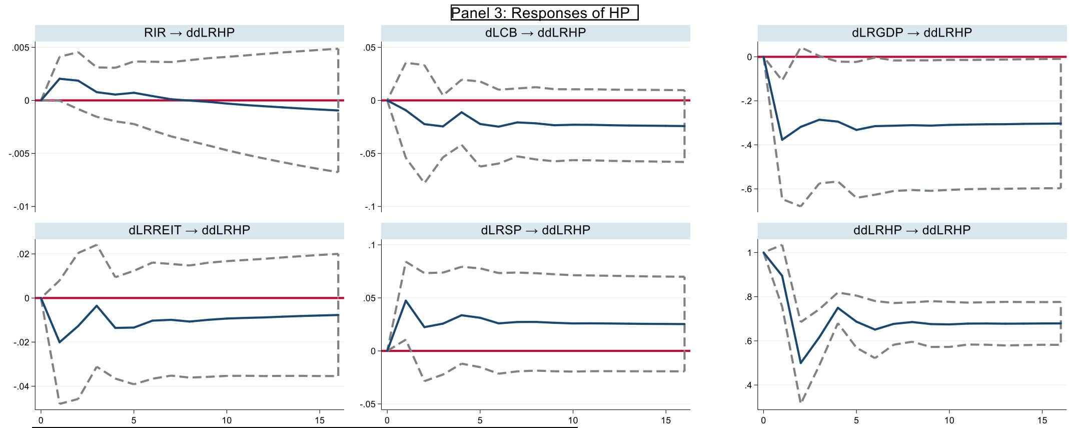
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 2: Responses of GDP



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 3: Responses of HP



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

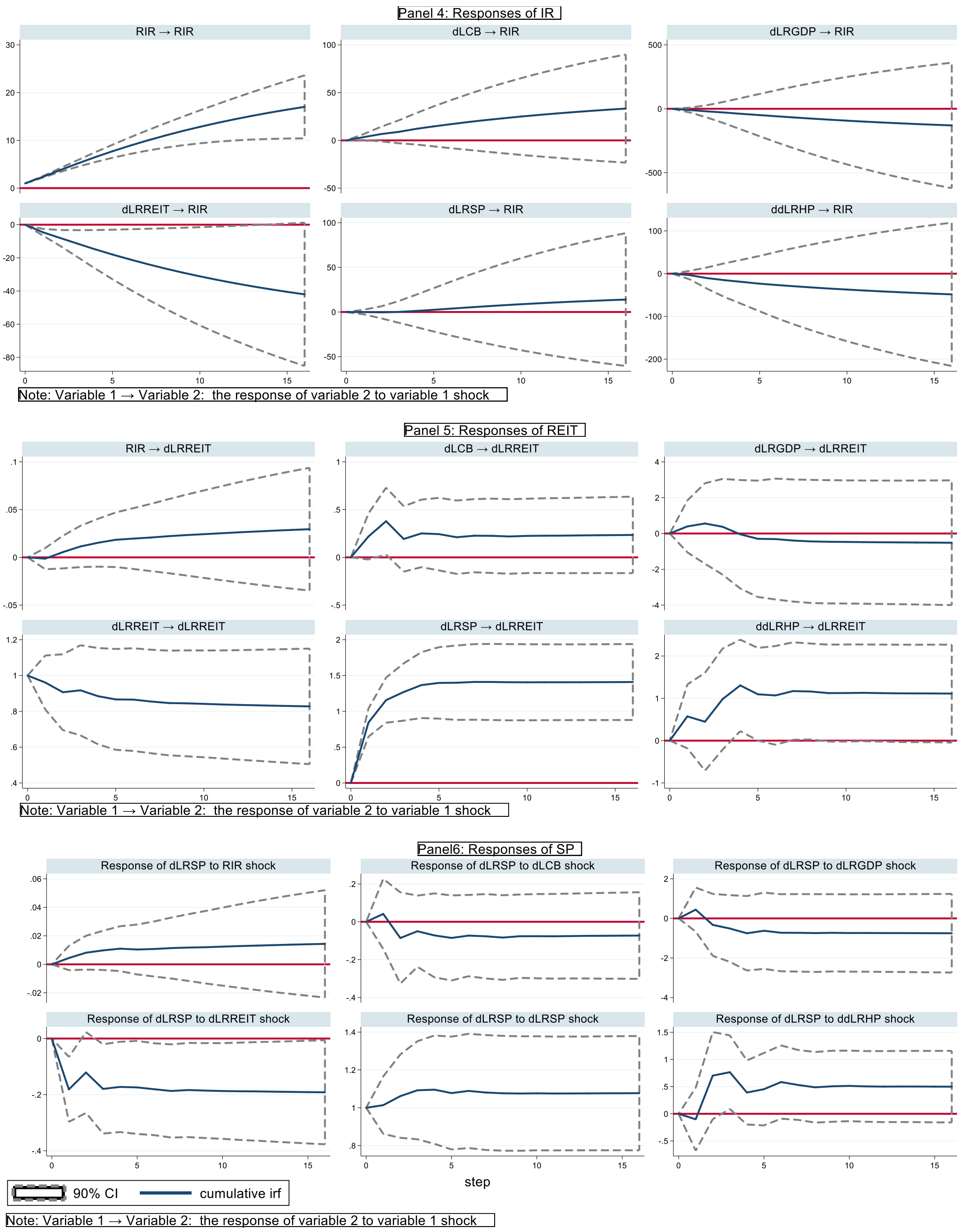


Figure 4-6 *Impulse response functions for the UK.*

Notes:

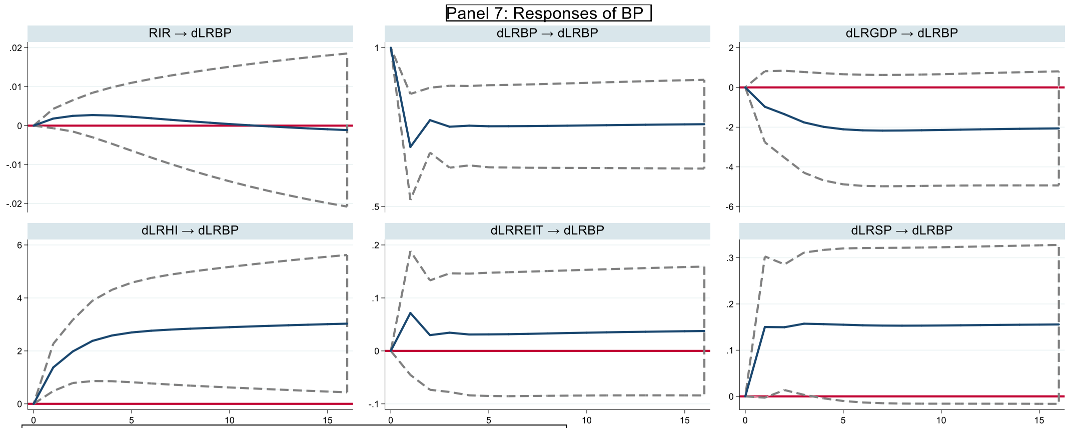
- This model applies accumulated responses of variables to shocks.
- CB--building completed to represent housing supply; HP-- housing price; IR--interest rate; SP--stock price.

- The model includes 2 lags, and Cholesky decomposition has been applied. The variables are in the following order: CB, GDP, HP, IR, REIT and SP.
- From the IRF result, CB responds positively to a shock in SP from the 3rd quarter. GDP reacts positively to a shock in CB and IR for the whole time period, and SP from the 3rd quarter. GDP reacts negatively in the 1st quarter to a shock in HP. HP reacts negatively to a shock in GDP and positively in the 1st quarter to a shock in SP. IR responds negatively to a REIT shock. REITs reacts positively to a shock in SP, positively between the 4th and 5th quarters to an HP shock, and positively in the 3rd quarter to a CB shock. SP responds negatively to REIT shock, and positively in the 3rd quarter to an HP shock.

Correspondingly in Canada, panel 7 shows that housing supply is closely connected with housing price, with housing supply immediately growing after a positive shock in real estate price. Housing supply additionally increases with a positive stock market shock in the first four quarters. More detailed study into the link between the stock market and housing supply can be the subject of future studies. With respect to the Canadian GDP level, in panel 8, a positive response in GDP is witnessed immediately after an interest rate and stock price shock. This positive reaction of GDP to interest rate is also found in the UK and China, as well as in previous studies such as Simionescu, Popescu, and Firescu (2017); Afrin (2017); Catão and Pagan (2010); and Wesołowski (2018). In addition, the housing supply contributes to national GDP positively in the first three years. Specifically, in panel 9, Canadian real estate prices only respond negatively to interest rate changes, but not to REIT movement. With respect to Canada's interest rate, as presented in panel 10, it responds negatively in the first four quarters to a GDP shock and negatively from the third quarter to a housing price shock. Other research such as Nelson (2004) has also asserted monetary policy neglect and a continuous lower interest rate under conditions of significant price expansion in the Canadian economy. It is worth noting that, in panel 11, Canada's REIT shows positive movement in the first five quarters in response to housing price shock. Additionally, there is a more consistent positive shift throughout the entire period in REIT price in response to stock market shock. Finally, in panel 12, stock price are seen to react positively in the first five quarters to real estate price in Canada.

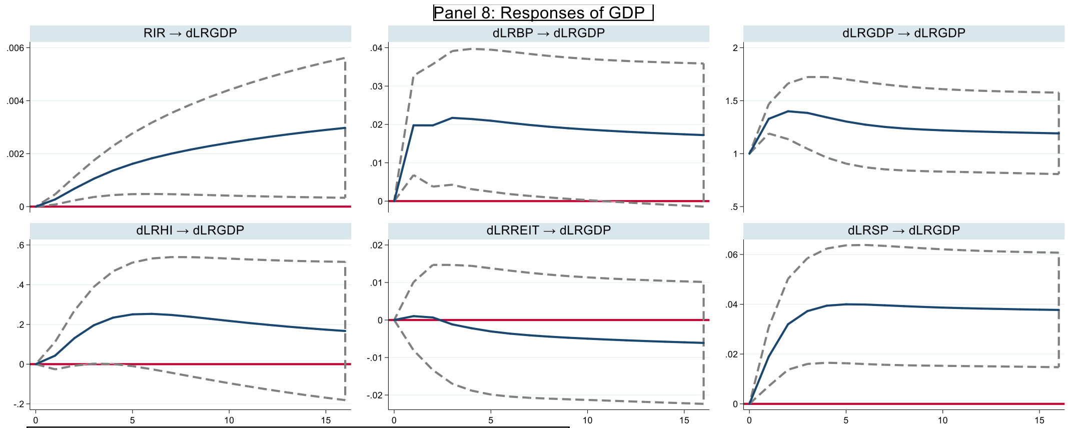
The interpretation of the result for the Canadian market is that first, housing price changes and stock market performance in Canada are vital factors to stimulate building constructions in the Canadian real estate market. Housing construction has also contributed remarkably to the GDP income in Canada. Second, it is the decreased monetary policy in Canada that amplifies the housing price level in the time period. There is also a feedback effect from housing price to interest rate, indicating the tight link between these two factors. Third, the findings for Canada are highly similar to those for the UK in that housing price and stock price growth can both shift the Canadian REIT price upward. Therefore, hypothesis H_2 is again proved in the Canadian market. At the same time, housing price also plays a vital role in the performance of the Canadian stock market.

Panel 7: Responses of BP



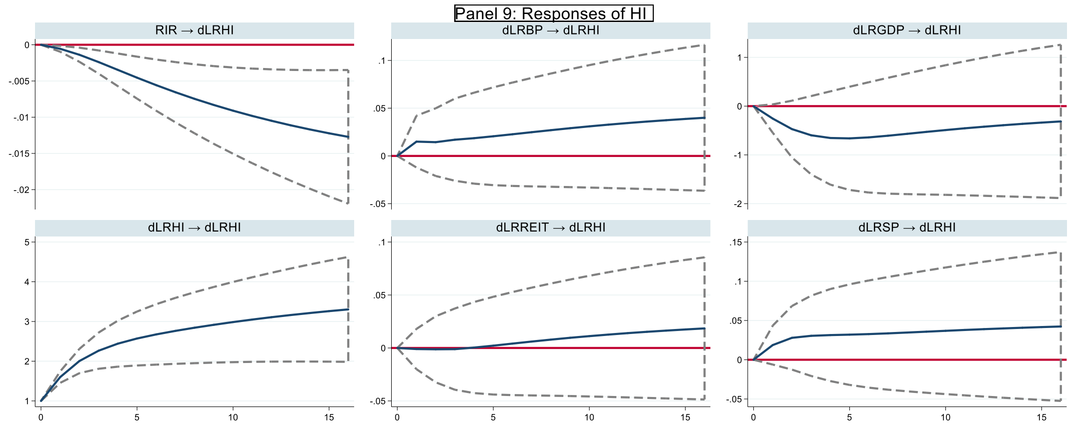
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 8: Responses of GDP



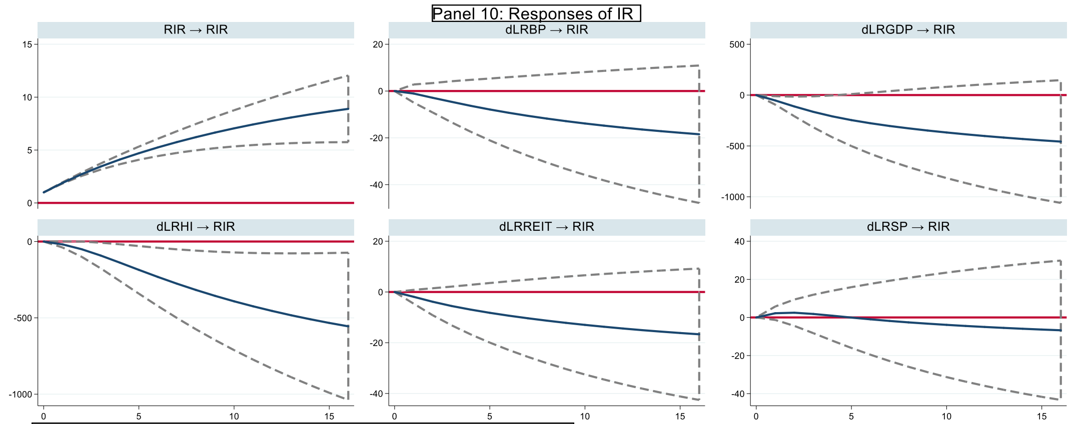
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 9: Responses of HI



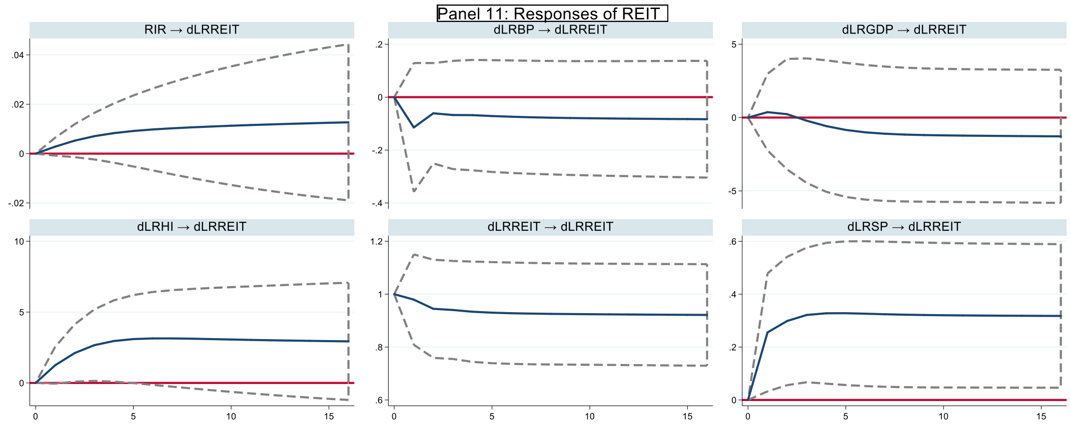
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 10: Responses of IR



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 11: Responses of REIT



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

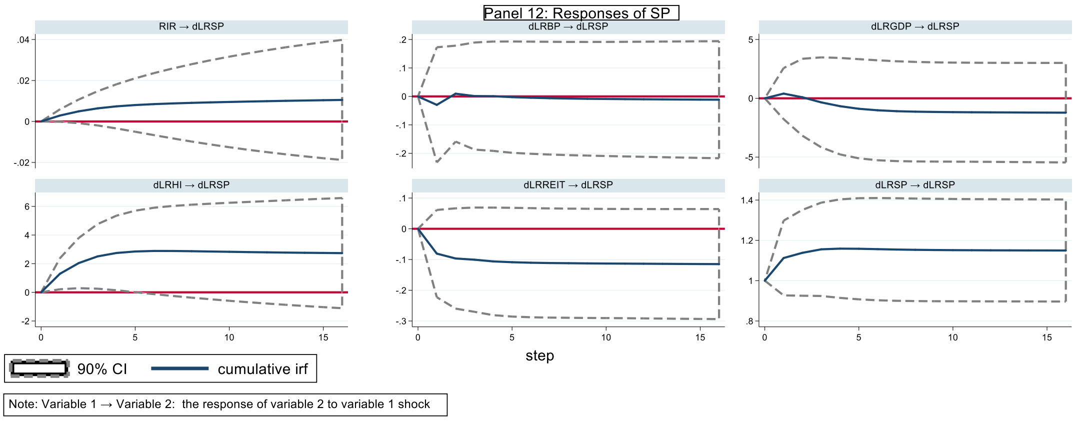


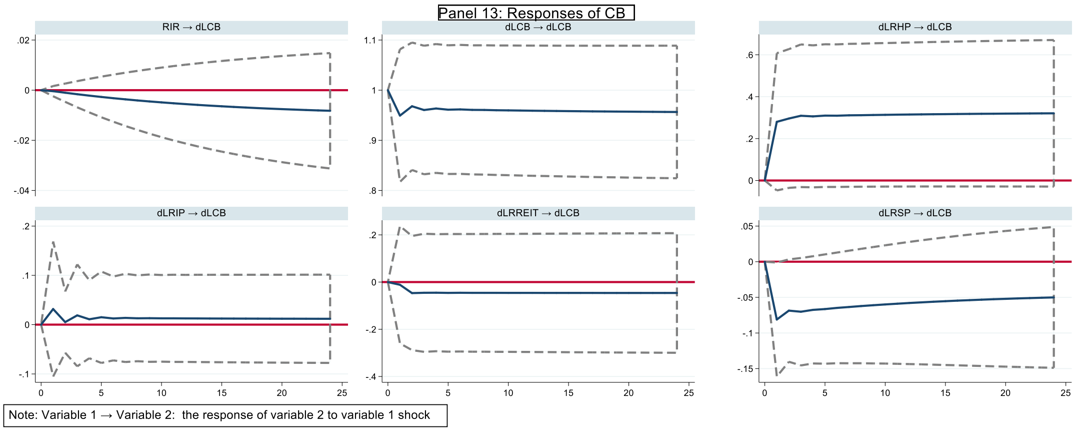
Figure 4-7 *Impulse response functions for Canada.*

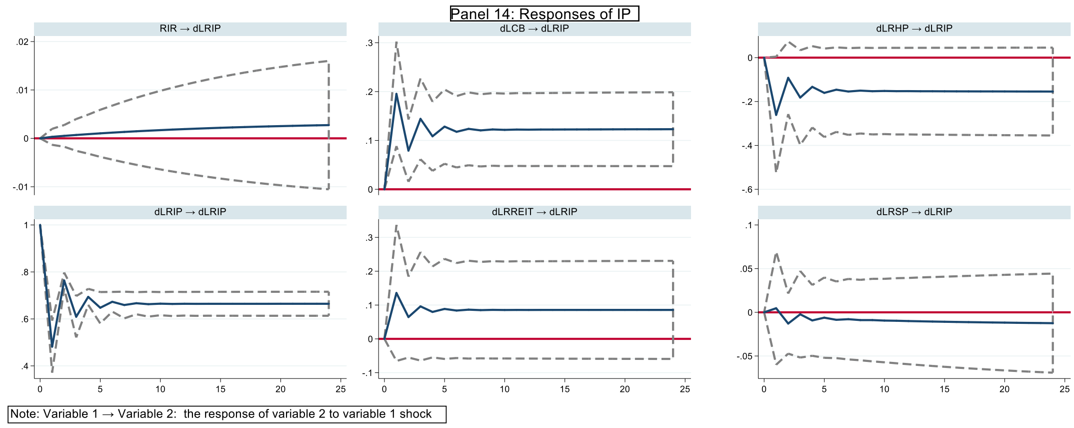
Notes:

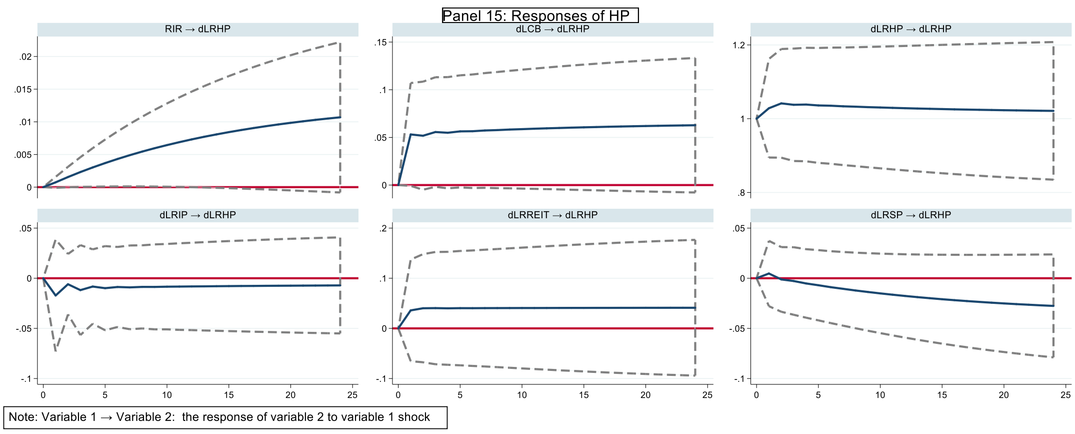
- This model applies accumulated responses of variables to shocks.
- BP--building permits to represent housing supply; HI-- housing price index; IR--interest rate; SP--stock price.
- The model includes 1 lag, and Cholesky decomposition has been applied. The variables are in the following order: BP, GDP, HI, IR, REIT and SP.
- From the IRF result, BP responds positively to a shock in HI, and positively in the first 3 quarters to a shock in SP. GDP reacts positively to a shock in IR, BP and SP, and positively from 3rd to 5th quarters to a shock in HI. HI and IR react negatively to a shock in each other from the first quarter and over subsequent time points. IR reacts negatively to a shock in GDP in the first 3 quarters. REIT responds positively to a shock in SP and positively in the first 5 quarters to a shock in HI. SP reacts positively to a shock in HI in the first 5 quarters.

When focussing on China, the housing supply is relatively inelastic, with no apparent response to any variable shock visible in panel 13. The result of panel 14 indicates that Chinese industrial production reacts positively to a shock in housing supply. Similar to the Canada model, housing price in panel 15 only responds positively to interest rate shock from the first year to the third year, although this reaction is minimal. However, interest rate shock is the only variable that causes a continuous positive movement of REIT in China (panel 17). This shows the failure of monetary policy in China, which has also been stated in Yao, Luo, and Loh (2013). Chinese housing investors are revealed to be speculative and irrational. Even under conditions of tightening monetary policy, they rush to purchase houses rather than leaving the market. The study of Song and Gao (2007) also captured a weak effect of monetary policy when the fund that flows to the asset market is speculative in nature. Moreover, panel 16 shows that the interest rate level is negatively affected by stock market shock, which is similar to the Canadian case and can be supported by Nelson (2004) using the theory of monetary policy neglect. Finally, as presented in panel 18, both interest rate and REIT shock cause an upward shift in stock price, although the reaction to REIT shock lasts for only 15 quarters. The investors in the Chinese stock market are comparable to those in the housing market, characterised by speculation and rushing to invest in assets under a heightened interest rate (Yao et al., 2013). This result indicates that housing construction industry in China is a relatively stable growth process which is not easily affected by macroeconomic factors, and this steadily developed sector has contributed greatly to China's soaring GDP. However, increased housing prices in China can also be regarded as being influenced prominently by government monetary policy, with a rise in interest rates leading to a climb in housing prices. However, China's REIT prices are no longer affected by housing prices, while expansionary monetary policy is proved to have stimulated REIT prices. Finally, the Chinese REIT sector has also made a vital contribution to the Chinese stock market.

These results indicate a notable positive and significant relation between housing price and REIT in the UK and Canada, as a dramatic response of REIT has been noticed when there is an impulse on housing price, although this is not the case in China. This result proves hypothesis H_2. Meanwhile, REIT is also closely linked to composite stock market price performance in the UK and Canada, while this relationship is opposite in China.


Panel 13: Responses of CB
RIR → dLCB
dLCB → dLCB
dLRHP → dLCB
dLRIP → dLCB
dLRREIT → dLCB
dLRSP → dLCB
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock


Panel 14: Responses of IP
RIR → dLRIP
dLCB → dLRIP
dLRHP → dLRIP
dLRIP → dLRIP
dLRREIT → dLRIP
dLRSP → dLRIP
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock


Panel 15: Responses of HP
RIR → dLRHP
dLCB → dLRHP
dLRHP → dLRHP
dLRIP → dLRHP
dLRREIT → dLRHP
dLRSP → dLRHP
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

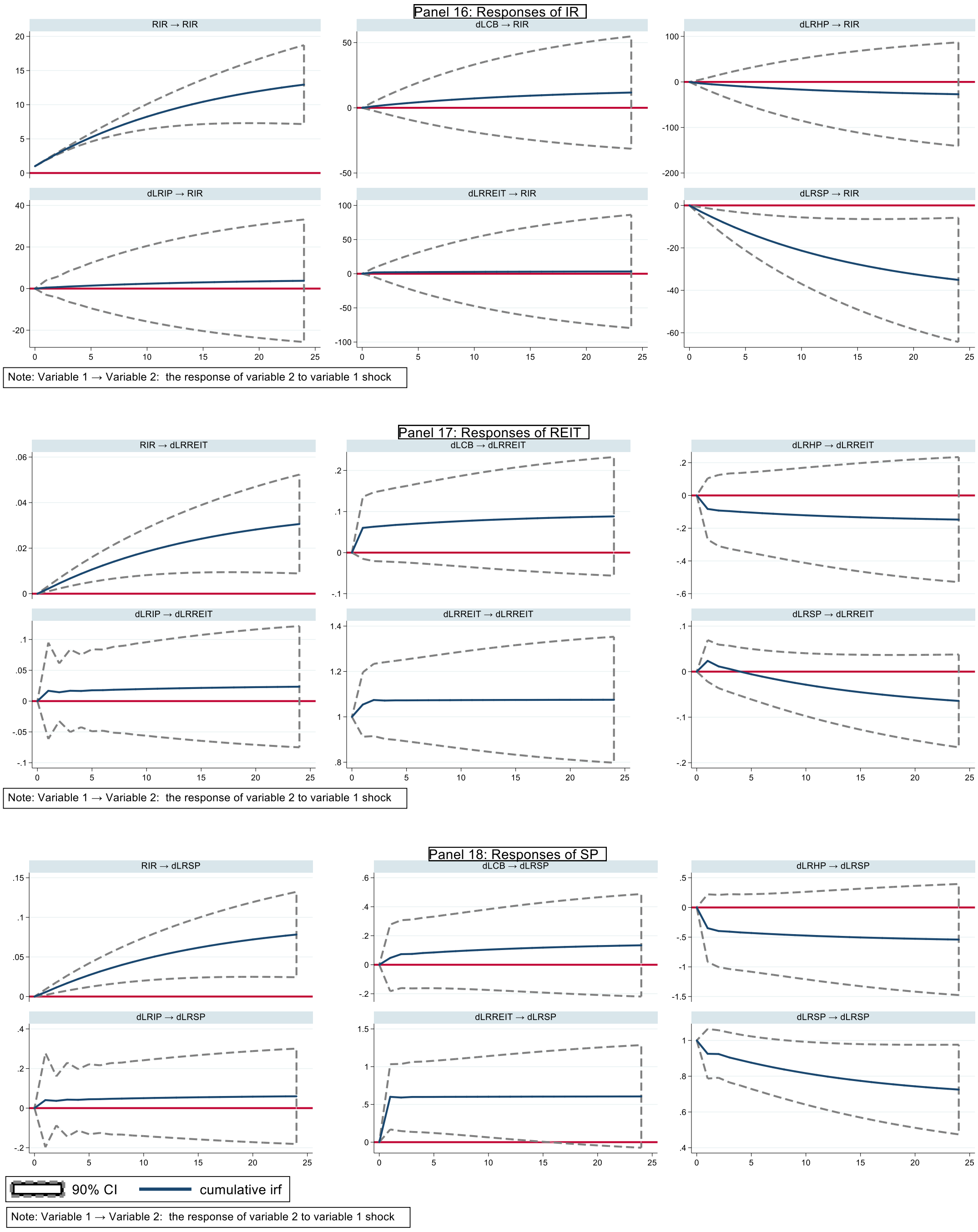


***Figure 4-8** Impulse response functions for China*.

Notes:

- This model applies accumulated responses of variables to shocks.
- CB--building completed to represent housing supply; IP—industrial production; HP--housing price; IR--interest rate; SP--stock price.

- The model includes 1 lag, and Cholesky decomposition has been applied. The variables are in the following order: CB, IP, HP, IR, REIT and SP.
- From the IRF result, IP reacts positively to a shock in CB. HP responds positively to a shock in IR in the first 10 quarters. IR reacts negatively to a shock in SP, while SP and REIT respond positively to a shock in IR. SP also reacts positively to REIT in the first 15 quarters.

In conclusion, the evidence from this chapter indicates that REITs, as an emerging industry in many economies, have not yet become a substantial determinant of housing price change. Particularly from the results of this study, REITs cannot explain the movements of UK, Canadian, or Chinese housing prices, and this result cannot confirm the effect that REITs have on housing prices, meaning that hypothesis H_1 is rejected. In the meantime, housing and stock prices have prominently influenced REITs in the UK and Canada. This result is different from previous studies in the United States, such as Chang, Chen, and Leung (2011), which states that REITs behave more like stocks, while the dynamic of the housing market is different from that of REITs. Our study has indicated that UK and Canadian REITs are in line with the movements of both the stock market and the housing market. This result validates hypothesis H_2. At the same time, the REITs for Chinese properties have not shown a considerable link with the real estate market, although it can significantly affect stock prices movements. This result is in the context of limited REITs available on Chinese properties. Only seven REITs listed in Hong Kong and Singapore involve mainland-Chinese housing investment, and they are all emerging real estate–related assets which only began to be listed to the market in recent years. As a result, instead of responding to housing or stock prices, these REITs are indicated to be closely affected by Chinese interest rate changes. Time is thus required for the Chinese REITs sector to grow and mature. Overall, hypotheses H_1 is rejected, while hypothesis H_2 is accepted, confirming the vital role the actual housing market in determining REIT returns.

4.4.5 Robustness check

Based on the aim of the study, to demonstrate the relationship between the actual real estate market and REIT returns in the stock market, this chapter proposed an SVAR model to discuss the connections among variables. Particularly, the certainty and accuracy of the result from this model is of central importance before it can contribute to the implications in this area. Because of the design of the SVAR model, it is sensitive to the assumed process of estimation, such as the assumptions of restrictions involved therein. More importantly, the adoption of Cholesky decomposition in this model makes the ordering of variables essential. Correspondingly, this section employs one of the common approaches, altering variable ordering, for a robustness check. The test for robustness reveals whether the specific model in this chapter works well under different assumptions. Following the theoretical support, stating the degree of the endogeneity nature of each time series, the initial order of the variables is housing supply, GDP, housing price, interest rate, REIT, and stock price. On the basis of the economic plausibility of the alternative ordering, the order of the less endogenous and the more endogenous variables is altered, so that the ordination for the robustness test is GDP, housing supply, housing price, interest rate, stock price, and REIT. The estimated results of IRF are displayed in **Tables B1–B3** in **Appendix B**. The acquired results from the new ordering are highly similar to the results in this chapter, illustrating that housing market returns do not depend significantly on REIT returns in the three countries, while housing market movements can significantly explain REITs in the UK and Canada. Accordingly, the robustness of the discussion in this chapter is confirmed in this section.

4.5 Conclusion

This chapter aimed to explore the empirical relation between the direct and indirect real estate market, in the form of REITs, with evidence for the UK, Canada, and China by using an SVAR model. The contribution this study has made lies in the relation between the real estate and REIT sectors in the three countries. The effect of REITs as an emerging indirect real estate investment instrument in most countries on the traditional real estate market been analysed in terms of their short-term effects, causality, and impulse response. Furthermore, the discussion on the determinants of REIT returns can offer implications to regulators and investors. The findings in this chapter cannot demonstrate a compelling effect of REITs on housing price movements in the three countries, as it remains an emerging industry with insufficient scale in the market and thus limited power. Comparatively, this chapter has indicated an explanatory power from both housing price and stock price on REIT in the UK and Canada, revealing a close connection between REITs and both the stock and real estate asset markets. Meanwhile, REITs in Chinese properties and housing prices in China have not shown any evidence of short-term links, given the initial developmental stage of REITs in China. This result is not surprising because REIT remains an emerging industry with insufficient scale in the market and thus limited power to influence the real estate market. The fund injected to the housing market from the REITs sector in these three countries is still relatively inconsequential and thus produces an insignificant effect on housing price fluctuations. When the inverse relationship is examined, the significant effect of housing and stock prices on REITs follows the theoretical framework and the hypothesis in this chapter. The vital influence from housing and stock markets to REITs is also supported by existing literature such as Bouchouicha & Ftiti (2012); Morawski et al. (2008); and Oikarinen et al. (2011). The result for the Chinese market also conforms with expectations because there is not yet REIT listed in China, and the REITs with underlying Chinese properties listed in Hong Kong and Singapore are newly established investment tools. The first unit of Chinese REIT started as late as 2007, providing a small sample size in this study. The Chinese REITs remain in the very initial stage, which may still present high uncertainty, fluctuations and departure from the real estate market. The implication from this result is in favour of developing the REIT sector in these three countries. This emerging financial instrument can contribute to a new source of funds for economic development, while at the same time causes no pressure to overheating housing price. At the same time, it also advises close supervision on the growth of REITs in the UK and Canada, as it may be influenced heavily by severe boom and bust in real estate prices.

As a particular financial instrument for investors to participate in the real estate sector, the REIT market is a vital field to study regarding the soundness of real estate development. The evidence discovered in this chapter proposes that changes in REITs in the three countries would not affect real estate prices, although both housing and stock prices influence REIT levels in the UK and Canada. This outcome indicates a close connection between the actual and indirect real estate sectors as well as the stock market in the UK and Canada, helping investment decisions and policy-making to be more focussed on related areas. However, further study can be conducted to address the limitations of this study. Possible suggestions are including more relevant variables and economies, considering the limited literature reviewed in this chapter. In addition, this study in China is especially restricted due to data availability, as REIT are an extremely new investment tool in China. Further research may be required when this circumstance has improved. Similar to the previous chapter, the limitations of the applied SVAR model are also worth to be discussed. This model offers a restricted evidence on whether the information mechanism or credit effect mechanism dominants the effect from housing price to REITs. This may be solved by employing models with variables for bank lending to reveal the influence of credit effect channel, or models to collect primary data targeting at investor behaviour and expectation. These proposed future studies may add new understanding to the current findings in this chapter. Furthermore, as mentioned before, the adopted restrictions following the variable ordering in Cholesky decomposition may be another limitation in this chapter. Alternative models may consider other reasonable restrictions or implementing sign restrictions under theoretical support, although the selection of these restrictions should be carefully examined to avoid inferior result. At present, a proper level of legislation regarding REITs in China is absent, and these financial activities are conducted on a limited basis (KPMG, 2007). However, a huge potential for the REIT market in China has been generated. The strengthening of the REIT industry around the world will reduce the exposure of banks to the housing industry and promote the professional management of properties. More available channels for property investment not only domestically but also globally will thus be provided.

Chapter 5 Conclusion

This thesis has contributed to the understanding of the real estate market and the determinants of housing price fluctuations based on evidence from the UK, Canada, and China. The dynamics of housing market movement and the possibilities of housing bubbles in the context of the three target markets has been examined in this thesis, as has explored the connection between the housing market and foreign investment to identify potential explanations of booming housing prices. Moreover, this study has also investigated the mechanism under the housing and stock markets through the discussion on housing prices and REITs. Based on the research topic, the three objectives of this thesis have been covered by three empirical chapters, and the econometric approaches of explosive VAR, recursive unit root tests, and SVAR models have been developed. This chapter primarily serves to describe the work of each chapter and present the empirical findings and conclusions. It then provides a general summary of the overall conclusions and value of the thesis and is followed by policy implications, extracted from the results of each chapter. Finally, the limitations of this thesis and the intentions and suggestions for further study are presented.

5.1 Housing bubbles

The first empirical chapter examined the presence of housing bubbles in the dynamic of housing market fluctuation. The discussion was based on the context of the UK, Canadian, and Chinese real estate sector, and the chapter aimed to find evidence of the distinctive behaviour of real estate prices over its fundamentals to detect housing bubble patterns during the period of study. This chapter first provided a comprehensive discussion of the background of housing market development and trends in housing price movement in the UK, Canada, and China. All of the three real estate markets that were focussed on have experienced a dramatic growth in housing prices. Canadian and Chinese housing prices have been continuously increasing for the past several decades with little downswing, under during global crisis of 2008. Meanwhile, the UK housing supply has been consistently lower than housing demand for a long period, which has boosted UK housing prices over time. This chapter summarised the previous literature, testing the concept of housing bubbles in the UK housing market and the real estate sector in different provinces in China. Limited study has been devoted to evidence of a housing bubble in Canada. Moreover, the economic theory on the links between housing prices and economic factors such as interest rate and GDP, as well as rental price, was explicated. The literature review also outlined the diverse methodologies adopted in previous studies. Motivated by the background and literature review, this chapter identified the gaps in which to apply explosive bubble tests to address the missing understanding of the Canadian and Chinese housing markets.

This chapter proposed the methodology of both using an co-explosive VAR model and conducting recursive unit root tests to estimate the presence of housing bubbles in the three countries. Both these models focus mainly on the explosive pattern of asset bubble and design the model to detect explosiveness in housing prices as the indicator of bubbles. In particular, the co-explosive VAR model tests for explosiveness in housing price rather than rental price to prove the existence of a housing bubble in one market. The two time series in this model are housing price and rental price. The VAR model, cointegration test, and VECM model were applied, and the characteristic roots in the model were tested to detect roots larger than one. Comparatively, the recursive unit root tests applied right-tailed ADF tests to capture explosive roots in housing price, rental price, and price-to-rent ratio. These three time series variables were tested separately over the model to compare the outcomes. Indicatively, the two right-tailed unit root tests, supremum ADF and generalised SADF, both of which contain a recursive right-tailed unit root test over a series subsamples to detect explosive roots within the sample, were estimated. We focussed more on the GSADF result though, as it provides more comprehensive and convincing results. From this methodology, this study has gained, interpreted, and compared the results from two empirical models.

The co-explosive VAR was first conducted with the tests on real estate and rental prices in the UK, Canada, and China, and the model statistics were accordingly gathered. The reduced form VAR model and testing of characteristic roots in the model in all the three countries produced explosive roots larger than one. Additionally, the cointegration rank test was done on the model to decide whether to proceed to the VECM model. The outcome suggests one rank in all the three countries, and the characteristic roots were then revealed using the VECM model. The explosive root disappeared for all the three countries after building the VECM model, providing no evidence of housing bubbles in the UK, Canadian, or Chinese real estate markets. Nevertheless, this model does not allow for structural breaks within the sample, limiting the reliability of its results. The recursive unit root tests were thus conducted to provide a better understanding of this topic.

Explicitly under the recursive unit root tests, SADF and GSADF were estimated on the time series of housing price, rental price, and price-to-rent ratio in the UK, Canada, and China. Two recursive ADF tests, on housing price and rental price, indicated solid explosiveness in both real estate and rental prices in the UK, Canada and China, leading to a further test on the price-to-rent ratio to detect housing bubbles. Furthermore, the price-to-rent ratio was tested under the SADF and GSADF to find an explosive pattern between housing price and rental price. Through this step, the explosiveness is consistent in the price-to-rent ratio in the three countries, proving the existence of housing bubbles. To this end, the technique of date-stamping the bubble episodes was conducted over the price-to-rent ratio in each country to specify the periods that contained real estate bubbles. Three bubble periods were detected in the UK, 1988 Q3–1989 Q4, 1999 Q4–2008 Q1, and a continuous one starting from 2016 Q4. The first two bubbles coincided with historical crises in the UK market, in the late 1980s and 2008. In addition, the estimation in Canada captured three housing bubble periods, 1980

Q4–1982 Q1, 1988 Q4–1990 Q1, and an ongoing bubble from 2002 Q1, which nearly burst in 2008. The housing bubble detected in the beginning of 1980s contributed to the extreme drop in real rental prices in Canada, while the early 1990s crisis in Canada was seen in the second bubble period in the outcome. Moreover, a real estate bubble starting from 2002 can be seen in Canada, and while it almost burst in the 2008 global crisis, it immediately recovered and continues to grow. Finally, in China, one housing bubble was identified, starting from 2004, although the evidence is limited after 2010 due to insufficient data availability. This chapter thus discussed the topic of housing bubbles in the UK, Canadian, and Chinese real estate sectors, and noteworthy property bubbles were detected in the three markets.

5.2 Housing prices and FDI

The previous empirical chapter proved the presence of real estate bubbles in the UK, Canadian, and Chinese housing market, which led to the discussion in the subsequent chapter of the determinants of housing prices and the connection between housing and other markets. The link between the real estate sector and foreign investment was studied in this chapter in the UK, Canadian, and Chinese markets. This connection is based on the fast growth of foreign investment and increasing capital inflow to the real estate sector in major economies, together with the boom in the housing market. In particular, the movements in FDI have been highlighted when examining the explanatory power of foreign investment in the real estate market. Therefore, this chapter aimed to explore the link between foreign capital inflow and housing price growth to provide evidence of whether FDI acted as a notable explanatory factor.

This chapter first provided a detailed illustration of the trends in the development of the FDI sector in the three target countries. Past decades have seen a dramatic expansion in capital inflow, especially into the real estate sector around the global market. With the prosperous development of the housing market over the years, tremendous profit has been generated by property trading, which has become the reason that real estate is highly attractive for receiving funds not only from domestic investment but also in the form of overseas capital inflow. Meanwhile, with tightened regulations in some markets on direct house purchases, other forms of foreign investment in the real estate industry, such as direct investment in real estate corporations, are flourishing (He & Zhu, 2010). This topic has been explicitly studied in emerging economies demonstrating rapid economic and real estate market growth. A large amount of capital has chased after abundant resources in developing countries, a dynamic which is especially noticeable in China, whose economy and housing sector is undergoing rapid development. At the same time, the foreign investment in major developed countries and their housing industries continue to occupy a dominant proportion of the overall amount, as these countries have mature, stable, developed real estate sectors. Specifically, the uptrend of foreign investment has been witnessed in their property markets, with increasing numbers of speculative foreign investors moving their funds into the housing area in developed countries such as the UK and Canada. The study of the relationship between foreign investment and housing prices in the context of developed economies is nevertheless rare. However, this relationship tends to be apparent under different theoretical mechanisms, including the aggregate demand–driven, demand for property–driven, and liquidity-based mechanisms. This chapter introduces a detailed explanation of the transmission mechanism under the three channels. Moreover, the literature review highlights the different methodologies, such as VAR and regime-switching models, used in earlier studies, whereafter the gaps in the literature are identified. First, we worked on the connection between foreign investment and real estate prices in the developed economies of the UK and Canada. Additionally, FDI was selected, together with rental price and housing supply, to be comprised as critical factors for housing price fluctuation. Moreover, this chapter selected SVAR as the empirical technique with which to find evidence to answer the research question. The six time-series variables in this model, supported by economic theory, were housing price, FDI, rental price, housing supply, interest rate, and GDP. The traditional VAR model was built on these variables, and restrictions based on Cholesky decomposition were applied to the model to construct the SVAR. Furthermore, Granger causality and IRF were tested under this model to provide more comprehensive evidence on the research topic. In this way, the empirical results for the three countries were gathered and interpreted.

The Granger causality test first provided knowledge on the causal relationship among variables in the model. The statistics from this test indicate that UK housing prices can only be causally explained by rental price level, which proposes a close connection between housing price and its fundamental in the UK. Comparatively, both FDI and housing supply can causally explain Canadian and Chinese housing prices, although the housing prices in these two countries are not closely linked to their fundamentals. The results from IRF demonstrated the relationships among variables. Similar to the Granger causality test, the shocks of FDI did not noticeably change UK housing prices, although FDI inflow was positively affected by housing supply shock. As a result, the UK housing sector was found to not be affected by the amount of FDI into the country, but the development of housing construction in the UK has been absorbing more FDI funds from other countries. Meanwhile, the considerable response of housing prices to rental price shock indicates that there is no property bubble in the UK housing market. When moving on to the case of Canada, both housing price and housing supply level reacted positively to FDI shocks, while housing price did not respond notably to rental price. This indicates that Canadian housing prices have been driven up by the inflow of FDI into the market, and the construction of new houses has been boosted by funds from FDI as well. This result indicates the vital role played by FDI in the dramatic development in the Canadian housing market. A negative response of Chinese housing prices was found in response to FDI shocks, whereas the response of the housing supply was positive in response FDI shocks. Consequently, increasing FDI to China has enormously stimulated the construction of new properties and buildings in the Chinese market, leading to a negative influence on housing price movement. At the same time, rental price shocks in neither Canada nor China caused noteworthy fluctuation in housing prices, suggesting the presence of housing bubbles in the two countries.

5.3 Housing price and REIT

In addition to foreign investment, when analysing external factors that affect the housing market, the stock market is one indispensable sector to be examined. The fluctuations in the stock market have been frequently discussed in relation to other asset markets, such as the property market. Therefore, this thesis examines the link between the housing and stock markets. Real estate investment trusts are an emerging financial product which turns real estate investment into shares of investment trust companies. Hence, the third empirical chapter in this thesis analyses the relationship between REITs and housing prices in the UK, Canada, and China. This proposal was made based on the rapid development of this securitised form of housing investment and the great amount of funds collected from this trust for the expansion of the actual housing sector. Consequently, this chapter aimed to examine whether REITs in stock market had substantial effects on the fluctuations in the actual real estate market in the UK, Canada, and China.

The background of the development in the REIT industry in the global market and within the three specific countries was first introduced. The generation of REITs occurred first in the United States, and many countries have since applied the REIT regime into their own financial systems. This investment functions through the following process: REIT companies sell their REITs as company shares to collect funds from investors, and this capital functions as investments into income-generated real estate to gain rents and profits. These returns are then transferred to shareholders in the form of dividends. Individual investors in REITs can thus invest in the unaffordable and illiquid assets of properties, and it becomes easier for the public to share the benefits of the real estate sector, and the global market as a whole has responded positively to this opportunity. Given its proximity to the United States, the Canadian REIT sector appears earlier than the UK and Chinese one, and it has experienced steady but swift growth. Canadian REIT investment has provided consistently high returns to buyers, leading to high expectations on the part of the public regarding its development. The introduction of REITs to the UK occurred in 2007, with a group of large real estate companies becoming REITs. Further policies have also shown an encouraging attitude towards the development of REITs, contributing further to the rapid growth of REIT investment in the UK. In China, by contrast, there is no mature REIT market in the financial system, although several REIT companies trading on Chinese property assets have been listed for investors in the Hong Kong and Singapore stock exchanges. The returns from these REITs on Chinese real estate have been growing dramatically, reaching the highest level of all Asian countries in recent years. The theoretical framework of this chapter regarding the relationship between housing prices and REITs was then summarised. The framework was introduced in detail through the four channels: the information mechanism, wealth effect mechanism, credit effect mechanism, and composition risk mechanism. Housing prices and REITs were closely connected through these mechanisms. Correspondingly, related studies on the topic of the stock and housing markets in different countries were discussed. Most previous research has examined the relationship between the general stock market and the housing sector in countries such as the US, UK, and China, while a lack of attention has been paid in particular to the Canadian market. In particular, the literature on REITs is severely limited within the United States, with a lack of evidence being gathered for the UK, Canada, and China. Consequently, based on the gaps in the literature, the methodology in this chapter was developed.

In the methodology, the short-term relationships among the variables were examined via an SVAR model, Granger causality test, and IRF. The six variables contained in the first section were housing price, REITs, housing supply, stock price, interest rate, and GDP, all variables suggested by the theory to have a vital role in the model. Correspondingly, the empirical results were gained for the UK, Canada, and China. The first step provided the empirical outcome for the links among variables. The Granger causality test showed that housing prices and REITs are not significantly causally connected in any of the three countries. GDP can explain housing prices in the UK, and REIT prices can be explained by stock price in the short term. In Canadian case, housing prices were explained by interest rate movement, while stock prices have explanatory power on REIT prices. Meanwhile, REITs in China can only be mildly explained by interest rate in the short term. With respect to the SVAR and IRF results, housing prices in the UK only responded to shocks in GDP and stock price, not REITs. However, REITs in the UK reacted positively to housing price shock and to housing supply and stock price shocks. Similarly, in Canada, a positive reaction of REITs to housing price and stock price shocks was found, while Canadian housing prices were found to only respond negatively to interest rate shock. In China, both housing prices and REITs reacted positively to interest rate shock but did not cause any significant response on each other. Thus, a vital effect of housing price on REITs was found in the UK and Canadian markets, while housing price was found to be relatively independent of REIT shocks in the three countries. Moreover, stock price levels explain REITs in the UK and Canada, and in China, monetary policy explains REIT prices. Housing prices were thus not influenced by REIT movements, while REIT returns could be prominently affected by stock and housing prices.

5.4 Summary

In general, this thesis explored the development of the housing market in the context of the UK, Canadian, and Chinese markets. Critical discussions centred on the movement of housing prices and the presence of housing bubbles, the relationship between the housing market and foreign investment, and the link between the stock and housing markets. By analysing the various aspects related to growth in the real estate sector growth, the empirical results from each chapter indicate different dynamics of housing sector development in different economies. Therefore, this section summarises the distinctive evidence and understanding from the empirical chapters on the three real estate markets.

The first market studied was the UK real estate market. The research aimed to identify housing bubbles and test for a link among foreign investment, the stock market, and the housing sector using time-series data. Recursive unit root tests captured several historical real estate bubbles, as well as an ongoing housing bubble. The two housing bubble bursts in the model, in the late 1980s and in 2008, are confirmed by historical crisis, demonstrating the empirical power of this model in detecting bubbles. Thus, there is a bubble, ongoing from late 2016, in the UK housing market. This finding, together with the recent boom in UK housing prices, indicates that the fundamental growth rate in housing prices must be monitored. The discussion of the following topics in this thesis aims to provide further understanding of the driving force of such a surging in housing price and the method of regulating housing price growth. The second empirical chapter presented estimates of the connection between housing prices and FDI. If a significant relationship between the two variables was detected, the FDI sector might be regarded as an essential determinant of housing price increases in the UK. Accordingly, the empirical results from this section suggests that there is no apparent connection between housing price and FDI in the UK, and the inflow of FDI cannot be regarded as a determinant of the increasing housing prices in this market. However, FDI was proved to be positively affected by UK housing constructions, which indicates a vital attractiveness of the housing sector to FDI. The rapid development of the UK housing supply has triggered more FDI into the market. This result ought to be examined in further research. The outcomes from Chapter 4 provided evidence on the relationship between housing prices and REITs in the UK. Housing prices in the UK were found to be explicable by GDP and general stock prices, while the effect from REITs remained relatively small in affecting housing prices. Meanwhile, REIT development was linked tightly with housing prices, housing supply, and stock market movements. From this thesis, then, there is a housing bubble in the UK real estate market, which shows an extreme growth of property prices over their fundamental. The UK housing prices are affected mainly by national GDP, rental price, and general stock market performance, while FDI and REITs are not important factors affecting the housing price level. However, the return of the newly developed real estate-based financial asset, REITs, is linked closely with housing price changes and stock market fluctuations.

The Canadian dynamic also involves housing bubbles and the effects of FDI and REITs on the housing market. The first empirical chapter applies an explosiveness asset bubble detecting method to capture the Canadian housing bubble. Accordingly, it finds three housing bubbles in different time periods. The previous two bubbles revealed the historical changes in rental prices and the early 1990s crisis in Canada. A bubble was also found to be ongoing from 2002, almost bursting in the 2008 global crisis but quickly recovering and continuing to grow. Chapter 3 has provided evidence on the relationship between the housing price growth described in Chapter 2 and FDI inflow. This chapter demonstrated that movements in FDI inflow positively influenced both housing price and housing supply. The expansion in housing price and new house being construction in Canada was profoundly affected by the funds from FDI. Additionally, the impact of one factor in the stock market, REITs, was explored in the next empirical chapter. However, REITs in Canada were found to not have a noticeable effect on housing price fluctuations. Instead, Canadian real estate prices are only influenced by interest rate. At the same time, both the stock market movements and housing price changes substantially affected the development of the REIT sector in Canada. To summarise, Canadian housing prices have also grown to exceed the rate of increase of their fundamentals, creating a bubble in the Canadian housing market. In particular, FDI inflow to the Canada market has substantially contributed to this state of affairs in the real estate sector, as has the loose monetary policy of low interest rates from the Bank of Canada. The development of the Canadian REIT industry, however, is tightly connected with housing price fluctuations and stock market movements.

Finally, the Chinese real estate market was examined in terms of whether a housing price bubble exists and what the determinants are for housing price variations. First, the presence of housing bubbles was examined, and one housing bubble was found, from 2004 to 2010, though this result is restricted due to the limited data availability on rental prices in China. Meanwhile, explosive housing prices were detected after 2010, and the recent explosiveness in real estate prices continue since 2016. Under such a context of soaring housing prices in China, the following chapters have studied the effects of FDI and REITs on housing prices. The results of Chapter 3 suggest that FDI movements in China have positively improved the construction of new buildings in China by providing sufficient capital for real estate development companies. As a consequence, heightened FDI has negatively affected housing prices by driving up the Chinese housing supply. Furthermore, the analysis also focussed on housing prices and REITs in China. The estimation revealed that REITs and housing prices do not noticeably affect each other in China; instead, the interest rate is the crucial factor in explaining housing price and REIT fluctuations. Moreover, REIT returns on Chinese properties are mainly affected by stock market changes. Thus, Chinese housing prices have developed at an explosive rate in recent years, and FDI to China can negatively affect housing prices, while monetary policy can have a mild positive effect on housing prices. At the same time, REITs on Chinese real estate affect stock market performance and monetary policy in China.

5.5 Contributions

The real estate market has been one of the pillar industries for many economies, and the pace of development in the real estate market in various countries is exceptionally high. In the meantime, this rapid growth has been accompanied by increasing interest in properties from foreign investors and the emergence of the real estate stock sector REITs. It is crucial to any economy to study the dynamics of the housing sector. This thesis has thus provided a new understanding of the presence of housing bubbles and the connections among FDI, REITs, and the housing market in the UK, Canada, and China. The research conducted in this thesis has contributed to diverse aspects in the topic of real estate market.

Primarily, this study has contributed to the existing conceptual framework by re-contextualising existing theory in new settings and applying the previous concept to a different situation. In detailed, the test for the presence of housing bubbles has been employed to the three economies, the UK, Canada and China, at the national level with updated samples to provide a new perspective on the topic. Additionally, chapter 2 has extended and specified the discussion of capital inflow and the housing market by bringing the discussion of the relation between FDI and housing price to not only developing but also developed economies. Furthermore, the topic of REIT, as an emerging financial sector, and its connection with the actual real estate market has been extensively explored in the three countries where REITs are in their initial stage of development.

Contributions made by this thesis also rest in the methodology framework. A relatively new approach with a combination of two explosive bubble models have been employed to test for housing bubbles in the target countries. Existing approaches have been expanded by proposing an inclusive model containing both explosive and unit roots to examine both explosiveness and cointegration, which has seldom been achieved in previous studies. Also, the in-depth understanding of the presence of real estate bubbles has been contributed by this technique together with the support from another explosive model, recursive unit root tests, to generate a more comprehensive knowledge.

Distinctive results have been found for the three countries, showing different levels of significance for the relationships among the markets. Accordingly, this thesis has added value to the existing research and presented implications for authorities, researchers, households, and investors on whether a bubble exists and what the critical factors are in influencing housing prices in these three countries. Potential investors in the real estate market may reshape their understanding of the UK, Canada and China market, especially since housing bubbles are detected in each economy. The findings in this study also contribute to enhancing the knowledge of foreign investors on the property market in the three target countries. With distinctive results on the relation between FDI and real estate prices, overseas speculators on Canadian properties may seek alternative investment tools as FDI significantly drives up housing price boom. Meanwhile, foreign investors may be cautious on their fund to Chinese property construction sector because it significantly stimulates housing supply, causing negative pressure on housing prices.

5.6 Policy implications

In general, the results from the three empirical chapters have offered several implications for regulators, researchers, and the public concerning the development of the housing market and related sectors. History has proven the vital role of appropriate policy responses in preventing a dramatic boom-bust in an economy (Jurgilas & Lansing, 2013). During the period in which Japan became extremely prosperous, beginning in 1985, regulators did not respond correctly to the overheated market with controlling governance. Instead, expansionary policies such as lower interest rates and free lending to companies and individuals buying houses were implemented, which led to a huge slump in the Japanese economy that has persisted since 1990 (Johnston, 2009). Similar evidence can be seen before the 2007 financial crisis in the United States, at which time the government was deviating in terms of monetary policy, triggering the subprime financial crisis that led to the subsequent global crisis (Taylor, 2018). Correspondingly, as real estate bubbles form, policymakers could intervene to prevent or ease dangerous imbalances among markets. Increasing regulatory oversight is necessary on the financial and housing markets and related institutions. The government can also apply macroprudential regulations and monetary policies to contain the overheat in the market. The primary goal of governmental policies should be to constrain the bubble from growing too large (Yellen, 2009). Policymakers should positively seek preventative measures to restrain excessive volatility in the real estate sector. In addition, dramatic deflation usually occurs after the burst of the asset bubble, and this is extremely destructive to an economy. Therefore, the government should also implement regulations aiming to prevent deflation in response to signs of credit expansion and overheated housing prices. Furthermore, it is not only the uncertainty in housing price escalation, but also its connection with the banking system and borrowing that make real estate bubbles extraordinarily costly. The household leverage from the mortgage loans for purchasing properties has magnified the contractionary influence of housing price decline and extended the length of recessions after the burst of housing bubbles (Fisher, 1930). Correspondingly, policymakers should also work on policies, interventions, and oversight relating to the domestic banking system and mortgage regulations to control for credit expansion and excess liquidity in the market. The growth in the household debt ratio must be tightly monitored by macroprudential regulation to reflect the financial stress of house owners paying back debts. The ratio of household mortgage loans to household income is one measurement which can signal the government about this financial stress (Jurgilas & Lansing, 2013). Overall, to regulate the real estate market and related financial sectors, a balanced approach of cooperation between policies such as macroprudential, monetary, and fiscal policies can be adopted. This combination can ease the shortcoming of individual policies and allow for multiple transmission channels to amplify each other's effectiveness (Ding et al., 2017).

This research has found undeniable evidence of housing bubbles in the UK, Canada, and China, and a visible explosive pattern of housing prices in China since 2010. Therefore, the implications for UK and Canadian policymakers are related to controlling any further boost in housing prices, monitoring the stability of the market, and decreasing the bubble element. Similarly, for Chinese policymakers, regulations should also be introduced in order to adjust and supervise the explosive growth in housing prices. Additionally, regulators should also strategically evaluate the potential consequences of bubble bursts and establish preparatory measurements (Jurgilas & Lansing, 2013). These actions can be conducted in the following aspects.

I. Real estate and financial markets

Based on the empirical results of this thesis, housing bubbles exist in the UK and Canada, and Chinese housing prices show a consistent explosive pattern. As a consequence, a general tightening of regulations on the real estate market and related financial sectors is suggested to be adopted by policymakers in the three countries. A general idea of migrating speculative purchases is to magnify the cost of purchase (Ding et al., 2017). Therefore, a contractionary monetary policy such as increasing the mortgage rate would help raise the expense of purchasing properties. Moreover, taxes can be applied to capital gains from property earning, purchasing houses, or applying for a mortgage to place constraints on overheated purchasing behaviour. At the same time, set restrictions to home purchases can suppress demand for properties. Policymakers should also contribute to eliminate speculative purchasing by changing public perceptions of houses as good investment assets and providers of funds for retirement. Through the period of asset price boom, more mortgage loans are issued to the market, and lenders sell these loans to financial intermediaries in the form of mortgage-backed securities. Therefore, higher barriers and requirements can be set together with regular reports to select lower-risk loan borrowers and thereby reduce the possibility of unaffordability and stabilise the market (Scottish Government, 2010). Higher audit and review mechanisms within the process of securitising mortgages is another way of excluding manipulation in securitising subprime loans.

II. Housing supply

The supply of real estate in the market is one of the major factors proved to have a remarkable effect on real estate price movement. Depending on the distinctive cases in the three markets, different suggestions can be offered to policymakers. Primarily, although the housing supply has not been stated to be significant factor affecting housing prices in the UK, the housing supply in the UK has been depressed over time, generating an imbalance between real estate supply and demand. However, the UK housing supply has been considerably attractive to FDI and has raised REIT returns. Accordingly, the government can contribute to stimulating the construction of new houses to drive up house stocks in the market, to diminish the supply-demand imbalance, and to improve FDI and REIT sector performance. In Canada, a direct positive link between housing supply and housing price can be found, and FDI inflow has provided dramatic funds for both new house construction and housing price growth. Similar results have been found in China, with positive effects seen between the Chinese housing prices and supply. This result shows an extremely positive public expectation of the real estate market, with both sectors growing rapidly. Accordingly, the housing supply sector in Canada and China must be monitored and constrained to dampen the high expectations of households and investors. This, however, must be undertaken with caution, as, in theory, supply negatively affects price level, and this positive relationship between housing price and supply has only been proved in conditions of boom. Further study is required to justify a more detailed relationship.

III. FDI inflow

Each economy exists in the broader context of the global market and considerable trade and interaction among countries. Foreign investment, especially FDI, as studied in this thesis, has offered substantial capital for business activities in the domestic economy. Accordingly, policy regulations with respect to foreign investment sector must ensure that the appropriate investments flow into the domestic market. These investments should be sustainable, provide job opportunities, and support economic growth. An effective policy can, therefore, boost the performance of FDI to contribute maximally to the economy. In addition, when the topic of the real estate sector is discussed together with foreign investment, the relation between the two fields provides further implications to guarantee the sound development of the housing market. In the meantime, investors may also acquire implications when making decisions strategically on the best assets in which to put money. As presented in the second empirical chapter, housing prices in the UK are not explained by FDI inflow, whereas the UK housing construction sector has attracted an enormous amount of FDI inflow. This result indicates that FDI has not yet led to sufficient fluctuations in the housing market, although more foreign capital has flowed into the UK due to construction. Consequently, policymakers should be cautious in monitoring this sector to allow the inflow of sound and valuable investments and avoid speculative funds into the real estate market. In the meantime, the results in Canada suggest that FDI has positively and vitally contributed to both housing prices and construction growth. Accordingly, FDI has indeed provided massive funds to lead to overheated housing prices, housing market development, and high public expectations. Therefore, FDI into Canada should be carefully filtered to exclude speculative investments in the housing sector. Higher requirements, limited rules, or higher tax rates can be attached to FDI into real estate companies. Policymakers can also contribute to solutions to redirect public interest from the housing market to other productive industries. Finally, FDI into China has supported the development of new house constructions and negatively affects the housing price uptrend. Although FDI has not explained the surge in real estate prices, the Chinese real estate market is undergoing a booming period, with extremely high expectations from the public that are partly due to the growth in new building construction. Accordingly, policymakers in China should monitor foreign funds to the construction sector to reduce the expectations of the China real estate market and divert resources into productive industries to transfer knowledge, skills, and job vacancies.

IV. REIT sector

As an emerging stock sector directly linked to the property market, REITs collect investments from the public and transfer them into actual housing investments. If there is a connection between the REIT growth and housing price escalation, policymakers will pay particular attention to the regulation of this financial sector to control for housing price increases. However, even though if REIT may not have sufficient temporal effects on housing price changes, it provides funds for real estate growth. Therefore, regulations on the REIT industry would be prudent to generate the appropriate support for the housing and stock markets. This thesis found that REITs have not contributed to any fluctuations in the UK, Canadian, or Chinese real estate markets, and policymakers in the three countries can therefore establish loose policies and offer opportunities to support the development of REITs without worsening the development of the housing market. However, tight monitoring and supervision is required in the updated relationship between the two markets. In addition, REITs in the UK and Canada are affected by housing price and stock market movements, and, accordingly, regulators must be vigilant of the trend of REIT growth to maintain stability and avoid large fluctuations together with the housing and stock markets. In China, monetary policy plays a crucial role in affecting REIT prices apart from stock market changes. However, the REITs being studied in the case of China are listed and sold in Hong Kong and Singapore. Therefore, the implication for the regulators in these two economies is to monitor Chinese monetary policy changes with the aim of regulating the Chinese property-based REIT asset.

5.7 Limitations and further study

The study of housing markets, foreign investment, and the REIT sector in this thesis was conducted in the context of the UK, Canadian, and Chinese markets as the representative economies. However, this thesis and its findings should be seen in light of several limitations. First, the results gained from this estimation are limited to the situations in these three countries to explore the topic more broadly and might not be sufficient to explain the circumstances in other countries. Because of diverse backgrounds, cultures, and traditions, residents and investors in different areas might hold contrasting views of the same issue (Saunders et al., 2009). Therefore, public reactions and expectations in other countries to market changes, policy adjustments, property purchases, and portfolio investments may be distinct. Nevertheless, it is impractical to examine all the countries in the global market, so this thesis has chosen three suitable economies. At the same time, the circumstances of the real estate sector among the provinces and cities in the three countries vary enormously; these include the different provinces in Canada and China, and London versus other cities in the UK. However, within the current time frame, more specific study is not possible, and this can be followed up by future studies.

In addition, the time series variables selected in each empirical chapter may be another limitation to this study. The co-explosive VAR model in Chapter 2 used a present value model to assume that the fundamental of housing price is measured as the present value of future incomes, represented as the rental price. Further studies can build their evaluation by including a more comprehensive set of variables to represent housing price fundamentals. When Chapter 3 discusses foreign investment, FDI is used to analyse its relationship with the housing market. Further research can examine other sources of foreign investment, such as foreign portfolio investment and FREI. Diverse categories of investment can measure different mechanisms of the effects of foreign investment into housing market. In addition, Chapters 3 and 4 have contained variables such as GDP and interest rate that are suggested by theory and past studies to be significant endogenous variables to the model. However, due to the restricted amount of literature being reviewed and the limited research schedule, there is the possibility that vital factors have been omitted. Excluding one relevant variable from the econometrics analysis would lead to an incorrect result and the misinterpretation of economic activities (Verbeek, 2017). Consequently, other variables, which might also be important in explaining the dependent variable, could be explored and incorporated for further study. Only one of the supply-side variables in real estate market, the completed housing numbers in the UK and China and building permits in Canada, were selected in this model, though other housing supply factors such as land price or construction cost could be evaluated in future studies.

Several limitations to the models used in this study can be addressed in future studies. The models used in the three empirical chapters are only suggestions of suitable methodologies for analysing the research topics of housing bubbles and the relationships among the various markets. However, future work examines other econometric models to gain a more comprehensive view of the research topics. In Chapter 2, when co-explosive VAR and recursive VAR models are applied to test the time-series variables, the co-explosive VAR model is conducted using the full sample size. However, the drawback of this model is that it does not allow for structural breaks in the sample period, while several historical bubble bursts can be found in the three countries from the recursive unit root test. Therefore, further study is needed to report tests of co-explosive VAR models on subsample periods to provide a better understanding of the presence of housing bubbles. Chapters 3 and 4 employ a structural VAR model with restrictions following the Cholesky decomposition. Nevertheless, future studies may conduct an analysis with the more suited restrictions to be applied to the SVAR.

The availability of time-series data, especially in the case of China, may be regarded as a limitation to the scope of this study. When analysing the topic of real estate bubbles in China, the available data for rental price index was limited to the period between 1998 Q1 and 2010 Q4. This limited sample period could not provide evidence of the presence of housing bubbles in China. Additionally, the study of FDI and housing prices also used rental price as a variable. Limited rental price data might, therefore, hinder a trend relationship between FDI and housing prices as well as other variables in China. Moreover, there is no official REIT in the China market, while only seven REITs investing in Chinese properties, listed in the Hong Kong and Singapore stock markets, have been detected. Therefore, the sample period for China when discussing REITs and housing price is restricted to 2005–2018. This obstacle can be vital in finding a meaningful relationship between the Chinese housing market and REIT movements. Correspondingly, future work from government departments and other data collection institutions can focus on collecting up-to-date rental price index data, and more effort can be devoted to developing an understanding of the Chinese REIT sector. At the same time, the method of data collection can also inhibit the gathering of more integrated data to provide a thorough study of the research topic. The secondary data in this thesis are gathered from official websites of data providers and the DataStream database. Future research can work from other databases or resources with more data to be inclusive.

Additionally, several limitations concern the results of the three empirical topics. Although housing bubbles have been identified in the UK real estate market by applying recursive unit root tests in Chapter 2, the SVAR model in Chapter 3 containing housing price and rental prices indicates that these two time-series variables are intimately connected. Housing price in the UK is shown to respond positively to rental price shock. This result might state that real estate prices move firmly with their fundamentals, with no bubbles. Consequently, considering the distinct outcomes using two models from the two chapters, further study is necessary to justify the evidence in the existence of a housing bubble in the UK. Furthermore, the suggested variables in the model, such as housing supply, have not been proved to have a noticeable effect on the housing prices in some economies. Therefore, other determinants of housing price movements such as land cost can be discussed in future studies. Moreover, future research may clarify the issue of supply elasticity to find a more precise relationship between real estate supply and price movement. Moreover, the interest rate in the UK has been shown to be affected negatively by REIT prices, which is inconsistent with one previous study from Furlanetto (2008), indicating a minor reaction. Further research may be conducted to assess this topic. Overall, the empirical results reported in this thesis should be interpreted cautiously, subject to the limitations enumerated here in the variables and methods selected, the sample size, and the results.

Finally, although lies outside of the research presented in this thesis, there is a range of other factors that is important for the analysis of housing price issues. For instance, banking system stability is stated to link closely to property market in one country. Historical evidence of a tight connection between housing bubble burst and banking system crisis has been presented in many countries such as the United States and Japan (Herring and Wachter, 1999). This effect transmits through the mortgage sector, as excessive high real estate price may result in moral hazard and adverse selection problem when banks provide their loans (Koetter and Poghosyan, 2010). This will further put more pressure on real estate market and even the whole economy (Honohan and Klingebiel, 2003). Moreover, for big economies such as China and Canada, demographical diversities among cities is worth investigating, especially when previous studies such as … indicated regional differences of foreign investment inflow. Similar idea can also be proposed to London and other areas in the UK, considering the significant distinctions of economic activities in London. Moreover, conspicuous consumption on housing stock is an interesting extension to the existing analysis on the explanation to housing price boom in many economies. Although this may act as the assumption for the common factor in countries with high property prices, the possibility of divergence across countries can still be examined in the future study. All the above topics are recognised as avenues for future research.

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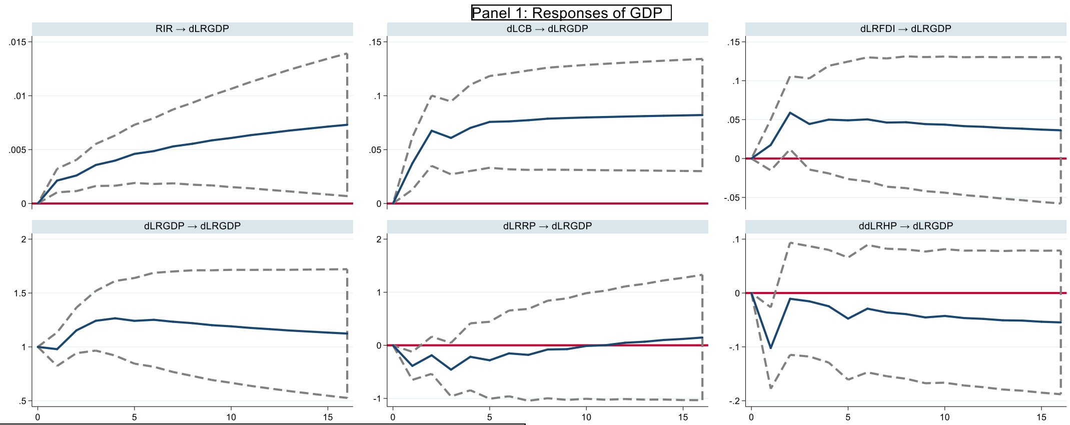
Appendix A

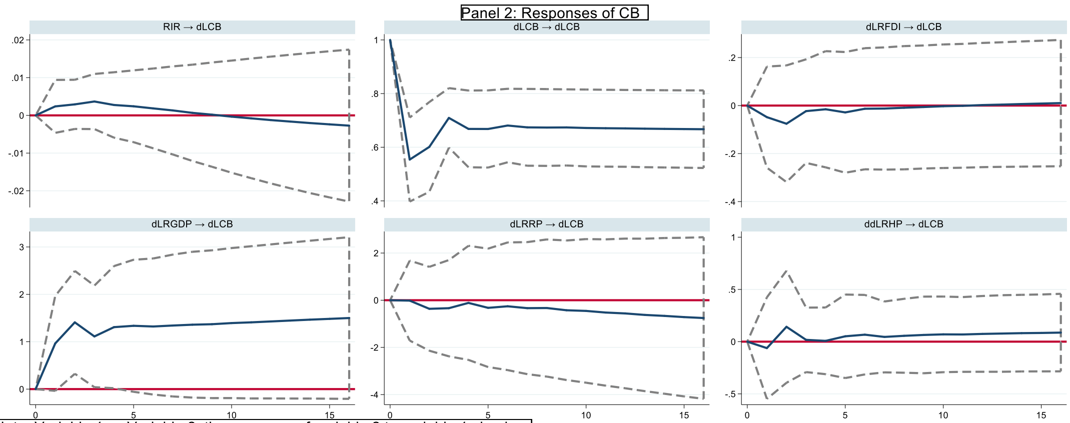
This appendix presents the Impulse Response Function results under the Chapter 3 Robustness check.

Panel 1: Responses of GDP



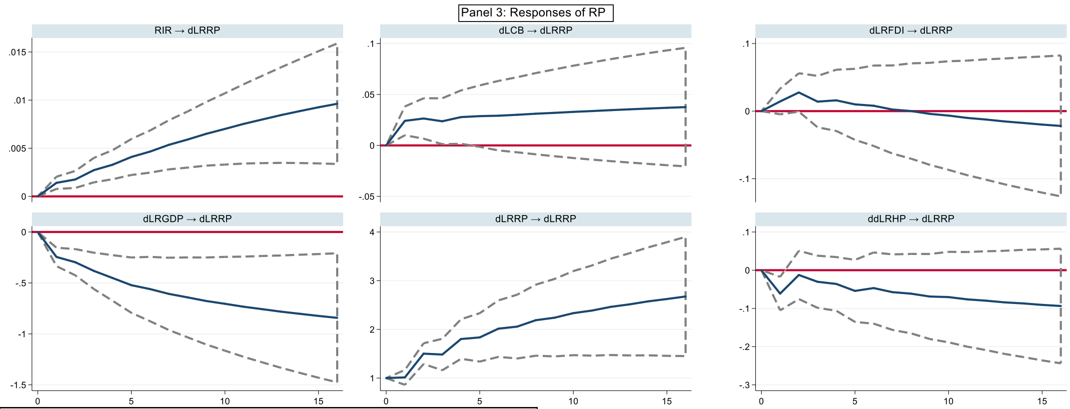
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 2: Responses of CB



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 3: Responses of RP



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

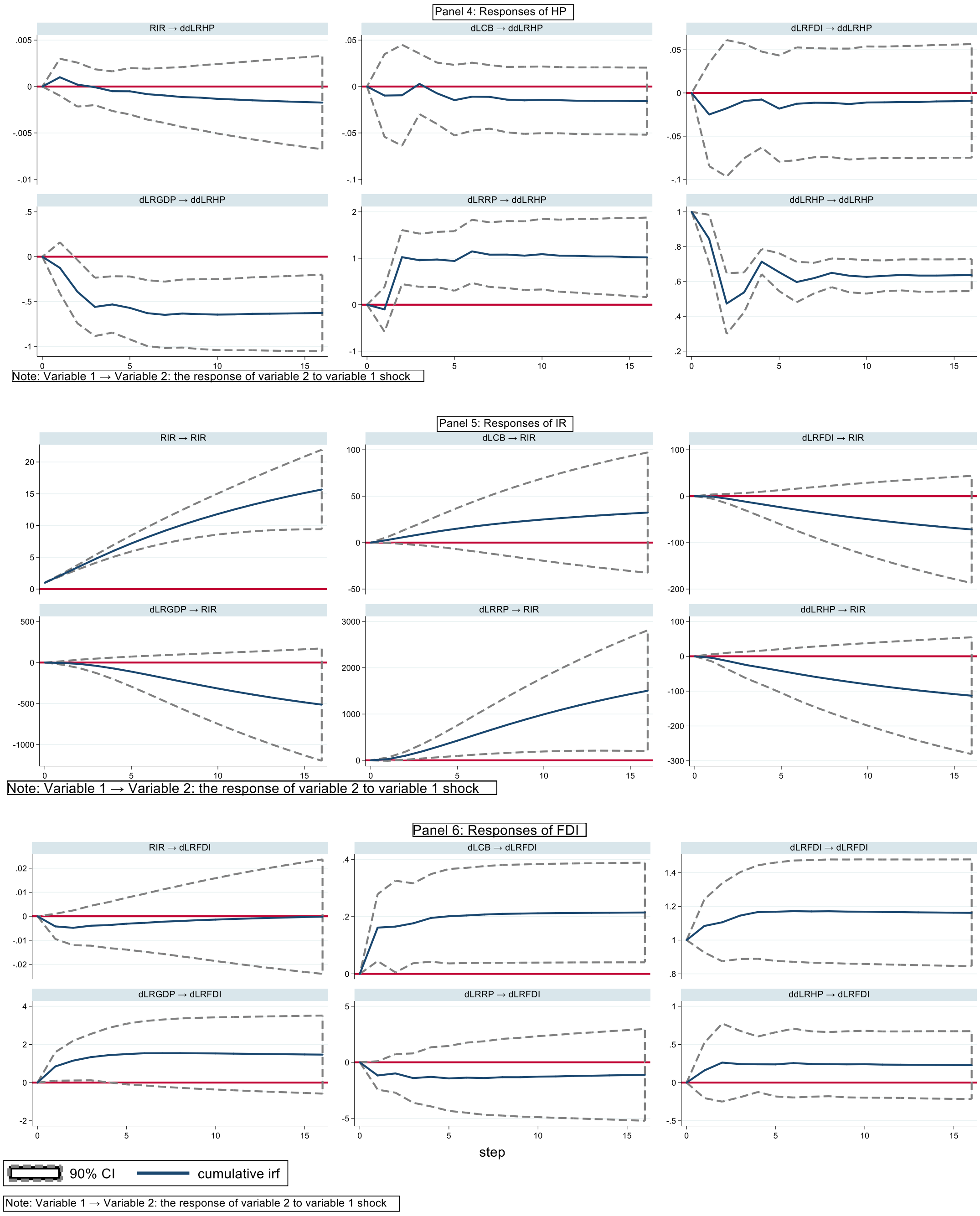


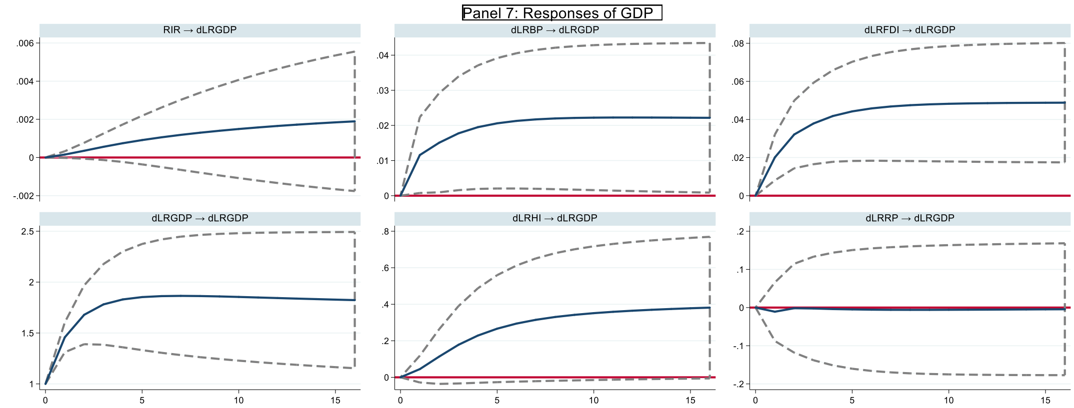
Figure A1. *Impulse Response Function for Chapter 3 the UK Robustness check*

Notes:

- This model applies accumulated responses of variables to shocks.
- CB--building completed to represent housing supply; HP-- housing price; IR--interest rate; RP--rental price.
- The model includes 2 lags, and Cholesky decomposition has been applied. The variables are in the following order: GDP, CB, RP, HP, IR, FDI.

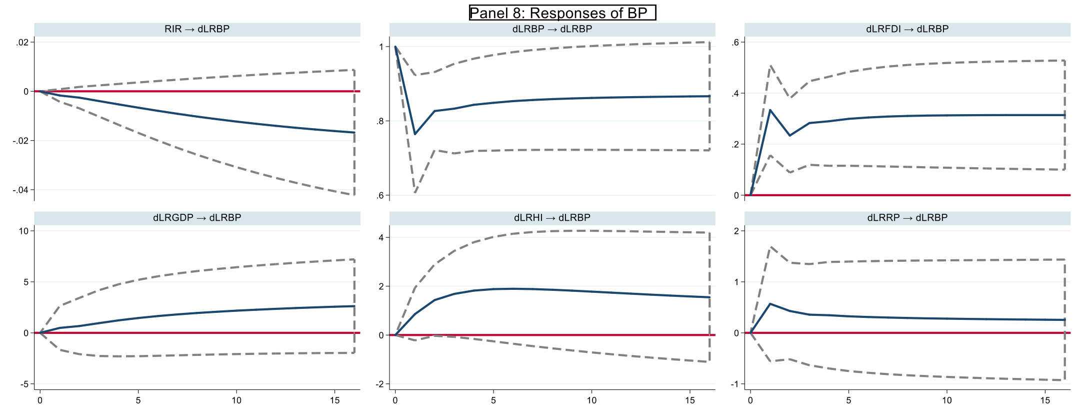
- The result in the robust test is highly similar with the original test. CB and GDP respond to the shocks in each other positively. This positive response in CB happens in the first year. GDP also reacts positively to a shock in IR. There is also a negative response from GDP in the first two quarters to shocks in RP and HP. RP reacts positively to IR shock while negatively to GDP shock. In addition, there is a positive response from RP to CB in the first year and negative reaction from RP to HP in the first two quarters. HP reacts positively to RP shock but negatively to GDP shock from the 3rd quarter. IR reacts positively to a shock in RP. FDI responds positively to CB shock and positively to GDP shock in the first three quarters.

Panel 7: Responses of GDP



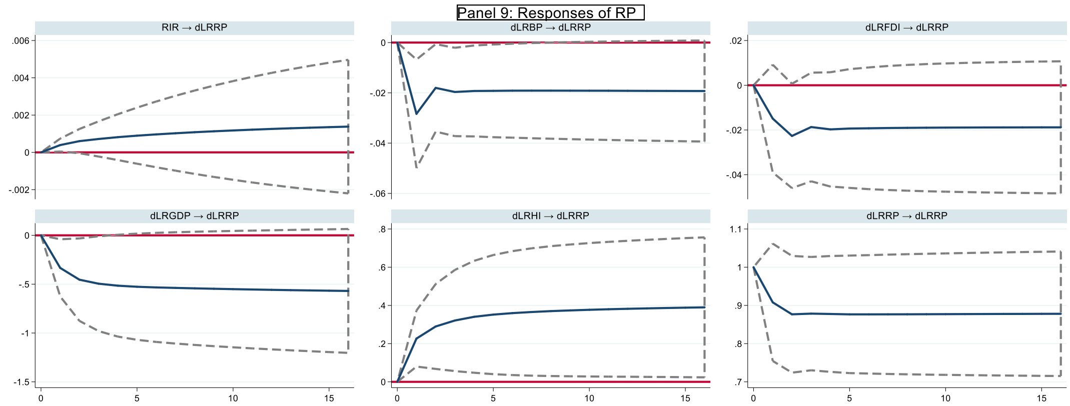
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 8: Responses of BP



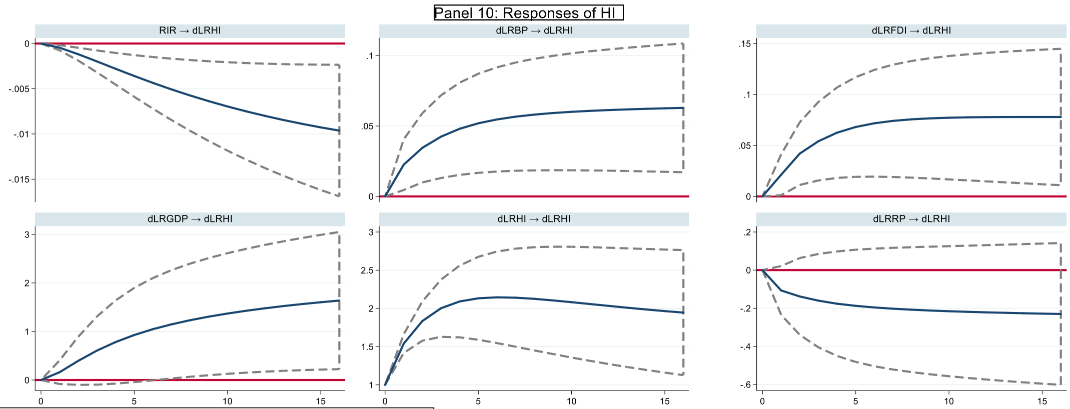
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 9: Responses of RP



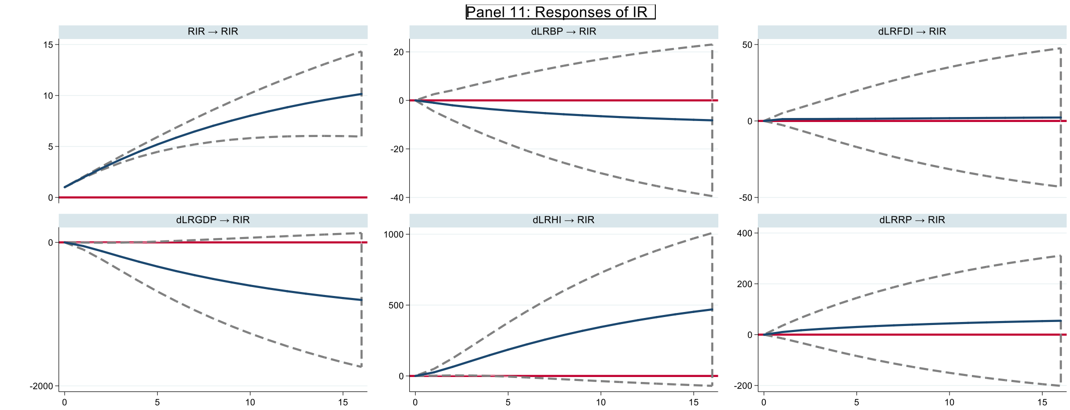
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 10: Responses of HI



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 11: Responses of IR



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

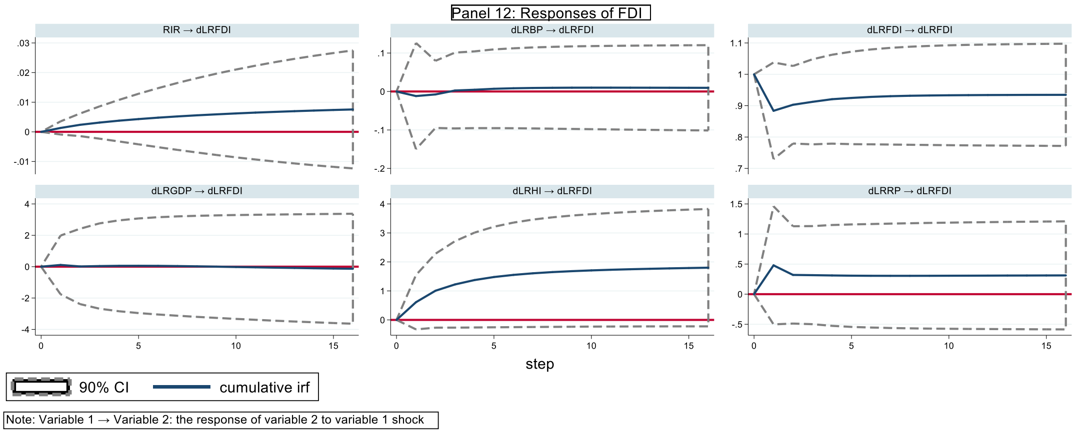
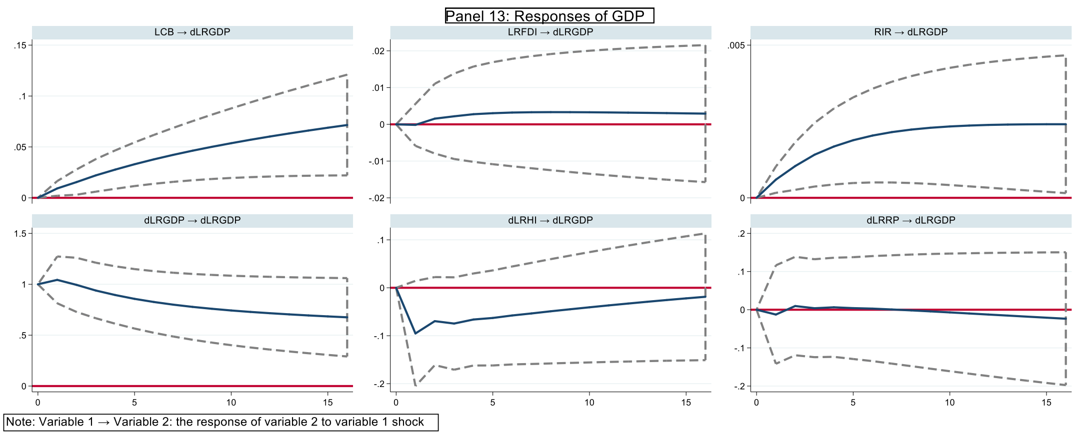


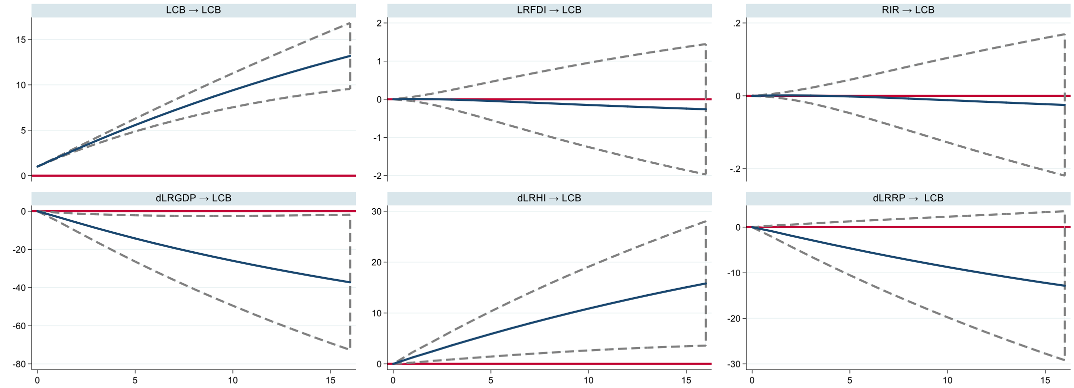
***Figure A2**. Impulse Response Function for Chapter 3 Canada Robustness check*

Note:

- This model applies accumulated responses of variables to shocks.
- BP—building permit to represent housing supply; HI-- housing price index; IR-- interest rate; RP--rental price.
- The model includes 1 lag, and Cholesky decomposition has been applied. The variables are in the following order: GDP, BP, RP, HI, IR, FDI.
- The result in the robust test is highly similar with the original test. GDP reacts positively to shocks in FDI and BP. BP responds positively to a shock in FDI. RP reacts negatively to shocks in BP in the first six quarters and GDP in the first three quarters, while positively to HI shock. HI respond negatively to IR shock, while positively to BP and FDI shock, and positively to GDP shock from the 7th quarter.

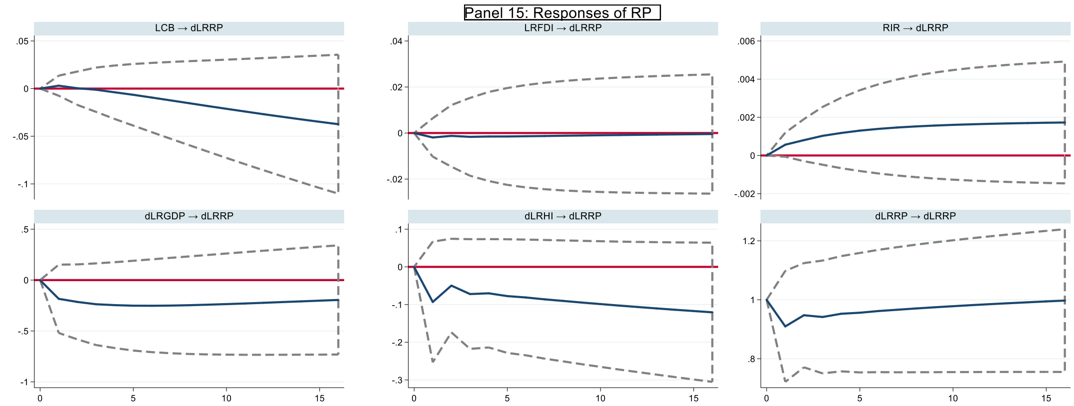


Panel 14: Responses of CB



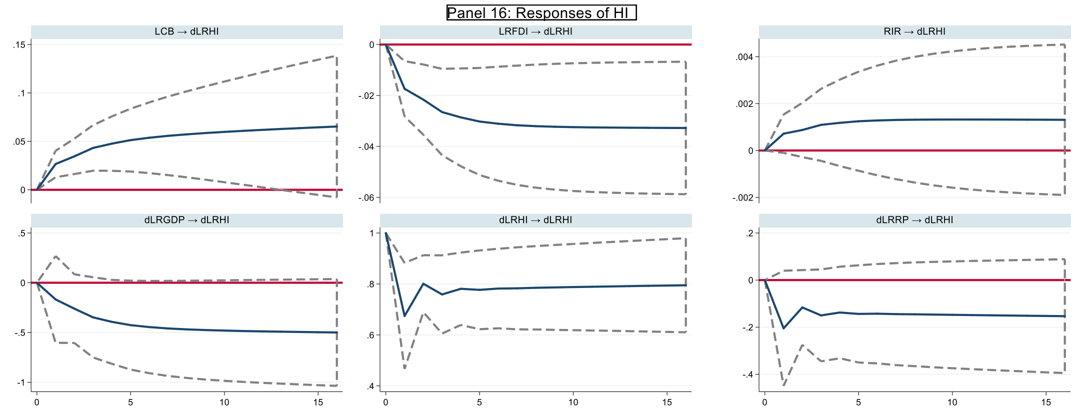
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 15: Responses of RP



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 16: Responses of HI



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

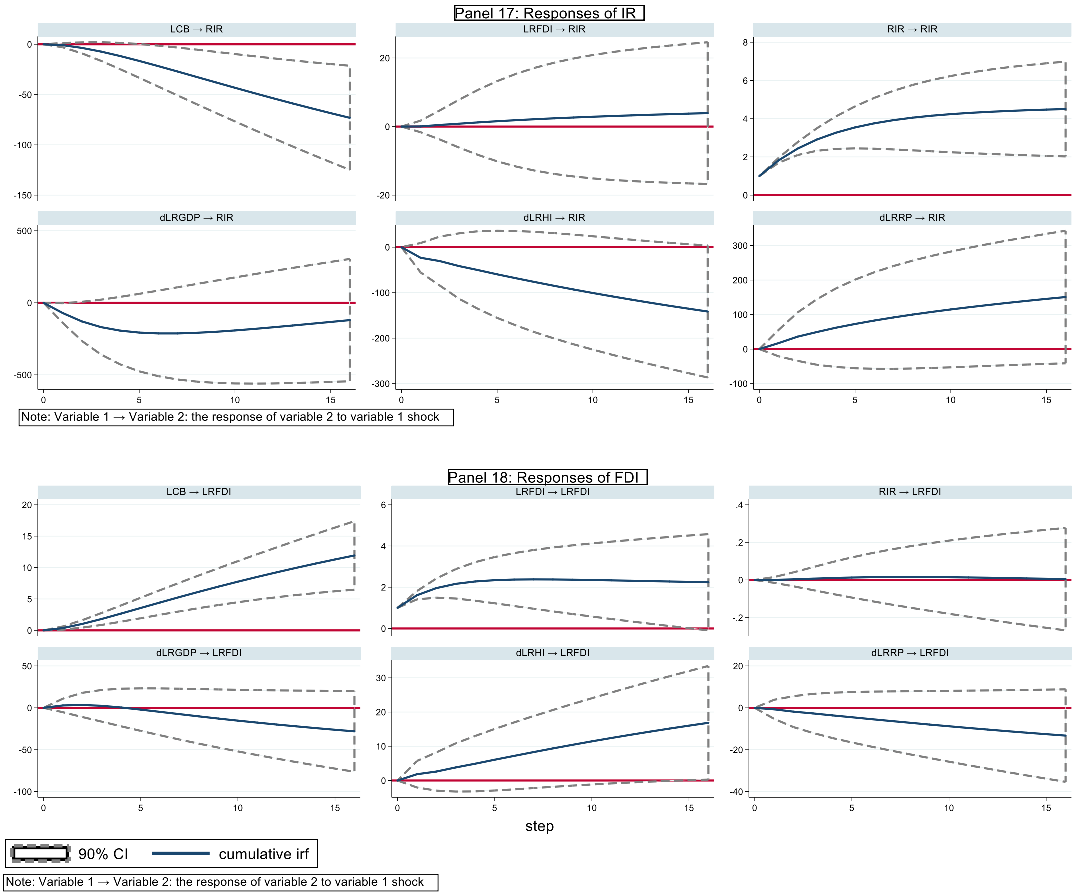


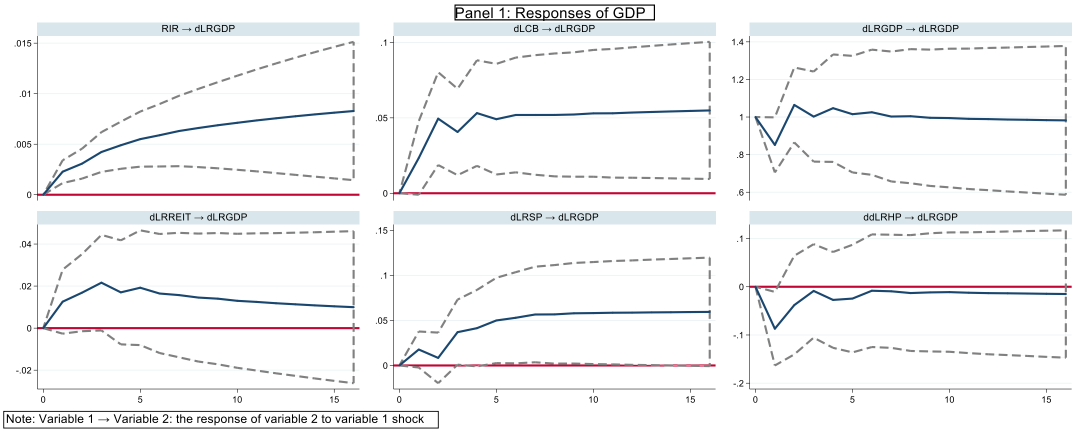
Figure A3. *Impulse Response Function for Chapter 3 China Robustness check*

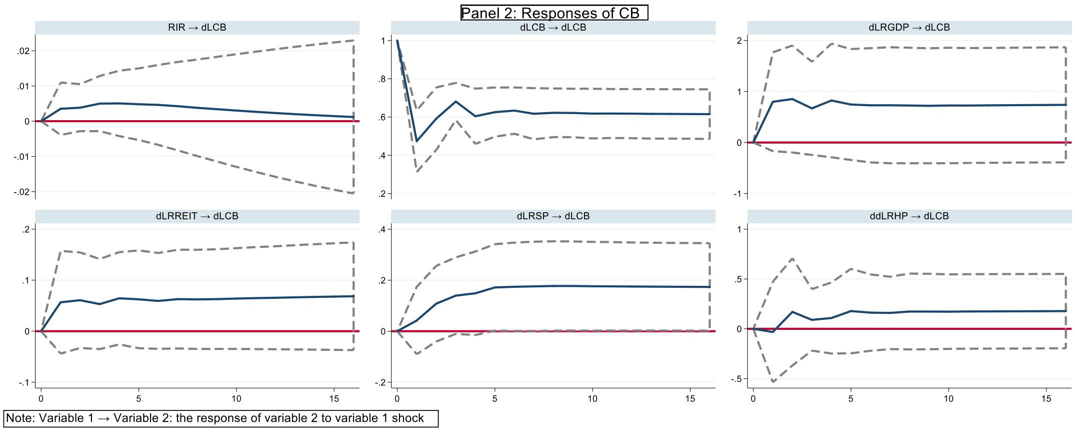
Note:

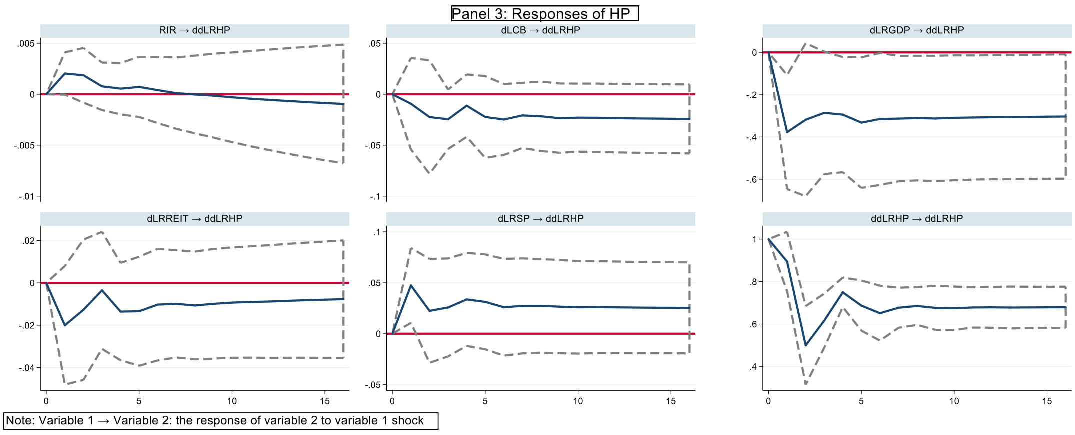
- This model applies accumulated responses of variables to shocks.
- CB--building completed to represent housing supply; HI-- housing price index; IR--interest rate; RP--rental price.
- The model includes 1 lag, and Cholesky decomposition has been applied. The variables are in the following order: GDP, CB, RP, HI, IR, FDI.
- The result in the robust test is highly similar with the original test. GDP reacts positively to shocks in CB and IR. BP responds positively to a shock in HI and negatively to a GDP shock. HI responds negatively to FDI shock, while positively to CB shock. IR responds negatively to a shock in CB from the 5th quarter. FDI reacts positively to CB shock.

Appendix B

This appendix presents the Impulse Response Function results under the Chapter 4 Robustness check.







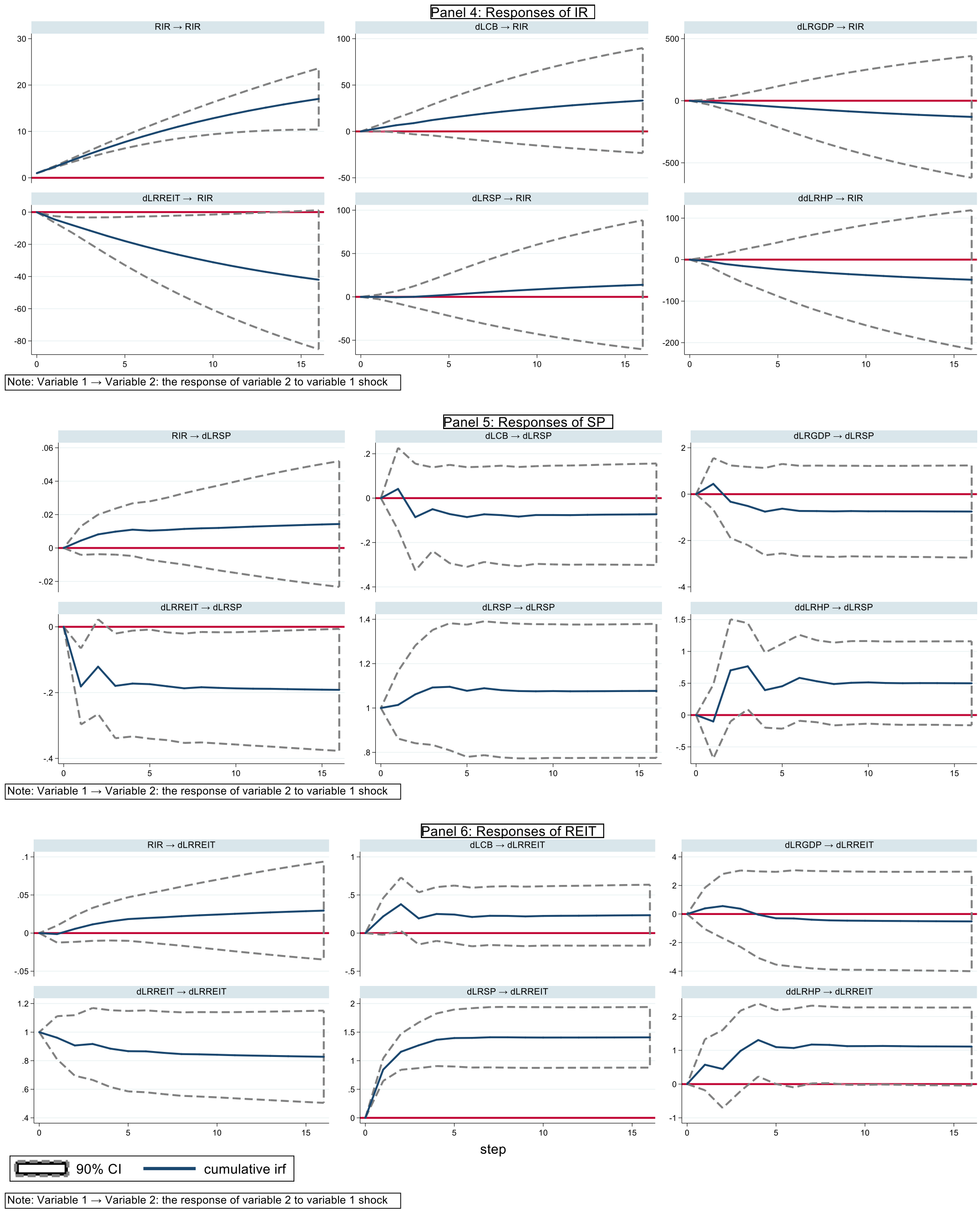


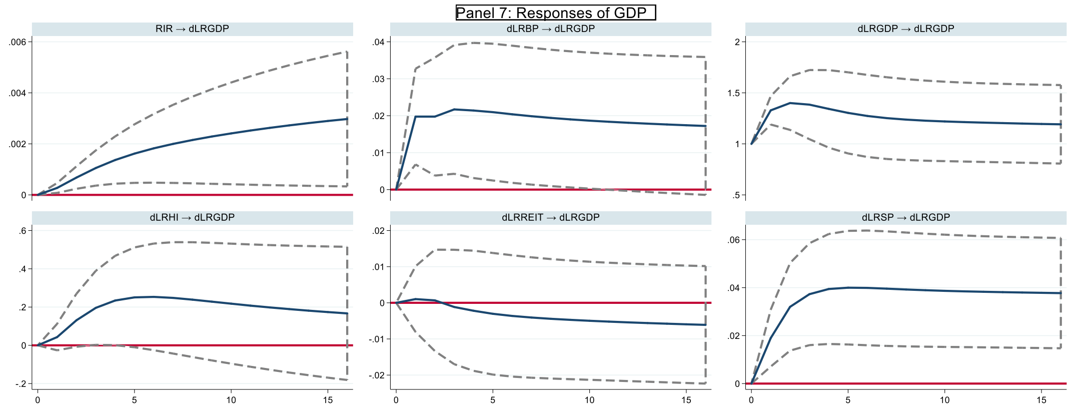
Figure B1*. Impulse Response Function for Chapter 4 the UK Robustness check*

Notes:

- This model applies accumulated responses of variables to shocks.
- CB--building completed to represent housing supply; HP-- housing price; IR--interest rate; SP--stock price.

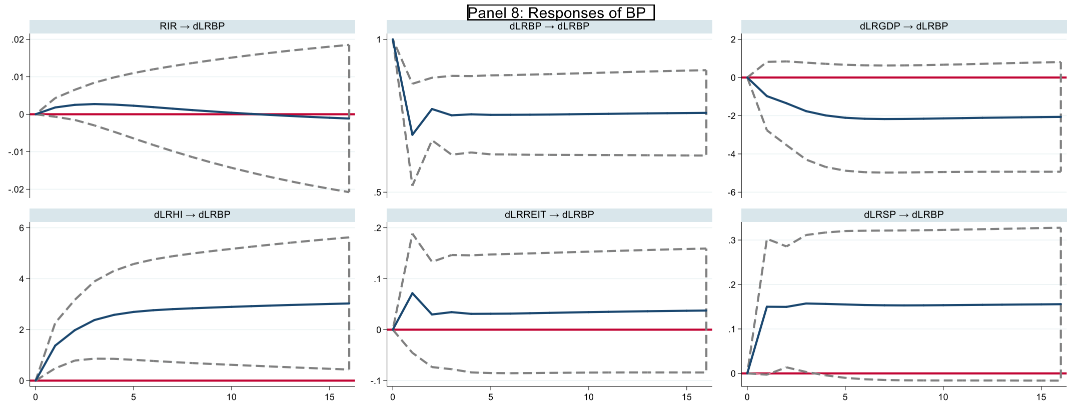
- The model includes 2 lags, and Cholesky decomposition has been applied. The variables are in the following order: GDP, CB, HP, IR, SP and REIT.
- From the IRF result, GDP reacts positively to a shock in CB and IR for the whole time period, and SP from the 3rd quarter. GDP reacts negatively in the 1st quarter to a shock in HP. CB responds positively to a shock in SP from the fifth quarter. HP reacts negatively to a shock in GDP and positively in the 1st quarter to a shock in SP. IR responds negatively to a REIT shock. SP responds negatively to REIT shock, and positively in the 3rd quarter to an HP shock. REITs reacts positively to a shock in SP, positively between the 4th and 5th quarters to an HP shock, and positively in the 3rd quarter to a CB shock.

Panel 7: Responses of GDP



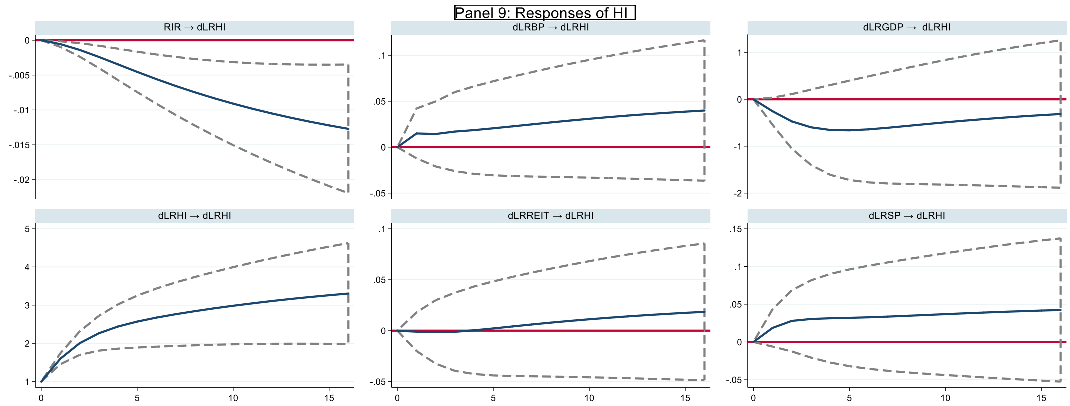
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 8: Responses of BP



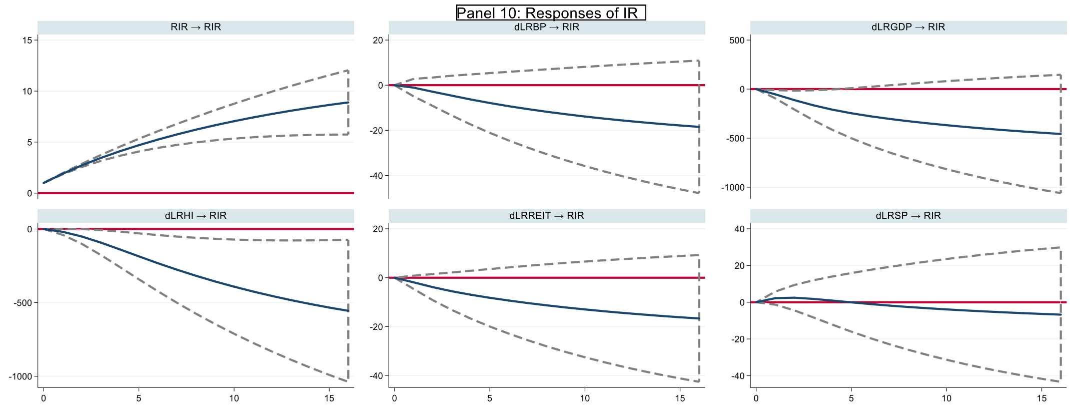
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 9: Responses of HI



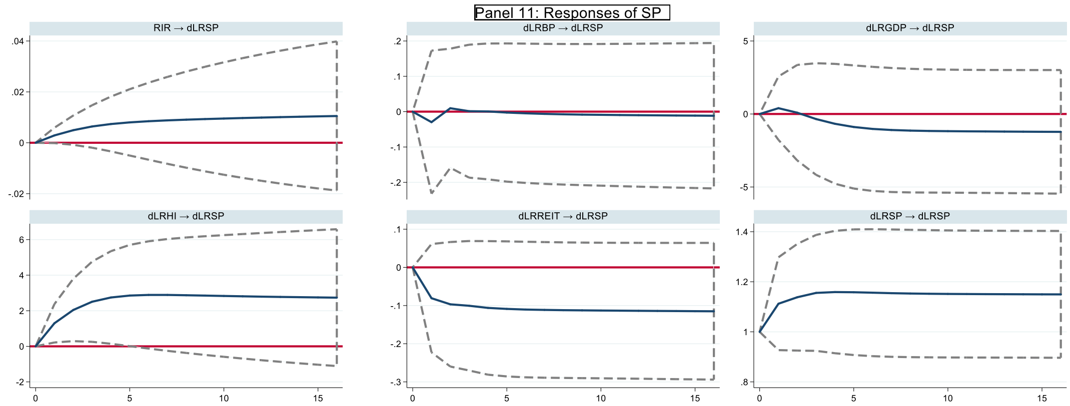
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 10: Responses of IR



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 11: Responses of SP



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

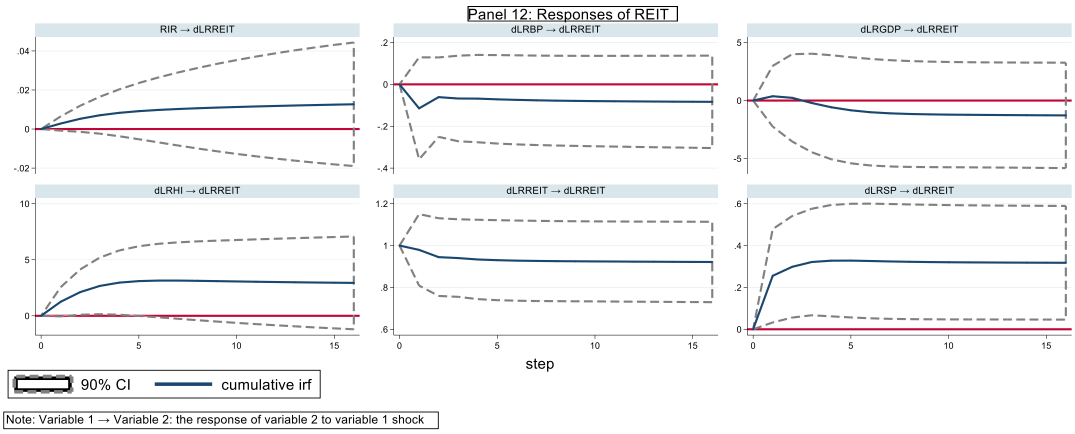
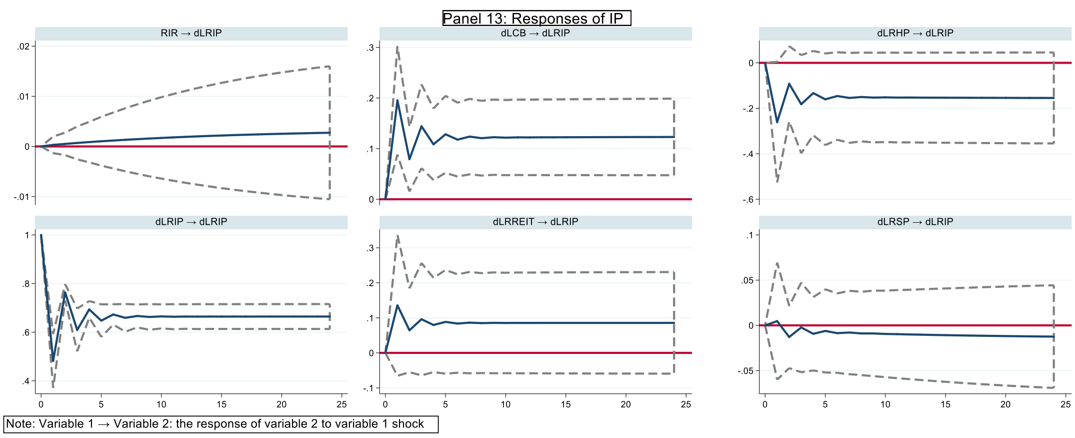


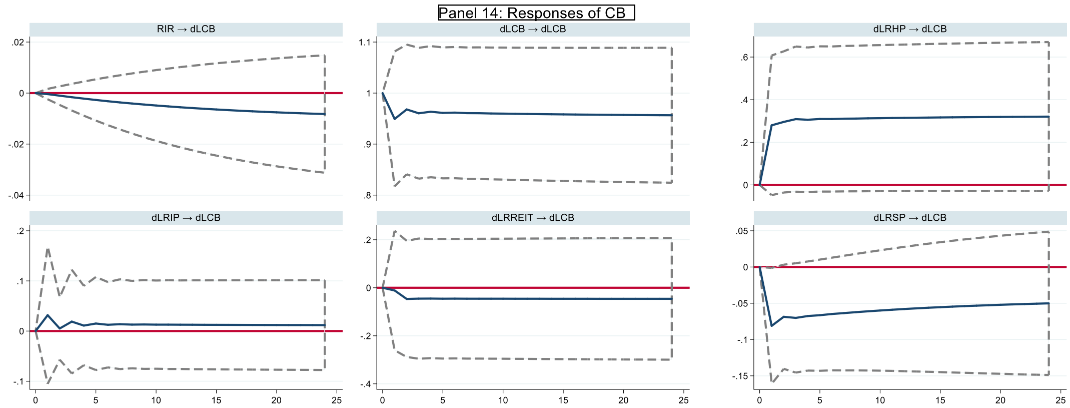
Figure B2. *Impulse Response Function for Chapter 4 Canada Robustness check*

Notes:

- This model applies accumulated responses of variables to shocks.
- BP--building permits to represent housing supply; HI-- housing price index; IR-- interest rate; SP--stock price.
- The model includes 1 lag, and Cholesky decomposition has been applied. The variables are in the following order: GDP, BP, HI, IR, SP and REIT.
- From the IRF result, GDP reacts positively to a shock in IR, BP and SP, and positively from 3rd to 5th quarters to a shock in HI. BP responds positively to a shock in HI, and positively in the first 3 quarters to a shock in SP. HI and IR react negatively to a shock in each other from the first quarter and over subsequent time points. IR reacts negatively to a shock in GDP in the first 3 quarters. SP reacts positively to a shock in HI in the first 5 quarters. REIT responds positively to a shock in SP and positively in the first 5 quarters to a shock in HI.

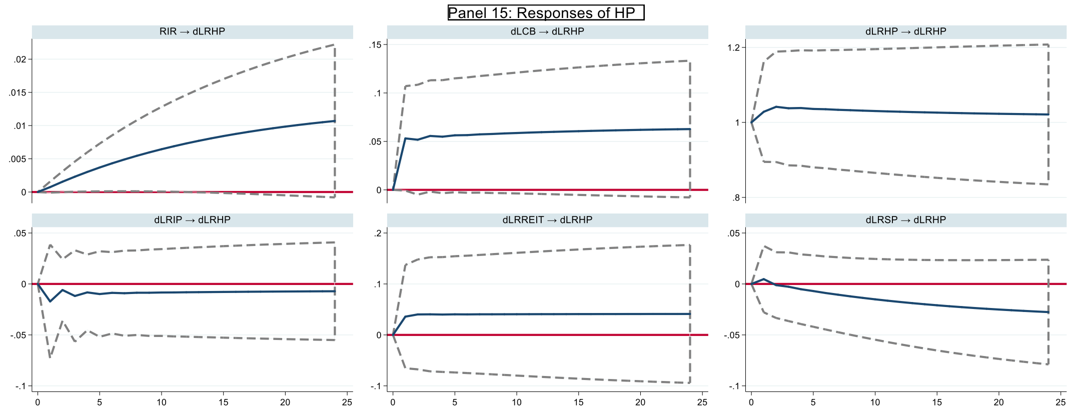


Panel 14: Responses of CB



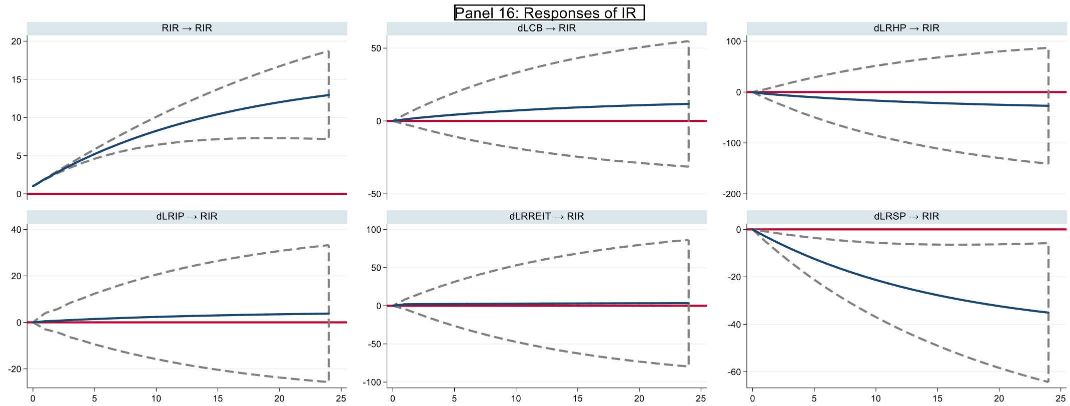
Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 15: Responses of HP



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

Panel 16: Responses of IR



Note: Variable 1 → Variable 2: the response of variable 2 to variable 1 shock

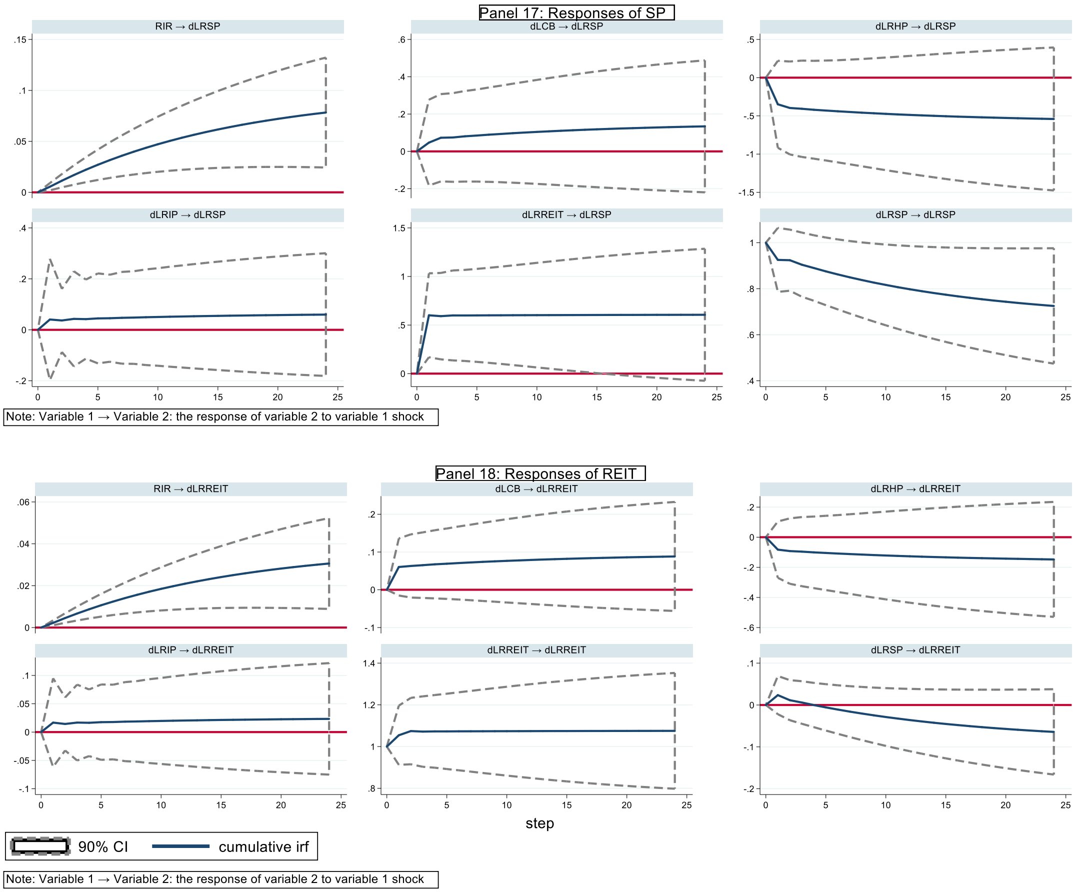


***Figure B3**. Impulse Response Function for Chapter 4 China Robustness check*

Notes:

- This model applies accumulated responses of variables to shocks.
- CB--building completed to represent housing supply; IP—industrial production; HP--housing price; IR--interest rate; SP--stock price.
- The model includes 1 lag, and Cholesky decomposition has been applied. The variables are in the following order: IP, CB, HP, IR, SP and REIT.
- From the IRF result, IP reacts positively to a shock in CB. HP responds positively to a shock in IR in the first four years. IR reacts negatively to a shock in SP, while SP and REIT respond positively to a shock in IR. SP also reacts positively to REIT in the first four years.

Appendix C

FORM UPR16

Research Ethics Review Checklist

<u>Please include this completed form as an appendix to your thesis (see the Research Degrees Operational Handbook for more information</u>

UNIVERSITY of PORTSMOUTH

Postgraduate Research Student (PGRS) Information				**Student ID:**	753504
PGRS Name:	Xi Zhang				
Department:	Economics and Finance	**First Supervisor:**	Dr. Ioannis Chatziantoniou		
Start Date: (or progression date for Prof Doc students)		08/09/2014			
Study Mode and Route:	Part-time ☐ Full-time ☒	MPhil ☐ PhD ☒	MD ☐ Professional Doctorate ☐		

Title of Thesis:	Essays on the housing market, foreign investment, and the stock market: Evidence in the UK, Canada, and China
Thesis Word Count: (excluding ancillary data)	65797

If you are unsure about any of the following, please contact the local representative on your Faculty Ethics Committee for advice. Please note that it is your responsibility to follow the University's Ethics Policy and any relevant University, academic or professional guidelines in the conduct of your study

Although the Ethics Committee may have given your study a favourable opinion, the final responsibility for the ethical conduct of this work lies with the researcher(s).

UKRIO Finished Research Checklist:
(If you would like to know more about the checklist, please see your Faculty or Departmental Ethics Committee rep or see the online version of the full checklist at: http://www.ukrio.org/what-we-do/code-of-practice-for-research/)

a) Have all of your research and findings been reported accurately, honestly and within a reasonable time frame?	YES ☒ NO ☐
b) Have all contributions to knowledge been acknowledged?	YES ☒ NO ☐
c) Have you complied with all agreements relating to intellectual property, publication and authorship?	YES ☒ NO ☐
d) Has your research data been retained in a secure and accessible form and will it remain so for the required duration?	YES ☒ NO ☐
e) Does your research comply with all legal, ethical, and contractual requirements?	YES ☒ NO ☐

Candidate Statement:	
I have considered the ethical dimensions of the above named research project, and have successfully obtained the necessary ethical approval(s)	
Ethical review number(s) from Faculty Ethics Committee (or from NRES/SCREC):	One
If you have *not* submitted your work for ethical review, and/or you have answered 'No' to one or more of questions a) to e), please explain below why this is so:	
Signed *(PGRS)*:	**Date:** 02/12/2019