Government intervention in land markets and its impacts on residential land supply, new housing supply and housing price: evidence from major Chinese markets

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Publications

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List of abbreviations

CBD	Central Business District
C-GARCH	Component-generalized Autoregressive Conditional Heteroscedasticity
CH	Critical Habitat
CPI	Consumer Price Index
FAR	Floor Area Ratio
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
GNP	Gross National Product
LPAs	Local Planning Authorities
LURs	Land Use Rights
MLE	Maximum Likelihood Estimation
MSAs	Metropolitan Statistical Areas
MSOAs	Medium-level Super Output Areas
OLS	Ordinary Least Squares
PBC	People's Bank of China
PDL	Previously developed land
PRC	People's Republic of China
SOEs	State-owned Enterprises
SSE	Explained Sum of Squares
SST	Total Sum of Squares
UK	United Kingdom
UN	United Nations
US	United States

VAR	Vector Autoregressive
VEC	Vector Error Correction

Abstract

Government intervention in land markets can have profound impacts on the operation of housing markets. Although many empirical studies have examined the impact that government intervention in land markets has on housing price, only a limited number of studies have examined the impact that government intervention in land markets has on housing supply. In addition, the vast majority of existing studies were conducted in developed countries, and relatively little attention has been devoted to developing countries. Having identifying the research gaps, this study investigates the process leading to stronger government intervention in the land markets in China, and examines the impacts that government intervention in the land markets has on residential land supply, new housing supply and housing price using data for 16 major Chinese cities for the period 2001-2011.

The process of the 2004 reform which led to stronger government intervention in the land markets in China was examined by reviewing the literature and government policy documents. The change in residential land supply before and after the 2004 reform was also investigated. The impacts that the decline in land supply has on new housing supply and housing supply elasticities were examined by developing and estimating econometric models of new housing supply, and the impact that the decline in land supply has on housing price was examined by developing and estimating the model of housing price.

The findings of this study suggest that there was a decline in residential land supply in the 16 major Chinese cities after the 2004 reform. Land supply is found to be positively related to new housing supply, and thus the decline in land supply after the

2004 reform has put downward pressure on new housing supply. It is also found that there was a decline in housing supply elasticities after the government strengthened the intervention in the land markets. Land supply is found to be negatively related to housing price, and thus the decline in land supply after the 2004 reform has put upward pressure on housing price. The major policy implications are that promoting the redevelopment of existing urban land and adjusting the allocation of new urban land among different uses can help ensure an adequate supply of residential land in regions where there is a strong demand for housing.

Chapter 1: Introduction

1.1 Research background

Government intervention in land markets exists in countries with different land use systems. The intervention generally takes one of two forms (Evans 1999). The first involves various types of land use regulations (zoning, urban growth boundaries, green belts, etc.) that impose control over the uses to which land can be put. The second involves direct government control over land supply where a government acts as a market participant and directly supplies land to land users. Government intervention in land markets can have profound impacts on both the demand and supply side of housing market. On the demand side, because government intervention in land markets can help preserve environmental amenities, enhance accessibilities and promote more efficient provision of public service and infrastructure, it can increase the demand for housing through an amenity effect (Cheshire & Sheppard 2002; Dawkins & Nelson 2002; Ihlanfeldt 2007). On the supply side, government intervention in land markets can have a depressing effect on new housing supply by limiting the supply of land for housing development (Cheshire & Sheppard 2004, 2005; Dawkins & Nelson 2002; Hui & Ho 2003; Ihlanfeldt & Mayock 2014; Ihlanfeldt 2007; Kim 1993; Monk & Whitehead 1999; Saiz 2010). Because governments around the world are faced with the task of ensuring an adequate supply of housing to meet demand, improving housing affordability and maintaining stability in the property market (Chen, Hao & Stephens 2010; Chiu 2007; Kim & Cho 2010; Ooi, Sirmans & Turnbull 2011; Rosen & Ross 2000), examining the impacts that government intervention in land markets has on the operation of housing markets is an area that deserves research attention.

Many empirical studies have examined the impacts that government intervention in land markets has on the operation of housing markets. However, those studies mainly focused on the impact that government intervention in land markets has on housing price,[1] and only a limited number of studies have examined the impact that government intervention in land markets has on housing supply (Bramley 1993; Glaeser & Ward 2009; Green, Malpezzi & Mayo 2005; Ihlanfeldt & Mayock 2014; Mayer & Somerville 2000a; Quigley & Raphael 2005; Saiz 2010; Zabel & Paterson 2006). Many scholars suggested that inadequate attention to the impact that government intervention in land markets has on housing supply could be problematic, since researchers could not determine whether the price effect of government intervention in land markets emanated from supply-side or demand-side changes within the housing markets (Dawkins & Nelson 2002; Ihlanfeldt 2007; Mayer & Somerville 2000a). Another limitation of the literature on the impacts of government invention in land markets is that the vast majority of existing studies were conducted in developed countries, and relatively little attention has been devoted to developing countries. Since many fast-growing developing countries are under great demand pressure (as a result of high rates of population and income growth), the unresponsiveness of housing supply to the increase in housing demand can easily lead to a significant housing price appreciation and deteriorating housing affordability in those countries. Thus, it is reasonable to argue that the situation in developing countries deserves special attention. In addition, because many developing countries are undergoing economic transition, institutional changes in land markets may occur at

1. According to the literature review conducted by Fischel (1990) and Quigley & Rosenthal (2005), there are numerous empirical studies on the impact that government intervention in land markets has on housing price.

a higher frequency in developing countries than in mature market economies. China's real estate markets provide a good opportunity to examine the impacts that government intervention in land markets has on residential land supply, new housing supply and housing price in fast-growing emerging economies.[2] The market-oriented urban housing sector was established in China in 1998. In the post-1998 period, major institutional changes in urban residential land markets occurred in 2004. Since 2004, municipal governments have acquired complete control over urban residential land supply, and the regulatory constraints on rural-urban land conversion have become more stringent. There was a decline in residential land supply in many major cities after the 2004 reform which led to stronger government intervention in the land markets, and it is expected that the decline in land supply has a depressing effect on new housing supply and plays a role in pushing up housing prices.

Many researchers suggested that relatively to the demand side of the housing market, housing supply is understudied (Ball, Meen & Nygaard 2010; Blackley 1999; Dipasquale 1999; Gitelman & Otto 2012; Green, Malpezzi & Mayo 2005; Malpezzi & Maclennan 2001; Meen & Nygaard 2011; Pryce 1999; Rosenthal 1999). While there is an extensive literature on the determinants of housing demand and household behaviour in the housing market, relatively fewer studies have been conducted to explore the determinants of new housing supply and estimate the responsiveness of housing supply to the change in housing price (Ball, Meen & Nygaard 2010; Dipasquale 1999; Green, Malpezzi & Mayo 2005; Rosenthal 1999). Examining the impacts that government intervention in land markets has on residential land supply

2. China's gross domestic product (GDP) increased significantly from 11,027 billion RMB in 2001 to 48,412 billion RMB in 2011, with the compound annual growth rate being 15.9%.

and new housing supply helps enhance the understanding of the supply side of the housing market.

There has been a remarkable housing price boom in China since the establishment of the market-oriented housing system, with the average housing price increasing from 2017 RMB/ square meter in 2001 to 4993 RMB/square meter in 2011 (National Bureau of Statistics of China). Since rapidly rising housing price seriously eroded housing affordability and potential price misalignment posed substantial risks to financial and economic stability (Ahuja et al. 2010a; Wu, Gyourko & Deng 2012b), the housing price boom in China has attracted considerable attention from government officials, academic researchers and the general public in recent years. Although many studies have examined the determinants of housing price in China (Ahuja et al. 2010a; Chen, Guo & Wu 2011b; Li & Zhao 2013; Li & Chand 2013; Shen & Liu 2004; Wang, Yang & Liu 2011; Xu & Chen 2012; Zhang, Hua & Zhao 2012), relatively little attention has been paid to the role that government intervention in the land markets plays in determining housing price.

1.2 Definitions

This section specifies some key definitions in this research.

Land market The term "land market" can have different meanings under different land tenure systems. While land ownership can be traded on the land market under the freehold tenure system, it is the rights to use a parcel of land for a certain time period (land use rights) that is traded on the land market under the leasehold tenure system (Chiu 2007; Hui, Leung & Yu 2014; Hui & Soo 2002; Lai 1998; Xie, Parsa & Redding 2002).

Residential land supply In existing empirical research, residential land supply generally refers to land with planning permissions and sold to developers for housing development in a given period (Ho & Ganesan 1998; Hui, Leung & Yu 2014; Hui & Ho 2003; Peng & Wheaton 1994; Tse 1998).

New housing supply In existing empirical research, new housing supply generally refers to new housing units on which construction has been started in a given period (Ball, Meen & Nygaard 2010; Blackley 1999; Dipasquale & Wheaton 1994; Mayer & Somerville 2000b; McLaughlin 2011, 2012; Pryce 1999; Topel & Rosen 1988).

1.3 Aim and objectives

This study investigates the process leading to stronger government intervention in the land markets in China, and examines the impacts that government intervention in the land markets has on residential land supply, new housing supply and housing price using data for 16 major Chinese cities for the period 2001-2011. Although this study focuses on the real estate markets in major Chinese cities, the research findings and policy implications are relevant to other emerging market economies which are undergoing both rapid economic growth and significant institutional changes.

The specific research objectives are as follows:

- Objective 1: to investigate the process leading to stronger government intervention in the land markets in China;
- Objective 2: to examine the change in residential land supply before and after the 2004 reform;

● Objective 3: to develop and estimate econometric models of new housing supply to examine the impacts that the decline in land supply has on new housing supply and housing supply elasticity;

● Objective 4: to develop and estimate econometric model of housing price to examine the impact that the decline in land supply has on housing price;

● Objective 5: to discuss the implications of the empirical findings for land use and housing policies.

1.4 Scope of the research

Since China is a geographically large country, social and economic conditions can vary significantly across different cities. The empirical analysis in this research focuses on the real estate markets in 16 major Chinese cities, rather than examining the real estate markets in all the Chinese cities. The 16 major cities are Shanghai, Beijing, Chengdu, Tianjin, Guangzhou, Shenzhen, Wuhan, Qingdao, Hangzhou, Xian, Nanjing, Ningbo, Hefei, Fuzhou, Jinan and Nanchang. There are four reasons for choosing these cities as sample cities. Firstly, these cities all have high administrative status. Secondly, these cities are among the most populous cities in China. Thirdly, these cities are among the most important cities in terms of economic activities. Fourthly, the real estate markets in these cities are among the most important markets in terms of the volume of housing transactions (the administrative status of the 16 cities, and the population, economic conditions and the volume of housing transactions in the 16 cities are analysed in detail in Chapter 5).

The empirical analysis focuses on the period 2001-2011, which is a period characterized by a significant growth in population and income and a remarkable

housing price boom (the change in population and income in the 16 cities during the sample period is analysed in detail in Chapter 5). During the sample period, average housing price in China increased from 2017 RMB/square meter in 2001 to 4993 RMB/square meter in 2011 (China Statistical Yearbook series (2002-2012)).

The empirical analysis uses the city-level panel data[3] to examine the impacts that government intervention in land markets has on residential land supply, new housing supply and housing price. Housing submarkets within specific cities are not examined in this research.

1.5 Methodology

In order to achieve the research objectives, the following methodology is used (Figure 1-1 provides a graphic illustration of the methodology used in this research).

Firstly, a theoretical framework for the analysis of the impacts that government intervention in land markets has on residential land supply, new housing supply and housing price is established based on the existing theoretical literature. Within the framework there is an analysis of government intervention in land markets and its impact on residential land supply, an analysis of the factors affecting new housing

3. A panel data set is one that follows a given sample of units over time, and thus has both a cross-sectional and a time-series dimension (Hsiao 2003; Wooldridge 2012). The panel data set exhibits several major advantages over conventional cross-sectional or time-series data set (Hsiao 2003; Wooldridge 2002). An overview of panel data models and their estimation is provided in Chapter 6. Many recent studies have estimated the models of housing markets using city-level panel data or province-level panel data (Chen, Guo & Wu 2011b; Coulson, Liu & Villupuram 2013; Gonzalez & Ortega 2013; Grimes & Aitken 2010; Harter-Dreiman 2004; Hwang & Quigley 2006b; Li & Chand 2013; Mayer & Somerville 2000a; Wang, Yang & Liu 2011; Wen & Goodman 2013).

supply, an analysis of housing supply elasticity and its importance for housing price dynamics, and an analysis of the factors affecting the demand for housing.

Secondly, a review of the empirical literature on residential land supply, new housing supply and housing price is conducted. The first and second parts of the literature review focus on existing studies on the impact that government intervention in land markets has on residential land supply and the impacts of land supply on new housing supply and housing price. In order to facilitate the development of models of new housing supply in the empirical analysis, an overview of the empirical studies on modelling new housing supply and estimating housing supply elasticity is provide in the third part of the literature review. The fourth part of the literature review focuses on the empirical research on the demand-side determinants of housing price to facilitate the development of model of housing price in the empirical analysis.

Thirdly, the process leading to stronger government intervention in the land markets in China (including the establishment of complete municipal government control over urban residential land supply and the imposition of more stringent regulatory constraints on rural-urban land conversion) - here referred to as the 2004 reform - is examined by reviewing the literature and government policy documents. The data on residential land supply are collected, and the change in residential land supply before and after the 2004 reform is examined.

Fourthly, two research hypotheses about the impacts that the decline in land supply has on new housing supply and housing supply elasticity are established based on the theoretical framework. The first hypothesis is that the decline in land supply after the government strengthened the intervention in the land markets has put downward

pressure on new housing supply, and the second hypothesis is that there was a decline in housing supply elasticity after the government strengthened the intervention in the land markets. The hypotheses are tested by developing and estimating econometric models of new housing supply. The models of new housing supply are developed based on the theoretical analysis of the factors affecting new housing supply and the review of existing literature on modelling new housing supply. The data used (mainly including the floor area of housing starts, average housing price, construction cost, loan interest rates, and the site area of land sold to developers for housing development) are collected from various Statistical Yearbook series (mainly including China Real Estate Statistics Yearbook series and China Statistical Yearbook series). The models of new housing supply are estimated using the fixed-effects regression approach. A series of statistical techniques (mainly including Hausman test, R-squared statistics and robust *t* statistics) are used in the regression analysis.

Fifthly, the research hypothesis about the impact that the decline in land supply has on housing price (i.e., the decline in land supply after the government strengthened the intervention in the land markets has put upward pressure on housing price) is established based on the theoretical analysis. The hypothesis is then tested by developing and estimating an econometric model of housing price. The model of housing price is developed based on the theoretical analysis of the factors affecting new housing supply and the demand for housing. The data used (mainly including average housing price, the number of permanent residents, per capita disposable income, construction cost, loan interest rates, and the site area of land sold to developers for housing development) are collected from various Statistical Yearbook series (mainly including China Real Estate Statistics Yearbook series, China Statistical

Yearbook series, and Statistical Yearbook series/ Statistical Communique on the Economic and Social Development series of each city). The model of housing price is estimated using the generalized method of moments (GMM) approach. A series of statistical techniques (mainly including the Arellano-Bond test for serial correlation, R-squared statistics and robust *t* statistics) are used in the regression analysis.

Sixthly, in order to support the findings obtained from the econometric analysis, the operation of the real estate markets in two case-study cities (Beijing and Ningbo) is examined in more detail. The demand side of the housing markets is investigated by examining the change in population, GDP, per capita disposable income, and local fiscal revenue during the sample period. The supply side of the housing markets is investigated by examining the change in land supply and new housing supply. The change in average real housing price in the two cities is also examined.

Finally, a discussion of the empirical findings is presented and the implications of the empirical findings for land use and housing policies are analysed.

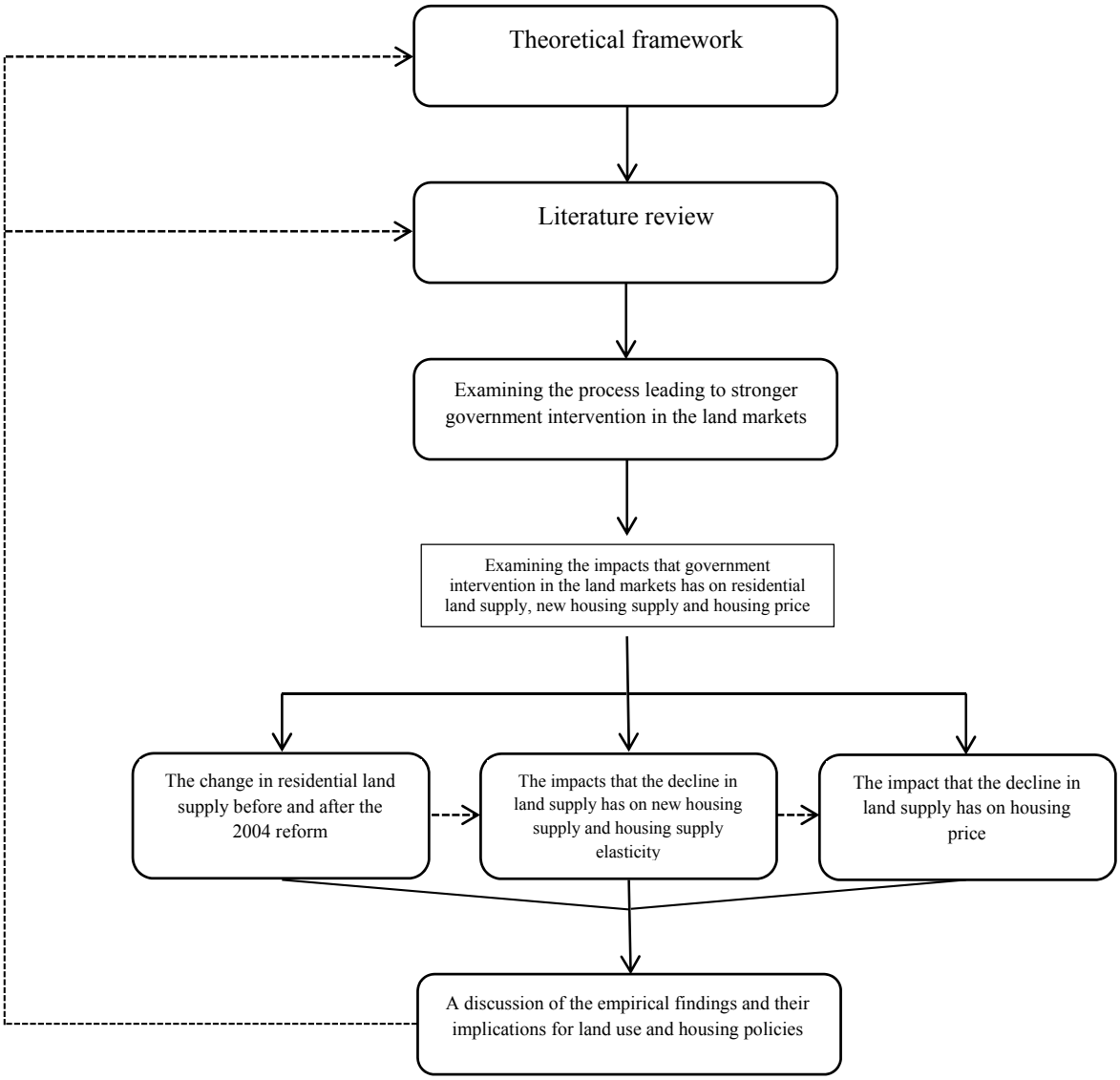

Figure 1-1 The methodology used in this research

Source: Author

1.6 Research contributions

This research contributes to the literature on government intervention in land markets and the determinants of new housing supply and housing price. It also provides insight into the operation of the real estate markets in China. The specific research contributions are discussed in this section.

Firstly, this research contributes to a better understanding of the impacts that government intervention in land markets has on the operation of housing markets. As discussed in section 1.1, many empirical studies have examined the impacts that government invention in land markets has on the operation of housing markets in different countries. However, those studies mainly focused on the impact that government intervention in land markets has on housing price, and only a limited number of studies have examined the impact that government intervention in land markets has on housing supply. Having identified the research gap, this study examines the supply-side effects of government intervention in land markets using data for the 16 major Chinese cities for the period 2001-2011.

Secondly, a theoretical framework for the analysis of the impacts that government intervention in land markets has on residential land supply, new housing supply and housing price is established in this research. This theoretical framework can be used to analyze the impacts of government intervention in land markets in countries with different land use systems.

Thirdly, this research facilitates international comparisons of land use and housing policies. Existing studies on government intervention in land markets and its impacts have been conducted mainly in developed countries, and less attention has been paid to developing countries which can have institutional settings different from those in developed countries. Having identified the research gap, this research analyses the land supply system in China (which is a fast-growing developing country) and examines how the government intervenes in the land markets in China. This research also compares government intervention in the land markets in China with that in other countries/regions and discusses the effects that different institutional features can have

on the operation of real estate markets.

Fourthly, the findings of this study have implications for modelling new housing supply and housing price. Land supply variable or land-related variables were not included in the models of new housing supply and housing price in many existing studies (this issue is discussed in detail in section 9.2.2 and section 9.2.3). However, the findings of this research suggest that land supply can play an important role in determining new housing supply and housing price. Thus, land supply variable or land-related variables should be included in the models of new housing supply and housing price when the relevant data are available.

The fifth contribution is that this study examines some aspects of China's real estate markets which were previously understudied. Firstly, although the establishment of complete municipal government control over urban residential land supply is widely recognized as a fundamental institutional change (Du, Ma & An 2011; Li & Chand 2013; Peng & Thibodeau 2012), relatively few studies have examined the process leading to the institutional change. This research investigates the process leading to the establishment of complete municipal government control over urban residential land supply and analyses the consequent change in the structure of urban residential land markets. Secondly, although housing supply elasticities are of critical importance in explaining housing price movements, relatively few studies have estimated the housing supply elasticities in China. This research provides an estimate of the average housing supply elasticity across the 16 major Chinese cities by estimating the models of new housing supply. Thirdly, existing studies on the determinants of housing price in China mainly focused on the demand-side factors affecting housing price. This research contributes to the literature by providing evidence that land supply also

played an important role in determining housing price in China.

1.7 Structure of the thesis

The thesis is structured as follows.

Chapter 2 establishes the theoretical framework for this research. The main focus is given to two types of government intervention in land markets (regulatory constraints on rural-urban land conversion and direct government control over land supply) and their impacts on residential land supply, and the impact of land supply on new housing supply and housing supply elasticity.

Chapter 3 reviews the empirical literature on residential land supply, new housing supply and housing price. The literature review lays the foundation for the regression analysis in the empirical work.

Chapter 4 reviews the history of China's housing reform and urban land reform during the period 1970s-1990s, and provides some basic information about China's land use system.

Chapter 5 investigates the process leading to stronger government intervention in the land markets in China, and examines the change in residential land supply in the 16 major Chinese cities before and after the 2004 reform.

Chapter 6 examines the impacts that the decline in land supply has on new housing supply and housing supply elasticity, and chapter 7 explores the impact that the decline in land supply has on housing price. These two chapters have a similar

structure. They begin with the development of research hypotheses, and then explain model development, data collection and regression procedures. The empirical results and analysis is presented at the end of each chapter.

Chapter 8 investigates the operation of the real estate markets in Beijing and Ningbo to support the findings obtained from the regression analysis.

Chapter 9 presents a discussion of the empirical findings and analyses the implications of the empirical findings for land use and housing policies. Conclusions follow in Chapter 10.

Chapter 2: Theoretical framework

2.1 Introduction

A theoretical framework for the analysis of the impacts that government intervention in land markets has on residential land supply, new housing supply and housing price is established in this chapter. The supply of land, which is the starting point of the housing development process, is restricted by government intervention in land markets. This chapter begins with a theoretical analysis of government intervention in land markets and its impact on residential land supply. Government intervention in land markets can exert an influence on new housing supply by limiting the supply of land. In addition to land supply, new housing supply is also affected by other factors, such as housing price and the cost of housing production. A theoretical analysis of the factors affecting new housing supply is presented in section 2.2. The price elasticity of supply of housing is a measure of the responsiveness of housing supply to the change in housing price, and plays an important role in explaining the evolution of housing price. Land availability is an important determinant of housing supply elasticity. A theoretical analysis of housing supply elasticity is provided in section 2.3. The price of housing is determined by the interaction between housing supply and demand. In order to get a complete picture of the factors affecting housing price, one also needs to look into the demand side of the housing market. Thus, a theoretical analysis of the factors affecting the demand for housing is presented in the last section of this chapter.

2.2 Government intervention in land markets and its impact on residential land supply

Land use patterns and its determinants are an important theme in urban economic studies (Dipasquale & Wheaton 1996; Fujita 1989; O'sullivan 2000). According to urban economic theory, market forces play an important role in determining land use patterns. In the absence of government intervention, a particular parcel of land will be allocated to the land user who is willing to pay the highest rent for the land (Dipasquale & Wheaton 1996; O'sullivan 2000). For example, because manufacturers are willing to pay a high rent for land parcels in close proximity to a motorway when freight costs account for a significant proportion of the total cost to the manufacturer, it is common to see the land near motorways occupied by manufacturers. Similarly, since firms in the office sector rely on speedy collection, processing, and distribution of information and are willing to pay for accessibility, the land in the CBD is usually occupied by office firms. However, since there is government intervention in land markets in almost all countries, the actual land use patterns are shaped by both market forces and government policies (Dipasquale & Wheaton 1996; O'sullivan 2000; Vermeulen 2008). Government intervention in land markets can reduce the supply of land for specific uses (including residential use) below the level which would have occurred in an unrestricted market (Dawkins & Nelson 2002; Kim 1993; Rosen & Katz 1981).

The analysis presented in section 1.1 suggests that government intervention in land markets generally takes two forms: land use regulations and direct government control over land supply. The first part of this section focuses on an important type of land use regulations - regulatory constraints on rural-urban land conversion and its impact on

residential land supply. The second part of this section deals with direct government control over land supply and its impact on residential land supply.

2.2.1 Regulatory constraints on rural-urban land conversion and its impact on residential land supply

Governments around the world use land use regulations to manage the development of land and deal with land use externalities. Land use externalities occur when a certain land use activity imposes costs or benefits on those not directly involved in the activity (Cheshire & Vermeulen 2009; Vermeulen 2008). In unregulated land markets with significant land use externalities, land prices do not reflect the full costs or benefits imposed by certain land use activities, and land users do not take into account the external costs or benefits when making land-use decisions. Thus, unregulated land markets are inefficient in the sense that the well-being in a society can be increased by internalising the externalities (Cheshire & Vermeulen 2009; Vermeulen 2008). In the case of agricultural land use, agricultural land can provide a number of environmental benefits to society, such as flood control, carbon sequestration, protecting open space, ground water and wildlife habitat[4] (Duke 2008; Irwin, Nickerson & Libby 2003; Kline & Wichelns 1996; Tan et al. 2009; Wasilewski & Krukowski 2004). However, the environmental values are usually not reflected in agricultural land price in unregulated land markets, and land users tend not to fully take into account the environmental loss incurred by urban development when making decisions about converting agricultural land to urban uses. Thus, the level of rural-urban land conversion in an unregulated market is generally higher than the socially optimal level (Cheshire & Vermeulen

4. Protecting agricultural land is also important for long-term food security (Tan et al. 2009; Yang & Li 2000).

2009; Vermeulen 2008). In order to protect agricultural land and prevent urban sprawl, governments usually impose regulatory constraints on rural-urban land conversion. In developed countries, regulatory constraints on rural-urban land conversion usually come in the form of designating urban growth boundaries or green belts. The urban growth boundary refers to a regulatory line drawn around an urban area beyond which development would not be permitted, and green belts refer to broad swath of designated undeveloped, wild, or agricultural land surrounding or neighbouring urban areas (Dawkins & Nelson 2002; Gennaio, Hersperger & Burgi 2009; Millward 2006). The restriction on rural-urban land conversion can lead to a reduction in the amount of land available for housing development (Dawkins & Nelson 2002; Kim 1993; Rosen & Katz 1981).

In order to illustrate how the regulatory constraints on rural-urban land conversion can be used to enhance social welfare and what is the impact that the restriction on rural-urban land conversion has on residential land supply, a simple economic framework for the residential land use in a monocentric city is considered. The city has an urban core and is surrounded by agricultural land. People living in the city derive utility from the consumption of residential land, from enjoying the environmental amenities generated by agricultural land and from the consumption of all other goods and services. New residential construction only occurs in urban fringe in this city. Thus, residential development will lead to a reduction in the amount of agricultural land. Figure 2-1 provides a graphic illustration of the residential land use in the monocentric city. This figure features the amount of residential land (S) at the horizontal axis, and the price of residential land (P) at the vertical axis. The two supply curves MPC and MSC indicate marginal private cost and marginal social cost, respectively. The

downward sloping line D indicates the demand for residential land. The private cost of producing a unit of residential land consists of the price of agricultural land and the conversion costs. The marginal social cost adds to the private cost the environmental loss (which is the burden imposed on society but is not reflected in market price). Without government regulations, households will choose to buy residential land up to point a (at which the supply curve MPC and the demand curve D intersect), with the privately optimal level of residential land use being OS^P. Apparently, the free-market equilibrium is not socially optimal. At point a, a marginal reduction in the consumption of residential land by one unit can make society better off (it can reduce the social cost by an amount equal to OP', but it will only reduce the social benefits by OP^P). The socially optimal equilibrium is indicated by point b (at which the supply curve MSC and the demand curve D intersect), and the socially optimal level of residential land use (OS^S) is smaller than the free-market equilibrium quantity (OS^P). In order to yield the socially optimal outcome, the government usually imposes regulatory constraints on rural-urban land conversion. The restriction on rural-urban land conversion will reduce residential land supply below the level which would have occurred in the un-intervened market.

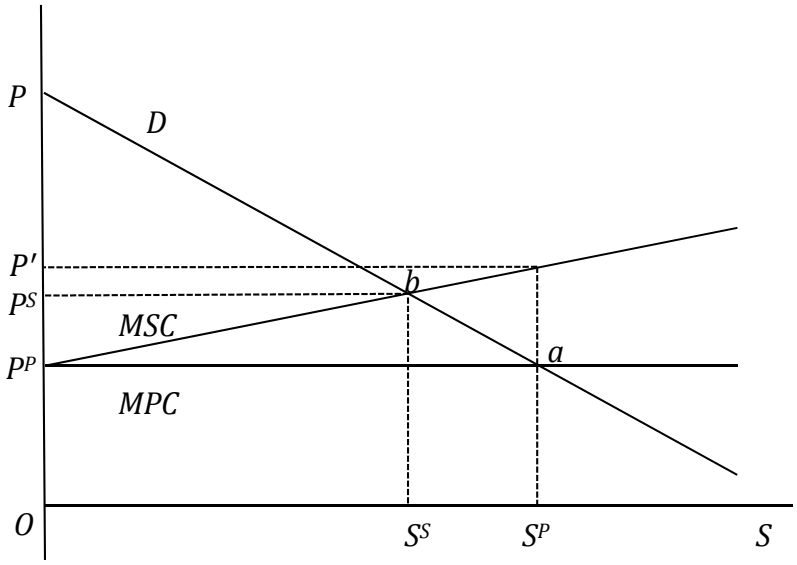

Figure 2-1 Residential land use in a monocentric city

Source: Author

2.2.2 Direct government control over land supply and its impact on residential land supply

Although government intervention in land markets usually come in the form of land use regulations, it can also come in the form of direct government control over land supply. Direct government control over land supply (also referred to as government supply of land) means that governments buy up agricultural land or existing urban land well ahead of anticipated development or redevelopment, conduct preliminary land development (mainly including removing buildings and ancillary structures, site clearance, levelling land and providing water, electricity, road, telecommunications, gas, etc.), and then sell land to land users (Barlow 1993; Evans 2004; Evans 1999; Needham 1992; Ooi, Sirmans & Turnbull 2011). When government obtain direct control over land supply, it can impose direct control over urban land development (Evans 2004; Evans 1999; Tian & Ma 2009; Xu, Yeh & Wu 2009).

Previous studies have suggested that direct government control over land supply can lead to a scarcity of residential land in the presence of high demand for housing (Chiu 2007; Evans 2004; Hannah, Kim & Mills 1993; Kim 1993; Kim & Cho 2010). The reasons are threefold. First, direct government control can make residential land supply less responsive to demand change (Chiu 2007; Hannah, Kim & Mills 1993; Kim 1993; Kim & Cho 2010). When government obtains direct control over residential land supply, it usually determines the quantity of land supply based on the projected demand for housing (Chiu 2007). However, because the demand for housing is determined by various demographic and socioeconomic factors such as the number of households, population structure, income, interest rates, etc., it is very difficult to accurately forecast it (Cheshire & Sheppard 2005; Chiu 2007; Vermeulen 2008). When government fails to accurately forecast the demand for housing, residential land supply will be insufficient to meet the increased demand. Secondly, if the government derives a considerable proportion of its revenue from land sales, it may operate a restrictive land supply policy in order to keep land prices high and get more revenue from land sales (Bertaud 2012; Evans 2004; Hui, Leung & Yu 2014; Hui, Lam & Ho 2006; Ooi, Sirmans & Turnbull 2011). The third reason is related to the ability of government to supply land. As mentioned earlier, when the government becomes a land supplier, it will buy up agricultural land or existing urban land and conduct preliminary land development before selling land to new land users. Because acquiring land and conducting preliminary land development can be costly and time-consuming, the government may have a limited ability to ensure an adequate supply of residential land (Barlow 1993).

2.3 The factors affecting new housing supply

During the last three decades, there has been a growing body of literature devoted to examining the determinants of new housing supply and modelling new housing supply. As suggested by Ball, Meen & Nygaard (2010) and Meen & Nygaard (2011), there is a consensus about the factors affecting new housing supply. These factors mainly include housing price (Ball, Meen & Nygaard 2010; Gitelman & Otto 2012; Grimes & Aitken 2010; Hwang & Quigley 2006b; McLaughlin 2011, 2012), the cost of housing production (Blackley 1999; Dipasquale & Wheaton 1994; Mayer & Somerville 2000b; Poterba 1984; Pryce 1999; Topel & Rosen 1988), land supply (Bramley 1993; Dipasquale & Wheaton 1994; Hui, Leung & Yu 2014; Lai & Wang 1999; Pryce 1999), and regulatory constraints (Green, Malpezzi & Mayo 2005; Mayer & Somerville 2000a; Mayo & Sheppard 1996; Mayo & Sheppard 2001).

2.3.1 Housing price and the cost of housing production

Since developers' decision to build new homes is based on the expected profitability of new residential construction (Poterba 1984; Topel & Rosen 1988), housing price and the cost of housing production (mainly including the cost of labour, building materials and equipment, land cost, and financing cost for developers) are important in determining the level of building activities. Figure 2-2 provides a graphic illustration about how the changes in housing price and the cost of housing production affect new housing supply. In this figure quantity of built space (Q) is measured along the horizontal axis and housing price (P) along the vertical axis. The demand for housing is represented by the downward-sloping straight lines (D_1 and D_2), and the supply of total housing stock is represented by the upward-sloping straight lines (S_1 and S_2). Initially, the housing market is in equilibrium at point a, with the demand for housing

being equal to the supply, i.e. the total housing stock. In addition, housing price (P_1) is equal to the replacement costs at point a, thus there is no incentive for developers to produce new housing units. Suppose that there is a positive demand shock that drives up the housing price so that the line representing the demand for housing shifts outwards from D_1 to D_2 (the positive demand shock can be caused by an increase in disposable income, an inflow of population, a decrease in mortgage interest rates, etc.). With housing price now above the cost of housing production, new residential construction will take place. If the number of new housing units arriving on the market exceeds the number of demolition (the conversion of existing housing units is ignored), the supply of total housing stock will expand to satisfy the increased demand for housing (it is shown graphically as an upward movement along the line representing the supply of total housing stock). However, the divergence between housing price and the cost of housing production will be diminished due to two reasons. Firstly, as housing supply increases, demand is satisfied and housing price will begin to fall back towards the replacement costs. Secondly, if factors of production are not perfectly elastic in supply, the cost of housing production will rise with the increase in building activities. This is shown graphically as an inward shift of the line representing the supply of total housing stock from S_1 to S_2. Although the interest rates for construction loans and the price of building materials (timber, cement, aluminium, copper, etc.) tend to be determined at the national or international level (Gyourko & Saiz 2006; Saiz 2010) and may not be related to the local output level, land price tends to increase substantially with the increase in building activities since the supply of residential land is relatively inelastic due to geographic and regulatory constraints.[5] Thus, as new

5. Another explanation for land price rising with the increase in building activities is that as housing stock increases, urban fringe will become further away from the city centre, which will lead to an

housing supply adds to the existing housing stock, the cost of housing production will be driven up by higher land price. The profit of new residential construction will decrease as the divergence between housing price and the cost of housing production is diminished. Eventually, a new market equilibrium will be reached at pint *b* where housing price equals the replacement costs and housing starts are equal to zero again. It is apparent from the figure that both the supply of total housing stock and housing price reach a higher level in the new equilibrium.

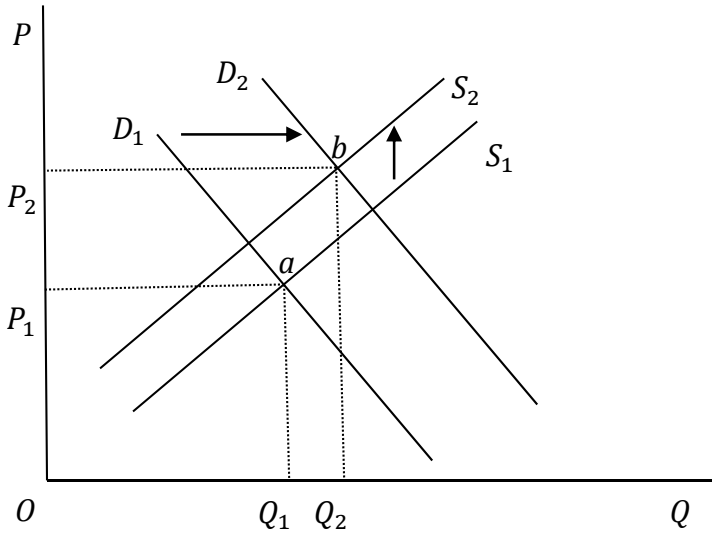

Figure 2-2 The response of housing supply following a positive demand shock

Source: Author

2.3.2 Land supply

Since any housing unit has to be built on a parcel of land, given a certain building density, land supply should be positively related to new housing supply. Another explanation for the positive relationship between land supply and new housing supply

increase in land price at all interior locations within the city (Dipasquale & Wheaton 1994; Mayer & Somerville 2000b).

is that land supply constraints can lead to an increase in land price and the cost of housing production, which in turn will put downward pressure on new housing supply (Evans 2004). In the presence of high demand for housing, land supply constraints will drive up land price. As land price increases relative to structure costs, developers will substitute capital for land in the production of housing, i.e. build higher-density housing units. However, the effect of increased land price can only be partially offset by the factor substitution, and higher land price will inevitably translate into higher cost of housing production and eventually into lower level of new construction. In reality, the presence of density regulation reduces the degree of factor substitution, and further ensures that higher land price results in higher cost of housing production and lower level of new housing supply. Figure 2-3 provides a graphic illustration about how an increase in land price caused by more restrictive land supply policy can lead to an increase in the cost of housing production. This figure features the quantity of capital at the horizontal axis and the quantity of land at the vertical axis. A quantity of built space (Q), can be produced using varying quantity of capital and land and the technical possibilities are represented in the figure by the downward-sloping curves (QQ and $Q'Q'$), called an isoquant. The slope of the curve indicates that if the quantity of one factor is gradually reduced then an increasing quantity of the other factor would be needed to produce the same quantity of space. The combination of factors used at any given cost is determined by their relative prices. The possible price ratios are represented in this figure by the downward-sloping straight lines (AB and AB'), called isocost lines. The point at which an isocost line is tangent to the isoquant curve determines the maximum quantity of space which can be produced at a given cost. Initially, the price ratio is represented by the isocost line AB, and OB of land can be bought at the same total cost as OA of capital. The maximum quantity of space which

can be produced at this total cost is indicated by the point where the isocost line AB is tangent to the isoquant curve QQ (point H), with OC of capital and OL of land being used. Suppose that there is an increase in land price due to more restrictive land supply policy so that only a maximum OB' of land can be bought at this total cost. The new isocost line AB' would have a lower slope, and would be tangent to a lower isoquant curve $Q'Q'$ at the point H', with OC' of capital and OL' of land being used. As a result of the rise in land price, less space can now be produced for the given cost.

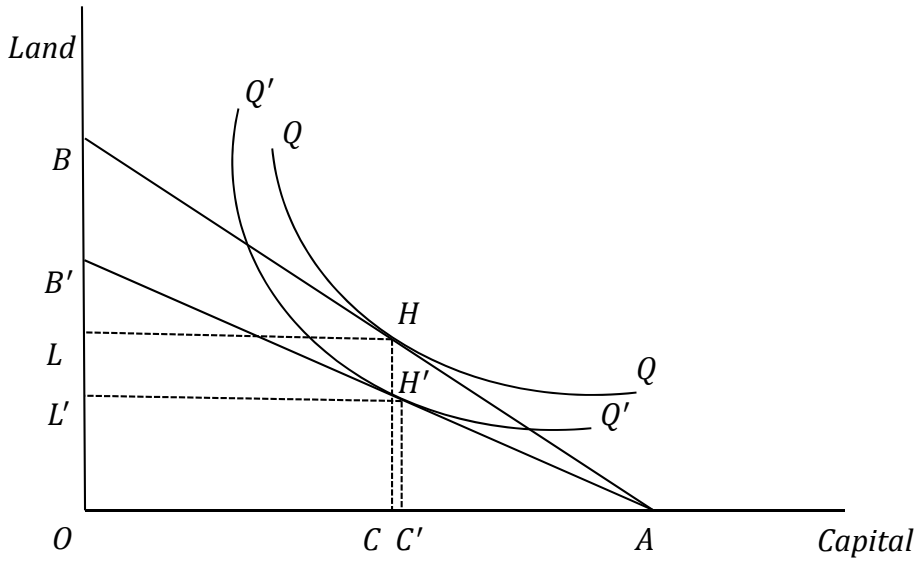

Figure 2-3 The impact that the increase in land price has on the cost of housing production

Source: Author

According to the above analysis, land supply should be positively related to new housing supply in a well-functional market. However, if developers conduct speculative land hoarding rather than build homes on purchased land, there will be no significant relationship between land supply and new housing supply (Hui & Ho 2003; Peng & Wheaton 1994; Tse 1998).

2.3.3 Regulatory constraints

Regulatory constraints can exert impacts on new residential construction in many different ways. Firstly, some types of regulatory measures (such as annual limit on building permits, moratorium on development, etc.) directly restrict the number of housing starts within a certain period of time (Ihlanfeldt 2007; Quigley & Rosenthal 2005). Secondly, the analysis presented in section 2.2.1 suggests that the amount of land available for housing development is restricted by land use regulations. While urban containment strategies (including urban growth boundaries and green belts) are mainly used to regulate rural-urban land conversion and influence all types of urban land uses, zoning regulation can directly limit the amount of land available for housing development. Thirdly, the floor area ratio (FAR) limit affects the quantity of new housing supply by determining how much floor area can be built given a certain amount of land supply (Peng & Wheaton 1994; Quigley & Rosenthal 2005; Tse 1998). Fourthly, the imposition of development impact fees and the requirement of certain pre-existing service levels can increase the cost of housing production and have an adverse impact on new housing supply (Ihlanfeldt 2007; Mayer & Somerville 2000a; Quigley & Rosenthal 2005). Fifthly, the planning application process can cause delay in housing development, since it takes time for planning authorities to determine whether a proposed development satisfies prescribed rules (Ball 2011; Mayer & Somerville 2000a). This type of delay can impose explicit financial and time costs on developers and have a depressing effect on new residential construction (Mayer & Somerville 2000a). In addition, since the granting of approval for development to proceed is based on human decision making which involves some randomness, the outcome of planning application is subject to uncertainty. This type of uncertainty can

reduce developers' desire to build (Ball, Meen & Nygaard 2010; Mayer & Somerville 2000a; Mayo & Sheppard 2001).

Some studies have provided evidence that regulatory constraints can have an adverse effect on new housing supply. Mayo & Sheppard (1996) examined the housing supply elasticities for three countries (Korea, Malaysia and Thailand) which are subject to different levels of regulatory constraints. Among the three countries, Korea has the most restrictive planning system (greenbelt is designated around urban areas to constrain the supply of developable land in Korea and any rural-urban land conversion requires planning permission) and Thailand exhibits the lowest level of development controls (planning authorities in Thailand tend to guide development by providing different levels of infrastructure service in different locations rather than by imposing direct constraints on development). Due to the introduction of a new planning system, regulatory constraints have become more restrictive in Malaysia since 1976. Mayo and Sheppard found that housing supply elasticities were lower in countries with more stringent regulatory environment (Korea and Malaysia), and there was a remarkable decrease in housing supply elasticity in Malaysia owing to the change in regulatory regime. Mayer & Somerville (2000a) examined the effects of two specific types of land use regulations (development impact fees and the delay in planning application process which was measured by the number of months required to receive the subdivision approval) on new residential construction using panel data for 44 US metropolitan areas for the period 1985-1996. They found that the delay in planning approval process had a greater impact on the number of housing starts than development impact fees. They also found that the responsiveness of new housing supply to change in housing price was weaker in more regulated cities (defined as

cities where the time required to obtain subdivision approval was greater or equal to 4.5 months or cities where at least one growth management technique was used).

2.4 The price elasticity of housing supply and its importance for housing price dynamics

The price elasticity of housing supply (also referred to as housing supply elasticity) is a measure of the responsiveness of housing supply to the change in housing price. There are generally two ways to think about housing supply elasticity: the price elasticity of housing stock and the price elasticity of new housing supply (Dipasquale & Wheaton 1994; Gitelman & Otto 2012; Mayer & Somerville 2000b). The price elasticity of housing stock is defined as the percentage change in housing stock divided by the percentage change in housing price, and the price elasticity of new housing supply is defined as the percentage change in new housing supply divided by the percentage change in housing price. Because the amount of new housing supply is generally documented at higher frequency than the amount of housing stock and new housing supply tends to be more volatile than housing stock, existing studies mainly focus on the estimates of the price elasticity of new housing supply (Ball, Meen & Nygaard 2010; Blackley 1999; Green, Malpezzi & Mayo 2005; Grimes & Aitken 2010; Hwang & Quigley 2006b; McLaughlin 2012; Poterba 1984; Pryce 1999; Topel & Rosen 1988; Zabel & Paterson 2006).

Housing supply elasticity plays an important role in explaining the evolution of housing price. An increase in the demand for housing caused by population growth, income increase or the decline in mortgage interest rate can put upward pressure on housing price. However, how housing price adjusts in response to the increased

housing demand depends on the magnitude of housing supply elasticity (Blackley 1999; Glaeser, Gyourko & Saiz 2008; Glaeser, Gyourko & Saks 2006; Malpezzi & Maclennan 2001; Ooi & Le 2012; Pryce 1999). If housing supply elasticity is relatively high, new housing supply will increase significantly to meet the increased demand and the rate of housing price appreciation will be relatively modest. If housing supply elasticity is relatively low, new housing supply will not respond adequately to the increased demand and the rate of housing price appreciation will be relatively high. It is noteworthy that since it generally takes several years to complete a housing development project, increased demand for housing cannot be met instantly even if new housing supply is perfectly elastic. Before starting construction, developers have to obtain planning permits and building permits. After starting construction, it takes time to build new housing units. In addition to having an effect on housing price dynamics, housing supply elasticity can have profound impacts on the broader economy. Firstly, high housing price appreciation which is closely related to low housing supply elasticity can erode housing affordability and pose substantial risks to financial and economic stability (Ahuja et al. 2010a; Wu, Gyourko & Deng 2012b). Secondly, inelastic housing supply can limit the supply of labour by restricting the number of households in a region, with implications for local wage rate and employment (Case 1992; Glaeser, Gyourko & Saks 2006; Saks 2014; Vermeulen 2008; Vermeulen & van Ommeren 2009).

Figure 2-4 provides a graphic illustration about how a positive demand shock can lead to divergent housing price developments under different supply schedules. Quantity of housing stock (Q) is measured along the horizontal axis in this figure, and housing price (P) is measured along the vertical axis. The demand for housing is represented

by downward-sloping lines (D_1 and D_2). Two types of housing supply conditions are considered, one is relatively elastic housing supply which is represented by the line S_1 which is less steeply upward-sloping, the other is relatively inelastic housing supply which is represented by the line S_2 which is more steeply upward-sloping. Initially, the housing market is in equilibrium at point a, with the demand for housing being equal to the supply, i.e. the total housing stock. Suppose that there is a positive demand shock which puts upward pressure on housing price so that the line representing the demand for housing shifts outwards from D_1 to D_2. As housing price rises, new residential construction will take place to meet the increased demand for housing. When the supply of total housing stock equals the demand for housing again, a new market equilibrium will be reached. However, housing price developments are different under different supply conditions. When housing supply is relatively inelastic, the new market equilibrium is reached at point b, with the volume of new housing supply and the increase in housing price being Q_aQ_b and P_aP_b, respectively. When housing supply is relatively elastic, the new market equilibrium is reached at point c, with the volume of new housing supply and the increase in housing price being Q_aQ_c and P_aP_c, respectively. It is apparent from the figure that when housing supply is relatively elastic, the volume of new housing supply is significantly larger and the increase in housing price is significantly lower.

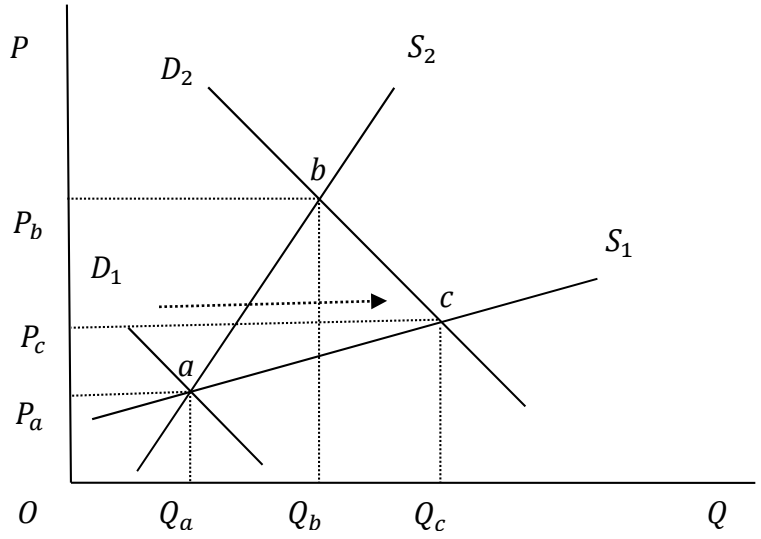

Figure 2-4 Housing Price developments under different housing supply conditions

Source: Author

Land availability is an important determinant of the price elasticity of new housing supply (Goodman 2005a, 2005b; Saiz 2010). When there is an adequate supply of land, developers are able to respond quickly to an increase in housing price by building more housing units. By contrast, the responsiveness of new housing supply to the change in housing price will be constrained when land supply is inadequate. Saiz (2010) developed a theoretical model to explore the determinants of housing supply elasticities. This model predicts that housing supply elasticity is positively related to land availability. In the empirical analysis, he estimated the city-specific housing supply elasticities for US metropolitan areas and examined the determinants of housing supply elasticities. He found that land constraints caused by geographic features and land use regulations played an important role in determining housing supply elasticities. Goodman (2005, 2005b) estimated the housing supply elasticities for suburban areas and central cities of US metropolitan areas. He found that housing supply was more elastic in suburban areas than in central cities. He argued that this is due to the fact that there is generally a larger amount of undeveloped land in suburban

areas than in central cities. Meen & Nygaard (2011) argued that many geographic features such as mountains, oceans, lakes, rivers and marshes serve as natural barriers to residential construction. Thus, geographic constraints play an important role in determining land availability and housing supply elasticities. They estimated a model of housing supply using data for the medium-level super output areas (MSOAs) in two contrasting areas of England (the Thames Gateway and the Thames Valley). The key distinctions between the two areas lie in the patterns of wealth and poverty and the patterns of land use. The Thames Gateway faces a higher level of poverty and is more built-up with a greater proportion of land area denoted to domestic and non-domestic buildings. They found that housing supply elasticities were lower in MSOAs that have a higher proportion of land devoted to green space, paths and water. Ihlanfeldt & Mayock (2014) estimated the county-specific housing supply elasticities and examined the determinants of housing supply elasticities using data for 63 counties in Florida in the US. They found that the amount of developable land played an important role in determining housing supply elasticities.

2.5 The factors affecting the demand for housing

Many scholars have suggested that the demand for owner-occupied housing in a city can be taken as the product of the number of households in the city and the proportion of households that choose owner-occupancy (Asberg 1999; Dipasquale & Wheaton 1994; Hwang & Quigley 2006b). Thus, factors affecting the demand for housing fall into two categories: factors affecting the number of households and factors affecting the housing tenure choice. Factors affecting the number of households can be further divided into two categories: population and factors affecting household formation decision. The determinants of household formation decision include economic factors

(including the cost of living independently and the capacity to live independently), demographic factors (such as age, gender and race/ethnicity) and trigger events occurring during the life-course (such as marriage and the birth of children) (Andrew & Meen 2003b; Chen et al. 2012; Di & Liu 2006; Ermisch 1999; Haurin, Hendershott & Dongwook 1994). Because housing tenure choice also depends on economic factors (including the cost of owning a home and the capacity to own a home), demographic factors and trigger events occurring during the life-course, many studies estimate the model of household formation and the model of housing tenure choice simultaneously (Andrew & Meen 2003b; Asberg 1999; Chen et al. 2012; Haurin, Hendershott & Dongwook 1994). The appropriate measure of the cost of living independently in the model of household formation is not clear-cut. Different studies use different measures, which include real rent (Di & Liu 2006; Haurin, Hendershott & Dongwook 1994), the user cost of owner-occupied housing (Asberg 1999; Haurin, Hendershott & Dongwook 1994), real housing price (Ermisch 1999) and the mortgage cost (Andrew & Meen 2003b; Chen et al. 2012). In the model of housing tenure choice, the cost of owning a home is generally measured by real housing price and the user cost of owner-occupied housing. In general, the capacity to live independently or the capacity to own a home is measured by income level (Chen et al. 2012; Di & Liu 2006; Ermisch 1999). Figure 2-5 provides a graphic illustration of the factors affecting the demand for housing.

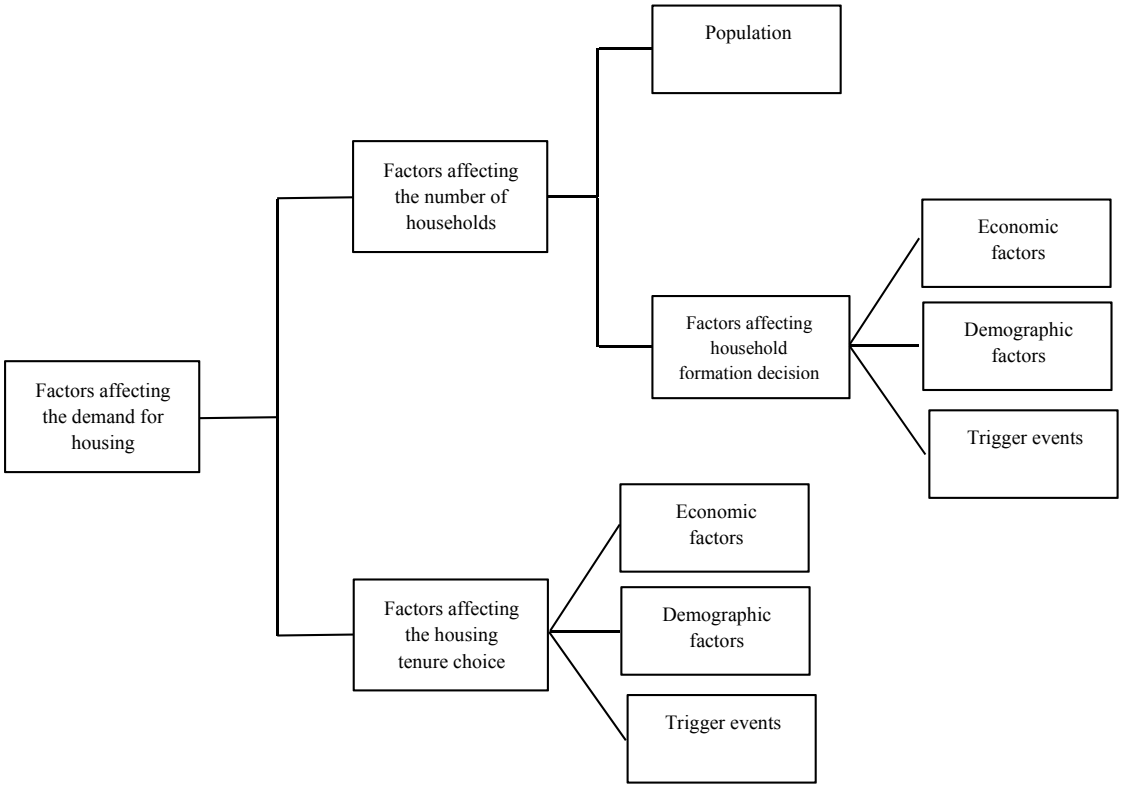

Figure 2-5 The factors affecting the demand for housing

Source: Author

2.6 Summary

This chapter establishes a theoretical framework for the analysis of the impacts that government intervention in land markets has on residential land supply, new housing supply and housing price. Within the framework, the impact that government intervention in land markets has on residential land supply, the factors affecting new housing supply, housing supply elasticity and its importance for housing price dynamics, and the factors affecting the demand for housing is analysed. According to the theoretical analysis, regulatory constraints on rural-urban land conversion and direct government control over land supply can restrict the amount of land available for housing development. The factors affecting new residential construction mainly include housing price, the cost of housing production, land supply and regulatory

constraints. Land supply should be positively associated with new housing supply in a well-functional market. However, if developers conduct speculative land hoarding rather than build homes on purchased land, there will be no significant relationship between land supply and new housing supply. Housing supply elasticity is a measure of the responsiveness of housing supply to the change in housing price, and plays an important role in explaining the evolution of housing price. Land availability is an important determinant of housing supply elasticity. The factors affecting the demand for housing mainly include population, housing price, the user cost of owner-occupied housing, income and the demographic factors.

Chapter 3: Literature review

3.1 Introduction

This chapter presents a review of the empirical literature on residential land supply, new housing supply and housing price. The purposes of the literature review are twofold. Firstly, existing studies can provide empirical evidence supporting the theoretical analysis presented in last chapter. Secondly, the literature review facilitates the development of models of new housing supply and housing price in the empirical analysis.

This chapter begins with a review of the empirical studies on government intervention in land markets and its impact on residential land supply, and then focuses on the empirical studies on the impacts of land supply on new housing supply and housing price and the empirical studies on modelling new housing supply and estimating housing supply elasticity. Attention is given to the empirical research on the demand-side determinants of housing price, housing price volatility and the empirical research on the determinants of housing price in China in the last three sections of this chapter.

3.2 The impact that government intervention in land markets has on residential land supply

Some researchers have investigated how governments in different countries intervene in land markets and examined the impact that government intervention in land markets has on residential land supply. The empirical studies conducted in different countries/regions are reviewed in the first part of this section. Since the imposition of urban containment policies is widely used by governments around the world to curb

urban sprawl and preserve agricultural land (as mentioned in section 2.2.1), special attention is paid to urban containment policy implementation and its impact on residential land supply in the second part of this section.

3.2.1 Empirical evidence in different countries/regions

The theoretical analysis presented in section 2.2 suggests that government intervention in land markets generally takes two forms: land use regulations and direct government control over land supply. In western countries which have a freehold tenure system, governments intervene in land markets primarily through land use regulations (Cheshire & Sheppard 2005; Dawkins & Nelson 2002; Evans 1999; Ihlanfeldt 2007; Quigley & Rosenthal 2005). In some East Asian countries/regions (such as mainland China, Korea, Singapore and Hong Kong), governments or the public sector can intervene in land markets in a more direct way by directly participating in land development and land supply (Chiu 2007; Hui, Leung & Yu 2014; Hui & Ho 2003; Kim 1993; Ooi, Sirmans & Turnbull 2011; Peng & Thibodeau 2012). In this subsection, the empirical studies conducted in the UK, Korea, Hong Kong and Spain regarding the impact that government intervention in land markets has on residential land supply are reviewed. While the UK and Spain can be taken as representatives of the countries where government intervention in land markets mainly comes in the form of land use regulations, Korea and Hong Kong can be taken as representatives of the countries/regions where governments or the public sector directly participate in land development and land supply. Since the government in mainland China intervenes in the land markets both through land use regulations and direct government control over land supply (this issue is discussed in detail in Chapter 5),

empirical evidence from those countries/regions also has implications for understanding the operation of the land and housing markets in China.

(1) Empirical evidence from the UK

Monk & Whitehead (1999) investigated the land use planning system in the UK and examined the impacts of planning controls on residential land supply in three local authority districts which were subject to different levels of growth pressure and regulatory constraints. They suggested that while land is privately owned in the UK, every proposal for housing development must obtain planning permission. The decision on land release is made through a top-down process. At the starting point of the process, the Department of the Environment makes national household projections which are allocated between regions and counties. The county planning authorities then translate the household projections into projections of dwelling requirements, and work out forecast figures for land release in each district. Finally, at the lowest tier of the planning system, district planning authorities translate the land release figures into actual sites. Among the three districts which were examined in their study, Fenland experienced the lowest growth pressure and near "zero" planning constraints, and South Cambridgeshire and North Hertfordshire faced significant growth pressure and stringent planning constraints. Monk and Whitehead found that during the housing boom in late 1980s, residential land supply rose notably in area with weak planning controls (Fenland), but it rose only slightly or even declined in areas with stringent planning controls (South Cambridgeshire and North Hertfordshire). Because residential land supply was unresponsive to changing market conditions in South Cambridgeshire and North Hertfordshire, the patterns of housing completion were more constant and housing price appreciation was more evident in those areas.

Sayce, Walford & Garside (2012) examined the impact that planning policy in the UK which favours brownfield development has on residential land supply. In England, a series of Planning Policy Statements (which provide statements of government policy on national land use planning matters and are a material consideration when determining planning applications) explicitly state that local planning authorities (LPAs) should attempt to promote the more efficient use of previously developed land (PDL), and the government has set a target for 60 per cent of new housing to be built on PDL. Sayce, Walford and Garside argued that since garden sites were classified as PDL under Planning Policy Statement 3 before June 2010 (when the Labour party lost the general election and the definition of PDL was amended), residential development on gardens helped LPAs to fulfil the target for housing development to be on PDL. From policy makers' point of view, it also promotes more efficient use of the existing transport infrastructure and social cohesion, and avoids the loss of greenfield which is closely associated with biodiversity. Developers also favour the development of garden sites since it is a form of small-scale development and free from the provision of affordable housing and the restriction on the sale prices (which are the requirement of large-scale development). In addition, garden development is also less costly as it usually doesn't incur costs related to site clearance and remediation. In the empirical work, Sayce, Walford and Garside investigated whether garden development was regarded by LPAs as a significant means of meeting housing targets and the extent of garden development in England through a questionnaire survey sent to LPAs. They found that garden development was viewed as a crucial issue and added significantly to housing stock in London, the South-East, the South-West and West Midlands. The vast majority of the areas are classified as semi-rural or rural locations where brownfield sites availability are limited and garden development may offer the only

realistic means of increasing housing stock. By contrast, garden development was less of an issue in the north-western conurbations of Great Manchester and Merseyside, where the supply of other forms of brownfield land is sufficient.

(2) Empirical evidence from Korea

Hannah, Kim & Mills (1993) investigated the land supply system in Korea and the change in residential land supply in Korea during the 1970s and 1980s. They suggested that new urban land is supplied within the framework of the national land use plan in Korea. The government forecasts the amount of land needed for various urban purposes based on the projection of population growth and economic development, and then changes the permitted use of developable land. In addition, a predominant proportion of new urban land is directly developed and supplied by the public sector. Hannah, Kim and Mills found that while urban population and the standard of living rose dramatically during the 1970s and 1980s in Korea, urban residential land increased at a speed much lower than the rate of urban population growth, leading to extraordinarily rapid rise in land and housing prices. They argued that the government tended to under-allocate land to residential use in urban areas to obtain higher revenue from land sales. Thus, residential land supply was unresponsive to the increase in housing demand during that period in Korea. A case study of five urban development projects in or near Seoul showed that the government revenue from land sales was between 1.7 and 6.8 times the cost of purchasing rural land and providing infrastructure. Kim (1993) also argued that the reason urban residential land supply was inelastic during the 1970s and 1980s in Korea was because of stringent government control.

Son & Kim (1998) developed a method to measure the urban land shortage/surplus based on the analysis of land price gradients under the framework of monocentric city model. They argued that an equilibrium point (which represents a certain distance from the urban centre) at which the owner of a parcel of land is indifferent whether the land is rented for urban or rural use can be determined by estimating the price gradients for urban and rural land. Since the urban land price curve is steeper than the rural land price curve (given the fact that accessibility measured by the marginal transportation cost is more crucial for urban economic activities), the land parcels located within the equilibrium distance will be used for urban purposes. The urban land shortage or surplus can be defined as the difference between the equilibrium amount of urban land and the quantity of the land currently being used for urban purposes. Son and Kim calculated urban land shortage/surplus for 171 Korean cities and found that urban land shortage was most severe in the six largest cities and the cities in Kyunggi Province. They also explored the determinants of the urban land shortage/surplus by regressing the measure of urban land shortage against the explanatory variables representing natural and contrived constraints. They found that land use regulations (such as the green belt regulation) played a more important role than the geographic constraints in causing the urban land shortages in Korean cities.

(3) Empirical evidence from Hong Kong

In Hong Kong, all land is owned by the government except for one land parcel at St. John's Cathedral, and land is leased to land users by the government for periods ranging from 50 to 999 years (Chiu 2007; Hui & Soo 2002). The land available for housing development mainly comes from two sources: one is newly developed land and the other is the redevelopment of existing urban area (Chiu 2007; Ho & Ganesan

1998; Tse 1998). The supply of newly developed land is directly controlled by the government through land sales, and the redevelopment of existing urban area is generally conducted after land exchange or lease modifications.[6] Chiu (2007) argued that since the government is the sole supplier of newly developed land and the single largest land supplier, government control plays a crucial role in influencing residential land supply in Hong Kong.

Chiu (2007) examined the change in the amount of land sold by the government for residential development in Hong Kong during the period 1989-1993. He found that although the demand for housing was strong and housing price had risen sharply during that period, the amount of land sold by the government stayed at a relatively low level (not exceeding 50 hectares). He argued that because in 1987 the government forecasted that the demand for housing was going to decline in the following 10 years and then determined the amount of land sales based on the projected diminishing housing demand, residential land supply was insufficient to meet the increased housing demand during the period 1989-1993.

(4) Empirical evidence from Spain

Solé-Ollé & Viladecans-Marsal (2012) investigated the impacts of the degree of political competition on local land supply in Spain. Local governments (municipalities) are responsible for formulating and implementing land use policies (including the designation of developable land in town planning) in Spain, and voters make their

6. Land exchange refers to a process in which developers surrender an existing land holding and are granted a new lot (Hui, Leung & Yu 2014; Liu, Wu & Lee 1997). Lease modifications mean that the development requirements stipulated in land leases can be modified to allow changes of use or of development intensity (Liu, Wu & Lee 1997).

decisions in election according to a party's proposed land policies and other commitments it has made. Solé-Ollé and Viladecans-Marsal developed a theoretical framework explaining how municipalities determine the amount of new developable land. They argued that in making land supply decision, local governments weigh both the quantity of political rents they can obtain in their current term of office (which is positively associated with the amount of new developable land) and the probability of re-election (which is negatively associated with the amount of new developable land). Since the weight on the probability of re-election is positively related to the extent of political competition, the amount of new developable land is assumed to decrease as the degree of political completion increases. The model also predicts that the effect of political competition is more marked in places where residents have an aversion to urban growth. In the empirical work, Solé-Ollé and Viladecans-Marsal tested the hypotheses using data for 2034 Spanish municipalities for the period 2003-2007. The degree of competition was measured by a local incumbent's vote margin. To correct the potential bias caused by the endogeneity of the vote margin, they used two variables ("historical margin" and "provincial margin") to instrument for the vote margin. They found that the growth in political competition significantly decreased the amount of new land made available for development, and the results were robust to using different instruments and adopting a different approach to computing the political competition variables. By dividing the sample into various subsamples, they also found that the impact of political competition was more pronounced in places where urban growth had a stronger disamenity effect. In light of the findings, they argued that who will dominate the local land use policies (resident voters or developers) depends on the degree of political completion.

3.2.2 The impact of urban containment policy implementation on residential land supply

Dawkins & Nelson (2002) investigated urban containment policy implementation in different countries. They argued that the imposition of urban containment policies can result in a reduction in the quantity of developable land, which in turn will translate into a reduction in new housing supply in the presence of high demand for housing. Kim (1993) explored the role of green belts in restricting residential land supply in Korea. By developing a simple model of land and housing price, he showed that the release of green belts for new residential construction can lower land and housing price significantly. He suggested that a competitive land market should be established to allow for more responsive land supply, and the government should rezone adequate land near city centres for housing development. It is worth noting that the negative effect of urban containment policy implementation on residential land supply and new housing supply can be weakened by many factors. Firstly, an overly loose urban growth boundary will impose little restriction on the supply of developable land. Gennaio, Hersperger & Burgi (2009) evaluated the effectiveness of urban containment policies in four Swiss municipalities. They found that due to overly optimistic population forecasts and political reasons, the building zones designated in 1960s were extremely large in three of the four municipalities and one fourth of the building zones in those areas were still available for further development in 2000. Secondly, if a substantial amount of development occurs outside the urban growth boundary, the scarcity of developable land caused by urban containment policies can be alleviated. Jun (2004) examined the impact of Portland's urban containment policies on urban development patterns. He found that the share of housing units outside the urban growth boundary had increased significantly from 25% in 1960s to 40% in 1990s.

Couch & Karecha (2006) examined the implementation and effectiveness of urban containment policies in Liverpool, England. They found that around 270 hectares of land within green belts was developed for residential purpose each year during the period 2000-2003 in England. Thirdly, the depressing effect of urban containment policy implementation on new residential construction can be weakened by other government policies which are aimed at facilitating housing production. Knaap & Nelson (1992) found that the policies aimed at facilitating the construction of multiple-family or government-supported housing were effective in increasing housing production in Oregon, US (urban containment policies were implemented in Oregon), and housing price was lower in Oregon than in other western American states in the 1980s.

Although this section mainly focuses on the impact of urban containment policy implementation on residential land supply, it is worth noting that the imposition of urban containment policies can also cause demand-side changes within the housing market. Since urban containment policy implementation can preserve environmental amenities, enhance accessibilities and promote more efficient provision of public service and infrastructure, it can increase the demand for housing through an amenity effect (Cheshire & Sheppard 2002; Dawkins & Nelson 2002; Ihlanfeldt 2007). Nelson (1999) examined the efficiency of growth-management efforts in three American states. He found that compared with the state without growth management (Georgia), the states with growth management (Oregon and Florida) were more effective in curbing urban sprawl, preserving farmland, improving accessibility, reducing energy consumption and lightening the tax burden. Since urban containment policy implementation can depress new housing supply and increase the demand for housing,

it can have a positive effect on housing price. Phillips & Goodstein (2000) examined the effect of urban containment policy implementation on housing price using data for 37 major American cities. They found that the imposition of urban containment policies generated upward pressure on housing price, but the impact was relatively small in magnitude. Jun (2006) examined the effect of Portland's urban growth boundary on housing price by estimating a hedonic housing price model using spatially disaggregate data. He found that there was no significant difference between housing price inside and outside the urban growth boundary.

3.3 The impacts of land supply on new housing supply and housing price

The theoretical analysis presented in section 2.3.2 suggests that land supply is expected to be positively related to new housing supply in a well-functional market. However, if developers conduct speculative land hoarding rather than build housing units on the supplied land, there will be no significant relationship between land supply and new housing supply. As shown in this section, existing studies on the impacts of land supply on new housing supply and housing price have provided empirical evidence supporting the theoretical analysis.

Bramley (1993) and Pryce (1999) examined the effect of land supply on new housing supply in the UK. Bramley (1993) estimated a model of new housing supply using data for 90 English local authority districts for the period 1986-1988. The explanatory variables of the model include housing price, land supply (measured by the stock of land with outstanding planning permissions), and a series of planning variables (including ward density, the percentage of green belts in non-urban area, the total area of unconstrained land, dummy variables for regulatory restrictiveness, structure plan

provisions and permissions as a percentage of applications). Bramley found that land supply had a positive and statistically significant effect on new housing supply and the planning variables had a depressing effect on new housing supply. He argued that in order to keep an even inventory of developable land to meet unexpected demand and to benefit from enhanced land value, home builders would reduce current output when they expect little land to be released in the future. Pryce (1999) estimated a model of new housing supply using data for 162 English local authority districts for the years 1987, 1988, 1991 and 1992. The explanatory variables of the model include housing price, the costs of housing production, land supply (measured by land stock with outstanding planning permissions), percentage of residential development on previously developed land, and unemployment rate. He found that land supply had a positive and statistically significant effect on new housing supply and the elasticity of new housing supply with respect to land supply was slightly greater during a housing boom (1988) than during a bust (1992).

Some studies have examined the impacts of land supply on new housing supply and housing price in Hong Kong. Peng & Wheaton (1994) examined the impacts of land supply on new housing supply and housing price in Hong Kong by estimating models of new housing supply and housing price using data for the period 1965-1990. They assumed that expectations about future housing price (which influence the demand for housing) are formed based on the rate of recent land sales, and thus land supply was included as an explanatory variable in both the models of new housing supply and housing price. They found that land supply (measured by the amount of government land sales) did not significantly affect new housing supply, but land supply had a negative and statistically significant effect on housing price. They argued that housing

production was not curtailed by more restrictive land supply due to Hong Kong's flexible restriction on housing density and the existence of speculative land hoarding. They also suggested that the decrease in land sales was taken as a sign of more restrictive land supply policy in the long run, which would drive up the anticipated future housing rent. In a rational market, the expectation of higher future housing rent would be capitalized into higher current housing price. Ho & Ganesan (1998) also examined the effect of land supply on housing price in Hong Kong by estimating a model of housing price for the period 1980-1996. A distinctive feature of their research involves the method for measuring land supply. They argued that apart from land sales by the government through auction and tender, there are other land-supply channels in Hong Kong, such as lease modifications. Thus, land supply was defined as the gross floor area of land supply actually put on the market in their study. They found that land supply had a negative and statistically significant effect on housing price, but the effect was modest in magnitude. Tse (1998) examined the relationship between land sales by the government and housing price in Hong Kong using the Granger causality test and data for the period 1976-1990. He found that there was no causal relationship between the two variables during the sample period. He provided three explanations for the empirical results. Firstly, he argued that since more than half of the land available for housing development came from redevelopment in the 1990s, government land sales accounted for only a small proportion of residential land supply. Secondly, since a substantial amount of the new developable land supplied by the government was not developed immediately, but simply absorbed into developers' land banks, government land sales had no significant effect on housing price. Thirdly, since the restriction on housing density was relatively loose in Hong Kong, developers could substitute capital for land in the presence of constrained land supply. He

suggested that the average plot ratio of the new land for public auctions had increased significantly from 3.4 for the period 1975-1985 to 4.3 for the period 1985-1994. Hui & Ho (2003) examined the impacts of government land sales and land use planning on housing price in Hong Kong. They found that government land sales did not significantly affect housing price. They argued that this was mainly due to land banking behaviour of developers. Hui, Leung & Yu (2014) investigated the impacts of different land-supplying channels on housing supply in Hong Kong by estimating a vector error correction model using data for the period 1985:2-2012:4. They argued that when a land parcel is sold through government land sales in Hong Kong, lease conditions (such as the size of the flats and to whom the flats were to be sold) are generally determined by the government before the land parcel was put on the market. Thus, government land sales are a government-initiated process which tends to overlook developers' profit incentives and development strategies. By contrast, when developers lodge an application for land exchange, the lease conditions are negotiable between the government and developers. Hui, Leung and Yu (2014) found that land exchange had a much larger effect on housing supply than government land sales did. They argued that the government should take measures to reduce the delay in the application process for land exchange.

Costello & Rowley (2010) examined the impact of land supply on housing price in a number of Perth (Western Australia) metropolitan suburbs by comparing the rate of land supply with change in housing price. They found that there was only a weak relationship between land supply and housing price growth, and provided three possible explanations for the weak relationship. Firstly, large-scale land release in the Perth metropolitan area delivered a very similar housing product (usually the large

four-bedroom, two-bathroom house), and failed to produce a much greater diversity of housing directed at those in need. Secondly, large-scale land release can result in improvements in infrastructure and the overall 'quality' of a suburb, which in turn would put upward pressure on housing price. Thirdly, land release in a single suburb may not affect housing price in that suburb owing to a restricted land supply in other suburbs within the same submarket.

Zabel & Paterson (2006) investigated the impact that the designation of "critical habitat" (CH) has on building activities in California municipalities (the US). CH is defined as the areas which are identified as being crucial for the conservation of the endangered species. Zabel and Paterson developed a model of housing starts in which the number of building permits issued is expressed as a function of change in housing price, the dummy variable for the designation of CH, the ratio of the area of the CH to the area of the municipality and some other factors affecting housing starts. They estimated the model using panel data for California municipalities for the period 1990-2000, and found that the designation of CH had a negative and statistically significant effect on new residential construction. They also found that the effect was economically large and only increased slightly in magnitude as the ratio of the area of the CH to the area of the municipality increased. They argued that this implied that the designation of CH acted as a signal to the developers that costs of development would be higher for all development in that municipality. Noting that economic impact was taken into account when specifying a particular area as CH, they suggested that the two CH variables and housing starts tended to be simultaneously determined. They corrected the possible endogeneity bias by using the annual rainfall and the area of forestland, shrubland, water and wetlands to instrument for the two CH variables. To

test whether the impact of CH designation varied over time, they included a set of time dummy variables in a variant of the model.

It is noteworthy that since density regulation and floor area ratio regulation control how much floor area can be built on a parcel of land, these types of regulations can exert effects on new housing supply. Glaeser & Ward (2009) examined the effects of land use regulations using data for 187 cities and towns in the Greater Boston region in the US. They found that there was a strong positive relationship between density and new residential construction.

3.4 Studies on modelling new housing supply and estimating housing supply elasticity

As mentioned in Chapter 2, there has been a growing body of literature devoted to examining the determinant of new housing supply, modelling new housing supply and estimating housing supply elasticities during the last three decades. Studies on modelling new housing supply are reviewed in the first part of this section, and studies on estimating housing supply elasticites are reviewed in the second part of this section,

3.4.1 Studies on modelling new housing supply

As many scholars have suggested (Hwang & Quigley 2006b; Mayer & Somerville 2000b; Zabel & Paterson 2006), an important issue in modelling new housing supply involves whether it should be specified as a function of the levels of housing price and cost variables or as a function of the changes in price and costs. New housing supply is generally specified as a function of the levels of housing price and cost variables in

early studies. However, new housing supply is specified as a function of changes in housing price and cost variables in many recent studies.

Poterba (1984) and Topel & Rosen (1988) applied Tobin's q theory of investment (Tobin 1969) to modelling new housing supply. The q theory implies that the decision to build new homes is based on the expected profitability of new residential construction, and new housing units will be built only when q (the ratio of housing price to the cost of housing production) is greater than 1. According to the theory, new housing supply should be positively associated with the level of housing price and negatively associated with the level of the cost of housing production. Poterba (1984) took account of the effects that alternative use of construction resources and credit rationing have on new housing supply. In his model, the driving forces behind new residential construction include real housing price, the real price of alternative construction projects, credit availability and the wage rate in the construction industry. New housing supply was measured by both the real value of new one-family housing construction put in place and the ratio of investment in one-family residences to gross national product (GNP). A distributed lag on net deposit influx to savings and loan institutions and a dummy variable for periods that defined as "credit rationed" were employed as two alternative measurements of credit availability. Poterba estimated a variety of specifications of the investment supply model using quarterly time-series data for the US for the period 1974-1982. In the best fitting equations, the estimated price elasticities of new residential construction ranged between 0.5 and 2.3. The real price of non-residential buildings had a negative effect on new housing investment, suggesting that decisions on allocating construction resources among alternative uses were based on the relative prices of different construction projects. Credit availability

significantly affected new housing investment, supporting the view that credit availability not only determines the quantity of housing services demanded, but also determines the flow of new residential construction. The wage rate and other measurements of construction costs had unexpected positive coefficients, but the coefficients were not statistically significant. Topel and Rosen's (1988) model is built on dynamic marginal cost pricing considerations. They argued that if short- and long-run housing supply coincides, housing investment decision will be myopically determined by comparing current asset price with current marginal cost of housing production. If short-run supply is less elastic than long-run supply (the reason for this is that construction cost is affected by the rate of change in building activities, leading to investment being spread over a longer period of time to reduce the overall construction cost), current asset prices will be no longer the sufficient statistics for investment decisions, and current investment decisions will be made based on the expectation of future prices. Topel and Rosen developed both a myopic model in which only current housing price and input costs are relevant to investment decisions and a dynamic enriched model with expectation and internal adjustment cost. They estimated alternative versions of those models using quarterly US data for the period 1963:1-1983:4, with new housing supply measured by single-family housing starts. In both the myopic and internal adjustment cost models, real interest rate, expected inflation rate and the median time on the market for new homes had negative and statistically significant effects on housing starts. They argued that those effects were too large to be generated by variations in the cost of working capital to builders, but could be interpreted as reflecting the change in the ability to sell new homes at current price. The other measurements of construction cost had insignificant effects on housing investment. As the statistical significance of the autoregressive structure in

the myopic model indicated misspecification of supply dynamics, the empirical results caused the rejection of the myopic model in favour of the internal adjustment cost model. For their preferred model, the estimates of housing supply elasticity were about 1.0 for short-run and around 3.0 for long-run. The difference between the short-run and long-run housing supply elasticities converged within one year.

Dipasquale & Wheaton (1994) and Mayer & Somerville (2000b) suggested that the investment-based models of new housing supply developed by Poterba (1984) and Topel & Rosen (1988) do not take into account the role of land as an essential input in housing production. Dipasquale & Wheaton (1994) argued that, following an increase in the demand for housing, rising housing price will initially generate excess return and bring about higher level of new residential construction. However, because land price will rise significantly as the size of housing stock increases, the marginal cost of housing production will eventually equal housing price, resulting in new residential construction returning to its normal level. Thus, new housing supply responds to a growth in housing price only temporarily, until the existing housing stock adjusts to its equilibrium level. Based on the above analysis, they incorporated a stock adjustment process into the model of new housing supply. They specified new housing supply as a function of the levels of housing price and cost variables and the lagged housing stock. They estimated the model using aggregate annual US data for the period 1963-1990. To improve the explanatory power of the model, the change in employment and the number of months on the market for new homes recently sold were introduced as indicators of housing market conditions. Estimates of the price elasticity of the desired stock ranged from 1.2 to 1.4; Estimates of the price elasticity of new housing supply ranged from 1.0 to 1.2. Except for the short-term real interest rate, the cost variables

were all statistically insignificant. Mayer & Somerville (2000b) formally derived the relationship between new housing supply and changes in housing price and cost variables based on the Capozza-Helsley urban growth model (Capozza & Helsley 1989). In the theoretical model developed by them, housing price at an interior location of a city is regarded as the sum of agricultural land price, structure cost, the present value of location rent and the present value of the expected increase in housing rent. After a simple derivation, the distance from the city centre to the border (which is an index of the city size) can be expressed as a function of the levels of housing price and cost variables. Housing stock, which is another index of the city size, can also be taken as a function of the levels of housing price and cost variables. Housing starts, which are equal to the change in housing stock when ignoring abandonment and demolition, can then be expressed as a function of changes in housing price and cost variables. They suggested that using changes in housing price and cost variables rather than their levels to explain new housing supply is also more consistent with the time series properties of housing market data. Mayer and Somerville estimated the model of new housing supply using quarterly US data for the period 1975-1994. In order to be consistent with the theoretical model, the Freddie Mac repeat sales price index which adjusts for the increase in location rent rather than the hedonic new house price index was employed to measure housing price movement. Changes in housing price and interest rate were found to have statistically significant effects on housing starts. The estimate of the price elasticity of housing stock was 0.08, and the estimate of the price elasticity of new housing supply was 3.7.

Grimes & Aitken (2010) emphasized the importance of including land cost in the q theory model of new housing supply. They argued that the failure to find a statistically

significant relationship between the cost variables and new housing supply in previous studies was due to the omission of land cost. Thus, they developed a fully specified q theory model in which the ratio of new residential construction relative to the current housing stock is explained as a linear combination of the ratio of housing price to building cost and the ratio of building cost to land price (both in logarithm form). They estimated the model of new housing supply with and without the restriction that the coefficients on explanatory variables being identical across regions using panel data for 73 territorial local authorities in New Zealand for the period 1991:1-2004:2. The restricted estimation yielded an estimate of housing supply elasticity of 1.1, the unrestricted estimation yielded a mean value of the region-specific elasticities of 0.7. They also explicitly examined the relationship between housing supply elasticities and housing price adjustment dynamics. They did this in two steps. In the first step, they estimated both an equilibrium housing price model and an error correction housing price model. In the second step, they regressed the housing price adjustment coefficients against the estimated housing supply elasticities. They found that regional housing price dynamics was inversely related to housing supply elasticities, implying that housing price increased less in response to a demand shock in regions with relatively elastic housing supply.

Ball, Meen & Nygaard (2010) estimated a housing market model which consists of equations for housing price, housing transactions, new residential construction and construction cost to obtain the estimates of housing supply elasticities for the US, the UK and Australia. In the model, change in housing price, new residential construction and the volume of housing transactions are all associated with the disequilibrium in the housing stock which is measured by the ratio of the equilibrium housing stock to

the actual stock. New residential construction is related to the level of and the change in housing price, the volume of housing transactions, construction cost and short-term interest rate. They argued that because the methodologies and model structures used in different studies are different, the simple comparison of the estimates of housing supply elasticities obtained in different studies can be problematic. However, their estimates using a similar model structure allows for a convincing comparison of the housing supply elasticites across countries. The regression results showed that housing supply elasticities for the US were higher than those for the UK and Australia. Given that national housing supply elasticities tend to disguise variations in local housing supply responsiveness which arise from the differences in regulatory stringency and land use patterns, they also examined housing supply elasticities at a smaller spatial scale. They estimated the model of housing supply using data for 210 Medium Level Super Output Areas in the Thames Gateway in the UK and found that housing supply elasticities were relatively higher in areas with a smaller percentage of land devoted to paths, green space and water. They argued that since planning policies aimed to direct new residential construction towards existing built-up areas, housing supply was more elastic in those areas despite the fact that brownfield redevelopment was generally more expensive than greenfield development. They also used the firm-level data to explore whether the housing supply elasticities for largest firms are different from those for the house building industry as a whole. They found that the largest firms were more responsive to market signals than the industry as a whole. They argued that this was due to the fact that larger companies were more capable of acquiring land by taking over smaller companies and were more likely to have sufficient funds to persist in persuading local planners to grant planning permissions.

Miles (2009) argued that since housing represents a form of "irreversible" investment, an increase in uncertainty can decrease housing investment. He employed the Generalized Autoregressive Conditional Heteroskedasticity-in-Mean model to generate a measure of uncertainty, and investigated the role of uncertainty in affecting housing investment using quarterly data from the US Census Bureau. He found that uncertainty had a negative effect on housing starts. Lee & Jin (2011) applied the Generalized Autoregressive Conditional Heteroskedasticity-in-Mean model to examine the volatility series of housing supply in Australia for the period 1974-2010. They found that higher uncertainty indeed lowered housing starts.

3.4.2 Studies on estimating housing supply elasticity

There are basically two approaches to estimating housing supply elasticities: structural modelling approach and reduced-form modelling approach (Dipasquale 1999). The structural modelling approach involves directly obtaining the estimates of housing supply elasticities by estimating the structural model of new housing supply. The reduced-form modelling approach involves estimating the reduced-form model of housing price and draw inference about housing supply elasticities based on the estimates of the income elasticity of housing price and the estimates of the elasticities of housing demand with respect to housing price and income. Because the structural models of new housing supply in existing studies have been discussed in subsection 3.4.1, this subsection mainly focuses on the reduced-form modelling approach to estimating housing supply elasticities.

Malpezzi & Maclennan (2001) drew inferences about housing supply elasticities based on the estimates of the elasticities of housing demand with respect to housing price

and income from literature and the estimates of the income elasticity of housing price from their estimation. They developed a three-equation flow model of housing market and derived a reduced-form model of housing price in which housing price is specified as a function of income and population. They then expressed housing supply elasticities as a linear combination of the income elasticity of housing price and the elasticities of housing demand with respect to housing price and income. The income elasticity of housing price can be obtained by estimating the reduced-form model of housing price, and the elasticities of housing demand with respect to housing price and income can be obtained from literature. Considering the durable nature of housing, construction lags and significant transaction costs, they also developed a stock adjustment model. Recognizing that the estimation results can be sensitive to the time span of the data, they estimated housing supply elasticities over very long time frames (1889-1994 for the US and 1850-1995 for the UK). According to the inferences based on the estimation results for the flow models, in the pre-war period the implied housing supply elasticities were between 4 and 10 for the US and between 1 and 4 for the UK. In the post-war period the implied housing supply elasticities were between 6 and 13 for the US and between 0 and 1 for the UK. According to the inferences based on the estimation results for the stock adjustment models, in the post-war period the implied housing supply elasticities were between 1 and 6 for the US and between 0 and 1 for the UK (due to the lack of good housing stock data, the stock adjustment model was not estimated using data for the pre-war period). They argued that since housing finance and tax polies were more preferential and the regulatory environment was less restrictive in the US, housing supply was more elastic in the US.

The approach used by Harter-Dreiman (2004) to estimating housing supply elasticities is similar to that used by Malpezzi & Maclennan (2001). Harter-Dreiman also drew inferences about the housing supply elasticities based on the estimates of income elasticity of housing price and the assumption about the elasticities of housing demand with respect to housing price and income. The estimates of income elasticity of housing price were obtained by estimating a co-integrating equation which represents the long-run relationship between housing price and income. She estimated the co-integrating equation using panel data for 76 US metropolitan statistical areas (MSAs) for the period 1980-1998. She also split the data into subgroups according to population density or Malpezzi's city-specific regulatory index (Malpezzi 1996) and estimated the model using date for each subgroup. According to the inferences based on the full sample estimation, the implied housing supply elasticities were between 1.8 and 3.2. According to the inferences based on the estimation for the pools of constrained and unconstrained MSAs, the implied housing supply elasticities for the unconstrained MSAs (between 2.6 and 4.3) were larger than those for the constrained MSAs (between 1.0 and 2.1). This result is consistent with the theoretical expectation that housing supply responds more quickly and efficiently to a demand shock in unconstrained areas. According to the inferences based on the estimation for the pools of large and small MSAs, the implied housing supply elasticities for the large MSAs (between 1.4 and 2.7) were greater than those for the small MSAs (between 0.9 and 2.1). She argued that this indicates that population density was not likely to be the source of differences in the housing supply elasticities.

3.5 The demand-side determinants of housing price

The theoretical analysis presented in section 2.5 suggests that population, the cost of owning a home and the capacity to own a home are important factors affecting the demand for housing in a particular city. This section reviews empirical studies on the demand-side determinants of housing price.

3.5.1 Population and population structure

As analysed in section 2.5, population is expected to be positively related to the demand for housing and the level of housing price. Maennig & Dust (2008) examined the impacts of population growth and decline on housing price using date for 98 German metropolitan areas in 2002. They found that population growth had no significant impact on housing price. However, population decline led to a significant decline in housing price. They argued that the asymmetric housing price reaction was due to the asymmetric housing supply reaction. Because the building industry in Germany exhibited an adequate level of construction capacity, housing supply was able to respond quickly to demand shocks. Thus, the increase in the demand for housing caused by population growth could be satisfied without price effects. However, as a result of the typical European construction methods, the reduction in housing stock occurred very slowly in regions subject to population decline, resulting in a significant decrease in housing price. Levin, Montagnoli & Wright (2009) examined the effects of demographic changes on housing price in Scotland and England using the so-called difference-in-differences methodology. They regressed the difference in housing price growth between the two regions on the difference in income growth, the difference in total population growth and the difference in the population growth of each age group. They argued that the major advantage of the

difference-in-differences methodology was that the determinants of housing price which were constant across regions (such as the financial and institutional factors) could be netted out, allowing one to focus more exclusively on the effects of demographic changes. They found that population growth, or more specifically, the increase in the number of people aged 20-29 and 30-44 put upward pressure on housing price. Hwang & Quigley (2006b) investigated the impacts of national and regional economic conditions on local housing markets using panel data for 74 US metropolitan areas for the period 1987-1999. They estimated an empirical model consisting of three equations predicting housing price, housing supply and vacancies in the owner-occupied housing markets. They found that the change in the number of households had a positive and statistically significant effect on housing price.

Population growth is often caused by the inflow of immigrants. Chen, Guo & Wu (2011a) examined the impacts of rural-urban migration and urbanization on China's housing price using panel data for 29 provinces for the period 1995-2005. They argued that as a result of the unique household registration system, the internal migration in China is divided into two categories: official migration with the transfer of household registration and unofficial migration without the transfer of household registration. The state-supported urban affordable housing is not available for the migrants without the transfer of household registration (also referred to as the floating population). They found that the effects of urbanization level and unofficial migration on housing price varied between developed coastal provinces and less-developed inland provinces. In coastal provinces, unofficial migration had no significant effect on housing price while the urbanization level had a negative and statistically significant effect on housing price. In inland provinces, unofficial migration and the urbanization level had a

positive and statistically significant effect on housing price. They argued that the different effects of urbanization and unofficial migration on housing price can be explained by different housing price and different thresholds of obtaining official urban household registration in different regions. van der Vlist, Czamanski & Folmer (2011) examined the effect of immigration on housing price in Haifa (Israel). As a result of Israel's fairly loose immigration policy, there was a large inflow of immigrants during the 1990s in Haifa. They estimated an autoregressive distributed model of housing price using panel data for 34 tracts for the period 1989-1999. The spatial spill-over effects and the effect of the government mortgage programme were taken into account in the model. They found that there existed a co-integrating relationship between housing price and population. Population had a positive and statistically significant effect on housing price. They also found that over 70 per cent of the gap between the current price and its fundamental value was filled within one year. They argued that because the planning application system was relatively efficient in Israel and there were many national programmes implemented to promote housing construction, housing supply was able to respond quickly to demand shocks. Gonzalez & Ortega (2013) examined the impacts of immigration on housing price and housing stock in Spain using panel data for 50 provinces for the period 2000-2010. The change in housing price (or the change in housing stock) was explained as a function of the change in working-age population (which was largely driven by immigration in the sample years) and a vector of control variables (including one-year lag of housing price or quantities, the employment-to-population ratio and regional dummies). Since housing price and migration decision tend to be simultaneously determined, they used two variables to instrument the change in working-age population: an "ethnic networks" instrument based on the settlement patterns of earlier immigrants and a

"gateways" instrument based on the geographical accessibility of each province with respect to immigrants' countries of origin. They argued that the use of the "gateways" instrument is justified by the fact that immigrants from some main source countries have only entered Spain in recent years. They found that the estimates of the coefficients on the change in working-age population obtained when using the instrumental variable approach were almost twice the magnitude of the corresponding OLS estimates. Immigration resulted in a sizable increase in both housing price and the housing stock.

Levin, Montagnoli & Wright (2009) suggested that the age structure of the population played an important role in determining housing price. They argued that young people aged 20s and early 30s tend to be first-time buyers and people aged 30s and 40s tend to sell and buy housing in response to increased income and life-cycle events. Andrew & Meen (2003b) and Chen et al. (2012) estimated models of household formation using data from the British household Panel Survey. They found that the probability of forming a new household increased with age. Huang & Clark (2002) estimated a model of housing tenure choice using data from the 1996 national survey of housing in China. They found that age had a curvilinear impact on the probability of choosing home ownership. The coefficient on age was positive and the coefficient on age squared was negative, and the probability of owning was highest at the age of 41. In an influential paper, Mankiw & Weil (1989) investigated the effect of demographic change on the demand for housing in the US using cross-sectional data from the US 1970 and 1980 census. They found that the demand for housing service of each individual (measured by per capita housing consumption) jumped sharply between age 20 and 30, remained stable between age 30 and 40, and then declined steadily

afterwards. They then combined the results about the relationship between age and housing demand with time series on the age distribution of the population to generate a new time series about the quantity of housing demand. Mankiw and Weil argued that when the baby bust generation enters the housing market in the 1990s and 2000s, the demand for housing would grow more slowly than in any time between the 1940s and 1980s, and housing price would decrease substantially by 47 per cent by the year 2007. Mankiw and Weil's research has received widespread attention and motivated a series of other works. Hamilton (1991) argued that there are two drawbacks in Mankiw and Weil's model which links the demand for housing to real housing price. Firstly, the model includes a large negative time trend which is difficult to explain. Secondly, housing demand should have a direct impact on the rental price of housing, rather than on asset price. According to Dipasquale & Wheaton (1994), Mankiw and Weil's study pays inadequate attention to the housing supply response. They argued that demographic change would have little effect on housing demand and housing price if the stock elasticity of housing supply is high. Green & Hendershott (1996) examined the impact of age on the demand for housing using data from the US 1980 census. They estimated a hedonic housing price model to estimate the contribution to housing demand of each housing characteristic, and then regressed these contributions on the housing characteristics, the households' demographic characteristics, and the households' income net of housing expenditure. They found that the willingness to pay for a constant-quality house increased slightly with age.

3.5.2 Income

Income level is a measure of the capacity to own a home (or the capacity to live independently). Thus, income level is expected to be positively related to the demand

for housing and housing price. Many studies have examined the role income plays in household formation decision and housing tenure choice.

Ermisch (1999) established a theoretical model of the young people's living arrangements based on an economic analysis of parental-young adult co-residence decisions. In the model, parents are altruistic towards their children, and their welfare is a function of their own utilities and the child's "egoistic" utility. Housing is a local public good for a household. The decisions concerning the finical transfers from the parents to the children are made based on parental income relative to child's income. The model predicts that the parental income is negatively related to the chance of young adults living apart, and the children's income is positively related to the chance of young adults living apart. The effect of housing price on the probability of living apart is closely associated with the price elasticity of the parents' housing demand. Ermisch estimated an empirical model of household formation decisions using data from the British household Panel Survey (1991-1995). He found that higher income for young people increased their departure rete, and higher parental income made it less likely that the young adults left home. The empirical results are consistent with their theoretical analysis. Di & Liu (2006) investigated the determinants of household formation of young adults using data from the American Housing Survey (1985-1995). They found that young people's earning capacity (represented by educational attainment) and their current earnings played an important role in their decision making regarding whether or not to stay with their parents. Differing from the empirical results of Ermisch's study, they found that the level of parents' current earnings was positively related to the tendency of young adults to live independently. They argued that low parental income is associated with generational poverty which

can reduce the probability of young adults living independently. Haurin, Hendershott & Dongwook (1994) examined the household formation decision and housing tenure choice of American youth. They took into account the possible simultaneity between income and household formation. They argued that income is the product of wage rate and the quantity of labour supplied which is associated with both household formation decision and housing consumption. Thus, income should be treated as an endogenous variable in the models of household formation and housing tenure choice. They estimated a truncated bivariate probit model using data from the US National Longitudinal Survey of Youth. They chose the wage rate (an exogenous variable) rather than the current or permanent income as the measure of potential earning capacity to address the endogeneity problem. They found that wage rate played an important role in the young adults' decision making about whether to live alone or live with their parents or other adults. The elasticity of demand for housing with respect to wage rate was about 0.5.

Because housing price is usually relatively high for young adults whose earning capacity is relatively low, it is quite common for parents to help their children finance home purchases. The capacity of parents to assist their children in purchasing a home is usually measured by parental homeownership, parental education level and parental social class. Smits & Mulder (2008) investigated the impacts of parental homeownership and household events (including cohabitation, marriage and having children) on transition to first-time homeownership. They argued that there are four potential explanations for the intergenerational transmission of homeownership. Firstly, parents who own their housing are more capable of providing financial assistance for their children than parents who rent their housing. Secondly, parents and

children tend to operate in similar housing markets. Thus, if the parents receive housing service from the owner-occupied sector, the children are more likely to become homeowners. Thirdly, homeownership can be taken as the outcome of an individual's socio-economic status. Higher socio-economic status of the parents tends to lead to higher socio-economic status of the children and the higher likelihood of homeownership for the children. Fourthly, young adults who grow up in an owner-occupied household appear to have a strong motivation to become homeowners themselves. Smits and Mulder estimated a logistic regression model using data from the Netherlands Kinship Panel Study. They found that those with parents who owned their homes had a greater probability of becoming homeowners, and parental ownership had become more important in determining the housing tenure choice of young adults over time. They argued that rising housing price increased the importance of parental support and parental ownership. Ost (2012) examined the impacts of family background on fist-time homeownership. He estimated a model of housing tenure choice using data from the Swedish Housing and Labour Market Career Cohort study. The dataset includes the information on three birth cohorts (born in 1956, 1964 and 1974) that face different housing policies and housing market conditions when entering the housing market, allowing the investigation of cohort effect for tenure decision. Parental wealth was measured in three dimensions in their study: whether the parents owned their housing; the father's occupational group; and whether the young adult grew up with a single parent. It is also noteworthy that homeownership in Sweden includes both owner-occupancy and tenant-ownership. They found that family background played an important role in determining the housing tenure choice of young adults. Having parents who owned their housing significantly increased the likelihood of youngsters becoming homeowners (for both

owner occupancy and tenant ownership). All else equal, young adults with a father who was university educated or self-employed were more likely to buy a tenant-owned apartment. Having grown up with a single parent seemed to restrict access to homeownership for young people. There was a significant cohort effect in youngsters' decision to become a tenant owner, and parents' homeownership had become a more important predictor of whether to buy a tenant-owned apartment for youngsters born in 1974.

3.5.3 The user cost of owner-occupied housing

As analysed in section 2.5, the user cost of owner-occupied housing is a measure of the cost of owning a home. The demand for owner occupancy tends to decrease as the user cost of owner-occupied housing increases.

In the late 1970s and early 1980s, some scholars (Dougherty & Van Order 1982; Kearl 1979; Poterba 1984) applied the life-cycle models to housing consumption and suggested that the correct measure of the user cost of owner-occupied housing should be an after-tax inflation-adjusted measure. Since then, many studies have found that the user cost of owner-occupied housing play an important role in determining housing price (Dipasquale & Wheaton 1994; Hwang & Quigley 2006b; Li & Chand 2013; Oikarinen 2009; Oikarinen 2012). According to existing studies, the formula for calculating the user cost of owner-occupied housing generally takes the following form:

$$UC = \left(1 - t_y\right)\left(i + t_p\right) + m + \delta + \gamma - \pi^e \tag{3.1}$$

where UC is the user cost of owner-occupied housing, t_y and t_p are the marginal tax rates on income and property, respectively, i is the nominal interest rate, m is the

maintenance cost as a percentage of replacement asset value, δ is the depreciation rate for housing, γ is the risk premium to compensate homeowners for the higher risk of owning than renting, and π^e is the expected rate of housing price appreciation. Mortgage interest and property tax payments are deductible from taxable income in many countries. Thus, $(1 - t_y)(i + t_p)$ is the after-tax cost of debt and property tax. There are generally two approaches to estimating the expected rate of housing price appreciation (π^e). One approach is based on the macroeconomic theory of rational expectations (Dipasquale & Wheaton 1994). The theory assumes that consumers constantly adjust their price expectation according to the best available information on exogenous changes. Thus, the expected value of future housing price can be estimated based on the expected value of future exogenous variables. Another approach assumes that expectations are formed from the patterns of past price movements (Dipasquale & Wheaton 1994; Englund, Hendershott & Turner 1995; Himmelberg, Mayer & Sinai 2005; Oikarinen 2009; Oikarinen 2012). Most existing studies have employed the second approach (the backward-looking price expectations approach) to estimate the expected rate of housing price appreciation. Dipasquale & Wheaton (1994) used the three-year moving average of past housing price inflation to measure the expected rate of housing price appreciation. Himmelberg, Mayer & Sinai (2005) used the average real growth rate of housing price between 1940 and 2000 as the proxy for the expected rate of housing price appreciation. Oikarinen (2009) used the average real housing price inflation for the period 1975:1-2006:2 to measure the expected rate of housing price appreciation. Hwang & Quigley (2006a) calculated the expectation of annual housing price appreciation with AR-GARCH processes.

3.5.4 Mortgage lending constraints

Mortgage lending constraints can reduce the capacity of households to finance home purchases. Thus, the demand for owner occupancy tends to decrease as mortgage lending constraints become more restrictive.

Linneman & Wachter (1989) examined the impact of mortgage lending constraints on the likelihood of homeownership. They estimated the model of housing tenure choice using data from 1977 Survey of Consumer Credit and 1983 Survey of Consumer Finances in the US. They found that income-, and wealth-constrained households were less likely to choose homeownership than unconstrained households, but the adverse impact of borrowing constraints on homeownership had reduced over time. They argued that the diminished effect of borrowing constraints was attributable to financing innovations during the early 1980s (such as adjustable-rate mortgage, seller financing and the growing secondary mortgage markets). Haurin, Hendershott & Wachter (1997) extended Linneman and Wachter's method and took into account the endogeneity of wealth and income. They argued that because housing tenure choice and labour supply are made jointly and labour supply partially determines saving and a household's wealth, wealth tends to be determined simultaneously with housing tenure choice. They used an instrumental variable approach to address the endogeneity problem. Considering that income is also jointly determined with tenure choice, they used an estimate of the wage earned if employed full time instead of permanent income to measure earning ability. They estimated a housing tenure choice model using data from the National Longitudinal Survey of Youth in the US. They found that the mortgage lending constraints significantly reduced the tendency towards homeownership.

Barakova et al. (2003) also investigated the impact of mortgage lending constraints on the likelihood of homeownership. Their research distinguishes between the effects of income-based constraints due to lack of income to meet the requirement to receive mortgage credit, wealth-based constraints due to lack of wealth to satisfy the down payment requirement, and credit-based constraints due to impaired credit and quantifies the importance of each. They estimated a model of housing tenure choice using data from the Survey of Consumer Finances for the years 1989, 1995, and 1998 in the US. To examine the effect of credit-based constraint, they developed a credit score imputation model and applied it to the households in their samples to obtain a pseudo credit score for each household. They found that wealth- and credit-based constraints were key barriers that restricted access to homeownership for households. They also found that because mortgage products were made more accessible to households with little accumulated wealth, the importance of wealth-based constraints had declined steadily during the 1990s.

Oikarinen (2009) added a household debt variable in the model of housing price. He argued that household borrowing data reveal different types of important information related to the demand for housing. Firstly, household borrowing data gives information regarding the credit constraints faced by the households, and credit constraints have a substantial impact on housing tenure choice and housing consumption. Secondly, because household debt is closely associated with interest rate, income expectations and income uncertainty, it is reasonable to argue that it can provide information concerning expected housing price growth (which is included in the user cost of owner-occupied housing). He estimated a model of housing price for Helsinki Metropolitan Area in Finland using a quarterly dataset for the period 1975:1-

2006:2. The explanatory variables in the model include income, household borrowing and the user cost of owner-occupied housing. The loan-to-GDP ratio was used as a measure of household debt. The aggregate income variable was created by multiplying population and per capita disposable income. Thus, the variable caters for both the impacts of income and population growth on housing price. He found that the four variables form a co-integrating relationship. Thus, it is shown that household debt data is of importance in modelling housing prices, particularly when lacking direct data on credit constraints and housing price expectation.

3.6 Housing price volatility

Housing price volatility generally refers to a measure for the variation of housing price over time (Lee & Reed 2014b). Higher housing price volatility can prevent newly-formed households from being committed to homeownership, exacerbate the risks faced by households, increase the likelihood of mortgage foreclosure, and affect decisions to build new homes as well as intergenerational equity (Lee & Reed 2014b; Miller & Peng 2006).

There has been increasing research interest in housing price volatility in recent years. Miller & Peng (2006) employed Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models to examine possible time variation of housing price volatility, using a quarterly panel dataset covering 227 metropolitan statistical areas (MSAs) in the US for the period 1990:1-2002:2. They found that there was evidence of time-varying volatility in about 17 per cent of the MSAs. Miles (200, 2011) also found that there was volatility clustering effect in US housing markets. The presence of volatility clustering effect has also been observed in many Australian

capital cities (Lee 2009). Using a Component-generalized Autoregressive Conditional Heteroscedasticity (C-GARCH) model, Lee & Reed (2014a) found that the conditional volatility of housing price can be decomposed into a "permanent" component and a "transitory" component.

3.7 The determinants of housing price in China

As analysed in chapter 1, there has been a remarkable boom in housing price in China since the establishment of the market-oriented urban housing sector. Existing studies have suggested that the determinants of housing price in China mainly include population, income, the user cost of owner-occupied housing, monetary policy and land price.

3.7.1 Population and income

As mentioned in section 3.5.1, Chen, Guo & Wu (2011b) found that rural-urban migration and urbanization had a positive and statistically significant effect on housing price in inland provinces. Many studies have also found that income played an important role in determining housing price in China (Ahuja et al. 2010a; Chen, Guo & Wu 2011b; Li & Zhao 2013; Li & Chand 2013; Shen & Liu 2004). Shen & Liu (2004) examined the determinants of housing price in 14 major Chinese cities during the period 1995-2002. They found that a 1 per cent rise in personal disposable income increased housing price by 9 per cent - 11 per cent. Li & Zhao (2013) examined the relationship between income and housing price using data for 35 Chinese cities for the period 1999-2010. They found that there was a nonlinear relationship between income and housing price, and the nonlinear relationship varied significantly across cities.

3.7.2 The user cost of owner-occupied housing

Li & Chand (2013) estimated a model of housing price using data for 29 provincial-level divisions for the period 1998-2009. They found that a 1 percentage point rise in the user cost of owner-occupied housing reduced housing price by 0.95 per cent. Wu, Gyourko & Deng (2012b) calculated the ratios of price-to-rent in 8 major Chinese cities using constant-quality housing price and rent series developed by themselves, and found that the ratios of price-to-rent were fairly high. They argued that the results implied that the user cost of owner-occupied housing was very low (between 2.5 per cent and 3.3 per cent) in those cities.

3.7.3 Monetary policy

Xu & Chen (2012) examined the impacts of monetary policy on housing price in China. They argued that monetary policy can exert effects on housing price through a variety of channels in China. Firstly, the mortgage interest rates are adjusted according to the long-term benchmark bank loan rates set by People's Bank of China (PBC, China's central bank). Secondly, the money supply, which influences the loan-making capacity of commercial banks, is controlled by PBC through setting reserve requirements and conducting open market operations, i.e. purchasing and selling government bonds and issuing central bank bills. Thirdly, the real estate credit policies such as mortgage down payment requirement, mortgage interest rate requirement, etc. formulated by the central government play an important role in influencing mortgage availability. In the empirical analysis, they estimated a model of housing price using quarterly data for the period 1998:1-2009:4 and monthly data for the period July 2005-February 2010. Hot money flow, lagged stock market return and CPI growth were included as control variables in the model. They found that decreasing benchmark

bank loan rates, faster money supply growth and loosening mortgage policy all tended to accelerate housing price growth. Lagged stock market return had a positive and statistically significant effect on housing price. They argued that this effect can be explained by the wealth effects of stock market. Liang & Cao (2007) examined the relationship between bank lending and housing price in China using data for the period 1999:1-2006:2. They found that there was a unilateral causality running from bank lending to housing price.

3.7.4 Land price

Wen & Goodman (2013) examined the relationship between land price and housing price in China. They estimated a simultaneous equation model of land price and housing price using data for 21 major Chinese cities for the period 2000-2005. They argued that their research differs from previous studies examining the relationship between land price and housing price in three ways. Firstly, they took into account the possibility that land price and housing price are determined simultaneously. Secondly, in addition to land price and housing price, they also included a set of exogenous variables such as per capita disposable income, population growth rate and employment rate in their model. Thirdly, they used panel data set which provides diverse regional and time-varying experiences rather than national-level time series data. They found that land price has a positive and statistically significant effect on housing price.

Wu, Gyourko & Deng (2012b) examined the change in the price of residential land transacted by public bidding or auction in Beijing for the period 2003-2010. They found that the average share of land price in housing price during the sample period

was 0.37 and residential land had become more expensive relative to structure since 2008. They also estimated a hedonic land price model, and found that the winning bidder being a central state-owned enterprise significantly increased land price. Developers' expectation of housing price (measured by lagged change in housing price) was positively associated with land price. They suggested that the effect of central state-owned enterprise bidders on land price can be explained by the fact that they were more ambitious in acquiring land parcels and had relatively easy access to low-cost capital.

3.8 Summary

This chapter reviews the empirical literature on residential land supply, new housing supply and housing price. The review shows that although government intervention in land markets takes different forms in different countries, it does play an important role in limiting the supply of land for housing development. Existing studies have provided empirical evidence that land supply can be an important determinant of new housing supply and housing price. Based on the urban spatial theory, new housing supply is specified as a function of the changes in housing price and cost variables rather than a function of the levels of housing price and cost variables in many recent studies. Structural modelling approach and reduced-form modelling approach are two widely used approaches to estimating housing supply elasticities. Existing studies have provided empirical evidence that population and population structure, income, the user cost of owner-occupied housing and mortgage lending constraints are important factors affecting the demand for housing and housing price.

Chapter 4: China's housing and land reform during the period 1970s-1990s and the introduction of China's land use system

4.1 Introduction

China had a planned economy between the establishment of the People's Republic of China and the implementation of reform and opening up policies in 1978 (Peng & Thibodeau 2012). In the period of planned economy, housing was treated as a component of social welfare and was produced and allocated under a welfare-oriented system (Chen, Hao & Stephens 2010; Wang 1995; Wang & Murie 1996). The Chinese government launched pilot housing reform programmes in some selected cities shortly after the beginning of the economic reform. The housing reform was then extended to the whole country in the late 1980s (Deng, Shen & Wang 2011; Huang 2004; Wu 1996). Although the housing reform aimed at commercialising the urban housing sector, a large proportion of housing units were not allocated through market mechanism until 1998. In 1998, the traditional welfare-oriented system was abolished, and the market-oriented urban housing system was finally established in China (Chen, Hao & Stephens 2010; Deng, Shen & Wang 2011; Wu, Gyourko & Deng 2012b).

Although the empirical analysis in this study focuses on the period after the establishment of the market-oriented urban housing sector, reviewing the history of China's housing reform and urban land reform during the period 1970s-1990s helps one to get a better understanding of the evolution of China's housing and land systems. Thus, an overview of China's housing reform and urban land reform during the period 1970s-1990s is presented in this chapter (section 4.2 and section 4.3). This chapter

also provides an introduction of China's land use system (presented in section 4.4) to facilitate the empirical analysis in following chapters.

4.2 China's housing reform during the period 1970s-1990s

China's housing reform during the period 1970s-1990s can be divided into three stages: pilot reform implemented in selected cities between the late 1970s and late 1980s, nationwide housing reform from the late 1980s to 1998, and the establishment of a market-oriented urban housing system in 1998.

4.2.1 The pilot reform between the late 1970s and the late 1980s

In the period of planned economy, renting public housing was the only tenure choice available for urban households in China (Chen, Hao & Stephens 2010; Huang & Clark 2002; Wu 1996). Work units (government institutions and state-owned enterprises) played a major role in housing allocation (Chen, Hao & Stephens 2010; Deng, Shen & Wang 2011; Wu, Gyourko & Deng 2012b). They leased housing units to their employees at low rent according to the employees' occupational rank, seniority, marital status, family number, current housing conditions, etc. (Deng, Shen & Wang 2011; Ho & Kwong 2002; Wu 1996). The work units which were at a higher level of administrative hierarchy (or which were good at making a profit) were more capable of providing public housing for their employees (Huang 2004; Huang & Clark 2002; Wu 1996). A major problem in this heavily subsidised public housing system was that the costs of housing construction and maintenance could not be recouped. Thus, housing investment became a heavy burden on the state budget, and the lack of funding led to severe housing shortage and poor living conditions (Fong 1989; Ho & Kwong 2002; Wang 1995; Wang & Murie 1996; Wu 1996). According to the first

national housing survey, 3.3% of the urban households were clarified as homeless, approximately 11.5% were living in overcrowded conditions with one or two families in a single room, and the average per capita living space for all households was merely 6.4 square meters (Fong 1989; Wang 1995). The survey also revealed that a large percentage of housing units were not well-equipped. Approximately one-third of housing units had no kitchen or running water, and two-thirds had no flush toilet (Fong 1989; Ho & Kwong 2002).

In order to provide adequate housing for urban residents and reduce the fiscal burden on the government, the Chinese government launched housing reform in the late 1970s (Deng, Shen & Wang 2011; Fong 1989; Wang & Murie 1996; Wu 1996). In the initial stage of the reform, a series of experiments were carried out in pilot cities to encourage the commodification of public housing. In 1982, new housing units were allowed to be sold to the households in four selected cities (Zhengzhou, Changzhou, Siping and Shashi) (Fong 1989; Wang & Murie 1996, 2000). According to the selling policy, the local governments and the work units provided the potential homebuyers with a subsidy equal to two thirds of the stipulated housing price and the homebuyers only had to pay one third of the housing price. However, the trial was terminated in 1985 for two reasons (Ho & Kwong 2002; Wang & Murie 1996). Firstly, although the price of new housing units was pretty low compared with the annual household income, there was still no adequate incentive for most of the households to enter into homeownership since the heavily subsidized rental system remained intact. Secondly, the local governments and the work units were reluctant to provide the huge subsidies for home purchases. Based on the lessons learned from the previous reform trial, new measures (raising public housing rent and selling public housing to the households at

the same time) were implemented in Yantai in 1987 (Fong 1989; Wang & Murie 1996, 2000). The public housing rent was increased from 0.07 - 0.08 RMB/square meter to more than 1 RMB/square meter. The new rent could largely cover maintenance fee, management fee, depreciation expense and investment interest expense. In order to alleviate the impact of the upward rental adjustment, housing vouchers (which could be used to pay the rent) were provided for urban households. The public housing was sold at a price which consisted of the construction cost and the compensation fee for land expropriation.

4.2.2 Nationwide housing reform between the late 1980s and 1998

In 1988, the State Council (China's central government) issued an important document, *Implementation Plan for a Gradual Housing System Reform in Cities and Towns,* which marked the commencement of the nationwide housing reform (Deng, Shen & Wang 2011; Ho & Kwong 2002; Wang & Murie 1996, 2000). After the issue of the document, local governments in many cities formulated policies to adjust public housing rent and sell public housing units to urban residents. In 1994, the central government issued a more comprehensive policy document, *The Decision on Deepening the Urban Housing Reform*, which set goals for the housing reform and laid out the overall strategies (Deng, Shen & Wang 2011; Ho & Kwong 2002; Wang & Murie 1996, 2000). It was claimed that the reform aimed at realising the commercialization of the urban housing sector, boosting residential construction, improving housing conditions and satisfying the growing demand for housing. The new strategies comprised four aspects: establishing a dual housing provision system in which middle- and low-income households could purchase subsidized affordable housing and high-income households could purchase commercial housing; Setting up

a compulsory housing saving programme called Housing Provident Fund; establishing a housing insurance system and a housing finance system within which both policy-oriented loans and commercial loans are provided; establishing a regulated market system of housing transactions, maintenance and management.

During the 1990s, although a significant proportion of new housing units had been constructed through the market mechanism, housing units were not necessarily allocated through the market mechanism (Deng, Shen & Wang 2011; Ho & Kwong 2002; Huang 2004; Wang & Murie 1996; Wu 1996). Work units were still providing low-rent housing or heavy rent subsidies for their employees until the late 1990s. For example, the rent for public housing was less than 5% of the household income in Chongqing in 1998 (Huang 2004). In addition, many work units bought commercial housing units (the housing units which are constructed by housing development companies and sold at the market price) and then resold them at discounted price to their employees. In 1992, only 5.9%, 18.9% and 22.3% of the commercial housing units were sold directly to the urban households in Beijing, Tianjin and Shanghai, respectively (Wu 1996). Many researchers argued that the deep involvement of work units in housing provision was due to the persistence of traditional wage and work-units systems (Deng, Shen & Wang 2011; Huang & Clark 2002; Wang & Murie 1996; Wu 1996). Under the traditional wage and work-units systems, the cash salary received by the labours was too low to cover the costs of purchasing commercial housing units. Thus, work units continued to provide low-rent public housing for their employees or sell housing units to the employees at heavily discounted price.

4.2.3 The establishment of the market-oriented urban housing system in 1998

In 1998, the State Council issued *Notice on Further Deepening the Reform of the Urban Housing System and Accelerating Housing Construction*, which marked the establishment of the market-oriented urban housing system (Deng, Shen & Wang 2011; Ho & Kwong 2002; Wang & Murie 2000). According to the document, work units were prohibited from providing rental housing for their employees from the second half of 1998 onwards. In cities where the ratio of housing price to income was greater than 4, work units were allowed to provide home purchase allowance for the employees who didn't own a home or who lived in a housing unit below the stipulated standard. After the 1998 housing reform, the vast majority of urban households have to buy or rent housing in the private housing market (Chen, Hao & Stephens 2010; Wu, Gyourko & Deng 2012b). Existing studies have suggested two reasons for the abrupt abolition of the traditional welfare-oriented housing system in 1998. Firstly, after the Asian financial crisis in 1997 which had a significant negative effect on the Chinese economy, the Chinese government intended to stimulate economic growth by promoting housing consumption, which in turn hinged on the separation of housing provision from the old social benefit system (Deng, Shen & Wang 2011; Lee & Zhu 2006). Secondly, the tremendous expenditure on housing provision under the welfare-oriented housing system had significantly impaired the competitiveness of the state-owned enterprises (SOEs), and served as a major obstacle to the reform of the SOEs (Deng, Shen & Wang 2011; Wang 2001).

4.3 China's urban land reform during the period 1970s-1990s

China's urban land reform during the period 1970s-1990s can be divided into two stages: the introduction of the land use fee/tax between the late 1970s and late 1980s,

and the establishment of the legal foundation of China's land market system between the late 1980s and 1990s.

4.3.1 The introduction of the land use fee/tax between the late 1970s and late 1980s

Before the establishment of the People's Republic of China (PRC) in 1949, private land ownership existed in China (Ding 2003; Xie, Parsa & Redding 2002). After 1949, land reform was launched to nationalize urban land and collectivize rural land, and there has been no private land ownership in China since 1958 (Ding 2003; Lin & Ho 2005). Between the late 1950s and the late 1970s, state-owned urban land was allocated to land users free of charge and without a stipulated time period. In addition, all types of land transactions were prohibited (Xie, Parsa & Redding 2002). The traditional urban land use system led to low efficiency of land use and severe shortage of funds for urban infrastructure. The density of land use was very low in many Chinese cities, and it was quite common that large areas of land in city centres was occupied by warehouses and factories (Ding 2003; Xie, Parsa & Redding 2002).

Since a market economy could not be established without the commercialization of land, the Chinese government put urban land reform on the agenda in the late 1970s (shortly after the commencement of economic reform). Qian (2008) suggested that the introduction of the land use fee can be viewed as the beginning of the urban land reform. In 1979, the National People's Congress enacted *Law on Sino-foreign Cooperative Joint Ventures*, which stipulated that joint ventures were liable to pay a land use fee. After the issue of the document, the land use fee was first charged in Shenzhen, a newly established special economic zone, and then in other pilot cities. In

1988, the State Council enacted *The Provisional Ordinance of Urban Land Use Tax*, which stipulated that all land users in urban areas and industrial zones (except for foreign investors and investors from Hong Kong, Macao and Taiwan, who continued to pay the land use fee) were liable to pay a land use tax. The introduction of the land use fee/tax raised public awareness of the concept of land values and facilitated the subsequent reform (Qian 2008; Xie, Parsa & Redding 2002).

4.3.2 The establishment of the legal foundation of China's land market system between the late 1980s and 1990s

The legal foundation of China's land market system was formally established between the late 1980s and early 1990s (Qian 2008; Xie, Parsa & Redding 2002). In 1988, China's constitution, which previously prohibited all types of land transactions, was amended to allow the transfer of land use rights, and the relevant article in *Land Administration Law* was amended accordingly (Peng & Thibodeau 2012; Qian 2008; Xie, Parsa & Redding 2002; Xu, Yeh & Wu 2009). Since then, land use rights were separated from land ownership, making it possible to privatize land use rights while ownership remains public. In order to provide more detailed legal guidelines for the construction of urban land markets, the State Council issued *the Provisional Ordinance on the Conveyance and Transfer of Land Use Rights over State-owned Urban Land* in 1990 and the National People's Congress enacted *Urban Real Estate Administration Law* in 1994.

4.4 An overview of China's land use system

Under the legal framework which was established in the late 1980s and early 1990s, land ownership is divided into two categories in China: state land ownership and

collective land ownership. Urban land (mainly including land that is located in urban areas and used for transportation, public administration and public services, commercial, industrial, warehousing and residential purposes) is owned by the state, and rural land (mainly including agricultural land located in rural areas) is owned by rural collective economic organizations. Land use rights (LURs), meaning the rights to use a parcel of land (subject to regulatory constraints) for a certain time period, is separated from land ownership, and only LURs, not land ownership, is tradable. Urban development has to be conducted on state-owned urban land, and rural land cannot be used for urban development. The conversion of agricultural land to urban purposes is controlled by the government through land expropriation. The amount of the rural land that can be converted to urban uses in a certain city during a certain time period is regulated by the so-called General Land Use Planning (Tan et al. 2009). Municipal governments[7] are responsible for making the General Land Use Planning at the prefectural level, and the central government and provincial governments are responsible for examining and approving the General Land Use Planning.

In urban areas, the uses to which a piece of urban land can be put are regulated by urban planning. Municipal governments are responsible for making urban planning, and the central government and provincial governments are responsible for examining and approving urban planning. The approaches to allocating the LURs of urban land vary across different types of land uses. When land is used for commercial, industrial and residential purposes, LURs are allocated through market approaches (through land transactions). When land is used for transportation, public administration and public

7. There are five levels of local government in China: provincial level, prefectural level, county level, township level, and village level. Municipal governments refer to the local governments at prefectural level.

services, municipal governments will grant the LURs to land users free of charge and without a stipulated time period. Figure 4-1 provides a graphic illustration of China's land use system.

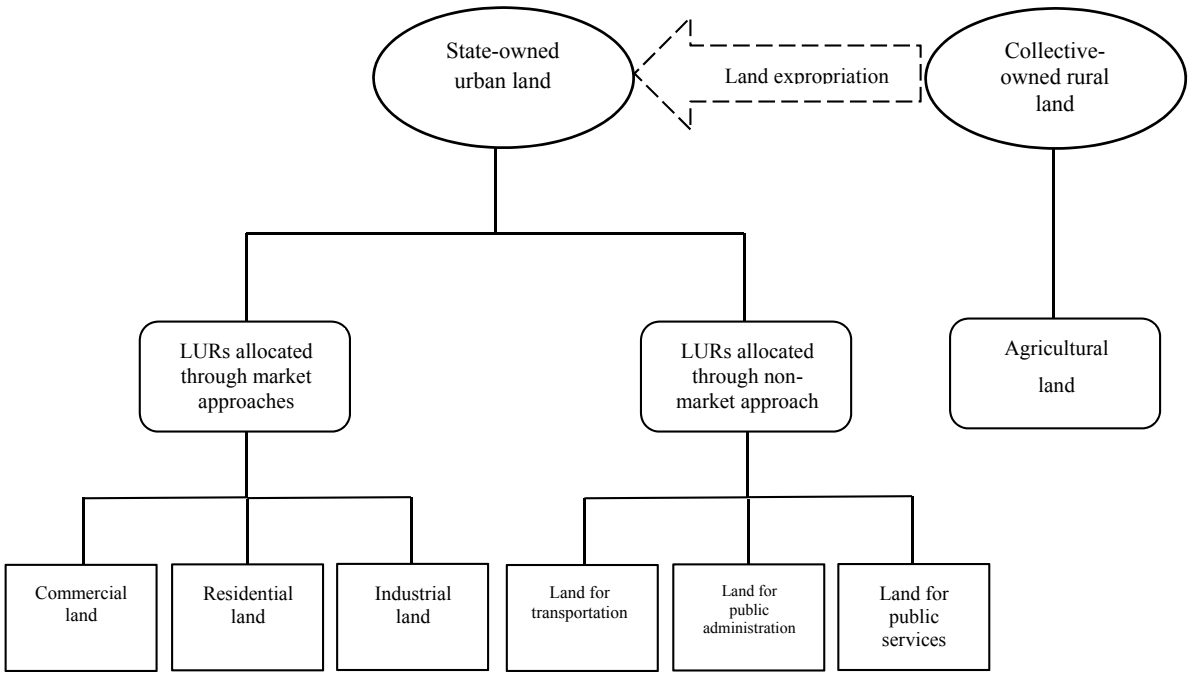

Figure 4-1 An overview of China's land use system

Source: Author

4.5 Summary

This chapter provides an overview of China's housing and land reform during the period 1970s-1990s and an introduction of China's land use system. China's housing reform began with a series of experiments carried out in pilot cities which aimed at commercializing public housing. The housing reform was then extended to the whole country between the late 1980s and 1998. The market-oriented urban housing system was finally established in 1998 when work units were prohibited from providing housing for their employees. China's urban land reform began with the introduction of the land use fee in the late 1970s. The legal foundation of China's land market system was established between the late 1980s and early 1990s when China's constitution was amended and a series of laws and legislations were enacted. Under the legal framework, LURs is separated from land ownership, and only LURs is tradable. Urban development has to be conducted on state-owned urban land, and the conversion of agricultural land to urban purposes is controlled by the government through land expropriation.

Chapter 5: The process leading to stronger government intervention in the land markets in China and the change in residential land supply

5.1 Introduction

The theoretical analysis presented in section 2.2 suggests that government intervention in land markets generally takes one of two forms: land use regulations and direct government control over land supply. In western countries, government intervention in land markets mainly comes in the form of land use regulations (urban containment policies, zoning regulations, master planning, etc.) (Cheshire & Sheppard 2005; Dawkins & Nelson 2002; Evans 1999; Ihlanfeldt 2007; Quigley & Rosenthal 2005). In some countries or regions that have a leasehold tenure system (such as Singapore and Hong Kong), governments can intervene in land markets in a more direct way by acting as a supplier of developable land (Chiu 2007; Hui, Leung & Yu 2014; Hui & Soo 2002; Hui & Ho 2003; Ooi, Sirmans & Turnbull 2011).

In mainland China, the government intervenes in the land markets both through land use regulations and direct government control over land supply. The unique character of the residential land markets in mainland China is that the supply of urban residential land has been completely controlled by municipal governments since 2004. This chapter investigates the process leading to stronger government intervention in the land markets in China (including the establishment of complete municipal government control over urban residential land supply and the imposition of more stringent regulatory constraints on rural-urban land conversion), and examines the

change in residential land supply in the 16 major Chinese cities before and after the 2004 reform.

5.2 The process leading to stronger government intervention in the land markets

Before the establishment of complete municipal government control over urban residential land supply, both existing urban land users and municipal governments were the suppliers in the urban residential land markets in China. After the Ministry of Land and Resources issued Decree No. 71 in 2004, municipal governments have become the sole supplier of urban residential land. In addition, the regulatory constraints on rural-urban land conversion have become more stringent since the issue of *Decision on Deepening Reform and Tightening Land Management* in 2004.

5.2.1 The establishment of complete municipal government control over urban residential land supply

As in many other countries, agricultural land and land previously used for other urban purposes are two important sources of urban residential land in China (Li 2011). Before the establishment of complete government control over residential land supply in August 2004, urban land could be converted from other uses (such as industrial and warehousing purposes) to residential use in two ways (Ding 2007; Du, Ma & An 2011; Peng & Thibodeau 2012; Xie, Parsa & Redding 2002; Yu 2010). In the first way, LURs could be transferred from existing urban land users (such as the stated-owned enterprises) to developers (Ding 2007; Li 2011; Peng & Thibodeau 2012). After obtaining the LURs, developers had to lodge a planning application for the change of land use before starting construction. In the second way, municipal governments

purchased the LURs from existing urban land users,[8] conducted preliminary land development (including removing buildings and ancillary structures, site clearance, levelling land, providing water, electricity, roads, telecommunications and gas infrastructures, and dividing large land tracts into small plots suitable for the conveyance of LURs), and then conveyed the LURs to developers (Li 2011; Xie, Parsa & Redding 2002; Xu, Yeh & Wu 2009). Before August 2004, municipal governments generally conveyed the LURs to developers through four approaches, i.e. tender, auction, listing and negotiation (Du, Ma & An 2011; Peng & Thibodeau 2012; Xu, Yeh & Wu 2009). Tender, auction and listing all referred to a process in which municipal governments made a public announcement to invite developers to bid for the LURs of a given land parcel, and the LURs was conveyed to the bidder who offered the highest land price. When negotiation was employed for land sales, there was no competitive bidding and the land price was determined by the bargaining between municipal governments and developers. Differing from the situation for redevelopment of existing urban land, rural-urban land conversion was completely controlled by the government (Xie, Parsa & Redding 2002). When agricultural land was converted to urban residential use, municipal governments first undertook land expropriation and preliminary land development, and then conveyed the LURs to developers through tender, auction, listing or negotiation. Figure 5-1 shows the processes of urban residential land development before August 2004.

8. Municipal governments generally pay a land price based on the current land use to existing urban land users. For example, when a parcel of land is converted from industrial use to residential use, municipal governments will pay the existing land user based on the estimated price of industrial land.

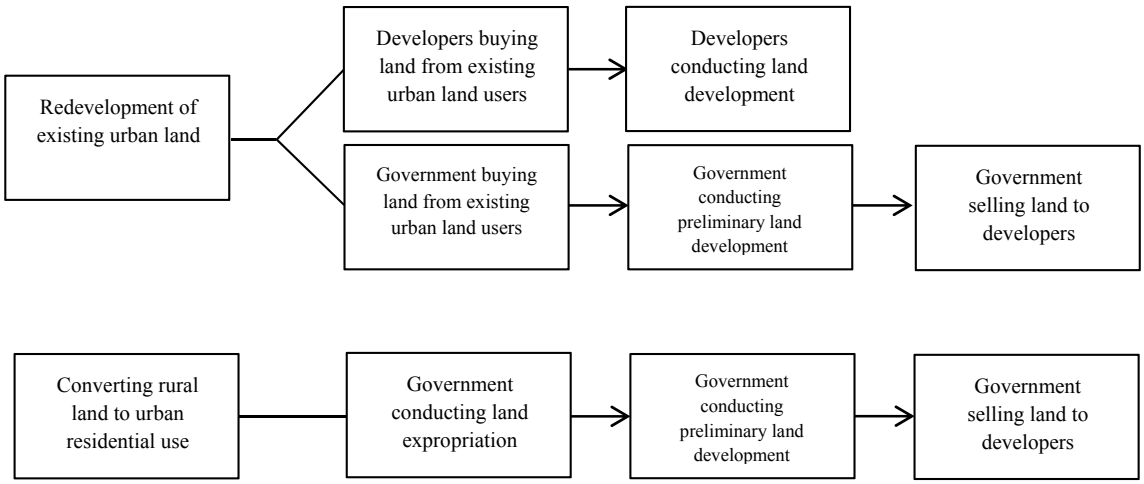

Figure 5-1 Processes of urban residential land development before August 2004

Source: Author

As can be seen from the above analysis, both existing urban land users and municipal governments were the suppliers in the urban residential land markets before August 2004. Figure 5-2 shows the structure of the urban residential land markets before August 2004.

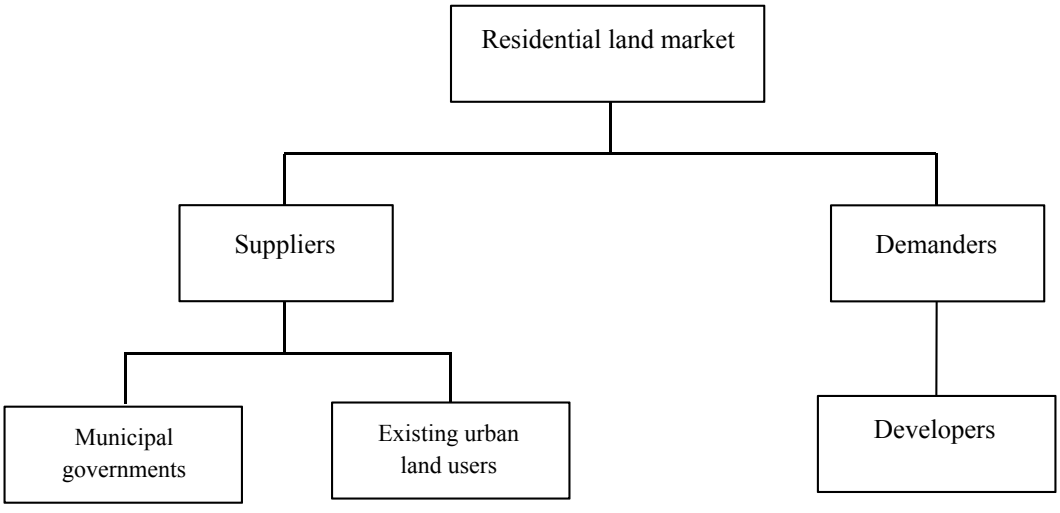

Figure 5-2 Structure of the urban residential land markets before August 2004

Source: Author

In March 2004, the Ministry of Land and Resources issued Decree No. 71, which stipulated that all the land used for urban commercial or residential purposes has to be supplied by municipal governments through tender, auction or listing from August 31th, 2004 onwards (Du, Ma & An 2011; Peng & Thibodeau 2012; Xu, Yeh & Wu 2009). Accordingly, existing urban land users are not allowed to supply land to developers. Urban land can be converted from other uses to residential use in only one way. That is municipal governments purchase the LURs from existing urban land users, conduct preliminary land development, and then convey the LURs to developers. Figure 5-3 shows the processes of urban residential land development after August 2004. There are two main reasons why the Chinese government reformed the urban land supply system in 2004. Firstly, the government intended to ensure the effective implementation of land use planning by imposing more stringent control over urban land development (Qian 2008; Tian & Ma 2009; Xu, Yeh & Wu 2009). Secondly, the reform of urban land supply system can assist municipal governments in increasing their revenues (Tian & Ma 2009; Xu, Yeh & Wu 2009). The tax reform in 1993 led to a reallocation of tax revenue between the central and local governments in China (Chen, Arye & Gu 2002; Wang & Qin 2008). While the tax revenue share for local governments was decreased significantly, the fiscal pressure on local governments to provide public services and infrastructure was not lessened at the same time. Under this situation, municipal governments have increasingly relied on land sales to acquire fiscal revenue. Obtaining complete control over land supply helps municipal governments acquire more revenue from land sales.

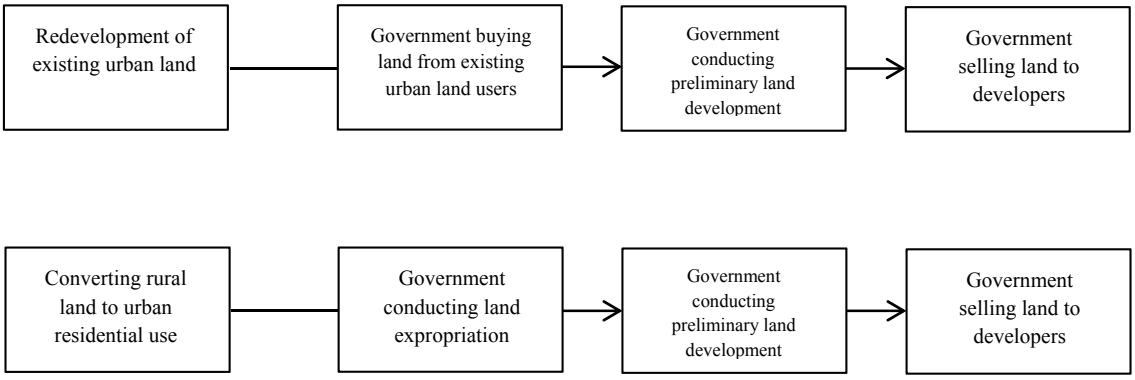

Figure 5-3 Processes of urban residential land development after August 2004

Source: Author

As can be seen from the above analysis, municipal governments became the sole supplier of urban residential land in August 2004. Figure 5-4 shows the structure of the urban residential land markets after August 2004.

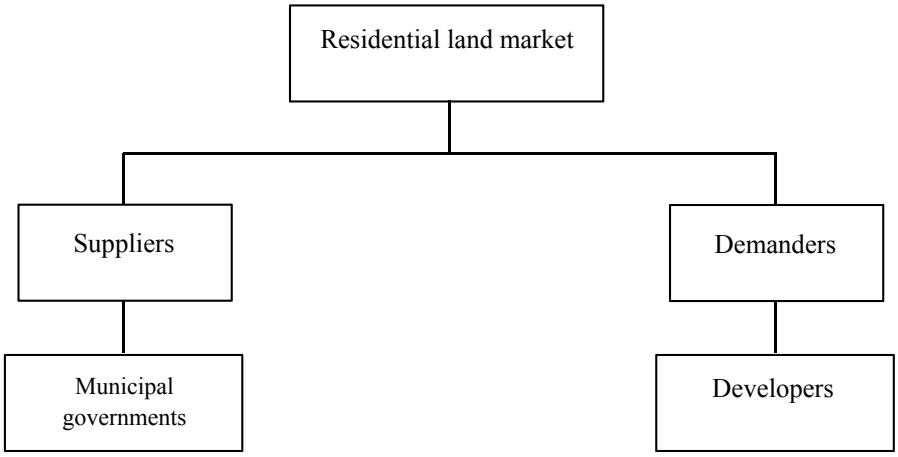

Figure 5-4 Structure of the urban residential land markets after August 2004

Source: Author

5.2.2 The imposition of more stringent regulatory constraints on rural-urban land conversion

The analysis presented in last section suggests that the way in which urban land could be converted from other uses to residential use changed in August 2004, and municipal governments have become the sole supplier of urban residential land. In addition to this change, the regulatory constraints on rural-urban land conversion have become more stringent since the issue of *Decision on Deepening Reform and Tightening Land Management* in October 2004. In the late 1990s and early 2000s, numerous industry parks, economic development zones and urban residential districts were established by municipal governments for the purpose of promoting local economic growth and a large amount of rural land was converted to urban uses without the approval from the central government or provincial governments. In 2004, the central government decided to impose stricter regulatory constraints on rural-urban land conversion based on the following considerations. Firstly, cultivated land protection and food security have always been central concerns of the Chinese government (Deng et al. 2006; Yang & Li 2000). Since China is a country characterised by a vast population and a relative low level of per capita arable land, the central government worried that the rapid loss of cultivated land would threaten food security and lead to social instability. Secondly, slowing down rural-urban land conversion has been used as a measure for cooling down excessive fixed asset investment (Tian & Ma 2009). Rapid growth in investments in some industries (such as steel, aluminium and cement) created excess production capacity during the early 2000s, which posed a serious threat to a sustainable economic growth. The imposition of more stringent restrictions on rural-urban land conversion could be used by the government to cool down an overheated economy. In October 2004, the State Council

issued *Decision on Deepening Reform and Tightening Land Management*, which marked the imposition of stricter regulatory constraints on rural-urban land conversion. In the document, it is stressed that only the central government and provincial governments have the power to approve rural-urban land conversion and land expropriation, and the provincial governments are not allowed to devolve the approval power to lower-level local governments. The establishment of economic development zones and urban residential districts are not allowed beyond the designated urban growth boundaries, and the amount of rural land which can be converted to urban uses during one year cannot exceed mandatory quotas stipulated in the land use planning. All construction projects which entail rural-urban land conversion have to be scrutinised and approved by land administration authorities before starting.

5.3 The change in residential land supply in the 16 major Chinese cities before and after the 2004 reform

Based on the theoretical analysis presented in section 2.2, it is reasonable to expect that the 2004 reform which led to stronger government intervention in the land markets can result in a decline in residential land supply. This section examines the change in residential land supply in the 16 major Chinese cities (which are mentioned in section 1.4) during the period 2001-2011 (before and after the 2004 reform). The reasons for choosing the 16 cities as sample cities are explained in subsection 5.3.1, followed by an overview of the demand side of the real estate markets in the 16 cities in subsection 5.3.2. Subsection 5.3.3 focuses on the change in residential land supply.

5.3.1 Reasons for choosing the 16 cities as sample cities

Since China is a geographically large country with a huge population, the administrative divisions of China consisted of fives levels: provincial level, prefectural level, county level, township level, and village level. At the provincial level, there are 23 provinces, 5 autonomous regions, 4 provincial-level municipalities, and 2 special administrative regions (Xinhuanet 2014). Province-level municipalities are the highest-ranked cities in China. They are not part of provinces, but independent entities whose leaders report directly to the central government (Xinhuanet 2014). At the prefectural level, there are 287 prefectural-level cities. Among the 287 cities, provincial capital cities and sub-provincial cities are cities with higher administrative status. A provincial capital is generally the administrative, economic and transportation hub of a province. A sub-provincial city is governed by a province, but is administratively independent in regard to economy and legislation. The status of sub-provincial cities is above the status of regular prefecture-level divisions which are completely ruled by their provinces.

The empirical analysis in this research focuses on the real estate markets in 16 major Chinese cities, rather than investigating the real estate markets in all the Chinese cities. The 16 major cities are Shanghai, Beijing, Chengdu, Tianjin, Guangzhou, Shenzhen, Wuhan, Qingdao, Hangzhou, Xian, Nanjing, Ningbo, Hefei, Fuzhou, Jinan and Nanchang. Figure 5-5 shows the location of the 16 major Chinese cities. There are four reasons for choosing these cities as sample cities. Firstly, these cities all have high administrative status. Among the 16 cities, there are 3 province-level municipalities (Shanghai, Beijing and Tianjin), 10 provincial capitals (Chengdu, Guangzhou, Wuhan, Hangzhou, Xian, Nanjing, Hefei, Fuzhou, Jinan and Nanchang),

and 3 sub-provincial cities (Shenzhen, Qingdao and Ningbo). Secondly, these cities are among the most populous cities in China. As shown in table 5-1, all the 16 cities had a population of more than 5 million persons in 2011, and the population of the 16 cities accounted for 12.8 per cent of the nation's population in 2011. Thirdly, these cities are among the most important cities in terms of economic activities. As can be seen from table 5-1, 27.2 per cent of China's gross domestic product (GDP) was generated in these cities in 2011. Fourthly, the real estate markets in these cities are among the most important markets in terms of the volume of housing transactions. As demonstrated in table 5-1, the transaction volume for new home sales in the 16 cities constituted 16.2 per cent of the nation's total transaction volume for new home sales in 2011.

Figure 5-5 The location of the 16 major Chinese cities

Table 5-1 Population, GDP and transaction volume for new home sales in the 16 major Chinese cities in 2011

Cities	Administrative status	Population (1,000 persons)	GDP (billion RMB)	Transaction volume for new home sales (hectare)
Shanghai	municipality	23,475	1,920	1,500
Beijing	municipality	20,186	1,625	1,035
Chengdu	provincial capital	14,071	685	2,285
Tianjin	municipality	13,546	1,131	1,366
Guangzhou	provincial capital	12,751	1,242	992
Shenzhen	sub-provincial city	10,467	1,151	469
Wuhan	provincial capital	10,020	676	1,182
Qingdao	sub-provincial city	8,795	662	919
Hangzhou	provincial capital	8,738	702	600
Xian	provincial capital	8,513	386	1,664
Nanjing	provincial capital	8,109	615	681
Ningbo	sub-provincial city	7,628	606	343
Hefei	provincial capital	7,521	364	1,058
Fuzhou	provincial capital	7,200	374	532
Jinan	provincial capital	6,885	441	539
Nanchang	provincial capital	5,089	269	436
Sum of 16 cities (①)		172,994	12,847	15,601
The nation (②)		1347,350	47,156	96,528
①/②		12.8%	27.2%	16.2%

Notes: Population is measured by the number of permanent residents.[9]

Source: Statistical Yearbook of each city (2012), Statistical Communique on the Economic and Social Development of each city (2012), and China Real Estate Statistics Yearbook (2012).

9. In mainland China, the government uses the household registration (hukou) system to control migration between regions and determine the eligibility for access to state-provided public services. According to the definition specified by China's National Bureau of Statistics, the permanent residents in a particular city can be divided into three groups: those who live in the city and have a local household registration, those who have lived in the city for more than half a year but don't have a local household registration, and those who have a local household registration but lived in other cities for less than half a year.

It is noteworthy that the 16 major Chinese cities can be classified into two groups according to population size. Among the 16 cities, seven (i.e. Shanghai, Beijing, Chengdu, Tianjin, Guangzhou, Shenzhen and Wuhan) had a population of more than 10 million persons in 2011, and nine (i.e. Qingdao, Hangzhou, Xian, Nanjing, Ningbo, Hefei, Fuzhou, Jinan and Nanchang) had a population of between 5 million and 10 million persons in 2011. As can be seen from table 5-1, cities with a large population also tend to have a large GDP and a high volume of housing transactions.

5.3.2 An overview of the demand side of the housing markets in the 16 cities

As a result of the rapid increase in population and income, the demand for housing is expected to be high in the 16 cities during the period 2001-2011. Table 5-2 shows the change in population and income in the sample cities during the period. Population increased by more than 10 per cent in all the 16 cities from 2001 to 2011. The population growth rates were highest in Hefei, Beijing and Shenzhen, and lowest in Fuzhou, Nanchang and Jinan. Per capita disposable income increased by more than 100 per cent in 14 out of the 16 cities during the sample period. The growth rates of income were highest in Xian, Nanjing and Nanchang, and lowest in Shenzhen and Guangzhou. Although the growth rates of population and income varied across cities, it is reasonable to argue that most of the cities have experienced a significant growth in population and income which can be expected to generate a significant increase in the demand for housing during the period 2001-2011.

Table 5-2 The change in population and income in the 16 major Chinese cities during the period 2001-2011

Cities	Population in 2001 (1,000 persons)	Population in 2011 (1,000 persons)	Population change (%), 2001-2011	Income level in 2001 (RMB)	Income level in 2011 (RMB)	Income change (%), 2001-2011
Shanghai	16,683	23,475	40.7%	16,287	36,230	122.4%
Beijing	13,851	20,186	45.7%	14,637	32,903	124.8%
Chengdu	11,342	14,071	24.1%	10,276	23,932	132.9%
Tianjin	10,041	13,546	34.9%	11,326	26,921	137.7%
Guangzhou	9,968	12,751	27.9%	18,576	34,438	85.4%
Shenzhen	7,246	10,467	44.5%	29,765	36,505	22.6%
Wuhan	8,313	10,020	20.5%	9,235	23,738	157.0%
Qingdao	7,616	8,795	15.5%	11,038	28,567	158.8%
Hangzhou	7,156	8,738	22.1%	13,775	34,065	147.3%
Xian	7,543	8,513	12.9%	8,477	25,981	206.5%
Nanjing	6,370	8,109	27.3%	11,186	32,200	187.9%
Ningbo	6,112	7,628	24.8%	15,159	34,058	124.7%
Hefei	4,538	7,521	65.7%	8,618	22,459	160.6%
Fuzhou	6,444	7,200	11.7%	10,967	26,050	137.5%
Jinan	6,011	6,885	14.5%	12,092	28,892	138.9%
Nanchang	4,455	5,089	14.2%	7,846	20,741	164.4%

Notes: Population is measured by the number of permanent residents. Income level is measured by per capita disposable income (adjusted to 2011 price level using national consumer price index compiled by China's National Bureau of Statistics).

Source: Statistical Yearbook series of each city (2002-2012) and Statistical Communique on the Economic and Social Development series of each city (2001-2011).

5.3.3 The change in residential land supply before and after the 2004 reform

There was a decline in residential land supply after the 2004 reform. As shown in figure 5-6, for the 16 cities as a whole, annual residential land supply (the site area of land sold to developers for housing development each year) increased noticeably from 8,477 hectares in 2001 to 11,938 hectares in 2002, and stayed relatively high at around 11,000 hectares in 2003 and 2004. It declined dramatically immediately after the 2004

reform (from 10,932 hectares in 2004 to 7,765 hectares in 2005), and fluctuated around a relatively low level afterwards. The average annual land supply for the period 2005-2011 (5,922 hectares) is significantly lower than that for the period 2001-2004 (10,381 hectares). Table 5-3 shows the change in average annual land supply in each city before and after the 2004 reform. All the 16 cities experienced a decrease in average annual land supply after the 2004 reform. Average annual land supply declined by more than 50 per cent in 6 cities (Shanghai, Beijing, Guangzhou, Shenzhen, Wuhan and Ningbo), by more than 30 per cent in 4 cities (Hangzhou, Nanjing, Fuzhou and Nanchang), by more than 15 per cent in 4 cities (Chengdu, Tianjin, Xian and Jinan), and by around 10 per cent in 2 city (Qingdao and Hefei). As can be seen from the above analysis, land supply did not keep pace with the increased demand in the 16 cities after the 2004 reform which led to stronger government intervention in the land markets.

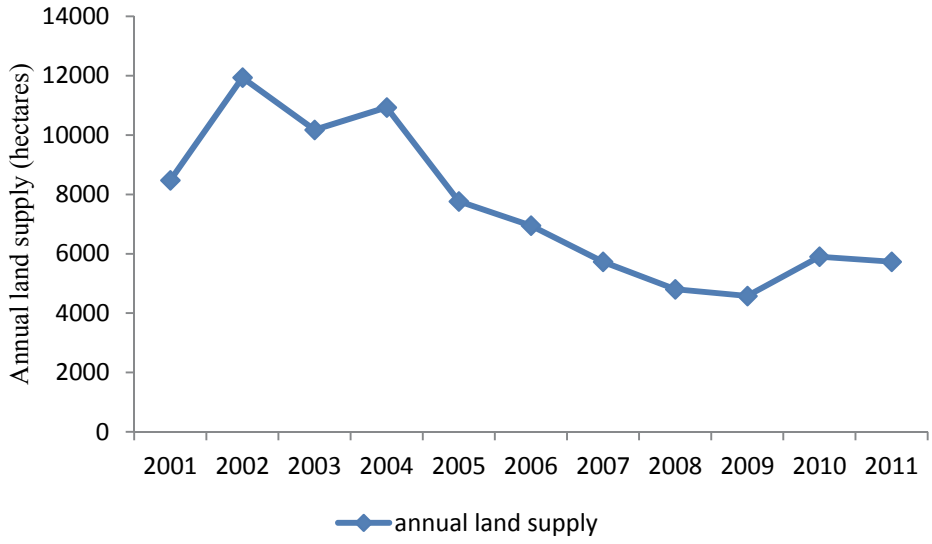

Figure 5-6 The Change in annual land supply for the 16 major Chinese cities during the period 2001-2011

Source: China Statistical Yearbook series (2002-2012)

Table 5-3 The change in average annual land supply in each of the 16 major Chinese cities before and after the 2004 reform

Cities	Average annual land supply for the period 2001-2004 (hectare) (①)	Average annual land supply for the period 2005-2011 (hectare) (②)	(②-①)/ ①
Shanghai	1,064	429	-59.7%
Beijing	1,632	611	-62.6%
Chengdu	751	573	-23.7%
Tianjin	814	703	-16.4%
Guangzhou	745	335	-55.1%
Shenzhen	286	56	-80.4%
Wuhan	957	416	-56.5%
Qingdao	558	507	-9.2%
Hangzhou	801	439	-45.2%
Xian	313	261	-16.8%
Nanjing	507	270	-46.8%
Ningbo	465	217	-53.3%
Hefei	505	430	-14.8%
Fuzhou	433	277	-36.0%
Jinan	258	212	-17.7%
Nanchang	292	186	-36.1%

Source: Author's calculation based on the data collected from China Statistical Yearbook series (2002-2012).

According to the theoretical analysis presented in section 2.2, government intervention in land markets can limit the supply of land for housing development and lead to a potential scarcity of residential land in the presence of high demand for housing. Based on the theoretical analysis, there are primarily three possible explanations for the decline in residential land supply after the 2004 reform. Firstly, more stringent regulatory constraints on rural-urban land conversion can reduce the amount of land available for housing development (Dawkins & Nelson 2002; Kim 1993; Rosen & Katz 1981). Secondly, complete government control can make residential land supply

less responsive to change in the demand for housing. As municipal governments established complete control over residential land supply, they generally determine the annual residential land supply at the beginning of each year based on the projected housing demand and the ability of the government to supply land. However, because the demand for housing is determined by various demographic and socioeconomic factors such as population, income, interest rates, etc., it is difficult to accurately forecast it (Cheshire & Sheppard 2005; Chiu 2007; Vermeulen 2008). When municipal governments are not able to accurately forecast the demand for housing, residential land supply will fail to keep pace with increased demand. In addition, because all residential land transactions have to be incorporated into the tender/auction/listing system after August 2004, the procedures for supplying residential land have become more complicated and time-consuming. This can also reduce the responsiveness of residential land supply to demand change. Thirdly, complete government control over residential land supply can slow down the pace of land conversion from industrial/warehousing use to residential use. As in many other countries, former industrial/warehousing land is an important source of residential land in China (Li 2011). Before the establishment of complete government control over residential land supply, redevelopment of old industrial/warehousing land can be initiated both by developers and municipal governments (as shown in figure 5.1). After the establishment of complete government control, redevelopment of old industrial/warehousing land can only be initiated by municipal governments. Thus, the 2004 reform led to a reduced level of flexibility in the redevelopment process, which in turn can slow down the pace of industrial-residential land conversion. In addition, because municipal governments generally pay a land price based on the current land use to existing urban land users, existing urban land users may feel reluctant to sell old

industrial land to municipal governments. This may also slow down the pace of industrial-residential land conversion.

As mentioned earlier, the decline in residential land supply after the government strengthened the intervention in the land markets was less significant in Chengdu, Tianjin, Xian, Jinan, Qingdao and Hefei. A possible explanation is that because the amount of agricultural land in these cities was higher than that in the other cities (as shown in table 5-4), more agricultural land could be converted to urban residential use in these cities. The effects of the more stringent regulatory constraints on rural-urban land conversion may therefore have been smaller in these cities.

Table 5-4 The amount of cultivated land in each of the 16 major Chinese cities in 2011

	Beijing	Tianjin	Shanghai	Nanjing	Hangzhou	Ningbo	Hefei	Fuzhou
Cultivated land (hectare)	231,688	441,090	243,960	242,100	179,171	236,767	337,560	162,300
	Nanchang	Jinan	Qingdao	Wuhan	Guangzhou	Shenzhen	Chengdu	Xian
Cultivated land (hectare)	280,841	388,724	512,800	204,940	101,200	3,057	325,530	251,400

Source: Statistical Yearbook 2012 of each city.

5.4 Summary

This chapter investigates the process leading to stronger government intervention in the land markets in China, and examines the change in residential land supply in the 16 major Chinese cities before and after the 2004 reform. Since 2004, municipal governments have acquired complete control over urban residential land supply and the central government has imposed more stringent regulatory constraints on rural-urban land conversion. There was a decline in residential land supply after the 2004 reform, but the decline was less significant in cities with a relatively high amount of agricultural land.

Chapter 6: The impacts that the decline in land supply has on new housing supply and housing supply elasticity

6.1 Introduction

New housing supply and its responsiveness to change in housing price deserves critical research attention since it influences the dynamics of housing price and has a significant impact on the broader economy (Glaeser, Gyourko & Saks 2006; Mayer & Somerville 2000b; Saks 2014; Vermeulen 2008; Vermeulen & van Ommeren 2009). Firstly, as suggested by the theoretical analysis presented in section 2.4, an increase in the demand for housing will lead to greater housing price appreciation in regions where housing supply is inelastic (Blackley 1999; Glaeser, Gyourko & Saiz 2008; Glaeser, Gyourko & Saks 2006; Grimes & Aitken 2010; Malpezzi & Maclennan 2001; Ooi & Le 2012; Pryce 1999). Secondly, new residential construction contributes to economic growth both directly and indirectly (Mayer & Somerville 2000b). The demand for building materials, building equipment and construction workers rises with housing starts. New homeowners tend to purchase other commodities (such as furniture and home appliance) when they buy their homes. Thirdly, housing supply can limit the supply of labour by restricting the number of households in a region, with implications for local wage rate and employment (Case 1992; Glaeser, Gyourko & Saks 2006; Saks 2014; Vermeulen 2008; Vermeulen & van Ommeren 2009).

The analysis presented in last chapter suggests that there was a decline in residential land supply in the 16 major Chinese cities after the 2004 reform which led to stronger government intervention in the land markets. Based on the theoretical analysis presented in section 2.3 and section 2.4, it is reasonable to expect that the decline in

land supply can have impacts on new housing supply and the price elasticity of housing supply, and this issue is explored in this chapter. Two research hypotheses are first developed and then tested by developing and estimating models of new housing supply, using panel data for the 16 major Chinese cities for the period 2001-2011.[10]

The remainder of this chapter is organized as follows. Development of research hypotheses is presented in section 6.2. Section 6.3 develops the models of new housing supply which are used to test the hypotheses, and section 6.4 describes the data used for model estimation. Because the models of new housing supply are estimated using panel data, an overview of panel data models and their estimation is provided in section 6.5, followed by a description of the regression procedures in section 6.6. Section 6.7 reports empirical results. A summary follows in section 6.8.

6.2 Development of research hypotheses

The theoretical analysis presented in section 2.3.2 suggests that land supply is positively related to new housing supply in a well-functional market. However, if speculative land hoarding is a prevailing phenomenon, there may be no significant relationship between land supply and new housing supply (Hui & Ho 2003; Peng & Wheaton 1994; Tse 1998). Because the Chinese government has taken measures to prevent speculative land hoarding,[11] land supply is expected to be positively related to new housing supply in China. If land supply is positively related to new housing

10. Some recent studies have estimated the models of new housing supply using city-level panel data or province-level panel data (Gonzalez & Ortega 2013; Grimes & Aitken 2010; Hwang & Quigley 2006b; Mayer & Somerville 2000a; Wang, Chan & Xu 2012).

11. The Ministry of Land and Resources has issued *Measures for the Disposal of State-owned Idle Land* (first issued in 1999, revised in 2012), which stipulated that if developers leave land idle for more than 2 years, local land administration authorities are entitled to confiscate the LURs with no compensation.

supply, it is reasonable to argue that the decline in land supply after the government strengthened the intervention in the land markets has put downward pressure on new housing supply. Thus, the first hypothesis is proposed.

Hypothesis 1: *That the decline in land supply after the government strengthened the intervention in the land markets has put downward pressure on new housing supply*.

According to the theoretical analysis presented in section 2.4, land supply is an important determinant of housing supply elasticity. Thus, the decline in land supply after the government strengthened the intervention in the land markets should lead to a decline in housing supply elasticity. The second hypothesis is proposed based on the above analysis.

Hypothesis 2: *That there was a decline in housing supply elasticity after the government strengthened the intervention in the land markets*.

6.3 Development of models of new housing supply

In this section, models of new housing supply are developed to test the research hypotheses proposed in last section. The basic model of new housing supply is developed to test Hypothesis 1, and a model that incorporates an interaction term between the time dummy variable and the housing price variable is developed to test Hypothesis 2.

6.3.1 The basic model of new housing supply

The theoretical analysis presented in section 2.3 suggests that the factors affecting new housing supply mainly include housing price (Ball, Meen & Nygaard 2010; Gitelman & Otto 2012; Grimes & Aitken 2010; Hwang & Quigley 2006b; McLaughlin 2011,

2012), the cost of housing production (Blackley 1999; Dipasquale & Wheaton 1994; Mayer & Somerville 2000b; Poterba 1984; Pryce 1999; Topel & Rosen 1988), land supply (Bramley 1993; Dipasquale & Wheaton 1994; Hui, Leung & Yu 2014; Lai & Wang 1999; Pryce 1999), and regulatory constraints (Green, Malpezzi & Mayo 2005; Mayer & Somerville 2000a; Mayo & Sheppard 1996; Mayo & Sheppard 2001). The identified factors are included as independent variables in the model of new housing supply. The lagged effect of land supply on new housing supply due to the existence of the pre-development process is also taken into account in developing the model.

The basic model of new housing supply takes the following form:

$$lnHS_{it} = \beta_0 + \beta_1 \Delta lnHP_{it} + \beta_2 \Delta lnCCOST_{it} + \beta_3 \Delta FCOST_{it} + \beta_4 lnLS_{i,t-1} + \beta_5 lnLS_{i,t-2} + \alpha_i + \lambda_t + \varepsilon_{it} \quad (6.1)$$

where subscripts i and t refer to city i and year t, respectively; ln denotes the natural logarithm; Δ denotes the first difference of relevant variables; α_i is a city-specific effect, λ_t is a vector of year-specific dummy variables, and ε_{it} is the idiosyncratic error. The definitions of the variables are as follows:

HS is new housing supply, which is measured by the floor area of housing starts.

HP is average real housing price. Because profit from housing production will increase as housing price increases, developers will become more motivated to undertake new residential construction as housing price increases. Thus, housing price is expected to be positively related to new housing supply.

$CCOST$ is construction cost, which means the cost to build the physical structure of housing units (including the cost of labour, building materials and equipment but

excluding the cost of land). Because profit from housing production will increase as construction cost decreases, developers will become more motivated to undertake new residential construction as construction cost decreases. Thus, construction cost is expected to be negatively related to new housing supply.

$FCOST$ is financing cost for developers, which is measured by the 1-3 year term benchmark bank loan rates. Banks are not free to set interest rates in China, and the People's Bank of China, which is China's central bank, guides the interest rates offered by banks through setting the benchmark interest rates and floating range. Interest rates on real estate development loans can only fluctuate within the stipulated floating range around the 1-3 year term benchmark bank loan rates. Thus, the 1-3 year term benchmark bank loan rates can be used as a proxy for the interest rates on real estate development loans. Because profit from housing production will increase as financing cost decreases, financing cost is expected to be negatively related to new housing supply.

LS is residential land supply, which is measured by the site area of land sold to developers for housing development. Because developers have to obtain planning permits and building permits after acquiring the LURs of new residential land (Zhong, Zhu & Li 2006), land supply tends to affect housing starts with a lag.[12] Zheng (2008) and Ye (2009) suggested that there is generally an interval of one or two years between acquiring the LURs of new residential land and starting construction. In order to test the lagged effect of land supply on housing starts, 1- and 2-year lags of land

12. Because new housing supply is measured by the floor area of housing starts, the time interval between starting construction and completing construction is not taken into account here.

supply are included as independent variables in the model of new housing supply. The analysis presented in section 6.2 suggests that land supply is expected to be positively related to new housing supply in China.

Following Mayer & Somerville (2000b) and many other scholars (Ball, Meen & Nygaard 2010; Hwang & Quigley 2006a; McLaughlin 2012; Meen & Nygaard 2011; Zabel & Paterson 2006), new housing supply is specified as a function of the changes in housing price and cost variables (the first differences of housing price and cost variables) rather than a function of the levels of housing price and cost variables (Poterba 1984; Topel & Rosen 1988). The reasons for doing this are threefold. Firstly, housing starts occur in response to changing market conditions (i.e. an increase in the demand for housing) that require a growth in the housing stock relative to last period (Zabel & Paterson 2006). While the equilibrium level of housing price matches housing stock with the demand for housing, it is the changes in housing price and cost variables that influence the change in housing stock (i.e. new housing supply). Secondly, modelling new housing supply as a function of the changes in housing price and cost variables is more consistent with the temporary response of new housing supply to housing price growth.[13] Dipasquale & Wheaton (1994) suggested that following an increase in the demand for housing, rising housing price will lead to a temporary rather than a permanent increase in building activities. As increased land price moves the cost of housing production towards housing price, housing stock will gradually adjust to the equilibrium level. Thirdly, because new housing supply is a

13. Modelling new housing supply as a function of the levels of housing price and cost variables implies that housing price growth leads to a permanent increase in new housing supply (Dipasquale & Wheaton 1994).

flow variable,[14] it should be specified as a function of other flow variables and the changes in stock variables (Mayer & Somerville 2000b). It is worth noting that since land supply (LS) is a flow variable, it appears in the level form in the model of new housing supply.

In model (6.1), the coefficient β_1 represents the estimate of the average housing supply elasticity across the 16 cities for the full sample period 2001-2011. The city-specific effects allow for the effects of factors that vary substantially across cities but are relatively invariant over time. These factors can include geographical features, climate conditions, and regulatory constraints. A positive and statistically significant coefficient on 1- and 2-year lags of land supply indicates that land supply is positively related to new housing supply. If it is found that land supply is positively related to new housing supply, it is reasonable to argue that the decline in land supply after the government strengthened the intervention in the land markets has put downward pressure on new housing supply (Hypothesis 1).

6.3.2 The model that includes an interaction term between the time dummy variable and the housing price variable

In order to test the hypothesis that there was a decline in the price elasticity of new housing supply after the government strengthened the intervention in the land markets (Hypothesis 2), an interaction term between the dummy variable for the subsample

14. Stock variable refers to a variable which is measured at one specific time, and represents a quantity existing at that point in time. Flow variable refers to a variable which is measured over a period of time. In model (6.1), new housing supply and land supply are flow variables, and average real housing price, construction cost and financing cost for developers are stock variables.

period 2006-2011 and the housing price variable ($D_{0611} \times \Delta InHP_{it}$) is added to the basic model to allow the housing supply elasticity to vary over time:

$$lnHS_{it} = \beta_0 + \beta_1 \Delta lnHP_{it} + \beta_2 D_{0611} \times \Delta lnHP_{it} + \beta_3 \Delta lnCCOST_{it} + \beta_4 \Delta FCOST_{it} + \beta_5 lnLS_{i,t-1} + \beta_6 lnLS_{i,t-2} + \alpha_i + \lambda_t + \varepsilon_{it} \quad (6.2)$$

where D_{0611} is a dummy variable that is zero for the subsample period 2001-2005 and one for the subsample period 2006-2011. The interaction term approach has been widely used in recent studies to examine whether housing supply elasticities vary over time or across regions (Gitelman & Otto 2012; Mayer & Somerville 2000a; McLaughlin 2012; Meen & Nygaard 2011; Saiz 2010). Because in 2005 developers could still use land acquired in 2003 or 2004, it is assumed that housing supply elasticity did not decrease immediately after the government strengthened the intervention in the land markets.

In model (6.2), the coefficient β_1 represents the estimate of the average housing supply elasticity across the 16 cities for the subsample period 2001-2005, the sum of β_1 and β_2 represents the estimate of the average housing supply elasticity across the 16 cities for the subsample period 2006-2011. A negative and statistically significant coefficient β_2 indicates that there was a decline in housing supply elasticity after the government strengthened the intervention in the land markets (Hypothesis 2).

The literature review presented in section 3.3 suggests that some studies have examined the impact of land supply on new housing supply by developing and estimating models of new housing supply (Bramley 1993; Dipasquale & Wheaton 1994; Hui, Leung & Yu 2014; Pryce 1999). The models of new housing supply developed in this research differ from those developed in previous studies primarily in

two aspects. Firstly, while new housing supply is specified as a function of the levels of housing price and cost variables in most previous studies (Bramley 1993; Peng & Wheaton 1994; Pryce 1999), it is specified as a function of the changes in housing price and cost variables in this research. As discussed earlier, the "change" specification is considered to be a more appropriate specification of the model of new housing supply. Secondly, in addition to investigate the impact of land supply on new housing supply, this research also examines whether the decline in land supply after the government strengthened the intervention in the land markets led to a decline in housing supply elasticity.

6.4 Data

The data used for model estimation consist of floor area of housing starts, average real housing price, construction cost, 1-3 year term benchmark bank loan rates, and site area of land sold to developers for housing development. The data are collected from various Statistical Yearbook series (mainly including China Real Estate Statistics Yearbook series and China Statistical Yearbook series).

Data on floor area of housing starts, average housing price and construction cost (at the city and year level) are sourced from China Real Estate Statistics Yearbook series (2002-2012), which are compiled by China's National Bureau of Statistics and China Index Academy. Average housing price is adjusted to 2011 price level using the housing price index for large and medium-sized cities compiled by China's National Bureau of Statistics.[15] Construction cost is adjusted to 2011 price level using national

15. China's National Bureau of Statistics established the housing price index for 35 large and medium-sized cities in 1997, and all the sample cities were included in the 35 cities. The coverage of the housing price index has expanded to 70 cities since 2005, and all the sample cities are still included in the 70

consumer price index compiled by China's National Bureau of Statistics. Data on 1-3 year term benchmark bank loan rates are collected from the report of the People's Bank of China.[16] Data on site area of land sold to developers for housing development (at the city and year level) are sourced from China Statistical Yearbook series (2002-2012), which are compiled by China's National Bureau of Statistics. Table 6-1 presents variable definitions and data sources, and table 6-2 presents summary statistics of the raw data.

Table 6-1 Variable definitions and data sources

Variables	Definitions	Data Sources
HS	Floor area of housing starts (unit: 1,000 square meters)	China Real Estate Statistics Yearbook series (2002-2012)
HP	Average real housing price (unit: RMB/square meter)	China Real Estate Statistics Yearbook series (2002-2012)
$CCOST$	Cost to build the physical structure of housing units (unit: RMB/square meter)	China Real Estate Statistics Yearbook series (2002-2012)
$FCOST$	Financing cost for developers (unit: %)	The report of the People's Bank of China
LS	Site area of land sold to developers for housing development (unit: hectare)	China Statistical Yearbook series (2002-2012)
D_{0611}	D_{0611} = 0 for the subsample period 2001-2005; D_{0611} = 1 for the subsample period 2006-2011;	

Table 6-2 Summary statistics of the raw data

Variables	Mean	Std. Dev.	Min	Max
HS	10,026	6,194.4	972.4	26,688.4
HP	7,651.46	3,504.95	2,916	21,307
$CCOST$	2,380.14	906.51	963	6,985
$FCOST$	3.68	1.87	0.95	6.49
LS	471.48	348.03	13.87	2,092.5
D_{0611}	0.55	0.50	0	1

cities. This index is the best available housing price index in China and has been widely used by studies published in SSCI-listed journals (Wang, Chan & Xu 2012; Xu & Chen 2012; Zhang, Hua & Zhao 2012).

16. http://www.pbc.gov.cn/.

6.5 Panel data models and their estimation

Because the models of new housing supply developed in section 6.3 are estimated using panel data for the 16 major Chinese cities for the period 2001-2011, an overview of panel data models and their estimation is provided in this section.

6.5.1 An overview of panel data models

A panel data set (also called longitudinal data set) is one that follows a given sample of units (individuals, families, firms, cities, states, etc.) over time, and thus has both a cross-sectional and a time-series dimension (Hsiao 2003; Wooldridge 2012). The panel data set exhibits several major advantages over conventional cross-sectional or time-series data set (Hsiao 2003; Wooldridge 2002). Firstly, it usually gives the researchers a large number of observations, increasing the degree of freedom and reducing the multicollinearity among the independent variables, and thus improving the efficiency of econometric estimates. Secondly, with panel data, it is possible to control for some types of unobserved omitted variables, and thus address the problem of omitted variable bias - a problem that arises when some independent variables which are correlated with both the dependent variable and one or more included independent variables are omitted from the regression model. By including the individual-specific effect, the omitted variables that vary across cross-sectional units but are constant over time can be controlled for in panel data models; by including the time-specific effect, the omitted variables that vary over time but are constant across cross-sectional units can be controlled for. Thirdly, because the panel data set includes both the cross-sectional information and the time-series information, using it allows one to develop and estimate more complicated behavioural models than purely cross-sectional or time-series models.

The panel data models can be classified into two categories: static panel data models and dynamic panel data models, according to whether the models include one or more lagged dependent variables as independent variables (Anderson & Hsiao 1981; Arellano & Bond 1991; Arellano & Bover 1995; Blundell & Bond 1998; Holtz-Eakin, Newey & Rosen 1988). Static panel data models refer to the panel data models that do not include lagged dependent variables as independent variables, and dynamic panel data models refer to the panel data models that include one or more lagged dependent variables as independent variables (Anderson & Hsiao 1981; Arellano & Bond 1991; Holtz-Eakin, Newey & Rosen 1988). Because the models of new housing supply developed in section 6.3 are static panel data models, the approaches to estimating static panel data models are introduced in this chapter. The approaches to estimating dynamic panel data models will be introduced in next chapter.

6.5.2 Static panel data models and their estimation

The static panel data models generally take the following form (Hsiao 2003):

$$y_{it} = \beta_0 + \alpha_i + \lambda_t + \sum_{k=1}^{K} \beta_k x_{kit} + \varepsilon_{it,} \qquad i = 1, \dots, N; t = 1, \dots, T \tag{6.3}$$

where, y is the dependent variable, and x represents a vector of independent variables; the subscripts i and t refer to cross-sectional unit i and period t, respectively; β_0 is the common intercept term; α_i is the individual-specific effect, and λ_t is the time-specific effect; ε_{it} is the idiosyncratic error.

The static panel data models can be further classified into the fixed effects models and the random effects models, depending on whether the individual-specific effect α_i is correlated with the independent variables (Hsiao 2003; Wooldridge 2002, 2012). When the individual-specific effect is thought to be correlated with one or more of the

independent variables, the static panel data model is referred to as the fixed effects model; when the individual-specific effect is thought to be independent of all independent variables in all time periods, the static panel data model is referred to as the random effects model (Wooldridge 2012). The approaches to estimating the fixed effects model and random effects model are generally referred to as fixed effects regression approach and random effects regression approach, respectively.

Before estimating the static panel data models, one has to choose between the fixed effects regression approach and the random effects regression approach (Wooldridge 2012). A generally accepted way of choosing between the two approaches is running the Hausman test (Hausman 1978). The idea underlying the Hausman test is that one uses the random effects regression approach unless the Hausman test rejects the random effects assumption.

6.5.3 Statistical techniques used in the regression analysis

Since heteroskedasticity and serial correlation can be potential problems in regression analysis (Wooldridge 2002, 2012), this section provides an analysis of heteroskedasticity and serial correlation and the approach to dealing with them. The statistical technique used to test the statistical significance of independent variable, the statistical technique used to assess the stationarity properties of variables, and the statistical technique used to measure goodness of fit of a model are also introduced in this section.

Heteroskedasticity means that the variance of the error, conditional on the independent variables, is not constant. Serial correlation means that the errors are correlated across time. In the presence of heteroskedasticity or serial correlation, the usual ordinary least

squares (OLS) standard errors and the usual *t* statistics which are used to test whether an independent variable is statistically significant are not valid (Wooldridge 2002, 2012). Econometricians have developed approaches to adjusting standard errors and *t* statistics so that they are valid in the presence of heteroskedasticity and serial correlation. Thus, one popular approach to dealing with heteroskedasticity and serial correlation in recent years is to use the so-called robust standard errors and robust *t* statistics (Wooldridge 2012). In this research, the standard errors and *t* statistics that are robust to cross-sectional heteroskedasticity and within panel serial correlation (Arellano 1987, 2003; Wooldridge 2002) are used to test the statistical significance of each independent variable.

Regressions using multiple non-stationary series can result in spurious correlations (Granger & Newbold 1974). To avoid the spurious regression problem due to non-stationarity of the variables, unit root tests are usually undertaken to assess the stationarity properties of variables before formally estimating models (Wooldridge 2012). It is noteworthy that in one important case, a regression involving non-stationary variables is not spurious, and that is when the variables are co-integrated (Wooldridge 2012). In this research, the panel unit root test proposed by Im, Pesaran & Shin (2003) is employed to assess the stationarity properties of the variables.[17] If any variable is found to be non-stationary, the panel co-integration tests proposed by Westerlund (2007) are employed to test for the presence of long-run relationships among variables.

17. Compared with other panel unit root tests, the Im-Pesaran-Shin test has the advantage of relaxing the assumption that all panels share a common autoregressive parameter.

R-squared is a widely used measure of goodness of fit of a model (Wooldridge 2012). It is calculated as the explained sum of squares (SSE) divided by the total sum of squares (SST), and can be interpreted as the fraction of the sample variation in the dependent variable that is explained by the independent variables. An important disadvantage of R-squared is that it never decreases when another independent variable is added to a regression model. Compared to R-squared, another statistic called adjusted R-squared imposes a penalty for adding additional independent variables to a regression model (the adjusted R-squared can go up or down when another independent variable is added to a regression model).

6.6 Statistical software used in this research and the regression procedures

This section introduces the statistical software used in this research and describes the procedures for estimating the models of new housing supply.

6.6.1 Statistical software used in this research

The statistical software used in this research is Stata 12. Stata's capabilities include data management, statistical analysis, graphics, simulations, regression analysis (linear and multiple), and custom programming. It is a widely used statistical software package and allows the use of many advanced statistical techniques such as dynamic panel data regressions and generalized estimating equations.

6.6.2 The regression procedures

The regression procedures in this chapter consist of the following steps: transformation of the raw data, pre-regression tests, and formally estimating the static panel data models.

● Transformation of the raw data

The starting point of the regression analysis is the transformation of the raw data. In model (6.1) and model (6.2), the dependent variable is the log of new housing supply, and the independent variables include the first difference of the log of average real housing price, the first difference of the log of construction cost, the first difference of financing cost for developers, and the log of 1- and 2-year lags of land supply. Thus, the data transformation techniques used include the first-difference transformation, the log transformation, and the lag transformation. The reasons for using the first-difference transformation and the lag transformation have been explained in section 6.3. As suggested by Wooldridge (2012), the reasons for using the log transformation are threefold. Firstly, the slope coefficients can be interpreted as elasticities in a log-linear model. Secondly, the conditional distributions of strictly positive variables are often heteroskedastic or skewed; taking logs can mitigate the problems. Thirdly, taking logs can narrow the range of the variables and make estimates less sensitive to outlying (or extreme) observations.

● Pre-regression tests

The second step of the regression analysis involves the pre-regression tests. It mainly consists of investigating whether each variable follows a normal distribution, the preliminary examination of the relationships between the dependent variable and each independent variable and panel unit root test.

The kernel density estimation, which is a non-parametric way to estimate the probability density function of a random variable (Parzen 1962; Rosenblatt 1956), is generally used to examine whether each variable follows a normal distribution. Figure

6-1 and figure 6-2 show the results of the kernel density estimation for the log of new housing supply and the log of average real housing price, respectively (the kernel density estimation for the other variables are included in Appendix 1). As can be seen from the two figures and Appendix 1, the variables in model (6.1) generally follow a normal distribution.

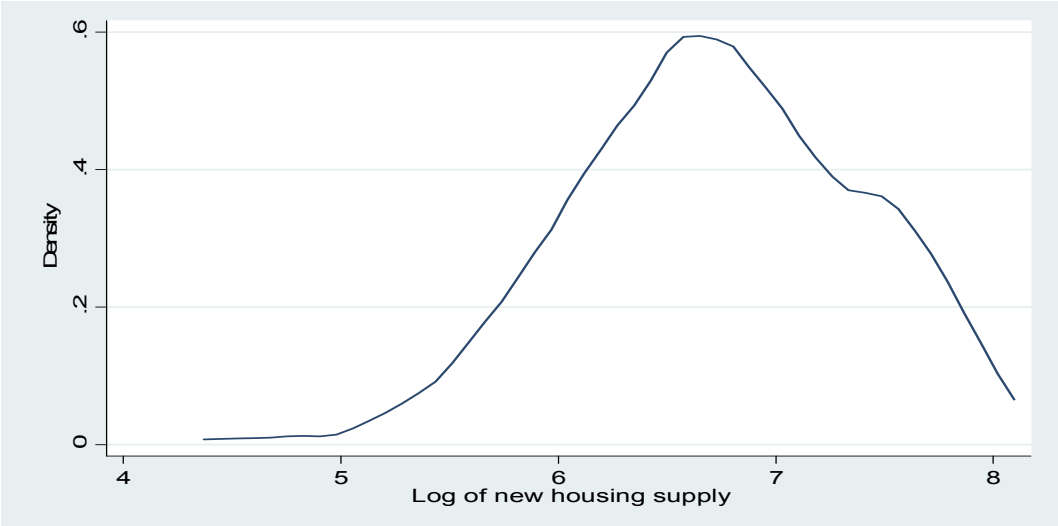

Figure 6-1 The kernel density estimation for the log of new housing supply

Figure 6-2 The kernel density estimation for the log of average real housing price

Following previous studies (Gonzalez & Ortega 2013; Hwang & Quigley 2006b), the preliminary examination of the relationships between the dependent variable and each independent variable is done by drawing and examining the scatter plots of the dependent variable against each independent variable, and by simply regressing the dependent variable against each independent variable. Figure 6-3 and figure 6-4 show the scatter plots of the log of new housing supply against the log of 1- and 2-year lags of land supply. The scatter plots of the log of new housing supply against the other independent variables are presented in Appendix 2. As can be seen from the two figures, there is a strong positive relationship between land supply and new housing supply, and the slope coefficients on the log of 1- and 2-year lags of land supply are statistically significant at the 5% level.

Interdependence among the independent variables is investigated by examining the correlation matrix for the independent variables. The results (as shown in Appendix 3) suggest that there is no strong interdependence among the independent variables.

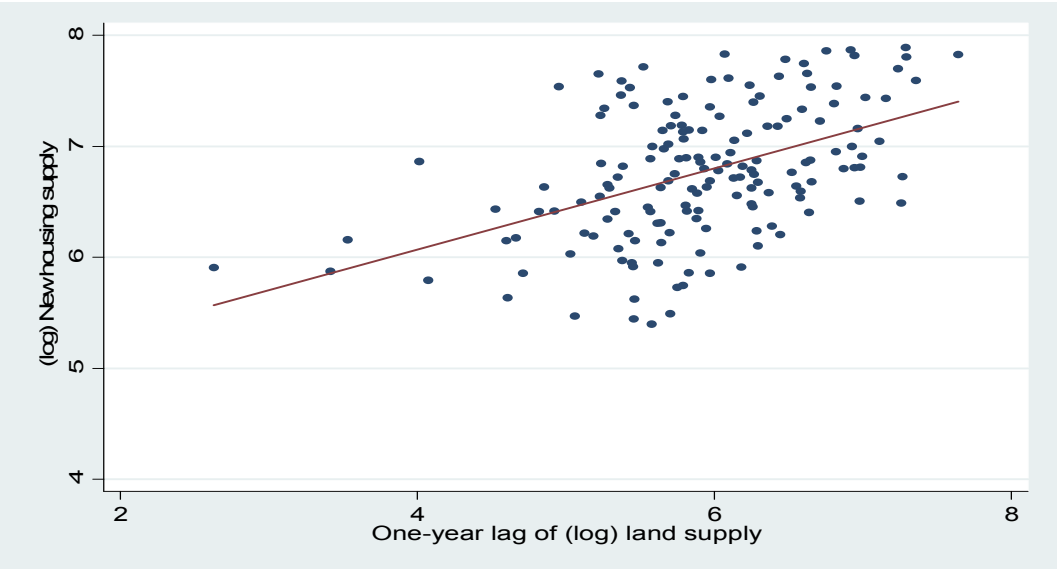

Figure 6-3 The scatter plot of the log of new housing supply against the log of 1-year lag of land supply

Note: The regression relationship (standard errors in parentheses) between the log of new housing supply, $lnHS_{it}$, and the log of 1-year lag of land supply, $lnLS_{i,t-1}$, is

$$lnHS_{it} = 6.053 + 0.121 lnLS_{i,t-1}$$
$$(0.313) \quad (0.051)$$

As discussed in section 6.5.3, the Im-Pesaran-Shin panel unit root test is employed to assess the stationarity properties of the variables in the models of new housing supply. The results (as shown in table 6-3) suggest that the null hypothesis of a unit root in the log of new housing supply can be rejected at the 5 per cent significance level, and the null hypothesis of a unit root in the change in the log of housing price, the change in the log of construction cost and the log of land supply can all be rejected at the 1 per cent significance level. Thus, all the variables in the models of new housing supply are stationary.

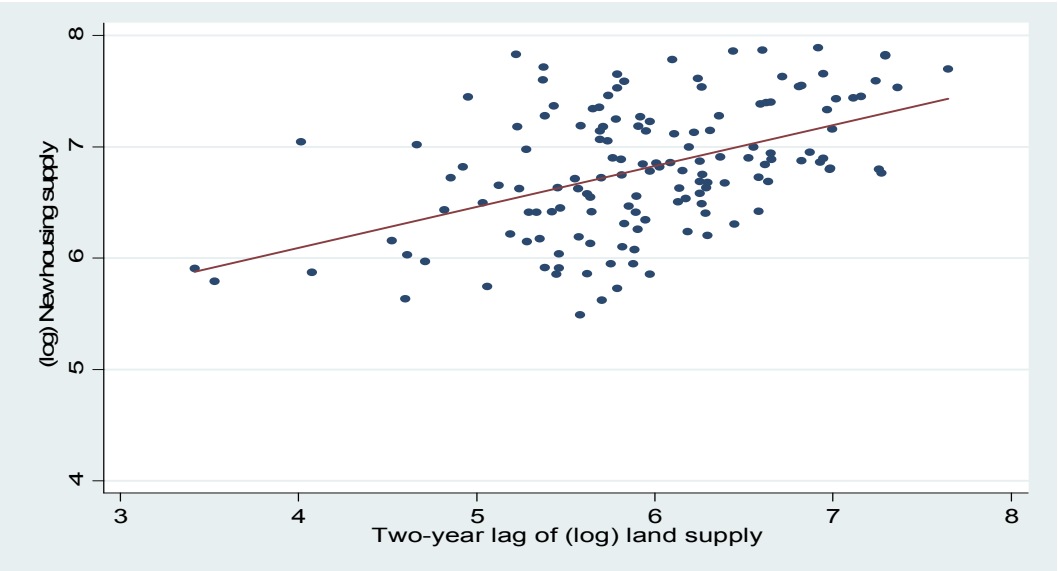

Figure 6-4 The scatter plot of the log of new housing supply against the log of 2-year lag of land supply

Note: The regression relationship (standard errors in parentheses) between the log of new housing supply, $lnHS_{it}$, and the log of 2-year lag of land supply, $lnLS_{i,t-2}$, is

$$lnHS_{it} = 6.140 + 0.112 lnLS_{i,t-2}$$
$$(0.323) \quad (0.053)$$

Table 6-3 The Im-Pesaran-Shin panel unit root test for the variables in the models of new housing supply

	Im-Pesaran-Shin test statistic	*p*-value
$\ln HS$	-1.998	0.023
$\Delta \ln HP$	-3.220	0.001
$\Delta \ln CCOST$	-4.830	0.000
$\ln LS$	-3.219	0.001

● Formally estimating the static panel data models

The third step of the regression analysis is formally estimating the static panel data models. The Hausman test is used to choose between the fixed effects regression approach and the random effects regression approach (see analysis presented in section 6.5.2). As discussed in section 6.5.3, the *t* statistics that are robust to cross-sectional heteroskedasticity and within panel serial correlation are used to test whether an independent variable is statistically significant, and the adjusted R-squared is used to measure goodness of fit of the model.

6.7 Empirical results

As discussed in section 6.3, model (6.1) is estimated to test the hypothesis that the decline in land supply after the government strengthened the intervention in the land markets has put downward pressure on new housing supply (Hypothesis 1), and model (6.2) is estimated to test the hypothesis that there was a decline in housing supply elasticity after the government strengthened the intervention in the land markets (Hypothesis 2). Model (6.1) and model (6.2) are first estimated using the data for the 16 major Chinese cities for the period 2001-2011. Since the 16 cities can be classified into two groups according to population size (see discussion presented in section 5.3.1), the two models are then estimated using sub-datasets of the 16 cities. This section first reports and discusses the regression results obtained when the full dataset of the 16 cities is used, and then reports and discusses the regression results obtained when the sub-datasets of the 16 cities are used.

6.7.1 Regression results obtained when the full dataset of the 16 cities is used

Table 6-5 and table 6-6 report regression results when model (6.1) is estimated using the data for the 16 cities for the period 2001-2011. Because the Hausman test rejects the random effects assumption (the result is presented in table 6-4), fixed effects regression is used for model estimation. As shown in table 6-5, change in housing price has a positive and statistically significant impact on new housing supply. A 1 per cent increase in housing price will result in a 1.49 per cent increase in new housing supply. As documented in many previous studies (Blackley 1999; Dipasquale & Wheaton 1994; Mayer & Somerville 2000b; Poterba 1984; Pryce 1999; Topel & Rosen 1988), the coefficient on change in construction cost is not statistically different from zero. One explanation for the poor performance of the construction cost variable is that since new housing supply and construction cost tend to be simultaneously determined, treating construction cost as an exogenous variable in the model of new housing supply can cause simultaneity bias (Blackley 1999; Mayer & Somerville 2000b; Olsen 1987; Poterba 1984; Pryce 1999; Topel & Rosen 1988). A primary approach to dealing with the simultaneity bias is to use the instrumental variable approach.[18] However, as in most previous studies, appropriate instruments for the construction cost variable cannot be found in this study due to data limitations. Thus, the construction cost variable is dropped from the model later. Change in financing cost has a negative and statistically significant effect on new housing supply, and the effect is sizable in magnitude. A 1 percentage point rise in interest rate can reduce new

18. Instrumental variable methods allow consistent estimation when the independent variables are correlated with the error terms. In this method, an instrument is a variable that does not itself belong in the explanatory equation but is correlated with the endogenous independent variables (Pearl 2000; Wooldridge 2012).

residential construction by 5.1 per cent, indicating that financing cost plays an important role in decision making in housing development. Of primary interest are the coefficients on the land supply variables. The coefficients on 1- and 2-year lags of land supply are positive and statistically significant. A 1 per cent increase in 1-year lag of land supply will result in a 0.2 per cent increase in new housing supply, and a 1 per cent increase in 2-year lag of land supply will result in a 0.22 per cent increase in new housing supply. Because land supply is positively related to new housing supply, it is reasonable to argue that the decline in land supply after the government strengthened the intervention in the land markets has put downward pressure on new housing supply (Hypothesis 1). Table 6-6 reports regression results when the poorly performing construction cost variable ($\Delta lnCCOST_{it}$) is dropped. The exclusion of the construction cost variable slightly increases the size of the coefficient on change in housing price (from 1.494 to 1.498). The coefficient on change in financing cost and the coefficients on 1- and 2-year lags of land supply all stay unchanged.

Table 6-4 Results of Hausman test for model (6.1) (full dataset of the 16 cities)

Chisq	*p*-value
20.43	0.0397

Table 6-5 Regression results for model (6.1) (full dataset of the 16 cities, construction cost variable included)

	Coef.	Robust Std. Err.	Robust t-value	P > | *t* |
$\Delta lnHP_{it}$	1.494	0.839	1.78	0.095*
$\Delta lnCCOST_{it}$	-0.018	0.091	-0.20	0.843
$\Delta FCOST_{it}$	-0.051	0.006	-9.08	0.000***
$lnLS_{i,t-1}$	0.200	0.061	3.26	0.005***
$lnLS_{i,t-2}$	0.222	0.060	3.70	0.002***
Year dummies (λ_t)	Yes			
Adj. R-squared	0.611			

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level.

Table 6-6 Regression results for model (6.1) (full dataset of the 16 cities, construction cost variable excluded)

	Coef.	Robust Std. Err.	Robust t-value	P > | *t* |
$\Delta lnHP_{it}$	1.498	0.832	1.80	0.092*
$\Delta FCOST_{it}$	-0.051	0.006	-9.03	0.000***
$lnLS_{i,t-1}$	0.200	0.061	3.25	0.005***
$lnLS_{i,t-2}$	0.222	0.060	3.70	0.002***
Year dummies (λ_t)	Yes			
Adj. R-squared	0.611			

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level.

Table 6-8 reports regression results when model (6.2) is estimated using the data for the 16 cities for the period 2001-2011. Because the Hausman test rejects the random effects assumption (the result is presented in table 6-7), fixed effects regression is used for model estimation. In model (6.2), the coefficient on the housing price variable represents the estimate of the average housing supply elasticity across the 16 cities for

the subsample period 2001-2005, the sum of the coefficient on the housing price variable and the coefficient on the interaction term represents the estimate of the average housing supply elasticity across the 16 cities for the subsample period 2006-2011 (see discussion presented in section 6.3.2). As shown in table 6-8, the coefficient on the interaction term is negative and statistically significant, and the estimated housing supply elasticity decreases significantly from 2.617 for the subsample period 2001-2005 to 0.515 for the subsample period 2006-2011. The coefficient on change in financing cost and the coefficients on 1- and 2-year lags of land supply are very similar to those reported in table 6-5 and table 6-6, and they are all statistically significant.

Table 6-7 Results of Hausman test for model (6.2) (full dataset of the 16 cities)

Chisq	*p*-value
19.40	0.0544

Table 6-8 Regression results for model (6.2) (full dataset of the 16 cities)

	Coef.	Robust Std. Err.	Robust t-value	P > | *t* |
$\Delta lnHP_{it}$	2.617	0.911	2.87	0.005***
$D_{0611} \times \Delta InHP_{it}$	-2.102	1.288	-1.63	0.105*
$\Delta FCOST_{it}$	-0.048	0.009	-5.36	0.000***
$lnLS_{i,t-1}$	0.200	0.040	4.96	0.000***
$lnLS_{i,t-2}$	0.224	0.042	5.34	0.000***
Year dummies (λ_t)	Yes			
Adj. R-squared	0.620			

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level.

According to the regression results, when the models of new housing supply are estimated using the full dataset of the 16 cities, the coefficients on 1- and 2-year lags of land supply are positive and statistically significant, and the coefficient on the interaction term between the dummy variable for the subsample period 2006-2011 and the housing price variable is negative and statistically significant. Thus, the regression results obtained when the full dataset of the 16 cities is used provide strong evidence supporting Hypothesis 1 and Hypothesis 2.

6.7.2 Regression results obtained when the sub-datasets of the 16 cities are used

The analysis presented in section 5.3.1 suggests that the 16 major Chinese cities can be classified into two groups according to population size. For ease of analysis, the 7 cities (i.e. Shanghai, Beijing, Chengdu, Tianjin, Guangzhou, Shenzhen and Wuhan) which had a population of more than 10 million persons in 2011 are referred to as "group-1 cities", and the 9 cities (i.e. Qingdao, Hangzhou, Xian, Nanjing, Ningbo, Hefei, Fuzhou, Jinan and Nanchang) which had a population of between 5 million and 10 million persons in 2011 are referred to as "group-2 cities". This subsection reports the regression results when the models of new housing supply are estimated using the data for the group-1 cities and the group-2 cities. However, caution should be used in interpreting these results, since the sample size of each sub-dataset is relatively small. Wooldridge (2012) suggested that other things being equal, it is more difficult to detect a statistically significant effect in smaller samples (in other words, statistical power is relatively lower in smaller samples).

● Regression results for the group-1 cities

Table 6-10 reports regression results when model (6.1) is estimated using the data for the group-1 cities for the period 2001-2011. Because the Hausman test rejects the random effects assumption (the result is presented in table 6-9), fixed effects regression is used for model estimation. As shown in table 6-10, the coefficient on change in housing price is positive but not statistically significant (p-value = 0.326). Change in financing cost has a negative and statistically significant impact on new housing supply. The coefficients on 1- and 2-year lags of land supply are positive and statistically significant.

Table 6-9 Results of Hausman test for model (6.1) (the group-1 cities)

Chisq	p-value
22.63	0.0122

Table 6-10 Regression results for model (6.1) (the group-1 cities)

	Coef.	Robust Std. Err.	Robust t-value	P > | t |
$\Delta lnHP_{it}$	0.677	0.641	1.06	0.326
$\Delta FCOST_{it}$	-0.046	0.009	-5.00	0.002***
$lnLS_{i,t-1}$	0.259	0.063	4.12	0.004***
$lnLS_{i,t-2}$	0.190	0.085	2.24	0.060*
Year dummies (λ_t)	Yes			
Adj. R-squared	0.602			

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level.

Table 6-12 reports regression results when model (6.2) is estimated using the data for the group-1 cities for the period 2001-2011. Because the Hausman test rejects the random effects assumption (the result is presented in table 6-11), fixed effects regression is used for model estimation. As shown in table 6-12, the coefficient on the interaction term is negative but not statistically significant (p-value = 0.368). The estimates of housing supply elasticities for the subsample periods 2001-2005 and 2006-2011 are 1.247 and 0.101, respectively.

Table 6-11 Results of Hausman test for model (6.2) (the group-1 cities)

Chisq	p-value
84.6	0.0000

Table 6-12 Regression results for model (6.2) (the group-1 cities)

	Coef.	Robust Std. Err.	Robust t-value	P > | t |
$\Delta lnHP_{it}$	1.247	0.755	1.65	0.143
$D_{0611} \times \Delta InHP_{it}$	-1.146	1.190	-0.96	0.368
$\Delta FCOST_{it}$	-0.042	0.009	-4.54	0.003***
$lnLS_{i,t-1}$	0.258	0.068	3.82	0.007***
$lnLS_{i,t-2}$	0.192	0.088	2.18	0.065*
Year dummies (λ_t)	Yes			
Adj. R-squared	0.606			

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level.

● Regression results for the group-2 cities

Table 6-14 reports regression results when model (6.1) is estimated using the data for the group-2 cities for the period 2001-2011. Because the Hausman test rejects the random effects assumption (the result is presented in table 6-13), fixed effects regression is used for model estimation. As shown in table 6-14, change in housing price has a positive and statistically significant impact on new housing supply, and change in financing cost has a negative and statistically significant impact on new housing supply. The coefficients on 1- and 2-year lags of land supply are positive, but only the coefficient on 2-year lag of land supply is statistically significant.

Table 6-13 Results of Hausman test for model (6.1) (the group-2 cities)

Chisq	*p*-value
37.11	0.0001

Table 6-14 Regression results for model (6.1) (the group-2 cities)

	Coef.	Robust Std. Err.	Robust t-value	P > | *t* |
$\Delta lnHP_{it}$	3.916	1.490	2.63	0.034**
$\Delta FCOST_{it}$	-0.045	0.012	-3.81	0.007***
$lnLS_{i,t-1}$	0.064	0.051	1.27	0.243
$lnLS_{i,t-2}$	0.149	0.059	2.51	0.040**
Year dummies (λ_t)	Yes			
Adj. R-squared	0.787			

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level.

Table 6-16 reports regression results when model (6.2) is estimated using the data for the group-2 cities for the period 2001-2011. Because the Hausman test rejects the random effects assumption (the result is presented in table 6-15), fixed effects regression is used for model estimation. As shown in table 6-16, the coefficient on the interaction term is negative but not statistically significant (p-value = 0.217). The estimates of housing supply elasticities for the subsample periods 2001-2005 and 2006-2011 are 5.720 and 1.977, respectively.

Table 6-15 Results of Hausman test for model (6.2) (the group-2 cities)

Chisq	p-value
84.6	0.0000

Table 6-16 Regression results for model (6.2) (the group-2 cities)

	Coef.	Robust Std. Err.	Robust t-value	P > | t |
$\Delta lnHP_{it}$	5.720	1.819	3.14	0.016**
$D_{0611} \times \Delta InHP_{it}$	-3.743	2.757	-1.36	0.217
$\Delta FCOST_{it}$	-0.047	0.009	-4.99	0.002***
$lnLS_{i,t-1}$	0.073	0.052	1.41	0.201
$lnLS_{i,t-2}$	0.158	0.061	2.59	0.036**
Year dummies (λ_t)	Yes			
Adj. R-squared	0.798			

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level.

It is worth noting that the coefficients on some variables are not statistically significant when the models of new housing supply are estimated using the data for the group-1 cities and the group-2 cities. As mentioned earlier, this can be due to the fact that statistical power is relatively lower in smaller samples. According to the regression results, when the models of new housing supply are estimated using the data for the group-1 cities, the coefficients on 1- and 2-year lags of land supply are positive and statistically significant. The coefficient on the interaction term is negative but not statistically significant. When the models of new housing supply are estimated using the data for the group-2 cities, the coefficients on 1- and 2-year lags of land supply are positive, but only the coefficient on 2-year lag of land supply is statistically significant. The coefficient on the interaction term is negative but not statistically significant. Thus, the regression results obtained when the sub-datasets of the 16 cities are used provide strong evidence supporting Hypothesis 1 and relatively weak evidence supporting Hypothesis 2.

It is interesting to compare the regression results for the group-1 cities and the group-2 cities. The estimates of the housing supply elasticities for the group-1 cities are significantly lower than those for the group-2 cities. This result implies that new housing supply tends to be less elastic in cities with a larger population in China. The coefficients on land supply variables reported in table 6-9 are larger than those reported in table 6-13, indicating that land supply has a larger impact on new housing supply in cities with a larger population.

6.8 Summary

This chapter examines the impacts that the decline in land supply has on new housing supply and housing supply elasticity by developing and estimating models of new housing supply. The models of new housing supply are developed based on the theoretical analysis of the factors affecting new housing supply and the review of existing studies on modelling new housing supply. The models of new housing supply are estimated using the fixed effects regression approach. The regression results suggest that land supply is positively related to new housing supply, implying that the decline in land supply after the government strengthened the intervention in the land markets has a depressing effect on new housing supply. There was also a decline in housing supply elasticity after the government strengthened the intervention in the land markets. Consistent with the theoretical expectation, housing price and financing cost for developers are found to be important determinants of new housing supply.

Chapter 7: The impact that the decline in land supply has on housing price

7.1 Introduction

Housing price changes and its determinants has been the focus of considerable research for a number of reasons. Firstly, since real estate investment constitutes a significant proportion of GDP, volatile housing price poses a threat to financial and economic stability (Ahuja et al. 2010a; Wu, Gyourko & Deng 2012b). Secondly, change in housing price has distributional effects and important implications for housing affordability (Vermeulen 2008). While those who own homes will benefit from housing price appreciation, those who rent or are would-be home buyers will suffer from rising cost when housing price goes up. Thirdly, since housing is a major component of household wealth, fluctuations in housing price affect households' consumption decisions (Campbell & Cocco 2007; Case, Quigley & Shiller 2005). Rising housing price can stimulate consumption by relaxing borrowing constraints, or by increasing households' perceived wealth.

As suggested in the literature review presented in chapter 3, many studies have found that the demand-side factors play an important role in determining housing price in China. However, relatively little attention has been paid to the supply-side factors affecting housing price. This chapter attempts to fill this gap by examining the impact that the decline in land supply has on housing price. A research hypothesis is first developed and then tested by developing and estimating a model of housing price using panel data for the 16 major Chinese cities for the period 2001-2011.

The remainder of this chapter is organized as follows. Development of research hypothesis is presented in section 7.2. Section 7.3 develops the model of housing price which is used to test the research hypothesis, and section 7.4 describes the data used for model estimation. An overview of dynamic panel data models and their estimation is provided in section 7.5, followed by a description of the regression procedures (presented in section 7.6). Section 7.7 reports empirical results. A summary follows in section 7.8.

7.2 Development of research hypothesis

The empirical analysis presented in last chapter suggests that land supply is positively related to new housing supply in major Chinese cities. Given the fact that housing price is negatively related to housing supply, land supply is expected to be negatively related to housing price. Thus, the third hypothesis of this research is proposed.

Hypothesis 3: *That the decline in land supply after the government strengthened the intervention in the land markets has put upward pressure on housing price*.

7.3 Development of model of housing price

Many studies have examined the determinants of housing price by developing and estimating reduced-form models of housing price (Dipasquale & Wheaton 1994; Ge 2004; Hwang & Quigley 2006b; Malpezzi 1996; Malpezzi & Maclennan 2001). These studies suggested that the reduced-form model of market-clearing housing price can be derived from the structural models of housing demand and housing supply. However, because housing price adjusts gradually in response to demand or supply changes, housing market may not clear within one period and the actual housing price can be different from the market-clearing housing price (Andrew & Meen 2003a; Harter-

Dreiman 2004; Oikarinen 2012). Thus, a price adjustment mechanism is usually incorporated to yield the model of actual housing price (Dipasquale & Wheaton 1994; Hwang & Quigley 2006b; Malpezzi & Maclennan 2001).

In this section, the structural models of housing demand and housing supply are first developed. The reduced-form model of market-clearing housing price is then derived from the structural models. Finally, the model of actual housing price is derived based on the market-clearing price and the price adjustment mechanism.

7.3.1 Models of housing demand and housing supply

● Structural model of housing demand

The theoretical analysis presented in section 2.5 and the literature review presented in section 3.5 suggest that population, housing price, the user cost of owner-occupied housing, income, and population structures such as the age, sex and ethnic structures of the population are the major factors affecting the demand for housing. Thus, the model of the demand for housing takes the following form:

$$Q_{it}^{D} = \alpha_1 POP_{it} + \alpha_2 HP_{it} + \alpha_3 UC_{it} + \alpha_4 INC_{it} + \alpha_5 X_{it} \quad (7.1)$$

where subscripts i and t refer to city i and year t, respectively; Q_{it}^{D} is the quantity of housing demanded; POP_{it} is population, HP_{it} is housing price, UC_{it} is the user cost of owner-occupied housing, INC_{it} is income level, and X_{it} is the demographic factors.

● Structural model of housing supply

The quantity of housing supplied (Q_{it}^{S}) equals the housing stock in last period ($HST_{i,t-1}$) plus new housing supply (HS_{it}) (demolition and abandonment are ignored here):

$$Q_{it}^{S} = HST_{i,t-1} + HS_{it} \quad (7.2)$$

The analysis presented in previous chapter suggests that new housing supply can be specified as a function of change in housing price, change in construction cost, change in financing cost for developers, and 1- and 2-year lags of land supply[19]:

$$HS_{it} = \beta_1 \Delta HP_{it} + \beta_2 \Delta CCOST_{it} + \beta_3 \Delta FCOST_{it} + \beta_4 LS_{i,t-1} + \beta_5 LS_{i,t-2} \quad (7.3)$$

Substituting the expression for HS_{it} into the expression for Q_{it}^{S}, then equation (7.2) can be rewritten as (7.4):

$$Q_{it}^{S} = HST_{i,t-1} + \beta_1 \Delta HP_{it} + \beta_2 \Delta CCOST_{it} + \beta_3 \Delta FCOST_{it} + \beta_4 LS_{i,t-1} + \beta_5 LS_{i,t-2} \quad (7.4)$$

7.3.2 The model of market-clearing housing price

When the housing market reaches an equilibrium, the market-clearing housing price (HP_{it}^{*}) can be derived by equating housing supply (Q_{it}^{S}) and housing demand (Q_{it}^{D}):

$$HP_{it}^{*} = [1/(\beta_1 - \alpha_2)](\alpha_1 POP_{it} + \alpha_3 UC_{it} + \alpha_4 INC_{it} + \alpha_5 X_{it} + \beta_1 HP_{i,t-1} - HST_{i,t-1} - \beta_2 \Delta CCOST_{it} - \beta_3 \Delta FCOST_{it} - \beta_4 LS_{i,t-1} - \beta_5 LS_{i,t-2}) \quad (7.5)$$

7.3.3 The model of actual housing price

Many studies have found evidence that housing price adjusts gradually in response to demand or supply changes and housing markets may not clear within one period (Andrew & Meen 2003a; Dipasquale & Wheaton 1994; Harter-Dreiman 2004; Hort 1998, 2000; Malpezzi 1999; Oikarinen 2012). There are both demand-side and supply-side explanations for gradual price adjustment and slow market clearing. On the

19. A large proportion of new housing units in China are sold in the pre-sale (or forward-sale) market (Deng & Liu 2009; Deng & Peng 2008). Pre-sale means that developers sell new housing units before their completion, sometimes even before construction begins.

supply side, given the lag in construction, increased demand for housing cannot be met instantly (Ball 2011; Malpezzi & Maclennan 2001; Mayer & Somerville 2000a). On the demand side, with product heterogeneity, information asymmetries and costly and time-consuming search, the sales time for a housing unit can be fairly long (Dipasquale & Wheaton 1994; Evans 2004; Wheaton 1990).

Because housing price adjusts gradually in response to demand or supply changes, the actual housing price can be different from the market-clearing housing price. Thus, following Dipasquale & Wheaton (1994) and Hwang & Quigley (2006b), a price adjustment mechanism is incorporated to yield the actual housing price:

$$HP_{it} - HP_{i,t-1} = \delta(HP_{it}^{*} - HP_{i,t-1}) \tag{7.6}$$

or

$$HP_{it} = \delta HP_{it}^{*} + (1-\delta)HP_{i,t-1} \tag{7.7}$$

where HP_{it} is the actual housing price in current period, and $HP_{i,t-1}$ is the housing price in last period; δ is the speed at which the current housing price adjusts to its equilibrium level ($0 < \delta < 1$).

Substituting (7.5) into (7.7) yields the model of actual housing price in current period

$$\begin{aligned} HP_{it} = {} & [\beta_1/(\beta_1 - \alpha_2) + 1 - \delta]HP_{i,t-1} + [\delta/(\beta_1 - \alpha_2)]\,(\alpha_1 POP_{it} + \alpha_3 UC_{it} \\ & + \alpha_4 INC_{it} + \alpha_5 X_{it} - HST_{i,t-1} - \beta_2 \Delta CCOST_{it} - \beta_3 \Delta FCOST_{it} \\ & - \beta_4 LS_{i,t-1} - \beta_5 LS_{i,t-2}) \end{aligned} \tag{7.8}$$

Because there is no available data on housing stock and population structures such as the age, sex and ethnic structures of the population at the city and year level in China, lagged housing stock ($HST_{i,t-1}$) and the demographic factors (X_{it}) are dropped from

model (7.8), and the empirical specification of the model of housing price takes the following form:

$$lnHP_{it} = \gamma_0 + \gamma_1 lnHP_{i,t-1} + \gamma_2 lnPOP_{it} + \gamma_3 UC_{it} + \gamma_4 lnINC_{it} + \gamma_5 \Delta lnCCOST_{it} + \gamma_6 \Delta FCOST_{it} + \gamma_7 lnLS_{i,t-1} + \gamma_8 lnLS_{i,t-2} + \alpha_i + \lambda_t + \varepsilon_{it} \quad (7.9)$$

where subscripts i and t refer to city i and year t, respectively; ln denotes the natural logarithm; α_i is a city-specific effect, λ_t is a vector of year-specific dummy variables, and ε_{it} is the idiosyncratic error. The definitions of the variables are as follows:

HP is average real housing price.

POP is population, which means the number of permanent residents in a particular city. The theoretical analysis presented in section 2.5 suggests that the demand for housing tends to increase as population increases. Thus, population is expected to be positively related to housing price.

UC is the user cost of owner-occupied housing. As discussed in section 2.5, the user cost of owner-occupied housing is a measure of the cost of owning a home. The literature review presented in section 3.5.3 suggests that the formula for calculating the user cost of owner-occupied housing generally takes the following form:

$$UC = (1 - t_y)(i + t_p) + m + \delta + \gamma - \pi^e \quad (7.10)$$

where t_y and t_p are the marginal tax rates on income and property, respectively, i is the nominal interest rate, m is the maintenance cost as a percentage of replacement asset value, δ is the depreciation rate for housing, γ is the risk premium to compensate homeowners for the higher risk of owning than renting, π^e is the expected rate of housing price appreciation. Because property tax was not imposed in most Chinese

cities during the sample period[20] and mortgage interest payments are not deductible from taxable income in China, t_y and t_p are dropped from the formula for calculating the user cost of owner-occupied housing in mainland China:

$$UC = i + m + \delta + \gamma - \pi^e \quad (7.11)$$

In empirical calculation, the 5-year term benchmark bank loan rates are used as the proxy for nominal long-term interest rates (i). Following previous studies on the user cost of owner-occupied housing, it is assumed that the maintenance cost (m) plus the depreciation rate (δ) equals 2.5% and the risk premium (γ) is 2% (Li & Chand 2013; Poterba & Sinai 2008; Wu, Gyourko & Deng 2012b). The literature review presented in section 3.5.3 suggests that a widely used approach to estimating the expected rate of housing price appreciation (π^e) is based on the assumption that expectations are formed from the patterns of past price movements. Following Dipasquale & Wheaton (1994), the 3-year moving average of past housing price appreciation is used as the proxy for the expected rate of housing price appreciation. The analysis presented in section 2.5 suggests that the demand for owner occupancy tends to decrease as the user cost of owner-occupied housing increases. Thus, the user cost of owner-occupied housing is expected to be negatively related to housing price.

INC is income level, which is measured by per capita disposable income. The analysis presented in section 2.5 suggests that income level is a measure of the capacity to own a home and the demand for housing tends to increase as income increases. Thus, income level is expected to be positively related to housing price.

20. Property tax was not imposed in China before 2011. The Chinese government launched a property tax pilot in Shanghai and Chongqing in January 2011. It is noteworthy that property tax is not imposed on all properties in the two cities. Property tax is imposed on newly-purchased second or second-plus homes of a household in Shanghai, and property tax is imposed on high-end homes in Chongqing.

$CCOST$ is construction cost, which means the cost to build the physical structure of housing units (including the cost of labour, building materials and equipment but excluding the cost of land). As discussed in section 6.3.1, new housing supply tends to decrease as construction cost increases. Given the fact that housing price goes up as housing supply decreases, construction cost is expected to be positively related to housing price.

$FCOST$ is financing cost for developers, which is measured by the 1-3 year term benchmark bank loan rate. The analysis presented in section 6.3.1 suggests that financing cost for developers is negatively related to new housing supply. Given the fact that housing price is negatively related to housing supply, financing cost for developers is expected to be positively related to housing price.

LS is residential land supply, which is measured by the site area of land sold to developers for housing development. The empirical analysis presented in last chapter suggests that new housing supply tends to decrease as land supply decreases. Given the fact that housing price goes up as housing supply decreases, land supply is expected to be negatively related to housing price.

In model (7.9), the city-specific effects allow for the effects of factors that vary substantially across cities but are relatively invariant over time. Those factors can include geographical features, natural amenities, climate conditions, and regulatory stringency. The year-specific dummy variables allow for the effects of factors that vary substantially over time but are relatively invariant across cities. Those factors can include national monetary and credit policies. A negative and statistically significant coefficient on 1- and 2-year lags of land supply indicates that land supply is negatively

related to housing price. If it is found that land supply is negatively related to housing price, it is reasonable to argue that the decline in land supply after the government strengthened the intervention in the land markets has put upward pressure on housing price (Hypothesis 3).

The literature review presented in section 3.3 suggests that some studies have examined the impact of land supply on housing price by developing and estimating models of housing price (Ho & Ganesan 1998; Hui & Ho 2003; Peng & Wheaton 1994). The model of housing price developed in this research differs from those developed in previous studies primarily in two aspects. Firstly, in most previous studies examining the impact of land supply on housing price, the user cost of owner-occupied housing is not included as an independent variable in the models of housing price. If the user cost of owner-occupied housing plays an important role in determining the demand for housing and housing price, leaving out this variable can lead to omitted variable bias. Secondly, the model developed in this research takes into account the gradual housing price adjustment.

7.4 Data

The data used for model estimation consist of average real housing price, the number of permanent residents, per capita disposable income, construction cost, 1-3 year term and 5-year term benchmark bank loan rates, and the site area of land sold to developers for housing development. The data are collected from various Statistical Yearbook series (mainly including China Real Estate Statistics Yearbook series, China Statistical Yearbook series, Statistical Yearbook series of each city, and Statistical Communique on the Economic and Social Development series of each city).

Data on the number of permanent residents (at the city and year level) are sourced from Statistical Yearbook series of each city (2002-2012, compiled by Bureau of Statistics of each city) and Statistical Communique on the Economic and Social Development series of each city (2001-2011, compiled by Bureau of Statistics of each city). Data on the per capita disposable income (at the city and year level) are collected from Statistical Yearbook series of each city (2002-2012). Per capita disposable income is adjusted to 2011 price level using the national consumer price index compiled by China's National Bureau of Statistics. Data on the 5-year term benchmark bank loan rates are sourced from the report of the People's Bank of China. The data sources of average real housing price, construction cost, financing cost for developers and land supply have been described in the previous chapter. Table 7-1 presents variable definitions and data sources, and table 7-2 presents summary statistics of the raw data.

Table 7-1 Variable definitions and data sources

Variables	Definitions	Data Sources
HP	Average real housing price (unit: RMB/square meter)	China Real Estate Statistics Yearbook series (2002-2012)
POP	The number of permanent residents (unit: 1,000 persons)	Statistical Yearbook series/ Statistical Communique on the Economic and Social Development series of each cities (2002-2012)
UC	The user cost of owner-occupied housing (unit: %)	Author's calculation
INC	Per capita disposable income (unit: RMB)	Statistical Yearbook series of each city (2002-2012)
$CCOST$	Cost to build the physical structure of housing units (unit: RMB/ square meter)	China Real Estate Statistics Yearbook series (2002-2012)
$FCOST$	Financing cost for developers (unit: %)	The report of the People's Bank of China
LS	Site area of land sold to developers for housing development (unit: hectare)	China Statistical Yearbook series (2002-2012)

Table 7-2 Summary statistics of the raw data

Variables	Mean	Std. Dev.	Min	Max
HP	7,651.46	3,504.95	2,916	21,307
POP	9,467.3	3,999.6	445.51	23,474.6
UC	5.95	3.43	-5	14.5
INC	19,921.04	7,207.23	7,846	36,505
$CCOST$	2,380.14	906.51	963	6,985
$FCOST$	3.68	1.87	0.95	6.49
LS	471.48	348.03	13.87	2,092.5

7.5 Dynamic panel data models and their estimation

The analysis presented in section 6.5.1 suggests that panel data models can be classified into two categories: static panel data models and dynamic panel data models. Static panel data models refer to the panel data models that do not include lagged dependent variables as independent variables, and dynamic panel data models refer to the panel data models that include one or more lagged dependent variables as independent variables. Because the model of housing price developed in section 7.3 (model (7.9)) includes lagged dependent variable as independent variable, it is a dynamic panel data model. The approaches to estimating dynamic panel data models are introduced in this section.

In the context of dynamic panel data models, the fixed-effects estimators and the random effects estimators are biased and inconsistent (Nickell 1981). Thus, Holtz-Eakin, Newey & Rosen (1988) and Arellano & Bond (1991) developed a consistent dynamic panel data estimator (often referred to as the Arellano-Bond estimator) using

the generalized method of moments (GMM) approach.[21] To see what this method involves, consider a dynamic panel data model containing a lagged dependent variable:

$$y_{it} = \alpha_i + \beta_1 y_{i,t-1} + \beta_2 x_{1it} \ldots + \beta_{k+1} x_{kit} + \mu_{it}, \quad i = 1, \ldots, N; t = 1, \ldots, T \qquad (7.12)$$

where, y is the dependent variable, and x represents a vector of independent variables; the subscripts i and t refer to cross-sectional unit i and period t, respectively; α_i is the individual-specific, time-invariant effect; μ_{it} is the idiosyncratic error. First differencing both sides of the equation yields:

$$\Delta y_{it} = \beta_1 \Delta y_{i,t-1} + \beta_2 \Delta x_{1it} \ldots + \beta_{k+1} \Delta x_{kit} + \Delta \mu_{it}, \quad i = 1, \ldots, N; t = 1, \ldots, T \qquad (7.13)$$

In model (7.13), the individual-specific, time-invariant effect is removed. Then the moment conditions can be created using the first differenced errors and instruments. Lagged levels of the dependent variable are used to form GMM-type instruments, and first differences of the strictly exogenous variables are used to form standard instruments. Arellano & Bover (1995) and Blundell & Bond (1998) suggested that if the autoregressive process is too persistent or the ratio of the variance of the individual-specific effect to the variance of the idiosyncratic error is too large, then the lagged levels are weak instruments and the Arellano-Bond estimator can perform poorly. These authors proposed a system estimator (often referred to as the Arellano-Bover/Blundell-Bond system GMM estimator) that uses additional moment conditions in which lagged differences are used as instruments for the level equation.

The moment conditions used by GMM estimation are valid only if there is no autocorrelation in the first-differenced errors, and the Arellano-Bond test for serial

21. Unlike maximum likelihood estimation (MLE), GMM estimation does not require the full shape of the distribution function of the data. Only specified moment conditions (which are the functions of the model parameters and the data) are needed for GMM estimation. See Ruud (2000), Davidson & MacKinnon (2004), and Hall (2005) for the comprehensive textbook treatments of GMM.

correlation is generally used to test for autocorrelation in the first-differenced errors (Arellano & Bond 1991). The null hypothesis of the test is that there is no autocorrelation in the first-differenced errors. When the idiosyncratic errors are independently and identically distributed, the first-differenced errors should be first-order auto-correlated. Thus, rejecting the null hypothesis at order one does not imply that the model is misspecified. Rejecting the null hypothesis at an order greater than one implies that the moment conditions are not valid.

7.6 The regression procedures

The regression procedures in this chapter consist of the following steps: transformation of the raw data, pre-regression tests, and formally estimating the dynamic panel data model.

● Transformation of the raw data

The starting point of the regression analysis is the transformation of the raw data. In model (7.9), the dependent variable is the log of average real housing price, and the independent variables include the log of 1-year lag of average real housing price, the log of population, the user cost of owner-occupied housing, the log of income, the first difference of the log of construction cost, the first difference of financing cost for developers, and the log of 1- and 2-year lags of land supply. Thus, the data transformation techniques used include the first-difference transformation, the log transformation, and the lag transformation.

● Pre-regression tests

The second step of the regression analysis involves the pre-regression tests. It mainly consists of investigating whether each variable follows a normal distribution, the preliminary examination of the relationships between the dependent variable and each independent variable and panel unit root test.

As discussed in section 6.6.2, the kernel density estimation is generally used to examine whether each variable follows a normal distribution. Figure 7-1 and figure 7-2 show the results of the kernel density estimation for the log of income and the user cost of owner-occupied housing, respectively (the kernel density estimation for the other variables are presented in Appendix 11). As can be seen from the two figures and Appendix 11, the variables in model (7.9) generally follow a normal distribution.

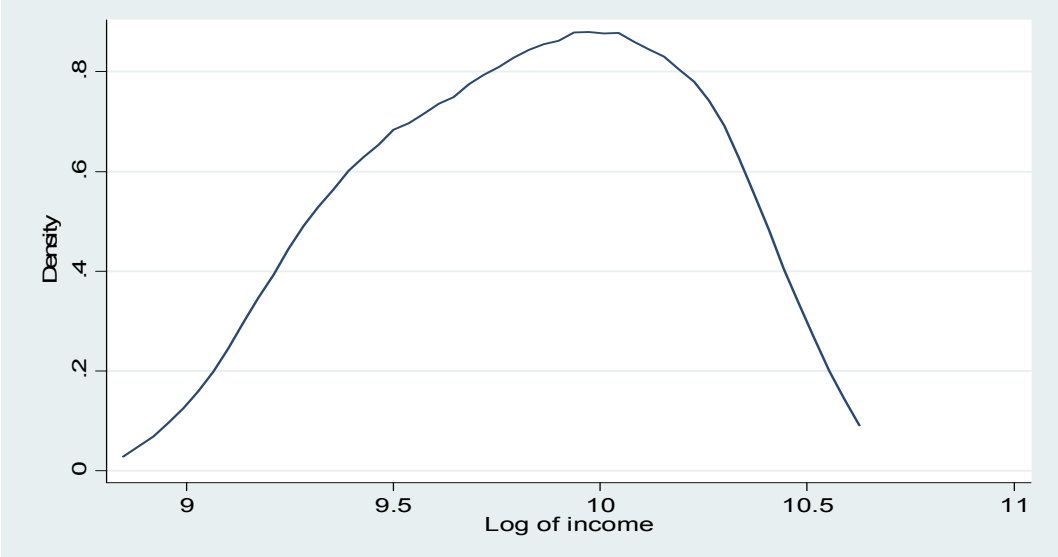

Figure 7-1 The kernel density estimation for the log of income

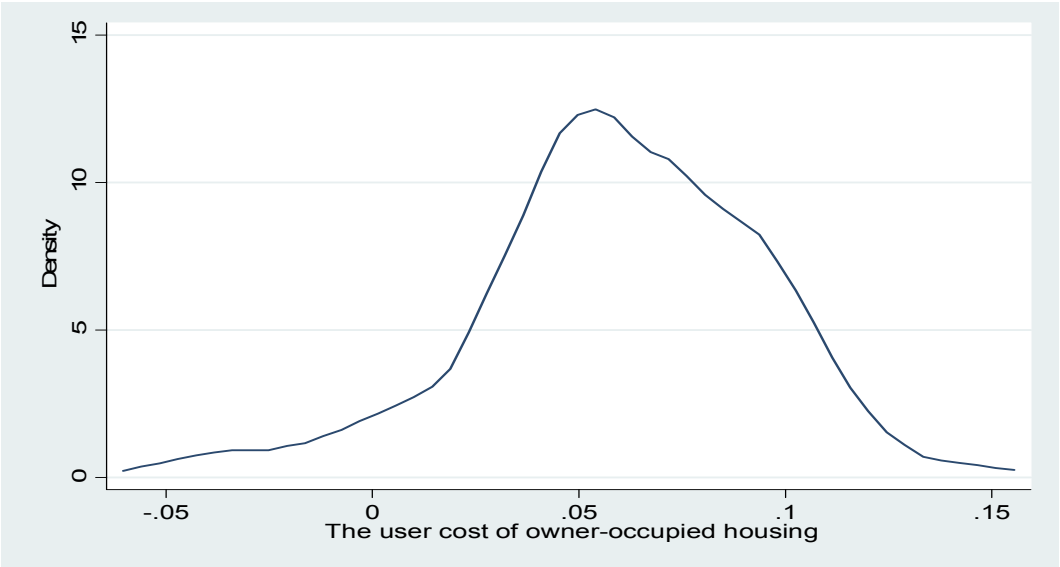

Figure 7-2 The kernel density estimation for the user cost of owner-occupied housing

The preliminary examination of the relationships between the dependent variable and each independent variable is done by drawing and examining the scatter plots of the dependent variable against each independent variable, and by simply regressing the dependent variable against each independent variable. Figure 7-3 and figure 7-4 show the scatter plots of the log of average real housing price against the log of 1- and 2-year lags of land supply. The scatter plots of the log of average real housing price against the other independent variables are presented in Appendix 12. As can be seen from the two figures, there is a strong negative relationship between land supply and housing price, and the slope coefficients on the log of 1- and 2-year lags of land supply are statistically significant at the 1% level.

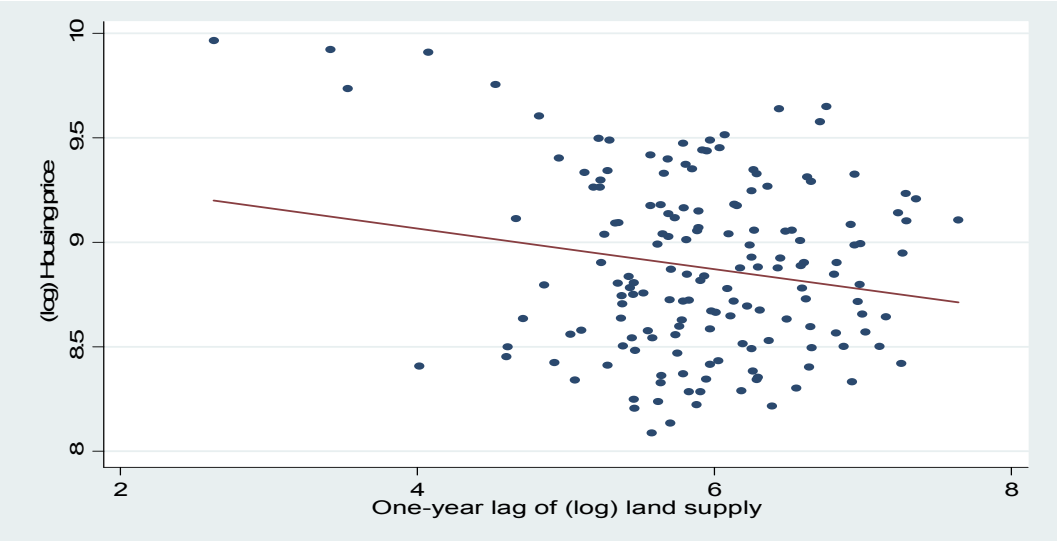

Figure 7-3 The scatter plot of the log of housing price against the log of 1-year lag of land supply

Note: The regression relationship (robust standard errors in parentheses) between the log of average real housing price, $lnHP_{it}$, and the log of 1-year lag of land supply, $lnLS_{i,t-1}$, is

$$lnHP_{it} = 9.743 - 0.146 lnLS_{i,t-1}$$

(0.170) (0.029)

Interdependence among the independent variables is examined by investigating the correlation matrix for the independent variables. The results (as shown in Appendix 13) suggest that there is no strong interdependence among the independent variables.

As discussed in section 6.5.3, the Im-Pesaran-Shin panel unit root test is used to assess the stationarity properties of the variables in the model of housing price. The results (as shown in table 7-3) suggest that while the log of housing price, the change in the log of construction cost and the log of land supply are stationary, the log of population and the log of income are I(1) (integrated of order one). Thus, the panel co-integration tests proposed by Westerlund (2007) are employed to test for the presence of long-run relationships among the variables in the model of housing price (see the discussion in

section 6.5.3). The results (as shown in Appendix 15) suggest that the variables are co-integrated.

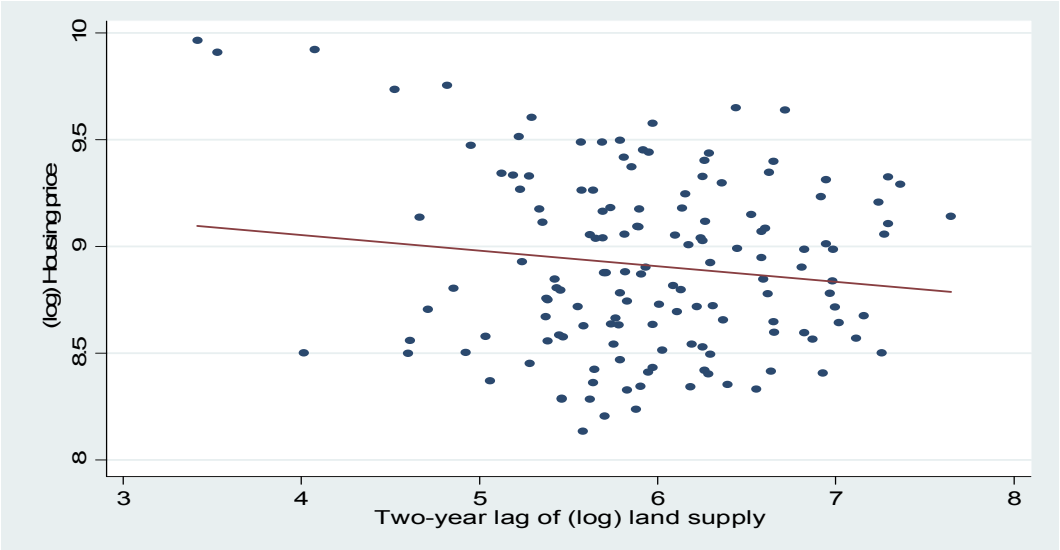

Figure 7-4 The scatter plot of the log of housing price against the log of 2-year lag of land supply

Note: The regression relationship (robust standard errors in parentheses) between the log of average real housing price, $lnHP_{it}$, and the log of 2-year lag of land supply, $lnLS_{i,t-2}$, is

$$lnHP_{it} = 9.720 - 0.136 lnLS_{i,t-2}$$
$$(0.196) \quad (0.033)$$

Table 7-3 The Im-Pesaran-Shin panel unit root test for the variables in the model of housing price

	Im-Pesaran-Shin test statistic	*p*-value
$\ln HP$	-2.476	0.007
$\ln POP$	5.207	1.000
$\Delta \ln POP$	-1.223	0.111
$\ln INC$	1.927	0.973
$\Delta \ln INC$	-4.562	0.000
$\Delta \ln CCOST$	-4.830	0.000
$\ln LS$	-3.219	0.001

● Formally estimating the dynamic panel data model

The third step of the regression analysis is formally estimating the dynamic panel data model. The Arellano-Bover/Blundell-Bond system GMM estimator (see discussion presented in section 7.5) is used for estimating model (7.9). The Arellano-Bond test for serial correlation is used to test for autocorrelation in the first-differenced errors (see analysis presented in section 7.5). As in previous chapter, the *t* statistics that are robust to cross-sectional heteroskedasticity and within panel serial correlation are used to test whether an independent variable is statistically significant, and adjusted R-squared is used to measure goodness of fit of the model (see discuss presented in section 6.5.3).

7.7 Empirical results

Tables 7-5 and table 7-6 report regression results when model (7.9) is estimated using the data for the 16 cities for the period 2001-2011.[22] The results of the Arellano-Bond test for serial correlation suggest that the null hypothesis of no autocorrelation in the first-differenced errors cannot be rejected at order two (see table 7-4), implying that there is no evidence of model misspecification.[23] As shown in table 7-5, the coefficient on lagged housing price is positive and statistically significant, suggesting that housing price adjusts gradually towards its equilibrium level. The regression results

22. Because the Arellano-Bover/Blundell-Bond system GMM estimator is designed for datasets with many panels and fewer periods, the model of housing price is not estimated using the sub-datasets of the 16 cities.

23. The analysis presented in section 7.5 suggests that when the idiosyncratic errors are independently and identically distributed, the first-differenced errors should be first-order auto-correlated. Thus, rejecting the null hypothesis of no autocorrelation in the first-differenced errors at order one does not imply that the model is misspecified.

suggest that population, income, and the user cost of owner-occupied housing are important demand-side determinants of housing price. Population has a positive and statistically significant impact on housing price. A 1 per cent increase in population will result in a 0.16 per cent increase in housing price. The user cost of owner-occupied housing has a negative and statistically significant impact on housing price. A 1 percentage point rise in the user cost of owner-occupied housing reduces housing price by 0.4 per cent. Per capita disposable income has a positive and statistically significant impact on housing price. A 1 per cent increase in per capita disposable income will result in a 0.12 per cent increase in housing price. As in the models of new housing supply, the construction cost variable performs poorly (the coefficient on change in construction cost is not statistically different from zero). The coefficient on change in financing cost for developers is positive but not quite within the conventional bounds of statistical significance (p-value = 0.132). Of primary interest are the coefficients on the land supply variables. The coefficients on 1- and 2-year lags of land supply are negative and statistically significant. A 1 per cent increase in 1-year lag of land supply reduces housing price by 0.01 per cent, and 1 per cent increase in 2-year lag of land supply reduces housing price by 0.02 per cent. Because land supply is negatively related to housing price, it is reasonable to argue that the decline in land supply after the government strengthened the intervention in the land markets has put upward pressure on housing price (Hypothesis 3).

Table 7-4 The Arellano–Bond test for serial correlation in the first-differenced errors

Order	z	Prob > z
1	-1.693	0.091
2	0.602	0.547

H_0 : no autocorrelation

Table 7-5 Regression results for model (7.9) (construction cost variable and financing cost variable included)

	Coef.	Robust Std. Err.	Robust t-value	P > | *t* |
$lnHP_{i,t-1}$	0.707	0.059	12.04	0.000***
$lnPOP_{it}$	0.155	0.069	2.25	0.024**
UC_{it}	-0.004	0.002	-2.37	0.018**
$lnINC_{it}$	0.123	0.064	1.92	0.055**
$\Delta lnCCOST_{it}$	-0.013	0.022	-0.57	0.569
$\Delta FCOST_{it}$	0.002	0.001	1.51	0.132
$lnLS_{i,t-1}$	-0.007	0.004	-1.67	0.095*
$lnLS_{i,t-2}$	-0.019	0.009	-2.14	0.033**
Year dummies (λ_t)	Yes			
Adj. R-squared	0.979			

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level.

Table 7-6 reports regression results when the insignificant construction cost variable ($\Delta lnCCOST_{it}$) and financing cost variable (($\Delta FCOST_{it}$) are dropped. The exclusion of the two variables slightly decreases the size of the coefficient on lagged housing price (from 0.707 to 0.706), and slightly increases the size of the coefficients on population and per capita disposable income (from 0.155 to 0.158, and from 0.123 to 0.124, respectively). The coefficient on the user cost of owner-occupied housing and the coefficients on 1- and 2-year lags of land supply all stay unchanged.

Table 7-6 Regression results for model (7.9) (construction cost variable and financing cost variable excluded)

	Coef.	Robust Std. Err.	Robust t-value	P > | *t* |
$lnHP_{i,t-1}$	0.706	0.058	12.28	0.000***
$lnPOP_{it}$	0.158	0.070	2.27	0.023**
UC_{it}	-0.004	0.002	-2.33	0.020**
$lnINC_{it}$	0.124	0.064	1.94	0.052**
$lnLS_{i,t-1}$	-0.007	0.004	-1.71	0.087*
$lnLS_{i,t-2}$	-0.019	0.009	-2.17	0.030**
Year dummies (λ_t)	Yes			
Adj. R-squared	0.978			

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level.

7.8 Summary

This chapter examines the impact that the decline in land supply has on housing price by developing and estimating the model of housing price. A reduced-form model of market-clearing housing price is first derived from the structural models of housing demand and housing supply, and the model of actual housing price is then derived based on the market-clearing price and a price adjustment mechanism. The model of housing price is estimated using the Arellano-Bover/Blundell-Bond system GMM estimator. The regression results suggest that land supply is negatively related to housing price, implying that the decline in land supply after the government strengthened the intervention in the land markets played a role in pushing up housing price. Consistent with the theoretical expectation, housing price is found to adjust gradually towards its equilibrium level. It is also found that population, income and the user cost of owner-occupied housing are important demand-side determinants of housing price.

Chapter 8: The operation of the housing markets in Beijing and Ningbo: a case study of two cities

8.1 Introduction

Previous chapters examine the change in residential land supply in the 16 major Chinese cities before and after the 2004 reform, and explore the impacts that the decline in land supply has on new housing supply and housing price using a multiple regression approach. However, previous chapters do not look into the operation of the real estate market in a particular city. As discussed in chapter 5, the 16 cities can be classified into two groups according to population size. The 7 cities (i.e. Shanghai, Beijing, Chengdu, Tianjin, Guangzhou, Shenzhen and Wuhan) which had a population of more than 10 million persons in 2011 constitute the "group-1 cities", and the 9 cities (i.e. Qingdao, Hangzhou, Xian, Nanjing, Ningbo, Hefei, Fuzhou, Jinan and Nanchang) which had a population of between 5 million and 10 million persons in 2011 constitute the "group-2 cities". In this chapter, two case-study cities, i.e. Beijing and Ningbo, are chosen from the "group-1 cities" and "group-2 cities" respectively. The operation of the real estate markets in the two cities are examined in more detail to support the findings obtained from the econometric analysis. The demand side of the housing markets is investigated by examining the population growth, economic development and income growth, and the supply side of the housing markets is investigated by examining the change in land supply and new housing supply. The change in housing price in the two cities is also examined.

The remainder of this chapter is organized as follows. Section 8.2 explains reasons for choosing Beijing and Ningbo as the case-study cities. Section 8.3 and section 8.4 investigate the operation of the housing markets in Beijing and Ningbo, respectively. Section 7.5 summarizes the findings from the case study of the two cities.

8.2 Reasons for choosing Beijing and Ningbo as the case-study cities

As discussed in section 5.3.1, the "group-1 cities" tend to have a larger population and GDP than the "group-2 cities". Among the "group-1 cities", Beijing deserves special attention, since it is China's capital city and its housing market is generally taken as a bellwether market in China. Thus, Beijing is chosen from the "group-1 cities" as a case-study city.

Ningbo is chosen from the "group-2 cities" as a case-study city since its population size and economic size is typical among the "group-2 cities". As is evident from table 8-1, Ningbo ranked in the middle of the population and GDP lists of the "group-2 cities". It had the 5th largest population and the 4th largest GDP among the "group-2 cities" in 2011.

Table 8-1 Population and GDP in the "group-2 cities" in 2011

Cities	Population (1,000 persons)	GDP (at current prices, billion RMB)
Qingdao	8,795	662
Hangzhou	8,738	702
Xian	8,513	386
Nanjing	8,109	615
Ningbo	7,628	606
Hefei	7,521	364
Fuzhou	7,200	374
Jinan	6,885	441
Nanchang	5,089	269

Notes: Population is measured by the number of permanent residents.

Source: Statistical Yearbook of each city (2012), Statistical Communique on the Economic and Social Development of each city (2012), and China Real Estate Statistics Yearbook (2012).

8.3 The operation of the housing market in Beijing

8.3.1 A brief introduction of Beijing

Beijing is the capital of China. It is located in northern China and borders Hebei Province and Tianjin Municipality. It covers an area of 16,410.54 km^2, and had a permanent resident population of 20,186,000 in 2011 (Beijing Municipal Bureau of Statistics, Beijing Statistical Yearbook 2012). Beijing is China's political, cultural, and educational centre, and is among the most developed cities in China. The headquarters of many of the country's largest companies are located in Beijing. There are also many large multinational corporations who locate their regional headquarters in Beijing.

8.3.2 The demand side of the housing market in Beijing

As a result of rapid population and income growth and significant economic development, the housing market in Beijing was under great demand pressure during the period 2001-2011. Table 8-2 shows the change in population, GDP, per capita

disposable income and local fiscal revenue in Beijing during the sample period. As is evident from the table, the period 2001-2011 saw a remarkable growth of population in Beijing, with permanent resident population growing from 13.85 million persons in 2001 to 20.19 million persons in 2011. It is worth noting that inner-country migration contributed significantly to the population growth in Beijing. The migrants from other regions of the nation accounted for 36.8% of the permanent residents in Beijing in 2011 (Beijing Municipal Bureau of Statistics, Beijing Statistical Yearbook 2012). Beijing also experienced rapid economic development during the sample period. There was a significant increase in the GDP (at current prices) in Beijing, from 371 billion RMB in 2001 to 1,625 billion RMB in 2011. The per capita GDP in Beijing had also increased considerably, from 26,771 RMB in 2001 to 80,511 RMB in 2011. As a result of the rapid economic growth, per capita disposable income in Beijing rose significantly from 11,578 RMB in 2001 to 32,903 RMB in 2011, with the compound annual growth rate being 11%. There was also a significant increase in the local fiscal revenue in Beijing, from 51 billion RMB in 2001 to 436 billion RMB in 2011. This implies that the ability of Beijing municipal government to provide public services (education, health care, public transportation, etc.) and infrastructures had increased significantly during the sample period. Better public services can increase the demand for housing and put upward pressure on housing price (Haurin & Brasington 1996; Nechyba & Strauss 1998; Yinger 1982).

Table 8-2 Changes in population, GDP, income and local fiscal revenue in Beijing during the period 2001-2011

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Population (1,000 persons)	13,851	14,232	14,564	14,927	15,380	16,010	16,760	17,710	18,600	19,619	20,186
GDP (billion RMB)	371	432	501	603	697	812	985	1,112	1,215	1,411	1,625
Per capita GDP (RMB)	26,771	30,319	34,381	40,418	45,315	50,705	58,752	62,761	65,339	71,938	80,511
Per capita disposable income (RMB)	11,578	12,464	13,883	15,638	17,653	19,978	21,989	24,725	26,738	29,073	32,903
Local fiscal revenue (billion RMB)	51	60	67	83	101	124	188	228	268	381	436

Notes: Population is measured by the number of permanent residents. Per capita disposable income is adjusted to 2011 price level using the national consumer price index compiled by China's National Bureau of Statistics.

Source: Beijing Statistical Yearbook series (2002-2012) and Beijing Statistical Communique on the Economic and Social Development series (2001-2011).

8.3.3 The supply side of the housing market in Beijing

The change in annual land supply in Beijing during the period 2001-2011 is shown in figure 8-1. Annual land supply fluctuated around 1,500 hectares between 2001 and 2004 in Beijing, with a record high of 2,093 hectares being reached in 2002. It declined dramatically immediately after the government strengthened the intervention in the land markets (from 1,572 hectares in 2004 to 774 hectares in 2005), reached a record low of 295 hectares in 2006, and then increased until 2008. Between 2008 and 2011, annual land supply fluctuated around 800 hectares. A comparison of land supply before and after the 2004 reform shows that the average annual land supply for the period 2005-2011 (611 hectares) is significantly lower than that for the period 2001-2004 (1,632 hectares).

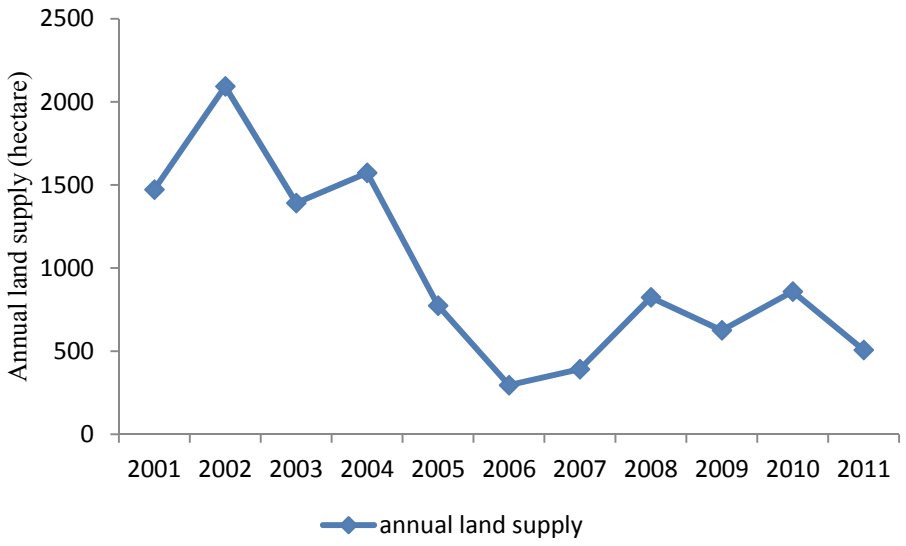

Figure 8-1 The change in annual land supply in Beijing during the period 2001-2011

Source: China Statistical Yearbook series (2002-2012)

The change in new housing supply in Beijing during the period 2001-2011 is shown in figure 8-2. New housing supply in Beijing increased from 2,237 hectares in 2001 to 2,503 hectares in 2003, and then declined until 2009. It started to increase again from 2010 and returned to a high level in 2011. It appears that new housing supply did not keep pace with the increased demand between 2005 and 2011.

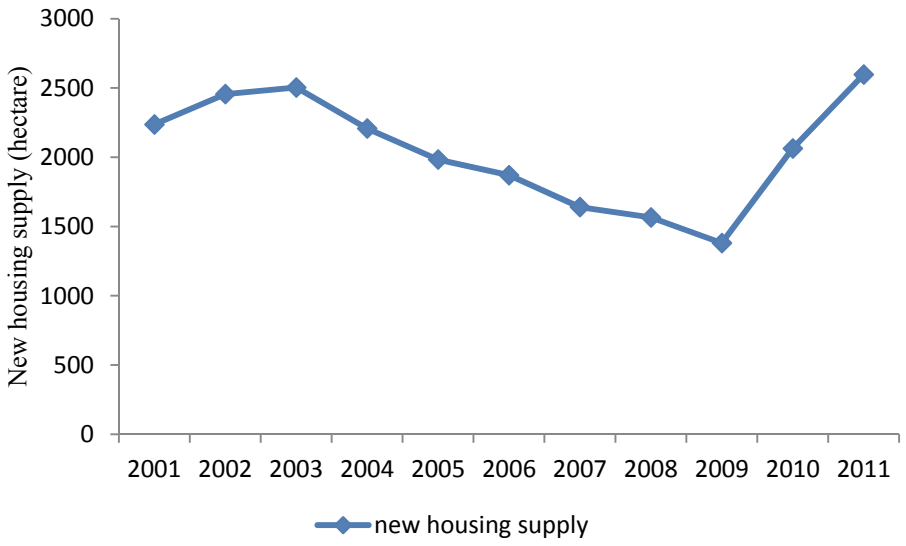

Figure 8-2 The change in new housing supply in Beijing during the period 2001-2011

Source: China Real Estate Statistics Yearbook series (2002-2012)

As can be seen from figure 8-1 and figure 8-2, there is a positive relationship between land supply and new housing supply, and the decline in land supply after the 2004 reform seems to have a depressing effect on new housing supply in Beijing. Both land supply and new housing supply were relatively high during the period 2001-2004. After 2004, there was a 5-year decline in new housing supply when the level of annual land supply was relatively low. New housing supply started to rise again following the increase in land supply in recent years.

8.3.4 The change in housing price in Beijing

The change in average real housing price in Beijing during the period 2001-2011 is shown in figure 8-3. Average real housing price in Beijing stayed relatively stable between 2001 and 2004, and then rose dramatically from 5,816 RMB/square meter in 2004 to 18,059 RMB/square meter in 2010. Because the Chinese government

introduced a battery of measures to head off housing price boom in 2011, there was a decrease in average real housing price in Beijing in that year.

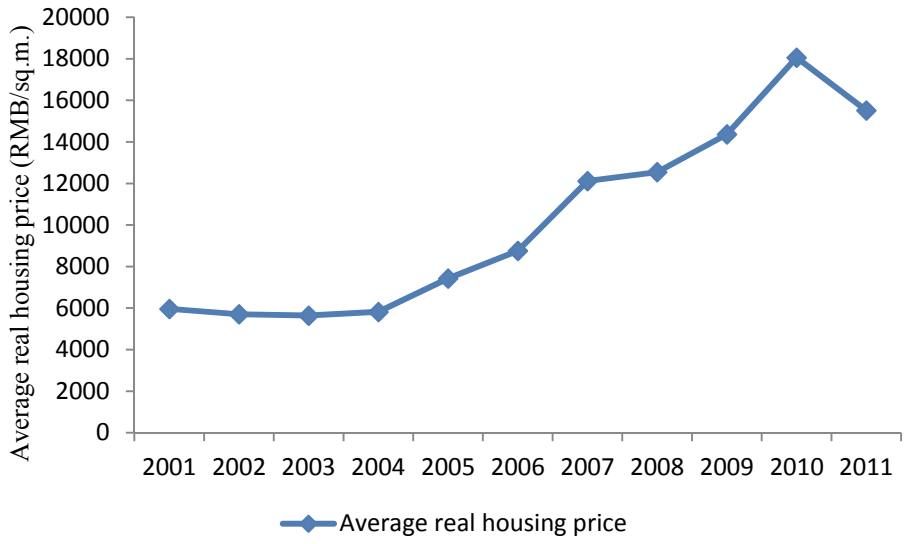

Figure 8-3 The change in average real housing price in Beijing during the period 2001-2011

Notes: Average housing price is adjusted to 2011 price level using the housing price index for large and medium-sized cities compiled by China's National Bureau of Statistics

Source: China Real Estate Statistics Yearbook series (2002-2012)

As can be seen from figure 8-1 and figure 8-3, there is a negative relationship between land supply and average real housing price, and the decline in land supply after the 2004 reform appears to play a role in pushing up housing price in Beijing. When the land supply was relatively high during the period 2001-2004, the average real housing price remained at a relatively low level. By contrast, in the post-2004 period which was characterized by constrained land supply, there was a remarkable increase in the average real housing price, with the compound annual growth rate being as high as 15.1%.

8.4 The operation of the housing market in Ningbo

8.4.1 A brief introduction of Ningbo

Ningbo is a seaport city in Zhejiang province. It is located in the south of the Yangtze River Delta and faces the East China Sea to the east. It covers an area of 9,816 km^2, and had a permanent resident population of 7,628,000 in 2011 (Ningbo Municipal Bureau of Statistics, Ningbo Statistical Yearbook 2012). Ningbo is a sub-provincial city, and is one of the earliest coastal cities which were opened to foreign investment.

8.4.2 The demand side of the housing market in Ningbo

As a result of significant economic development and rapid population and income growth, the housing market in Ningbo was under high demand pressure during the period 2001-2011. Table 8-3 shows the change in population, GDP, per capita disposable income and local fiscal revenue in Ningbo during the sample period. As is evident from the table, Ningbo experienced significant population growth during the period 2001-2011, with the permanent resident population growing from 6.11 million persons in 2001 to 7.63 million persons in 2011. A high rate of economic growth has been documented in Ningbo in the period 2001-2011. The GDP (at current prices) in Ningbo increased considerably from 128 billion RMB in 2001 to 606 billion RMB in 2011. The per capita GDP in Ningbo more than tripled between 2001 and 2011 (from 20,926 RMB to 79,431 RMB). As a result of the rapid economic growth, there was a remarkable increase in per capita disposable income in Ningbo (from 15,159 RMB in 2001 to 34,058 RMB in 2011). The sample period also saw a significant increase in the local fiscal revenue in Ningbo, from 19 billion RMB in 2001 to 143 billion RMB in 2011.

Table 8-3 The change in population, GDP, income and local fiscal revenue in Ningbo during the period 2001-2011

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Population (1,000 persons)	6,112	6,261	6,410	6,559	6,709	6,858	7,007	7,156	7,275	7,611	7,628
GDP (billion RMB)	128	145	175	211	245	287	342	395	433	516	606
Per capita GDP (RMB)	20,926	23,207	27,285	32,154	36,473	41,907	48,794	55,157	59,505	67,836	79,431
Per capita disposable income (RMB)	15,159	16,564	18,072	19,463	20,973	23,366	25,349	27,238	29,716	31,754	34,058
Local fiscal revenue (billion RMB)	19	26	33	40	47	56	72	81	97	117	143

Notes: Population is measured by the number of permanent residents. Per capita disposable income is adjusted to 2011 price level using the national consumer price index compiled by China's National Bureau of Statistics.

Source: Ningbo Statistical Yearbook series (2002-2012) and Ningbo Statistical Communique on the Economic and Social Development series (2001-2011).

Although Ningbo experienced rapid population growth and economic development in the period 2001-2011, the rates of population and income growth in Ningbo were smaller than those in Beijing (the compound annual rate of population growth between 2001 and 2011 was 3.8% in Beijing, and 2.2% in Ningbo; the compound annual rate of income growth between 2001 and 2011 was 11% in Beijing, and 8.4% in Ningbo). Thus, it is reasonable to argue that the demand pressure in the housing market in Ningbo was smaller than that in Beijing during the sample period.

8.4.3 The supply side of the housing market in Ningbo

The change in annual land supply in Ningbo during the period 2001-2011 is shown in figure 8-4. Annual land supply increased from 298 hectares in 2001 to 721 hectares in 2003, and then declined to 362 hectares in 2004. It further declined to 207 hectares in 2005 and fluctuated around 200 hectares between 2005 and 2011. A comparison of

land supply before and after the 2004 reform shows that the average annual land supply for the period 2005-2011 (217 hectares) is significantly lower than that for the period 2001-2004 (465 hectares).

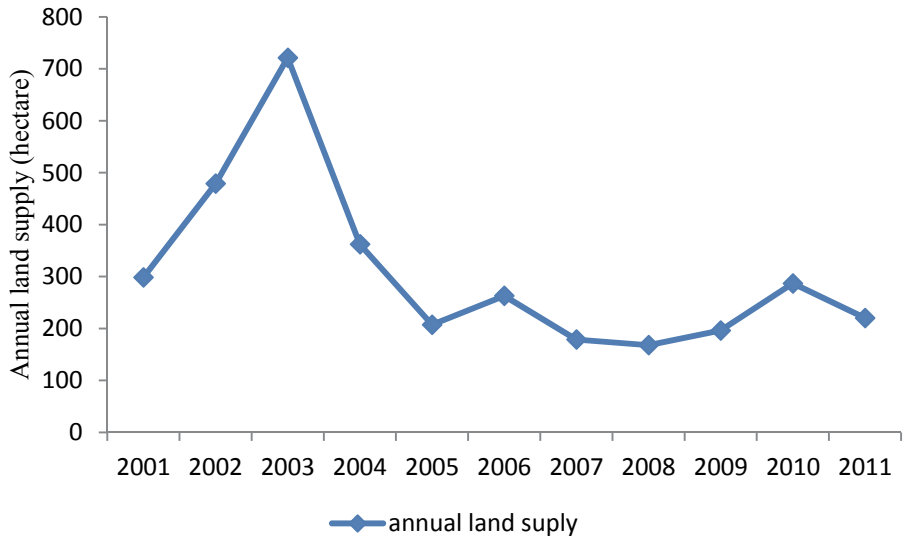

Figure 8-4 The Change in annual land supply in Ningbo during the period 2001-2011

Source: China Statistical Yearbook series (2002-2012)

The change in new housing supply in Ningbo during the period 2001-2011 is shown in figure 8-5. New housing supply increased from 402 hectares in 2001 to 831 hectares in 2003, and then trended downwards until 2009. It started to increase again from 2010 and reached a record high in 2011. It seems that new housing supply was not responsive to the increase in the demand for housing between 2005 and 2009.

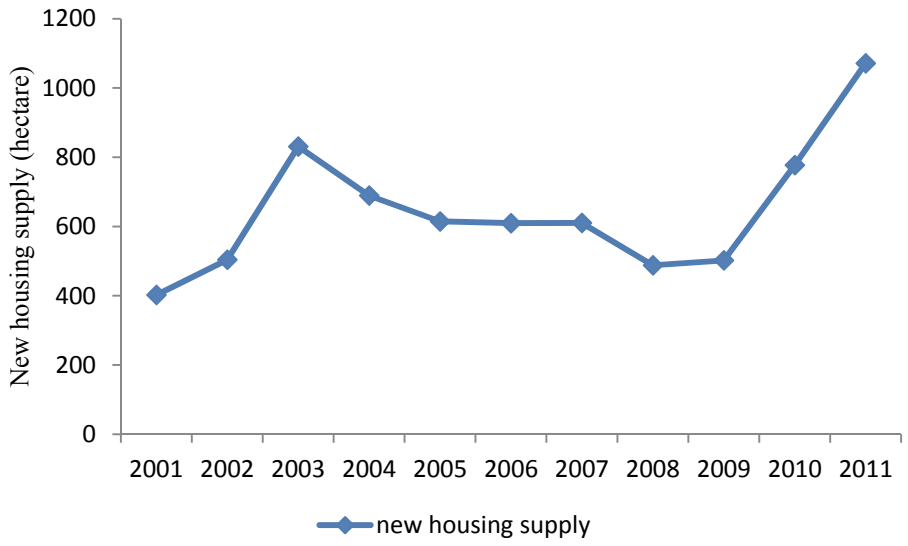

Figure 8-5 The Change in new housing supply in Ningbo during the period 2001-2011

Source: China Real Estate Statistics Yearbook series (2002-2012)

As can be seen from figure 8-4 and figure 8-5, there is a positive relationship between land supply and new housing supply, and the decline in land supply after the 2004 reform appears to have a depressing effect on new housing supply in Ningbo. Both land supply and new housing supply showed an upward trend between 2001 and 2003. When land supply was relatively low in the post-2004 period, new housing supply stayed stable at a relatively low level for many years and only started to rise in recent years.

8.4.4 The change in housing price in Ningbo

The change in average real housing price in Ningbo during the period 2001-2011 is shown in figure 8-6. Average real housing price rose from 2,356 RMB/square meter in 2001 to 3,708 RMB/square meter in 2004. It more than tripled between 2004 and 2010, from 3,708 RMB/square meter to 12,287 RMB/square meter. When the Chinese government took measures to curb housing price boom in 2011, there was a decrease

in the average real housing price in Ningbo. It is worth noting that the average real housing price in Ningbo increased at a faster rate after the 2004 reform. While the compound annual rate of housing price appreciation between 2001 and 2004 was 16.3%, the compound annual rate of housing price appreciation between 2004 and 2011 was 17.2%. Thus, the decline in land supply after 2004 appears to play a role in pushing up housing price in Ningbo.

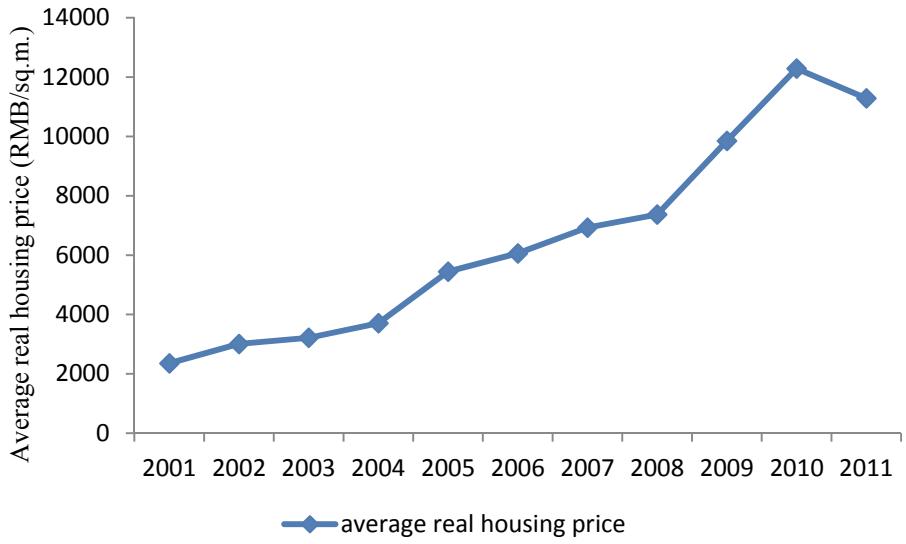

Figure 8-6 Change in average real housing price in Ningbo during the period 2001-2011

Notes: Average housing price is adjusted to 2011 price level using the housing price index for large and medium-sized cities compiled by China's National Bureau of Statistics

Source: China Real Estate Statistics Yearbook series (2002-2012)

8.5 Findings from the case study of the two cities

As can be seen from the above analysis, on the demand side of the housing markets, both Beijing and Ningbo experienced remarkable population growth and economic development during the period 2001-2011. Because the rates of population and

income growth in Beijing were higher than those in Ningbo, the demand pressure in housing market in Beijing tended to be greater. On the supply side of the housing markets, after the 2004 reform which led to stronger government intervention in the land markets, land supply and new housing supply was not responsive to the change in the demand for housing. New housing supply in Beijing and Ningbo only started to increase in 2010. The mismatch between housing demand and supply led to remarkable increase in the housing price in the two cities, with the compound annual rate of housing price appreciation being higher after 2004. In summary, land supply remained at a relatively low level in the two cities after the 2004 reform. The constrained land supply had a depressing effect on new housing supply and played a role in pushing up housing price.

8.6 Summary

This chapter uses a case study approach to examine the impacts that government intervention in the land markets has on residential land supply, new housing supply and housing price. The operation of the real estate markets in two selected cities (Beijing and Ningbo) during the period 2001-2011 is examined. It is found that land supply and new housing supply did not keep pace with the increased demand under the influence of stronger government intervention in the land markets, and the rate of housing price appreciation was higher after the 2004 reform. The findings from the case study support the findings from the econometric analysis which are presented in previous chapters.

Chapter 9: Discussion and policy implications

9.1 Introduction

The analysis presented in chapter 5 suggests that there was a decline in residential land supply in the 16 major Chinese cities after the 2004 reform. The analysis presented in chapter 6 and chapter 7 suggests that the decline in land supply has a depressing effect on new housing supply and plays a role in pushing up housing price. The empirical results have implications for understanding government intervention in land markets and its impacts and the determinants of new housing supply and housing price. Potential avenues through which a more responsive land supply system can be achieved can also be identified based on the empirical results. This chapter presents a discussion of the findings reported in previous chapters and analyses the implications of the empirical findings for land use and housing policies.

9.2 Discussion of the research findings

9.2.1 Discussion of the findings reported in chapter 5

Chapter 5 investigates the process leading to stronger government intervention in the land markets in China, and examines the change in residential land supply in the 16 major Chinese cities before and after the 2004 reform. It is found that municipal governments have acquired complete control over urban residential land supply since 2004. In addition, the central government has imposed more stringent regulatory constraints on rural-urban land conversion since 2004. There was a decline in residential land supply in the 16 major Chinese cities after the 2004 reform.

Since demand pressure can result in very different housing market outcomes under different land supply and planning systems (Mayo & Sheppard 1996), it is interesting to compare government intervention in land markets in different countries (see table 9-1). In western countries which have a freehold tenure system, governments intervene in land markets primarily through land use regulations, and governments generally do not act as a supplier of developable land. Although the uses to which land can be put are controlled by land use regulations, developers are free to buy agricultural land from farmers or buy old industrial land from existing urban land users. In the US, government intervention in land markets mainly comes in the form of zoning regulations and the designation of urban growth boundaries. Zoning regulations designate permitted uses of land in a certain region. If a proposed residential development conforms to the zoning regulations and other local regulations (such as building or safety regulations), building permits are usually granted as requested (Cheshire & Sheppard 2005; Mayer & Somerville 2000a); if the land parcel on which the developer intends to build homes is not zoned for residential use, the developer will have to lodge a rezoning application. As discussed in section 2.2.1, the urban growth boundary refers to a regulatory line drawn around an urban area beyond which development will not be permitted. It is generally used to curb urban sprawl and protect agricultural land. In the UK, although land is identified as suitable for specific uses by planning authorities, land is not explicitly zoned as in the US (Cheshire & Sheppard 2005; Monk & Whitehead 1999; White & Allmendinger 2003). A planning permit must be obtained prior to starting any land development. The decision to approve or deny a permit application is made by local planning authorities on a non-statutory, discretionary basis, and this regulatory process is costly, time-consuming and highly uncertain in outcome (Ball 2011; Bramley 2007). In addition, the

designation of green belts, which refer to broad swaths of designated undeveloped, wild, or agricultural land surrounding or neighbouring urban areas, serves the same function as the designation of urban growth boundaries in the US.

In some East Asian countries/regions (such as mainland China, Singapore and Hong Kong), governments can intervene in land markets in a more direct way by directly participating in land development and land supply. However, it is noteworthy that government land sales is not the only way in which land can be supplied for housing development in Singapore and Hong Kong. In Singapore, there are two sources of residential land supply: government-owned land and privately owned land (Ooi, Sirmans & Turnbull 2011). In Hong Kong, in addition to government land sales, land can be supplied for housing development by means of land exchange and lease modifications (see discussion presented in section 3.2.1 and section 3.3) (Ho & Ganesan 1998; Hui, Leung & Yu 2014; Tse 1998). Since government land sales is not the only source of land supply, there is some flexibility in the land supply systems in the sense that land supply process can be initiated by existing urban land users or developers (Hui, Leung & Yu 2014). In addition, Ooi, Sirmans & Turnbull (2011) suggested that since the revenue from land sales constitutes only a small percentage of total government revenues in Singapore, the Singapore government is unlikely to exploit its market power to maximize or stabilize revenues.

Differing from the situation in Singapore and Hong Kong, the supply of urban residential land has been completely controlled by municipal governments in China since 2004. The establishment of complete government control over land supply can have significant effects on the operation of real estate markets. Firstly, as discussed in section 5.3.3, complete government control can make residential land supply less

responsive to changing market conditions. When land and housing supply is inelastic, an increase in the demand for housing will translate into higher increase in housing price (Caldera & Johansson 2013; Glaeser, Gyourko & Saks 2006; Grimes & Aitken 2010; Ihlanfeldt & Mayock 2014; Ooi & Le 2012). Secondly, when land is supplied for housing development through government land sales, the development requirements (such as maximum gross floor area and the period allowed for building) are determined by municipal governments before a land parcel is put on the market. Thus, government land sales is a government-initiated process which tends to overlook developers' profit incentives and development strategies (Hui, Leung & Yu 2014).

Table 9-1 Government intervention in land markets in different countries

Countries	Government intervention in land markets
The US	zoning regulations and the designation of urban growth boundaries
The UK	planning permission process and the designation of green belts
Singapore	land use regulations and the government acting as a land supplier
Hong Kong	land use regulations and the government acting as a land supplier
Mainland China	land use regulations and complete government control over land supply

9.2.2 Discussion of the findings reported in chapter 6

In chapter 6, the impacts that the decline in land supply has on new housing supply and housing supply elasticity is examined by estimating the models of new housing supply using data for the 16 major Chinese cities. The empirical results suggest that land supply is positively related to new housing supply, and thus the decline in land supply after the 2004 reform has had a depressing effect on new housing supply. There was also a decline in the housing supply elasticity after the government strengthened the intervention in the land markets. Housing price and financing cost for developers

play an important role in determining new housing supply, and construction cost has no significant impact on new housing supply. In addition to the main findings, it is found that housing supply elasticities and the elasticities of new housing supply with respect to land supply vary across the group-1 cities and the group-2 cities. The finding that land supply is positively related to new housing supply is in line with the findings of two UK studies (Bramley 1993; Pryce 1999), but is different from the findings of some Hong Kong studies (Lai & Wang 1999; Peng & Wheaton 1994). The findings that housing price and financing cost for developers are important determinants of new housing supply are consistent with the findings of most existing studies (Ball, Meen & Nygaard 2010; Blackley 1999; Caldera & Johansson 2013; Grimes & Aitken 2010; Hwang & Quigley 2006b; Ihlanfeldt & Mayock 2014; Mayer & Somerville 2000b; McLaughlin 2012; Saiz 2010). The finding that construction cost has no significant effect on new housing supply is also in line with the findings of most existing studies (Blackley 1999; Dipasquale & Wheaton 1994; Mayer & Somerville 2000b; Poterba 1984; Pryce 1999; Topel & Rosen 1988). In this section, the findings reported in chapter 6 are compared with those reported in existing studies. The implications of the findings for studies on new housing supply are also discussed.

Differing from the findings of this research, Peng & Wheaton (1994) and Lai & Wang (1999) found that land supply had no significant impact on new housing supply in Hong Kong which also has a leasehold tenure system. Peng & Wheaton (1994) provided two explanations for the findings in Hong Kong. Firstly, the flexible restriction on density and floor area ratio in Hong Kong means that developers could substitute the structural capital for land relatively freely. Secondly, the widespread land hoarding practice in Hong Kong had prevented the efficient translation of land

supply into new housing supply. Lai & Wang (1999) argued that the housing industry in Hong Kong was primarily constituted by a few large developers such as Cheng Kong (Holdings) Limited, Sun Hung Kai Properties limited, New World Development Limited, and Henderson Land Development Limited, and these large developers held a substantial amount of land in their land banks. Thus, newly supplied land could be simply absorbed into the developers' land banks, and an increase in residential land supply did not necessarily lead to the increase in new housing supply.[24] Differing from the situation in Hong Kong, the Chinese government has taken measures to prevent speculative land hording (see analysis presented in section 6.2) and the restriction on density and floor area ratio is relatively strict in mainland China. Thus, it is not surprising that a positive and statistically significant relationship between land supply and new housing supply can be found in major Chinese cities.

Although land supply can play an important role in determining new housing supply,[25] land supply variable or land-related variables were not included in the models of new housing supply in many existing studies. Table 9-2 lists some highly cited studies on modelling new housing supply over the last 30 years and shows the independent variables used in those studies. As is evident from table 9-2, housing price, construction cost and financing cost were usually included as independent variables in the models of new housing supply. However, among the 18 listed studies, land supply was used as independent variable in only 3 studies (Bramley 1993; Dipasquale & Wheaton 1994; Pryce 1999). Some other studies took account of the effects of land

24. Some other researchers also suggest that land banking behaviour of developers had prevented the efficient translation of land supply into new housing supply in Hong Kong (Hui & Ho 2003; Tse 1998).

25. As discussed in section 3.3, two studies conducted in the UK also found that land supply has a positive and statistically significant effect on new housing supply (Bramley 1993; Pryce 1999).

supply by using land price variable (Blackley 1999; Dipasquale & Wheaton 1994; Grimes & Aitken 2010). In the models of new housing supply developed by Dipasquale & Wheaton (1994) and Blackley (1999), the price of agricultural land was included as independent variable. However, Grimes & Aitken (2010) argued that there was no reason to expect that the price of residential land equalled the price of agricultural land due to the existence of geographical constraints and regulatory restrictions. Thus, they used the price of residential land rather than the price of farmland as independent variable in the model of new housing supply. Given the important role that land supply can play in determining new housing supply, it is reasonable to argue that land supply or residential land price should be included as an independent variable in the model of new housing supply, and not including land-related variables can give rise to omitted variable bias.

Table 9-2 Some existing studies on modelling new housing supply and the independent variables used in those studies

Authors	Data	Independent variables
Poterba (1984	quarterly data	housing price, construction cost, credit availability and the price of alternative construction projects
Topel & Rosen (1988	quarterly data	housing price, construction cost, financing cost and the median time on the market for new homes
Bramley (1993	annual data	housing price, land supply and planning variables
Dipasquale & Wheaton (1994	annual data	housing price, construction cost, financing cost, the price of farm land, lagged housing stock, the change in employment and the time on the market for new homes
Peng & Wheaton (1994	annual data	housing price, the change in housing price, construction cost, financing cost and land supply
Blackley (1999	annual data	housing price, the change in housing price, construction cost, financing cost, the price of farm land
Pryce (1999	annual data	housing price, construction cost, land supply and percentage of housing development on existing urban land
Mayer & Somerville (2000b	annual data	change in housing price, change in construction cost, change in financing cost and the time on the market for new homes
Green, Malpezzi & Mayo (2005	annual data	housing price
Zabel & Paterson (2006	annual data	change in housing price, planning variables and population and land area in a specific region
Hwang & Quigley (2006b	annual data	change in housing price, change in construction cost, change in financing cost and restrictiveness of local regulation
Grimes & Aitken (2010	quarterly data	housing price, construction cost and residential land price
Ball, Meen & Nygaard (2010	quarterly data	the levels of and the changes in housing price, the volume of housing transaction, construction cost and financing cost
Meen & Nygaard (2011	annual data	the levels of and the changes in housing price and land use variables
McLaughlin (2011	quarterly data	change in housing price, construction cost, financing cost, planning variables and population
Gitelman and Otto (2012)	annual data	housing price and the median time taken by the local planning authorities to determine a development application
McLaughlin (2012	quarterly data	change in housing price, change in construction cost and change in financing cost
Caldera & Johansson (2013	quarterly data	housing price, construction cost and a demographic variable

Consistent with the findings of many existing studies (Blackley 1999; Dipasquale & Wheaton 1994; Mayer & Somerville 2000b; Poterba 1984; Pryce 1999; Topel & Rosen 1988), construction cost is found to have no significant effect on new housing supply in this study. As discussed in section 6.7.1, one explanation for the poor performance of the construction cost variable is the endogeneity between construction cost and new housing supply. However, Somerville (1999b) suggested that poor performance of construction cost variable can also be due to biased measurements of construction costs. He developed quality-controlled hedonic construction cost series for new residential construction in Baltimore, Cincinnati, and Houston for the period 1979-1991, and used the series in estimating the models of new housing supply. The empirical results suggested that the increase in construction cost did reduce new housing supply. Somerville (1999b) suggested that the commercial construction cost index employed in the existing housing supply literature used an inappropriate measure of labour costs and thus failed to reflect actual construction costs. An important implication of Somerville's study is that there is a need to use more accurate measures of construction costs in estimating models of new housings supply.

Although the empirical results reported in chapter 6 suggest that housing supply elasticities and the elasticities of new housing supply with respect to land supply vary across the group-1 cities and the group-2 cities, the estimates of average housing supply elasticities across cities rather than the estimates of city-specific housing supply elasticities are obtained in this study. The reason for this is that the time series used in this research is relatively short, and the models of new housing supply are not estimated using time series data for individual cities. As more relevant data (especially quarterly data or monthly data) become available, it will be interesting to estimate the

models of new housing supply using time series data for individual cities and further examine how housing supply elasticities vary across cities.

Some studies have estimated housing supply elasticities using national-level data or city-level panel data (Ball, Meen & Nygaard 2010; Grimes & Aitken 2010; Harter-Dreiman 2004; Hwang & Quigley 2006b; Mayer & Somerville 2000a, 2000b; Wang, Chan & Xu 2012). It is interesting to compare the estimates of housing supply elasticities for major Chinese cities with those for other countries reported in existing studies. As shown in table 9-3, the estimates of housing supply elasticities are reported to be smaller than 5 in most of the existing studies, and the estimates of housing supply elasticities for the US are generally higher than those for other countries. Compared with the estimates reported in existing studies, the estimate of housing supply elasticity for the 16 major Chinese cities for the subsample period 2001-2005 was moderately high. However, the estimate of housing supply elasticity for the 16 major Chinese cities for the subsample period 2006-2011 was relatively low.[26]

26. As discussed in chapter 6, because in 2005 developers could still use land acquired in 2003 or 2004, it is assumed that housing supply elasticity did not decrease immediately after the 2004 reform. Thus, the housing supply elasticity for the subsample period 2006-2011 is estimated in chapter 6.

Table 9-3 The estimates of housing supply elasticities in different countries

Countries	Period	Data	Source	Estimate of housing supply elasticity
The US	1950-1994	national-level, annual	Blackley (1999	0.8 ~ 3.7
The UK	1988, 1992	regional-level, annual	Pryce (1999	0.58 for the year 1988 and 1.03 for the year 1992
The US	1975-1994	national-level, quarterly	Mayer & Somerville (2000b	3.7 (price elasticity of new housing supply), 0.08 (price elasticity of housing stock)
The US	1985-1996	city-level, quarterly	Mayer & Somerville (2000a	14.4 ~ 18
The US	1980-1998	city-level, annual	Harter-Dreiman (2004	1.8 ~ 3.2
The US	1979-1996	city-level, annual	Green, Malpezzi & Mayo (2005	-0.3 ~ 29.9
The US	1987-1999	city-level, annual	Hwang and Quigley (2006)	0.01~ 0.09
New Zealand	1991-2004	city-level, quarterly	Grimes & Aitken (2010	0.7 ~ 1.1
The US	1970-2000	city-level, decadal	Saiz (2010	0.6 ~ 5.45
UK, US and Australia	1970-2008	national-level, quarterly	Ball, Meen & Nygaard (2010	1.68 for the UK, 3-3.5 for the US and 1.8 for Australia
The UK	2004-2007	regional-level, annual	Meen & Nygaard (2011	-0.01 ~ 1.0
Australia	1991-2006	city-level, annual	Gitelman & Otto (2012	0.18~ 2.56
China	2001-2011	city-level, annual	This study	1.49
China	2001-2005	city-level, annual	This study	2.62
China	2006-2011	city-level, annual	This study	0.52

Many scholars have suggested that an increase in the demand for housing can lead to high housing price growth if housing supply is inelastic (Blackley 1999; Caldera & Johansson 2013; Glaeser, Gyourko & Saiz 2008; Glaeser, Gyourko & Saks 2006; Grimes & Aitken 2010; Ihlanfeldt & Mayock 2014; Malpezzi & Maclennan 2001; Ooi & Le 2012; Pryce 1999). The housing market situation in the 16 major Chinese cities is consistent with the theoretical prediction. As shown in table 9-4, housing price in the 16 major Chinese cities has increased significantly during the period when the housing supply elasticity was relatively low. Compound annual growth rate of average real housing price for the period 2006-2011 was greater than 15% in 1 cities (Fuzhou), greater than 10% in 8 cities (Shanghai, Beijing, Shenzhen, Hangzhou, Nanjing, Ningbo, Hefei and Jinan), and greater than 8% in 7 cities (Chengdu, Tianjin, Guangzhou, Wuhan, Qingdao, Xian and Nanchang). The considerable housing price appreciation which is closely associated with low housing supply elasticity can have profound impacts on housing affordability, urbanization process and the broader economy. Firstly, the high housing price has significantly eroded housing affordability. As shown in table 9-5, housing price was very high relative to income in the 16 major Chinese cities in 2011. Price-to-income ratio in 2011 was greater than 15 in 1 city (Shenzhen), greater than 10 in 4 cities (Shanghai, Beijing, Hangzhou and Fuzhou), and greater than 6 in 11 cities (Chengdu, Tianjin, Guangzhou, Wuhan, Qingdao, Xian, Nanjing, Ningbo, Hefei, Jinan and Nanchang). Secondly, the high housing price can slow down the pace of urbanization. Urban living is often related to higher levels of literacy and education, better health care and greater access to social services, and urbanization is a key driver of economic development and poverty reduction (UN 2014). Thus, promoting urbanization has long been one of the central concerns of the Chinese government. According to *the National New-type Urbanization Plan (2014-*

2020) formulated by the Central Committee of the Communist Party of China, the Chinese government intends to raise the share of permanent urban residents in the nation's population to 60 per cent by 2020 and raise the share of residents with an urban household registration in the nation's population to 45 per cent by 2020 (according to the statistics published by the National Bureau of Statistics, at the end of 2013, permanent urban residents and residents with an urban household registration accounted for 53.7 per cent and 35.7 per cent of the nation's population, respectively). However, high housing price can limit rural-urban migration and slow down the pace of urbanization. Thirdly, the remarkable price appreciation and the consequent high housing price can have significant impacts on the broader economy. Since real estate investment accounts for a significant proportion of GDP[27] and real estate development loans and mortgage loans together constitute a substantial proportion of total loans, volatile housing price poses a threat to economic and financial stability (Ahuja et al. 2010a; Wu, Gyourko & Deng 2012b). In addition, the high housing price can limit the supply of labour in a certain city by restricting rural-urban migration, with implications for local wage rate and employment.

Table 9-4 Housing price growth in the 16 major Chinese cities for the period 2006-2011

	Shanghai	Beijing	Chengdu	Tianjin	Guangzhou	Shenzhen	Wuhan	Qingdao
Compound annual growth rate of average real housing price	10.2%	12.1%	8.9%	9.1%	8.4%	14.9%	9.7%	8.6%
	Hangzhou	Xian	Nanjing	Ningbo	Hefei	Fuzhou	Jinan	Nanchang
Compound annual growth rate of average real housing price	12.5%	9.8%	10.7%	13.2%	10.4%	15.1%	11.1%	8%

27. According to the statistics published by the National Bureau of Statistics, real estate investment accounted for 16 per cent of GDP in China in 2011.

Table 9-5 Price-to-income ratios in the 16 major Chinese cities in 2011

	Shanghai	Beijing	Chengdu	Tianjin	Guangzhou	Shenzhen	Wuhan	Qingdao
Price-to-income ratios	11.23	14.15	7.97	9.53	9.52	17.29	8.44	7.53
	Hangzhou	Xian	Nanjing	Ningbo	Hefei	Fuzhou	Jinan	Nanchang
Price-to-income ratios	11.23	6.73	7.84	9.94	7.49	11	6.92	7.7

Notes: The approach used here to calculate the price-to-income ratios follows that used in a highly cited study on housing market conditions in China (Wu, Gyourko & Deng 2012b). Wu, Gyourko & Deng (2012b argued that the price-to-income ratio in urban China can be calculated using the following formula:

$$price - to - income\ ratio$$
$$= \frac{average\ housing\ price\ per\ sq.m.\ floor\ area\ \times housing\ unit\ size}{per\ capita\ disposable\ income\ \times household\ size}$$
$$= \frac{average\ housing\ price\ per\ sq.m.\ floor\ area}{per\ capita\ disposable\ income} \times per\ capita\ living\ space$$

According to the statistics published by the Ministry of Housing and Urban-Rural Development, per capita living space in urban China was around 30 square meters in 2011 (Wu, Gyourko & Deng 2012b). Data on average housing price are sourced from China Real Estate Statistics Yearbook 2012, and data on per capita disposable income are sourced from Statistical Yearbook 2012 of each city.

9.2.3 Discussion of the findings reported in chapter 7

In chapter 7, the impact that the decline in land supply has on housing price is examined by estimating the model of housing price using data for the 16 major Chinese cities. The empirical results suggest that land supply is negatively related to housing price, and thus the decline in land supply after the government strengthened the intervention in the land markets has put upward pressure on housing price. Consistent with the theoretical expectation, population, income and the user cost of owner-occupied housing are found to be important determinants of housing price, and housing price is found to adjust gradually towards its equilibrium level.

Although land supply can play an important role in determining housing price, land supply variable or land-related variables (or, more broadly, supply-side variables) were not included in the models of housing price in many existing studies. Table 9-6 lists some highly cited studies on modelling housing price over the last 15 years and shows the independent variables used in those studies. As is evident from the table, demand-side determinants, such as income, population, employment, mortgage interest rates and the user cost of owner-occupied housing were usually included as independent variables in the models of housing price. However, among the 16 listed studies, supply-side determinants were used as independent variables in only 6 studies (Adams & Füss 2010; Caldera & Johansson 2013; Hwang & Quigley 2006b; Maennig & Dust 2008; Malpezzi 1999; Oikarinen 2012), and land-related variables were used as independent variables in only 2 studies (Maennig & Dust 2008; Malpezzi 1999). Given the important role that land supply can play in determining housing price, it is reasonable to argue that land supply variable or land-related variables should be included in the models of housing price.

Table 9-6 Some existing studies on modelling housing price and the independent variables used in those studies

Authors	Data	Independent variables
Malpezzi (1999	annual data	per capita income, population, geographical variables, mortgage interest rates and regulation variable.
Harter-Dreiman (2004	annual data	personal income
Hwang & Quigley (2006b	annual data	housing stock, the number of vacancies, the user cost of owner-occupied housing, housing rent, the number of households, per capita income and employment
Miller & Peng (2006	quarterly data	per capita personal income, population, unemployment rates and per capita gross metropolitan product
Maennig & Dust (2008	annual data	population, construction costs and per capita income, urban district variables and land use regulation variables
Oikarinen (2009	quarterly data	aggregate income, the loan-to-GDP ratio and the user cost of owner-occupied housing
Adams & Füss (2010	quarterly data	economic activity, long-term interest rates and construction costs
Beltratti & Morana (2010	quarterly data	the growth rates of real GDP, private consumption and investment, CPI, the long-term and short-term interest rates the money growth rate, exchange rate, stock price and oil price
Kuethe & Pede (2011	quarterly data	unemployment and per capita personal income
Agnello & Schuknecht (2011	annual data	growth in per capita real GDP, the short-term interest rates, the growth rate of real credit to the private sector, the growth rate of working-age population
Oikarinen (2012	quarterly data	aggregate income, the mortgage loan-to-income ratio, the user cost of owner-occupied housing and housing stock
Coulson, Liu & Villupuram (2013	annual data	earnings per share, employment, population, population, consumer confidence, income, the percentage of retirees and the percentage of government employees
Caldera & Johansson (2013	quarterly data	income, interest rate, housing stock and the percentage of the age cohort 25-44 in population
Gonzalez & Ortega (2013	annual data	working-age population, the share of the foreign-born population in total population and the employment-population ratio
Kallberg, Liu & Pasquariello (2014	monthly data	mortgage interest rate, the slope of the US Treasury yield curve, CPI, the civilian unemployment rate, the total US population, disposable personal income and nominal GDP
Yunus & Swanson (2013	quarterly data	per capita income and GDP

As shown in table 9-7, the elasticity of housing price with respect to land supply reported in this study is in line with those reported in existing studies (Feng, Miao & Jiang 2011; Ho & Ganesan 1998). This result suggests that change in land supply can significantly affect housing price. Here the data for Beijing is used as an example to show the extent to which change in land supply can influence housing price. As shown in figure 9-1, holding other factors affecting housing price constant, a one-standard-deviation increase in land supply would reduce housing price in Beijing in 2011 by 173 RMB/square meter.[28]

Table 9-7 The elasticity of housing price with respect to land supply reported in this study and those reported in existing studies

Regions	Sources	The elasticities of housing price with respect to land supply
Hong Kong	Ho & Ganesan (1998	-0.02
30 provincial-level divisions in China	Feng, Miao & Jiang (2011	-0.01
16 major Chinese cities	This study	-0.02

As shown in Appendix 13, the correlation coefficient between the population variable and the income variable tends to be relatively high (the correlation coefficients among the other independent variables tend to be relatively low). The relatively high correlation between the two variables can make the estimate of the impact of population (or income) on housing price less precise. Wooldridge (2012) suggested that there are generally two ways to reduce multicollinearity: increasing the sample size and dropping independent variables from the model. As more relevant data become available, estimating the model of housing price using a larger data set will allow a more precise estimate of the impact of population (or income) on housing price.

28. As reported in table 6-2, the standard deviation of land supply for the 16 major Chinese cities for the period 2001-2011 is 348.

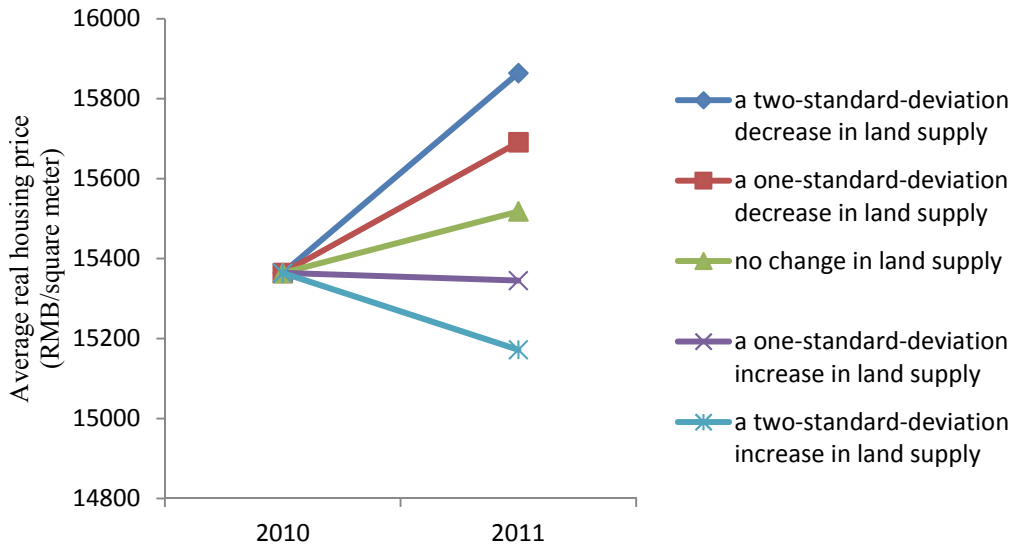

Figure 9-1 Housing price in Beijing with one-standard-deviation (or two-standard-deviation) change in land supply

Source: Author's calculation based on the empirical results reported in chapter 7

The findings reported in chapter 7 have implications for understanding the impacts of government policies on housing price. Since rapidly rising housing price seriously eroded housing affordability and potential price misalignment posed substantial risks to economic and financial stability (Ahuja et al. 2010b; Wu, Gyourko & Deng 2012a), the Chinese government has introduced a battery of measures to head off housing price boom since 2011. These measures mainly included raising mortgage rates, increasing minimum down payment requirement and imposing restriction on home purchases.[29] It is expected that these policies can be effective in slowing down housing price appreciation, since they can raise the user cost of owned-occupied housing and

29. Under the differentiated credit policies for home purchases, households who purchased their second housing unit were required to provide a 60 per cent down payment, and the mortgage rates for them were set at no less than 1.1 times the magnitude of the benchmark rate. The home-purchase restriction polices were implemented in municipalities, provincial capitals, cities specifically designated in the state plan and other cities with high and rising housing price. Under the policies, only those with a local household registration or those who could provide the proof of having worked in a specific city for a certain period of time (effective proof including tax receipts and social security records) were eligible for home purchases.

have a depressing effect on the demand for housing. Mortgage financing costs will rise as minimum down payment requirement and mortgage rates increase. In addition, home buyers will adjust their expectation of future housing price when restrictive credit and home-purchase policies are implemented.

Existing studies have suggested that the reaction speed of housing price to demand or supply shocks varies substantially across countries or regions (Dipasquale & Wheaton 1994; Harter-Dreiman 2004; Hort 1998; Li & Chand 2013; Malpezzi 1999; Oikarinen 2009; Oikarinen 2012). Although the empirical results reported in chapter 7 provide evidence that housing price adjustment is also gradual in China, the speed at which current housing price adjusts to its equilibrium level is not explicitly estimated. Estimating a vector error correction (VEC) model will allow the examination of the adjustment speed, and this work can be done as more relevant data become available.

9.3 The implications of the findings for land use and housing policies

The empirical results reported in chapter 5 - chapter 8 are consistent with previous studies that show government intervention in land markets can have an adverse effect on new residential construction by limiting the supply of land for housing development (Bramley 1993, 2007; Cheshire & Sheppard 2004; Dawkins & Nelson 2002; Monk & Whitehead 1999; Saiz 2010). An important implication of these findings is that when housing price rises rapidly, attention should be paid to the role that government intervention in land markets plays in limiting land and housing supply and pushing up housing price. Because land use is subject to regulatory constraints in almost all countries, this issue is not only relevant to the Chinese government, but relevant to governments in many other countries. Many researchers

have suggested that the traditional approach used by planners to forecast housing demand and determine the amount of land allocated for housing development is based on population projection or household projection (Bramley 2007; Cheshire & Sheppard 2005; Chiu 2007; Costello & Rowley 2010; Meen & Andrew 2008; Vermeulen 2008). This approach tends to ignore the economic factors affecting the demand for housing (income, interest rates, etc.) (Bramley 2007; Cheshire & Sheppard 2005; Vermeulen 2008). If the economic factors affecting the demand for housing are taken into account when determining the amount of land allocated for housing development, land supply system can be made more responsive to the change in the demand for housing.

The Chinese government has taken measures to reform the current land supply system by launching a pilot reform in Guangdong province where developable land is becoming increasingly scarce but a considerable proportion of developed land is not used intensively.[30] The pilot reform is called "San-jiu" renewal programme, which aims to promote the renewal and regeneration in old cities and towns, old industrial areas and old villages and increase the land use efficiency. Under the "San-jiu" renewal programme, existing users of old industrial land are allowed to conduct redevelopment by themselves and then use the land for commercial or residential purposes. They can also transfer their LURs to developers for commercial or housing development. Apparently, the pilot reform has generated a land market structure which is very similar to that before August 2004. Under this type of land market structure,

30. Guangdong province, located in southeast China, is the most populous province in China and has topped the total GDP rankings among all provincial-level divisions since 1989. According to the Second National Land Survey, the share of built-up area in total land area was as high as 32.6% in Guangdong province.

the process of urban redevelopment has become simpler and less time-consuming. In addition, developers can actively take part in the redevelopment process rather than waiting for the government to put serviced land on the market. As a result of these changes, the pace of the conversion from old industrial/warehousing land to residential use has sped up in many cities in Guangdong province. Since many regions which are under significant demand pressure have a large amount of industrial land (as shown in table 9-8), extending the pilot reform in Guangdong to those regions can help ensure an adequate supply of residential land in those regions.

Table 9-8 The industrial land use in major Chinese cities in 2011

Cities	Industrial land (square kilometre) ①	Built–up area (square kilometre) ②	①/②
Beijing	351.86	1231.3	28.6%
Chengdu	102.57	483.35	21.2%
Tianjin	209.07	710.6	29.4%
Guangzhou	267.22	990.11	27%
Wuhan	173.92	506.42	34.3%
Qingdao	81.58	291.52	28%
Hangzhou	60.15	432.98	13.9%
Xian	76.54	342.55	22.3%
Nanjing	177.98	637.71	27.9%
Ningbo	136.71	284.91	48%
Hefei	72.1	339.1	21.3%
Fuzhou	38.6	232.12	16.6%
Jinan	75.42	355.35	21.2%
Nanchang	45.2	208	21.7%

Source: China Urban Construction Statistical Yearbook 2011

Notes: The data on industrial land use in Shanghai and Shenzhen in 2011 is not available from China Urban Construction Statistical Yearbook 2011.

A major impediment to extending the pilot reform in Guangdong to other parts of the country can come from municipal governments, since this type of reform can weaken municipal government control over land supply and reduce municipal government revenue from land sales. However, if there are new sources of municipal government revenue, municipal governments are likely to support the reform of land supply system. A potential new source of government revenue is property tax. Since property tax is difficult to evade and is imposed on an immobile base, it can be a more stable revenue source than other taxes (such as sales and income taxes), and it is levied in many countries around the world. However, as discussed in section 7.3.3, property tax is not imposed in most Chinese cities at present. The imposition of a nationwide property tax requires the enactment of relevant laws and well-developed property registration and tax evaluation systems, which are currently not available in China. In addition, home buyers, home owners and property investors may be against levying property tax, since it increases the financial burden on them. If these obstacles are overcome, property tax can be imposed nationwide, which in turn can facilitate the reform of land supply system.

In addition to the redevelopment of existing urban land, there is also a problem with the allocation of new urban land (the land which is newly converted from agricultural use to urban uses) among different uses. In recent years, a large proportion of new urban land has been designated for industrial use rather than residential use in China (Tang, Tan & Xu 2011). The reasons for this are related to China's personnel control system and fiscal decentralization system. Under current political and personnel control system, local economic performance is used as the most important criterion for evaluating local government officials (Li & Zhou 2005; Zhou 2007). Since the

industrial sector contributes significantly to the local economy, municipal governments tend to favour industrial use in allocating new developable land. Under the fiscal decentralization system, enterprise income tax is a major source of municipal governments' budgetary revenue, and thus municipal governments can get more revenue by promoting the development of the industrial sector. In regions where there is a strong demand for housing, increasing the proportion of new urban land allocated to residential use can help ensure an adequate supply of housing in those regions. In addition, the improvement of infrastructures in rural-urban fringe can also facilitate housing development in those areas.

9.4 Summary

This chapter has presented a discussion of the findings reported in previous chapters and analyses the implications of the empirical findings for land use and housing policies. The discussion of the findings reported in chapter 5 suggests that the unique character of the residential land markets in China is that municipal governments have been the sole supplier of urban residential land since August 2004, and the establishment of complete government control over land supply can have significant effects on the operation of real estate markets. According to the discussion of the findings reported in chapter 6, the relationship between land supply and new housing supply depends on the institutional setting of real estate markets. Since land supply can play an important role in determining new housing supply, land supply or residential land price should be included as an independent variable in the model of new housing supply, and not including land-related variables can give rise to omitted variable bias. High housing price appreciation which is closely associated with low housing supply elasticity can have profound impacts on housing affordability,

urbanization process and the broader economy. The discussion of the findings reported in chapter 7 suggests that given the important role that land supply can play in determining housing price, it is reasonable to argue that land supply variable or land-related variables should be included as independent variables in the models of housing price. The major implications for land use and housing policies in China are that promoting the redevelopment of existing urban land and adjusting the allocation of new urban land among different uses can help ensure an adequate supply of residential land in regions where there is a strong demand for housing.

Chapter 10: Summary, Conclusions and Future Studies

10.1 Introduction

This research investigates the process leading to stronger government intervention in the land markets in China, and examines the impacts that government intervention in the land markets has on residential land supply, new housing supply and housing price using data for 16 major Chinese cities for the period 2001-2011. The concluding chapter reviews the research process and summarizes the research findings. It also presents a discussion of the limitations of the research and provides recommendations for future research.

10.2 Summary of research

At the beginning of this research, a theoretical framework for the analysis of the impacts that government intervention in land markets has on residential land supply, new housing supply and housing price is established based on the existing theoretical literature. Within the framework, the impact that government intervention in land markets has on residential land supply, the factors affecting new housing supply, housing supply elasticity and its importance for housing price dynamics, and the factors affecting the demand for housing has been analysed. According to the theoretical analysis, land use regulations and direct government control over land supply are the primary forms of government intervention in land markets, and they can restrict the amount of land available for housing development. The factors affecting new housing supply mainly include housing price, the cost of housing production, land supply and regulatory constraints. Land supply should be positively related to new

housing supply in a well-functional market. However, if developers conduct speculative land hoarding rather than build homes on purchased land, there will be no significant relationship between land supply and new housing supply. Housing supply elasticity is a measure of the responsiveness of housing supply to the change in housing price, and plays an important role in explaining the evolution of housing price. An increase in the demand for housing will translate into higher increase in housing price in areas where the housing supply elasticity is lower. Land availability plays an important role in determining housing supply elasticity. The factors affecting the demand for housing mainly include population, housing price, the user cost of owner-occupied housing, income and demographic factors.

Following the theoretical analysis is a review of the empirical literature on residential land supply, new housing supply and housing price. According to the literature review, although government intervention in land markets takes different forms in different countries, it does play an important role in restricting the supply of land for housing development. Based on urban spatial theory, new housing supply has been specified as a function of the changes in housing price and cost variables rather than a function of the levels of housing price and cost variables in many recent studies. Existing empirical studies have provided evidence that population and population structure, income, the user cost of owner-occupied housing and mortgage lending constraints are important factors affecting the demand for housing and housing price.

The empirical analysis in this research focuses on the process leading to stronger government intervention in the land markets in China, and examines the impacts that government intervention in the land markets has on residential land supply, new housing supply and housing price in the 16 major Chinese cities. In the first part of the

empirical research, the reform process leading to the establishment of complete municipal government control over urban residential land supply and the imposition of more stringent regulatory constraints on rural-urban land conversion has been examined by reviewing the literature and government policy documents. The change in residential land supply before and after the 2004 reform which led to stronger government intervention in the land markets has also been examined.

In the second part of the empirical research, the impacts that the decline in land supply has on new housing supply and housing supply elasticities have been examined by developing and estimating models of new housing supply. The models of new housing supply have been developed based on the theoretical analysis of the factors affecting new housing supply and the review of existing studies on modelling new housing supply, and estimated using panel data for the 16 major Chinese cities for the period 2001-2011. The Hausman test has been used to choose between the fixed effects regression approach and the random effects regression approach. Robust *t* statistics have been used to test whether independent variables are statistically significant, and adjusted R-squared has been used to measure goodness of fit of the models.

In the third part of the empirical research, the impact that the decline in land supply has on housing price has been examined by developing and estimating the model of housing price. The model of housing price has been developed based on the theoretical analysis of the factors affecting new housing supply and the demand for housing, and estimated using the Arellano-Bover/Blundell-Bond system GMM estimator.

In order to support the findings obtained from the econometric analysis, the operation of the real estate markets in two case-study cities (Beijing and Ningbo) has been

examined in more detail in the fourth part of the empirical research. The demand side of the housing markets has been investigated by examining the change in population, GDP, per capita disposable income, and local fiscal revenue during the sample period. The supply side of the housing markets has been investigated by examining the change in land supply and new housing supply. The change in average real housing price in the two cities has also been examined.

Following the empirical analysis, a discussion of the empirical findings has been presented and the implications of the empirical findings for land use and housing policies have been analysed.

10.3 Conclusions

Since 2004, municipal governments in China have acquired complete control over urban residential land supply, and the regulatory constraints on rural-urban land conversion have become more stringent. There was a decline in residential land supply in the 16 major Chinese cities after the 2004 reform. The decline in land supply was most significant in the largest cities (such as Shanghai, Beijing and Guangzhou) and less significant in cities with a relatively high amount of agricultural land. In summary, land supply did not keep pace with the increased demand in the 16 cities after the 2004 reform.

The results from estimating the models of new housing supply suggest that land supply is positively related to new housing supply, and thus the decline in land supply after the 2004 reform has put downward pressure on new housing supply. Housing price and financing cost for developers are also found to be important determinants of new housings supply. Given the important role that land supply plays in determining

new housing supply, it is reasonable to argue that land supply variable or land-related variables should be included in the models of new housing supply. It is also found that there was a decline in housing supply elasticity after the government strengthened the intervention in the land markets. The estimate of housing supply elasticity for the 16 major Chinese cities for the subsample period 2001-2005 was moderately high. However, the estimate of housing supply elasticity for the 16 major Chinese cities for the subsample period 2006-2011 was relatively low. High housing price appreciation which is closely associated with low housing supply elasticity has eroded housing affordability and posed a threat to economic and financial stability.

The results from estimating the model of housing price suggest that land supply is negatively related to housing price, and thus the decline in land supply after the government strengthened the intervention in the land markets has put upward pressure on housing price. Population, income and the user cost of owner-occupied housing are found to be important demand-side determinants of housing price, and housing price is found to adjust gradually towards its equilibrium level.

An important implication of the research findings is that when housing price rises rapidly, attention should be paid to the role that government intervention in land markets plays in limiting land and housing supply and pushing up housing price. For the specific implications for land use and housing policies in China, promoting the redevelopment of existing urban land and adjusting the allocation of new urban land among different uses can help ensure an adequate supply of residential land in regions where there is a strong demand for housing. Objectives and main findings of this research is summarized in table 10-1.

Table 10-1 Research objectives and main findings

Research objectives	Main findings
Objective 1: to investigate the process leading to stronger government intervention in the land markets in China	● Since 2004, municipal governments in China have acquired complete control over urban residential land supply, and the regulatory constraints on rural-urban land conversion have become more stringent. ● Complete government control tends to make residential land supply less responsive to changing market conditions.
Objective 2: to examine the change in residential land supply before and after the 2004 reform	● There was a decline in residential land supply in the 16 major Chinese cities after the 2004 reform. ● The decline in land supply was most significant in the largest cities and less significant in cities with a relatively high amount of agricultural land.
Objective 3: to develop and estimate econometric models of new housing supply to examine the impacts that the decline in land supply has on new housing supply and housing supply elasticity	● The results from estimating the models of new housing supply suggest that land supply is positively related to new housing supply, and thus the decline in land supply after the 2004 reform has put downward pressure on new housing supply. ● It is also found that there was a decline in housing supply elasticity after the government strengthened the intervention in the land markets.
Objective 4: to develop and estimate econometric model of housing price to examine the impact that the decline in land supply has on housing price	The results from estimating the model of housing price suggest that land supply is negatively related to housing price, and thus the decline in land supply after the government strengthened the intervention in the land markets has put upward pressure on housing price.
Objective 5: to discuss the implications of the empirical findings for land use and housing policies	● When housing price rises rapidly, attention should be paid to the effects that government intervention in land markets has on housing supply and housing price. ● Promoting the redevelopment of existing urban land and adjusting the allocation of new urban land among different uses can help ensure an adequate supply of residential land in regions where there is a strong demand for housing.

Source: Author

10.4 Limitations of the research

Since a market-oriented housing system was not established in China until 1998, the data used in this research does not cover a complete boom-and-bust housing cycle, and it only covers a period when the demand for housing was relatively high. While strong government intervention in land markets can lead to a scarcity of residential land in the presence of high demand for housing, it may result in an oversupply of residential land when the demand for housing is low.[31] As more relevant data become available, future research is required to examine the impacts of government intervention in land markets during bust periods. Another limitation of the data used in this research is that it does not cover the years 2012 and 2013. Various Statistical Yearbooks which contain data for the year 2012 are made available online in 2014 or later and couldn't be obtained at the time of final writing. In addition, the empirical analysis in this research focuses on the real estate markets in 16 major Chinese cities, and does not examine the real estate markets in small and medium-sized cities. Since many small and medium-sized cities did not experience a significant population and income growth as the large cities did, government intervention in the land markets may not have significant effects on housing market outcomes in small and medium-sized cities. This issue can be examined in future research.

Although the determinants of housing price in major Chinese cities is examined in this study, some demand-side factors have not been taken into account due to data limitation. For example, the impacts of demographic factors (such as the age and sex structure of the population) on housing price are not investigated in this study. In

31. Ooi, Sirmans & Turnbull (2011) suggested that when property price is low due to weak demand, the government may try to sell more land in order to stabilize its revenue.

addition, although this research provides evidence that housing price adjustment is gradual in major Chinese cities, the reaction speed of housing price to demand- or supply-side changes is not explicitly estimated.

10.5 Recommendations for future research

This research contributes to the growing literature on the supply side of housing market and housing price. Future research directions in these areas can also be identified based on the analysis presented in this research.

- Potential directions for future research on land supply

As municipal governments established complete control over urban land supply in China, the revenues from land sales have become an important source of extra-budgetary revenues for municipal governments (Wu, Li & Yan 2015). This type of fiscal revenue strategy for municipal governments is often referred to as "land finance" (Cao, Feng & Tao 2008; Wu, Li & Yan 2015; Zheng, Wang & Cao 2014). Although the "land finance" strategy has attracted considerable research attention in recent years (Cao, Feng & Tao 2008; Du & Huang 2009; Liu & Jiang 2005; Song & Yang 2008; Tao & Wang 2010; Wu, Li & Yan 2015; Zheng, Wang & Cao 2014), few studies have been conducted to examine the interaction between the "land finance" strategy and the operation of the real estate markets in China. Firstly, although it is widely held that the revenues from land sales tend to increase during the housing boom, little has been done to examine the impact of housing market conditions on the revenues from land sales. Secondly, since municipal governments derive a considerable proportion of their revenues from land sales, it is reasonable to argue that they may exploit their market power to ensure that the revenues from land sales are high. However, little has been

done to empirically test the hypothesis. Ooi, Sirmans & Turnbull (2011) examined the determinants of the timing of auctions for both government-owned land and privately-owned land in Singapore. They found that the government agencies timed land auctions in a way that was broadly consistent with the private landowners, and thus the Singapore government did not seem to be fully exploiting their market power in the land market. Future research can draw on the methodology employed in Ooi, Sirmans and Turnbull' study to test the hypothesis that municipal governments in China are exploiting their market power to maximise the profits from land sales.

The Chinese government has taken measures to reform the current land supply system by launching a pilot reform in Guangdong province. Since the pilot reform can simplify the process of urban redevelopment and help ensure an adequate supply of residential land, there is a need to systematically review these reform efforts and examine their impacts on housing market outcomes.

- Potential directions for future research on new housing supply

When the data on new housing supply, land supply and housing price are available at the city level on a quarterly or monthly basis, it will be interesting to estimate models of new housing supply using time series data for individual cities and obtain the estimates of city-specific housing supply elasticities. The estimates of city-specific housing supply elasticities can be used to investigate the relationship between housing supply elasticities and housing price volatility. Although it is well established theoretically that an increase in the demand for housing will lead to higher increase in housing price in areas where housing supply elasticities are lower (Glaeser, Gyourko & Saiz 2008; Glaeser, Gyourko & Saks 2006), empirical research on this issue has been limited by the non-availability of estimates of housing supply elasticities at the

local level (Ihlanfeldt & Mayock 2014). Glaeser, Gyourko & Saiz (2008) and Huang & Tang (2012) used proxy variables for housing supply elasticities to examine the relationship between housing supply elasticities and the change in housing price.[32] However, Cox (2011) argued that those proxy variables have important limitations that can lead to biased estimates. Having noticed the limitations, Grimes & Aitken (2010) and Ihlanfeldt & Mayock (2014) investigated the relationship between housing supply elasticities and the change in housing price based on actual estimates of housing supply elasticities. Future research can draw on the methodology employed in Grimes and Aitken' study and Ihlanfeldt and Mayock' study to examine the role that intercity differences in housing supply conditions play in explaining the differences in housing price changes across Chinese cities during the boom period. The estimates of city-specific housing supply elasticities can also be used to investigate the determinants of housing supply elasticities. As suggested by Ihlanfeldt & Mayock (2014), there are only a limited number of empirical studies that have examined the determinants of housing supply elasticities (Green, Malpezzi & Mayo 2005; Ihlanfeldt & Mayock 2014; Saiz 2010), and most of those studies were conducted in the US.

The impact that the restrictiveness of local regulatory environment has on new housing supply is not explicitly examined in this study. In existing studies, researchers usually formed a restrictiveness index to measure the stringency of local regulatory environment, and then ran a regression of new housing supply (or housing price) on the restrictiveness index to examine the effect of regulatory constraints (Green,

32. Glaeser, Gyourko & Saiz (2008) used the measure of developable land within a metropolitan area developed by Saiz (2010) as the proxy variable for housing supply elasticities. Huang & Tang (2012) used the Wharton Residential Land Use Regulatory Index (Gyourko, Saiz & Summers 2008) and the Saiz (2010) measure of developable land as the proxy variables for housing supply elasticities.

Malpezzi & Mayo 2005; Ihlanfeldt 2007; Malpezzi 1996; Mayer & Somerville 2000a; Pollakowski & Wachter 1990; Quigley & Raphael 2005; Saiz 2010). Due to data limitations, the restrictiveness index for Chinese cities is not available. Given the importance of regulatory constraints in influencing new housing supply, future research on this issue is needed.

Biased measurements of construction cost can lead to poor performance of the construction cost variable in the models of new housing supply (Somerville 1999b). In order to more accurately examine the effect of construction cost on new housing supply, there is a need to develop quality-controlled hedonic construction cost series and use the series in estimating the models of new housing supply.

Somerville (1999a) suggested that the traditional approach in housing-market analysis assumes that homebuilding is a homogeneous and competitive industry. However, several researchers have questioned the assumption and argued that property development companies of different sizes may react in distinct ways to market signals (Ball 2006; Ball, Meen & Nygaard 2010; Somerville 1999a). This is due to the fact that larger property development companies may have greater access to construction loans and can be more capable of exerting market power and overcoming regulatory constraints on homebuilding (Ball, Meen & Nygaard 2010; Somerville 1999a). Although new residential construction is the outcome of decision making by housing suppliers and the behaviours of larger property development companies can be quite different from those of small property development companies, relatively few studies have examined the behaviours of individual property development companies (Ball, Meen & Nygaard 2010; Dipasquale 1999). Dipasquale (1999) and Ball, Meen & Nygaard (2010) argued that this is mainly due to lack of data at the firm level. As

more relevant data become available, it will be interesting to estimate models of new housing supply using the firm-level data, and doing this can contribute to a better understanding of the micro foundations of housing supply.

- Potential directions for future research on housing price

Many studies have found that age structure of the population plays an important role in determining the demand for housing and housing price (Andrew & Meen 2003b; Chen et al. 2012; Huang & Clark 2002; Levin, Montagnoli & Wright 2009; Mankiw & Weil 1989). This is due to the fact that young people aged 20s and early 30s are more likely to be first-time home buyers and people aged 30s and 40s tend to sell and buy housing in response to increased income and life-cycle events (Levin, Montagnoli & Wright 2009). Since it is expected that there is going to be a significant decrease in the number of young people in China (Li & Chand 2013), more efforts should be made to examine the effect that the age structure of the population has on housing price in China.

Jones, Leishman & Watkins (2005) argued that in most housing market analysis the boundaries of a housing market have been assumed to coincide with city boundaries. However, since there often exist spatially defined housing submarkets within an urban area, using city boundaries as market boundaries can mask housing market segmentation within an urban area (Goodman & Thibodeau 1998, 2003; Jones, Leishman & Watkins 2005). The existence of housing submarkets is mainly due to two facts: firstly, the demand for housing tends to be segmented and can be neighbourhood specific; secondly, there can be significant housing-stock heterogeneity across neighbourhoods (Jones, Leishman & Watkins 2005; Watkins

2001). In recent years, a growing body of literature have provided evidence for the existence and significance of housing submarkets (Biswas 2012; Leishman et al. 2013; Ling & Hui 2013; Park 2013; Randolph & Tice 2013). Since a better understanding of the structure, operation and dynamics of housing markets can be achieved within the analysis framework of housing markets and submarkets (Jones, Leishman & Watkins 2005), efforts should be made to examine the housing submarkets in urban China.

Although some studies have used econometric approaches to investigate the impact of land supply on housing price (Ho & Ganesan 1998; Hui & Ho 2003; Peng & Wheaton 1994), few studies have formally examined the responsiveness of land supply to the change in housing price. Future research can use vector autoregressive (VAR) based Granger causality test or vector error correction (VEC) based Granger causality test to test whether land supply is responsive to the change in housing price.

The speed at which housing price adjusts to its equilibrium level is not explicitly estimated in this study. Future research can estimate the speed of price adjustment in China using a VEC model approach. Estimating a VEC model will also allow the investigation of the difference between the housing price determined by economic fundamentals and the actual housing price and facilitate the test of the existence of housing price bubbles.

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Appendices

Appendix 1 The kernel density estimation for the variables in the models of new housing supply

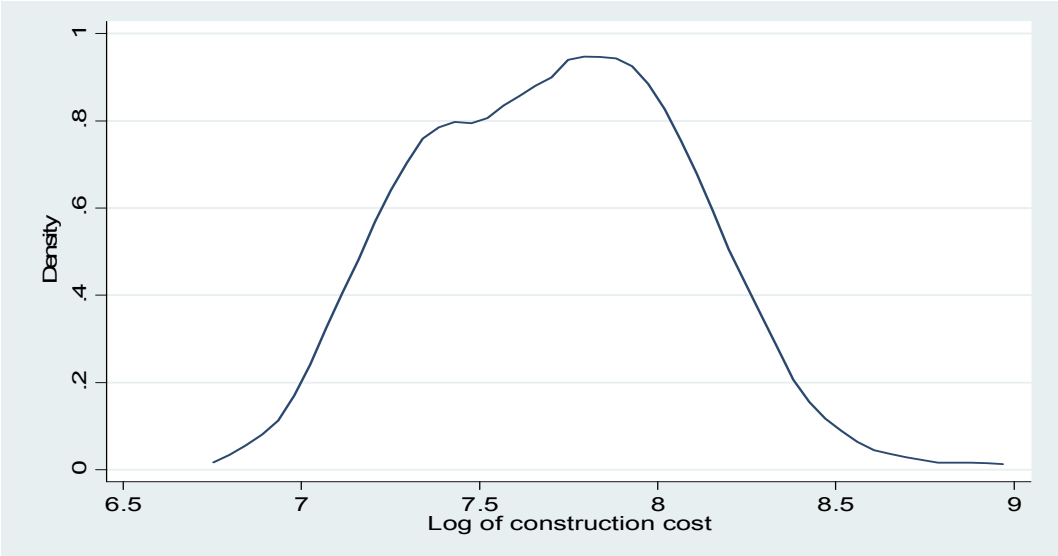


Figure A 1.1 The kernel density estimation for the log of construction cost

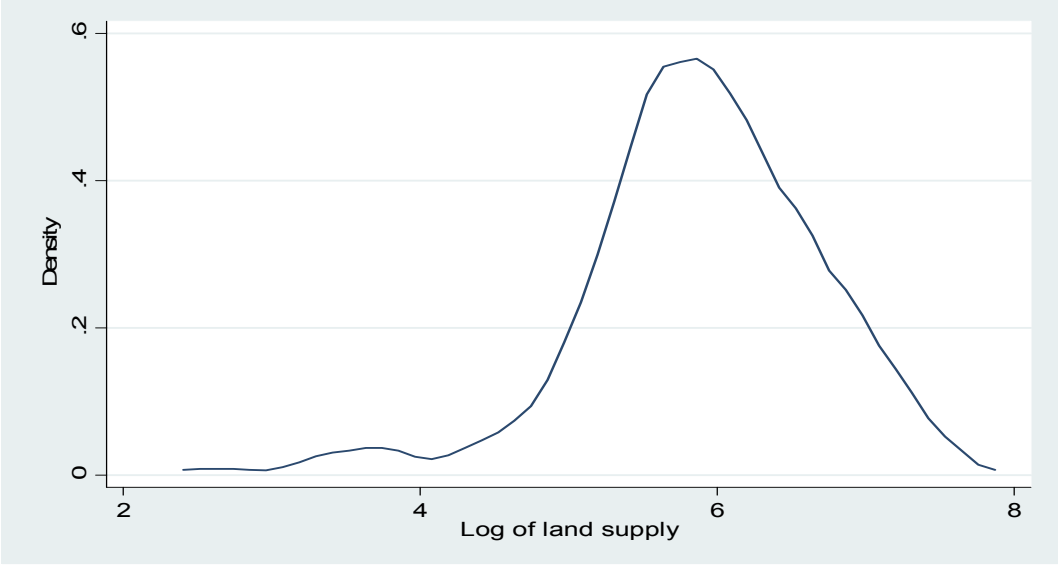


Figure A 1.2 The kernel density estimation for the log of land supply

Appendix 2 The scatter plots of the log of new housing supply against the independent variables in the model of new housing supply

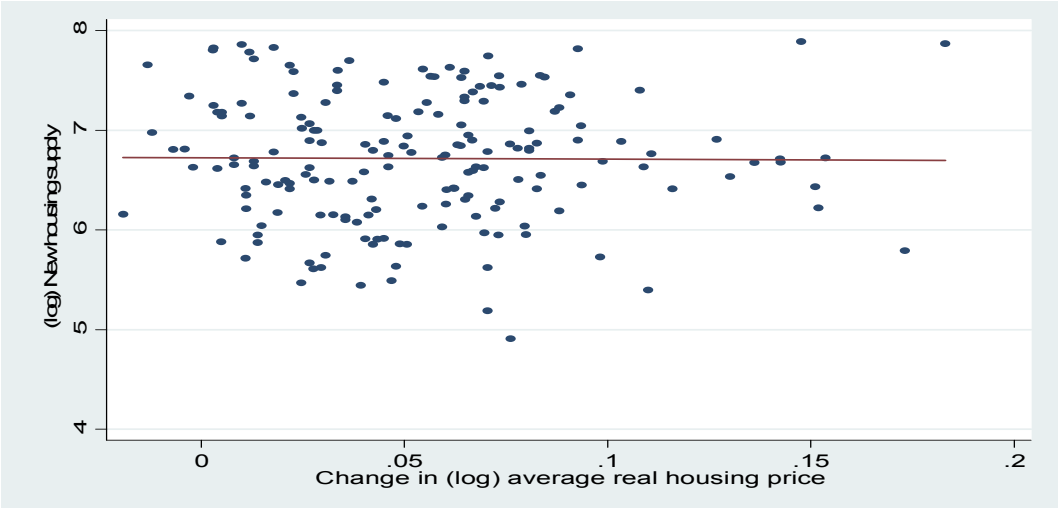


Figure A 2.1 The scatter plot of the log of new housing supply against the change in the log of housing price

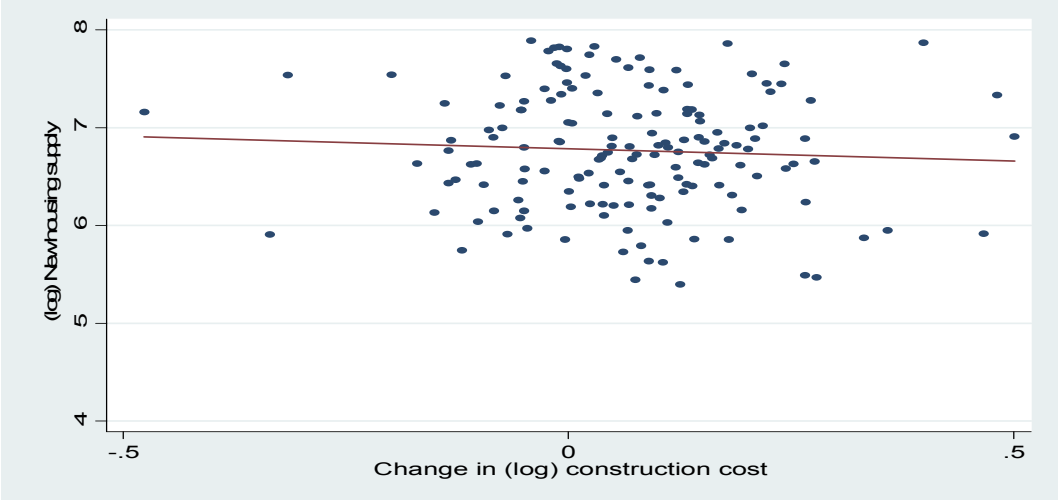


Figure A 2.2 The scatter plot of the log of new housing supply against the change in the log of construction cost

Appendix 3 The correlation matrix for the independent variables in the models of new housing supply

	D. lnhp	D. lnccost	D. fcost	lnls
lnhp				
D1.	1.0000			
lnccost				
D1.	0.0085	1.0000		
fcost				
D1.	0.1024	0.0711	1.0000	
lnls	0.0990	0.0863	-0.0283	1.0000

Figure A 3.1 The correlation matrix for the independent variables in the models of new housing supply

Appendix 4 The Im-Pesaran-Shin panel unit root test for the variables in the models of new housing supply

```
Im-Pesaran-Shin unit-root test for lnhs
-----------------------------------------
Ho: All panels contain unit roots           Number of panels  =     16
Ha: Some panels are stationary              Number of periods =     11

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: No lags included
------------------------------------------------------------------------------
                                                Fixed-N exact critical values
                     Statistic      p-value         1%      5%      10%
------------------------------------------------------------------------------
 t-bar                -1.9912                     -2.020  -1.870  -1.790
 t-tilde-bar          -1.6525
 Z-t-tilde-bar        -1.9975        0.0229
------------------------------------------------------------------------------
```

Figure A 4.1 The Im-Pesaran-Shin panel unit root test for the log of new housing supply

```
Im-Pesaran-Shin unit-root test for D.lnhp
-----------------------------------------
Ho: All panels contain unit roots           Number of panels  =     16
Ha: Some panels are stationary              Number of periods =     10

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: No lags included
------------------------------------------------------------------------------
                                                Fixed-N exact critical values
                     Statistic      p-value         1%      5%      10%
------------------------------------------------------------------------------
 t-bar                -2.7241                     -2.060  -1.890  -1.800
 t-tilde-bar          -1.8550
 Z-t-tilde-bar        -3.2196        0.0006
------------------------------------------------------------------------------
```

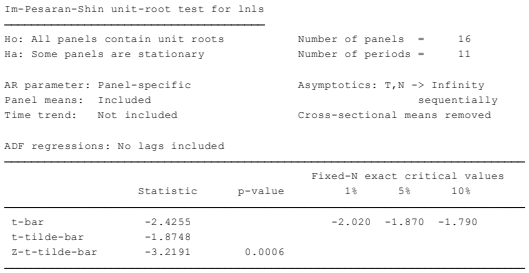
Figure A 4.2 The Im-Pesaran-Shin panel unit root test for the change in the log of housing price

```
Im-Pesaran-Shin unit-root test for D.lnccost
-----------------------------------------
Ho: All panels contain unit roots           Number of panels  =     16
Ha: Some panels are stationary              Number of periods =     10

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: No lags included
------------------------------------------------------------------------------
                                                Fixed-N exact critical values
                     Statistic      p-value         1%      5%      10%
------------------------------------------------------------------------------
 t-bar                -3.7882                     -2.060  -1.890  -1.800
 t-tilde-bar          -2.1455
 Z-t-tilde-bar        -4.8298        0.0000
------------------------------------------------------------------------------
```

Figure A 4.3 The Im-Pesaran-Shin panel unit root test for the change in the log of construction cost



```
Im-Pesaran-Shin unit-root test for lnls
-----------------------------------------

Ho: All panels contain unit roots           Number of panels  =     16
Ha: Some panels are stationary              Number of periods =     11

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: No lags included
-------------------------------------------------------------------------------
                                                 Fixed-N exact critical values
                     Statistic      p-value          1%       5%      10%
-------------------------------------------------------------------------------
 t-bar                -2.4255                      -2.020   -1.870   -1.790
 t-tilde-bar          -1.8748
 Z-t-tilde-bar        -3.2191        0.0006
-------------------------------------------------------------------------------
```

Figure A 4.4 The Im-Pesaran-Shin panel unit root test for the log of land supply

Appendix 5 Regression results for model (6.1) (full dataset of the 16 cities)

```
Fixed-effects (within) regression               Number of obs      =       144
Group variable: ct                              Number of groups   =        16

R-sq:  within  = 0.6114                         Obs per group: min =         9
       between = 0.7109                                        avg =       9.0
       overall = 0.6228                                        max =         9

                                                F(12,15)           =     38.77
corr(u_i, Xb)  = 0.3809                         Prob > F           =    0.0000

                                               (Std. Err. adjusted for 16 clusters in ct)
------------------------------------------------------------------------------
             |               Robust
       lnhs |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnhp |
         D1. |   1.494045   .8388493     1.78   0.095    -.2939197    3.28201
             |
     lnccost |
         D1. |  -.0182628   .0905699    -0.20   0.843     -.211308    .1747823
             |
       fcost |
         D1. |  -.0513791   .0056555    -9.08   0.000    -.0634335   -.0393247
             |
        lnls |
         L1. |   .1998266   .0613712     3.26   0.005     .0690169    .3306362
         L2. |   .2220808   .0599889     3.70   0.002     .0942176     .349944
             |
      year02 |           0  (omitted)
      year03 |  -.7568299   .1304645    -5.80   0.000    -1.034908   -.4787514
      year04 |  -.7855474   .1526914    -5.14   0.000    -1.111001   -.4600934
      year05 |   -.451773   .1257857    -3.59   0.003    -.7198788   -.1836671
      year06 |  -.4423255    .104683    -4.23   0.001     -.665452   -.2191989
      year07 |  -.4239701   .0883054    -4.80   0.000    -.6121886   -.2357515
      year08 |  -.3307951   .0684232    -4.83   0.000    -.4766358   -.1849545
      year09 |           0  (omitted)
      year10 |           0  (omitted)
      year11 |   .2669909   .0424389     6.29   0.000     .1765344    .3574473
       _cons |    4.52046    .634241     7.13   0.000     3.168607    5.872313
-------------+----------------------------------------------------------------
     sigma_u |   .3262651
     sigma_e |  .22467234
         rho |  .67833581   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Figure A 5.1 Regression results for model (6.1) (full dataset of the 16 cities, construction cost variable included)

```
Fixed-effects (within) regression               Number of obs      =       144
Group variable: ct                              Number of groups   =        16

R-sq:  within  = 0.6113                         Obs per group: min =         9
       between = 0.7107                                        avg =       9.0
       overall = 0.6226                                        max =         9

                                                F(11,15)           =     39.65
corr(u_i, Xb)  = 0.3808                         Prob > F           =    0.0000

                                                (Std. Err. adjusted for 16 clusters in ct)
```

lnhs	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnhp						
D1.	1.497806	.8322226	1.80	0.092	-.2760343	3.271647
fcost						
D1.	-.0514503	.0056976	-9.03	0.000	-.0635944	-.0393062
lnls						
L1.	.19966	.0614181	3.25	0.005	.0687504	.3305696
L2.	.2220638	.0599459	3.70	0.002	.0942921	.3498355
year02	0	(omitted)				
year03	-.7563512	.130732	-5.79	0.000	-1.035	-.4777024
year04	-.7853636	.1527155	-5.14	0.000	-1.110869	-.4598583
year05	-.4504398	.126408	-3.56	0.003	-.7198721	-.1810075
year06	-.4411112	.1055692	-4.18	0.001	-.6661266	-.2160959
year07	-.4230607	.0889504	-4.76	0.000	-.612654	-.2334674
year08	-.3295235	.0698897	-4.71	0.000	-.4784899	-.1805572
year09	0	(omitted)				
year10	0	(omitted)				
year11	.2690228	.0461388	5.83	0.000	.1706803	.3673653
_cons	4.519241	.6321854	7.15	0.000	3.171769	5.866712
sigma_u	.3263242					
sigma_e	.22372762					
rho	.68025068	(fraction of variance due to u_i)				

Figure A 5.2 Regression results for model (6.1) (full dataset of the 16 cities, construction cost variable excluded)

Appendix 6 Regression results for model (6.2) (full dataset of the 16 cities)

```
Fixed-effects (within) regression               Number of obs      =       144
Group variable: ct                              Number of groups   =        16

R-sq:  within  = 0.6200                         Obs per group: min =         9
       between = 0.7033                                        avg =       9.0
       overall = 0.6268                                        max =         9

                                                F(12,15)           =     43.91
corr(u_i, Xb)  = 0.3699                         Prob > F           =    0.0000

                                    (Std. Err. adjusted for 16 clusters in ct)
------------------------------------------------------------------------------
             |               Robust
        lnhs |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnhp |
         D1. |   2.616937   1.266171     2.07   0.056    -.0818437    5.315717
             |
       inter |  -2.101604    1.34366    -1.56   0.139    -4.965548    .7623406
             |
       fcost |
         D1. |  -.0483373   .0058092    -8.32   0.000    -.0607193   -.0359553
             |
        lnls |
         L1. |   .2001552   .0637726     3.14   0.007     .0642271    .3360833
         L2. |   .2243696   .0593377     3.78   0.002     .0978942     .350845
             |
      year02 |           0  (omitted)
      year03 |  -.8644322   .1677369    -5.15   0.000    -1.221955   -.5069095
      year04 |  -.9265522    .206754    -4.48   0.000    -1.367238   -.4858665
      year05 |   -.586666   .1730215    -3.39   0.004    -.9554526   -.2178794
      year06 |  -.4462925   .1087211    -4.10   0.001     -.678026    -.214559
      year07 |  -.4010618   .0883892    -4.54   0.000     -.589459   -.2126645
      year08 |  -.3253492   .0668257    -4.87   0.000    -.4677847   -.1829137
      year09 |           0  (omitted)
      year10 |           0  (omitted)
      year11 |   .2385337   .0408047     5.85   0.000     .1515606    .3255068
       _cons |   4.553687   .6437378     7.07   0.000     3.181592    5.925782
-------------+----------------------------------------------------------------
     sigma_u |  .32387816
     sigma_e |  .22215306
         rho |     .68005   (fraction of variance due to u_i)
------------------------------------------------------------------------------

.
```

Figure A 6.1 Regression results for model (6.2) (full dataset of the 16 cities)

Appendix 7 Regression results for model (6.1) (the group-1 cities)

```
Fixed-effects (within) regression               Number of obs      =        63
Group variable: ct                              Number of groups   =         7

R-sq:  within  = 0.6017                         Obs per group: min =         9
       between = 0.6866                                        avg =       9.0
       overall = 0.6502                                        max =         9

corr(u_i, Xb)  = 0.3230

                                                (Std. Err. adjusted for 7 clusters in ct)
------------------------------------------------------------------------------
             |               Robust
        lnhs |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnhp |
         D1. |   .6768494   .6406073     1.06   0.326    -.8379462    2.191645
             |
       fcost |
         D1. |  -.0456632   .0091299    -5.00   0.002     -.067252   -.0240743
             |
        lnls |
         L1. |   .2592755   .0629102     4.12   0.004     .1105165    .4080344
         L2. |   .1900668   .0847622     2.24   0.060    -.010364    .3904976
             |
      year02 |          0  (omitted)
      year03 |  -.5422321   .2010891    -2.70   0.031    -1.017732   -.066732
      year04 |   -.574857   .2068348    -2.78   0.027    -1.063944   -.0857705
      year05 |  -.3492241   .1827457    -1.91   0.098    -.7813489    .0829007
      year06 |  -.3251918   .1125084    -2.89   0.023     -.591232   -.0591516
      year07 |   -.296448   .1257614    -2.36   0.051    -.5938263    .0009304
      year08 |  -.2657367   .1331652    -2.00   0.086    -.5806223    .0491488
      year09 |          0  (omitted)
      year10 |          0  (omitted)
      year11 |    .242079   .0423809     5.71   0.001     .1418641    .3422939
       _cons |   4.423868   .7503814     5.90   0.001     2.649498    6.198239
-------------+----------------------------------------------------------------
     sigma_u |  .32415797
     sigma_e |  .20276275
         rho |  .71877409   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Figure A 7.1 Regression results for model (6.1) (the group-1 cities)

Appendix 8 Regression results for model (6.2) (the group-1 cities)

```
Fixed-effects (within) regression               Number of obs      =        63
Group variable: ct                              Number of groups   =         7

R-sq:  within  = 0.6063                         Obs per group: min =         9
       between = 0.6905                                        avg =       9.0
       overall = 0.6551                                        max =         9

corr(u_i, Xb)  = 0.3208

                                                (Std. Err. adjusted for 7 clusters in ct)
------------------------------------------------------------------------------
             |               Robust
        lnhs |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnhp |
         D1. |   1.246616   .7554523     1.65   0.143    -.5397452    3.032977
             |
       inter |  -1.146269    1.19002    -0.96   0.368    -3.960219    1.667681
             |
       fcost |
         D1. |  -.0416885   .0091851    -4.54   0.003    -.0634077   -.0199692
             |
        lnls |
         L1. |   .2581212   .0676348     3.82   0.007     .0981903    .4180521
         L2. |    .192004   .0879276     2.18   0.065    -.0159118    .3999198
             |
      year02 |          0  (omitted)
      year03 |  -.5975264   .2125638    -2.81   0.026     -1.10016   -.094893
      year04 |  -.6431912   .2345362    -2.74   0.029    -1.197781   -.0886013
      year05 |  -.4245864   .1994862    -2.13   0.071    -.8962964    .0471236
      year06 |  -.3267216   .1126191    -2.90   0.023    -.5930235   -.0604197
      year07 |  -.2718832   .1285794    -2.11   0.072    -.5759251    .0321587
      year08 |  -.2619025   .1292484    -2.03   0.082    -.5675265    .0437214
      year09 |          0  (omitted)
      year10 |          0  (omitted)
      year11 |    .228433   .0418679     5.46   0.001     .1294311    .3274349
       _cons |   4.448996   .7810471     5.70   0.001     2.602113    6.295879
-------------+----------------------------------------------------------------
     sigma_u |  .32151166
     sigma_e |  .20352128
         rho |  .71392553   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Figure A 8.1 Regression results for model (6.2) (the group-1 cities)

Appendix 9 Regression results for model (6.1) (the group-2 cities)

```
Fixed-effects (within) regression               Number of obs      =        81
Group variable: ct                              Number of groups   =         9

R-sq:  within  = 0.7870                         Obs per group: min =         9
       between = 0.6974                                        avg =       9.0
       overall = 0.5262                                        max =         9

corr(u_i, Xb)  = 0.1962

                                               (Std. Err. adjusted for 9 clusters in ct)
------------------------------------------------------------------------------
             |               Robust
        lnhs |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnhp |
         D1. |    3.91648   1.489712     2.63   0.034     .3938711    7.43909
             |
       fcost |
         D1. |  -.0454372    .011931    -3.81   0.007    -.0736494   -.017225
             |
        lnls |
         L1. |   .0643411   .0505186     1.27   0.243    -.0551165    .1837987
         L2. |   .1486759   .0591648     2.51   0.040     .0087734    .2885784
             |
      year02 |           0  (omitted)
      year03 |   -.880765   .1223307    -7.20   0.000    -1.170031   -.5914988
      year04 |  -.9696513   .1747473    -5.55   0.001    -1.382863   -.5564398
      year05 |  -.5101289    .164032    -3.11   0.017     -.898003   -.1222547
      year06 |  -.4050994   .1726088    -2.35   0.051    -.8132544    .0030556
      year07 |   -.447787    .142176    -3.15   0.016    -.7839799   -.1115942
      year08 |   -.316403   .0899172    -3.52   0.010    -.5290234   -.1037826
      year09 |           0  (omitted)
      year10 |           0  (omitted)
      year11 |   .3869013   .0804864     4.81   0.002     .1965813    .5772213
       _cons |   5.536406   .5956397     9.29   0.000     4.127942    6.94487
-------------+----------------------------------------------------------------
     sigma_u |  .37592647
     sigma_e |  .19637662
         rho |  .78561923   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Figure A 9.1 Regression results for model (6.1) (the group-2 cities)

Appendix 10 Regression results for model (6.2) (the group-2 cities)

```
Fixed-effects (within) regression               Number of obs      =        81
Group variable: ct                              Number of groups   =         9

R-sq:  within  = 0.7983                         Obs per group: min =         9
       between = 0.6098                                        avg =       9.0
       overall = 0.5488                                        max =         9

corr(u_i, Xb)  = 0.2021

                                               (Std. Err. adjusted for 9 clusters in ct)
------------------------------------------------------------------------------
             |               Robust
        lnhs |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnhp |
         D1. |    5.72016   1.818925     3.14   0.016     1.419086    10.02123
             |
       inter |   -3.742969   2.756687    -1.36   0.217    -10.2615     2.775561
             |
       fcost |
         D1. |   -.0468331   .0093799    -4.99   0.002    -.0690129   -.0246532
             |
        lnls |
         L1. |    .0729917   .0517307     1.41   0.201    -.0493319    .1953153
         L2. |    .1583771   .0610693     2.59   0.036     .0139712    .3027831
             |
      year02 |          0   (omitted)
      year03 |   -1.085909   .2034303    -5.34   0.001    -1.566945   -.6048724
      year04 |   -1.240568   .2470565    -5.02   0.002    -1.824764   -.6563725
      year05 |   -.7495167   .2597811    -2.89   0.023    -1.363801   -.1352321
      year06 |   -.4283288   .1880913    -2.28   0.057    -.8730939    .0164364
      year07 |   -.4479339   .1451243    -3.09   0.018    -.7910983   -.1047694
      year08 |   -.3173172   .0828235    -3.83   0.006    -.5131637   -.1214707
      year09 |          0   (omitted)
      year10 |          0   (omitted)
      year11 |    .3118023   .0926949     3.36   0.012     .0926137    .5309909
       _cons |    5.532722   .6112708     9.05   0.000     4.087297    6.978148
-------------+----------------------------------------------------------------
     sigma_u |  .36758269
     sigma_e |  .19292938
         rho |  .78401991   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Figure A 10.1 Regression results for model (6.2) (the group-2 cities)

Appendix 11 The kernel density estimation for the variables in the model of housing price

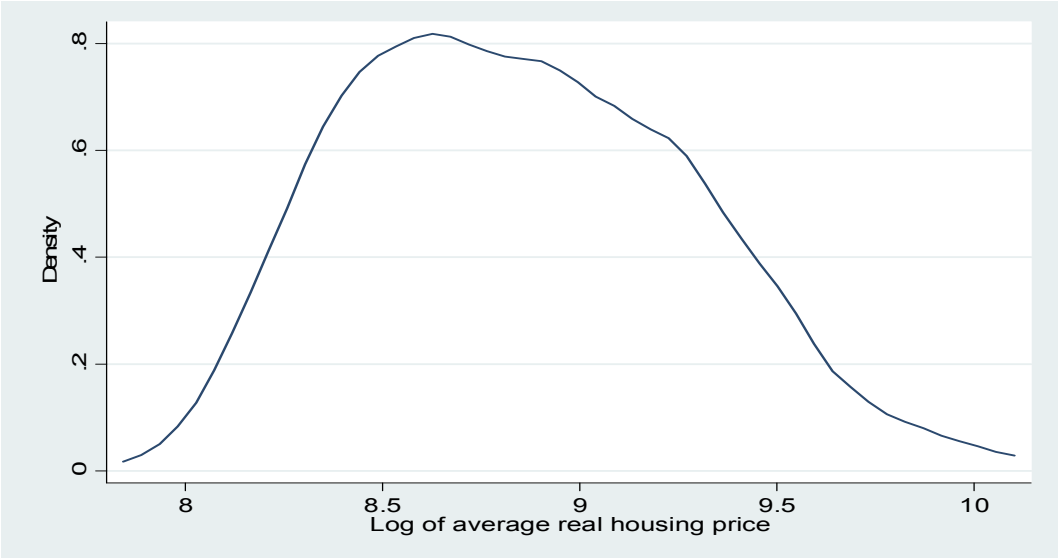


Figure A 11.1 The kernel density estimation for the log of housing price

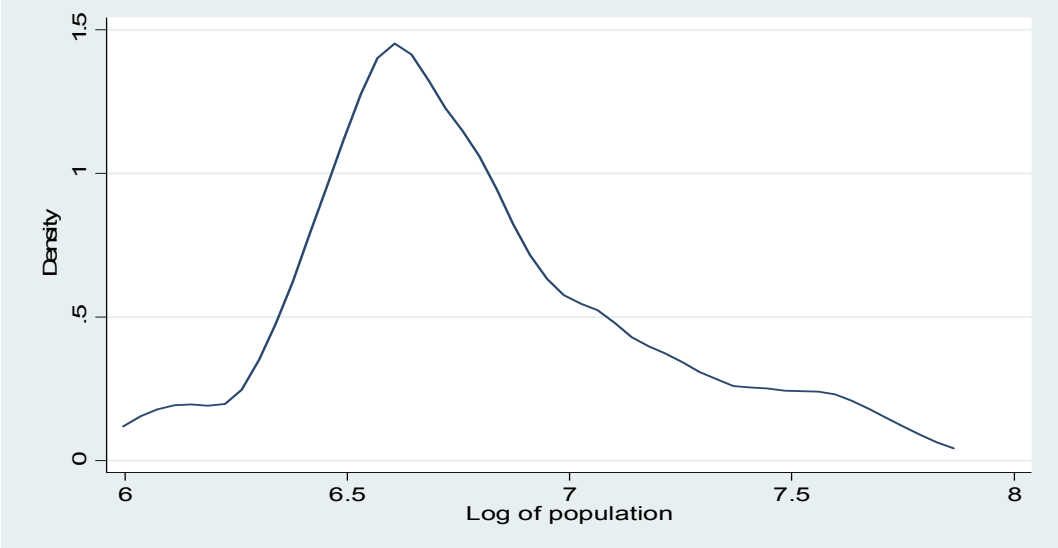


Figure A 11.2 The kernel density estimation for the log of population

Appendix 12 The scatter plots of the log of housing price against the independent variables in the model of housing price

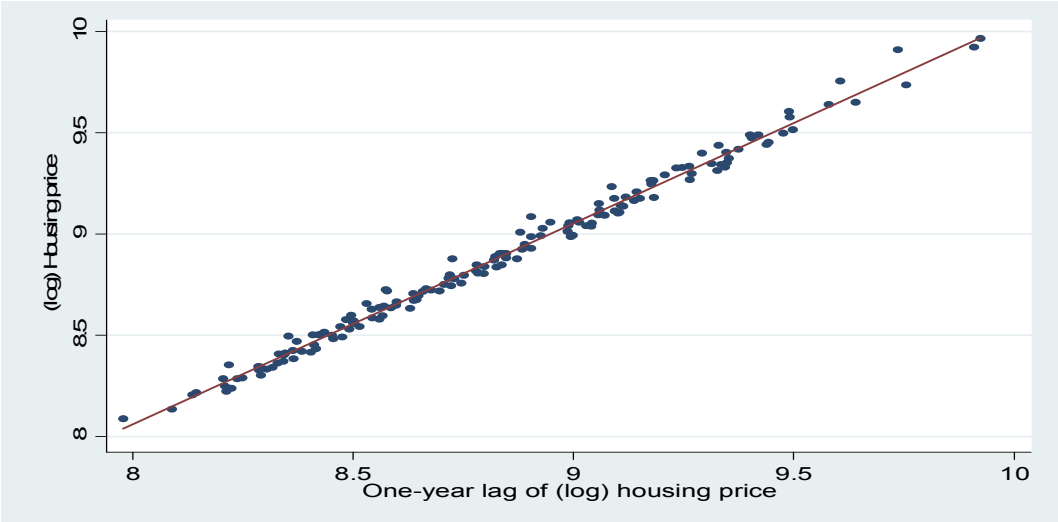


Figure A 12.1 The scatter plot of the log of housing price against 1-year lag of (log) housing price

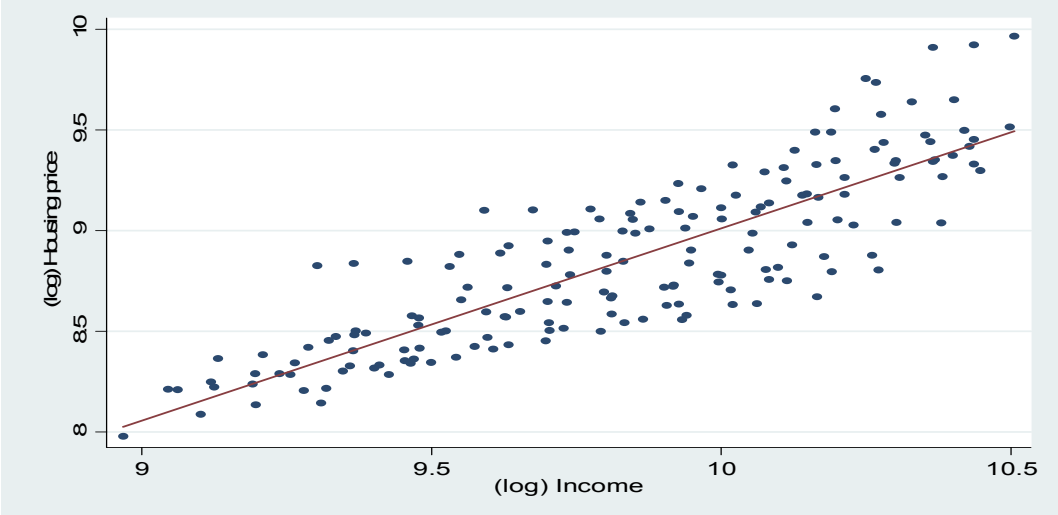


Figure A 12.2 The scatter plot of the log of housing price against the log of income

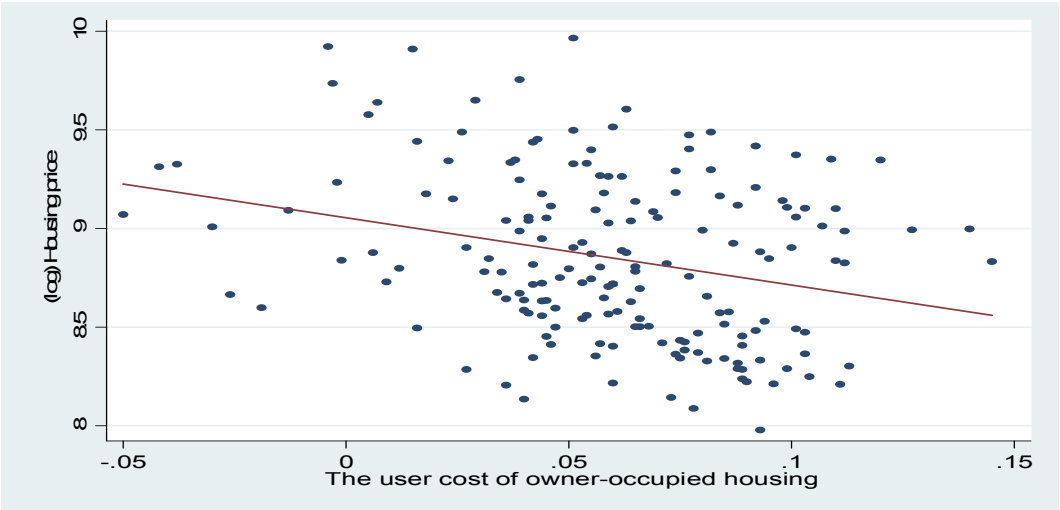


Figure A 12.3 The scatter plot of the log of housing price against the user cost of owner-occupied housing

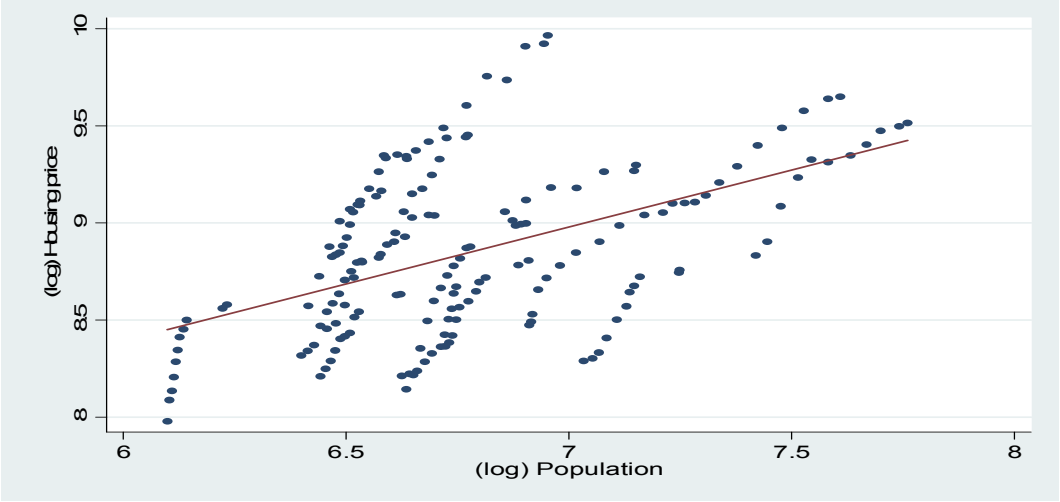


Figure A 12.4 The scatter plot of the log of housing price against the log of population

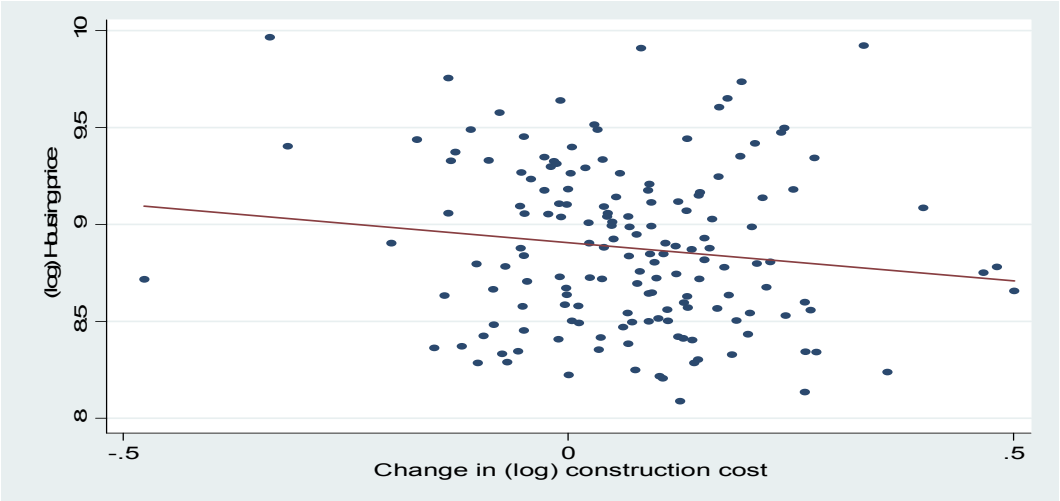


Figure A 12.5 The scatter plot of the log of housing price against the change in the log of construction cost

Appendix 13 The correlation matrix for the independent variables in the model of housing price

	lnpop	ucost	lninc	D. lnccost	D. fcost	lnls
lnpop	1.0000					
ucost	-0.0490	1.0000				
lninc	0.4018	-0.3035	1.0000			
lnccost						
D1.	-0.0534	0.0035	-0.1052	1.0000		
fcost						
D1.	-0.0275	-0.0264	-0.0586	0.0711	1.0000	
lnls	0.2678	0.1463	-0.3284	0.0863	-0.0283	1.0000

Figure A 13.1 The correlation matrix for the independent variables in the model of housing price

Appendix 14 The Im-Pesaran-Shin panel unit root test for the variables in the model of housing price

```
Im-Pesaran-Shin unit-root test for lnhp
-----------------------------------------
Ho: All panels contain unit roots           Number of panels  =     16
Ha: Some panels are stationary              Number of periods =     11

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: No lags included
------------------------------------------------------------------------------
                                                Fixed-N exact critical values
                     Statistic      p-value         1%      5%      10%
------------------------------------------------------------------------------
 t-bar                -2.4448                     -2.020  -1.870  -1.790
 t-tilde-bar          -1.7395
 Z-t-tilde-bar        -2.4759        0.0066
------------------------------------------------------------------------------
```

Figure A 14.1 The Im-Pesaran-Shin panel unit root test for the log of average real housing price

```
Im-Pesaran-Shin unit-root test for lnpop
-----------------------------------------
Ho: All panels contain unit roots           Number of panels  =     16
Ha: Some panels are stationary              Number of periods =     11

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: No lags included
------------------------------------------------------------------------------
                                                Fixed-N exact critical values
                     Statistic      p-value         1%      5%      10%
------------------------------------------------------------------------------
 t-bar                -0.3976                     -2.020  -1.870  -1.790
 t-tilde-bar          -0.3415
 Z-t-tilde-bar         5.2072        1.0000
------------------------------------------------------------------------------
```

Figure A 14.2 The Im-Pesaran-Shin panel unit root test for the log of population

```
Im-Pesaran-Shin unit-root test for D.lnpop
-----------------------------------------
Ho: All panels contain unit roots           Number of panels  =     16
Ha: Some panels are stationary              Number of periods =     10

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: No lags included
------------------------------------------------------------------------------
                                                Fixed-N exact critical values
                     Statistic      p-value         1%      5%      10%
------------------------------------------------------------------------------
 t-bar                -1.7712                     -2.060  -1.890  -1.800
 t-tilde-bar          -1.4947
 Z-t-tilde-bar        -1.2229        0.1107
------------------------------------------------------------------------------
.
```

Figure A 14.3 The Im-Pesaran-Shin panel unit root test for the change in the log of population

```
Im-Pesaran-Shin unit-root test for lninc
-----------------------------------------

Ho: All panels contain unit roots           Number of panels  =     16
Ha: Some panels are stationary              Number of periods =     11

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: No lags included
------------------------------------------------------------------------------
                                                 Fixed-N exact critical values
                     Statistic      p-value         1%       5%      10%
------------------------------------------------------------------------------
 t-bar                -1.1533                     -2.020   -1.870  -1.790
 t-tilde-bar          -0.9384
 Z-t-tilde-bar         1.9266        0.9730
------------------------------------------------------------------------------
```

Figure A 14.4 The Im-Pesaran-Shin panel unit root test for the log of income

```
Im-Pesaran-Shin unit-root test for D.lninc
-------------------------------------------

Ho: All panels contain unit roots           Number of panels  =     16
Ha: Some panels are stationary              Number of periods =     10

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: No lags included
------------------------------------------------------------------------------
                                                 Fixed-N exact critical values
                     Statistic      p-value         1%       5%      10%
------------------------------------------------------------------------------
 t-bar                -3.4477                     -2.060   -1.890  -1.800
 t-tilde-bar          -2.0973
 Z-t-tilde-bar        -4.5623        0.0000
------------------------------------------------------------------------------
```

Figure A 14.5 The Im-Pesaran-Shin panel unit root test for the change in the log of income

Appendix 15 Panel co-integration tests for the variables in the model of housing price

Results for H0: no cointegration
With 16 series and 2 covariates

Statistic	Value	Z-value	P-value
Gt	-13.638	-46.784	0.000
Ga	-0.370	3.989	1.000
Pt	-5.817	-1.557	0.060
Pa	-0.227	1.854	0.968

Figure A 15.1 Panel co-integration tests for the variables in the model of housing price

Appendix 16 Regression results for model (7.9) (full dataset of the 16 cities)

```
System dynamic panel-data estimation        Number of obs      =       144
Group variable: ct                          Number of groups   =        16
Time variable: year
                                            Obs per group:  min =         9
                                                            avg =         9
                                                            max =         9

Number of instruments =     68              Wald chi2(15)      =  84483.15
                                            Prob > chi2        =    0.0000
One-step results
```

lnhp	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnhp						
L1.	.7066208	.0586752	12.04	0.000	.5916196	.821622
lnpop	.1551152	.0688335	2.25	0.024	.020204	.2900264
ucost	-.0043338	.0018258	-2.37	0.018	-.0079122	-.0007554
lninc	.1227792	.0640662	1.92	0.055	-.0027883	.2483467
lnccost						
D1.	-.0126795	.0222483	-0.57	0.569	-.0562854	.0309263
fcost						
D1.	.0017792	.0011817	1.51	0.132	-.0005368	.0040952
lnls						
L1.	-.0073421	.0044001	-1.67	0.095	-.0159661	.0012819
L2.	-.018912	.0088449	-2.14	0.033	-.0362476	-.0015764
year03	.0155407	.0304725	0.51	0.610	-.0441844	.0752658
year04	.0477053	.0263583	1.81	0.070	-.003956	.0993667
year05	.0202041	.022147	0.91	0.362	-.0232033	.0636114
year06	.0025413	.0191273	0.13	0.894	-.0349476	.0400302
year07	.0351868	.0181418	1.94	0.052	-.0003704	.0707441
year08	.0148176	.0107914	1.37	0.170	-.0063331	.0359683
year11	-.0432096	.00702	-6.16	0.000	-.0569686	-.0294507
_cons	.5508945	.4390366	1.25	0.210	-.3096014	1.41139

```
Instruments for differenced equation
        GMM-type: L(2/.).lnhp
        Standard: D.lnpop D.ucost D.lninc D2.lnccost D2.fcost LD.lnls L2D.lnls D.year04 D.year05 D.year06 D.year07 D.year08 D.year10 D.year11
Instruments for level equation
        GMM-type: LD.lnhp
        Standard: _cons
```

Figure A 16.1 Regression results for model (7.9) (construction cost variable and financing cost variable included)

```
System dynamic panel-data estimation        Number of obs      =       144
Group variable: ct                          Number of groups   =        16
Time variable: year
                                            Obs per group:  min =         9
                                                            avg =         9
                                                            max =         9

Number of instruments =     67              Wald chi2(14)      =  168019.20
                                            Prob > chi2        =    0.0000
One-step results
```

lnhp	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnhp						
L1.	.706412	.0575103	12.28	0.000	.5936939	.8191302
lnpop	.1581689	.0697136	2.27	0.023	.0215328	.2948049
ucost	-.0042831	.00184	-2.33	0.020	-.0078895	-.0006767
lninc	.1239388	.0638789	1.94	0.052	-.0012615	.2491391
lnls						
L1.	-.0073977	.0043206	-1.71	0.087	-.015866	.0010705
L2.	-.0189323	.0087416	-2.17	0.030	-.0360654	-.0017991
year03	.0086804	.0233281	0.37	0.710	-.0370418	.0544026
year04	.0402963	.0197904	2.04	0.042	.0015077	.0790848
year05	.020429	.0123919	1.65	0.099	-.0038586	.0447166
year07	.0281704	.0090962	3.10	0.002	.0103422	.0459985
year08	.0085914	.0177533	0.48	0.628	-.0262045	.0433874
year09	.0046006	.0221195	0.21	0.835	-.0387528	.047954
year10	-.0117538	.0186731	-0.63	0.529	-.0483525	.0248448
year11	-.0494582	.0205496	-2.41	0.016	-.0897347	-.0091818
_cons	.5235235	.4362599	1.20	0.230	-.3315302	1.378577

```
Instruments for differenced equation
        GMM-type: L(2/.).lnhp
        Standard: D.lnpop D.ucost D.lninc LD.lnls L2D.lnls D.year04 D.year05 D.year06 D.year07 D.year08 D.year09 D.year10 D.year11
Instruments for level equation
        GMM-type: LD.lnhp
        Standard: _cons
```

Figure A 16.2 Regression results for model (7.9) (construction cost variable and financing cost variable excluded)