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Doctoral Dissertation

EMPIRICAL ANALYSIS OF THE HOUSING AFFORDABILITY AND HOUSING SUPPLY IN CHINA

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ABSTRACT

In the last decades, housing prices in China experienced a rapid increase putting on considerable pressure on home buyers, which brought about a big concern on the housing affordability problem. While there has been a large body of literature on housing demand, limited process has been made in the study area of housing supply. The objective of this dissertation, which consists of six chapters, is to explore the housing affordability problem, to estimate the housing supply elasticity and its determinants, and to examine whether the housing supply varies by region and type in China. A reduced-form model is used to estimate the housing supply elasticity nationwide, while the urban growth model is used to examine the variation in housing supply across regions and by housing type. Data used in this study mainly come from 31 provinces and 35 large and medium cities in China over the period 1998-2010. The main findings are as follows:

1) Inspite of the remarkable family income growth, the majority of the Chinese households are still suffering from the housing affordability problem.

2) Housing supply in China is less elastic compared to other countries and land regulation plays an important role in affecting housing supply.

3) The elasticity of housing supply not only varies by region, but also differs by housing type to type significantly.

This dissertation links the housing affordability problem to the elasticity of housing supply. The result supports that the current housing affordability problem in China is somewhat caused by the less elastic housing market, where housing supply cannot rise quickly in response to demand increases. This dissertation also examines differences in housing supply across regions and by type, which can be referenced in the establishment and implementation of housing policies and programs toward growth in the housing supply.

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The Chinese government officially launched the housing reform in order to improve the inferior living conditions in the beginning of the 1980s. From this point, onward housing reform has led to heated debates among Chinese scholars and later attracted attention to academic communities and financial organizations in the world (Shaw, 1997). Before the reform, the majority of houses were allocated directly by the government and the state-owned work units. Due to insufficient financial support, such welfare-oriented housing provision system[1] cannot offer sufficient houses and thus resulted in a housing shortage problem. A reform of the housing system was considered because the government recognized serious problems in the state provision of housing, including shortages, poor management, and corruption in the distribution (Wang and Murie, 1999). In 1998, the Chinese State Council issued the 23rd decree, which marked the housing allocation transforming from a welfare provision to a market-oriented system, was acknowledged as a milestone during the process of the housing reform. Since then, the era of housing distribution was ended. Thereafter, work units were no longer allowed to develop new houses for their employees. Instead, they had to integrate implicit housing benefits into employees' salary, and the households had to buy or rent their residential housing units in the private housing market (Wu et al., 2012). Under the new housing provision system, low-income households can either rent low cost units or purchase special affordable units at highly subsidized prices from the local governments. Moderate-income households can obtain subsidies to rent public rental units or to

[1] Before housing reform, China adopted a welfare housing system under which the production, allocation, and maintenance of housing has been the responsibility of the work unit (Danwei).

purchase price controlled units, while other high-income households are required to rent or buy commercial housing at market price. Meanwhile, multi-level housing funds come from housing public accumulation, mortgages, and flexible repayment terms were established to pool income from various sources for housing construction (Shaw, 1997). Housing reform has transformed China into a country with one of the highest rates of home ownership in the world (Wang, 2011). Accompanied with the housing reform, the rates of home ownership in urban areas increased from around 55 percent in the early 1990s to 88.1 percent in 2012[2].

Land-use policy was simultaneously changing through housing reform. Whereas land is concentrated in the hands of the state and local governments at different levels, land-use right has economic value and can be traded. The *Temporary Regulations for State-Owned Urban Land Use Right Conveyances and Transfers* in 1990 formally authorized that use of state-owned urban land were independent economic rights. In addition, these rights could be sold, exchanged, bestowed as a gift, leased, and or used for mortgages within a specified time limit of 50 years for industrial use, 40 years for commercial use, and 70 years for residential use. Under subsequent tax reforms implemented in 1995, the transfer of these property rights becomes subject to a land value-added tax with rates ranging from 30% to 60% (Mak, et al., 2007). The land revenue has become the most important revenue source for the local governments who monopolize the grant of rights of land-use. Since 2002, the state required that all urban land for residential and commercial use should only be transacted by public auction or bidding. Administrative allotment of land-use right was repealed. Furthermore, China strictly controlled land supply for construction use. In practice, the transforming of the land use type is strictly restricted to realize a special protection on cultivated land. In this case, the contradiction between the fast-growing demand of land for construction use and the strict cultivated land protection policy is increasingly outstanding. Stringent

[2] Data were announced by the Shanghai E-house R&D Institute, China, in 2012.

control of land supply was mainly responsible for the changes in land prices and thus has a huge impact on house prices (Zhang, 2008).

1.2 Statement of the Problem

Although great achievements have been made in the housing reform in China since the 1990s, many potential problems occurred with the housing market development (Wang, 2004). As an increasingly urbanized and industrialized country, China witnessed substantial economic growth and rapid urbanization over the last two decades, thus led to strong demand for residential housing[3]. Although the amount of new houses has been increased greatly, housing supply still chronically failed to meet the fast-growing housing demand. As a result, housing prices escalated. Since the housing reform, the average selling price of commercial housing has tripled. The price level is considered beyond reach of the average citizen. The escalated housing price in China has triggered public complains since housing is the single largest expenditure item in the budgets of most households. Indeed, average households devote more than two thirds of their income to housing expenditure, which indicates that even slight changes in housing prices will have considerable impact on household well-being and thus the entire economy of the country. At the request of the public that the government should 'do something' to rein in housing prices, the Chinese government launched a round of measures such as land-use controls, interest rate adjustments, and tax policies in order to provide more inexpensive housing to low-income households. In view of the above, an objective policy evaluation on effects of these policies is of great importance. In particular, since most housing models and policy analysis hinge on explicit or implicit estimates of the price elasticity of housing supply (DiPasquale (1999), Malpezzi and Maclennan (2001)), housing supply should be incorporated into analysis in order to

[3] The item of 'housing' or 'houses' appears in this study is limited to houses for living use (unless otherwise specified).

realize a full understanding of the entire housing market. However, while there has been a vast of studies exploring this issue in the demand side, few attentions have been paid to housing supply side for both the theoretical and empirical studies[4].

1.3 Purpose of the Study

This thesis aims to explore the current housing affordability problem from a perspective of the housing supply. In other words, it attempts to examine whether the housing affordability problem is potentially caused by inelastic housing supply in China. An analysis on housing supply enables us to observe the behavior of suppliers and assess the performance of the housing policies.

Multiple approaches are employed in this study surrounding the issues of housing supply. Chapter 2 stresses the problem of housing affordability based on the ratio measure and the residual income approach. Both of the difference between households' income and housing prices, and the situation that households face after paying for housing expenses is considered. Data on housing prices, household incomes by level over 1987-2011 are collected to analyze the housing affordability problem in China. Chapter 3 estimates housing supply elasticity by employing the reduced-form model, which combines the supply function and the demand function into a single one. Using panel data covering 31 provinces of China on the housing market over the years from 1999 to 2010, Chapter 3 estimates the housing supply elasticity and explores the determinants that affect the housing supply elasticity to provide a necessary reference for policy-makers. In Chapter 4, an improved urban growth model, which takes account of urban growth and land-use control, is introduced to examine whether housing supply elasticity varies across regions. New construction of housing is modeled as a function of

[4] Many factors should be responsible for this situation. On the one hand, housing supply is the outcome of complicated decision which is not only by builders but also by the owners of existing housing, and on the other hand, there is little direct evidence that permits us to observe the behavior of housing suppliers (DiPasquale, 1999, p.10).

changes in housing prices, costs of construction materials and capitals, and land supply. The data of 35 cities are divided into three regions according to their location to examine the regional difference in the housing supply. Meanwhile, using the similar approach the difference in housing supply by type is also examined in Chapter 5. The common residential housing, luxury houses, and economically affordable houses are assumed to have different elasticities of housing supply.

1.4 Outline of the Study

While housing spaces have been improved remarkably since the housing reform, most of the Chinese households fail to buy even a standard home without assistance by the government. The Chinese housing market is deemed to be one of the least affordable housing markets in the world. First concern of policy-makers and scholars has always been the housing affordability in China. Moreover, the Chinese government implemented a series of policies to stimulate housing supply in terms of land-use control, interest rates adjustment, and differential tax policies. One issue is how these policies are performed? To answer this question requires a thorough understanding of the entire housing market in China. In other words, both demand and supply should be considered. While there has been a vast of literature, which focuses on the relationship between housing demand and housing prices, progress on exploring the housing affordability problem in the housing supply side is limited. This study fills this gap by estimating the housing supply elasticities and examining their differences across regions and by housing type. Using the reduced form model to estimate housing supply elasticities enables us to make a comparison between our study and other existing studies. Furthermore, this study is distinguished from the existing studies which treat houses of various types as homogenous by observing differences in housing supply across regions and by housing type. The results are supposed to provide supporting

empirical evidences that the one-fit-all policies never work without any consideration of different housing supply elasticities across regions and by housing type.

Following the introductory chapter, Chapter 2 concerns the housing affordability problem to measure stresses that the Chinese households are experiencing in buying houses. This chapter emphasizes the potential problem in the housing market by giving an empirically based picture of housing in current China. Chapter 3 explores the potential causes of the housing affordability problem in the housing supply side by estimating the housing supply elasticity and examining its determinants. Chapter 4 extends the analysis of Chapter 3 by examining the variation in housing supply across three regions in China. In addition, Chapter 5 further investigates the variation of the price elasticity of housing supply among housing of various types. Chapter 6 concludes this dissertation with a summary of the main findings, the potential limits as well as a research plan for future study.

CHAPTER 2

HOUSING AFFORDABILITY IN CHINA: MEASUREMENTS, TRENDS, AND INTERPRETATIONS

2.1 Introduction

Housing is one of the biggest expense items in budgets of most households. Over the past 25 years, sharp increase in the housing price has caused an increasing concern on the housing affordability in China, particularly in the most developed cities such as Beijing and Shanghai. As documented by Lau and Li (2004), around two-thirds of households in the lowest 40 percent of the income range are found to be in housing stress in China. Housing affordability has been regularly raised as a major policy concern.

This chapter attempts to explore the problem of housing affordability[5] in China. Previous attempts to explore the determinants of housing price can be found in many studies such as Zhang et al. (2012), Zhang et al. (2007), Chow et al. (2008), Liu and Shen (2005), Shen and Liu (2002). They aim to figure out what makes the housing price in China so high. Most of these studies relate the current housing price to the economic fundamentals with a purpose to examine whether there is a bubble in the Chinese housing market. In particular, they ask whether the housing market in China can be explained by economic fundamentals. Great process has been made since Rosen and Ross (2000) and Chiu (2001), who raised the problem of housing affordability. Lau and Li (2004) and Chen et al. (2010) measure the housing affordability in Beijing and Shanghai respectively, while a recent work by Wu and Deng (2012) evaluates the

[5] Housing affordability is widely used as an international standard in measuring the pressure that home buyers bear to buy a new house under their current income.

affordability of major housing markets in China. However, the existing studies on the housing affordability are still limited. In particular, emphasis is not much diverted to housing conditions, problems of affordability, housing policies and their interactions (Mak et al. 2007, p. 177).

This chapter firstly outlines a picture of the Chinese housing market with a special focus on the problem of affordability. Both the ratio approach and the residual income approach are employed to measure the pressure of buying a decent house for households. Moreover, a comparison of housing affordability with other countries helps us to be fully aware of current problems of the Chinese housing market.

This chapter proceeds as follows. Section 2 introduces the term of affordability and addresses how to capture the housing affordability. Section 3 discusses the basics of housing markets in China to trace back to the possible source of the housing affordability problem. Section 4 reports the calculated housing affordability using alternative approaches during the past years since the housing reform. Section 5 reviews experiences of other countries and efforts made by the Chinese government to solve the housing affordability problem. Finally, Section 6 concludes this chapter with the main findings.

2.2 An under-served Chinese housing market

The real estate market in China has been gradually developing with reform of the urban housing system. Per capita living space has been widened remarkably in the past 20 years. However, the increase in housing supply cannot catch up with the rapidly growing housing demand. As a result, housing prices soared putting huge pressures on home buyers. We define a market where the supply lags behind the demand as an ‘under-served housing market’.

2.2.1 Demand

The year 1998 is widely described as a milestone in the Chinese housing market because thenceforth houses can be only obtained though market channels and then the urban housing market emerged. Figure 2.1 reveals that the transaction volume of housing in 2011 has increased six-fold since 1998. It is generally acknowledged that multiple forces including the economy development, the rapid urbanization, and the reduced size of the households stimulated the housing demand during the past 15 years.

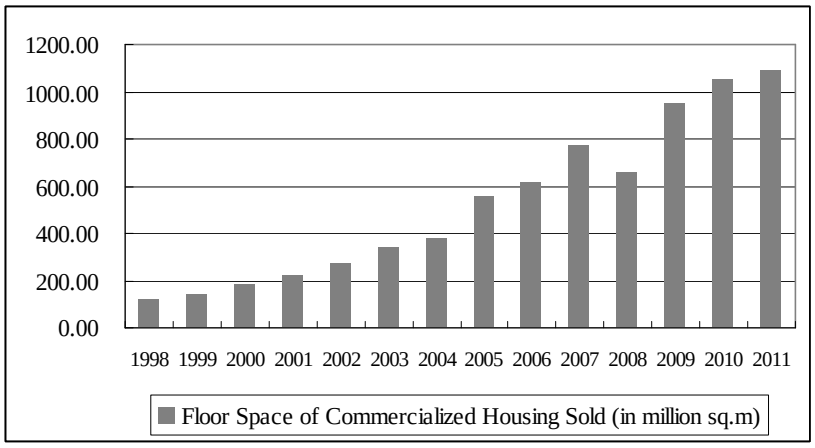

Figure 2.1 Floor space of commercialized housing sold during 1998-2011

Source: the Chinese Statistical Yearbook, 2012.

Note: The commercialized housing only involves the new construction of housing, while excludes the renovation and repair of the existing stock.

Apparently, the rapid development of the economy in the past two decades, which in turn leads to a rapid increase in household income, is an important contributing factor to the huge current housing demand. The increase in household income is a strong tendency to improve their living conditions. International experiences reveal that after the per capita GDP has reached $3,000 (a medium standard of living), the desire of households to improve their living conditions will be strengthened. Figure 2.2 shows that the per capita GDP had already exceeded RMB18, 000 (that is the U.S. $3,000) in 2006, which indicated a continuously growing housing demand in the following years.

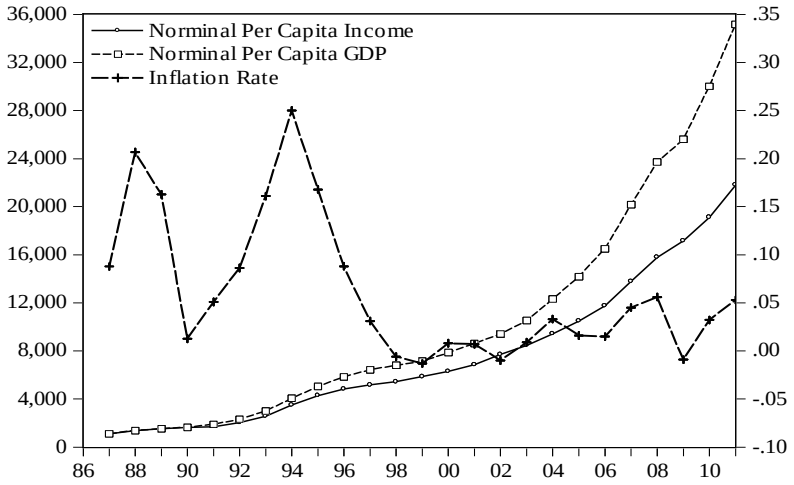

Figure 2.2 GDP per capita and disposable household income (unit: RMB)

Source: the Chinese Statistical Yearbook, 2012.

Another key factor underpinning housing demand in the Chinese urban market is a strong urbanization trend, as depicted in Table 2.1 which reports the urban population and its proportion in the overall population (urbanization rate) since 1986. The rapid urbanization attracts more and more people to immigrate into urban areas, and generates a huge demand for housing to accommodate the additional person.

Table 2.1 Urbanization in China: urban growth rate and urban population, 1986-2011

Year	1986	1995	1997	1999	2001	2003	2005	2007	2009	2011
Urban Population (100 million persons)	2.6	3.5	3.9	4.4	4.8	5.2	5.6	6.1	6.5	6.9
Urbanization Rate (%)	24.5	29.0	31.9	34.8	37.7	40.5	43.0	45.9	48.3	51.2

Source: the Chinese Statistical Yearbook, 2012.

Note. The urbanization rate equals the proportion of urban population to total population (including agricultural and non-agricultural).

Meanwhile, household size decreases from 3.7 persons in 1996 to 3.1 persons in 2010 which further contribute to the growing housing demand. The number of one-person households and two-person households has been growing rapidly (see Table 2.2). The

household size is becoming gradually smaller and the nucleus family is becoming the major form of modern Chinese families. Thus, demand from newly built family looking for homes also boosts the demand for houses.

Table 2.2 The household situation of urban residents

Year	Number of the One-person households (million)	Number of the Two-person households (million)	The average household size (persons)
2000	9.07	18.33	3.44
2010	23.10	35.79	3.10

Source: the demographic data are collected by the 5th national census in 2000 and the 6th national census in 2010.

Furthermore, it should be noted that the rapid development of the Chinese housing market also fueled the speculative demand for housing especially in the period of high inflation (as showed in Figure 2.2). To hedge against inflation and the rising user costs, buying property is particularly appealing in China because the limited financial sector offers few other investment options (Zhang et al., 2012). The current increasing demand of housing might be a sign that companies and investors are fear of inflation. According to the United States Department of Housing and Urban Development (HUD)[6], inflation heated up house prices and counterbalanced any increases in nominal wages, and eventually increased the pressure of urban residents to buy new homes.

2.2.2 Supply

The modern housing system encourages the private property developers to invest in housing construction, and leads to a significant increase in resource allocation for residential construction (Mak et al., 2007). Figure 2.3 illustrates a sharp increase in housing supply during the past periods of 1995-2011. The space of newly completed residential housing has more than doubled over the period of 1995-2011, reaching

[6] Source: The State of the Cities 2000, Fourth Annual June 2000, provided by the HUD.

nearly two billion square meters in 2011. Growing faster than the space of newly completed housing is the amount of investment on residential housing which increased more than six folds by 2011.

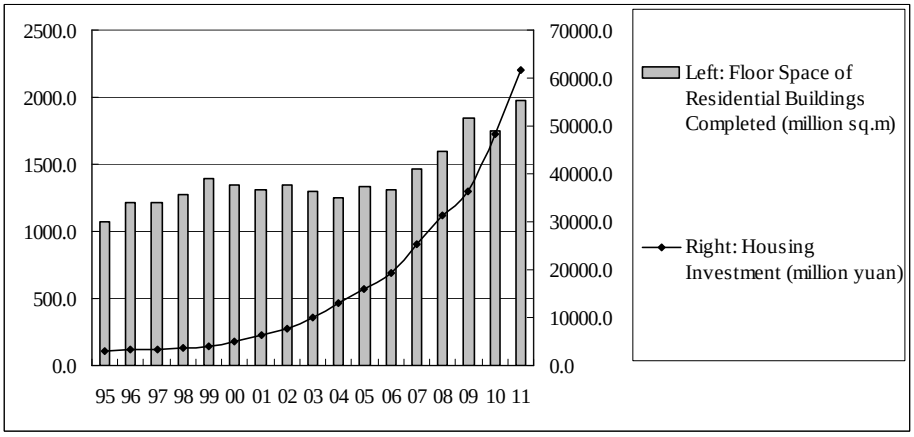

Figure 2.3 Housing supply in China, 1995-2011

Source: National Bureau of Statistics of China.

Moreover, investment in real estate accounted for the fixed assets reached 19.8% in 2011 as depicted in Table 2.3. Housing investment has become one of the most important components of the total urban fixed asset investment.

Table 2.3 Total fixed assets investment and housing investment (1995-2011)

Year	1995	1997	1999	2001	2003	2005	2007	2009	2011
Total investment in housing development (10 billion RMB)	31	32	41	63	102	159	253	362	618
Total investment in fixed assets (10 billion RMB)	200	249	298	372	555	887	1373	2246	3114
Proportion (%)[a]	15.7	12.7	13.7	17.0	18.2	17.9	18.4	16.1	19.8

Source: the Statistical Yearbook of China, published by the Chinese State Statistical Bureau, 2012.

[a] The proportion of urban housing investment in the total investment in fixed assets.

Meanwhile, loans for real estate development are also growing remarkably. The Chinese government worked out a policy entitled the ‘Management Provisions on

Residents Housing Loan' in 1998 to encourage the commercial banks to increase the financial support to housing consumptions since the housing reform (Leung and Wang, 2007). Over 60% of the real estate investment in China relies on the support of bank loans (Liu and Huang, 2004). At the end of 2012, the total balance of real estate development loans stood at 3 trillion RMB with an increase of 10.7%. More specifically, the total balance affordable housing[7] development loans reached to 571.1 billion RMB with an increase of 179.6 billion RMB which accounts for 66.5% of the total incremental real estate development loans over the same period[8]. In addition, a considerably large portion of bank lending was channeled into housing investment, which reflects a tendency of the Chinese government towards to increase affordable housing to solve the housing shortage problem. With the benefit of hindsight, it is clear that an influx of bank lending onto the housing markets simulates investment of houses through a multiplier effect remarkably.

In general, these data on housing supply in some sense indicate a success of urban housing reform in spurring housing construction. The large-scale housing investment has increased the supplies of residential houses considerably. The first household survey on housing conditions was carried out in 1985, and it revealed that the majority of urban residents were experiencing very poor living conditions (the per-capita living space was only 12 square meters in that year). Due to the economic development and housing reforms, per-capita living space in China has more than doubled since 2002 (see Figure 2.4).

[7] Affordable housing includes houses of two limits (limited price and habitable area), economically affordable housing, policy-regulated rental housing, low-rent homes and other types of government-subsidized house.
[8] Data sources: 'the 2012 Statistical Report on Credits Destination of the Financial Institutions' provided by the People's Bank of China.

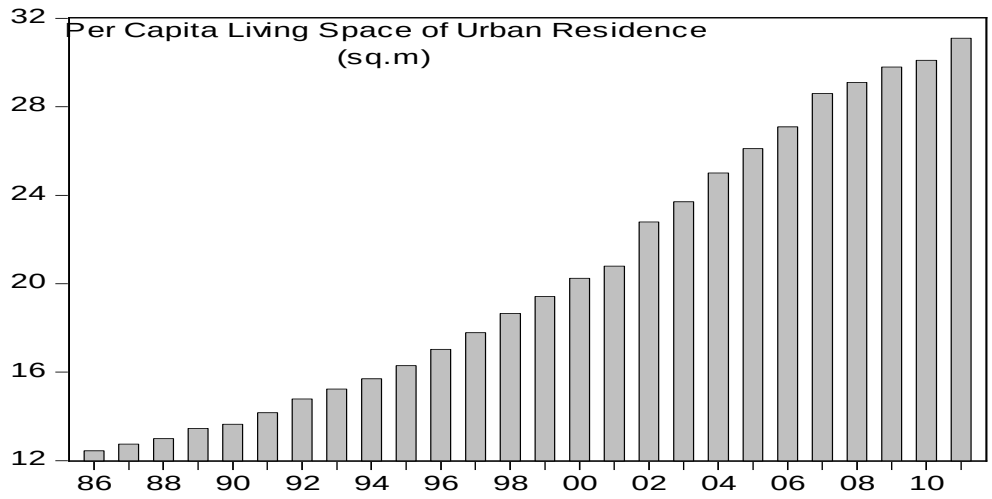

Figure 2.4 Housing conditions of urban residence (unit: sq.m)

Source: National Bureau of Statistics of China.

2.2.3 The soared housing price

In spite of the increased housing investment promoted by housing reform, there is a large gap between demand and supply since a relatively flat increase in supply cannot catch up with a substantially growing demand. Currently, large proportions of households are not able to have their own homes and have to share an apartment with their extended family or colleagues in China. The Galaxy Securities Statistics represents that during the periods 1995-2011 the total space of newly completed commercialized housing is 6.07 billion square meters and the space of commercialized housing actually sold is 6.86 billion square meters due to the pre-sale system, while the potential demand went up to 13.0 billion square meters. Furthermore, there are approximately more than eight million newly wedded couples every year (Global Information, Inc., 2003), who expect to establish their own families and seek new homes for themselves. Huang (2003) noted that it is common for unrelated adults to share a room. The married couples have to live with their parents and grandchildren have to share a room with their grandparents. Therefore, the upward trend of demand for new homes will remain strong for a long time, in terms of both quantity and quality (Mak et al., 2007). As a result, the shortage

of supply pushes housing prices up to 21,809 RMB/sq.m in 2011, more than eleven times their level of 1998. Figure 2.5 illustrates the path of house price changes both in normal and real item. In contrast to other commodities of which prices increased by 2.9%, the growth rate of housing prices has surged to around 11.2% in 2011. Housing prices have soared, and the average selling price of housing has tripled during the observed period.

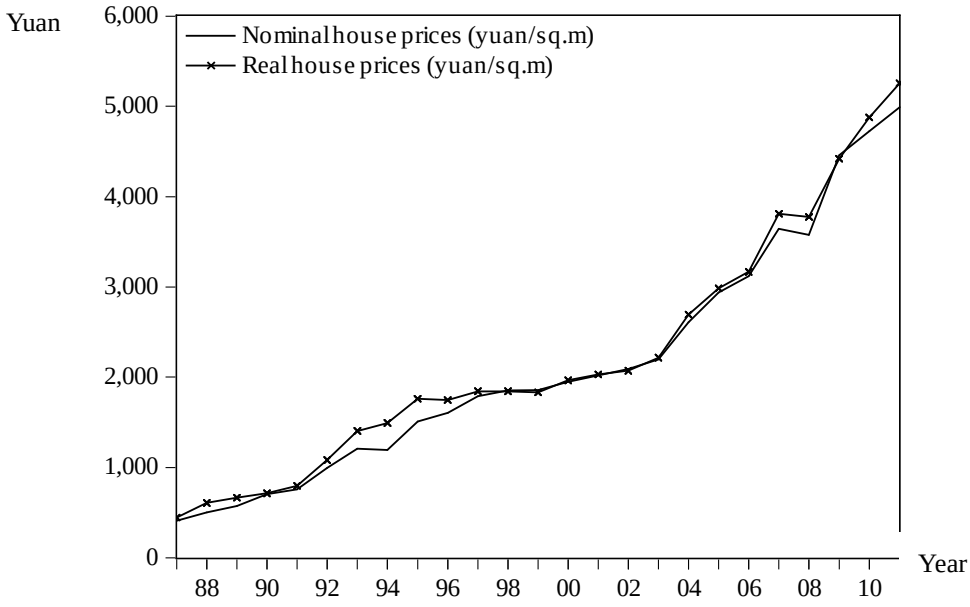

Figure 2.5 Real and nominal housing price movements: 1988-2011

Source: China Statistical Yearbook, 2012.

Note: Real house prices are adjusted for inflation, which are calculated by deflating the nominal house prices by the change in the consumer price index.

Compounding the housing affordability problem is the remaining stubbornly high inflation. Taking account of inflation, it is apparent that real house prices are considerably even higher especially in the high inflation environment during 1991-1998 and 2006-2011. The current high price has gone beyond the purchasing power of most urban households, put pressure on home buyers, and caused housing affordability problems.

2.3 Measurements, data and the assessed housing affordability

2.3.1 Measurements

Any consensus does not exist on the definition of affordable housing. Before starting to assess the housing affordability, it is strongly suggested to firstly clarify how to capture the housing affordability. A review of the literature on definitions of the housing affordability is conducted in this section. Notice first that the item of housing affordability should be distinguished from the 'affordable housing' which refers to houses that are appropriate for the needs of the low-to-moderate income households and are priced lower than market prices to ensure that these households are able to meet their other essential basic needs after paying for housing expenses[9]. These two items are totally different concepts.

The most general use of the term of housing affordability revolves around consideration of the extent to which housing costs for a given standard of housing threaten their capacity to meet their total household needs (Hancock, 1993). The term of housing affordability is widely used in evaluations of the cost burden of housing for consumers and thus is interpreted as the relationship between household incomes and housing expenditures (Kutty, 2005). Housing is deemed to be affordable if expenditure relative to income is reasonable or moderate. Meanwhile, Bogdon and Can (1997, p.47) state that measures of housing affordability quantify the extent of the discrepancy between current housing expenditures of households and what they are expected to spend given their consumption needs. Similar discussion can also be found in Bramley (1990). More accurately, Gan and Hill (2009, p.116) illustrate that the capability of a household to purchase a house can be viewed at least in three different ways: purchase affordability, repayment affordability and income affordability. Purchasing affordability

[9] As cited in the 'Housing Affordability Literature Review and Affordable Housing Program Audit,' Urban Research Centre, University of Western Sydney, July 2008.

considers whether a household is able to raise enough funds to buy a home and repayment affordability refers to the burden imposed on a household of repaying the mortgage, while income affordability simply measures the ratio of house prices to income.

2.3.1.1 *The ratio approach*

The first approach refers to the ratio measure which expresses defined housing costs as a proportion of income and relates this proportion to selected standards of affordability. The 30/40 rule and the ratio of price-to-income are used extensively not only in applied housing studies, but also widely reported in official housing statistics.

1) The 30/40 rule

The 30/40 rule, the preferred measure of housing stress, is currently the most widely used as a benchmark for 'housing stress' regarding its simple operation. This refers to the point at which 30 percent of the gross income of a household in the lowest 40 percent of the income distribution is allocated to housing costs. Beyond this level, housing is defined unaffordable. Housing stress is defined as occurring when more than 30% of household incomes are spent on housing costs for the bottom 40% of income groups (Yates et al, 2007).

2) The price-to-income ratio

An alternative measure of housing affordability is the 'median multiple' (median house price divided by gross annual median household income), a traditional measure, which is also called the price to income ratio (Demographia, 2013). This traditional measure deems that the household is having an affordability problem when the ratio of price-to-income goes beyond 30 percent. The standard formula for the price-to-income ratio in the housing literature is

$$ratio = hp / I \quad (1\text{-}1)$$

where hp denotes the median house price, while I denotes the gross annual household income. But in China, neither the total price indicator nor the household income indicator is regularly reported in China (Wu et al., 2012). The formula is amended to

Price-to-income ratio = (average housing price per sq.m floor area) × (housing unit size) / (average per capita income × household size) or Price-to-income ratio = (average housing price per sq.m floor area) × (housing size per person) / (average per capita income). (1-2)

Hence, larger value of the price-to-income ratio means worse performance of the housing market where housing is less affordable for home buyers.

2.3.1.2 *The residual income approach*

The second approach is the residual measure which focuses on the situation of 'after-housing poverty'. Suggested by this approach, the 'housing affordability' refers to the capacity of households to meet housing costs while maintaining the ability to meet other basic costs of living. Stone (1975) introduces the term 'shelter poverty' to characterize the households who are financially strapped and cannot afford other necessities after paying for housing, in other words, non-housing expenditures are limited by the amount of money after paying for housing. Later, Kutty (2005) re-emphasizes this measure of housing affordability and uses the concept of 'housing-induced poverty'[10] to describe the situation where a household cannot afford other basic needs after paying for housing. Housing is deemed to be not affordable if there is insufficient income left to sustain a reasonable living standard.

[10] The items used in Kutty (2005) and Stone (1975) are different, but they have the same meaning.

Apart from the traditional measure, this new measure believes that the households, who even undertake housing cost burdens more than 30% percent, can still afford basic necessities, but are not identified as having an affordability problem. The residual income approach is strongly supported by Stone (2006) and Chen et al. (2010). It can be used in predicting the occurrence probability of housing-induced poverty and is informative in determining the level of maximum affordable housing price. It also provides guidelines to suggest the magnitude of housing assistance that should be provided to low-income households[11]. However, the disadvantage of this approach is its dependence on subjective assumptions about household expenditure and the difficulty to define measurement criteria of basic necessaries – non-housing goods (Stone, 2006). What compounds the difficulty of using this approach to assess the housing affordability is lacking regularly published data on a minimum standard of adequacy for non-housing necessaries in China.

Whereas the ratio measure reveals an affordability problem when housing expenses are deemed relatively large in relation to income, the residual income approach considers whether housing is affordable taking account of income levels and broader basic household needs. In other words, the residual income measure is specifically concerned with the relationship between housing costs and living standards, while the ratio measure focuses exclusively on housing costs and incomes.

While the above two approaches have been used widely for its easy operation and data accessibility, they are criticized for overlooking housing quality. Consider a household who has chosen a higher level of housing consumption than the socially accepted community standards and may be counted as having an affordability problem by using the ratio measure and the residual measure (Whitehead, 1991). Therefore, a

[11] Stone (2006) points out that the appropriate indicator to describe the relationship between housing costs and incomes is the residual income left after paying for housing rather than the price-to-income ratio (p. 163). Chen et al. (2010) summarize that the residual income approach is more logically robust and has a number of theoretic merits (p. 885).

new approach which considers more factors regarding to housing quality, location, spatial differentiation, and household preferences, is suggested by Mulliner et al. (2013)[12].

2.3.2 Data

Taking account of data access, this study mainly uses the ratio approach and the residual income approach to measure the situation of housing affordability in China. Data on housing prices, household income comes from the Statistical Yearbook of China (1986-2012), the Statistical Yearbook of Beijing (2012), and the Statistical Yearbook of Shanghai (2013). A decent house is specified with a size of 70 square meters[13]. The dynamic housing affordability during 1987-2011 is obtained by using the price-to-income ratio. In addition, the residual income approach is used to explore whether a household can still afford for basic necessaries after deducting housing expenses. Data on basic expenses are gathered from the Statistical Yearbook of China (2012).

2.3.3 The assessed housing affordability

2.3.3.1 *Estimated results: using the 30/40 rule*

Take Beijing and Shanghai which are perceived to have the most severe housing affordability problem as examples. Combining the data reported in Table 2.4 and Table 2.5, the bottom 40% groups would never have a chance to buy a new house at the current housing prices and income level. Even if bank capital is available, the down payment of a 70 square meters house will cost almost seven years' income of the low 20% household in Beijing, while it is more than five years' income required for the

[12] Due to lack of regularly published data this study employs the ratio measure and the residual measure rather than the third measure.

[13] This study employs a conservative standard of a decent house of 70 square meters, which is more consistent with the housing condition faced by the majority of Chinese households.

down payment in Shanghai. Down payment of at least 30% house prices prevents households of the bottom 40% from entering the market without assistance by their parents due to the 'deposit gap'[14]. From this point of view, Beijing and Shanghai may suffer from severe affordability problem, where the monthly payment for buying a house of 70 square meters even exceeds the monthly income of the bottom 40% households. It is impossible for the bottom 40% households in these two cities to buy even a new house of 70 square meters.

Table 2.4 Per capita income and size of urban households by level in Beijing and Shanghai, 2011

	Beijing[1)]		Shanghai[2)]	
Categorized by income level	Income (RMB)	Households size (persons)	Income (RMB)	Households size (persons)
Low income households (20%)	15,034	3.1	17,206	3.06
Lower middle income households (20%)	23,551	2.9	24,824	2.92
Middle income households (20%)	28,949	2.6	31,414	2.87
Upper middle income households (20%)	36,621	2.6	40,771	2.87
High income households (20%)	63,292	2.5	70,067	2.76

Sources: 1) Beijing Statistical Yearbook, 2012 and 2) Shanghai Statistical Yearbook, 2012, released by Beijing and Shanghai Statistical Information Net respectively.

Note: Monthly income per household could be calculated by (Income*Households size)/12.

[14] The item of 'deposit gap' refers to the amount by which the average house price exceeds the amount that a household on the average income can borrow (see Wu et al. (2010)).

Table 2.5 Paying for new houses by installments for the bottom 40% groups in Beijing and Shanghai, 2011

	70 m^2			90 m^2		
	Total payment (million RMB)	Down payment (million RMB)	Monthly payment (RMB)	Total payment (million RMB)	Down payment (million RMB)	Monthly payment (RMB)
Beijing	1.365	0.326	5, 691	1.756	0.419	7, 317
Shanghai	1.184	0.282	4, 932	1.522	0.363	6, 342

Note: 1) The average selling price of residential housing has risen to 15,516.91 RMB/sq.m in Beijing while 13,448.35 RMB/sq.m in Shanghai in 2011. 2) The common installment payment methods of average capital plus interest method is used and the maturity of housing loans is assumed to 20 years. 3) Commercial loans used only without consideration of public accumulation fund loans for the ease of calculation.

2.3.3.2 *Estimated results: using the price-to-income ratio*

Using the data on average housing price, housing size per person, and average per capita income this study calculates the price-to-income ratios during the period 1987-2011 to measure the dynamic financial ability of Chinese households in purchasing new homes (see Appendix A).

Plotting the distribution of price-to-income ratios in Figure 2.6 indicates that the housing affordability problem had been particularly acute in two periods 1992-1993 and 2003-2011 with the price-to-income ratio more than seven. Drawing from the reported ratio of price-to-income the ability of first time home buyers to enter the housing market has been deteriorated over the past decades years. Higher housing price makes it particularly difficult to buy new homes for less well-off households (mainly young families).

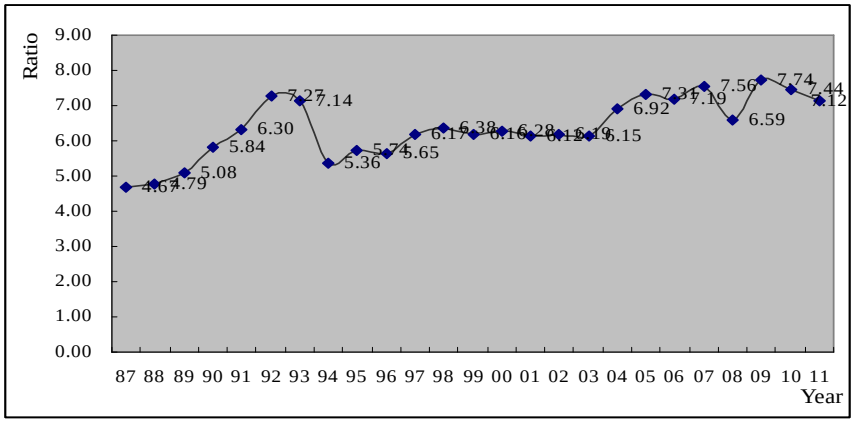

Figure 2.6 The path of housing affordability measured by the price-to-income ratio

Source: It is created based on data in Appendix A.

2.3.3.3 *Estimated results: using the residual income approach*

This study adds up the essential expenses on food, clothing, medical care, transportation & communication (T&C) and education to obtain a low-cost budget standard as a monetary level of necessities[15] (see Table 2.6).

Table 2.6 The basic budget standards of urban residents, 2011

Budget item of necessities	National average (RMB)	The bottom 20% households (RMB)	The median 20% households (RMB)
Food	5,506	3,332	5,467
Clothing	1,675	761	1,629
T&C	2,150	671	1,762
Medical care	969	1,063	911.03
Education[1)]	1,402	638	1,236
Subtotal	11,702	6,465	11,005

Note: [1)] Education expenses are the basic costs of education after taking out of cultural recreation expenses.

Source: The Statistical Yearbook of China, 2012.

[15] The statistics on housing affordability released by the Statistics New Zealand reports an adequate level of residual income (disposable income after housing costs are deducted) that is required for a household to meet other basic needs such as food, clothing, transport, medical care and education. The lowermost lives safeguard ordinance announced by China in 1999 gives the similar standard of necessities to sustain an adequate livelihood for urban residence.

Using per capita data on household income and expense enables to eliminate the effect of household size since any normative standard for non-housing items will increase monotonously with household size (Stone, 2006, p.172). For the average household, the annual payment (P&I) for a house of 70 square meters costs almost the entire annual deposable income of a household (see Table 2.7).

Table 2.7 Housing affordability on the residual income standard

	National average	The bottom 20%	The median 20%
Per Capita Disposable income (RMB)	21,810	8,774	19,545
Annual payment for a house of 70 square meters (P&I) [1] (RMB)	20,307		
Annual payment for a house of 90 square meters (P&I) (RMB)	26,112		
Minimum cost of non-housing items (RMB)	11,702	6,465	11,005

Note: [1] The principle and interest should be paid annually after deducting the down payment.

Source: the Statistical Yearbook of China, 2012.

More specifically, the bottom 20% households have no chance to buy a decent house even they spend all of their deposable income, while the median 20% households cannot afford a decent house at their current income level. Not only the bottom 20% households, but also the median 20% households need assistances to realize their ownerships of houses.

Although China's housing market has witnessed a great development over the past years, our assessments show that it is clear that China is suffering from a housing affordability problem no matter what measurement is used. Buying a decent home (around 70 square meters) for Chinese households will cost more than seven years' savings. According to the Demographia (2013) criterion of housing affordability (as reported in Table 2.8), the current Chinese housing market has fallen down into the interval of severely unaffordable housing market although the calculating method used

in this study is a slight different from Demographia (2013). The Chinese housing market is becoming one of the least affordable housing markets in the world.

Table 2.8 The criterion of housing affordability

	Affordable	Moderately Unaffordable	Seriously Unaffordable	Severely Unaffordable
the median house price / the median household income	≤ 3.0	3.1 to 4.0	4.1 to 5.0	≥ 5.1

Source: the 9th Annual Demographia International Housing Affordability Survey, 2013.

Moreover, the assessed housing affordability using the residual income measure shows that not only the low-income households but also the median-income households are suffering from pressures of housing costs. Facing this situation the Chinese government is required to 'do something' to ameliorate the housing affordability problem.

2.4 How to make housing more affordable

What might contribute to the deteriorating housing conditions in China? The affordability of housing is treated as a function of the costs of producing and financing housing, and of household income levels or purchasing power. Numerous interrelated factors may drive the decline of affordability, including an increased willingness and capacity to pay for housing due to increased incomes and more bank lending obtained. Concurrent increases in population, decreases in household size and increases in house size may further compound the affordability problem. The requirement of improving housing affordability is becoming an enduring issue that all governments have had to address. This section provides a review of overseas policies and programs to solve the housing affordability problem. Lessons can be drawn from multi-countries that are also facing housing affordability problems.

2.4.1 Experiences of other countries

2.4.1.1 *Australia*

Currently, Australia is in the midst of a housing affordability crisis (Beer et al., 2004). House price growth has continued to outstrip income growth to the point that more than one million low and middle income households are now experiencing housing stress (the Australian government, 2008). Yates et al. (2007) found that 65% of low-income private rental households were experiencing housing stress in Australia. As presented in Table 2.9, Australia has a housing affordability of 5.6 which is higher than other developed countries.

Table 2.9 Housing affordability across countries

Nation	Affordable	Moderately Unaffordable	Seriously Unaffordable	Severely Unaffordable	Total	Median Multiple
HK (China)	0	0	0	1	1	13.5
Australia	0	0	9	30	39	5.6
New Zealand	0	0	3	5	8	5.3
United Kingdom	0	2	14	17	33	5.1
Canada	8	17	4	6	35	3.6
Ireland	1	4	0	0	5	3.2
United States	100	87	13	16	216	3.1
Total	109	110	43	75	337	

Source: the 9th Annual Demographia International Housing Affordability Survey, 2013 (p. 3).

In response to an emerging housing affordability crisis, the Australian government has built a series of new initiatives which aimed to improve housing affordability. As summarized by Wilson et al. (2010), the major new initiatives include:

1) First Home Saver Accounts – whereby bigger deposits can be saved through low tax superannuation-style savings accounts topped up by additional contributions from the government.

2) Housing Affordability Fund – aims to lower the cost of building new homes by

working with all levels of government to reform infrastructure and planning requirements.

3) National Rental Affordability Scheme – seeks to increase the supply of affordable rental dwellings by providing tax incentives to encourage investment in properties rented to eligible tenants at 20% below the market rate.

4) Land release – releasing surplus commonwealth land for development to increase the overall land supply (Australian Government, 2008).

2.4.1.2 *The United Kingdom*

The *Barker's Review of Housing Supply* (2004) reveals that the U.K. has experienced a long-term upward trend in real house prices, 2.4% per year over the last 30 years which leads to affordability problems. Alternatively, Bramley (1994) argues that housing affordability in the U.K. has been deteriorated remarkably since the late 1990s, with housing price rising faster than income. A range of policy recommendations for improving the functioning of the housing market were proposed as follows[16]:

1) Providing support on the demand-side to help targeted groups of first time buyers through the Home-buy program[17] and via joint equity loans with mortgage lenders;

2) Continuing to tackle the under-supplied housing through measures to increase the amount of surplus public sector land being brought forward for development, and through reducing construction costs via the competition to construct homes;

3) Providing stamp duty helps for home-buyers and continuing to provide support to those who are left homeless and vulnerable.

[16] 'Housing policy: an overview', reported by the Office of the Deputy Prime Minister, July 2005.
[17] Being supported by this program, the householder could initially purchase an equity stake as little as 50% and then, in most cases, 'staircases up' to 100% ownership as their circumstances improve. Accordingly, when the householder chooses to sell the home, they receive a share of the sales proceeds proportionate to the size of their own equity stake.

2.4.2 Efforts of the Chinese government

The growing crisis in housing affordability due to the fact that the strongly growing demand has outpaced limited housing supply, and challenged governments of different levels that are required to 'do something' to make housing more affordable. A flurry of studies has recently emerged and suggests that the rapid decrease in affordability of Chinese housing markets is primarily due to supply constraints. The Chinese government has conducted a series of innovations with a strong volition to prompt the housing supply.

1) Increasing the gross of land supply for residential use

Demographia (2008, p47) regards supply constraints as the most important consideration that, '…Affordability of housing is overwhelmingly a function of just one thing, the extent to which government place artificial restrictions on the supply of residential land'. For instance, the newly announced five regulations provide that land supply for small and medium residential houses should be increased to stimulate effective housing supply. This regulation serves to improve the current structure of new construction through reducing the proportion of luxury houses and increase the proportion of common residential houses. Chen et al. (2010) argue that housing developers tend to produce large dwellings (more than 120 square meters), which leads to a mismatched supply structure and makes housing less affordable. Combining with other instruments such as the ratio of down payment and interest rate preference, this regulation aims to optimize the supply structure by stimulating the provision of common residential housing, while curbing the supply of luxury houses.

2) Discouraging speculative or investment-driven housing demand

The current regulations aim to encourage the demand of the first house and housing improvement while discouraging speculative or investment-driven housing demand by

different down payment and interest rate. The first time home buyers can enjoy preferences such as a 20%-30% down payment of the total housing price and discounted interest rates. In contrast, the bank is required to more strictly enforce rules on mortgages for second homes and the down payment of the second house is raised to 40%-60% to curb speculative demand for housing.

3) Shortening the process of administrative approvals

The current planning procedure is notoriously long. A lot of power rests in the hands of local authorities who are able to delay and block housing proposals. Take a recent innovation for instance; the rights to release pre-sale approvals of commercialized housing are further devolved to the county level according to the decision announced in 2012 by the State Council of China which aims to improve the speed of housing supply.

4) Increase the provision of public housing

The implementation of measures has been announced to encourage housing developers to produce affordable housing by reducing the financial cost and land cost.

Besides, the government has stepped up efforts to build and manage government subsidized housing, guaranteeing satisfactory housing for the low and median income households. The Comfortable Housing Project (‘Anju Scheme’), which was carried out in 1995, attempts to provide comfortable housing to medium and lower income households at a below market price. The Anju Scheme requires commercial banks to provide construction loans and the local government to provide free serviced land for developing low cost housing construction (Liu, p.139, 1998).

2.5 Concluding remarks

The mismatching housing market in China generates a soaring housing price which has gone beyond the financial capacity of urban residents nationwide. In spite of the Chinese government efforts to improve the housing conditions, it is widely acknowledged that the majority of its urban residents are still suffering from affordability problems. Considering the current income of households, the relatively high price of houses discourages the potential home buyers to enter into the housing market. Without any assistance from the government or relatives, buying a decent house is impossible not only for the low-income households but also for the median-income households.

Faced with the demand to ‘do something’ for the housing affordability crisis, the Chinese government has tried to solve the housing shortage by increasing effective housing supply and suppressing property speculation. But there are several obstacles that might discourage the government’s efficient policies. On the one hand, the governments’ efforts to increase land supply for construction use may clash with farmland protection. On the other hand, the pursuit of revenue obtained from land leasing surpasses the enthusiasm of governments to increase land supply for public affordable housing construction use. Thus, further study is required to examine whether the current housing affordability problem is caused by supply constraints. In particular, it is urgent to explore a cure to overcome the housing affordability problem. In order to fully understand the housing market of China and fill the existing research gap, next step is to explore the source of the housing affordability problem by estimating housing supply elasticity and its determinants.

CHAPTER 3
ESTIMATING THE HOUSING SUPPLY ELASTICITY AND ITS DETERMINANTS

3.1 Introduction

Housing constructions play a critical role not only in economic development, but also in affecting the household welfare. Given the importance of housing constructions, additional efforts in this field are thus justified. The vital importance of housing supply analysis for policy making has been stressed several times. For example, as Malpezzi and Maclennan (2001) argued, '…most housing models and policy analysis hinge on explicit or implicit estimates of the price elasticity of housing supply, does the market respond to demand side shocks with more supply or higher prices?' In fact, the Chinese housing market has experienced rapid growth since the housing system reform implemented in 1998. As a result, the demand of housing was enormously stimulated. Afterwards, housing prices jumped from 1,854 RMB per square meter in the year 1998 to 4,725 RMB per square meter in 2010 (with an average annual growth rate of nearly 12%), and caused a genuine concern in recent years. Consequently, a series of regulations has been implemented by the Chinese government to intervene in the housing market and to avoid overheating and possible bubbles. The interventions include interest rates adjustments, reducing and exempting real estate taxes and fees, and reducing land rents. An evaluation on pros and cons of policies requires a thorough understanding of both sides of housing demand and housing supply. However, while there are already extensive studies which focus on the housing demand side, few attentions have been paid to the housing supply side.

This chapter focuses on the supply side. The reduced-form model and the stock-adjustment model are used to estimate housing supply elasticities. It examines the

housing supply determinants in the Chinese housing market. Several questions will be explored. First, how elastic is housing supply in China? Second, do the reduced-form model and the stock-adjustment model show the same housing supply elasticity? Finally, does land regulation plays a crucial role in affecting housing supply elasticity?

The following section summarizes the existing literature. Section 3 discusses the methodology. Section 4 shows the estimated results. The final section discusses the main findings.

3.2 Previous Research

A comprehensive review of the previous studies can be found in DiPasquale (1999), who provides an excellent summary of the issues on the housing supply. This study discusses current studies on the latest developments in economics of housing supply. It pays particular attention to the most-recent studies which focus on the supply of housing in China, and in particular on the following disquieting issues. What is known concerning the approaches of housing supply research? What is the appropriate functional form for housing supply equations? What is known concerning determinants of housing supply? What appear to be the major determinants of the estimated housing supply elasticity in the previous studies?

One of the major continuing questions concerning housing supply is just how sensitive supply is to changes in prices. A perfectly elastic housing supply is supported by the earlier studies of Muth (1960), Follain (1979) and Stover (1986). Muth (1960) is generally cited as the first empirical research on the relationship between housing prices and housing supply. Using a regression model and the national data, he attempts to examine the relationship between new housing outputs and housing prices in the United States, but finds no statistically significant relationship. Alternatively, Follain (1979)

applies Muth's model to a longer and more recent period with full consideration of serial correlation or the possibility of simultaneity bias between prices and quantity of new constructions. He got a similar finding to Muth (1960). Afterwards, Stover (1986) and Olsen (1987) present a compelling argument on the method and data used in Follain (1979) and Muth (1960). Stover stresses that there might be aggregation bias existed when national data is used and consequently, and estimates price elasticity using cross-section data from 61 metropolitan areas of the United States. However, he did not find any significant relationships between new housing supply and housing price. The result can be treated as evidence to support a perfect elasticity housing supply in the United States. Further, Olson (1987) points out that there might be some misspecifications in Muth's (1960) and Follain's (1979) studies. He argues that if the relationship between housing price and input costs (capital cost, land cost, and labor cost) is correctly specified, then the coefficient on quantity is zero regardless of the elasticity of supply. As a result, the supply function with price as the dependent variable should have either input costs or housing output on the right-hand side, but not both. Since the goal of the analysis was to examine the relationship between long-run supply price and housing construction, input costs should not be included in their estimation. Input costs include capital costs, construction costs, land costs and labor costs. Generally, input's costs fluctuate under the regulation of the government. Unfortunately, he did not provide empirical evidence. In general, most of the above researches use a reduced-form model to examine the relationship between housing supply and housing price. The price elasticity of housing is derived from the coefficients on supply and demand shifters in the reduced form regression. Although various approaches have been utilized in the previous studies, the reduced-form model is frequently employed. Two recent studies by Mayo and Sheppard (1996) and Malpezzi and Maclennan (2001) also apply such approaches to comparative studies between countries.

However, one unusual characteristic of housing supply is that the short to medium

supply curve for housing embeds a fundamental asymmetry and can be probably best be viewed as kinked. When housing demand falls, the market cannot easily adjust the supply of housing downward because housing is so durable. On the other hand, under absent constraints on land supply, the market should be able to absorb increases in demand. Of course, it has been the case recently that the strong national market for new construction has led to material and labor shortages that have, in turn, driven up prices of materials and labor. This suggests that housing supply is not perfectly elastic in the face of increased demand, at least in the short run. Furthermore, due to a long construction period and the relatively small effect of annual construction on the total stock of housing, housing supply responds on partially to cyclical movement in demand (Arnott, 1987). Unlike the earlier studies, Poterba (1984), Topel and Rosen (1988), and DiPasquale and Wheaton (1994) employ the structural approach to estimate housing supply elasticity directly and finally provide evidence to support a less than perfectly elastic housing supply. In an effort to make a good comparison, later research by Blackely (1999) estimates the alternative models mentioned above using the annual aggregate data for with a longer time span in the United States.

On the other hand, the urban growth model takes full consideration of the role of land, which is superior to other models based on investment theory. Capozza and Helsley (1989) originally develop a simple model in which capital is durable and landowners have perfect foresights, and show that land price has four additive components: the value of agricultural land rent, the cost of conversion, the value of accessibility, and the value of expected future rent increases. As an extension of Capozza and Helsely (1989), Mayer and Somerville (2000) develop an urban growth model to estimate housing supply in the U.S. using the data of the period 1976-1987. Furthermore, they argue that new construction should be a function of changes in housing prices and construction costs rather than their levels. Their estimates suggest a fairly moderate response of supply to house price changes. The results give that a 10% rise in real house prices leads

to a 0.8% increase in the housing stock which is accomplished by an immediate 63% increase. Green et al. (2005) estimate separate supply elasticities for 45 metropolitan areas of the United States following a model based on a theory of urban form firstly developed by Capozza and Hlesley (1989), and then be applied to housing supply analysis by Mayer and Somerville (2000). They find housing supply elasticities to vary substantially from place to place due to different degrees of regulations. Table 3.1 shows the estimated results of previous studies on housing supply elasticities.

Table 3.1 A wide range of the estimated housing supply elasticity

Argument	Studies	Study area	Data used	Estimates
I. Perfectly elastic housing supply	Muth (1960), Follain (1979)	The United States	National level time-series data	Infinite
	Stover (1986)	The United States	Cross-sectional data	Infinite
II. Less perfectly elastic housing supply	Poterba (1984)	The United States	Quarterly time-series data for 1964:1-1982:2	0.5-2.3 for new construction; -0.9-1.8
	Topel and Rosen (1988)	The United States	Quarterly time-series data for 1963:1-1983:4	1.2-1.4 (myopic); 1.7-2.8 (cost adjustment)
	DiPasquale and Wheaton (1990)	The United States	Aggregate annual data for 1963-1990	1.0-1.2
Comparative studies across countries	Mayo and Sheppard (1996)	Malaysia, Thailand, Korea and the U.S.	Annual time-series data for 1970-1986	Malaysia: 0.0-0.35; Thailand: infinite; Korea: 0.0-0.17; the U.S.: 12.59-19.88
	Malpazzi and Maclennan (2001)	The United States and the United Kingdom	Annual time-series data for 1985-1995 for the U.K. while 1889-1994 for the U.S.	The United States: 4.0-13; the United Kingdom: 0-6.0

Source: summarized by the author.

Meanwhile, a large body of literatures explores the determinants in affecting housing supply elasticity. As a durable good, the supply of housing is determined not only by

decisions of new construction developers, but also by the decisions of existing home owners. In addition, there are two sources to increase housing availability: construction and renovation or repair of existing housing. Since data on the latter are not available, most existing studies only focus on new construction. Figure 3.1 illustrates the key factors and their inter-relationships in the housing market. An increase in population as well as households' income generally gives rise to increase in the housing demand. Meanwhile, housing supply is basically affected by housing prices, housing stock, and input costs. The government regulates housing market mainly through adjusting interest rates and controlling land supply for construction use to affect housing supply in order to eventually stabilize housing prices. The effect of these regulations on housing supply depends on the response of housing developers.

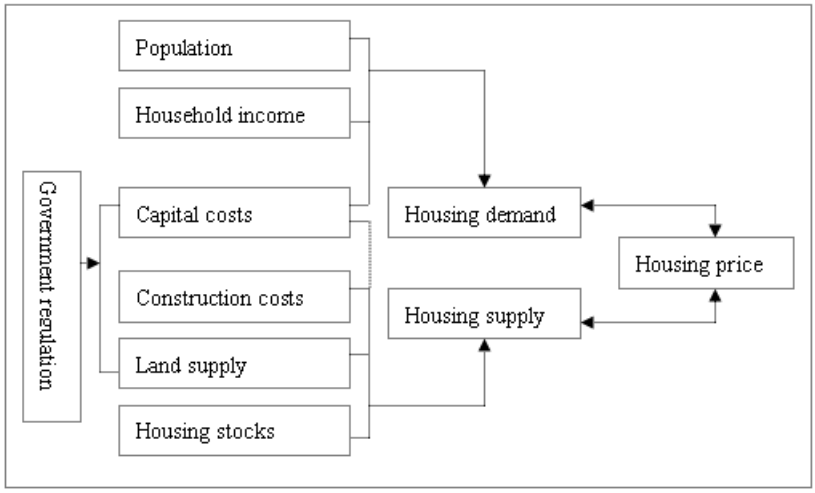

Figure 3.1 The key factors in the housing market

Source: drawn by the author.

Table 3.2 reports the previous studies on the estimated coefficient of explanatory variables such as construction costs, the housing stock and the vacancy rate. Most of them report a positive sign for the real interest rate and a negative sign for the vacancy rate, while there is no agreement on the coefficients of construction costs and the

housing stocks.

Table 3.2 Alternative explanatory variables for housing supply elasticity

Explanatory variables	Estimates of Coefficient signs	Studies
Real interest rate	Nine papers: "-" Only one paper: "Not significant"	Follain (1979); Topel and Rosen (1988); DiPasquale and Wheaton (1994); Mayer and Somerville (2000); Hwang and Quigley (2006)
Construction costs	Five papers: "-"; Five papers: "+"; Two papers: "Not significant"	Follain (1979); DiPasquale and Wheaton (1994); Somerville (1999); Mayer and Somerville (2000);
Stock of housing	Only one paper: "+"; Two papers: "-"; Four papers: "Not significant"	Muth (1960); Follain (1979); DiPasquale and Wheaton (1994); Blackley (1999); Mayer and Somerville (2000)
Vacancy rate	Four papers: "-"; Only one paper: "Not significant"	De-Leeuw and Ekanem (1971); DiPasquale and Wheaton (1992); Quigley (1999)

Source: Summarized by the author.

An overview of the existing studies, which focuses on the Chinese housing market, reveals that most researchers concentrate on the housing demand but, they usually overlook the housing supply. Using data for 35 cities, Gao and Wang (2008) investigate the elasticity of housing demand. They find an inelastic housing demand in China, and their finding also suggests a significant regional difference in housing demand elasticity across cities. Similarly, Chow and Niu (2010) estimate the housing demand elasticity using time-series data for years of 1987-2006. They report that the income elasticity of housing demand is 0.904, while the price elasticity of supply is 0.831. More recent work by Wang et al. (2012) makes several improvements in exploring the housing supply elasticity and its determinants in China. Using data for 35 cities from the year 1998 to 2009, they find a less elastic housing supply. They use an indicator of the developable

land ratio to measure land-use regulations in each city. The results suggest that there is a significant relationship between the availability of developable land and housing supply elasticity. Further, the results indicate that geographical constraint, the average built-up area, the rate of population growth and regulatory restrictions on land use matter in determining housing supply elasticity. Especially, as there are no published data on housing stock in China, their study measures housing stock by per-capita floor area multiplied by the urban population in 1999. Their results may be better convinced if they employ a more precise measure of the housing stock. Alternatively, Fu et al. (2011) explain housing supply elasticity across the Chinese cities, and obtain several interesting findings. Their results show that the supply elasticity increases with fixed investments and urban area expansion in a city. Although, holding investment and urban area expansion constant, the supply elasticity is independent of urban size and density.

This chapter extends the existing literature in several ways: 1) an update panel data for 35 cities from the year 1999 to 2010 is used to avoid the aggregation bias of employing aggregated time-series data, 2) both the flow model and stock-adjusted model are used to examine, and 3) it incorporates the impact of land-use regulation into the model.

3.3 Methodology

The analysis follows the work by Malpezzi and Maclennan (2001). As they criticized, the Muth-Follain test[18] cannot differentiate between perfectly elastic and inelastic. Based on their work, this study first conducts its analysis to explain sources of the housing supply elasticity considering the effect of land available to develop new

[18] The Muth-Follain test is frequently cited to examine the assumption of a perfectly elastic long-run supply of new housing constructions. It is based on the OLS estimation of two equations. One equation relates the new constructions to housing prices and a set of input price variables. The other equation relates the housing price with the new constructions and the input prices. A statistically significant positive relationship between housing prices and new constructions is observed, and it is treated as evidence to reject the assumption.

constructions. This study combines the supply and demand equations into a reduced form equation. Based on the reduced form, which had been used in Muth (1960), Follain (1979), Mayo and Sheppard (1996), and Malpezzi and Maclennan (2001), this study estimates the housing supply elasticity. The following procedure describes the derivation of the simple reduced form equation, and examines the price elasticity of housing supply with estimates of housing demand parameters.

3.3.1 Price elasticity of housing supply

A flow model of housing market consists of the following three equations,

$$\ln Q_d = \alpha^d + \varepsilon_y^d \cdot \ln Y + \varepsilon_p^d \cdot \ln P + \varepsilon_D^d \cdot \ln D \qquad (3\text{-}1)$$

$$\ln Q_s = \alpha^s + \varepsilon_p^s \cdot \ln P \qquad (3\text{-}2)$$

$$\ln Q_d = \ln Q_s \qquad (3\text{-}3)$$

where the parameters of ε_y^d and ε_p^d is the income and price elasticity of demand for housing respectively, and ε_p^s is the price elasticity of supply for housing. In equation (3-1) housing demand, Q_d, is treated as a function of household income (Y), housing price (P), and number of population (D). In equation (3-2) housing supply (Q_s), is assumed to be determined by the housing price only. Hence, combining the three equations yields a reduced-form equation which can be described as follows:

$$\ln P = \pi_0 + \pi_1 \ln Y + \pi_2 \ln D + \varepsilon, \qquad (3\text{-}4)$$

where the parameter π_1 is given by:

$$\pi_1 = \frac{\varepsilon_y^d}{\varepsilon_p^s - \varepsilon_p^d}. \quad (3\text{-}5)$$

Thus, the price elasticity of housing supply can be estimated by:

$$\varepsilon_p^s = \varepsilon_p^d + \frac{\varepsilon_y^d}{\pi_1}. \quad (3\text{-}6)$$

To begin with, we discuss briefly the relationship between these parameters. The equation (3-6) implies that if ε_y^d equals to 0, the price elasticity of housing supply will equal to the price elasticity of housing demand. When ε_y^d is greater than 0, and π_1 approaches to 0, the price elasticity of housing supply must be infinite. The value of π_1 can be easily obtained by estimating the equation (3-4), and ε_p^d and ε_y^d have been estimated from the previous studies. Then the regression coefficient π_1 can be transformed into the price elasticity estimate ε_p^s (for given value of ε_p^d and ε_y^d).

Following the work by Malpezzi and Maclennan (2001) this study takes the stock adjustment into account,

$$\ln Q_d = d(\ln K_t^* - \ln K_{t-1}), \quad (3\text{-}7)$$

where d is a parameter indicating the portion of the gap closed in period t and ranges from 0 to 1[19], and K_{t-1} is the actual stock in period $t-1$.

K^*, the equilibrium demand for housing stock, which is determined by

[19] Due to lack of data on housing stocks, the estimation of parameter d comes from experience data. Similar procedures were applied to estimation of housing supply in Mayer and Somerville (2000a, 2000b), Mayo and Sheppard (1996), and Melpezzi and Maclennan (2001).

$$\ln K^{*} = \beta_0 + \beta_1 \ln P_t + \beta_2 \ln Y_t + \beta_3 \ln D_t . \quad (3\text{-}8)$$

Combining the equation (3-7) and (3-8) to solve for the housing price (P) leads to the equation (3-9). The demand function is

$$\ln P_t = \pi_0 + \pi_1 \ln Y_t + \pi_2 \ln D_t + \pi_3 \ln K_{t-1} + \varepsilon . \quad (3\text{-}9)$$

Hereby, the price elasticity of housing can be obtained from

$$\varepsilon_p^s = d\varepsilon_p^d + \frac{d\varepsilon_y^d}{\pi_1} . \quad (3\text{-}10)$$

Following Muth (1960) and Malpazzi and Maclennan (2001) this study uses 0.3 and 0.6 as an estimation of parameter d .

3.3.2 Housing supply determinants

The quantity of housing that developers provide is sensitive to its prices and costs, and depends as well on available land for construction. Follain (1979) points out that the purchasing price of a new house essentially consists of two components, the price of the structure and the price of the land. Studies by Peng and Wheaton (1994) and Wang et al. (2012) suggest that there is a positive relationship between land supply and housing supply in Hong Kong and the Chinese mainland cities. Moreover, the finding of Wang et al. (2009) indicates that an increase in land price has little influence on housing supply, while the land supply increase is an effective stimulator to housing supply. This study performs a cross-sectional regression where housing construction is a dependent variable. The existing studies present two alternative measures for housing construction. One is the real value of residential construction, and the other is either starts or completions. This study measures housing output by new completions. By including dependent variables of housing price, housing stock, demographic characteristics, and

land variable, this study attempts to explore the determinants on housing supply elasticity using an improved measure of the housing stock and an update data set.

3.4 Data and empirical results

3.4.1 Data

The data for estimation is panel data for 35 Chinese cities from 1999 to 2010. The total sample size is 420. The descriptive statistics for variables of empirical analysis are in Table 3.3.

Table 3.3 Statistics of housing price and independent variables: 1999-2010, for 35 cities

Variable	Definition	Mean	Min.	Max.	Std. Dev	Obs.
P	Housing price (RMB/sq.m)	3,568.2	1,077.0	18,954.0	2,562.3	420
Y	Annual per capita disposable household income (RMB)	12,947.4	4,764.9	32,380.9	6,092.1	420
D	Non-agricultural population (10 000)	280.9	1.0	1,192.2	227.8	420
K	Housing stock (10 000 sq.m)	6,698.3	980.0	35,377.7	5,877.5	420
Q	Housing completion (10 000 sq.m)	526.7	19.9	3,380.1	522.0	420
LP	Land price(RMB/sq.m)	3,639.7	345.0	22,827.0	4,282.6	385
LS	Land purchased by developers in one year (10 000 sq.m)	397.0	2,092.5	13.9	358.0	385

Source: China Statistical Yearbook, 2010; China City Statistical Yearbook, 2000-2010; China land price information dynamic publishing platform.

Note: Data on land price and land supply are available only for 2000-2010.

Unlike the studies on developed countries, the data time period of this study is limited because the Chinese housing commercialization system was merely implemented in 1998. Especially, data on housing stock are only available for 1999. Using the data for 1999 as a benchmark, this study obtains its own time series of housing stock. In Kuang and Zhou (2010) and Wang et al. (2012) housing stock is estimated by per-capita floor

area multiplied by the number of population. Alternatively, Chow and Niu (2010) use the indicator per capita floor area separately to measure housing stock. This study measures the movement of housing price using the average sales price of residential buildings. Household income is measured by per capita annual disposable income of urban households. The data mainly comes from the Statistical Yearbook in each city. Data on population are the number of non-agricultural population. Most of the above data come from the China Statistical Yearbook released by the National Statistical Bureau of China (NBS). In addition, our study uses two instrumental measures of land regulation, land price and land space purchased by the developers. The data on land price are the land dynamic monitoring system data released by the Chinese land price information dynamic publishing platform, which was established in 2000 and provides the latest data on land price for 105 Chinese cities.

3.4.2 Estimated price elasticity of housing supply

This study conducted regressions based on the equation (3-4) and (3-9), and obtained the estimated coefficients on income elasticity of demand, π_1. Hence, given the estimated of price elasticity of demand, ε_p^d, and the income elasticity of demand , ε_y^d, the implied price elasticity of housing supply can be finally obtained. Table 3.4 represents the regression results.

The dependent variable is housing price in natural logarithm, while the independent variables include household income, population and the lagged housing stock. The first two cases are the estimation for flow model, while Case 3 and Case 4 describe the estimated results for the stock-adjusted model. Further, Case 1 and Case 3 is the direct estimation for equation (3-4) and (3-9) respectively. Case 2 and Case 4 are adjusted for autocorrelation by including an item of AR (1).

Table 3.4 Estimation results for income elasticity of housing supply

Variable	Case 1	Case 2	Case 3	Case 4
$\log Y$	1.061***	1.088***	0.900***	0.951***
	(0.026)	(0.057)	(0.038)	(0.077)
$\log D$	0.024	0.006	-0.009	-0.007
	(0.033)	(0.031)	(0.035)	(0.032)
$\log K_{t-1}$			0.227***	0.209***
			(0.039)	(0.073)
AR(1)		0.765***		0.737***
		(0.032)		(0.037)
Constant	-2.056***	-2.232	-2.302	-2.650***
	(0.168)	(0.539)	(0.191)	(0.561)
R^2	0.79	0.947	0.805	0.922
DW	0.696	1.998	0.727	2.036
Observations	420	385	385	350

Note: The dependent variable is $\log$ (housing price). Standard errors are in parenthesis. * indicates significant at 10% level, ** indicates significance at 5% level, and *** indicates significance at 1% level.

As demonstrated in Table 3.4, the estimated coefficient on household income is significantly greater than zero in all cases indicating a less perfectly elastic housing supply in China. On the other hand, the coefficient on demographic characteristics measured by the non-agricultural population is not significant in all cases. A correction for autocorrelation makes little difference in coefficients of household income. Similar to other studies, the stock-adjusted model yields a slightly lower elasticity compared to the flow model.

To estimate the price elasticity of housing supply, this study uses the estimates of these two parameters on ε_p^d and ε_y^d as summarized by Malpezzi and Mayo (1987) and Malpezzi and Maclennan (2001). Using these estimated parameters, this study calculates the implied price elasticity of supply with a combination of the estimates of income elasticity and price elasticity of demand. Some representative calculations are

reported in Table 3.5.

Table 3.5 Price Elasticity of Housing Supply

ε_p^d: -0.1~-0.5 ε_y^d: 0.5~1.0	Flow model (π_1 =1.088)	Stock-adjustment model (π_1 =0.951)	
		d =0.3	d =0.6
ε_p^d =-0.5, ε_y^d =1.0	0.419	0.126	0.251
	0.819	0.246	0.491
ε_p^d =-0.1, ε_y^d =1.0	-0.004	-0.001	-0.002
	0.360	0.108	0.216
ε_p^d =-0.5, ε_y^d =0.5			
ε_p^d =-0.1, ε_y^d =0.5			
Malpezzi and Maclennan (2001)	US: 4.4~12.7	US: 1.2~2.8	US: 2.4~5.6
	UK: 0.0~4.3	UK: 0.0~0.3	UK: 0.0~0.5

Note: ε_p^d is the price elasticity of demand; ε_y^d is the income elasticity of demand. The price elasticties of housing supply can be calculated by $\varepsilon_p^s = d(\varepsilon_p^d + \frac{\varepsilon_y^d}{\pi_1})$.

As noted in the Table 3.5, the implied price elasticities of supply based on the estimated results of the flow models fall in an interval between -0.004 to 0.819. In contrast, the stock adjustment elasticity is much lower ranging from -0.002 to 0.491. The similar approach was used in Malpezzi and Maclennan (2001), Mayo and Sheppard (1996). The former research chooses the value between -0.2 and -0.5 for price elasticity and the value between 0.5 and 1.0 for income elasticity. The latter one chooses the value between -0.1 and -0.5 for income elasticity and the same range as the former for price elasticity. Similarly, this study chooses the estimated price elasticity of demand between -0.1 and 0.5, and the estimated income elasticity of demand is between 0.5 and 1.0. Moreover, the baseline of the adjustment parameters is 0.3 and 0.6. However, as Malpezzi and Maclennan (2001) argued, the estimated elasticity of housing supply we obtained is only a range.

Other studies obtained similar magnitude of housing supply elasticity represented by Chow and Niu (2010) and Fu et al. (2011). Using the yearly national data of China, the former one obtained a price elasticity of supply of 0.831, although their focus is on the demand elasticity. The latter calculates an elasticity of housing supply in urban cities of China varying from 0.62 to 1.46. In contrast, Wang et al. (2012) obtained an average elasticity ranging from 2.82 to 5.64, which is larger than our study and other studies. Their estimated housing supply elasticity was derived from the average estimated housing supply of the 35 cities[20]. In general, most of the studies on the housing supply in China obtained a lower elasticity of supply.

3.4.3 The alternative determinants of housing supply

This study further conducts regressions on housing construction, Q. As an independent variable, Q is measured by housing completion in the corresponding year. Independent variables include housing price (P), lagged housing stock (K_{-1}), land price (LP), and land supply (LS). The regression result is as follow:

$$\log(Q) = -4.175 + 0.100\log(P) - 0.271\log(LP) + 0.241\log(LS) - 2.075\log(K(-1))$$

S.E. = (0.374) (0.056) (0.071) (0.022) (0.295)

Number of observations = 385, $R^2 = 0.821$

This study obtained expected coefficients. The estimated coefficients on land price are significantly negative indicating that an increase in land price will enormously decrease the housing output. Meanwhile, an increase in land supplies associates with an increase in housing output. In addition, a significantly positive relationship between

[20] Due to economic developments, geographic positions, and other factors, there are huge gaps among the Chinese cities. Ignoring the differences among cities may lead to serious biases.

housing output and housing price was found using housing completions as a dependent variable. The result can be treated as evidence to reject the Muth- Follain test, which means that housing supply in China is less elastic. Although an ignorance of other inputs such as capital cost and labor cost may slightly reduce the explanatory power, our specification can explain about 80 percent of the variation in housing output. Overall, the results are supportive of the importance of land-use regulations in affecting housing output.

3.5 Concluding remarks

This study conducted regressions on new housing constructions using cross-sectional data for 35 cities during the period 1999-2010. The estimated results of both the flow model and the stock adjustment model are represented. The estimated results based on the flow model suggest that the price elasticity of housing supply ranges from -0.004 to 0.819. But the stock adjustment model yielded a lower elasticity varying from -0.002 to 0.491. The findings reveal that housing supply in China is less elastic compared to developed countries. The lower estimated housing price supply elasticities imply that developers in China cannot respond quickly by releasing more houses to a shock from the demand side. Moreover, the results of this study confirmed that land-use regulation has a significant effect on housing supply. Housing supply elasticity in China is not only determined by the housing price, but also influenced by land-use regulations as well as the lagged housing stock.

Several researchers argue that supply conditions of housing may vary from place to place even in a country. Next chapter investigates housing supply variations across regions in China.

CHAPTER 4
EVALUATING VARIATIONS IN THE HOUSING SUPPLY ELASTICITY ACROSS REGIONS

4.1 Introduction

Chapter 3 has estimated the housing supply elasticity. The result shows that the housing supply in China is not perfectly elastic. In particular, it is slightly lower than that of developed countries. This chapter examines the variation in housing supply elasticities across regions and explains the variation in aspects of urban development and land use controls. The urban growth model is employed to capture the relationship between land-use controls, urban characteristics and the housing supply.

Section 2 begins with a brief summary of both the previous empirical studies and the development of the theoretical model on housing supply. Section 3 discusses the model derived from the urban growth model. The model captures the impact of urban growth and land-use controls on housing supply. This chapter also includes data descriptions. The estimated results are reported and discussed in Section 4. Section 5 concludes this chapter with a summary of the main findings.

4.2 Literature review

Two approaches, reduced-form and structural approaches, are often used to estimate the relationship between housing constructions and prices. Earlier empirical studies on housing supply tend to use the former approach, such as Muth (1960), Follain(1979), Stover (1986), and Olsen (1989). Most of these studies failed to reject the hypothesis that the housing supply is perfectly elastic. Thus, the researchers inferred that the supply

of new constructions is perfectly elastic.

On the other hand, recently there have been several attempts to build a structural model of housing supply. The theoretical underpinning of such literature comes from one of two sources: the investment theory and the urban spatial theory. The main difference in these approaches lies in the way of treating land (DiPasquale, 1999). The studies based on investment theory, which treat land the same as capitals and labors, but ignore the special characteristic of land. Unlikely, studies based on the urban theory explicitly incorporate the land market into the theory. This approach treats land differently from other variables and considers the supply is limited even in a long-run period. This section particularly focuses on the literatures based on urban growth and land development theory.

4.2.1 Variations in the housing supply elasticity and its alternative explanations

Malpezzi and Mayo (1997) argue that there are significant differences in supply elasticities across countries, and these differences may be due to the stringency of the regulatory framework for land and housing development. Their findings have been supported by many previous studies. For example, Malpezzi and Maclennan (2001) estimate the long-run housing supply elasticity for US and UK respectively, and report various estimated elasticities of housing supply for these two countries due to different regulatory and financial environments. Similarly, Mayo and Sheppard (1996) compare the housing supply in three rapidly growing countries: Malaysia, Thailand, and Korea. They present estimated price elasticities of housing supply for each country and confirm that differences in the planning between countries result in different supply elasticities.

As the supply elasticities differ across countries, there may be significant variations across regions or cities due to the differences in land-use controls and regulatory practices (Green, Malpezzi and Mayo, 2005). Studies of Goodman (1998) and later

literatures such as Green et al. (2005) provide strong evidence to prove that supply conditions vary from place to place even within a same country.

4.2.2 Urban growth and housing supply

Green et al. (2005) examine how urban form affects supply elasticities. They estimate supply elasticities for 44 metropolitan areas in the United States based on the theory of urban growth suggested by the work of Capozza and Helsley (1989), and Mayer and Somerville (2000). They find that estimates of the price elasticity of housing supply vary substantially from place to place. Green et al. (2005) similarly believe that heavily regulated metropolitan areas exhibit lower elasticities. In addition, they also find that while regulation and density (urban form) play essential roles in explaining variation in elasticities, urban growth rates and the city size have little effect on supply elasticities.

Unlike Green et al. (2005), Glaeser et al. (2005) pay particular attention to the role that the housing supply plays in mediating urban dynamics. Their focus is on how the nature of supply affects the urban dynamics. They further argue that the housing supply has become inelastic in some places because of restrictive zoning and other land-use controls. They develop an empirical framework that integrates heterogeneity of the housing supply into studies on urban change. They find that a shock will have bigger impacts on wage and growth of house price, and smaller impacts on population growth in places with more inelastic housing supply. In addition, they provide evidence that where land use control is less strict, and the population response to positive demand shocks is stronger. Thus, they infer that housing supply is crucial not only for understanding changes in population within metropolitan areas, but also changes in prices within those areas as well.

4.2.3 Land-use regulations and housing supply

There is a growing body of theoretical and empirical literatures, which explore effects

of land controls on the urban form, development patterns, and the price of housing. Further, most of these studies infer that areas with strict controls have higher housing prices. However, Mayer and Somerville (2000) point out that such an exclusive focus on housing prices is problematic since researchers cannot have direct measurement, whether higher prices are resulted from higher demand or lower supply. The authors further present a theoretical framework to describe the relationship between land use controls by the local government and new residential constructions. Using quarterly data on a panel of 44 metro areas from 1985 to 1996 in the United States, they find that land-use regulations have significant impacts on housing supply. Strict land-use controls not only lower the steady-state new construction, but also lessen the speed of developers responding to demand and cost shocks.

Mayer and Somerville (2000b) estimate a supply equation for new single-family residences which reflects the role of land in producing new housing and the theoretical treatments of urban growth. Further, in their former work (Mayer and Somerville (2000a)) housing starts are best described as a function of changes in current and lagged house prices rather than of their level. House prices regulate the stock of housing, and balance aggregate supply and demand for residential space. Their work further states that the level of house prices ensures a spatial equilibrium among residents of a given city. Thus, changes of housing price depend on the city size, its growth, and the opportunity cost of additional land. In their work, the new construction is modeled as a function of changes in housing prices, changes in the cost of capitals, and changes in construction costs. Using the national data, they find that both large-slow-growing cities and smaller-fast-growing cities have high house prices, yet these two types of cities will have unique patterns of housing constructions.

Contrast to the prior research, Mayer and Somerville (2000b) include land-use controls into their model concept, and the result shows that housing starts in cities with extensive land-use regulations are 45 percent lower than cities with less regulated one.

Panel data reveal that collected national data may slightly overestimate the price elasticity of new constructions and underestimate the time needed to respond to price shocks. Likewise, Ralph (2001) improves the urban growth model by taking land redevelopment and housing deterioration into account, and develops a method for tracing perfect-foresight growth paths for an urban area. Computer simulation for growth with myopic expectations is also conducted, and the result shows significant differences between myopic growth and perfect-foresight growth.

Their study shows that housing supplies are significantly correlated to urban form and local land-use controls. However, in China, there is an obvious lack of studies on reuniting housing supply and urban growth. They are treated as two separate ideas and land-use controls are normally ignored in analyzing the housing supply for a long period. Furthermore, most of the studies focus on the relationship between the housing price and land prices in China. Limited studies combine land use control with housing supply. Nevertheless, there are a couple of exceptions. Wang and Gao (2009) present an influential discussion of housing supply elasticity variation in China. They find that credits, land supplies and construction costs bring about elasticities of housing supply significantly different by regions. Besides, the study of Fu et al. (2011) uses a structural model to explain housing supply elasticities across the Chinese cities. They found that supply elasticity increases with fixed investment and urban area expansion in the city while it is independent of urban size and density, and cities experiencing stronger growth tend to have lower housing supply elasticity. However, the previous studies on Chinese housing market have not addressed whether land-use controls lead to a significant variation in housing supply across cities. Moreover, the studies have not fully considered the role of distinctive urban features and urban housing climates in affecting the housing supply. It would thus be of interest to learn effects of urban features and local land-use controls on the housing supply.

4.2.4 The urban growth model

This section introduces the original concept of the urban growth model which was firstly developed by Arnott (1980) and afterwards was improved by Capozza and Helsley (1989).

4.2.4.1 *Arnott's model: A general urban growth model with durable housing*

The city's population is exogenous. There are $N(t)$ identical residents who receive their utility from two commodities: housing services L, and other goods X which is numeraire. The utility function U(X, L) is homogeneous of degree 1, continuous and increasing in X and L. First-order conditions for maximized consumer utility hold when the marginal rate of substitution between housing and other goods equals the ratios of their respective prices. An individual lives at that location where the increase in transport costs from moving a near place to the central business district offset the housing rent decrease. A builder has perfect foresight by choosing housing density, which depends on land value and the construction time to realize a maximized profit. Since individuals are identical and the economy is competitive at each point, housing rents should be positively related to the distance between the household location and city center so that there is no utility difference among residents locating at non-identical area. Their model is different from residential location theory in several respects. Hence, housing density at a particular location is determined by the value of land there at the time of development rather than land rent (in residential location theory). In addition, a builder is assumed to have perfect foresight. Unlike the static model, their model stresses the importance of expectations in determining the pattern of spatial growth of the city. It is straightforward that Arnott's model has strict assumption and does not take land-use regulations into account.

4.2.4.2 *Capozza and Helsley's model: Urban growth and land development model*

The model assumes that an urban area is located on a homogeneous plain 2ϕ radians suitable for the construction use. The urban area available for housing construction is not only related to the landform, but also related to the household density in the interior of the city. It is obvious that a larger ratio of the hilly area to the total urban area will put the city at a serious disadvantage for developing new constructions. Furthermore, the higher the population density is, the more difficult for developers to acquire land for new constructions. Lot sizes are fixed at $\overline{L}$ units per household. Separate households live on annular lots at different distance from the central business district (CBD), a point in space at which all non-residential activity takes place. Every day, each household commutes to and from CBD to work and go to shopping, and locations are indexed by their distance z from the CBD. The cost of commuting a unit of distance is a positive constant T. If a household lives at a distance z, he has a commuting cost Tz.

Their model shows that if landowners have perfect foresight and the land market is competitive, the price of land equals to the present value of expected land rents. The value at time t of a unit of developed land at location z consists of three items: the present value of agricultural rent A at time t up to the conversion day; the present value of urban rent from the conversion day onward, and the present value of the conversion cost at t^* which denotes the best construction time.

According to Capozza and Helsley (1989) developers realize their profits maximized by choosing the best construction time t. Land is only developed when rent in the urban use, R, equals the opportunity cost of land plus the opportunity cost of conversion capital. The boundary of the urban area at time t , $\bar{z}$, can be implicitly defined by

$$R(t,\bar{z}) = A + rC, \tag{4-1}$$

where A is the agriculture rent, and r is the discount rate (often measured by the interest rate), and C is the cost of converting a unit of land from agricultural to urban use. Since each household consumes a fixed lot size $\overline{L}$, thus the city area can be measured by $N(t)\overline{L}$ (with a number of household $N(t)$) which can be computed by the sector dimensions:

$$N(t)\overline{L} = \phi z^2(t). \tag{4-2}$$

The locations of households are assumed close-set and there is no land undeveloped interior of the city. Hence, solving $z(t)$ from the Equation (4-2) yields

$$z(t) = [\frac{N(t)\overline{L}}{\phi}]^{1/2}. \tag{4-3}$$

Then this study considers city expanding in annular to accommodate all the increased households. New construction occurs only at the fringe of the city. If urban growth is assumed to increase exponentially at a constant rate g, current land price accordingly depends on the city's expected growth rate. It can be described as follow:

$$P(t,z) = A/r + C + (T/r)[z(t) - \bar{z}] + T \cdot \frac{g/2}{r(r-g/2)} \cdot z(t) \quad , \tag{4-4}$$

where the land price mainly consists of four items (Capozza and Helsley, 1999, p.299). The first item in Equation (4-4) is the agricultural rent; the second item is the construction cost; the third item is the location advantage rent for household indexed by $z(t)$, and the final term is the value of the anticipated future rent increase at location $z(t)$ when the urban areas expand exponentially.[21] Section 3 discusses the model

[21] See Cappzza and Helsley (1989) for more details about the original model of land development and the urban growth.

based on the urban growth theory and describes the data for empirical analysis.

4.3 Methodology and data

The general model can be extended in numerous directions. The urban growth and land development model in Capozza and Helsley (1989) is well cited by other papers, such as Mayer and Somerville (2000), and Green et al. (2005). This study also follows the theoretical framework of Capozza and Helsley (1989) and an empirical framework suggested by Mayer and Somerville (2000a, 2000b). It assumes that developers are perfectly foresight, and they can maximize their profits by choosing the best construction time t (time to convert agriculture land to urban use). They can smooth their products by delaying the period of construction time to get maximized profits according to their expectation of the price changes in the future. It ignores land redevelopment and assumes all the land has been developed in the interior of the city. The housing price equation, equation (4-4) can be rearranged. Hence, equation (4-5) is obtained by reversing the function of equation (4-4). Urban size at time t, which can be measured by the distance from the city center to the city border, is treated as a function of housing price.

$$\mathrm{z(t)} = (r - g/2)[\frac{P(z,t) - C}{T} - \frac{A}{Tr} + \frac{\bar{z}}{r}], \qquad (4\text{-}5)$$

where g denotes the urban growth rate. In general, g is measured by the urban area expanded or the population increase in one year. Similarly, this study includes both two indexes into its empirical model to examine the effect of urban growth on housing constructions. It is assumed that there is no land undeveloped, and no redevelopment in the interior of the city. In addition, each resident takes up a space of $\overline{L}$ housing. House stock of a mono-centric city with 2ϕ radians at time t can be described by

$$HS_t = N(t) \cdot \overline{L} = \phi z^2(t), \tag{4-6}$$

where HS_t is the equilibrium housing stock at time t and $N(t)$ is the number of households at time t as defined above.

Assuming the urban city grows exponentially at a constant rate g, the equilibrium housing stock can be described as follow:

$$HS_t = \phi\left\{(r - g/2)[\frac{P(z,t) - C}{T} - \frac{A}{Tr} + \frac{z(t)}{r}]\right\}^2. \tag{4-7}$$

When there is a demand shock, new constructions are required to accommodate the increased demand. New constructions can be treated as a change of housing stock. The change in housing stock between two periods, t and $t-1$, can be captured by the following Equation,

$$\Delta HS = \frac{\phi(r-g/2)^2}{Tr}[P(z(t),t) - P(z(t-1),t-1)] \cdot [rP(z,t) + P(z(t-1),t-1) - 2rC + T[z(t) + z(t-1)]]. \tag{4-8}$$

Thus, housing stock changes ($\Delta HS = HS_t - HS_{t-1}$) can be treated as a function of the changes in housing prices, urban growth, construction costs and other variables as described in equation (4-9).

$$\Delta HS = F(\phi, g, r, T, C, P), \tag{4-9}$$

where ΔHS is a flow variable usually measured by the new constructions. Unlike developed countries such as the United States and the United Kingdom, China does not possess of data directly related to the housing stock. Thus, this specification enables us to overcome the difficulty in collecting housing stock data.[22] Implications of this

[22]Several studies use the space of housing per capita multiplied by population to derive housing stock since the housing stock data is not available.

expression are as follow: as the city size expands, the more outputs are supplied. The theories based on the previous studies also suggest that as population, housing price and its changes rise, so do the new constructions. Furthermore, ϕ , the radians of the plain, which implies the area available for construction use, is assumed negatively related to the population density since in densely populated areas it is more difficult for developers to conduct new constructions. The higher the population density is, the more difficulties the developers have to conduct new constructions.

Suggested by Mayer and Somerville (2000a, 2000b), this study estimates a housing supply equation with new housing as a dependent variable and include urban attributes, land-use controls and housing prices as independent variables. Interest rates and construction costs are not included into the model since there is no significant difference for cities nation-wide. However, this study takes a variable of land supply into the empirical model with consideration of the special characteristics of the Chinese housing market. As a main input during housing production, land is strictly regulated by the local government, which may be responsible for the low elasticity of housing supply in China.

Hence, this study designs an empirical model to examine housing supply determinants for cities with changes of housing constructions as a dependent variable and includes population density (den , with an expected negative sign), urban population (pop , with an expected positive sign), urban sprawl (bua is used to grasp the changes in commute costs, with an expected positive sign), and urban land-use regulation as explanatory variables. Two indicators of land-use regulations, the land supply (ls , with an expected positive sign) and land prices (lp , with an expected negative sign) are both included into the empirical model.

Panel data on 35 Chinese cities for the years 2002 to 2010 are provided by the

National Bureau of Statistics in China: the Main Indicators of Real Estate Projects in 35 Large and Medium-sized Cities, published by the Press of China Statistics.[23] For each city, observations of housing prices, housing constructions, land availability and some other observations on urban characteristics such as the density, urban built-up areas and urban populations are amassed. While most existing studies on housing supply use national data, we use panel data. Since there are significant variations in the local housing market among the Chinese cities, panel data with obvious advantages enable this study to overcome the biases caused by using national data.

The definition of the variables and data sources is described as follows:

New housing constructions (Housing completions)

Two residential construction measures, the real value of residential construction in each country and either starts or completions are often used to estimate housing constructions. Complete data on spaces of housing completed are collected. Series of housing completions from the year 2002 to 2010 are provided by the Main Indicators of Real Estate Projects in 35 Large and Medium-sized Cities (China Statistical Yearbook, 2011).[24]

Housing Prices

Literatures on developed countries like the U.S. often use repeat sales price index and a hedonic house price series as a price variable in the supply equation. However, such

[23] 35 cities include 4 Municipalities directly under the Central Government (Beijing, Tianjin, Shanghai, and Chongqing), one Special Economic Zoon (Shenzhen) and 30 provincial capitals with the exception of Lhasa which is the capital city of Tibet.

[24] Follain (1979): A measure of the value of the stock of housing: net stocks, lagged one year, including nonfarm dwellings 1-4 units, nonfarm dwellings 5 or more units, farm dwellings, mobile homes (farm and non-farm), no housekeeping buildings, and equipment. Green, Malpezzi and Mayo (1999): Percentage change of housing stock is derived from the number of housing units for which building permits were issued, multiplied by 2.5, divided by population. Long et.al. (2008) use housing completions while Wang and GAO (2010) use new starts of residential building to measure the quantity of housing supplied.

data are not available in China. Thus, this study measures housing prices with the average selling price of residential housing in each city, which is calculated by dividing the aggregate sales value by the total space housing sold. This housing price cannot reflect quality improvements in housing stock, since a quality-adjusted housing price index or repeated-sales housing price index is not available for Chinese cities as argued in Liu and Shen (2005).

Land-use regulations

This study uses two measures of land-use controls: the land supply and land prices. The land supply and land prices are two most important instruments for local government to regulate the land market. The land supply is measured by spaces purchased by the developers in one year. Data on land supply come from 'the *Main Indicators of Real Estate Projects in 35 Large and Medium-sized Cities*' of the China Statistic Yearbook (2011) compiled by the National Bureau of Statistics of China. Land price is measured by the land price for residential construction use and sources from 'the *China Urban Land Price Dynamic Monitor*' released by the Chinese land price information dynamic publishing platform.

Urban attributes

This study uses the built-up area in one year to measure urban sprawl, and use urban population to measure the size of the city. Data on urban population density is also gathered. In addition, data on urban attributes mainly come from the City Statistical Yearbook (2011) and the China Real Estate Statistical Yearbook (2011).

Table 4.1 reports descriptive statistics for all the variables used in the empirical analysis. The coefficient of variance (Standard Deviation / Mean) is also included in Table 4.1 to show the dispersion of variables mentioned in this chapter.

Table 4.1 Descriptive Statistics for Variables

Variable	Mean	Median	Maximum	Minimum	Standard Deviation	Coefficient of Variation
Housing completions (0, 000 sq.m)	586.9	414.3	3,380.1	41.1	561.2	0.96
Housing price (RMB/sq.m)	4,057.9	3197.0	18,954.0	1,202.0	2,739.9	0.68
Urban Population (0, 000)	604.7	571.0	3303.4	64.1	508.9	0.00
Built up area (0, 000 sq.m)[25]	324.0	233.5	1,350.0	33.6	262.2	0.81
Density (Person/sq.m)	635.4	578.7	2,253.0	105.1	408.7	0.64
Land supply (0, 000 sq.m)[26]	418.4	313.3	2,092.5	13.9	370.4	0.89
Land price (RMB/sq.m)	3,911.7	2210.0	22,827.0	432.0	4,411.1	1.13

Note: 1) Housing stock changes are measured by new completions of residential constructions. 2) Measures for urban attributes include urban population, spaces of built-up area and population density. 3) Two indicators for land regulation are land supply and land price. Cross sections = 35, observations = 315.

4.4 Estimated results

Several regressions are conducted to find out the causes that lead to housing supply variations across the Chinese cities. The main focus is on whether variations in urban characteristics and local land-use regulations are the principal causes of discrepancies of housing supply among different cities. This study estimated the housing supply function suggested by the urban growth model, in which housing supply is mainly correlated to housing price, urban growth and land-use regulation. It constructed a double logarithmic model to explore the determinants in affecting housing supply elasticity. All the variables are expressed in their natural logarithms. Thus, the estimated coefficients of housing price can be interpreted as the housing supply elasticity. The regression model

[25] In China, the built-up area is defined as a largely continuous area covered by urban facilities. It is generated by the Ministry of Housing and Urban-Rural Development (MOHURD). This chapter treats it as a good proxy of urban sprawl.

[26] Distribution of benefits of lands, land supply, plan of land utilization and land price are the most important ways to regulate land market for government.

is described by the equation (4-10),

$$Ln(completions_{it}) = \alpha_0 + \alpha_{1,} Ln(P_{i,t}) + \alpha_2 Ln(den_{i,t}) + \alpha_3 Ln(pop_{i,t}) + \alpha_4 Ln(bua_{i,t}) + \alpha_5 Ln(ls_{i,t}) + \alpha_6 Ln(lp_{i,t}) + \mu_{i,t} \quad (4\text{-}10)$$

where i=35 cities, and t=2002, 2003… 2010. The dependent variable is the changes in housing stock, which is measured by spaces of housing completed (*completions*). The urban attributes are characterized by density, population, and city built-up areas. Alternatively, the land-use regulation is characterized by land spaces purchased by the developers in one year (ls) and land prices (lp).

It should be noted that using panel data may encounter the problem of heteroskedasticity and autocorrelation. In this case, the OLS (ordinary least square) estimator will be not efficient. To solve the above problem, the estimation method of fixed effect which allows for heterogeneity among individuals is also employed. Furthermore, an AR(1) item is included to correct autocorrelation[27]. The estimation results are presented in Table 4.2. No matter which estimation method is used, it is straightforward that housing price and land supply are two predominant factors in affecting housing supply. More specifically, the housing price is the most notable factor. The estimated coefficient of housing prices is significant ranging from 0.58 to 0.70. It implies that housing completions increase significantly associate with the housing price increases. Furthermore, land supply is another determining factor of housing supply which has a range of 0.16-0.61, but smaller than housing price in magnitude of estimated coefficient. An increase in land supply can significantly stimulate housing supply as suggested. However, the effects of urban attributes which are characterized by the population, density, and the built-up areas are uncertain. The result should be interpreted with caution.

[27] As described in Table 4.2, adding an AR (1) item greatly improved the DW-statistic. The third model outperformed the first two models with a stronger explanatory ability.

Table 4.2 Regression results

Variable	I		II		III	
	OLS	Fixed effect	OLS	Fixed effect	OLS	Fixed effect
$Ln(P)$	0.67***	0.64***	0.70***	0.64***	0.66***	0.58***
	(11.39)	(9.23)	(12.30)	(11.04)	(5.87)	(6.90)
$Ln(pop)$	-0.10*	0.09	-0.13**	0.09	-0.18**	-0.11
	(-1.82)	(1.43)	(2.34)	(1.51)	(-2.24)	(-1.57)
$Ln(den)$	-0.01	-0.26**	0.02	-0.25**	-0.14	-0.12
	(-0.26)	(-2.00)	(0.41)	(-2.01)	(-1.10)	(-0.85)
$Ln(bua)$	0.13*	-0.20	0.20***	-0.18*	-0.01	-0.19
	(1.94)	(-1.78)	(3.28)	(-1.85)	(-0.10)	(1.38)
$Ln(ls)$	0.61***	0.35***	0.60***	0.35***	0.24***	0.16***
	(17.74)	(10.82)	(17.56)	(10.88)	(6.41)	(5.01)
$Ln(lp)$	0.09*	0.01				
	(1.95)	(0.11)				
AR(1)					0.80***	0.47***
					(20.52)	(10.17)
Constant	-3.63***	0.86	-3.53***	0.59	1.36	2.87***
	(-7.35)	(0.93)	(-7.15)	(0.66)	(0.96)	(2.45)
DW-statistic	0.97	1.39	0.94	1.40	2.31	2.46
R^2	0.66	0.83	0.66	0.83	0.78	0.90

Note: T-values are in parenthesis. *** 1% significance ** 5% significance * 10% significance. Dependent variable is the natural log of completed housing constructions $Ln(completions)$. AR(1) is used to correct for autocorrelation.

To be specific, the first regression includes all the main variables (Case I). The OLS estimation shows that urban attributes variables are all insignificant, while fixed effect estimation reveals that density decreases housing supply significantly at 5% significance. This result is consistent with the fact that developers in densely populated cities have bigger difficulties in obtaining additional land to construct new houses. In addition, both the estimation of OLS and fixed effect shows that land price is insignificant. Then, Case II excludes the variable of land price. Apart from housing price and land supply, it is noticeable that OLS estimation also reports a significantly positive coefficient of built-up area and a significantly negative coefficient of population at significance of 5%. Meanwhile, fixed effect estimation shows a significantly negative coefficient of density, which is similar to Case I. Moreover,

excluding the variable of land price does not reduce the explanatory ability of the model. Case III excludes the variable of land price and includes an AR(1) term to correct autocorrelation. The OLS and fixed effect estimation appears to report similar results that housing price and land supply are two determinants of housing supply. However, the OLS estimation also shows that the population has a negative influence on housing supply. Case III, in general, shows housing prices, urban attributes and the land supply can explain more than 80% percent of the variation in housing supply.

More importantly, while the estimated coefficients of the land supply in all cases are significant, the estimated coefficients of land price are insignificant. The estimated results suggest that land supply is a significant factor in influencing housing supply for Chinese cities, while the variable of land price is not significant. Furthermore, this finding is similar to Wang and Liu (2009) in which they concluded that land supply increase moves the action to the housing supply very apparent, while the effect of the land price on housing supply is insignificant. The result can be interpreted that the land supply is strictly controlled by local governments in China and may lead to an inefficient land market. Similar work by Wu and Zheng (2011) found local governments pursue their own interests, which harm to degree of marketization in granting of land use rights.

Previous studies by Fu et al. (2011), Wang and Gao (2011), and Wang et al. (2012) argued that the geographical constraint plays critical roles in determining housing supply elasticity. Hence housing supply might differ from place to place. This is particularly the case for China where great differences exist among local markets for housing due to diverse local characteristics. To examine the above argument, this study divides 35 cities into three regions (the eastern region, the midland region, and the western region as represented in Table 4.3) according to their geographical positions and conduct regressions in each region.

Table 4.3 Geographical distributions of the 35 cities

Area	Cities
Eastern (17 cities)	Shijiazhuang, Shenyang, Dalian, Ningbo, Nanning, Tianjin, Shanghai, Xiamen, Shenzhen, Haikou, Beijing, Jinan, Qingdao, Guangzhou, Nanjing, Hangzhou, Fuzhou
Midland (9 cities)	Hohhot, Harbin, Changchun, Wuhan, Taiyuan, Nanchang, Zhengzhou, Changsha, Hefei
Western (9 cities)	Kunming, Urumqi, Chengdu, Guiyang, Yinchuan, Chongqing, Xining, Xi'an, Lanzhou

Note: Cities are divided into three groups according to their geographical positions.

Data from 35 cities fall into three regions. The pooled OLS model is implicitly assuming that the coefficients are the same for all the regions, and fails to control for characteristics that may differ across regions. Omitting the heterogeneity across regions results in endogeneity problem since the effects unique to each city will be all subsumed in the error term and hence the explanatory variables are no longer uncorrelated with the error terms. Due to the ignorance of unobservable factors, the estimates from OLS regression will be biased and inconsistent. In this case, the fixed effect model which allows for heterogeneity among cities is applied to eliminate omitted variable bias with an assumption that each city has time-invariant but unique effects on the dependent variable of housing construction. Therefore, both the estimation methods of OLS and fixed effect are applied to estimate the housing supply elasticity in each region, and the estimated results are summarized in Table 4.4. Based on the estimated results, the fixed effect estimates generate slightly higher price elasticites of housing supply compared to the OLS estimates in general. To be specific, the estimated results presented by the fixed effect method show that housing price and land supply are still two determinants of changes in housing supply for the eastern cities and western cities. However, housing supply in the midland cities only depends on changes in housing price but, is insensitive to changes in land supply. In contrast, the estimated results of the OLS method show that housing supply is significantly affected by housing price and land supply in all regions. Furthermore, the estimated coefficients of urban attributes variables differ by

region. While it appears to be unaffected by urban attributes in the midland cities, housing supply is positively related to build-up areas and density in eastern cities and negatively related to population and density in the western cities. It is noticeable that both of the OLS estimate and the fixed effect estimate show that land price takes effect only in the eastern cities. In the midland cities and western cities, changes in land price have little effect on housing supply. In general, housing supply in eastern cities and western cities involves changes in housing price and land use controls, but also depends on urban attributes. It suggests that developers in these cities tend to take various elements into the comprehensive consideration in making their supply decisions. Unlike the situation in eastern and western cities, housing supply in the midland cities is determined only by housing price.

Table 4.4 Estimation results for three regions

Variable	Eastern cities		Midland cities		Western cities	
	OLS	Fixed effect	OLS	Fixed effect	OLS	Fixed effect
$\ln(P)$	0.98***	0.70***	0.27	0.66***	0.68***	0.35**
	(7.21)	(6.46)	(0.08)	(2.88)	(3.76)	(2.03)
$\ln(pop)$	-0.21**	0.04	-0.00	0.00	-0.00	-0.55**
	(-2.07)	(0.43)	(-0.01)	(0.02)	(-0.00)	(-3.17)
$\ln(bua)$	0.07	0.36**	-0.37	-0.51	-0.08	0.25
	(0.42)	(2.15)	(-1.87)	(-1.06)	(-0.30)	(0.79)
$\ln(den)$	0.30	0.71***	-0.21	-0.57*	-0.12	-1.01***
	(1.63)	(2.86)	(-1.59)	(-2.00)	(-0.90)	(-5.88)
$\ln(ls)$	0.28***	0.43***	0.18**	0.17	0.66***	0.17**
	(5.49)	(9.76)	(2.10)	(1.84)	(7.74)	(2.36)
$\ln(lp)$	-0.25**	-0.33**	1.06***	0.29	0.10	0.47
	(-2.08)	(-2.33)	(3.87)	(0.60)	(0.51)	(1.75)
R^2	0.85	0.87	0.76	0.84	0.54	0.81
Observations	136	153	72	72	81	81

Note: T-values are in parentheses. *** 1% significance ** 5% significance * 10% significance. Cities are divided into three regions according to their geographic position. Including or excluding the item of AR(1) depends on D-W statistics.

While housing price and land supply are two important factors in affecting housing supply in all three regions, their effects differ from region to region. The fixed effect estimates suggest that developers in the eastern and midland cities seem to be more

sensitive to price changes. Specifically, the eastern cities and midland cities have greater coefficients of housing prices (0.70) than the midland cities (0.66) and western cities (0.35). In addition, eastern cities have greater coefficients of land supply (0.43) than the midland cities (0.17 but, insignificant) and western cities (0.17), which reveals that housing supply is subject to limited land supply in eastern and western cities rather than the midland cities. The result implies that housing developers in the eastern cities and the midland cities are more sensitive to housing price than those in the western cities. In contrast, developers in eastern cities and western cities seem to be more sensitive to the land supply than those in the midland cities.

The above result is in accordance with the current situation in China. Indeed, the space of land available to conduct new construction is limited in eastern cities due to rapid urban growth and high density of population. In contrast, it is much easier to obtain additional land for constructions use in western and midland regions with lower population density. Meanwhile, the cities in the eastern region are generally acknowledged being more developed than cities in the other regions. Accordingly, the land market in eastern cities is relatively mature and thus the land price can reflect the demand and supply of land for construction use compared to midland and western cities.

In general, the result reported in Table 4.4 reveals that the geographical position is such a significant factor in determining the housing supply elasticity which has been proved to vary by region. Adjustments of housing price and the land supply are effective in regulating housing supply national wide, while the land price only plays its due role in eastern cities. Housing market regulations should be made correspondingly based on the changed climate of the housing market in different regions. The response of developers to changes in housing price, the land use control, and urban attributes can be well observed through the estimated coefficients.

4.5 Summary and conclusions

Investigations on housing supply variation across cities and regions find that the housing price and land supply are two predominant effective factors in influencing housing supply. In general, land supply plays a crucial role in affecting housing supply rather than land price. This is due to the fact that the land supply is strictly controlled by the local government. In this situation, the land price cannot play its due diligence in regulating land market. However, it depends on degree of marketization in granting of land use rights. In the eastern region, land price has a significantly negative effect on housing supply. It suggests that developers tend to decline their supplies of housing as the land price increases.

On the one hand, using an urban growth model allows us to observe the factors that developers of various regions count in making their supply decisions. On the other hand, supporting evidence shows that effects of housing price and land supply on housing supply differ from region to region and hence regulations suitable for the local housing market conditions are strongly suggested to local governments.

CHAPTER 5
SUPPLY ELASTICITY BY HOUSING TYPE: DIFFERENCES AND INTERPRETATIONS

5.1 Introduction

Chapter 4 has examined the variation of housing supply elasticity across cities. This chapter further investigates whether the housing supply elasticity differs by type based on the evidence comes from 31 Chinese provinces. In China, housing can be divided into three categories: common residential houses, villas and high-grade apartments, and economically affordable housing[28]. Because the land for construction use is monopolized by the government, housing of various types has very different modes of access to land. For example, in the case of 'economically affordable housing' the land for its construction is directly supplied by government allotment. There is some reason for supposing that the supply elasticity by housing type is different. As declared by McLaughlin (2012) that '…there are no reasons to assume the supply elasticity of housing to be homogenous among housing types[29]'. However, even the latest literature such as Chow and Niu (2010), Fu et al. (2011), and Wang et al. (2012) ignore the difference among housing types. In particular, empirical evidence of differences in the supply elasticity among various types of housing is lacking in China.

It would be biased and not precise to estimate housing supply elasticity without considering differences by housing type. In addition, estimation of housing supply elasticity for each housing type is also important for policy-makers. To prompt new construction of housing, the Chinese government has implemented a series of policies

[28] Economically affordable housing refers to houses constructed by real estate development enterprises or housing units under the instruction of local government. As a kind of public housing, it is targeted to low-income household and be sold at below-market prices.

[29] McLaughlin (2012) examines the variation in housing supply elasticity between multifamily units and single-family homes in Australia.

including adjustments of interest rates and land-use controls. Although, the initial policies are typically one-size-fits-all ignoring the obvious difference among housing types, the government has realized that the effect of housing policies on supply differs from type to type. Policy target to regulate housing of one specific type is more and more popular.

This chapter investigates the variation of housing supply elasticities by type of use and the likely causes of this variation. Based on the theoretical framework suggested by the previous studies, it employs a revised urban growth model to investigate housing supply elasticity for each housing type. Currently, it is the first study to estimate housing supply elasticity by type in China. In particular, it distinguishes common residential housing from villas and high-grade apartments and economically affordable housing in the estimation. Further, it provides empirical evidence on housing supply elasticity of economically affordable housing which is barely mentioned in the previous studies.

This chapter proceeds as follows. The following section overviews the nature of the housing market in China. Section 3 presents a theoretical background and describes data as well as the estimation procedure. Section 4 shows the estimated results and gives the corresponding interpretations. Section 5 gives concluding remarks, in particular, some suggestions on how to extend the knowledge of the topic.

5.2 The supply structure of the Chinese housing market

Table 5.1 below shows the structure of various buildings newly started in 2010. Total commercialized buildings consist of commercialized residential housing, office buildings, and buildings for business use. Furthermore, as a component of aggregate commercialized housing, residential housing including villas and high-grade apartments and economically affordable housing takes up more than 80% of the total. According to

the definition of the Statistical Bureau of Economics of China, economically affordable housing is a kind of public housing subsidized by the government in terms of a land transfer fees remission and tax reduction. The land for its construction is provided in term of administrative transfer or bidding by the government. Thus, its costs and sales prices are lower than that of common residential buildings.

Table 5.1 Demand and supply: a comparison by buildings type

Housing type	New start (Ratio)		Sales space (Ratio)	
	1998	2010	1998	2010
Residential buildings:	16,638	129,359	10,827	93,377
(10 000 sq.m)	(81.6%)	(79.1%)	(88.9%)	(89.1%)
1.Villas and high-grade apartments	639	5,080	345	4,219
2.Economically affordable housing	3,466	4,910	1,667	2,749
Office buildings	872	3,668	401	1,890
(10 000 sq.m)	(4.3%)	(2.2%)	(3.3%)	(1.8%)
Houses for business use	1,939	17,473	811	6,995
(10 000 sq.m)	(9.5%)	(10.7%)	(6.7%)	(6.7%)
Others (%)	4.6%	8.0%	1.2%	2.4%

Note. Data sources from the Table 6-35 (New starts) and Table 6-38 (Sales space), China Statistic Yearbook, 2011.

There has been plenty of evidence to document that the supply elasticities differ from place to place[30]. To be specific, housing prices in areas with lower supply elasticity are usually higher and more vulnerable than the areas which have higher supply elasticity. Figure 5.1 represents the trend of housing prices during 1998-2010. It should be noted that prices of common residential houses (ordinary dwelling houses) and economically affordable housing have barely increased in contrast to the rapid increase in price of villas and high-grade apartments during the observed period. This chapter in particular raises a question whether such difference in the trend of various housing prices can be explained by variation in the elasticity of supply. This chapter assumes that villas and high-grade apartments have a lower price elasticity of supply, while common residential

[30] Studies such as Green, Malpezzi and Mayo. (2005), Goodman (1998).

housing has a higher elasticity. Furthermore, as a kind of public housing, economically affordable housing is assumed insensitive to changes in prices[31]. These assumptions will be examined in our following analysis.

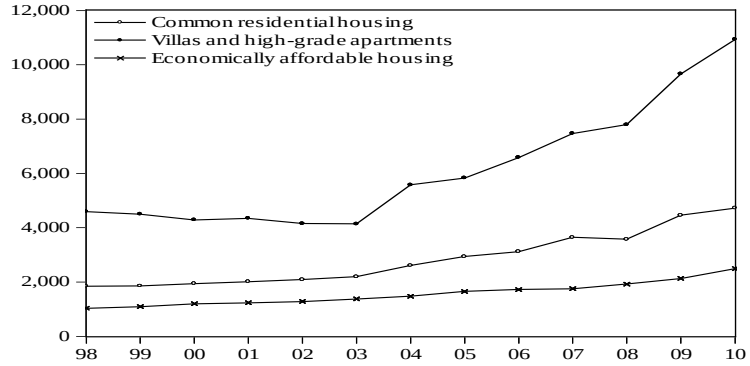

Figure 5.1 The average selling price of housing by type (unit: RMB/sq.m)

Source: the China Statistical Yearbook, 2011.

The Chinese government has implemented a round of policies to optimize the supply structure in housing market with a purpose of stimulating the supply of affordable housing, while reining the new constructions of luxury housing using instruments of land supply, taxation and financing. Liu and Huang (2004) noted that

'…It seems that the objective has been achieved partly with the continuous improvement of housing development investment distribution in each major type of uses. The share of development investment in the residential sector increased from 58.5% in 1994 to 67.1% in 2002. At the same time, the share of the commercial buildings including office and retails declined from 24.2% to 16.9% during the same period.'

Although they have pointed out that government regulations on optimizing the buildings structure might have achieved great progress, they failed to provide relative empirical evidence. In particular, they failed to notify that the effect of regulations on the housing supply differs by type. Take two main instruments, adjustments of interest

[31] Prices of economically affordable housing are not adjusted through housing market, the demand and supply.

rates and land-use controls which are widespread to control high home prices for the Chinese government as an example. Figure 5.2 shows the trend of benchmarked one-year rate deposit and lending. In 2004, the Central Bank of China raised interest rate after remaining unchanged for 9 years. One-year loans and deposit rates were regulated by 0.27%. In 2007, the Central Bank increased the benchmark deposit and loan interest rates to 4.14% and 7.47% respectively. This adjustment may have impacted on the housing market in the short term as well as medium term.

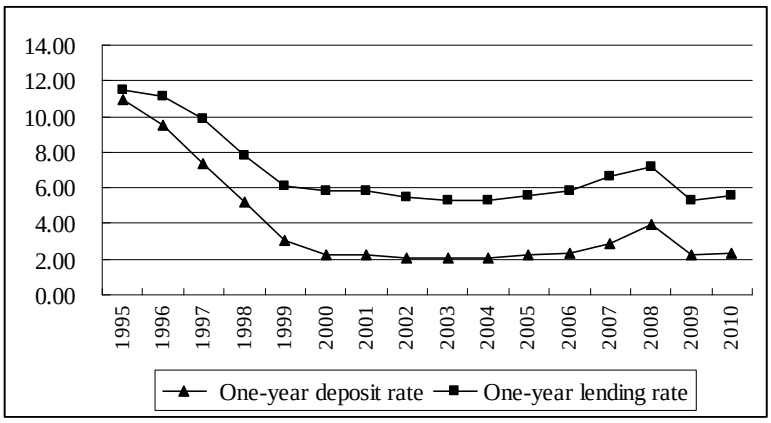

Figure 5.2 The benchmark rate of one-year deposit and one-year lending, 1995-2010

Note: Data are provided by the People's Bank of China. The monthly data on the rate of one-year deposit and one-year lending are transformed into annual data according to the actual runtime it have been carried.

The land use control is another important instrument to regulate the housing market. A constant stream of land policies has been implemented since 1998. In 2009 five ministries (Ministry of Finance, Ministry of Land and Resources, the People's Bank of China, Ministry of Supervisor, and Audit Administration) jointly released the announcement that the down payment of land transferred fees should be paid at least 50% of the total. Recently, the regulation issued by the Ministry of Land and Resources and the Department of Housing and Urban Construction stressed that the supply of land for common residential buildings use should be increased in the future. The Chinese government strictly controls the supply of land for villas and high-grade apartments, while encourages the supply of the land for common residential use. As a result, there is

a huge gap between the prices of different housing type mainly due to the various costs to get the land. It is feasible to believe that such inclination of regulations on land may actually lead to diverse housing supply elasticity among housing types.

Does an increase in land supply correspondingly bring about an increase in housing supply? Using the data provided by the Hong Kong housing market from 1973 to 1997, Lai and Wang (1999) explore the common belief that an increase in land supply can be a remedy for the shortage of housing supply. If the government land supply is positively related to housing supply, then increasing land supply will bring about an increase in housing supply. However, the results show that developers' housing supply is independent of the amount of land provided by the government. What concerns the developer is the economic conditions rather than the land supply in making their decisions. However, unlike the Lai and Wang (1999), Saiz (2010) finds a strong and positive relationship between restrictive land-use regulations and natural geographic constraints on land supply and suggests these two factors help explain soaring housing prices in areas with stringent regulations. In the United States, both stringent land-use regulations and natural geography affect the supply of elasticity of new housing. In particular, this chapter needs to examine whether the land supply has a homogenous effect on housing of different types.

5.3 Methodology

Following Mayer and Somerville (2000a), and McLaughlin (2012), the new construction is measured as a function of the change in construction costs (costs include all construction-related expenses, such as materials, financial inputs) as well as prices. Meanwhile, it is also affected by the government regulations on land-use (Mayer and Somerville, 2000b). For each type, new construction is modeled as follows:

$$newconstr_t = f(\Delta p_t, ..., \Delta p_{t-j}, \Delta c_t, \Delta c_{t-1}, \Delta r_t, \Delta r_{t-1}, \Delta land_t, \Delta land_{t-1}, \Delta loans_t, \Delta loans_{t-1}) \quad (5\text{-}1)$$

where *newconstr* is the new construction of housing, which can be treated as the changes in housing stocks. Δp is the change in housing prices, Δc denotes material costs changes. Δr is the change in interest rate, which measures the cost of financial inputs to developers. $\Delta land$ is land supply that government released, which is used to characterize the effect of land-use regulations. *loans* is added to capture the effect of the capacity of developers to obtain the capital.

The data used consists of 31 provinces in China over the period 1999 to 2010 with sample size 372. The provincial data avoid the problem that may cause by using national data since there are obvious variations in both the size of the housing stock and in housing prices. Residential housing consists of common residential housing, villas and high-grade apartments, and economically affordable housing. In order to realize a reasonably robust test on the variation, our paper employs two measures of new construction, (1) the new completion of housing investment, and (2) new starts of housing construction[32].

Table 5.2 reports the summary statistics for all variables used in this chapter. The description of data on economically affordable housing once again demonstrates that, as a commercialized housing, economically affordable housing is totally different from housing of other types. Aggregate estimations of the national housing market without distinguishing by type will be seriously biased.

[32] Malpezzi and Maclennan (2001) report two residential output measures: (1) the real value of residential construction and (2) either starts or completions.

Table 5.2 Descriptive statistics

Variable	Mean	Median	Max.	Min.	Std.Dev.
Amount of investment completions by type (100 million RMB) [a]					
Common residential housing	418	208	3,158	0.56	520
Villas and high-grade apartments	38	11.59	374	0.02	63
Economically affordable housing	29	19.92	294	0.06	35
New starts by type (10 000 sq.m)					
Common residential housing	1,956	1,385	10,586	15	1,855
Villas and high-grade apartments	94	48	786	0.1	125
Economically affordable housing	167	154	815	0.17	116
Housing price (RMB/sq.m)					
Common residential housing	2,716	2,081	17,151	854	2,074
Villas and high-grade apartments	4,553	3,485	28,680	830	3,388
Economically affordable housing	1,594	1,393	4,754	563	708
Interest rates (%)	5.82	5.58	7.22	5.31	0.58
Bank loans (100 billion RMB) [b]	1,627.	563	23,677	783	2,650
Material costs index (%)	102	101	115	93	4
Land supply (hectare)	5,652	3,407	106,283	11	7,988

Note: [a] Two measures of the quantity of new housing construction are used in this paper: (1) the new completions of the investment, and (2) the space of new starts.

[b] Domestic loans be obtained by Enterprises for Real Estate Development.

Before regression analysis, we conduct Levin-Lin-Chu (LLC)[33] tests and augmented Dickey-Fuller (ADF) tests for unit roots in the data series. The results are reported in Table 5.3. The LLC tests confirm that all data series of variables are stationary. But, the ADF tests show that only the data series of common residential housing completions is not stationary. Although, the level data of prices and costs variables are not stationary, changes in these variables (first differences) become stationary, which is consistent with specifications of the model in this chapter.

[33] According to Levin, Lin and Chu (2002), the LLC statistic performs well when i lies between 10 and 250 and when t lies between 5 and 250 for panel data (i, t).

Table 5.3 Unit root test results

Variable	LLC (Assumes common unit root process)		ADF (Assumes individual unit root process)		Obs
	Statistic	Prob. **	Statistic	Prob. **	
New starts					
1. Common residential	-7.215	0.000	114.62	0.001	331
2.Villas and high-grade	-11.180	0.000	119.704	0.000	321
3. Economically affordable	-4.420	0.000	90.593	0.007	318
Completions of investment					
1. Residential	-6.293	0.000	73.212	0.156	334
2. Villas and high-grade	-7.952	0.000	97.491	0.018	331
3. Economically affordable	-9.421	0.000	95.142	0.004	334
The change in prices					
1. Common residential	-9.996	0.000	151.385	0.000	307
2. Villas and high-grade	-7.952	0.000	87.491	0.018	331
3. Economically affordable	-7.112	0.000	104.665	0.000	335
The change in bank loans	-18.241	0.000	240.438	0.000	300
The change in interest rates	-17.230	0.000	192.081	0.000	310
The change in construction costs	-18.942	0.000	296.978	0.000	294
The change in land costs	-21.250	0.000	282.184	0.000	301

Note: LLC tests are designed to take care of the problem of heteroskedasticity and autocorrelation. ** denotes significance at 5% level.

Before estimating the equation, first and foremost, two issues are very necessary to address. One is the potential endogenous problem, and the other is the appropriate number of lags. This chapter uses land space released by the government of all levels as a good proxy of land regulation, which is expected to have a positive effect on new construction of housing. Since it is the decision of the local governments, this study treats it as an exogenous variable. However, there is still one explanatory variable in equation (5-1), changes in housing prices which is suspected to be endogenous. Because that the current changes in housing prices are determined simultaneously along with new construction, Δp is thus generally correlated with the error term. In this case, OLS estimates of a structural equation are not consistent. Instrumental variables of the current price are selected based on the previous studies (see Table 5.4).

Table 5.4 List of instruments of the current price

Studies	Instruments of current housing prices
1.Blackley (1999)	Real price of nonresidential construction, real personal consumption, percentage change in adult population, long-term real interest rate.
2. Topel and Rosen (1988)	Current and lagged values of interest rates on 25-years term mortgage, aggregate real consumption expenditure (as a proxy for permanent income), an index of family formation, and an energy price index.
3. Mayer and Somerville (2000a)	Current and lagged values of changes in non-construction employment, real energy prices, mortgage rates, and the number of married couples
4. This study	Current and lagged values of changes real energy prices (prices of fuels), aggregate consumption expenditure, and the size of households.

Note: summarized by the author.

In addition, considering the different duration of lagged effect, this study employs different lagged structures for variables of price and costs changes. However, it is difficult to determine the appropriate number of lags, which depends on the length of time required to obtain developed land and acquire housing permits, and builders' expectations about changes in future house prices. In China, the processes of obtaining land or acquiring permits are unobservable and differ from case to case. Thus, this study runs OLS regressions for new construction of housing with different lags for housing prices. A comparison among the indicators of AIC and Schwarz criterion being reported by different models shows that OLS regression with a lag of three years performs better than models with other lagged structure. Similar to the work by Mayer and Somerville (2000a, 2000b) and McLaughlin (2012), this study finally determines a length of lags with a period of three years to grasp the short-and-medium effect of the change in price, while considers a lag of one for costs variables.

Combining the unit root of each variable, the estimated function appears in this chapter for each housing type is as follow:

$$\begin{aligned} newconst_{i,t} &= \alpha_0 + \alpha_1 \Delta P_{i,t} + \alpha_2 \Delta P_{i,t-1} + \alpha_3 \Delta P_{i,t-2} + \alpha_4 \Delta P_{i,t-3} + \alpha_5 \Delta C_{i,t} + \alpha_6 \Delta C_{i,t-1} \\ &+ \alpha_7 \Delta r_{i,t} + \alpha_8 \Delta r_{i,t-1} + \alpha_9 \Delta land_{i,t} + \alpha_{10} \Delta land_{i,t-1} + \varepsilon_{i,t} \end{aligned} \quad (5\text{-}2)$$

Where i is an index of provinces (Beijing, Tianjin, Heibei …), while t is an index of years from 1999 to 2010. Definitions of other parameters are the same as above. All variables are in their forms of logarithm. The estimated coefficient of housing price changes can be interpreted as price elasticity of housing supply. To deal with the potential endogenous problem, equation (5-2) is estimated using an instrumental variable technique (IV)[34].

The empirical model in this study is based upon Mayer and Somerville (2000), in which new construction of housing is specified as a function of changes in house prices and costs rather than function of the levels of those variables. New construction depends on the change in housing price, changes in construction costs, and changes in the cost of capital. From an econometric perspective, this specification of housing supply will avoid spurious correlations problem. Mayer and Somerville (2000a) reports that treating starts as a function of house price changes is also consistent with the time series properties of housing stock and prices[35]. Afterwards, Mayer and Somerville (2000b) incorporate land use regulations into their original framework. Their model has been widely used in recent studies such as Jayantha and Lau (2008) and Maclaughlin (2012). Specifically, Maclaughlin (2012) firstly applied it to estimate new housing supply elasticity among dwelling types[36].

The next section discerns whether changes in land-use control, interest rates, and bank loans have an effect on housing completions or housing new starts. In addition, it makes a comparison of housing supply elasticities among housing by type.

[34] Instruments for current change in house prices are current and lagged values of changes real energy prices, long-term interest rate, aggregate consumption expenditure, and the size of households.
[35] Mayer and Somerville (2000), p.89.
[36] McLaughlin (2012) includes two types of new housing in Australia, multifamily units and single-family homes.

5.4 Estimated results and discussions

5.4.1 Estimated results

Tables 5.5, 5.6, and 5.7 presents the estimated results using equation (2) for common residential housing, villas and high-grade apartments, and economically affordable housing respectively. Dependent variables are logged completions and new starts. Multi-techniques are used for estimation. And, an AR (1) process is included to correct for autocorrelation. In addition, we pooled the province data from 1999 to 2010, which may bring about the heteroskedasticity problem. In that case, despite the OLS estimator is still unbiased and consistent, the estimated standard errors are not unreliable. Thus, we adjust our estimated standard errors using the White's standard errors to correct this bias.

5.4.1.1 *Results: common residential housing*

As reported in the first three columns of Table 5.5, the coefficients of price changes are significantly positive in the change of the current year and the subsequent one year using a method of pooled OLS for estimation. Summing up the magnitude of these significant price changes obtains elasticities of 0.58 for completions of common residential houses. This suggests that a 1% increase in housing prices leads to 0.58% increase in completions of common residential housing spread over the current and the subsequent one year. Considering the specific effects of cross sections, fixed effect estimates show that the coefficient of price changes is only significantly positive with a lag of one year. An IV approach is used to resolve the endogenous problem. TSLS estimates show that the coefficients of price changes are not significant. Employing different methods for estimation yields little difference in the estimated results.

Table 5.5 Regression results: common residential housing

Variable	(1) Log(completions of investment)			(2) Log (new starts)		
	Pooled OLS-AR	Fixed –effect -AR	TSLS -AR	Pooled OLS-AR	Fixed effects -AR	TSLS -AR
Change in price	0.31***	0.10	0.16	0.13	-0.11	0.10
	(0.10)	(0.07)	(0.21)	(0.09)	(0.06)	(0.21)
Change in price, t-1	0.27**	0.21**	0.13	0.00	-0.02	-0.03
	(0.15)	(0.1)	(0.27)	(0.12)	(0.15)	(0.27)
Change in price, t-2	-0.09	-0.04	-0.18	-0.26	-0.05	-0.28
	(0.13)	(0.1)	(0.23)	(0.12)	(0.15)	(0.23)
Change in price, t-3	-0.08	0.00	-0.13	-0.42***	-0.06	-0.42***
	(0.06)	(0.07)	(0.14)	(0.08)	(0.04)	(0.14)
Change in interest rates	0.14	0.04	0.17	0.28**	0.11	0.29**
	(0.08)	(0.06)	(0.14)	(0.12)	(0.11)	(0.14)
Change in interest rates, t-1	0.20	-0.00	0.19	-0.16	-0.78***	-0.16
	(0.10)	(0.15)	(0.05)	(0.06)	(0.11)	(0.05)
Change in the material costs	0.14	0.28	0.07	-0.21	-0.20	-0.22
	(0.31)	(0.12)	(0.50)	(0.45)	(0.3)	(0.5)
Change in the material costs, t-1	-0.06	0.12	-0.06	0.28	-0.20	0.28
	(0.35)	(0.20)	(0.32)	(0.31)	(0.17)	(0.32)
Change in the bank loan	0.10***	0.10***	0.09***	0.15***	0.17***	0.15***
	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)
Change in the bank loan, t-1	0.09***	0.08***	0.09***	0.16***	0.19***	0.16***
	(0.05)	(0.01)	(0.04)	(0.04)	(0.03)	(0.04)
Change in the land supply	0.00	-0.02	-0.00	0.00	-0.04**	0.00
	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Change in the land supply, t-1	0.00	-0.02	-0.00	0.03	-0.01	0.03
	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)
AR(1)	0.97***	0.95***	0.97***	0.99***	0.81***	0.99***
	(0.01)	(0.02)	(0.02)	(0.02)	(0.04)	(0.02)
Constant	17.31***	10.94***	17.38***	18.71	8.00***	18.77
	(6.69)	(2.78)	(12.5)	(12.62)	(0.17)	(12.48)
R-squared	0.99	0.99	0.99	0.97	0.98	0.97
Number of observations	217	215	217	217	215	215
D-W statistics	1.61	2.16	1.66	1.95	2.27	1.95
Log likelihood	112.95	-----	-----	59.95	-----	-----
S. E. of regression	0.15	0.13	0.15	0.19	0.17	0.19

Note: Dependent variables: log (completions of investment) and log (new starts). Instruments for the current change in housing price are annual expense of a household, household size, and prices of fuels. AR (1) process is used to correct for autocorrelation. White's standard errors are in parenthesis. *** denotes significance at 1% level, ** denotes significance at 5% level.

The coefficients of changes in the bank loans are significantly positive. In contrast, the coefficients of changes in interest rates, material costs, or land supply are not significant. The estimated result shows that completions of common residential housing rely on price changes and bank loan more than other factors.

The second three columns of Table 5.5 report the estimated results with dependent variable of housing new starts. The coefficients of changes in housing price are insignificant not only in the current year of the change, but also in the subsequent two years. However, pooled OLS estimates and TSLS estimates show that the changes in housing price are significantly negative with a lag of three years. Furthermore, the coefficients of changes in interest rates are significantly positive in the current year of the change using the estimation method of pooled OLS and TSLS. In contrast, fixed effect estimates show that the coefficients of changes in interest rates are significantly negative with a lag of one year. In addition, the coefficients of material costs and land supply are not significantly different from zero, while the coefficients of bank loans are significantly positive both in the current year of the change and the first subsequent year. New starts of common residential housing are sensitive to changes in interest rate and bank loans. However, the lagged effect of these variables is different.

5.4.1.2 *Results: Villas and high-grade apartments*

The first three columns of Table 5.6 show the estimated results with the dependent variable of completions. Using pooled OLS, fixed effect and TSLS method, this study obtained similar estimated results. Coefficients of changes in housing prices are insignificant in all regressions. The result suggests that changes in housing prices have little effect on completions of villas and high-grade apartments. In contrast, pooled OLS and TSLS estimates show that coefficients of interest rates are significantly positive not only in the current year of the change but also in the first subsequent year, which suggests that changes in interest rates have a significantly continuous effect on housing

completions. Moreover, the estimated results also show that changes in bank loans have a significant positive effect, while changes in material costs have a significantly negative effect on completions with a lag of one year. The result suggests that as interest rates and bank loans increase, completions of villas and high-grade apartments increase. Unlikely, as material costs increase, completions of villas and high-grade decrease sharply after one year of the change in material costs. More specifically, the speed of suppliers' response to changes in prices and costs is different. An increase in housing price, interest rates, and bank loans generate an immediate increase in housing completions or new starts in the change of the year.

In contrast, an increase in material costs only work on new construction of villas and high-grade apartments after one year of the change. The second three columns of Table 5.6 report the estimated results with the dependent variable of housing new starts. There is little difference in the estimated results compared to completions if the negative effects of changes in housing price on housing new starts can be omitted.

Table 5.6 Regression results: villas and high-grade apartments

Variable	Log(completions of investment)			Log (new starts)		
	Pooled OLS-AR	Fixed effects -AR	TSLS -AR	Pooled OLS-AR	Fixed effects-AR	TSLS -AR
Change in price	-0.14	-0.15	-0.44	-0.40**	-0.28**	-0.86**
	(0.13)	(0.1)	(0.24)	(0.2)	(0.12)	(0.31)
Change in price, t-1	-0.11	0.02	-0.38	-0.20	-0.04	-0.60
	(0.18)	(0.15)	(0.33)	(0.28)	(0.12)	(0.33)
Change in price, t-2	-0.10	0.02	-0.25	-0.03	0.17	-0.27
	(0.19)	(0.13)	(0.27)	(0.37)	(0.13)	(0.26)
Change in price, t-3	-0.04	0.15	-0.11	0.19	0.25**	0.09
	(0.15)	(0.08)	(0.19)	(0.22)	(0.10)	(0.17)
Change in interest	0.99**	0.38	1.12***	1.56***	1.19***	1.76***
rates	(1.37)	(0.38)	(0.29)	(0.42)	(0.22)	(0.45)
Change in interest	1.58***	0.07	0.61***	1.04**	0.10	1.20**
rates, t-1	(1.82)	(0.53)	(0.32)	(0.45)	(0.13)	(0.5)
Change in the	-0.18	-0.64	-0.23	-1.44	-1.74**	-1.46
material costs	(0.2)	(0.11)	(0.19)	(0.14)	(0.05)	(0.11)
Change in the	-3.23**	-2.06***	-3.23**	-3.34***	-2.82	-3.17**
material costs, t-1	(0.12)	(0.17)	(0.12)	(0.14)	(0.1)	(0.13)
Change in the bank	0.20**	0.14**	0.21**	0.49**	0.42***	0.49***
loan	(0.32)	(0.06)	(1.4)	(1.7)	(0.68)	(1.2)
Change in the bank	-0.13	0.10	-0.13	0.06	0.17	0.06
loan, t-1	(0.35)	(0.09)	(1.77)	(1.84)	(0.83)	(1.46)
Change in the land	0.08	0.04	0.07	0.13	0.05	-0.03
supply	(0.07)	(0.04)	(0.07)	(0.1)	(0.05)	(0.08)
Change in the land	-0.05	-0.04	-0.07	-0.02	-0.05	-0.03
supply, t-1	(0.15)	(0.05)	(0.15)	(0.17)	(0.06)	(0.09)
AR(1)	0.96***	0.69***	0.96***	0.88***	0.47***	0.88***
	(0.05)	(0.04)	(0.05)	(0.06)	(0.05)	(0.03)
Constant	9.18**	3.37***	9.47***	5.18***	4.16***	5.51
	(7.55)	(0.15)	(7.4)	(0.54)	(0.03)	(0.59)
R-squared	0.91	0.88	0.90	0.81	0.95	0.81
Number of observations	217	217	217	212	212	212
D-W statistics	1.96	2.09	1.97	1.77	2.28	1.74
Log likelihood	-182.44	-----	-----	-193.00	-----	-----
S. E. of regression	0.58	0.53	0.58	0.62	0.49	0.63

Note: Dependent variables: log (completions of investment) and log (new starts). Instruments for the current change in housing price are annual expense of a household, household size, and prices of fuels. AR (1) process is used to correct for autocorrelation. White's standard errors are in parenthesis. *** denotes significance at 1% level, ** denotes significance at 5% level.

5.4.1.3 *Results: Economically affordable housing*

Described in Table 5.7, changes in housing prices have little effect on both housing completions and housing new starts using estimation methods of pooled OLS and TSLS. Housing completions and new starts are insensitive to changes in housing prices. Only the fixed effect estimates show that changes in housing price have a significant positive effect on housing completions. Furthermore, fixed effect estimates also show that changes in interest rates have a negative effect on housing completions. With a 1% increase in interest rates, housing completions decrease by 0.58% after one year of the change. More importantly, economically affordable housing is sensitive to land supply, which is different to common residential housing and villas and high-grade apartments.

Although the coefficients of land supply were not as expected in advance, to some degree it suggests that houses of various types cannot be treated in the same way, especially for economically affordable housing which presents a feature of public housing but is sold as common commercialized housing. The result suggests that this type of housing relies on funds and the land supply much than the housing price.

Table 5.7 Regression results: economically affordable housing

Variable	Log (completions of investment)			Log (new starts)		
	Pooled OLS-AR	Fixed effects -AR	TSLS -AR	Pooled OLS-AR	Fixed effects -AR	TSLS -AR
Change in price	0.31	0.54***	-0.42	-0.40	-0.05	-0.94
	(0.31)	(0.23)	(0.73)	(0.23)	(0.3)	(0.92)
Change in price, t-1	-0.17	-0.04	-0.98	-0.85	-0.39	-1.45
	(0.42)	(0.23)	(0.77)	(0.35)	(0.24)	(0.98)
Change in price, t-2	-0.08	0.16	-0.65	-0.88	-0.34	-1.26
	(0.31)	(0.15)	(0.48)	(0.59)	(0.23)	(0.8)
Change in price, t-3	0.22	0.32	-0.00	-0.51	-0.28	-0.69
	(0.19)	(0.14)	(0.16)	(0.36)	(0.17)	(0.46)
Change in interest rates	-0.41	-0.58**	-0.58	-0.09	-0.22	-0.15
	(0.25)	(0.24)	(0.26)	(0.24)	(0.19)	(0.29)
Change in interest rates, t-1	0.30	-0.06	0.16	0.24	0.44	0.17
	(0.23)	(0.28)	(0.2)	(0.27)	(0.31)	(0.28)
Change in the material costs	1.51	1.39	2.05	2.19	1.56	2.32
	(1.0)	(0.4)	(1.25)	(0.66)	(0.43)	(0.74)
Change in the material costs, t-1	0.04	-0.32	0.30	1.01	-0.18	1.45
	(1.22)	(0.99)	(1.43)	(0.84)	(1.35)	(0.94)
Change in the bank loan	0.26**	0.28***	0.28***	0.50***	0.30**	0.52***
	(0.17)	(0.07)	(0.18)	(0.16)	(0.1)	(0.14)
Change in the bank loan, t-1	0.57***	0.38***	0.54***	0.47***	0.21	0.45***
	(0.22)	(0.07)	(0.21)	(0.18)	(0.08)	(0.18)
Change in the land supply	-0.22***	-0.23***	-0.22***	-0.19	-0.20**	-0.18
	(0.14)	(0.07)	(0.14)	(0.14)	(0.06)	(0.14)
Change in the land supply, t-1	-0.28	-0.25***	-0.30***	-0.33	-0.15	-0.34
	(0.09)	(0.08)	(0.09)	(0.17)	(0.13)	(0.17)
AR(1)	0.89***	0.51***	0.90***	0.85***	0.27***	0.86***
	(0.07)	(0.08)	(0.07)	(0.05)	(0.1)	(0.05)
Constant	3.00***	2.77***	3.32***	4.53***	4.64***	4.72
	(0.43)	(0.09)	(0.59)	(0.18)	(0.06)	(0.29)
R-squared	0.77	0.88	0.76	0.68	0.84	0.68
Number of observations	217	217	217	205	198	205
D-W statistics	2.30	2.09	2.23	2.34	2.15	2.27
Log likelihood	-189.15	-----	-----	-189.32	-----	-----
S. E. of regression	0.59	0.53	0.60	0.63	0.54	0.64

Note: Dependent variables: log (completions of investment) and log (new starts). Instruments for the current change in housing price are annual expense of a household, household size, and prices of fuels. AR (1) process is used to correct for autocorrelation. White's standard errors are in parenthesis. *** denotes significance at 1% level, ** denotes significance at 5% level.

5.4.2 Discussions

5.4.2.1 *Magnitude in price elasticity of housing supply*

Summing up the magnitude of these significant price changes, this study obtains the price elasticities of housing supply for each type. The estimated cumulative price elasticities of housing supply are reported in Table 5.8.

Table 5.8 Cumulative price elasticities of housing supply

Housing type	Pooled OLS estimates	Fixed effect estimates	TSLS estimates
Common residential housing	(1). 0.58	(1). 0.21	(1). Insignificant
	(2). -0.42	(2). Insignificant	(2).- 0.42
Villas and high-grade apartments	(1). Insignificant	(1). Insignificant	(1). Insignificant
	(2). -0.4	(2). -0.03	(2). -0.86
Economically affordable housing	(1). Insignificant	(1). 0.54	(1). Insignificant
	(2). Insignificant	(2). Insignificant	(2). Insignificant

Note: 1) Price elasticities of housing completions, and 2) price elasticities of housing new starts.

As described in the first row of Table 5.8, the cumulative price elasticity of residential housing completions is 0.58 and 0.21 using the pooled OLS and fixed effect method. In contrast, the cumulative elasticity of new starts is only -0.42 using the estimation method of pooled OLS and TSLS. The second row of Table 5.8 presents the estimated cumulative price elasticities of completions and new starts of villas and high-grade housing. Using different methods brings about little difference in the estimated results. Completions of villas and high-grade apartments seem to be unaffected by changes in prices, while the new starts are negatively related to changes in prices. A negative price elasticity of new starts reveals that an increase in prices may bring about a sharp decrease in housing demand which extends the increase of housing being supplied. This type of housing is widely seen to be luxury housing, which only can be afforded by high-income groups. The third row of Table 5.8 shows the estimated cumulative price elasticity of completions of economically affordable to be 0.54 when we used a method of fixed effect for estimation. However, when the other two methods are used this study

finds that not only the completions, but also the new starts are insensitive to changes in prices.

In general, the result suggests that the common residential housing and villas and high-grade apartments are more sensitive to changes in housing prices. In contrast, economically affordable housing in most cases is not sensitive to price changes. The result once again suggests that housing supply of various types cannot be treated in the same way, especially for economically affordable housing which presents a feature of public housing but is sold as common commercialized housing. The pricing of economically affordable housing is not determined according to the market condition of supply and demand.

Comparable estimates by Mayer and Somerville (2000) present an 15% increase in new construction over five quarters, while estimates by McLaughlin (2012) present an 5.4% increase in new construction of single-family units over the subsequent five quarters, and 17.3% for multi-family homes between 9 and 44 months later, after an initial delay of 6 months. Similar to McLaughlin (2012), our estimated results reveal that the effect of price changes on both housing completions and new starts varies by housing type.

5.4.2.2 *The effect of land-use control*

Since there is no single definite form of land policy, Mayer and Somerville (2000b) instead observes multiple government interventions in land and real estate markets. Zhang (2008) defines the land supply policy by the local government which changes the quota of land supply and land supply modes to regulate the relationship between housing suppliers and buyers. This study observes the space of land released by governments of all levels to examine whether land-use control has the same effect on housing supply of all housing types.

The estimated results relating to land supply reported in Tables 5.5, 5.6, and 5.7 shows that only the supply of economically affordable housing is sensitive to changes in land supply. In contrast, common residential housing and villas and high-grade apartments are not affected by changes in land supply[37].

Since the economically affordable housing, a kind of publicly provided housing is built on the land allocated being exempted from various fees and taxes by the government[38]. The supply of economically affordable housing is thus mainly affected by government decisions. In the real world, as argued by the Lincoln Institute of Land Policy (January, 2011) that '… the local government prefers offering land to the highest bidder among developers through the auction process to maximize their revenue, and they have little incentive to provide land for the construction of economically affordable housing…' As a result, the more land released by the government, the less land is available for construction use of economically affordable housing. This issue is even exacerbated by the limited scale of land reserving.

The result of this study is similar to Lai and Wang (1999) that developer's housing supply is independent of the amount of land provided by the government. They will examine economic conditions in making their housing supply decisions. This is true for at least common residential housing and villas and high-grade apartments.

5.4.2.3 *Interest rates and bank loans*

Two variables, interest rates and bank loans are used to measure the effect of the changes in financing costs and capacity of obtaining capital on housing supply. Given the estimated results reported in Tables 5.5, 5.6, and 5.7 regarding interest rates, this study finds that the effect of interest rate changes on housing of various types to be

[37] Gao et al. (2012) introduced both the variables of land costs and land supply into their model. The estimated result shows that new constructions of housing are only sensitive to changes in land costs rather than the land supply in China.
[38] In China, the government is the only owner of urban land. The governments at all levels have monopolies on urban land allocation.

obviously different. As described in Table 5.5, new starts rather than completions of common residential housing are sensitive to changes in interest rates. A 1% increase in interest rates brings about a 0.28% increase in new starts of common residential housing using the method of pooled OLS and TSLS. However, using the method of fixed effect yields different results which suggest that new starts of common residential housing decrease by 0.78% when there is an increase of 1% in interest rates. For villas and high-grade apartments, changes in interest rates have a larger effect on both completions and new starts compared to common residential housing (as described in Table 5.6). In contrast, the effect of interest rates on completions and new starts of economically affordable housing is insignificant. Only the fixed effect estimates suggest that a 1% increase in interest rates will decrease completions of economically affordable housing by 0.58%, which is smaller in magnitude than common residential housing (as shown in Table 5.7).

Generally, an increase in interest rates will increase the construction costs of developers. Some caution, however, should be exercised in interpreting the estimated results presented here since the change in interest rates can affect both demand and supply of housing. On the one hand, the cost of conducting new housing construction soars as interest rates increase for developers. On the other hand, the increase in interest rates drives up interest payment and thus decreases the needs of new homes for buyers. The reality is more complicated taking account of inflation. Investment in housing is treated as an effective way to head off inflation especially in a country like China, where people lack alternative investment channels. Limited availability of land and rising population growth will increase housing demand and hence housing in general has the potential to beat inflation easily (the Economic Times, 2012). In this case, an increase in interest rates has little effect on housing demand which is predicted to keep growing in long-term.

Most strikingly, the coefficients on bank loans which are used to measure the capacity

of obtaining additional capital for developers are significantly positive as we expected. More specifically, the effect of changes in bank loans on new construction differs by housing type in magnitude. According to the results reported in Tables 5.5, 5.6, and 5.7, changes in bank loans affect new construction of economically affordable housing more than common residential housing and villas and high-grade apartments. A 1% increase in bank loans will bring about 0.83% increase in completions and new starts of economically affordable housing in the current year of the change and the subsequent year.

The result shows that the effect of changes in bank loans is larger in magnitude for economically affordable housing than other housing. This is consistent with the fact that in China the financing of economically affordable housing depends upon funds from the housing provident fund which mainly sources from fees from land transfers.

5.4.2.4 *Construction costs*

As represented in Table 5.5, the change in construction costs has little effect on completions and new starts of common residential housing. In contrast, it significantly affects completions and new starts of villas and high-grade apartments (as described in Table 5.6). More specifically, a 1% increase in material costs causes a 3.23% decrease in completions and 3.34% decrease in new starts of villas and high-grade apartments one year after the change. For economically affordable housing, changes in material costs have no significant effect on completions and new starts of this type of housing (as described in Table 5.7).

Alternative empirical housing supply studies of Mayer and Somerville (2000), and McLaughlin (2012) find the coefficient on material costs is not statistically different from zero. This study extends the previous study by showing that the effect of an increase in material costs on new construction is different by housing type. An increase

in material costs only leads to a significant decline in new construction of villas and high-grade apartments. For common residential housing and economically affordable housing, the effect is not significant.

Although changes in prices have a significant effect on new construction of all types, this chapter finds that its effect varies in magnitude by housing type. In addition, the effect of the change in bank loans is significantly positive for all types of housing, revealing that new construction of housing in China heavily relies on the amount of capital that developers can obtain. Unlikely, the effect of the change in material costs is only significantly affect new construction of villas and high-grade apartments. An increase in material costs leads to a significant decline in supply of villas and high-grade apartments with a lag of one year. Furthermore, the effect of the change in land supply differs by housing type. It has little effect on common residential housing and villas and high-grade apartments, while it significantly affects new construction of economically affordable housing.

As discussed above in this chapter, the effect of changes in independent variables on new construction differs by housing type. Furthermore, even to the same housing type, the speed of suppliers' respond to changes in prices, costs, and land supply are also different. For example, an increase in bank loans brings about an immediate increase in new starts of villas and high-grade apartments, while an increase in material costs only affects the new starts after one year of the change.

5.5 Concluding remarks

This chapter extended the model firstly proposed by Mayer and Somerville (2000). New construction of housing by type is modeled as a function of changes in housing price, capital costs, construction material costs, land supply, and bank loans. Two

measures of new construction: housing completions and new starts were used to generate convincible results. Common residential housing is distinguished from villas and high-grade apartments and economically affordable housing.

This chapter investigated the variation of the price elasticity of housing supply among housing of various types using annual data on a panel of 31 provinces from 1999 to 2010. The result shows a significant variation in the magnitude of housing supply elasticity among various types. Common residential housing has a higher elasticity of supply, while the elasticity of villas and high-grade apartments is somewhat lower. Moreover, the effect of changes in independent variables on new construction differs by housing type. More specifically, new construction of common residential housing is mainly affected by changes in the price and bank loans. In contrast, new construction of villas and high-grade apartments mainly depends on changes in interest rates, material costs, and bank loans. However, new construction of economically affordable housing is mainly influenced by changes in bank loans and land supply. Based on the empirical evidence presented in this chapter, it is implied that housing policy should be more specific with a full consideration of variation in supply elasticity among various housing types.

Finally, it should be noted as argued by Wu, Gyourko, and Deng (2012) that data limitations make the issue on housing supply in China even harder to study and interpret because it is only since 1998 when there has been a true private market with competitive bidding and pricing of property. Quarterly data enable the time series long enough to observe the short-term behavior of the developers and to predict the new constructions in the following several years. In the future, further study on forecasting the housing constructions using quarterly data will be helpful.

CHAPTER 6
CONCLUSIONS

The conclusive chapter represents the main findings and gives implications based on the result. It also provides study limitations and some future research directions.

6.1 Summary of the Study

The thesis examined whether the housing affordability problem is caused by a less elastic housing market.

Chapter 2 investigated the housing affordability problem by employing several measurements such as the 30/40 rules, the price-to-income ratio, and the residual income approach. The analysis shows that a decent house (70 sq.m) costs a common household even more than seven years' income on average. Even the middle-income households feel pressures in buying a new home under the current housing prices and income level. Thus, Chapter 2 concludes that majority of the Chinese households are suffering from the housing affordability problem.

Chapter 3 estimated the housing supply elasticity of the Chinese housing market. It is acknowledged that the supply of housing cannot be quickly raised in a less elastic housing market to accommodate the increased housing demand that may cause by growth of population, down-adjustment of interest rates, or other driving factors. The reduced form model which amalgamated the supply equation and the demand equation into a single one is employed. The variables of housing prices depend on households' income, demographics, and the housing stock adjustment. The estimated result of the reduced model shows that the housing supply elasticity is between -0.004 to 0.819, while after considering the stock adjustment it is between -0.002 to 0.419. Apparently,

this study reported lower housing supply elasticities compared to that of developed countries, which usually vary from 0.5 to 2.8 (as summarized in Table 3.1). However, the result is consistent with most of the existing studies on the housing supply and the housing affordability problem is caused by a less elastic housing supply in China. In addition, land supply constraints and changes in housing prices are two predominant factors.

Chapter 4 and Chapter 5 examined whether the housing supply differs by region and by housing type, respectively. The urban growth model is considered superior to other models because the land is treated as different inputs from capitals and construction materials. New construction of houses is modeled as a function of changes in housing prices, changes in interest rates, changes in construction costs, and changes in land supply. Chapter 4 investigated the housing supply variation across cities and regions. The result suggests that while housing prices and the land supply are significantly positive to housing supply nationwide, the degree of influence differs by region. The price elasticity of housing supply in eastern cities and the Midland cities are higher than that in the western cities. In addition, changes in land supply play a more important role in eastern cities than in other two areas, and changes in land price only affect housing supply in eastern cities. Chapter 5 examined whether housing supply varies by housing type. The result confirmed that there is an obvious difference in the magnitude of housing price elasticities among three types of housing. The common residential houses have a higher elasticity than that of luxury housing and economically affordable housing.

This dissertation contributes to studies in the housing supply field by exploring the current housing affordability problem in China. In addition, the thesis also examined the variation in housing supply across regions and by housing type which was not mentioned in most of the existing studies. The result can be used to observe the behavior of suppliers and as a reference point for policy-makers.

Two widely used empirical models - the reduced form model and the urban growth model were employed to investigate issues of housing supply. The reduced-form model ignores the difference between land and other inputs. On the contrary, the urban growth model performs better for including land into the theoretical concept. We used it for estimating the variation in the housing supply across regions and by housing type. In spite of other models available to explore housing supply issues, using both of these two models enables us to make a good comparing with other studies.

6.2 Potential limitations and suggestions for future work

However, our analysis has several limits inevitably. Firstly, it only concerns the flow housing market due to the constraints of data availability. Covering housing stock market would make the results more convincing. Secondly, the annual time series of variables used is somewhat a little short due to the fact that the Chinese housing market is marked with a late start. As a result, the number of lags is restricted and a precise prediction is unlikelihood. Lastly, since there are no approved data on land-use regulation this study has to observe two indicators: space of land released and land costs to capture the effect of land-use regulation on the housing supply. In addition, although the endogenous problems have been addressed in this model, lacking appropriate instruments for housing prices may lower the accuracy of estimation.

We have to point out the remaining issues to be studied as follows.

1) Although the new constructions of housing take up a predominant percentage, the stock market adjustment should not be overlooked. Future work also needs to concern the housing stock market.

2) Housing markets often exhibit a high degree of volatility in both prices and the

quantity of new construction. On the supply side, construction volatility of constructions has substantial direct impacts on employment levels and the demand for raw materials. Hence, accurate forecasts of housing supply are essential for making local housing policies. The next step is forecasting construction activities in China with a consideration of the difference across regions and among housing types.

3) Facing the housing affordability problem, the Chinese government has implemented a series of policies to prompt housing supply. But empirical evidence on the dynamic effects of government interventions is still weak. Future study should pay attention to the dynamic effect of the government regulations.

4) The entire Chinese housing market consists of numerous local housing markets which interact with each other. An exploration on the spatial autocorrelation among local housing markets is suggested to seek a cure to solve the housing affordability problem.

Besides the above-mentioned, we also interested in doing comparative studies on housing supply among countries in consideration of the housing market developing level and the diverse financial conditions.

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APPENDIX

Appendix A. Housing Affordability: 1987-2011

Year	Per Capita Average Annual Disposable Income (RMB)	Floor Space of Residential Buildings (sq.m/person)	Average Selling Price of Residential Buildings (RMB/sq.m)	Price-to-Income Ratio [a]
1987	1112.38	12.74	408.18	4.67
1988	1365.51	13.00	502.90	4.79
1989	1519.00	13.45	573.50	5.08
1990	1644.00	13.65	702.85	5.84
1991	1700.60	14.17	756.23	6.30
1992	2026.60	14.79	996.40	7.27
1993	2577.40	15.23	1208.23	7.14
1994	3496.20	15.69	1194.05	5.36
1995	4283.00	16.29	1508.86	5.74
1996	4838.90	17.03	1604.56	5.65
1997	5160.30	17.78	1789.80	6.17
1998	5425.10	18.66	1854.00	6.38
1999	5854.02	19.42	1857.00	6.16
2000	6280.00	20.25	1948.00	6.28
2001	6859.60	20.80	2017.00	6.12
2002	7702.80	22.79	2092.00	6.19
2003	8472.20	23.70	2197.00	6.15
2004	9421.60	25.00	2608.00	6.92
2005	10493.00	26.10	2936.96	7.31
2006	11759.50	27.10	3119.25	7.19
2007	13785.80	28.60	3645.18	7.56
2008	15780.76	29.10	3576.00	6.59
2009	17174.65	29.80	4459.00	7.74
2010	19109.40	30.10	4725.00	7.44
2011	21809.80	31.10	4993.00	7.12

Note: Data on the average selling price of residential buildings and the average household income is reported by the National Bureau of Statistics of China.

[a] The Price-to-income ratio is calculated using the revised formula by Wu et al. (2010).