URBAN LAND SUPPLY, URBAN GROWTH, AND HOUSING PRICES IN CHINA

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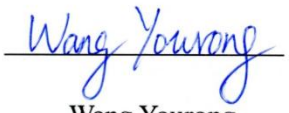
DECLARATION

I hereby declare that this thesis is my original work and it has been written by me in its entirety. I have duly acknowledged all the sources of information which have been used in the thesis.

This thesis has also not been submitted for any degree in any university previously.



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Summary

Urban land supply policy is a key part of the “reform and opening” that China initiated in the late 1970s and plays an important role in promoting both urban economic growth and housing market development. However, the policy also contributes to escalating housing prices and a lagging urbanization. There are two tasks embodied in the urban land supply policy of urban governances in the Chinese cities: to stimulate local economic growth and to generate revenue for the purpose of financing economic growth. As a result, the urban land supply policy has prioritized non-residential land uses. This research aims to investigate how the urban land supply policy, specifically the land supply pattern related to alternative land uses, has resulted in both desirable and undesirable urban outcomes in Chinese cities. I conduct this research in two stages.

A study conducted in the first stage is to investigate the impact of urban land supply on urban outcomes, including wage rates, housing prices, GDP per capita, total economic output and population size, along with the growth rates of wages, housing prices, GDP per capita, both theoretically and empirically. A two-sector urban economic model is developed, which predicts that an increase in the share of non-residential land increases urban wage rates, housing prices and output per capita, but decreases population size. The relationship between total urban economic output and the share of non-residential land appears as an inverse U-shape. Additional new land in

non-residential sectors boosts the growth rates of wages, housing prices, and output per capita. The empirical analyses, applying a cross-city dataset between 2003 and 2010 for China, support the predictions.

However, the mechanism of the effects of land-use patterns on housing prices is unknown. Do people consider the information of land supply pattern when making a home-buying decision? Therefore, in the second stage, I further explore how neighborhood urban land-use patterns influence micro housing transaction prices in Beijing. Adopting a disequilibrium hedonic model, I present the manner in which information about market activities, such as the land supply pattern related to alternative land uses, is incorporated into the process of housing prices determination through price adjustment. Applying the land transaction data between 2000 and 2010 and the housing transaction data from 2006 to 2011 for Beijing, the empirical results reveal that the shares of commercial, industrial and public service land supply in neighborhoods over the past five years have had positive impacts on Beijing's housing values.

Overall, the present research concludes that China's urban land supply policy, which has prioritized non-residential land uses for the purpose of pursuing economic growth, contributes to soaring housing prices and lagging urbanization that means the urbanization process is behind the industrialization process in urban China.

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Chapter 1 Introduction

1.1 Research background and research problems

Economic growth in China since the reforms started in the late 1970s is so remarkable that it has attracted global attention, as does the growth rate of housing prices since the housing reforms of the late 1990s. Urban land supply policy plays an important role in promoting both urban economic growth and housing market development. Aiming to stimulate economic growth, a large amount of low-cost land has been offered to the industrial and commercial sectors to attract investment by local governments. At the same time, the extra-budgetary revenues generated from land conveyance, especially from leasing residential land, have enabled local governments to finance the infrastructure investment that facilitates the expansion of the industrial and commercial sectors. The role of the residential land market is vital for developing the housing market in Chinese cities. The 1988 Constitutional Amendment that legitimized the commercialization of land-use rights enabled the transition from a welfare-oriented to a market-oriented urban housing provision system. However, urban land supply policy in China has also led to some undesirable outcomes.

Under China's current urban governance, which I introduce in detail in Section

2.2 of Chapter 2, promoting local economic growth has been one of the highest priorities of the government at all levels, and the city governments have been authorized to exercise a monopoly power over urban land supplies. Motivated by the pursuit of quick urban economic growth, China's urban land supply policy has favored non-residential land uses. Accordingly, the supply of residential land is limited and involves higher conveyance fees. As a result, residential land is under-supplied at a higher price, whereas non-residential land is over-supplied at a lower price. More explanations and evidence of this unique characteristic of China's urban land supply are given in Section 2.3 of Chapter 2.

Two research problems in the present research are linked to the above-described characteristics of China's urban land supply policy. The first problem is the existence of soaring housing prices observed in almost all of China's major cities. The literature addresses various aspects of the links between land supply and high housing prices. There are studies that suggest that rising housing land prices (Wu, et al., 2012) and the under-supply of housing land (Cai, et al., 2011) contribute to ever-increasing housing prices in Chinese cities. The present research follows this direction with a focus on the land supply structure—residential land uses versus nonresidential land uses. More theoretical and empirical evidence at both the macro and micro levels are provided. The second problem is the lagging urbanization process

observed in China[1]. Lagging urbanization means that China's urbanization rate, as measured by the ratio of urban population to total population, is behind its industrialization rate, as measured by the ratio of non-agricultural output to total output. Rising housing demand driven by rapid economic growth is mismatched to limited residential land supply. The high cost of living, especially high housing prices, prevents migrants from settling in cities. The housing shortage that has led to the escalation of housing prices has further resulted in lagging urbanization. The link between these two problems and China's land supply policy is further described in Section 2.2 of Chapter 2.

These two problems are particularly prominent in Beijing, a political, economic, and cultural center and China's capital. The most recent data show that Beijing's average price of housing in April 2013 was 13.4% higher than that in April 2012. Migrants' poor living conditions in Beijing reflect a serious problem in the urbanization process. The majority of migrants, especially migrants from rural regions, live in "urban villages" with inadequate infrastructure and services. Migrants' housing consumption behavior implies that they consider the city as a place to work rather than as a home (Zheng, et al., 2009). Beijing is also the Chinese city with the strictest government interventions in the housing market. However, despite the government's efforts to control housing prices, the growth trend remains strong. Therefore,

[1] The industrialization rate is measured by the percentage of non-agriculture output in total output, and the urbanization rate is measured by the ratio of urban population to total population. International experience shows that when the industrialization rate achieves 90 percent, the urbanization rate is usually 60 percent. However, in 2011, while China's non-agriculture output took 89.88 percent in total output, the urban population only accounted for 51.27 percent of the total population.

to address these problems, a better understanding of the links among the above problems and urban land supply policy is crucial.

The literature shows that land supply can influence housing prices at both the city level (Glaeser and Gyourko, 2003; Glaeser and Ward, 2009; Gyourko et al., 2008; Sinai, 2010) and neighborhood level (Grether and Mieszkowski, 1980; Cao and Cory, 1981; Geoghegan et al., 1997, Song and Knaap, 2004). Studies of the interrelationship between urban growth and the housing market consistently confirm the notion that stringent land-use regulations, which limit residential land supply, lead to high housing prices at the city level. Furthermore, when the housing supply is inelastic, urban growth manifests itself in terms of higher wages and higher housing prices instead of population growth (Glaeser et al, 2006; Saks, 2008).

With regard to how the pattern of different land uses in small geographic areas may have an impact on micro housing transaction prices, the literature provides inconsistent evidence. These inconsistent findings arise from the application of different measures or categories of neighborhood land uses in different studies (Mark and Goldberg, 1986; Geoghegan et al., 1997, Song and Knaap, 2004; Matthews and Turnbull, 2007). However, these findings generally suggest that neighborhood land-use patterns can influence housing values through both positive externalities such as retail proximity, and negative externalities such as traffic and visual externalities.

1.2 Objectives and research questions

This research aims to provide both a theory and evidence of the impact of China's urban land supply policy on urban growth and housing prices from both the macro and micro perspectives. Particular attention is given to the influence on housing prices of land allocation among alternative land uses. Specifically, this research has two objectives. First, I explore the impact of China's urban land supply policy on cities' outcomes, namely, wages, housing prices, GDP per capita, economic output, and population size, along with the growth rates of wage, housing prices, GDP per capita from a macro-economic view. Second, from a micro perspective, I study the question of how property values are affected by the land supply patterns of small geographic areas. Accordingly, this research was conducted in two stages: a study applying aggregated data at the city level in the first stage and a study using micro transaction data in the second stage.

In the first study, which is presented in Chapter 4, I explore the impact of the urban land supply structure—more specifically, the share of non-residential land uses—on housing prices and other urban outcomes, namely, wages, GDP per capita, economic output, and population size, along with the growth rates of wages, housing prices, GDP per capita, in context of Chinese cities. The following questions are investigated: In a city with a fixed physical size, how does the share of non-residential land uses affect urban outcomes, as indicated

by urban economic output, population size, wage rates, and housing prices? For each additional unit of land supply, how does the share of newly supplied land allocated to non-residential sectors influence the growth rates of wages, housing prices, and economic output per capita? In an attempt to answer these questions, I first develop a two-sector urban economic model that leads to the following predictions. Increasing the share of non-residential land increases urban wage rates, housing prices and output per capita, but decreases population size. The relationship between total urban economic output and the share of non-residential land appears as an inverse U-shape. Additional new land supply in the non-residential sector boosts the growth rates of wages, housing prices, and output per capita. Next, I apply a panel dataset at the prefecture city level in China between 2003 and 2010 to test the predictions. The empirical results support the theoretical predictions.

The findings of the first study imply that in a city with a higher share of non-residential land, housing prices are higher. The explanation of this effect is that the expansion of non-residential sectors creates more job opportunities, and then, generates a strong housing demand. Furthermore, residential land is under-supplied. The imbalance between housing supply and demand leads to rapid appreciation in housing prices. However, the first study cannot reveal the micro mechanism of the effect of land supply structure on housing prices. How are housing supply and demand conditions altered by land supply patterns in small geographic areas? How do the externalities associated with different land use structures affect the willingness to pay for a housing unit?

These questions are important because the positive city-level effect of non-residential land supply on housing prices, which has been revealed in the macro study, can only be achieved if buyers are willing to pay more for housing units located in neighborhoods with higher proportions of non-residential land uses. This fact motivated me to complete my research by conducting a micro study based on Beijing's land and housing transaction data.

Therefore, in the second study that is presented in Chapter 5, I further explore how land supply patterns affect housing prices in neighborhoods. The Western literature on the effects of neighboring land-use patterns on housing prices provides inconsistent evidence. Beijing, as a city that has both booming land and housing markets, provides an ideal subject to further explore how land-use patterns influence housing transaction prices in small geographic areas. I develop a theoretical framework to show how information about market activities, such as the variables of land supply patterns by usage, could be incorporated into the process of housing prices determination through a prices adjustment process. This study use Beijing's the land transaction data between 2000 and 2010 and housing transaction data from 2006 to 2011. The empirical results reveal that the shares of the commercial, industrial and public service land supply in neighborhoods over the past five years had a positive impact on housing values in those neighborhoods. After controlling for the influence of the spatial dependence problem, the impact pattern is the same, although it becomes less significant. In small geographic areas, a relatively abundant

supply of land for industrial and commercial uses creates more job opportunities and provides better amenities. The desire for access to workplaces and amenities drives up housing prices.

In general, by providing theory and evidence of the impact of urban land supply policy on urban growth and housing prices in China, the objectives of this research are achieved. The findings in both the macro and micro studies imply that urban land supply policy contributes to housing prices appreciation and lagging urbanization process in Chinese cities.

1.3 Research significance

The significance of this research can be reflected in how this research will enrich the existing literature as well as the practical implications of the findings to the problems concerned in this research.

This research contributes to the existing literature in at least three ways. First, despite the importance of the Chinese housing market, the studies on the interactions between urban growth and housing market are still limited. As is shown in section 3.2 of Chapter 3, the findings about the interactions between urban growth and housing supply are mainly drawn from the studies based on the markets of Western countries. In Western countries, the supply of land for both residential and non-residential sectors is determined by market forces. However, unlike the western countries, land supply decision is a political

decision of the local government in China. The existence of differential treatments between residential and non-residential land use in urban land supply in China challenges the traditional theories. Although it is true that differential treatments between residential and non-residential land in land supply always exist, the magnitude of the difference is manipulated by the local government in China rather than determined by market. Therefore, it is important to modify and apply the existing theories into the emerging Chinese market. In this sense, my research enriches the existing theories by providing new evidence from the Chinese market.

Second, this research extends the analytical framework of the studies on the interactions between urban growth and housing market. The literature on the interactions between urban growth and housing market usually starts with the housing supply instead of the land supply. As a result, the analytical framework does not consider the competing land uses between economic growth and housing market. Moreover, there is still no rigorous economic model with micro-foundation in this branch of literature. The macro study in this research develops a simple two-sector urban model with micro-foundation in which land is an input factor for both final consumption goods and housing sectors. Given that the focus of the research is Chinese cities where land supply policy is quite unique, the model developed here is the first model that is able to incorporate competing land uses and can be generalized to analyze the interactions between land supply and urban growth in other countries.

Third, the micro study is the first study that applies the disequilibrium hedonic framework into a Chinese housing market. Despite the convenience of the conventional hedonic housing prices model, it is inappropriate to price a property in a market characterized by disequilibrium and also serving as an investment good. To study the determinants of housing prices in a housing market, the disequilibrium factors needed to be considered. As is shown in Section 3.5 of Chapter 3, the disequilibrium hedonic framework is applicable to incorporate the impact of any market activity which can alter the demand or supply conditions of housing market into housing prices. However, it has not been applied to the Chinese housing markets where land supple pattern influences the conditions of housing market in many ways. In the micro study of this research, I modify the disequilibrium model into a framework that is capable of revealing the impact of land-use patterns on housing prices.

The findings of this research provide alternative explanations of the problems of high housing prices and lagging urbanization in China from the perspective of land supply policy. The theoretical and empirical evidence in the macro study reveal that a city with a higher share of non-residential land has higher wage rates and housing prices, but its population size mismatches its economic output size. These findings suggest that, to a certain degree, the surge in urban housing prices and the lagging urbanization process are related to China's urban supply policy. This helps in understanding a phenomenon called "cheap industrialization and expensive urbanization" in China. In the micro study, it is found that the shares of commercial, industrial, and public service land in the

neighborhood have significant and positive impact on housing transaction prices in Beijing's new housing market. These results suggest that, to address the housing prices problem in a city like Beijing, it is crucial to balance land supply among alternative land uses, even in small geographic areas. Therefore, the present research improves the understanding of housing prices escalation and lagging urbanization process in China and should be of interest to policy makers as well as academic scholars.

There are important policy implications. First, for urban land supply policy, this research reveals that the supply policy, which aims to pursue fast economic growth, may lead to some undesirable outcomes such as unaffordable housing and lagging urbanization. Second, for urbanization process, this research sheds light on how to smooth the urbanization process by increasing the flexibility in land supply. Third, for housing policy, balancing the supply structure among uses is crucial for stabilizing housing prices at both higher and lower aggregated geographic levels. Not only the city-level shares of different land uses matter, so do the geographic distribution inside a city. Last but not the least, the micro findings in this research suggest that the characteristics of land usage in neighborhoods should be considered when constructing housing prices index like any other neighborhood characteristics.

1.4 Organization of the thesis

This thesis is organized as following. Chapter 2 justifies the research problems by introducing the urban governance and urban land supply policy in contemporary China with an emphasis of a unique characteristic in land supply policy. Chapter 3 reviews the relative literature comprehensively. Chapter 4 reports the macro study titled by *Urban Land Supply Policy, Urban Growth, and Housing prices in China*. The micro study is presented in Chapter 5 and named *How Does Land Supply Pattern Affect Housing Prices in small geographic areas*. Finally, I review this research and summarize the main results, contributions, limitations and future research in a conclusion chapter.

Chapter 2 Urban Land Supply Policy in China

2.1 Introduction

Aiming to justify the concerned problems of urban land supply policy, this chapter presents a detailed introduction of urban supply policy in China. First, I clarify the objectives of urban land supply policy in Chinese cities from the perspective of urban governance. Driven by the pressure of regional competition and the incentive of promotion of local government officials, promoting economic growth has been one of the highest priorities of the Chinese government at all levels. By leasing out land use rights, a local government intends to stimulate local economic growth as well as to generate revenue to finance local economic growth by collecting land conveyance fee. Then, I introduce a big picture of land supply system in contemporary China with a focus on a distinguish characteristic in urban land supply policy, and this is local governments give priorities to non-residential land demands. Evidence of the priorities are provided and the associated problems are discussed.

2.2 Urban governance and the objectives of urban land supply

The fundamental institutions of China's reform and development are characterized by the combination of economic decentralization and political

centralization (Xu, 2010). On the one hand, the economic reforms in China initiated since the late 1970s can be viewed as a process of decentralization. The central government delegated more decision-making powers in investment approval, firm entry, revenue mobilization, and expenditure responsibilities to the lower levels of government. The result of these reforms was the "local developmental state", referring to local governments that actively promoted both public and private investments aiming at achieving greater economic growth (Zhu 2005). On the other hand, the central government's control is substantial in that the Chinese political and personnel governance structure has been highly centralized. Under the current political regime, the political legitimacy of the state largely builds on its ability to deliver economic growth (Liu, Tao, Yuan, and Cao, 2008). Performance in fostering economic growth is thus a key to the advancement for local officials as they compete for the advancement with officials from other localities. Therefore, promoting economic growth has been one of the highest priorities of the Chinese government at all levels.

To make decentralization work, local governments should not only be empowered, but also enabled (Xu, 2010). The fiscal decentralization played a very important role to enable the local governments before the mid of 1990s. The inter-governmental monetary system in 1980 divided revenue and expenditure responsibilities between the central and the provincial governments. The central-provincial fiscal arrangement experienced further changes by introducing proportional-sharing system in 1982 and the fiscal-contracting system in 1988. After that, the central government

negotiated different contracts with each province on revenue remittances to the state and permitted most provincial governments to retain the bulk of new revenues. Besides the benefits brought by fiscal decentralization, local governments also controlled local state-owned enterprises (SOEs) and were able to borrow much from the bank system so as to channel the finds to local SOEs and initiate large-scale industrial projects on their own (Liu, Tao, Yuan, and Cao, 2008). As a result, local governments not only share an average of 70% of tax revenue but also retain the remittance of enterprise profits before the middle of 1990s. Moreover, local governments could also attract investment by tax holiday policy which provided exempting taxes for industrial investors. However, when the economy was growing rapidly and some regional governments enjoyed high surpluses, the national government ran deficits and had to borrow from some provinces.

Since the mid of 1990s, China's central government has recentralized its fiscal system as well as its banking system. Tax collection was re-centralized in 1994. As a result, the share of sub-national governments' tax revenue in national tax revenue was reduced substantially from an average of 70% to 40% (Xu, 2010). Fiscal reform in 1994 also made it difficult for local governments to attract investment by exempting taxes for investors. Meanwhile, the local governments had much less access to direct financial resource through the banking system. However, that recentralization does not change local governments' expenditure obligations nor does it lessen the pressure of region competition among local governments. Consequently, local governments' losses in tax revenue were compensated by other means, such as

extra-budgetary and non-budgetary revenues, and land has become a key instrument in regional competition for investment (Liu, et al., 2008).

Table 2. 1 Income from land leases and local budget revenue (1991-2010)

Year	Land Lease Area (10 thousand hectare)	Average Lease Price (100 million per sq. km)	Land Lease Income (100 million)	Local Budget Revenue (100 million)	The Ratio of Land Income to Budget Revenue (%)
1991	0.2	1.022	101.9	2211.2	4.61
1992	1.3	2.431	500	2503.9	19.97
1993	5.73	0.713	511.2	3391.4	15.07
1994	4.94	0.756	649.7	2311.6	28.11
1995	4.31	0.803	388	2985.6	13.00
1996	3.4	0.901	349.2	3746.9	9.32
1997		0.952	428.5	4424.2	9.69
1998	6.21	1.013	507.7	4984	10.19
1999	4.54	1.155	514.3	5594.9	9.19
2000	4.86	1.253	595.6	6406.1	9.30
2001	9.04	1.451	1295.9	7803.3	16.61
2002	12.42	1.956	2416.8	8515	28.38
2003	19.36	2.834	5421.3	9850	55.04
2004	18.15	3.512	6412.2	11893.4	53.91
2005	16.56	3.522	5883.8	15100.8	38.96
2006	23.25	3.474	8077.6	18303.6	44.13
2007		5.183	13000	23572.6	55.15
2008	16.31		9600	28649.8	33.51
2009	20.9		15910.2	32602.6	48.80
2010			27000	35248	76.60

Data source: Study Center of Land Policy, Renmin University of China

The land supply system in China, which will be further explained in Section 2.3.1, makes it possible for local governments to attract investment and to raise extra-budgetary revenues by land conveyance. A large scale of low-cost land were offered to attract industrial investment and more evidence will be presented in Section 2.3.2. At the same time, the revenue from land lease did account an increasingly important proportion in total income of local governments in the past two decades. Table 2.1 presents the land lease income

and the local budget revenue from 1991 to 2010. The growth pace of the ratio of land income to budge revenue is quite remarkable. In 1991, the extra-budgetary revenue from land lease is nearly 10 billion and only is only 4.61 percent of budget revenue. It is surge to 2.7 trillion in 2010, and at the same year, the budget revenue of local governments is 3.5 trillion. This reflects that the local government increasingly relies on the income from land leases to support the expenditure (Ye, 2011).

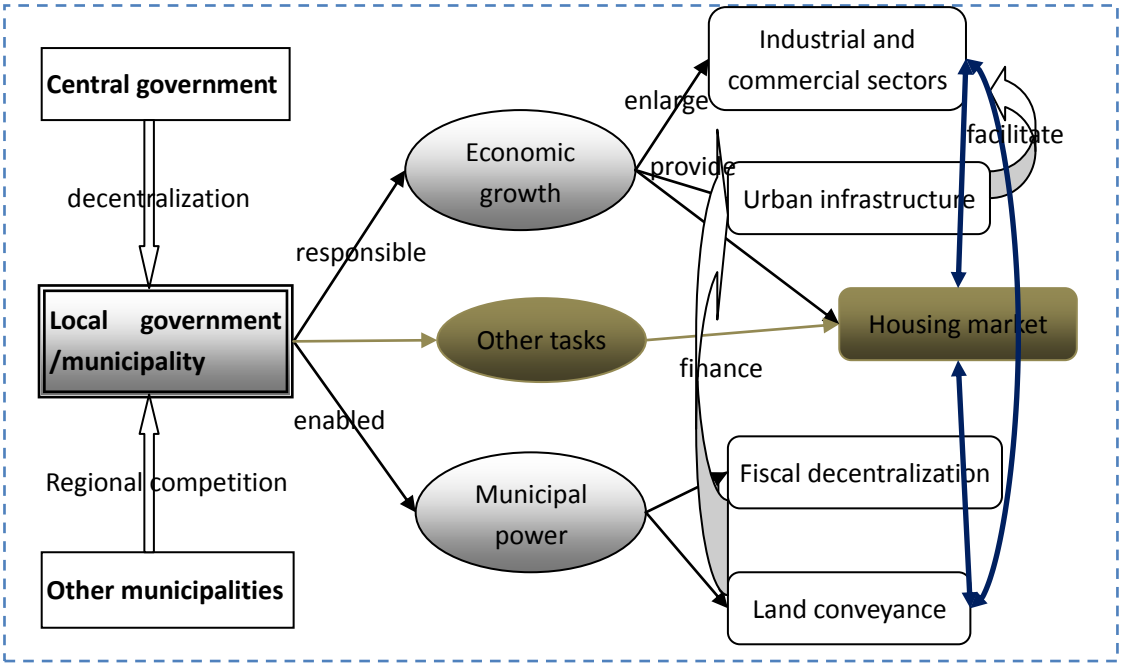


Figure 2. 1 The roles of the local government in China

Figure 2.1 summarizes the roles of the local government in China. Under the pressures both of performance valuation from central government and of regional competition from other municipalities, a local government has the incentives to promote the local economic growth. Limited fiscal decentralization and the strong control power of land supply enable the local government to finance the infrastructure investment which facilitates the

expansion of industrial and commercial sectors. This is not the full story. If the municipality only takes the responsibility of economic growth, regional competition creates powerful positive incentives to local government's officials to allocate resources efficiently. However, when the government's task is expanded to many other potentially conflicting tasks, such as managing inequality, protecting environment, and maintaining social stability etc., regional competition may create strong negative effects (Xu, 2010). Take housing market as a sample. If the local government ignores the social security function of housing and just treats the house as a localized product, the land for housing construction is definitely more expensive than land for manufactory. Unfortunately, it is true in Chinese cities.

Implied by Figure 2.1, two objectives are embodied in the process of land supply. By leasing out land use rights, a local government intends to stimulate economic growth by expanding industrial and commercial sectors, meanwhile, to generate revenue to finance local economic growth. The first aim implies low price of non-residential land to attract foreign and private investment, while the second one implies a local government should charge land, especially residential land, at a price as high as possible. These two objects that local governments try to achieves lead to significant differential treatments between residential and nonresidential land supply which will be further discussed in the next section.

2.3 Urban land supply policy in China

2.3.1 Land supply system in China

The Chinese Constitution stipulates two types of public ownership of land in China. All urban land is owned by the state and rural land is owned by rural collectives. Administrative allocation had been the only approach of urban land allocation and rural land was owned and operated by the Production Team under the commune system before land reform. The reform was initiated from rural areas. In 1978, the household production responsibility system was introduced. In late 1980s, the traditional administrative allocation of urban land was abandoned and a dual-track land system emerged in Chinese cities, in which administrative allocation of land for state units or nonprofit users coexists with the conveyance of land for commercial users. After three decades' reform, an extremely complicated land supply system formed. Lin and Ho (2005) provide a comprehensive introduction of land system in contemporary China . Here I briefly review it based on my understanding and show the big picture of land supply system in contemporary China as illustrated by Figure 2.2.

The rural collectively-owned land is either contracted to individual farm households for agricultural production. The rural collective also has the authority to allocate rural construction land within the rural collective sector for use as public welfare undertaking, township and village enterprises (TVEs), and housing sites for its members. With the growing importance of rural

industrialization, the value of construction land is increasingly attractive to conversion the agricultural land to construction land. For the consideration of food security and environmental sustainability, however, the state has imposed considerable constraints over the conversion of agricultural land to non-agricultural use. The conflictual interests of rural economic growth and national food security lead to active illegal land conversion and transaction, which is under intensive study in China and I label it as "Focus I" in Figure 2.2 (refer to "Black Market I" in Lin and Ho, 2005).

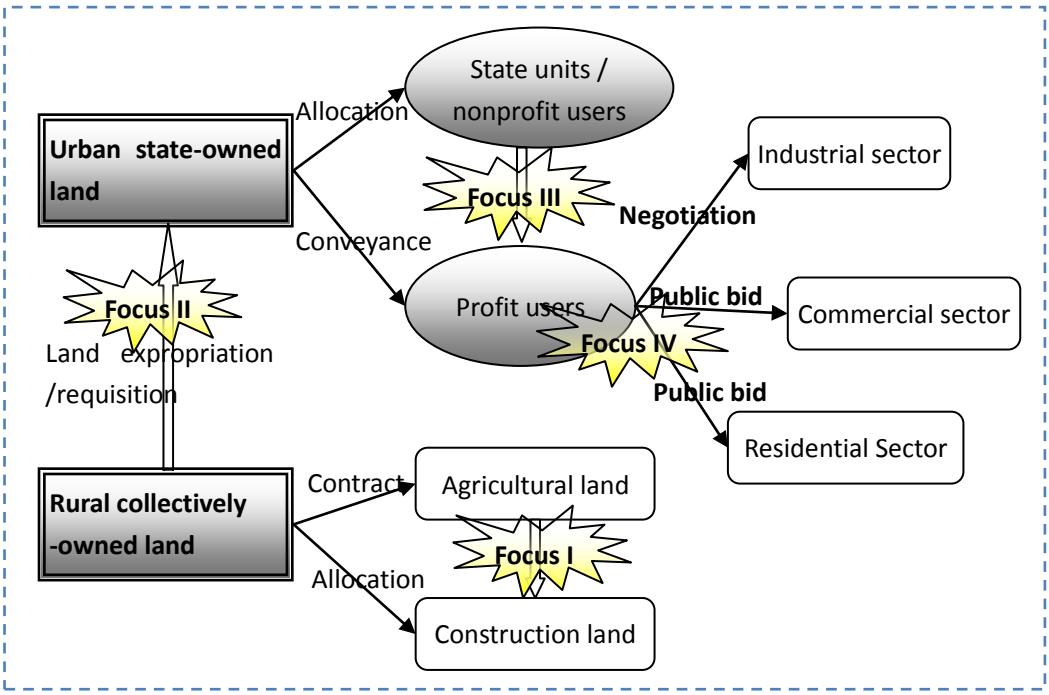


Figure 2. 2 Land supply system in China
(modified from Lin and Ho, 2005)

Under the China's Constitution, the state has the right to expropriate collectively owned land if it is in the public interest, and the state expropriation is the only way to shift land from the rural collective sector to the urban state. While the national annual land-utilization plan set the overall

limits, actual control was left to a hierarchical administrative system consisting of state agencies at various administrative levels to review requests for conversion. State agencies at various local levels had a strong revenue motive to expropriate rural land as much as possible for conveyance to commercial users for urban developments. To curb the shrink of cultivated land, in 1998, the central state revised the Land Management Law and regulated that all expropriation of agricultural land now require state approval at the provincial level or higher. However, this new rule has also been subject to local manipulations (Lin and Ho, 2005). The endless negotiation and contest among the state agencies at various administrative levels on land expropriation and the related issues, such as protection of arable land, corruption, and social discontent, have attracted global attention, as well as the interest of researcher, which is labeled as "Focus II" in Figure 2.2 (refer to the "Black Market II" in Lin and Ho, 2005).

Urban land in China is characterized by the dual-track land system. Article 10 of the Constitution in 1988 separates land ownership from land use rights which legitimizes the commercialization of land use rights. Land use rights are now assigned in two ways: administrative allocation of land for state units or nonprofit users without time limits, and conveyance of land use rights for profit users for a fixed period—70 years for residential uses, 50 years for industrial or mixed uses, and 40 years for commercial uses. The first land auction took place in Shenzhen in 1987, even before the 1988 Constitutional Amendment. Since then, the emergence of the urban land market in China has played an active role during the process of economic growth. However, due to

the significant difference between “allocation price” and “conveyance price”, this dual-track land system has turned out to be one source of corruption and other problems. Massive and uncontrolled land development occurred as it created profitable asymmetry between the two tracks for arbitrage. I label this as “Focus III” in Figure 2.2 which is also a hot topic in China (refer to the “Black Market III” in Lin and Ho, 2005).

There are two ways to lease out land use rights. One is by negotiation (Xieyi), and the other is by public bid. For public bid, there are three forms, tender (Zhaobiao), auction (Paimai), and list (Guapai). Leasing by negotiation refers to a one-to-one negotiation about leasing terms, prices, etc., between land users and a local government. Negotiation is the least transparent approach and the prices are usually very low. In the 1990‘s, most of land transactions were completed by negotiation in a hidden process. Discontent with corruption in urban land markets prompted a series of reforms and a 2002 law banned negotiated sales by land bureaus, with the last date for any negotiated sales being August 31, 2004. All urban land for profit users could only be transacted through public bid, with details of all transactions posted to the public on the internet. However, even after that a large scale of land for manufacturing purpose was still leased out through negotiation (Cao, Feng, and Tao, 2008). Moreover, pubic bid is also subject to corruption (Cai, Henderson, and Zhang, 2010). I believe lease of land use rights, also called urban land supply, could be regarded as “Focus IV” in Chinese land system and still call for more serious and systematic investigations. This is the focus of this research.

2.3.2 Priorities in urban land supply policy

As revealed in Section 2.2, the decision of urban land supply is driven by the incentive of pursuing local economic growth as well as generating extra-budgetary revenue. Chinese local governments profit from their monopolistic position in urban land market through manipulating land supply. Subsequently, the total amount of land supplied and the land allocation among competing land uses are politically decided, resulting that the land for housing is under-supplied at a higher price, whereas the land for non-residential use is over-supplied at a lower price. There are abundant evidence of the priorities that are given to non-residential sectors in urban land supply in China.

Firstly, since land was a key factor in regional competition for investment in the mid of 1990s, local governments have allocated abundant cheap land for industrial uses to attract both private and foreign investments. For example, by the end of 2003, there were already 3,837 economic development zones and industrial parks set up by the different levels of local governments across the country, and the figure further jumped to an astonishing 6,015 by the end of 2006 (Zhai and Xiang, 2007). The rental level is usually lower than the average cost of land requisition and land preparation. The rent is less than half of the cost in one quarter of the China's economic development zones (Tao, Lu, Shu and Wang, 2009). For example, in ZheJiang province, China, the average cost of land requisition and land preparation was RMB1.5m per hectare, whereas the average leasing price was less than RMB1.3m per hectare in the early 2000s (Huang, 2007).

Table 2. 2 Land supply in the China's urban area, categorized by alternative land uses

Area (unit:Ha)					
	total	commercial	industrial	residential	others
2003	193,604	39,082	99,435	43,323	11,764
2004	181,510	33,798	89,788	48,677	9,247
2005	165,586	23,268	90,512	43,675	8,131
2006	233,018	25,394	144,452	55,016	8,156
2007	234,961	26,975	135,629	66,575	5,782
2008	165,860	21,802	86,414	51,507	6,136
total	1,174,539	170,319	646,229	308,774	49,216
	100.00%	14.50%	55.02%	26.29%	4.19%
Land revenue (unit: Million RMB Yuan)					
	total	commercial	industrial	residential	others
2003	542,131	138,622	124,732	258,990	19,787
2004	641,218	182,041	118,438	326,032	14,706
2005	588,382	147,407	125,001	296,935	19,039
2006	807,764	167,234	172,239	452,913	15,378
2007	1,221,272	234,950	211,020	753,088	22,214
2008	1,025,890	241,629	174,242	591,171	18,848
total	4,826,657	1,111,883	925,672	2,679,129	109,973
	100.00%	23.04%	19.18%	55.51%	2.28%

Data source: China land and resources statistical yearbook (2004-2009)

Secondly, the land for industrial use takes the largest portion in new land supply but contributes the least to the local land release revenue, whereas the residential land takes a much smaller portion but contributes the most to the local land release revenue. Table 2.2 illustrates the pattern of competing land uses between residential and non-residential land uses in China from 2003 to 2009. In terms of land size, industrial land use, on average, represents the largest portion with 55.02 percent of the total new land supply; residential and commercial land uses accounted for 26.29 percent and 14.5 percent, respectively. Combining industrial land use with commercial land use, the land designated for non-residential use accounts for almost 70% of the total new land supply. However, the land revenue generated from non-residential land use contributes much less to the total land revenue. Between 2003 and 2009,

the revenue from industrial land releases accounted for 19.18% of the total land revenue and the revenue from commercial land releases was 23.04%. Meanwhile the revenue from residential land uses was 55.51% despite the fact that only a quarter of the new land supply was released to the residential sector. After adjusting by the difference in land lease tenures, which are 50 years, 40 years and 70 years for industrial, commercial and residential land, respectively, the average price of residential land almost equaled the average commercial land price and was 3.5 times the industrial land price.

Moreover, during the investigation period, a portion of the land used for manufacturing purposes was leased through negotiation, with the final prices being significantly lower than auction, whereas negotiation was forbidden in residential land transactions. Although negotiation was not allowed in the transactions for commercial land uses, the portion of commercial land was too small to change the pattern of competing land uses. Between 1993 and 1998, 89 percent of the total new land supply was leased out via negotiation and only 11 percent was transacted by auction (Ho and Lin, 2004). Because negotiation was publicly criticized for resulting in corruption (Cai et al., 2009), in 2004, the central government required both residential and commercial land uses to be transacted through auction, open bidding or listing. Since that time, the portion of land leased out via public auction, bidding, or listing increased dramatically, from 29.16 percent in 2004 to 88.27 percent in 2010[2]. However, most of the industrial land was still leased out through negotiation (Cai et al.,

[2] Calculated from the CEIC data sets. Source: http://ceicdata.securities.com.libproxy1.nus.edu.sg/cdmWeb/dataManager.html?languageCode=en

2011; Cao et al., 2008).

Thirdly, the land supply for non-residential uses is more elastic with respect to both GDP growth and population growth, while the land supply for housing is relatively inelastic. As newly supplied land data categorized by land uses at the prefecture city level are not available, I use the stock data of land areas to calculate elasticity. Table 2.3 reports the results. Between 2003 and 2010, the elasticities of the residential and non-residential land supply with respect to real GDP are 0.615, and 0.672, respectively. The elasticities of residential and non-residential land with respect to population size are 0.871, and 0.915, respectively. When only industrial land supply is considered, the elasticity reaches 0.798 with respect to real GDP and 1.054 with respect to population size. Therefore, the supply of both industrial land and non-residential land are more elastic than that for residential land in terms of the urban growth indicators.

Last but not the least, the literature consistently argues that industrial land is over-supplied at a lower price and residential land is under-supplied at a much higher price in China. Cao et al. (2008) revealed the practice of urban land supply in China. While city governments limited the land released for residential uses and released the land lots by auction or tender at much higher prices, a majority of the land for manufacturing purposes was leased out by negotiation and usually at much lower prices. Tao et al. (2009) suggested that the regional competition between cities in China increased the supply of non-residential land and reduced the supply of residential land. They define

this pattern as “cheap industrialization” because the local governments provided cheaper land to attract private and foreign investment and to speed the industrialization process. Following the evolution of the national land use structure from 1981 to 2008, Cai et al. (2011) found that in the first two decades, the residential land supply was increasing at a greater rate than the industrial land supply. However, between 2001 and 2008, the industrial land supply increased rapidly and the share of residential land in urban areas saw a decline.

Table 2. 3 Elasticities of residential, industrial, and non-residential land with respect to GDP and Population

	Residential	Industrial	Non-residential
GDP	0.615	0.798	0.672
Population	0.871	1.054	0.915

Notes: 1. Calculated from stock data of prefecture cities during the time period of 2003 to 2010;
2. Using real GDP value adjusted by inflation rates based on 2003’s price.

Literature has suggested that the China’s urban land supply pattern identified above has resulted in a series of negative consequences. Rising residential land prices (Wu et al., 2012) and an under-supply of residential land (Cai et al., 2011) contributes to soaring housing prices. Moreover, there is an argument that the differential treatments in land supply policy, which also results in overinvestment in the manufacturing sector and speculation in the real estate market, may have contributed to the observed real estate bubbles, leading to macroeconomic instability (Cao et al., 2008). Housing shortages and poor living condition for particular groups of people such as rural migrants in the cities, have become obstacles in the process of urbanization. The lagging process of urbanization in China suggested by the literature might be also

associated with the urban land supply policy (Au and Henderson, 2006; Wang, 2010). In addition to advocating for the release of migration restrictions, scholars also call for greater attention to the interrelationship between land development and urbanization in the ongoing transformation of the Chinese political economy (Lin and Yi, 2011). However, these studies lack of both theoretical underpinning and empirical evidences.

2.4 Summary

A dual-task is embodied in the urban land supply policy in China, which is to stimulate local economic growth and to generate revenue to finance economic growth. As a result, local governments in China give priorities to non-residential land demands in the decision of land supply. This research aims to examine how this land supply policy associates with the problems of high housing prices and the lagging urbanization process in Chinese cities. In the next chapter, I will review the related literature thoroughly to show the theories, evidence and methodologies that support this research.

Chapter 3. Literature Review

3.1 Introduction

The literature review includes two parts. Firstly, I focus on the literature regarding the interrelationships between urban growth and housing market. Land supply is the most fundamental factor of housing supply, as drawn from the studies of determinants of housing supply elasticity, it is rational to study the interactions between urban growth and housing supply from the aspect of urban land supply policy. In this sense, literature on the interactions between urban growth and housing market and the studies on determinants of housing supply elasticity are critical for my first stage research—the study of the impact of urban land supply policy on urban growth and housing prices in China from a macro perspective.

Secondly, my micro study is built on two bodies of literature. One is the particular studies on the effects of land uses controls on housing prices which have revealed the evidence that the pattern of land supply by different land uses in small geographic units has effects on housing prices. However, these empirical studies usually are conducted without a solid theoretical framework. The other is the literature on hedonic analysis of housing market in disequilibrium. The disequilibrium hedonic model enable users to capture the influence of market activity indicators, like mortgage interest rate, on

transaction prices and quantities, but has not been applied to Chinese housing market. Combining of these two strands of literature aid me to test the hypothesis that land supply pattern in small geographic units may impact micro transaction price of a house as a disequilibrium factor.

In this chapter, literature specializing in the interactions between urban growth and housing market is reviewed in Section 3.2, followed by a review of studies on of determinants of housing supply elasticity in Section 3.3. Section 3.4 presents the findings of the literature on the contributions of neighboring land pattern to housing prices. Then the development and the application of a disequilibrium hedonic model of housing market is reviewed in Section 3.5. The limitations of each stream of literature will be discussed in each section respectively. Finally, a summary of the literature and the gaps that I am trying to fill is given in Section 3.6.

3.2 Interactions between urban growth and housing market

The existing literature regarding the interplay between urban growth and the housing market has significantly improved the understanding of housing market dynamics in the past few decades (Sinai, 2010) and provided insights on how housing market conditions influence the process of urban growth (Glaeser and Gyourko, 2005; Glaeser et al., 2006; Saks, 2008). In this section, I review the studies of the interactions between urban growth and housing market from two aspects. One is urban prosperity brings challenges to housing

market, and another is how conditions of housing market, especially housing supply conditions affect urban success.

Urban growth brings prosperity as well as challenges to the real estate market (Sinai, 2010). As the focus of this research is related to the urban problems like high housing prices, the possible challenges are more concerned in this research. There are four challenges. First, housing supply is increasingly inelastic with the prospect of urban growth (Saiz, 2008; Gyourko, 2009). Urban growth attracts people to cities, increasing housing demand. At the early stage of urban growth, when the land is still plentiful, a city is able to build sufficient new housing units to satisfy new immigrants. Housing prices increase slowly and housing stock expands relatively quickly. The housing supply becomes more inelastic over time as the city continues to grow and land becomes scarcer. With the increasingly inelasticity of the housing supply, a positive housing demand driven by urban growth is capitalized into land rents and housing prices.

Second, there is a growing dispersion in housing prices across cities (Sinai, 2010; Gyourko, Mayer and Sinai, 2006). With the increasingly inelasticity of housing supply, positive demand shifts from urban growth are capitalized more into the land rents and housing prices. As the urban success manifests itself more in term of higher wages and housing prices, instead of expanding population, the composition of population will change because higher income householders outbid the lower income householders in some attractive cities that so called “superstar cities”. So the combination of inelastic housing

supply in superstar cities with an increasing number of high-income households explains the ever-widening gaps in housing values as well as income across cities.

Third, the concern regarding housing affordability has been a byproduct of global urban growth. Voith and Wachter (2009) and Sinai (2010) address the potential conflicts between urban growth and housing affordability. They conclude that over time, urban growth undoubtedly reduces the supply of affordable housing; housing prices in some urban areas in United States, for example, have grown increasingly unaffordable to a typical household. Studies in the Chinese housing markets also show that housing affordability is now one of the primary urban issues in China (Bertaud, 2009; Zheng et al., 2009).

Last but not the least, urban growth is always accompanied by the transformation of industrial composition. This transformation in industrial composition brings changes in market demand for real estate assets because of land is an immobile factor which is critical to both business activities and housing production. Therefore, a city's prospects for prosperity and even survival are determined by how flexible the same piece of land is adapted to changing market demand (World Development Report, 2009).

Regarding the influence of the housing market on urban growth, one key conclusion is that the conditions of the housing market, primarily the elasticity of residential land or housing supplies, may partly determine urban success. The linkages between flexibility of housing supply and urban growth is

well-studied (Glaeser and Gyourko, 2005; Glaeser, Gyourka and Saks, 2006; Saks, 2008). First, from a dynamic perspective, the durability of housing makes the housing supply more inelastic when the market facing a negative demand shock than facing a positive shock (Glaeser and Gyourko, 2005). The finding is supported by two observations. One is the city growth rates are skewed so that cities grow more quickly than they decline, and another is while positive shocks increase population more than increase housing prices, negative shock decrease housing prices more than they decrease population in the cities with housing prices is already lower than construction cost.

Second, the empirical framework proposed by Glaeser, Gyourko, and Saks (2006) predicted that the elasticity of housing supply which represented by density of housing units and regulatory environment helps determine the extent to which increases in productivity will create bigger cities or just higher wage rates and higher housing prices. Their empirical tests confirmed the predictions. In places with elastic housing supply, urban success was more likely to take the form of higher population levels. In contrast, in places with inelastic housing supply, urban success was more likely to leave population levels relatively unchanged while leading to higher levels of housing prices and income.

Moreover, Saks (2008) explored the impact of housing supply elasticity on local labor market and got consistent conclusions. Using information on the restrictiveness of land use regulation in each location to evaluate the responsiveness of the housing supply in individual metropolitan areas in USA,

he found that locations with a larger degree of housing supply regulation experienced less residential construction and larger increases in house prices in response to an increase in labor demand. In the long run, an increase in labor demand results in considerably lower employment in metropolitan areas with a low elasticity of housing supply. Findings in Saks (2008) also suggest inelastic housing supply will slow down urban growth as labor market expansion is an important aspect of urban growth. Therefore, as regards the influence of housing market on urban growth, the key conclusion is that the conditions of housing market, mainly the elasticity of housing land or housing, help to determine urban success.

To sum up, literature on the interplays between urban growth and housing market shows positive growth-shocks to a city manifest themselves in two ways. One is in terms of expanding population and homebuilding, and the other is in terms of higher wages and house prices (Gyourko, 2009). Which one will dominate over another depends on the elasticity of the housing supply. However, though as literature on determinants of housing supply in next section shows that the availability of land for housing construction determines the elasticity of housing supply (Glaeser, Gyourko and Saks, 2006; Saks, 2008), these analyses always start from housing supply instead of land supply. This inspire me to construct a more general model to predict the impact of urban land supply on urban growth and housing prices. However, incorporation of land supply will complicates the analyses because there are competing land uses between urban growth and housing supply. Land is an immobile factor with limited amount which is critical to both economic

activities and housing production in a city. Fortunately, the spatial equilibrium assumption and unique institutional environment in China help to simplify the framework and make it possible to fill the literature gap of overlooking competing land uses between urban growth and housing supply.

3.3 Determinants of housing supply

The determinants of housing supply have been revealed clearly and carefully. Dipasquale (1999) provides an excellent overview of the empirical research on housing supply to that day, and Gyourko (2009) reviews recently development in this research direction due to improved data combined with heightened interest in policies such as land use regulations respectively. Instead, I focus on studies which figure out the factors that restrict housing supply from adjusting elastically to the changes in housing prices and housing demand. The four key elements that determine the differences in the elasticity of new housing construction are land use regulations (Glaeser, Gyourko, and Saks, 2006; Saiz, 2008; Saks, 2008), construction cost (Gyourko and Saiz, 2006), topography constrains (Saiz, 2008), and "home-voter" hypothesis (Sinai, 2010). In this section, I first review these four conventional determinants, then emphasize that inelasticity of housing supply is rooted in the truth that the land resource is limited and housing land supply dominates housing supply. Literature on the determinants of housing supply elasticity which reveals land supply is the most fundamental factor rationalizes the need to examine the interactions between urban growth and housing market from the perspective of urban land supply policy.

Land use controls in general, and zoning in particular, have been applied to deal with the negative externalities which exist in urban land market or to produce efficient development patterns (Mark and Goldgerg, 1986). For example, development fee and urban growth boundary are introduced to internalize the positive externalities associated with the presence of greenspace and to reduce the fiscal externalities associated with providing infrastructure for public services to low density region (Turnbull, 2004). Though the efficiency of these land use regulations are still on debate, they undoubtfully reduce the quantity of land for development and impose restriction for land usage. Therefore, land use regulations partially explain a remarkable combination of increases in housing prices and decreases in new construction experienced in many US cities (Glaeser and Ward, 2009). Because the parameter of elasticity of housing supply is not easy to observe, it is tradition to use the information about the restrictiveness of land use regulations to proxy the elasticity of housing supply (Glaeser, Gyourko, and Saks, 2006; Saiz, 2008; Saks, 2008). There is a lengthy literature and an emerging consensus that local land use regulation has become a binding constraint on the supply of new housing units in certain markets and that this is leading to increased prices in the most constrained markets. There certainly is less of a consensus on the magnitude of the impact, but improved data and research designs hopefully will change that situation for the better in the near future.

Construction costs still account for the bulk of the price of new housing units in most markets though it does not play a important role as land cost in rising

in real housing prices. Moreover, construction costs affect elasticity of housing supply asymmetrically. Gyourko and Saiz (2006) point out that construction costs, too, vary considerably across metropolitan areas in U.S. Though the variation in the construction costs cannot account for the variation across cities, the elasticity of supply in a market depends on the relationship between real estate prices and construction costs. The reason is that new supply is constructed only when real estate prices are in excess of their cost of construction, so developers can make a profit. When prices are below construction costs, supply is inelastic. Because of the durability of housing, Glaeser and Gyourko (2005) argue that, real estate supply is much more inelastic when prices are not high enough to justify new construction than when prices are above construction costs.

With the improvement and popularization of geographical information systems (GIS) technology, the topograghic constrains have become more and more measurable. When much of a metropolitan area's footprint is steeply sloped or under water, it is more expensive to build new structures, leading to a lower elasticity of supply. Using geographical information systems (GIS) technology, Saiz (2008) computes the fraction of developable land in each metropolitan area. Providing a careful measure of land availability across all major metropolitan areas is a very useful contribution in its own right, and the paper's impact will be greater to the extent it can show that this is an exogenous measure that impact housing supply. When think about useful instruments for research, careful consideration will have to be given to a number of issues. For example, is land availability really orthogonal to

demand factors? Oceans and hills are thought to be amenities, too. This general concern is compounded by the general equilibrium issue of where people end up living. If they are residing in some place that is hard to build in, there well may be something else that is good about the location. Much more work needs to be done to establish the quality of the instrument, but the promise is great and more research on this issue is needed.

Because the political decision-makers are typically also property owners, the home owners in the location with higher inelasticity housing supply have more incentives to support the investment the amenities and public services because this kind of investment decision is more likely increase their property values (Sinai, 2010). Moreover, the home owners in the location with higher inelasticity housing supply are more likely to start-up more strict land use regulations, because they can get capital appreciation in their real estate. This is so called “home-voter” hypothesis. Sinai (2010) also show the mechanism of “home-voter” hypothesis has grown in importance as more areas have become inelastically supplied.

Most importantly, the four factors listed above are linked with each other and cannot explain the phenomenon that new housing supply has become more inelastic over time separately. To evaluate the conditions of housing supply in a certain location, we should consider the impact of combination of these four factors. However, it is obvious that the reason these four factors restrain housing supply elasticity is that the land resource is limited. Literature on the determinants of housing supply elasticity suggests that inelastic housing

supply is rooted in inelastic land supply. Therefore, the rationale I study the urban growth and housing prices escalation from the perspective of land supply policy is land supply dominates housing supply and both housing development and urban growth demand for land.

3.4 The effects of neighboring land uses on housing prices

With the prevalence of the practice of land use controls, the impact of zoning which advocates separated land uses or New Urbanism which suggests mixing land uses on housing values cause the interests of the researchers (Grieson and White 1981; Mark and Goldberg, 1986; Chung, 1994; Rossi-Hansberg, 2004; Turnbull, 2004). Though the effectiveness and efficiency of land use controls are still under debate, the findings on the effects on property values do suggest that land-use patterns can influence housing values in the surrounding area (Grether and Mieszkowski, 1980; Cao and Cory, 1981; Geoghegan et al., 1997; Song and Knaap, 2004; Matthews and Turnbull, 2007).

Literature which directly question whether property values are related to the pattern of land use development in the immediate neighborhood in which the house is located can been tracked back to 1980s. Grether and Mieszkowski (1980) employ data from 16 market experiments in the New Haven, Connecticut, metropolitan area to exam the effects of nonresidential land uses on the prices of nearby single-family dwellings. The results are mixed. It is supported that the industrial zone is a disamenity, but the prediction for

commercial zone is less clear. The effects of the public housing zone which is dominated by high-density dwellings are negative in some markets, but the results are reversed in others. Though no systematic relationship between nonresidential land use per se and housing prices was found, this study sets a precedent in this subject.

Cao and Cory (1981) reveal that though the effects of non-residential activities on residential property values are depend on the relative strength of associated positive and negative externalities theoretically, the careful empirical study using data from Tuscon, Arizona shows that increasing the amount of industrial, commercial, multifamily, and public land uses in a neighborhood tends to increase surrounding residential property values. Their results imply that mixing land uses in residential neighborhood need not lead to a depression of residential property values, as concerned by advocators of zoning. It is concluded that an optimal mix of land uses activities should be sought rather than the regional separation of activities.

The findings in Mark and Goldberg (1986) challenge the effectiveness of zoning that separates different land uses too. Employing a virtually unique data base for Vancouver, Canada to exam the ways in which various zoning classifications and land uses affect the sale prices of single-family residences over a 24-year period, they find that while there are impact, they are consistent in neither direction nor magnitude. Particularly, their findings show that non-single-family land uses often positively affect single-family housing values and land price is raised by zoning changes which allow higher densities

and different uses. Therefore, the use of zoning to control the effects of the presumed externalities associated with non-residential land uses may not be justified.

More recently, Geoghegan et al. (1997) test the hypothesis that the value of residential land is affected by the pattern of surrounding land uses. Data from the central Maryland region in Washington DC are employed and two spatial landcape indices which representing diversity and fragmentation of land uses are developed. They add these variables into hedonic price models and find that these indices are significant in the models though the marginal contributions to selling price of increased diversity and fragmentation changes vary in different landcape settings (urban, suburban, rural). The results in Geoghegan et al. (1997) suggest that land and housing values could be explained more completely by including two of the landcape indices that capture capturing how individuals value the diversity and fragmentation of land uses around their homes.

Started from the beginning of this century, mixing land uses as one of the key principles of the Smart Urban Growth became a popular concept and researchers started to investigate the effects of mixing land uses on property values. Song and Knaap (2004) first develop several quantitative measures of mixed land uses via Geographic Information System. After controlling the influences of other six sets of characteristics: physical housing attributes; public service levels; location; amenities and disamenities; socio-economic characteristics; and neighborhood design features, they estimate the

contributions of these measures of mixed land uses to single-family home values. Specifically, Song and Knaap (2004) find that housing prices increase with their proximity to—or with increasing amount of—public parks or neighborhood commercial land uses. Housing prices also increase if the neighborhood is dominated by single-family residential land use, or if non-residential land uses were evenly distributed in the neighborhood, or if there are more service jobs available in the neighborhood.

Matthews and Turnbull (2007) evaluate mixed land use by focusing on the relationship between neighborhood street layout, retail proximity, and property value. Data sets from King County, Washington are used and two different methods of indexing street layout are employed. They find that the positive effect of accessibility outweighs the negative externality effect from retail sites. They also show that street layout has a significant impact on price, but the conclusion are sensitive to the method used to measure neighborhood street connectivity. These findings imply that the estimated net advantages or disadvantage mixed land-use patterns are sensitive to how street layout is measured, and then sheds doubts on the claim that mixed land use can address market failure associated to highly segregated land uses.

The studies reviewed above all apply hedonic pricing model when study the effect of land uses pattern on housing prices. Application of hedonic pricing model assuming the housing market adjusts quickly in the short run to achieve

an equilibrium (Lancaster, 1966; Rosen, 1974) in housing research are widespread because of its beauty to deal with the valuation problem of differentiated durable consumptive products (Harrison and Rubinfeld, 1978; Witte, et al., 1979; Liao and Wang, 2012). However, as mentioned in the introduction section, a house may also serves as an investment good for a homeowner (Henderson and Ioannides, 1983, 1986) and the housing market is characterized by substantial disequilibrium, especially at the disaggregated level (Hanushek and Quigley, 1979). A hedonic analysis of housing market in disequilibrium has been developed (Anas and Eum, 1984, 1986), and the development and applications of the disequilibrium model will be reviewed in the next section.

3.5 Disequilibrium hedonic model

Hedonic model, originally designed to price the utility bearing attributes or characteristics of durable consumptive goods based on market equilibrium assumption (Lancaster, 1966) is the most widely used approach to study the determinants of housing prices. The beauty to deal with the valuation problem of differentiated products of the hedonic model makes it attractive to apply to the real estate market which characterized by heterogeneous buildings (Rosen, 1974; Harrison and Rubinfeld, 1978; Witte, et al., 1979). It is straightforward to understand the application of hedonic model to rental housing market, because housing is a durable consumption good for renters and the rent is likely an equilibrium price (Buchel and Hoesli, 1995). However, owner-occupied housing market differs from rental housing market in at least two ways. Firstly, differing from a renter, a homeowner may holds a house as

an investment good in a portfolio of assets (Henderson and Ioannides, 1983, 1986). Secondly, housing market subject to frequent disruptions arise from information asymmetries, high transaction costs, and long investment horizons. Early studies suggest that the market is often inefficient and adjusts slowly to changes in market conditions at both highly aggregated level and micro level (Hanushek and Quigley, 1979; Anas and Eum, 1986; Riddel, 2004). Periods of sustained disequilibrium is the norm in housing market and a less aggregated market should experience high level of disequilibrium. So the hedonic model has been wildly used in property valuation without careful adjustment to consider both the property as an investment good and the inefficiency of owner-occupied housing market.

Anas and Eum (1984) modify the standard hedonic analysis of a housing market by adding a disequilibrium price adjustment process that assume price changes are functions of excess demand or supply. They test the hypothesis that information about housing market activity and about specific dwellings can been capitalized into housing prices through the disequilibrium adjustment process. In their study, the mortgage interest rate, the turnover rate of all single-family dwellings in the zone which sold, and the price of the reference dwelling are chosen to capture the information about market activity and about specific dwellings. Empirical estimation with data on single family dwelling sale prices in the city of Chicago between 1972 and 1976 support this hypothesis and shows that up to 75% of the variance in prices unexplained by an equilibrium hedonic model and be explained by disequilibrium hedonic model.

Anas and Eum (1986) further incorporate the "short-side rule" that assume the observed number of transactions is equal to the minimum of supply and demand into the disequilibrium Hedonic model and then make it able to study housing stock dynamic. This approach is comparable to the famous stock-flow model developed lately by DiPasquale and Wheaton (1994, 1995). Also applying Chicago's single family dwelling sale data between 1972 and 1976, Anas and Eum (1986) simultaneously estimate the price elasticity of the supply and demand of existing single family dwellings. The demand elasticity is -0.5 and supply elasticity is 2.1. Moreover, the disequilibrium models appear substantially superior to equilibrium specifications.

In a disequilibrium housing market model of Riddel (2004), the source of disequilibrium is further decomposed. Supply-side disturbances mainly associate with construction cost, like changes in building material costs, wages of constructors, or lending rates for development loans. Demand disturbances can be brought about by macroeconomic conditions or changes in household consumption behavior. For example, unanticipated inflation and related fluctuations in mortgage interest rates or changes in marginal tax rates cause demand fluctuations. Applying the US housing market for the period 1967-1998, the results confirm that inefficiencies impede housing market clearing and show that stocks respond only to supply-side disturbances, whereas prices respond primarily to demand-side disturbances. Riddel (2004) also points out that the high degree of market aggregation might clouds the precise source and suggests to get better understanding of housing prices

dynamics by investigating some regional markets where large swings in prices and investment have occurred.

In summary, disequilibrium hedonic model quantifies disequilibrium effects and demonstrates the powerful effects of interest rates and market activity indicators on transaction prices and quantities. The literature also shows it is a quite flexible framework that allows users to investigate housing market dynamic more appropriately by capitalizing information about market activity into housing prices through a disequilibrium adjustment process. However, it has not been explored on Chinese housing market. As shown in Chapter 1, in content of Chinese housing market, as a political decision of local government, urban land supply pattern alters market conditions and contribute to the rising housing prices. Therefore, land supply pattern, specifically land allocation among usages carries information about housing market in Chinese cities. This makes a city in China an ideal object to investigate the effects of land allocation among usages on housing prices via a disequilibrium hedonic model.

3.6 Summary

Firstly, literature on the interrelationship between urban growth and housing market suggests housing supply elasticity helps to determine urban growth pattern and housing prices. However, there are two main gaps. First, as mentioned above, the current literature studies the interactions from the viewpoint of the housing supply instead of the residential land supply. Consequently, the competing land uses between urban growth and the housing

market have been overlooked. Considering the conclusion drawn from the studies of determinants of housing supply elasticity that land supply is the most fundamental factor of housing supply elasticity, it is rational to start the analysis with urban land supply. Urban growth is typically achieved through the expansion of the business sector, which drives up the demand for housing while shrinking the available land for housing construction. This paradox is particularly true in the cities in China. Therefore, urban land supply policy provides an insightful viewpoint through which to study the dynamics between urban growth and the housing market. Second, most existing findings are drawn from tractable empirical frameworks, which are based on the spatial equilibrium condition. To capture the interplays between urban growth and the housing market, a rigorous economic model with a micro-economic foundation needs to be developed. However, there is limited research along this vein. These two gaps motivate me to extend the literature by constructing a city economics model with micro-economic foundation which incorporate competing land uses. The model and its results will be presented in Chapter 4.

Secondly, there are evidence that land uses of the surrounding area can influence housing values though the direction and magnitude are inconsistent in literature. However, the studies that provide these evidence are empirical studies without a solid theoretical framework. This is because these studies apply hedonic model directly without careful adjustment to consider the influences of information about market conditions that might lead to the inefficiency of owner-occupied housing market. Moreover, the land uses pattern are usually drawn based on land uses pattern of developed land rather

than the new supplied land. So, there is no study focusing on the effects of land supply by usage on housing prices directly by applying micro land and housing transaction data. Literature also shows the disequilibrium hedonic model is a quite flexible framework that allows users to investigate housing market dynamic more appropriately by capitalizing information about market activity into housing prices through a price adjustment process. In Chapter 5, using Beijing as a study area, I modify this framework to investigate the effects of new land supply pattern in small geographic areas on housing prices.

Chapter 4 Urban Land Supply Policy, Urban Growth, and Housing prices in China

4.1 Introduction

The remarkable and persistent urban economic growth in China over the past several decades has engendered a series of urban problems: of these, the escalation of urban housing prices has received a huge amount of attention. In the literature, rising income, higher savings rates, wealth-transfer between generations, the rapid development of the housing finance market and the shortage of housing are often blamed for soaring housing prices (Peng et al., 2008; Yu, 2010). However, it is not clear why there have been consistent housing price appreciations when a substantial number of new residential housing units have been aggressively developed across urban China, and the central government has constantly and visibly committed to solving the problem of escalating housing prices. The question reflects a cause for concern and demonstrates that urban land supply policies are confronted by challenges (Chang and Brada, 2006; He et al., 2010; Wu et al., 2012; Zheng et al., 2009). It is argued that the imbalance between housing supply and demand results from China's urban land supply policy, which has prioritized non-residential land uses (Tao et al., 2009; Wu et al., 2012; Yu 2010). But the literature

provides limited theoretical predictions and empirical evidence on this aspect.

The ongoing housing prices inflation has instigated lagging urbanization, which may have subsequently hindered urban growth. Lagging urbanization means that China's urbanization process is behind its industrialization process, which is continuously fortified by the "cheap industrialization and expensive urbanization" in China (Wang, 2010). By prioritizing non-residential land uses, the urban land supply policy inexpensively facilitates China's industrialization, while the surge in housing prices and increasing living costs in Chinese cities prevent new rural-urban migrants as well as urban-urban migrants, from settling down in a city, which may eventually hamper urban growth. In recent years, with the fast development of many Asian countries, such as Thailand and Vietnam, China is losing its comparative advantages in manufacturing. To maintain and stimulate China's economy growth, the central government has focused on the expansion of inner-country demand, which primarily relies on China's urbanization process. However, a large portion of the cities in China are undersized (Au and Henderson, 2006; Chang and Brada, 2006.). Thus lagging urbanization may impede the expansion of inner-country demand.

A comparison between coastal cities and inland cities in Table 4.1 show that, generally, coastal cities in eastern region have higher average percentages of non-residential land, higher GDP per capita, and higher living costs, especially

higher housing prices, comparing to inland cities in central and western regions in China. In 2010, the average percent of non-residential land is 69.7 in the coastal cities and is 67.8 in the inland cities. GDP per capita and housing prices are 46.8 RMB thousand and 4.5 RMB thousand per square meter in 2003's price in the coastal. And those numbers are 32.4 and 2.5 in the inland cities, respectively. A smaller ratio of GPD per capita to housing prices in coastal cities reflects relatively higher living costs than that of inland cities in China. The uneven developments between coastal cities and inland cities suggest the concerns of housing prices escalation and lagging urbanization might related the urban land supply policy described in Section 2.2.2 of Chapter 2. In the coastal cities, more land has been supplied for non-residential uses at a relatively lower price. As a consequence, housing supply cannot meet the demand driven by the rapid economic growth, leading to rising housing prices. Rising living costs in cities result in lagging urbanization.

Table 4. 1 A comparison of urban indicators between the coastal cities and the inland cities in China, 2010

	Non-residential land share (%)	GDP per capita (thousang RMB)	Housing prices (thousang RMB)	Ratio of GDP per capita to housing prices
Coastal cities	69.7	46.8	4.5	10.4
Inland cities	67.8	32.4	2.5	13

Notes 1. Coastal cities are more developed cities located in eastern region; Inland cities are less developed cities located in central and western regions.

2. Real GDP per capita and housing prices adjusted by inflation rates based on 2003's price.

Literature confirms that increasingly stringent land use regulation is one of the causes of unaffordable housing in some expensive places in America (Glaeser and Gyourko, 2003; Glaeser and Ward, 2009; Gyourko, et al., 2008). Differing from the land use regulation in America which is out of concern of environmental issues, urban land supply policy in the Chinese cities is driven by economic growth and local public finance pressure (Tao et al., 2009; Xu, 2011). Though the driving forces of land use regulations are different in these two countries, China's urban land supply policy, which also leads to limited housing supply, could impact urban growth process in a way comparable to that in America. The existing literature regarding the interplay between urban growth and the housing market which has been thoroughly reviewed in Section 3.2 of Chapter 3 has improved our understanding of housing market booms, especially in some "superstar cities", over the past few decades (Gyourko et al., 2006; Sinai, 2010) and provided insights on how housing market conditions influence the process of urban growth (Glaeser and Gyourko, 2005; Glaeser et al., 2006; Saks, 2008). However, the literature is primarily empirical. Moreover, the role of the urban land supply in urban growth and housing market dynamics is not well explored, despite land being regarded as an important input in both the urban production function and the housing production function in urban economics textbooks. The present study incorporates land supply policy into both the urban output function and the housing production function.

The following questions arise: In a city with fixed physical size, how does the ratio of land supply allocation between non-residential and residential uses affect the urban outcomes as indicated by urban economic output, population size, the wage rates, housing prices, and output per capita? For each additional unit of land supply, how does the ratio of allocation influence the growth rates of wage rates, housing prices, and economic output per capita? I develop a two-sector urban economic model and find that allocating more urban land to the non-residential sector increases the wage rates, housing prices and economic output per capita but decreases the population size. The relationship between total urban economic output and the share of non-residential land appears to be an inverted U-shape. For each additional unit of land supply, allocating more new land supply for non-residential sector increases the growth rates of wage, housing prices, and economic output per capita. Using a cross city panel dataset between 2003 and 2010 in China, the empirical results mostly support the predictions. The findings partially explain the observed soaring housing prices as well as the lagging urbanization in contemporary China. An important policy implication is that optimizing urban land allocation between residential and non-residential land uses can help to achieve balanced urban economic development and urbanization and stabilize housing prices.

This chapter is organized as following. A simple model of Chinese urban growth and housing prices is developed which incorporates the role of urban land supply in next section. Section 4.3 introduces the data. Section 4.4 first specifies empirical models and then presents empirical results and analyses. Section 4.5 concludes with the findings and highlights the contributions.

4.2 An economic model of urban growth and housing prices in China—the roles of urban land supply

It is assumed that there are three players in a stylized city: the government, firms, and workers. The interactions of these three players result in the aggregate outcomes of a city: economic output, population size, wages, and housing prices. I modify a conventional urban economic model in two ways. First, the competing land uses between the residential and non-residential sectors are incorporated into both the firms' production function and the housing production function. Second, in a typical city in China, the decision regarding land supply is determined by political pressure on the local government and regional competition rather than by market forces. This implies that firms and workers have no influence in land supply decision. Therefore, for firms and workers, the urban land supply, and specifically the ratio between the residential and non-residential land supply, is exogenous.

4.2.1 Model framework

The theoretical framework consists of a firm's production function, the workers' utility function and the housing production function. Under the conditions of land market clearing, housing market clearing and spatial equilibrium, the prices of both residential land and non-residential land, wage rates, housing prices, population size and economic output are determined. The impact of land supply policy on urban growth and housing prices is analyzed.

There are two production sectors in the city's economy. One is the production sector of the composite final consumption good Y, which is a tradable good with a price unified to one. The other is the production sector of housing, which is a localized good. Assuming an open city with one unit of land resource, the local government allocates φ unit of land for non-residential use, and leaves $1-\varphi$ unit of land for housing construction. The prices of non-residential land and residential land, r_1 and r_2 are the offer prices of the firms from the final good sector and housing sector, respectively. To simplify the analyses, I abstract away the input of capital in both the final consumption good production and the housing production. The production function is assumed to have Cobb-Douglas form.

$$Y = N^{\alpha} L_1^{\beta} \tag{4.1}$$

where Y is the output of the final good production, and L_1 and N are the

imputed land and labor in the final good production sector, respectively. The production function has decreasing returns to scale, $\alpha + \beta < 1$. The Cobb-Douglas function form implies that inputs are Pareto complements, meaning that an increase in one input increases the marginal return of the other. In the housing production function, land is assumed to be the only input with diminishing marginal returns.

$$H = L_2^{\gamma} \tag{4.2}$$

where H is the output of housing production, L_2 is the imputed land in the housing production sector, and $\gamma < 1$. The decreasing return to scale of housing production implies that as residential land becomes more precious, housing density will increase. Let X represent the total urban economic outcome, which consists of the outcomes of the final good sector and the housing sector. The price of the final consumption good is unified to one. Let the housing prices be p, and then the total economic output X is:

$$X = N^{\alpha} {L_1}^{\beta} + p{L_2}^{\gamma} \tag{4.3}$$

Now I turn to the labor market and the workers' utility function. For a city in a larger economy, the labor supply is fully elastic because I assume free inter-city migration and rural-urban migration[3]. Therefore, the demand for

[3] In the past decade, Chinese cities experienced a large scale of inter-city migration. The spatial equilibrium that relies on the assumption of labor mobility is a reasonable framework within which to study Chinese urban growth, despite the institutional constraints that discourage the population from moving between cities (Zhang, Fan, and Mo, 2012).

labor can always be satisfied once the worker can receive the reservation utility level $\bar{v}$ that prevails in the larger economy (Glaeser et al., 2006). However, in each individual city, the labor market will clear itself because of free labor mobility. Assume that the demand for housing is inelastic, and each worker consumes a fixed amount of housing, h. Therefore, the worker's utility is a linear function of the consumption of the final good:

$$u = c \tag{4.4}$$

In an open economy, consumption is not necessarily equal to production in the final good sector. The equilibrium is defined as an output vector (Y, X, N) and a price vector (r_1, r_2, w, p) that satisfy the following conditions: (i) workers maximize utility, (ii) producers maximize profit, and (iii) both the land market and the housing market clear.

The profit maximization problem of the representative firm in the final good sector is established in equation (4.5).

$$\max_{L_1,N} N^{\alpha} L_1^{\beta} - wN - r_1 L_1 \tag{4.5}$$

The first order conditions give rise to the demand functions for labor and non-residential land.

$$N = w^{\frac{\beta-1}{1-\alpha-\beta}} r_1^{\frac{-\beta}{1-\alpha-\beta}} \alpha^{\frac{1-\beta}{1-\alpha-\beta}} \beta^{\frac{\beta}{1-\alpha-\beta}} \tag{4.6}$$

$$L_1 = w^{\frac{-\alpha}{1-\alpha-\beta}} r_1^{\frac{\alpha-1}{1-\alpha-\beta}} \alpha^{\frac{\alpha}{1-\alpha-\beta}} \beta^{\frac{1-\alpha}{1-\alpha-\beta}} \tag{4.7}$$

The representative firm in the housing sector has the following maximization

problem:

$$\max_{L_2,} L_2^{\gamma} * p - r_2 L_2 \quad (4.8)$$

The first order condition generates the demand function for residential land.

$$L_2 = (\gamma p)^{\frac{1}{1-\gamma}} r_2^{\frac{1}{\gamma-1}} \quad (4.9)$$

The theory of labor mobility without migration cost suggests that workers are indifferent as to where to live (Glaeser et al., 2006; Roback, 1982.). Assume that all cities in a larger economy are identical, and there are uniform urban amenities. The living costs excluding housing prices are the same for all cities. The workers living in each city receive a wage rates and bear a housing cost that satisfies their reservation utility $\bar{v}$. Then, the worker's utility maximization problem is represented by equation (4.10).

$$\max_c \; u = c \quad (4.10)$$

$$s.t \quad c \leq w - ph$$

$$u = \bar{v}$$

which provides equation (4.11).

$$p = w - \bar{v} \quad (4.11)$$

The conditions of both non-residential and residential land market clearing mean that equations (4.12) and (4.13) hold.

$$L_1 = \varphi \quad (4.12)$$

$$L_2 = 1 - \varphi \quad (4.13)$$

Housing market clearing means that equation (4.14) holds.

$$H = N * h \quad (4.14)$$

First, the price vector (r_1, r_2, w, p) is derived from equations (4.11) to (4.14).

$$r_1 = \beta h^{-\alpha}\varphi^{\beta-1}(1-\varphi)^{\alpha\gamma} \tag{4.15}$$

$$r_2 = \gamma\left[\alpha h^{1-\alpha}\varphi^{\beta}(1-\varphi)^{\gamma(\alpha-1)} - \bar{v}\right](1-\varphi)^{\gamma-1} \tag{4.16}$$

$$w = \alpha h^{1-\alpha}\varphi^{\beta}(1-\varphi)^{\gamma(\alpha-1)} \tag{4.17}$$

$$p = \alpha h^{-\alpha}\varphi^{\beta}(1-\varphi)^{\gamma(\alpha-1)} - \bar{v}h^{-1} \tag{4.18}$$

Then, the city size, in terms of both population size and economic outcome, is calculated.

$$N = h^{-1}(1-\varphi)^{r} \tag{4.19}$$

$$X = (h^{-\alpha} + \alpha h^{1-\alpha})\varphi^{\beta}(1-\varphi)^{\alpha\gamma} - \bar{v}(1-\varphi)^{\gamma} \tag{4.20}$$

Define output per capita $f(\varphi) = {}^{X}/_{N}$, and,

$$f(\varphi) = (h^{1-\alpha} + \alpha h^{2-\alpha})\varphi^{\beta}(1-\varphi)^{\gamma(\alpha-1)} - \bar{v}h \tag{4.21}$$

Thus, the analytical functions for all of the urban outcome indicators are derived.

Further assume the model city is in equilibrium at the beginning of each time period. Disequilibrium happens when one unit of new land supply is provided to the economy. The model city will reach a new equilibrium at the end of the time period. L01 and L02 donate the amount of non-residential and residential land at the time period zero respectively. The local government allocates ω unit of new land to the non-residential sector, and 1-ω unit of land to the residential sector. At the end of time period one, the amount of non-residential

and residential land is $L_{01} + \omega$ and $L_{02} + 1 - \omega$ respectively.

Based on equations (4.15)-(4.18), and equilibrium conditions (i)-(iii), the equilibrium values of prices (r1, r2, w, p) and urban size (N, X) in both periods are derived. To simplify the analytical process, I further assume that the reservation level of utility does not change from time period zero to time period one. The equilibrium values of urban land prices, wage, housing prices, population size, economic output, and output per capita in period zero and period one are presented in Table 4.2.

To derive the growth rates of wage, housing prices, and output per capita, I compare the values at period zero and period one. g_w, g_p, and g_f donate the growth rates of wage, housing prices, and output per capita respectively. Based on the equilibrium values at both time period zero and time period one, I get:

$$g_w = a(1 + \frac{\omega}{L_{01}})^{\beta}(1 + \frac{1-\omega}{L_{02}})^{\gamma(\alpha-1)} - 1 \quad (4.22)$$

$$g_p = \frac{g_w}{1 - \frac{\bar{v}}{\alpha h^{1-\alpha} L_{01}^{\beta} L_{02}^{\gamma(\alpha-1)}}} \quad (4.23)$$

$$g_f = \frac{(h^{1-\alpha} + \alpha h^{2-\alpha}) L_{01}^{\beta} L_{02}^{\gamma(\alpha-1)} (1+\frac{\omega}{L_{01}})^{\beta} (1+\frac{1-\omega}{L_{02}})^{\gamma(\alpha-1)} - \bar{v}h}{(h^{1-\alpha} + \alpha h^{2-\alpha}) L_{01}^{\beta} L_{02}^{\gamma(\alpha-1)} - \bar{v}h} - 1 \quad (4.24)$$

Table 4. 2 The equilibrium values of urban land prices, wage rates, housing prices, population size, and economic output

	Time period zero	Time period one
Non-residential land price	$r_{01} = \beta h^{-\alpha} {L_{01}}^{\beta-1} {L_{02}}^{\alpha\gamma}$	$r_{11} = \beta h^{-\alpha}(L_{01}+\omega)^{\beta-1}(L_{02}+1-\omega)^{\alpha\gamma}$
Residential land price	$r_{02} = \gamma[\alpha h^{1-\alpha} L_{01}^{\beta} L_{02}^{\gamma(\alpha-1)} - \bar{v}] L_{02}^{\gamma-1}$	$r_{12} = \gamma[\alpha h^{1-\alpha}(L_{01}+\omega)^{\beta}(L_{02}+1-\omega)^{\gamma(\alpha-1)} - \bar{v}](L_{02}+1-\omega)^{\gamma-1}$
Wage rate	$w_0 = \alpha h^{1-\alpha} L_{01}^{\beta} L_{02}^{\gamma(\alpha-1)}$	$w_1 = \alpha h^{1-\alpha}(L_{01}+\omega)^{\beta}(L_{02}+1-\omega)^{\gamma(\alpha-1)}$
Housing price	$p_0 = \alpha h^{-\alpha} L_{01}^{\beta} L_{02}^{\gamma(\alpha-1)} - \bar{v} h^{-1}$	$p_1 = \alpha h^{-\alpha}(L_{01}+\omega)^{\beta}(L_{02}+1-\omega)^{\gamma(\alpha-1)} - \bar{v} h^{-1}$
Population size	$N_0 = h^{-1} L_{02}^{\gamma}$	$N_1 = h^{-1}(L_{02}+1-\omega)^{\gamma}$
Total economic output	$X_0 = (h^{-\alpha} + \alpha h^{1-\alpha}) L_{01}^{\beta} L_{02}^{\alpha\gamma} - \bar{v} L_{02}^{\gamma}$	$X_1 = (h^{-\alpha} + \alpha h^{1-\alpha})(L_{01}+\omega)^{\beta}(L_{02}+1-\omega)^{\alpha\gamma} - \bar{v}(L_{02}+1-\omega)^{\gamma}$

4.2.2 Predictions and analyses

From equations (4.15)-(4.18), it is obtained that $\frac{\partial r_1}{\partial \varphi} < 0$, $\frac{\partial r_2}{\partial \varphi} > 0$, $\frac{\partial w}{\partial \varphi} > 0$, and $\frac{\partial p}{\partial \varphi} > 0$. Based on the above deductions, I obtain the following predictions:

Prediction 1: Increasing the share of non-residential land decreases the non-residential land price but increases the residential land price. The share of non-residential land has positive effects on the wage rates and housing prices.

The economic implication is that the non-residential land price decreases when the local government increases the supply of non-residential land. Lower

non-residential land prices lead to a high demand for non-residential land. The Cobb-Douglas production form implies that inputs are Pareto complements, meaning that an increase in the land input increases the marginal product of labor. Therefore, the wage rates rises. A higher wage rates attracts more labor into the city and pushes up the housing prices.

Equation (4.19), $\frac{\partial N}{\partial \varphi} < 0$, indicates that the city's population size is negatively related to the share of non-residential land. Equation (4.20) shows that the relationship between total urban economic output and the share of non-residential land presents an inverted U-shape[4]. At the beginning of urban growth in a city, both the final good sector and the ratio of non-residential land to total urban land are small. If the local government increases the non-residential land supply relative to the residential land supply, the increase helps to grow the economic output. When the share of non-residential land reaches a level that maximizes the city's economic output, any increment in this share will reduce the magnitude of the economic output. If the share of non-residential land exceeds the level implied by $\frac{\partial X}{\partial \varphi} = 0$, which maximizes the city's economic output and is denoted by φ^*, the non-residential land is considered to be oversupplied and residential land to be undersupplied.

[4] To ensure a positive output, the share of non-residential land, φ, ranges from the implied value by $(h^{-\alpha} + \alpha h^{1-\alpha})\varphi^{\beta} = \bar{v}(1-\varphi)^{\gamma(1-\alpha)}$ and 1.

Equation (4.21) shows that $[f(\varphi)]'_{\varphi} > 0$, where the apostrophe is the derivative sign. Therefore, with an increased share of non-residential land, the output per capita increases. This result provides another reason for the oversupply of non-residential land and the undersupply of residential land in urban land policy. When $\varphi < \varphi^*$, an increase of non-residential land pushes up the economic output and shrinks the population size, while after $\varphi > \varphi^*$, the decreasing rate of economic output, $(-\frac{(\mathrm{X})'_{\varphi}}{\mathrm{X}})$, is lower than the decreasing rate for the population size, $(-\frac{(\mathrm{N})'_{\varphi}}{\mathrm{N}})$[5]. This result may explain the lagging urbanization phenomenon in Chinese cities. Summing up the above analysis, the following prediction is derived::

Prediction 2: Population size is negatively related to the share of non-residential land; the relationship between total urban economic output and the share of non-residential land presents an inverted U-shape. However, output per capita is always positively related to the share of non-residential land.

Regarding to the effects of new land supply, on the one hand, growth rates of wage, housing prices, and output per capita all increase with ω because it can been seen from equations (4.21)-(4.23) that $\frac{\partial \mathrm{g_w}}{\partial \omega} > 0$, $\frac{\partial \mathrm{g_p}}{\partial \omega} > 0$ and $\frac{\partial \mathrm{g_f}}{\partial \omega} > 0$.

[5] Proof of $-\frac{(\mathrm{X})'_{\varphi}}{\mathrm{X}} < -\frac{(\mathrm{N})'_{\varphi}}{\mathrm{N}}$: we have $f(\varphi) = \frac{X(\varphi)}{N(\varphi)} = (h^{1-\alpha} + \alpha h^{2-\alpha})\varphi^{\beta}(1-\varphi)^{\gamma(\alpha-1)} - \bar{v}h$, then $[Log(f(\varphi))]'_{\varphi} > 0$ because $[f(\varphi)]'_{\varphi} > 0$. So $\frac{(\mathrm{X})'_{\varphi}}{\mathrm{X}} - \frac{(\mathrm{N})'_{\varphi}}{\mathrm{N}} > 0$. End of the proof.

When the share of non-residential land in the new supplied land goes up, wage goes up because the demand for labor increases. On the other hand, housing prices grows faster than wage because $g_p > g_w$ as shown by equation (4.22)[6]. Housing prices is pushed up because of the increase in housing demand as well as the shrinking of housing supply. When more new land is allocated to the non-residential sector, economic output grows faster than population size. As a result, the output per capita is positively relative to ω. Therefore, prediction 3 is drawn.

Prediction 3: For each additional unit land supply, allocating more new land supply for non-residential use drives up the growth rates of wage, housing prices, and output per capita.

The economic explanation of this result is that the local government tries to stimulate economic growth by allocating more land resource for non-residential use. Expanding of final-good sector drives up the demand for labor. Increasing in wage rates and labor size creates strong housing demand generating higher housing prices. However, residential land supply doesn't match to the new demand, housing supplies are decreased which may push housing prices even higher. Because only a small number of workers can be

[6] Because $1 - \frac{\bar{v}}{\alpha h^{1-\alpha} L_{01}^{\beta} L_{02}^{\gamma(\alpha-1)}} < 1$, $g_p > g_w$.

housed in the city, the growth in population size cannot catch up with the growth in economic output, which results in higher growth rate of output per capita.

I also find the effects of the share of non-residential land in the one unit new supply, ω, on the growth rates of land prices, population size, and economic output. For the land prices, on the one hand the growth rate of non-residential land price decreases with ω, on the other hand the growth rate of residential land price increases with ω (refer to table 4.2). This finding echoes the land supply policy in favor of non-residential use which has been introduced in Chapter 2. The growth rate of population size is negatively related to ω. However, the relationship between the growth rate of economic output and ω is ambiguous. Similar to the finding of Prediction 2, this may reflects that the land supply policy in favor of non-residential use in China may have resulted in the population growth behind the economic growth, supporting the hypothesis of lagging urbanization.

4.3 Data

A cross-city panel dataset is constructed for 2003 to 2010 for 284 prefecture cities in China. Article 10 of the Constitution in 1988 separated land ownership from land use rights and legitimized the commercialization of land use rights, symbolizing the beginning of China's urban land reform. But in

2003, the central government announced that all urban land sales for residential and commercial use could only be transacted through public auctions, which witnessed the beginning of China's urban land market[7]. The data are collected from three official statistical yearbooks: the Chinese City Statistical Yearbook, the Chinese Regional Economic Statistical Yearbook, and the Chinese City Construction Statistical Yearbook. After removing the outliers, I obtain an imbalanced panel dataset with all values being adjusted to the 2003 price.

Table 4.3 provides definitions of the variables that are used in the empirical models, and Table 4.4 presents the descriptive statistics. As shown in Table 4.4, an average Chinese city has a size of 831 thousand people, 95 square kilometers of developed land, and approximately 47 RMB billion of annual economic output. China is still on the path of industrialization. Over one half of output is attributed to the industrial sector and nearly 83 percent of cities (235 out of 284 cities) are labeled industrial cities. The growth rate of housing prices was higher than wage growth, but lower than growth of GDP per capita in general. There are notable differences between a service city and an

[7] Commercial land is the land allocated to the service sector and is considered to be non-residential use. Land is now assigned through two methods in China: the administrative allocation of land for state units or nonprofit users and the conveyance of land use rights for commercial use. There are ten categories of land use. Residential, industrial, and commercial land represents almost 95 percent of the land conveyance via either negotiation or public auction. However, the stock data of urban land that we apply to perform the empirical analysis do not provide separate data for commercial land. Therefore, non-residential land in my empirical analysis includes all land uses other than residential use.

industrial city. In general, a service city tends to be bigger in terms of GDP, population, and geographic size. However, for per unit of developed land, an industrial city has higher residential density, more intensive fixed asset investment, but less economic output as indicated by *PopperArea*, *FixedperArea* and *GDPperArea* (see Table 4.3 for definitions), respectively. While wages in a service city are 22 percent higher than those in an industrial city, housing prices in a service city are almost two times those in an industrial city. Moreover, though wage and GDP per capita increased faster in industrial cities, housing prices appreciation rate in service cities was more than 2 percent higher on every four years' interval.

Table 4. 3 Variable list and definitions for panel analyses

Variable	Definition
	Dependent Variables
Wage	Average annual real wage rates in a city (10 thousand RMB Yuan).
HousingPrice	Average real transaction price of new commercial housing in a city (10 thousand RMB Yuan/sq.m).
GDP	Annual real GDP in a city (billion RMB yuan).
Population	Total annual urban population in a city (10 thousand people).
GDPperCapita	Annual real GDP per capita in a city (10 thousand RMB Yuan).
GDPperArea	Annual real GDP per unit urban developed land in a city (billion RMB yuan/km^2)
PopperArea	Total annual urban population per unit urban developed land in a city (10 thousand people/km^2)
g_Wage	Growth rate of annual real wage during the time period of 2003-2006 or 2007-2010, in a city (percent).
g_Housingprice	Growth rate of real housing prices in a city during the time period of 2003-2006 or 2007-2010 (percent).
g_GDPperCapita	Growth rate of annual real GDP per capital in a city during the time period of 2003-2006 or 2007-2010 (percent)

Table 4.3 Variable list and definitions (Continued)

	Key Testing Variables
DevelopedLand	Urban developed land area (km^2)
NonresidentialLand	The share of the non-residential land area in total urban developed area in a city, annual.
IndustrialLand	The share of the industrial land area in the total urban developed area in a city, annual.
new_NonrLand	The share of the non-residential land in the increment of developed land on every four years' interval, 2003-2006 or 2007-2010.
new_InduLand	The share of industrial land in the increment of developed land on every four years' interval, 2003-2006 or 2007-2010.
	Control Variables
IndustrialSector	The share of the output of the industrial sector in total output in a city, annual.
ServiceSector	The share of the output of the service sector in total output in a city, annual.
g_InduSector	The change of the share of output of industrial sector in total output on every four years' interval, 2003 -2006, or 2007-2010, (percent)
g_ServSector	The change of the share of output of service sector in total output on every four years' interval, 2003-2006, or 2007-2010, (percent)
FixedAssets	Annual real fixed assets investment in a city (billion RMB Yuan).
FixedperCapita	Annual real fixed assets investment per capita in a city (10 thousand RMB yuan)
FixedperArea	Annual real fixed assets investment per unit urban developed land in a city (billion RMB yuan/km^2)
InitialNonresidential	The initial value of N**onresidentialLand** which is the share of non-residential land area in total urban developed area in 1999 in a city.
InitialIndustrial	The initial value of **IndustrialLand** which is the share of the industrial land area in total urban developed area in 1999 in a city.
InitialPopperArea	The initial value of **PopperArea** which is the urban population per unit urban developed land in 1999 in a city (10 thousand people/km^2).
CapitalCity	A dummay variable with 1 indicating that a city is the capital city of a province or if it is Beijing, Tianjin, Shanghai or Chongqing, otherwise, 0.
East[2]	A dummy variable with 1 indicating a city locates in the east region, otherwise, 0.
Middle[2]	A dummy variable with 1 indicating a city locates in the middle region, otherwise 0.
West[2]	A dummy variable with 1 indicating a city locates in the west region, otherwise, 0.
Notes	1. **InitialIndustrial** and **InitialNonresidential** are included in the regressions to control the influences of individual heterogeneity when conduct rubost tests. 2. China is divided into three regions according to the economic development: east region includes Beijing, Tianjin, Shanghai and other eight provinces, Hebei, Liaoning, Jiangshu, Zhejiang, Shandong, Guangdong, and Hainan; middle region includes Shanxi, Jilin, Helongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan provinces; western region includes Chongqing city and Inner Mongolia, Guangxi, Sichuan, Guizhou, Yunnan, Tibet, Shannxi, Gansu, Qinghai, Ningxia, Xinjiang provinces. 3. Year 2003 is the base year for all real values.

Table 4. 4 Descriptive statistics of the data by prefecture city (2003-2010)

Variable	Whole sample		Service cities		Industrial cities	
	Mean	S. D.	Mean	S. D.	Mean	S. D.
Wage[a]	2.008	0.774	2.415	0.938	1.978	0.714
HousingPrice[c]	0.219	0.145	0.387	0.304	0.205	0.112
GDP[a]	46.736	95.744	167.114	247.473	37.129	61.143
Population[a]	83.101	119.185	217.982	250.399	69.443	83.862
GDPperCapita[a]	2.682	1.951	3.309	2.037	2.689	1.968
g_Wage[a]	42.504	59.942	39.077	15.611	40.251	20.793
g_Housingprice[c]	43.859	31.698	45.899	39.097	43.750	30.272
g_GDPperCapita[a]	48.260	43.529	43.571	32.676	49.978	45.485
GDPperArea[ab]	0.450	2.925	0.415	0.259	0.462	3.197
PopperArea[ab]	0.914	1.444	0.831	0.282	0.905	1.564
DevelopedLand[b]	94.741	135.837	255.267	328.993	82.945	97.688
NonresidentialLand[b]	0.687	0.070	0.725	0.052	0.682	0.071
IndustrialLand[b]	0.207	0.074	0.178	0.071	0.213	0.074
new_NonrLand[b]	0.785	1.068	0.782	0.383	0.794	1.155
new_InduLand[b]	0.302	0.911	0.242	0.445	0.316	0.980
IndustrialSector[a]	0.510	0.125	0.369	0.091	0.533	0.115
ServiceSector[a]	0.411	0.106	0.560	0.091	0.391	0.095
g_InduSector[a]	0.830	6.244	-2.268	6.629	1.237	6.152
g_ServSector[a]	0.265	5.872	3.647	6.145	-0.101	5.784
FixedAssets[a]	23.843	44.500	67.640	89.906	20.603	36.673
FixedperCapita[a]	1.589	1.358	1.870	1.426	1.610	1.372
FixedperArea[ab]	0.224	0.591	0.204	0.144	0.230	0.643
InitialNonresidential[b]	0.696	0.078	0.714	0.071	0.693	0.079
InitialIndustrial[b]	0.230	0.072	0.202	0.058	0.235	0.073
InitialPopperArea[ab]	1.079	0.479	1.105	0.303	1.077	0.506
CapitalCity	0.103	0.304	0.613	0.488	0.052	0.223
East	0.353	0.478	0.405	0.492	0.360	0.480
West	0.235	0.424	0.301	0.460	0.217	0.412

Notes 1. All variables are defined in table 4.3;

2. Data of variables superscripted by *a* are collected or calculated from Chinese City Statistical Yearbook; data of variables superscripted by *b* are collected or calculated from China City Construction Statistical Yearbook; Data of variables superscripted by *c* are collected or calculated from Chinese Regional Economic Statistical Yearbook;

Table 4.4 also illustrates that non-residential land is relatively oversupplied compared to residential land. The industrial land share is 20.7 percent of the total urban developed land and the share of non-residential land is 68.7 percent. These percentages mean that, on average, residential land only accounts for approximately 30 percent of Chinese cities. This rate is lower than the share of residential land in some other Asian countries, such as Japan and South Korea at approximately 40 percent and 35 percent, respectively. This phenomenon became more obvious if we look at *New_NonrLand* and *New_InduLand*. 78.5 percent of newly developed urban area was used for non-residential sectors, and 30.2 percent of which was industrial land. Furthermore, there are significant differences in non-residential and industrial land share between cities. The share of industrial land varies from 5.04 percent to 44.41 percent; for non-residential land share, the range is from 39.67 percent to 87.53 percent. These percentages reflect how urban land supply policy, particularly in terms of the land allocation between residential and non-residential sectors, does vary across the cities in China.

4.4 Empirical results and analysis

4.4.1 Econometric model specifications

The dependent variables are chosen as indicated below. Wages, housing prices and economic output per capita are measured using the average annual wage

rates (*Wage*), the average selling price of new commercialized housing (*HousingPrice*), and annual GDP per capita (*GDPperCapita*) at the prefecture city level (see Table 4.3 for definitions). The theoretical model investigates the effects of land supply on economic output and population in a city with a fixed boundary. Empirically, these effects are indicated by output density and residential density. Therefore, I use GDP and population per unit of urban developed land to measure economic output and population, and they are denoted by *GDPperArea* and *PopperArea* in Table 4.3. As mentioned in the data section, the growth rates of wage, housing prices, and GDP per capital are calculated in 4 years interval, from 2003 to 2006, and from 2007 to from 2010, and they are denoted by *g_Wage*, *g_Housingprice*, and *g_GDPperCapita* in Table 4.3.

According to theoretical prediction 1, the share of non-residential land, denoted by *NonresidentialLand*, has a positive effect on both wage rates and housing prices. The empirical specifications are illustrated by equations (4.25) and (4.26).

$$Wage_{ij} = c_1 + \alpha_1 NonresidentialLand_{ij} + \beta_1(X_1) + \varepsilon_1 \quad (4.25)$$

$$HousingPrice_{ij} = c_2 + \alpha_2 NonresidentalLand_{ij} + \beta_2(X_2) + \varepsilon_2 \quad (4.26)$$

where *i* indicates a city, and *j* indicates a year. α_1 and α_2 are coefficients of the test variable, and they are both expected to be positive. X_1 and X_2

represent the vectors of the control variables, and β_1 and β_2 are the respective vectors of the coefficients of the control variables. ε_1 and ε_2 are residual terms.

Theoretical prediction 2 predicts that with an increase in non-residential land share, output per unit land first increases, then decreases; residential density decreases; and output per capita increases. This predication is empirically specified by equations (4.27), (4.28), and (4.29):

$$GDPperArea_{ij} = c_3 + \alpha_3 NonresidentialLand_{ij} + \gamma_3 NonresidentialLand_{ij}^2 + \beta_3(X_3) + \varepsilon_3 \quad (4.27)$$

$$PopperArea_{ij} = c_4 + \alpha_4 NonresidentialLand_{ij} + \beta_4(X_4) + \varepsilon_4 \quad (4.28)$$

$$GDPperCapita_{ij} = c_5 + \alpha_5 NonresidentialLand_{ij} + \beta_5(X_5) + \varepsilon_5 \quad (4.29)$$

where *i* indicates a city, and *j* indicates a year. α_3 and γ_3 are coefficients of *NonresidentialLand* and its square item. α_3 is expected to be positive and γ_3 is expected to be negative. α_4 and α_5 are coefficients in the estimations of the effect of non-residential land share on population density and output per capita. It is predicted that α_4 is negative and α_5 is positive by theoretical prediction 2. X_3, X_4 and X_5 are the vectors of the control variables, and β_3, β_4 and β_5 are the vectors for the coefficients of the control variables, respectively. ε_3, ε_4 and ε_5 are residual terms.

Four categories of control variables are included in the estimations. First, capital investment, which is assumed away in the theoretical model to simplify analysis, is added into the empirical model. In China, fixed asset investment is usually adopted as a proxy for capital investment. The capital investment intensity with respect to labor (*FixedperCapita*) helps to determine output per capita, wage rates and, hence, housing prices, while the capital investment intensity with respect to land (*FixedperArea*) influences the output per unit of land and the population density. Second, a city's industrial structure influences its wage rates and housing prices because the industrial structure determines output per worker. Compared to the agricultural sector, output per worker in the industrial sector is relatively higher, and it is the highest in the service sector. The shares of the industrial sector and the service sector are indicated by *IndustrialSector* and *ServiceSector*. Third, two regional dummy variables are included. One dummy indicates the capital city and the other dummy indicates the region. In China, the capital cities of each respective province and autonomous city such as Beijing, Shanghai, Tianjin, and Chongqing, have more public resources than other prefecture cities. These resources will affect the workers' acceptable wages and their willingness to pay for housing. According to the stages of economic development, China is divided into three regions. East China is the most developed and west China is the least developed, while central and northeast China are in between. Finally, year dummies are included to control the time-variant differences.

The theoretical prediction 3 implies that the allocation of new land supply between non-residential and residential sectors affects the growth rates of wage, housing prices and output per capita. Empirically, it is specified into equations (4.30), (4.31) and (4.32).

$$g\_Wage_{ij} = c_6 + \alpha_6 new\_NonrLand_{ij} + \beta_6(X_6) + \varepsilon_6 \quad (4.30)$$

$$g\_Housingprice_{ij} = c_7 + \alpha_7 new\_NonrLand_{ij} + \beta_7(X_7) + \varepsilon_7 \quad (4.31)$$

$$g\_GDPperCapita_{ij} = c_8 + \alpha_8 new\_NonrLand_{ij} + \beta_8(X_8) + \varepsilon_8 \quad (4.32)$$

where i indicates a city, and j indicates a year. α_6, α_7 and α_8 are coefficients in the estimations of the effects of non-residential land share on the growth rates of wage, housing prices, and GDP per capita. They all are expected to be positive by theoretical prediction 3. X_6, X_7 and X_8 are the vectors of the control variables, and β_6, β_7 and β_8 are the vectors for the coefficients of the control variables, respectively. ε_6, ε_7 and ε_8 are residual terms.

The dependent variables are the growth rates of wage, housing prices and output per capita measured by *g_Wage*, *g_HousingPrice* and *g_GDPperCapita*. The testing variable is the share of non-residential land in each additional unit land. Empirically, I use the percentage of non-residential land in total new urban developed land, *new_NonrLand*, as the key testing variable for whole sample, and that of industrial land, *new_InduLand* for industrial cities as a sensitivity test. Besides capital city dummy, regional dummies, and year

dummy, the changes in the shares of output of industrial sector and service sector in total output during the corresponding time period, *g_InduSector* and *g_ServSector*, are included as control variables given the reason that economic growth may driven by the transformation in industrial structure.

4.4.2 Empirical results

Using the panel data, a pooled OLS with cluster effects is employed. As shown in Chapter 2, the policy priority given to non-residential land use is primarily indicated by the amount of industrial land use. The share of industrial land can serve as a predictor to investigate the impact of land supply policy on urban outcomes. In sensitivity tests, *IndustrialLand* is therefore used in the empirical models based on the sub-samples of the industrial cities. With panel data, it is better to apply fixed effects models to control for the city-specific factors. However, the fixed effects models perform poorly in this study, and the results are not reported. Instead, to control the influence of city-specific heterogeneity, I add the initial 1999 values for the share of non-residential and industrial land into the regressions (See definitions of *InitialNonresidential* and *InitialIndustrial* in Table 4.3).

Table 4.5 presents the empirical results. Column (1) shows that the cities with a higher share of non-residential land have a higher wage rates. The results are robust when using the share of industrial land in the subsample of industrial

cities in column (4) and when including the initial value of non-residential or industrial land share. Capital investment increases the wage rates as expected. The results suggest that the output shares of both the industrial and the service sectors positively affect the wage rates. The wage rates is higher in a capital city and in a city located in east China. Wage rates have been rising over time.

Table 4.6 reports the results of the impact of the urban land supply on housing prices, and all results are significant and consistent. A higher share of non-residential land drives up housing prices in all cities, and a higher share of industrial land increases housing prices in the industrial cities, both evidenced by the positive coefficients of *NonresidentialLand* and *IndustrialLand* in columns (1) to (4). Capital investment is positively related to housing prices. While the housing prices is insignificantly lower in the cities with a higher share for the industrial sector, the development of the service sector in a city adds a premium to the housing prices. Housing prices are higher in a capital city or in east China. The increasing trend of housing prices over time is significantly observed in the results.

Table 4. 5 The impact of the urban land allocation pattern on wage rates

	Whole Sample						Industrial Cities					
	(1)			(2)			(3)			(4)		
	Coef.	S.E.		Coef.	S.E.		Coef.	S.E.		Coef.	S.E.	
NonresidentialLand	0.433	0.249	*	0.393	0.339							
IndustrialLand							0.522	0.293	*	0.770	0.362	**
FixedperCapita	0.152	0.016	***	0.146	0.020	***	0.152	0.016	***	0.148	0.020	***
IndustrialSector	1.138	0.227	***	1.353	0.222	***	1.073	0.301	***	1.375	0.313	***
ServiceSector	1.102	0.306	***	1.350	0.307	***	0.729	0.388	*	1.038	0.389	***
CapitalCity	0.348	0.085	***	0.342	0.087	***	0.322	0.095	***	0.313	0.098	***
East	0.336	0.050	***	0.338	0.051	***	0.271	0.051	***	0.263	0.053	***
West	0.140	0.046	***	0.152	0.050	***	0.157	0.048	***	0.161	0.051	***
Year2004	0.098	0.010	***	0.104	0.011	***	0.089	0.012	***	0.092	0.012	***
Year2005	0.221	0.017	***	0.227	0.018	***	0.230	0.020	***	0.231	0.021	***
Year2006	0.413	0.046	***	0.421	0.048	***	0.368	0.020	***	0.365	0.021	***
Year2007	0.583	0.022	***	0.585	0.023	***	0.576	0.025	***	0.572	0.027	***
Year2008	0.829	0.028	***	0.834	0.030	***	0.828	0.031	***	0.826	0.034	***
Year2009	1.021	0.033	***	1.027	0.037	***	1.024	0.035	***	1.022	0.041	***
Year2010	1.200	0.041	***	1.211	0.046	***	1.199	0.044	***	1.203	0.051	***
InitialNonresidential				-0.038	0.321							
InitialIndustrial										-0.403	0.353	
Constant	-0.295	0.263		-0.457	0.278		0.077	0.284		-0.160	0.274	
No. of observations	2178			2072			1790			1716		
R-sq	0.659			0.651			0.735			0.734		

Notes: 1. * p<0.10, ** p<0.05, *** p<0.01

2. All variables are defined in Table 4.3

3. Dependent variable is Wage (unit: 10 thousand RMB Yuan)

Table 4. 6 The impact of the urban land allocation pattern on housing prices

	Whole Sample						Industrial Cities					
	(1)			(2)			(3)			(4)		
	Coef.	S.E.		Coef.	S.E.		Coef.	S.E.		Coef.	S.E.	
NonresidentialLand	0.116	0.061	*	0.127	0.074	*						
IndustrialLand							0.174	0.061	***	0.231	0.081	***
FixedperCapita	0.036	0.009	***	0.035	0.006	***	0.026	0.005	***	0.030	0.005	***
IndustrialSector	-0.079	0.064		-0.080	0.068		-0.004	0.050		0.022	0.063	
ServiceSector	0.134	0.067	**	0.130	0.074	*	0.154	0.068	**	0.198	0.086	**
CapitalCity	0.104	0.026	***	0.107	0.023	***	0.074	0.023	***	0.064	0.023	***
East	0.096	0.012	***	0.091	0.012	***	0.073	0.011	***	0.067	0.010	***
West	-0.006	0.007		-0.003	0.007		0.001	0.006		0.002	0.006	
Year2004	0.010	0.003	***	0.010	0.003	***	0.012	0.003	***	0.012	0.003	***
Year2005	0.022	0.003	***	0.024	0.003	***	0.027	0.003	***	0.026	0.003	***
Year2006	0.035	0.006	***	0.038	0.004	***	0.039	0.004	***	0.037	0.004	***
Year2007	0.052	0.006	***	0.053	0.005	***	0.052	0.004	***	0.050	0.004	***
Year2008	0.061	0.008	***	0.063	0.006	***	0.064	0.006	***	0.060	0.006	***
Year2009	0.078	0.013	***	0.080	0.008	***	0.084	0.008	***	0.078	0.009	***
Year2010	0.107	0.016	***	0.110	0.010	***	0.112	0.010	***	0.105	0.010	***
InitialNonresidential				-0.020	0.062							
InitialIndustrial										-0.125	0.087	
Constant	-0.022	0.061		-0.014	0.062		-0.012	0.048		-0.026	0.057	
No. of observations	2120			2017			1739			1666		
R-sq	0.538			0.557			0.556			0.561		

Notes: 1. * p<0.10, ** p<0.05, *** p<0.01

2. All variables are defined in Table 4.3

3. Dependent variable is HousingPrice (unit: 10 thousand RMB Yuan/sq.m)

The impact of the land supply policy on GDP per unit of land are presented in Table 4.7 and two interesting phenomena appear. Firstly, with or without the control of heterogeneity, the relationship between *NonresidentialLand* and *GDPperArea* appears to be an inverted U-shape, supporting the theoretical prediction. With an increase in the land share for non-residential use, the economic output first increases and then declines. However, the result for *IndustrialLand* in the subsample of industrial cities shows the opposite pattern. Secondly, it appears that the industrial sector is more economically efficient in land use than the service sector in China because *IndustrialSector* is positively and significantly related to *GDPperArea,* but *ServiceSector* is not. This result may be attributed to that fact that the industrial sector is represented by less land-intensive industries than the other non-residential sectors. The two phenomena deserve further investigation when data permits. The other results in Table 4.7 are as expected. The intensities of labor input and capital investment (*PopperArea* and *FixedperArea*) drive up output per unit of land. It is found that being a capital city or being in eastern or even in west China, has a negative effect on the GDP per unit of urban developed land. Year dummies have no significant effects of *GDPperArea*, especially for the industrial cities. This reflects that the inefficiency in land uses does not change over time.

Table 4. 7 The impact of the urban land allocation pattern on the GDP per unit urban developed land

	Whole Sample						Industrial Cities					
	(1)			(2)			(3)			(4)		
	Coef.	S.E.		Coef.	S.E.		Coef.	S.E.		Coef.	S.E.	
NonresidentialLand	1.220	0.606	**	1.537	0.630	**						
NonresidentialLand^2	-0.769	0.462	*	-1.075	0.479	**						
IndustrialLand							-0.680	0.215	***	-0.637	0.226	***
IndustrialLand^2							1.607	0.463	***	1.807	0.479	***
PopperArea(t-1)	0.122	0.012	***	0.121	0.013	***	0.109	0.015	***	0.112	0.016	***
FixedperArea	1.099	0.034	***	1.105	0.034	***	1.168	0.038	***	1.166	0.039	***
IndustrialSector	0.368	0.053	***	0.413	0.057	***	0.423	0.064	***	0.554	0.071	***
ServiceSector	0.041	0.067		0.082	0.073		-0.032	0.079		0.085	0.086	
CapitalCity	0.039	0.014	***	0.036	0.015	**	0.002	0.020		-0.003	0.021	
East	0.070	0.009	***	0.069	0.009	***	0.053	0.010	***	0.045	0.010	***
West	0.029	0.010	***	0.034	0.010	***	0.020	0.011	*	0.023	0.012	*
Year2004	0.006	0.017		0.006	0.017		0.006	0.019		0.008	0.019	
Year2005	0.018	0.016		0.017	0.016		0.020	0.017		0.022	0.018	
Year2006	0.029	0.015	*	0.030	0.016	*	0.023	0.017		0.024	0.017	
Year2007	0.031	0.016	**	0.032	0.016	**	0.024	0.017		0.026	0.018	
Year2008	0.034	0.016	**	0.035	0.016	**	0.023	0.018		0.024	0.018	
Year2009	0.009	0.017		0.006	0.017		-0.009	0.019		-0.008	0.019	
Year2010	0.002	0.017		0.000	0.018		-0.015	0.019		-0.012	0.020	
InitialNonresidential				0.125	0.058	**						
InitialIndustrial										-0.274	0.075	***
Constant	-0.683	0.207	***	-0.014	0.062		-0.144	0.067	**	-0.217	0.072	***
No. of observations	1914			1842			1596			1539		
R-sq	0.591			0.596			0.598			0.604		

Notes: 1. * p<0.10, ** p<0.05, *** p<0.01

2. All variables are defined in Table 4.3

3. Dependent variable is GDPperArea (unit: billion RMB yuan/km2)

4. 2sls estimator is applied to control the endogeneity problem between GDPperArea and PopperArea

The influences of land supply policy on population is illustrated in Table 4.8. Because the population in a city is path dependent, I include population per unit of land in 1999 (*InitialPopperArea*) as one of the control variables. As reported in column (1), population per unit of land declines with the share of non-residential land for the entire sample, and this result is robust when the initial share of non-residential land is included. Though the result becomes less significant in the sub-sample of industrial cities, the coefficient is still negative as expected. A positive relationship between capital investment and the population size is found, reflecting that labor and capital are complementary inputs. While population per unit of land does not vary geographically, it has been decreasing since 2007. One caveat is that *PopperArea* is not exactly the same as residential density. A decreasing *PopperArea* implies that population size is shrinking in the city, rather than that people have more living space.

The impact of the land supply policy on GDP per capita is consistent with the theoretical prediction (Table 4.9). The share of non-residential land in all cities and the share of industrial land in the industrial cities have a positive and significant impact on output per capita. GDP per capita also increases with the proportions of both the industrial sector and the service sector. Moreover, GDP per capita is higher in the capital cities and the cities in east China because these cities have a higher productivity level.

Table 4. 8 The impact of the urban land allocation pattern on the population per unit developed land

	Whole Sample						Industrial Cities					
	(1)			(2)			(3)			(4)		
	Coef.	S.E.		Coef.	S.E.		Coef.	S.E.		Coef.	S.E.	
NonresidentialLand	-0.411	0.215	*	-0.556	0.284	*						
IndustrialLand							-0.222	0.303		-0.773	0.426	*
FixedperArea	0.734	0.226	***	0.737	0.225	***	0.778	0.235	***	0.761	0.242	***
InitialPopperArea	0.287	0.069	***	0.285	0.069	***	0.260	0.056	***	0.258	0.044	***
IndustrialSector	0.117	0.286		0.101	0.285		0.063	0.329		-0.143	0.321	
ServiceSector	0.254	0.363		0.235	0.362		0.332	0.418		0.197	0.408	
CapitalCity	-0.059	0.067		-0.059	0.067		-0.113	0.068	*	-0.110	0.067	
East	0.018	0.052		0.019	0.052		0.000	0.048		0.032	0.050	
West	0.015	0.043		0.014	0.043		0.016	0.037		0.031	0.036	
Year2004	0.042	0.030		0.040	0.029		0.031	0.030		0.030	0.029	
Year2005	0.011	0.028		0.010	0.028		-0.010	0.025		-0.012	0.025	
Year2006	-0.040	0.027		-0.041	0.026		-0.066	0.024	***	-0.063	0.024	***
Year2007	-0.087	0.029	***	-0.088	0.029	***	-0.103	0.028	***	-0.099	0.028	***
Year2008	-0.163	0.038	***	-0.164	0.038	***	-0.174	0.038	***	-0.170	0.039	***
Year2009	-0.230	0.052	***	-0.231	0.052	***	-0.257	0.052	***	-0.253	0.052	***
Year2010	-0.283	0.061	***	-0.284	0.060	***	-0.300	0.059	***	-0.295	0.059	***
InitialNonresidential				0.214	0.247							
InitialIndustrial										0.878	0.334	***
Constant	0.649	0.303	**	0.620	0.303	**	-0.144	0.067	**	0.511	0.309	*
No. of observations	1712			1712			1439			1439		
R-sq	0.216			0.217			0.236			0.254		

Notes: 1. * p<0.10, ** p<0.05, *** p<0.01

2. All variables are defined in Table 4.3

3. Dependent variable is PopperArea (unit: 10 thousand people/km2)

Table 4. 9 The impact of the urban land allocation pattern on the GDP per capita

	Whole Sample						Industrial Cities					
	(1)			(2)			(3)			(4)		
	Coef.	S.E.		Coef.	S.E.		Coef.	S.E.		Coef.	S.E.	
NonresidentialLand	1.922	0.531	***	1.974	0.706	***						
IndustrialLand							0.727	0.902		1.686	0.824	*
FixedperCapita	0.903	0.070	***	0.885	0.087	***	0.946	0.077	***	0.915	0.093	***
IndustrialSector	5.423	0.647	***	5.692	0.716	***	6.221	0.839	***	6.844	0.958	***
ServiceSector	2.675	0.956	***	2.839	1.053	***	2.637	1.058	**	3.023	1.112	***
CapitalCity	0.500	0.186	***	0.512	0.193	***	0.227	0.176		0.271	0.179	
East	0.436	0.144	***	0.441	0.147	***	0.300	0.146	**	0.271	0.162	*
West	0.013	0.120		0.004	0.129		0.033	0.146		0.007	0.162	
Year2004	0.053	0.027	***	0.063	0.028	***	0.038	0.036		0.052	0.037	
Year2005	0.125	0.035	***	0.138	0.037	***	0.121	0.043	***	0.142	0.046	***
Year2006	0.205	0.044	***	0.217	0.048	***	0.174	0.055	***	0.194	0.059	***
Year2007	0.254	0.061	***	0.269	0.067	***	0.222	0.076	***	0.251	0.083	***
Year2008	0.378	0.074	***	0.401	0.083	***	0.329	0.091	***	0.369	0.101	***
Year2009	0.202	0.111	*	0.236	0.126	*	0.099	0.131		0.161	0.146	
Year2010	0.114	0.138		0.118	0.166		0.009	0.162		0.049	0.189	
InitialNonresidential				0.334	0.705							
InitialIndustrial										-1.341	1.047	
Constant	-4.311	0.731	***	-4.773	0.842	***	-3.583	0.665	***	-3.932	0.743	***
No. of observations	2178			2071			1789			1717		
R-sq	0.700			0.682			0.703			0.688		

Notes: 1. * p<0.10, ** p<0.05, *** p<0.01

2. All variables are defined in Table 4.3

3. Dependent variable is GDPperCapita (unit: 10 thousand RMB Yuan)

Table 4.10 reports the empirical results of theoretical prediction 3. Column (1)-(3) shows the results are contrary with my expectation. The share of nonresidential land in total new supply land influences growth rates of wage and GDP per capita negatively. The effect of *new_NonrLand* on housing prices growth is positive but insignificant. However the coefficients of *new_InduLand* are positive as expected in column (4)-(6) and coefficients for wage growth and GDP per capita growth are significant, implying that for industrial cities in China, allocating more new supply land to industrial sector speeds up the growth of wage and GDP per capita. Moreover, the model performs poorly as indicated by the extremely small R-sq. One possible explanation is the poor data quality. As it is discussed earlier, new land supply by types of land uses at the prefecture city level is not available while using the difference of the total developed land area in any two successive years as proxy cannot capture the variations accurately. As a result, the growth rates derived from every four years are used and this leads to very small sample size. There are about only 500 observations in the regressions in Table4.8. Moreover, the data of the developed land area classified by the types of land uses are only available from the *Chinese City Construction Statistical Yearbook.* But this yearbook is publically criticized for being inaccuracy. The inconsistent results in Table 4.8 call for further exploration of impact of new land allocation among usages on growth rates of wage, housing prices, at GDP per capita when high quality data become available.

Table 4. 10 The impact of the urban land allocation pattern on growth rates of wage rates, housing prices and the GDP per capita

	Whole sample									Industrial cities								
	(1)			(2)			(3)			(4)			(5)			(6)		
Dependent Variable	g_Wage			g_HousingPrice			g_GDPperCapita			g_Wage			g_HousingPrice			g_GDPperCapita		
	Coef.	S.E.		Coef.	S.E.		Coef.	S.E.		Coef.	S.E.		Coef.	S.E.		Coef.	S.E.	
new_NonrLand	-0.295	0.156	*	0.680	0.945		-0.608	0.302	**									
new_InduLand										0.223	0.075	***	0.475	0.343		0.567	0.078	***
FixedperCapita	-0.868	0.840		0.658	0.672		3.703	1.992	*	-0.340	0.650		0.568	0.672		3.596	2.181	
g_InduSector	-0.251	0.468		1.562	0.715	**	5.852	0.545	***	0.031	0.360		1.118	0.566	**	6.170	0.614	***
g_ServSector	-0.001	0.383		1.499	0.777	*	5.341	0.567	***	0.197	0.395		0.939	0.550	*	5.593	0.628	***
CapitalCity	-4.614	4.384		-4.878	2.828	*	-8.398	4.321	*	1.350	2.907		-6.030	3.954		-4.034	5.758	
East	-2.056	2.000		0.194	2.540		-12.926	3.912	***	-1.610	2.215		0.200	2.650		-12.612	4.355	***
West	14.136	10.698		3.704	4.066		6.195	4.849		5.273	2.576	**	9.048	4.652	*	11.285	5.430	**
year_07-10	-0.063	4.212		5.616	3.131	*	-7.263	4.380	*	4.288	2.261	*	4.075	3.319		-7.670	4.944	
_cons	42.414	4.225	***	36.762	2.692	***	42.257	3.723	***	38.250	2.544	***	37.625	2.782	***	41.575	4.095	***
No. of observations	536			511			534			448			425			446		
R-sq	0.015			0.037			0.176			0.028			0.039			0.184		

Notes: 1. * p<0.10, ** p<0.05, *** p<0.01

2. All variables are defined in Table 4.3

To sum up, the empirical results confirm the theoretical predictions. For a city with a fixed boundary, a greater land supply for non-residential uses leads to a higher wage rates, higher housing prices, and greater output per capita. With an increase in the proportion of non-residential land, the economic output first increases and then decreases. However, the population size is negatively related to the share of non-residential land. The sensitivity tests, using the share of industrial land in the subsample of industrial cities, provide supporting evidence. For a city with an expanding physical size, more new land supply for industrial or non-residential use drives up the growth rates of wage, housing prices, and output per capita though the empirical results are insignificant due to the poor quality of data. Therefore, my findings indicate that an urban land supply policy that prioritizes non-residential uses can partly explain China's housing prices escalation and the lagging urbanization in China.

4.5 Summary

The macro study in this chapter finds that when more land resources are allocated to non-residential sectors in a city, the wage rates, housing prices, and output per capita increase, the population size decreases, and the economic output first increases and then decreases. These findings are consistent with the works by Glaeser et al. (2006) and Sakes (2008). The possible underlying mechanism is that when a city's government tries to

promote local economic growth by supplying more and cheaper non-residential land, the resulting economic growth creates a higher demand for labor and generates higher wage rates. Both results increase housing prices. Meanwhile, the land supply policy, by giving priority to non-residential land uses, undermines the supply of residential land, causing a housing shortage, which further increases the already high housing prices. These consequences of land supply policy are comparable with those in context of American cities (Glaeser and Gyourko, 2003; Glaeser and Ward, 2009) though the causes of land supply policy are different in these two countries.

Because urban land supply policy is one of the primary tools through which a local government can pursue economic growth as well as generate local revenue in China, my findings have important policy implications. The monopolistic power over the land supply allows a local government to influence urban growth, population and the housing market via their politically driven land supply decision. Therefore, the present study provides an alternative explanation for the surge in housing prices as well as the lagging urbanization process in China.

The study in this chapter sheds light on both housing policy and urban growth policy. For housing policy, the findings suggest that the urban land supply policy must consider how to achieve a balanced land supply between the

demand from urban growth and the demand for housing construction to avoid housing prices escalation and lagging urbanization. The literature has suggested that urban growth policy could be accelerated by facilitating agglomeration economies, smoothing the process of industrialization, relaxing the elasticity of housing supply, and improving the urban amenities. My research reveals that a balanced urban land supply policy is another way to facilitate the urbanization process. The ability of a city to quickly adapt its immobile factors, such as land, to different land uses according to changing market needs will enable sustainable growth (World Development Report, 2009). Therefore, when further urban growth relies on economic structure transformation, it is crucial to adjust land allocation among the competing economic sectors.

Chapter 5 How Do Urban Land Supply Patterns in Neighborhoods Influence Housing Prices in Beijing?

5.1 Introduction

In Beijing, nominal transaction prices of new housing, per square meter, almost tripled from the first quarter of 2006 to the fourth quarter of 2011. Moreover, not only the prices but also the growth rates of prices varied greatly across neighborhoods in Beijing[8]. For example, in the fourth quarter of 2011, the lowest average price was 4 thousand RMB in Xinggu Jiedao, Pinggu District, and the highest price 74 thousand RMB in Tuanjiehu Jiedao, Chaoyan District. Housing prices were very stable in Pingguyuan Jiedao, Shijingshan District, but it increased ten times in Tuanjiehu Jiedao, Chaoyan District.

The literature has provided micro evidence of the effects of neighboring land use patterns on housing prices, although it is lack of consistency (Grether and Mieszkowski, 1980; Cao and Cory, 1981; Geoghegan et al., 1997, Song and Knaap, 2004). Grether and Mieszkowski (1980) find that there is no systematic relationship between nonresidential land use per se and

[8] I define a Jiedao, the lowest level of a Chinese city's administrative organization, as a neighborhood.

neighborhood property values. Cao and Cory (1981) and Song and Knaap (2004) present evidence that housing prices are higher in neighborhoods with more non-residential land uses and where more jobs are available. Geoghegan et al. (1997) focus on the diversity and fragmentation of surrounding land uses and find that diversity and fragmentation are positively valued in highly developed urban and rural areas, but are negatively valued in suburbs. The findings by Mark and Goldberg (1986) show that, although housing values are influenced by different land uses, the impacts are not consistent in either direction or magnitude over time. Matthews and Turnbull (2007) find that the positive external effects of mixed land uses outweigh the negative external effects. However, the net advantages of mixed land uses are sensitive to how the land-use patterns are measured. There is no study on the effects neighborhood land uses on housing prices in Chinese housing market (See Section 3.4 of Chapter 3 for a more detailed literature review).

Table 5.1 reports increase rates of real housing prices and land supply pattern in Beijing and its eight employment centers from 2007 to 201. As shown in the table, along with the housing prices increase, the share of non-residential land compared to the total amount of newly supplied land also increased. Comparing the increasing rates in housing prices (Panel A of Table 5.1) and the share of the non-residential land supply (Panel B of Table 5.1) in eight

employment centers[9], it is also found that, in general, areas with higher five-year average shares of non-residential land supply than Beijing's five-year average saw higher growth rates in housing prices. An example is Tongzhou commercial service center[10], a newly established employment center in Beijing. Before 2009, housing price appreciation was lower than Beijing's average growth rate in housing prices. In 2004, a commercial service center was established in the Tongzhou district in accordance with Beijing's Master Plan (2004-2020). Since then, the share of non-residential land supply has increased dramatically for the purpose of promoting economic growth. In 2009, the share of non-residential land over the previous five years in the Tongzhou commercial service center rose to a higher than Beijing's average share. In 2010, the growth of housing prices in that area outpaced the Beijing's average rate. The relationship between housing prices and land supply patterns in Beijing is similar to the findings by Cao and Cory (1981) and Song and Knaap (2004).

[9] According to Beijing's Master Plan (2004-2020), Beijing is becoming a mega city with multiple employment centers. Those centers include a traditional CBD in the Guomao area, a high-tech center in the Zhongguancun area, a financial center in the Fuxingmen area, a national Olympic center, two commercial service centers Tongzhou and Shijingshan, a development zone in Yizhuang, and a manufacturing center in Shunyi.

[10] The Tongzhou district is one of Beijing's ten suburban districts and is used to as a satellite city because it is close to the CBD Guomao area. In Bijing's Master Plan (2004-2020), the sub-center of Tongzhou district is planned to be developed into an employment center specializing in commercial services. Since 2004, a large amount of land has been leased to non-residential sectors in Tongzhou.

Table 5. 1 The growth rates of real housing prices and land supply patterns in Beijing and its eight employment centers[1] (2007-2011)

	Beijing	CBD area	High-tech centre	Financial centre	National Olympic centre	Tongzhou commercial service centre	Shijingshan commercial service centre	Yizhuang development zone	Shunyi manufactory centre
	Panel A: Growth rate of average housing prices [2]								
2007	0.33	**1.19**	**0.80**	**1.45**	**0.72**	-0.15	0.32	0.10	-0.10
2008	0.03	**0.06**	-0.01	**0.24**	**0.21**	**0.15**	**0.04**	**0.19**	**0.12**
2009	0.16	**0.22**	**0.23**	**0.22**	**0.46**	0.15	0.14	**0.26**	0.04
2010	0.39	0.32	-0.21	0.15	0.10	**0.76**	**0.44**	**0.49**	0.21
2011	-0.02	-0.13	**0.65**	**0.10**	**0.34**	**0.08**	-0.06	**0.03**	-0.16
	Panel B: Share of non-residential land supply from year t-6 to t-1 [3]								
2007	0.47	**0.59**	**0.69**	**0.67**	0.45	0.44	**0.62**	0.30	0.15
2008	0.49	**0.62**	**0.74**	**0.66**	**0.51**	0.36	**0.64**	0.29	0.33
2009	0.56	**0.63**	**0.78**	**0.75**	0.54	**0.61**	**0.64**	**0.57**	0.30
2010	0.65	**0.86**	0.52	**1.00**	0.56	**0.75**	**0.66**	**0.72**	0.37
2011	0.65	**0.86**	0.52	**1.00**	0.46	**0.77**	0.56	**0.78**	0.58

Notes: 1. Besides a traditional central business district (CBD), there are seven sub employment centers in Beijing. See Section 3 for a detailed introduction;

2. Increase rates of housing prices are calculated from the transaction data of new housing in Beijing from 2006 to 2011. See Section 5 for data sources;

3. Only land parcels leased out through conveyance are included. Land supply pattern is represented by the share of non-residential land with a time span from year t-6 to t-1. See Section 5.4 for a detailed introduction and data sources;

4. The numbers in bold are those with higher values than the averages of the whole Beijing city.

The present paper aims to investigate how land-use supply for alternative land uses in the neighborhood influences Beijing's new housing transaction prices. I first allow for a price adjustment process in a hedonic model to show how neighborhood land supply pattern could be capitalized into housing prices. Land supply information affects both people's expectations for a neighborhood and how that neighborhood's spatial attributes may change in the future. These effects should be capitalized into housing prices (Kiefer, 2011). Non-residential land supply creates job opportunities and brings some desirable amenities to the neighborhoods. The willingness to pay for a housing

unit in such neighborhoods increases because of easy accessibility to workplaces and amenities. Next, I focus empirically on the competing uses of land supply between residential and non-residential sectors, as represented by the shares of commercial, industrial and public service land supplies in neighborhoods over the past five years. I find that increases in the shares of commercial, industrial and other non-residential land supply in the surrounding areas over the past five years have positive effects on the transaction prices of new housing in Beijing. These results are consistent when using alternative definitions of neighborhoods and applying spatial econometrics to capture the influence of the spatial dependence problem.

This study is of great significance. First, this is the first micro study to document the impact of patterns of neighborhood land uses per se on housing prices in Chinese cities. Previous Studies of the China's housing market either show that rising residential land prices (Wu et al., 2012) and an under-supply of residential land (Cai et al., 2011) contribute to the soaring housing prices from the macro view, or empirically investigate how accessibilities to workplaces and nearby public goods affect property values by applying micro transaction data (Ding, et al., 2010; He, et al., 2010, Zheng and Kahn, 2008). There are no studies directly question how the neighborhood land supply pattern affect housing prices. Second, the analytical framework developed in this study can be applied to incorporate the impact of any market activity that

can alter the supply of demand conditions of housing markets into housing prices. Since the owner-occupied housing market is characterized by disequilibrium, it is necessary to consider the disequilibrium factors in that market when studying the determinants of housing prices in a particular housing market. Therefore, the methodology employed has important implications for both the determinants of housing prices and construction of a housing price index.

Moreover, the findings revealed in the paper helps to understand to what extent the oaring housing prices in Chinese city attributes to neighborhood land supply pattern. The issue of soaring housing prices has become one of the hottest topics in China today. Since 2010, several serious government interventions have been introduced to curb rising housing prices, for example, charging a higher tax on property transactions, increasing the down payment and interest rate if a household buys a second home, forbidding migrants without resident certifications to buy property in some major cities, and setting housing quotas for city residents[11]. However, housing prices continue to rise across urban China. Why is it impossible to temper the housing market despite

[11] In 2010, "The Second Housing Reform" proposal won the support of the majority of delegates at the "Two Sessions" conferences. The reason that the proposal is called "The Second Housing Reform" is that the central government wants to show its determination to curb soaring housing prices by making this reform comparable to the first housing reform, which started in 1998. The 1998 change was an important milestone in Chinese urban housing reform that abolished the provision of welfare housing and resulted in the market-oriented urban housing provision system.

the central government's willingness and effort? This has become an impassioned debate in China, and no agreement has been reached. Without a full understanding of the determinants of housing prices, these administrative interventions might be not only less effective but also harmful to the housing market. This study provides evidence that allocating more land to non-residential sectors increases neighborhood housing prices. It provides a more empirical basis for optimizing land supply to stabilize housing price.

This chapter is outlined as follows. Section 5.2 provides an introduction to land supply and Beijing's new housing market. In Section 5.3, the disequilibrium hedonic framework developed by Anas and Eum (1984) is modified and specified to model Beijing's new housing market. The data used in the micro study and the empirical results of how land allocation among alternative land uses has influenced housing prices in Beijing are reported in Section 5.4 and Section 5.5, respectively. Finally, a summary of the results and their intuitions and implications are set forth in Section 5.6.

5.2 Land supply and the development of Beijing's new housing market

The Beijing Administrative Area consists of eighteen districts centered around Tiananmen Square (see the star point in Figure 5.1). The eight districts inside the thick dark line in Figure 5.1 are Beijing's inner city, and ten districts

outside the thick dark line are suburban areas. During the last decade, Beijing has experienced rapid urban expansion and has been developed into a mega city with multiple employment centers. From 2000 to 2010, Beijing's population increased by six million, more than 77 percent of the increase occurred outside the fifth ring road. Although the inner city is traditionally regarded as the urbanized area, due to the rapid urban expansion, the nearby areas have been built up as satellite cities, and the suburban sub-centers have been developed into employment centers. In addition to the traditional central business district of Guomao, seven employment subcenters have emerged: the high-tech center (Zhongguancun), the financial center (Fuxingmen), the national Olympic center, and the Shijingshan service center in the inner-city, and the Yizhuang development zone, the Shunyi manufactory center, and the Tongzhou service center in the suburban areas. Beijng's administrative system has three levels: municipality, district and sub-district district (Jiedao—or in rural areas, Xiangzhen). Jiedao is the lowest level of a Chinese city's administrative organization. It is only responsible for providing some minor services such as garbage collection and the population census, not responsible for infrastructure construction and land supply. In this sense, Jiedao is a geographical unit of analysis that allows for research and data collection but not a political player that uses tax revenues and land resources to provide public services (Zheng, and Kahn, 2012).The geographic size of a Jiedao varies greatly between the inner city and the suburban areas. The average size

of a Jiedao in the inner city is approximately 9.35 km^2 while it is approximately 54.8 km^2 in the suburban areas.

Beijing's provision of public goods is highly centralized. Most of its public infrastructure and services, such as transportation, education, and healthcare, are provided by the municipal government. Figure 5.2 shows the spatial distribution of Beijing's public infrastructures in 2011, including ring roads, subway stations, core primary schools, core hospitals, and parks. During the past decade, vast investments have been made by Beijing's city government to improve public infrastructure. To host the 2008 Summer Olympics, the city government spent 20.5 billion RMB to construct Olympic Park and scheduled rapid subway construction to occur from 2003 to 2008. By the end of 2011, there were 14 subway lines and 174 subway stations in Beijing, and its subways or light rails had reached all of the important suburban sub-centers. In its 11th-five-year Development Plan, the city government made additional plans to invest 85.1 billion RMB into the local public infrastructures, including facilities related to education, medicine, sports, and social assistance. Because Beijing's traditional public goods, such as primary and secondary schools and hospitals, are highly geographically centralized, which led to congestion in the city center, according to the 11th five-year Development Plan, no additional schools and hospitals will be developed in the city center. Therefore, the public infrastructure is gradually decentralizing.

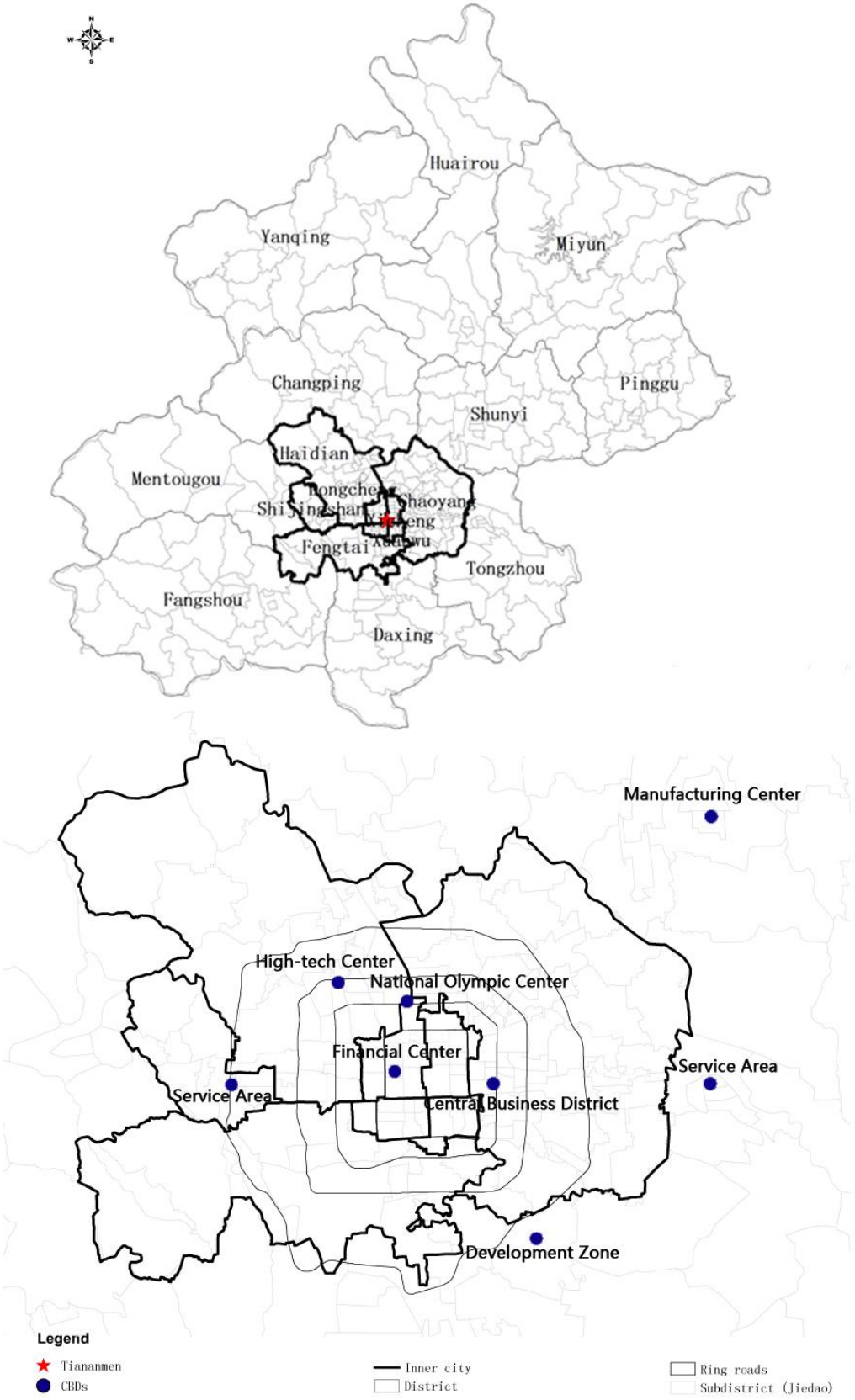


Figure 5. 1 Beijing administrative area and employment centers

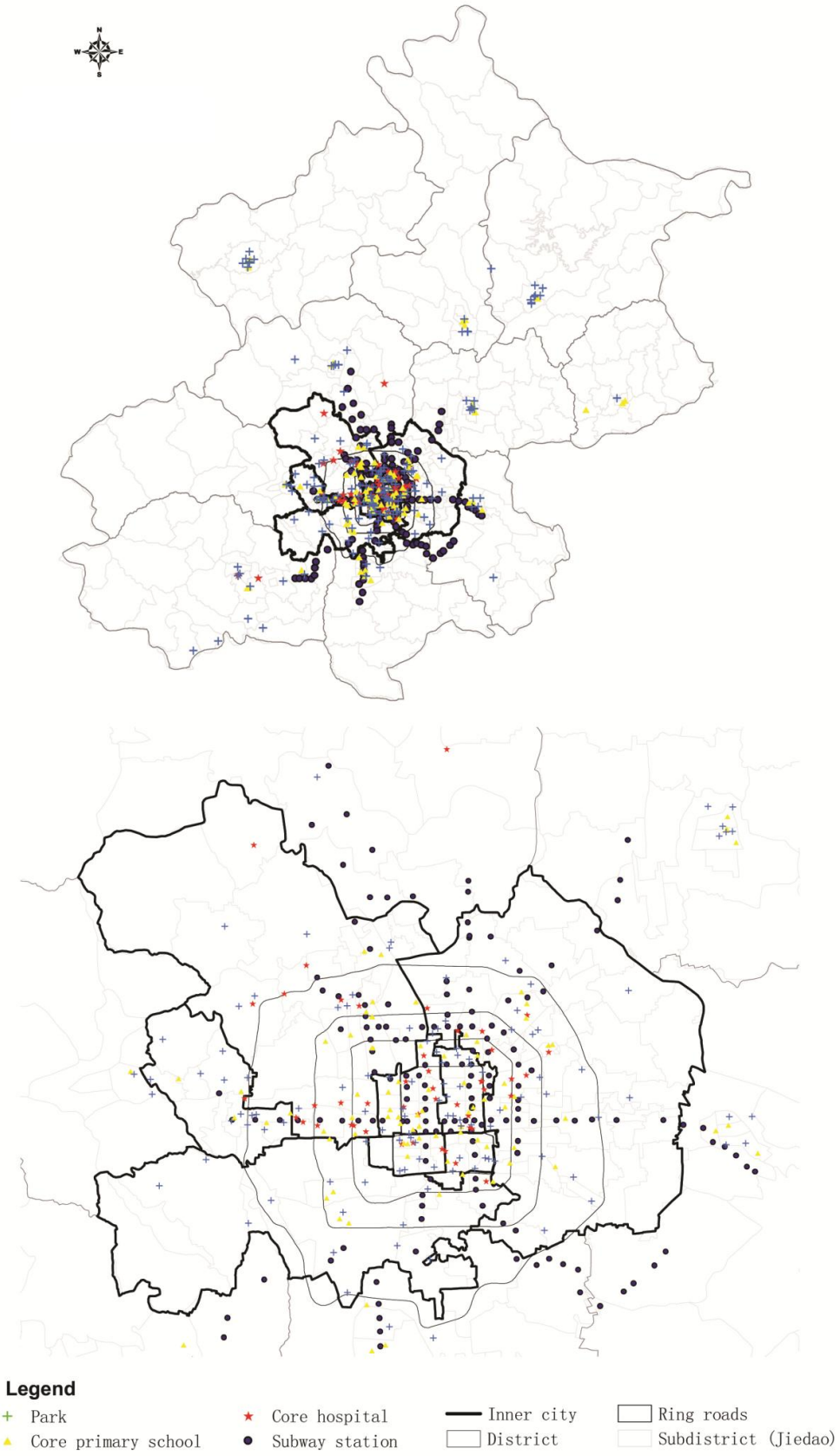


Figure 5. 2 Public infrastructure in Beijing

Beijing's land market has boomed and played a crucial role in economic growth and urban transition. Although the district governments are allowed to apply to develop land in their own administrative areas, only the Beijing Municipal Bureau of Land and Resources is authorized to lease urban land parcels, which suggests that the land supply process is under the control of the Beijing municipal government. In total, between 1993 and 2011, more than 270 square kilometers of land had been supplied through the process of land conveyance in Beijing, generating more than 647 billion RMB in land revenue. Table 5.2 presents the urban land supply by usage from 2000 to 2011[12]. The land supply peaked in 2004 and then shrunk dramatically in 2005. This is because, in 2003, China's central government enforced an order that all residential and commercial land could only be transacted through public bid—i.e., tender, auction, and public list—and set a deadline of August 31, 2004, for local governments to clarify their historical and ongoing land conveyance processes. Accordingly, Beijing's government began to supply land more quickly in 2003 and 2004. Since 2006, land supply in Beijing has gradually increased. As shown in Table 5.2, residential land accounted for 48.27 percent of the supply, and commercial and industrial land accounted for

[12] Land transaction data from 2000 to 2004 includes all land leased out via land conveyance, including negotiation and pubic bids. After 2004, only land transactions through public bids are available. Because residential and commercial land is leased out only through public bid, land transactions from 2005 to 2011 include all residential and commercial land. It is possible, however, that industrial land has been transacted by negotiation more recently than 2004. Thus, the amount of transacted industrial land in the 2005-2010 data might be less than the actual amount of transacted industrial land.

21.74 percent and 22.76 percent, respectively[13]. However, in terms of land revenue, the contribution shares for these three sectors are 46.09 percent, 49.32 percent, and 4.28 percent, respectively. This reflects that Beijing's land supply system prioritizes non-residential uses, as has been shown in Section 2.2.2 of Chapter 2

Table 5. 2 Land supply for alternative land uses in Beijing from 2000 to 2011 (unit: hectare)

Year	Industrial[1]	Commercial service	Public service[2]	Residential	Total
2000	313.17	86.38	56.21	511.13	966.88
2001	230.79	202.98	329.84	675.55	1,439.16
2002	404.77	303.58	117.71	1,203.52	2,029.58
2003	333.21	436.83	10.58	2,215.95	2,996.56
2004	406.6	1,294.97	5.59	2,336.95	4,044.11
2005	NA	151.65	44.28	158.04	353.96
2006	NA	246.66	80.41	472.36	799.44
2007	NA	258.02	154.76	485.14	897.92
2008	495.06	265.72	139.64	569.5	1,469.91
2009	724.04	336.48	362.87	523.9	1,947.29
2010	1,145.66	708.88	204.8	947.56	3,006.92
2011	935.48	472.79	78.29	478.93	1,965.49
Total	4,988.77	4,764.94	1,584.97	10,578.52	21,917.21
	22.76%	21.74%	7.23%	48.27%	100.00%

Note: 1. Land transactions by negotiation are not available since 2005. This leads to missing industrial land supply from 2005 to 2007. As after 2004, all commercial and residential land is leased out through tender, auction, or public list and the transaction records are public in official website of the Center of Land's Organization and Reservation of Beijing. However, negotiation is still allowed for industrial land but the land transactions by negotiation are not public.

2. Public service land is usually supplied by administrative allocation in Beijing. However, there are a few land parcels for public service are transacted via land conveyance in the data .

[13] The share of industrial land has been underestimated because the data related to land transactions by negotiation are not available after 2005.

Beijing's housing boom is remarkable. Prior to the 1988 housing reform, which abolished the provision of welfare housing, there was no private housing market. In 2011, investment in the housing sector reached 177.83 billion RMB, and 71.68 million square meters of residential construction had been newly completed. In addition, 10.35 million square meters of construction area were sold in 2011. Although there is no reliable public data for housing price appreciation in Beijing, soaring housing prices are quite notable and have caused policy makers and researchers to express concern. Our data show that the nominal transaction prices of new housing increased by 155.37 percent between the first quarter of 2006 and the fourth quarter of 2011. Housing transactions are experiencing suburbanization. In the first quarter of 2006, 75.01 percent of new housing transactions were in the inner city, however, only 34.91 percent of new housing transactions were located in the inner city by the fourth quarter of 2011. Several factors related to the land supply patterns have been identified as the driving forces of housing prices by literature. Zheng and Kahn (2008) document the accessibility to the public transit infrastructure, core high schools, clean air, and major universities, most of which have exogenous locations, as important determinants of real estate prices. He, Wang, et al. (2010) show that the main driving forces of housing transaction prices in Beijing are floor area ratio and land transaction price. Controlling for the structure and other characteristics of urban housing units, Song and Zenou (2011) find that housing prices are lower the closer the

buildings are to urban villages. However, these studies provide only limited empirical evidence about how neighborhood land supply patterns per se have contributed to the rising housing prices.

5.3 Econometric model specification

The hedonic model, which was originally designed to price the utility-bearing attributes or characteristics of durable consumptive goods based on a market equilibrium assumption (Lancaster, 1966), is the most widely used approach for studying the determinants of housing prices. The beauty of hedonic model in dealing with the valuation problem of a complex good makes it attractive to apply to real estate markets, which are characterized by heterogeneous buildings (Rosen, 1974; Harrison and Rubinfeld, 1978; Witte, et al., 1979). The application of hedonic model to a rental housing market is straightforward, because housing is a durable consumption good for renters and rent is likely at an equilibrium price (Buchel and Hoesli, 1995). However, an owner-occupied housing market differs from a rental housing market in at least two ways. First, unlike a renter, a homeowner may hold a house as an investment good in a portfolio of assets (Henderson and Ioannides, 1983, 1986). Second, a housing market is subject to frequent disruptions arising from information asymmetries, high transaction costs, and long investment horizons. Early studies suggest that the market is often inefficient and adjusts slowly to the changes in market conditions at both highly aggregated and micro levels (Hanushek and Quigley,

1979; Anas and Eum, 1986; Riddel, 2004). Periods of sustained disequilibrium are the norm in a housing market, and a disaggregated market would typically experience high levels of disequilibrium.

A hedonic analysis of a housing market in disequilibrium has been developed by Anas and Eum (1984) to model disequilibrium housing prices. These authors add a price adjustment process into the hedonic analysis to incorporate the influences of disequilibrium on housing transaction prices. Their empirical analyses, which use micro data related to the sale prices of single-family dwellings in the city of Chicago between 1972 and 1976, confirm the hypothesis that information about housing market activity and about specific dwellings, as represented by interest and turnover rates in a manually drawn 1/2*1.2-mile square zone, becomes capitalized into housing prices through a disequilibrium adjustment process. The later literature identifying the source of disequilibrium suggests that mortgage rates, marginal tax rates, changes in demographic structure, and other market activities that can alter housing supply and demand conditions should be incorporated into the house price determination process (Anas and Eum, 1986; Riddel, 2004). In the present study, I apply the disequilibrium hedonic to illustrate the determination process of housing prices under the disequilibrium condition.

Unlike the context In Anas and Eum (1984, 1986) where the reference prices

are available, represented by historic prices for the dwelling that had sold two or more times or prices of reference dwellings, house market in Beijing is dominated by new housing transaction. Therefore, instead of p_{jt-1}, I assume there is a market price that are perceived by both sellers and buyers. Suppose a seller's decision to sell a housing unit is based on the perceived market price, housing characteristics, and other observable market activities that could lead to changes in market conditions. Given a perceived market price $\bar{P}_{ij}$, the supply function of housing unit i located at a neighborhood j is

$$S_{ij} = \alpha_0 + \alpha_1 \bar{P}_{ij} + \alpha_2 X_{ij} + \alpha_3 Y_j + u_{ij}, \qquad \alpha_1 \geq 0 \tag{5.1}$$

where X_{ij} is a vector of the hedonic attributes of the housing unit, including physical characteristics, neighborhood characteristics, accessibility, and the availability of amenities. Y_j is a vector of variables of market activities that are assumed to influence the supply conditions of neighborhood j, such as housing supply shock or other socioeconomic factors. α_2 and α_3 are the vectors of appropriate coefficients and u_{ij} is a random term capturing the effects of missing variables and measurement errors in the supply function.

Potential home buyers also decide to purchase a particular housing unit based on perceived market price, the housing unit's characteristics, and market activities that could change housing market conditions. Accordingly, the demand function for this housing unit is

$$D_{ij} = \beta_0 + \beta_1 \bar{P}_{ij} + \beta_2 X_{ij} + \beta_3 Z_j + v_{ij}, \qquad \beta_1 \leq 0 \tag{5.2}$$

where X_{ij} is the same housing characteristics vector in supply function and Z_j is a vector of variables of market activities assumed to influence the demand conditions of neighborhood j, such as demographic change or other socioeconomic factors. The variables in Y_j and Z_j can be overlapped because some market activities could alter both supply and demand conditions at the same time. For example, when a parcel of land in a neighborhood is supplied to the commercial sector, the housing demand increases because the growth of commercial sector creates job opportunities. Meanwhile, the potential housing supply shrinks when there is less and less land available in the neighborhood. β_2 and β_3 are the vectors of appropriate coefficients and v_{ij} is a random term that captures the effects of missing variables and measurement errors in the demand function.

For a particular housing unit, when the seller makes the offer decision and only one buyer makes a bid for this housing unit, the market is in equilibrium. Thus, the equilibrium price path P_{ij}^* is derived by setting $D_{ij} = S_{ij}$. This yields an equilibrium price, as follows:

$$P_{ij}^* = \frac{1}{(\alpha_1 - \beta_1)}[(\beta_0 - \alpha_0) + (\beta_2 - \alpha_2)X_{ij} - \alpha_3 Y_j + \beta_3 Z_j - u_{jt} + v_{jt}] \quad (5.3)$$

Because periods of sustained disequilibrium are the norm in the housing market, sellers adjust reserve prices, and buyers adjust offer prices according to excess demand (or supply). Suppose the price adjustments for both sellers

and buyers follow the same process by supposing that

$$P_{ij} - P_{ij}^{*} = \lambda(D_{ij} - S_{ij}) + \varepsilon_{ij}, \quad 0 \leq \lambda \leq \infty \tag{5.4}$$

where the deviation between the seller's reserve price or the buyer's offer price and the equilibrium price is proportional to the excess demand (or supply) at a speed of adjustment λ, up to some random disturbance ε_{ij}. A deal can be reached when the buyer's offer price meets the seller's reserve price. Substituting the supply and demand functions (equation (5.1) and (5.2)) and the equilibrium price path (equation (5.3)) into equation (5.4) and rearranging terms, the final transaction price is:

$$P_{ij} = \frac{1}{(\alpha_1 - \beta_1)}[(\beta_0 - \alpha_0) + (\beta_2 - \alpha_2)X_{ij} - \alpha_3 Y_j + \beta_3 Z_j] - \omega_{ij}, \tag{5.5}$$

where the random disturbance term

$$\omega_{ij} = -\frac{u_{ij} - v_{ij}}{(\alpha_1 - \beta_1)} + \frac{\varepsilon_{ij}}{1 + \lambda(\alpha_1 - \beta_1)} \ . \tag{5.6}$$

The disturbance term is composed of the random error terms of housing supply and demand functions, v_{ij} and u_{ij}, and the random disturbance ε_{ij} from the price adjustment process. If v_{ij}, u_{ij}, and ε_{ij} are normal independent with means zero and variances σ_v^2, σ_u^2, and σ_ε^2, it follows that ω_{ij} is normal independent with means zero and variance $\sigma_\omega^2 = (\frac{1}{\alpha_1 - \beta_1})^2(\sigma_v^2 + \sigma_u^2) + (\frac{1}{1 + \lambda(\alpha_1 - \beta_1)})^2\sigma_\varepsilon^2$. Then OLS estimation can yield consistent and asymptotically efficient estimators of $\frac{\beta_0 - \alpha_0}{\alpha_1 - \beta_1}$, $\frac{\beta_2 - \alpha_2}{\alpha_1 - \beta_1}$, $\frac{-\alpha_3}{\alpha_1 - \beta_1}$, and $\frac{\beta_3}{\alpha_1 - \beta_1}$, as in the case discussed in Anas and Eum (1984, 1986). In this study, it is assumed that ε_{ij} is normal independent with means zero and variance σ_ε^2, and v_{ij} and u_{ij} are

subject to spatial interdependence as suggested by the literature on housing property values (Pace, Barry, and Sirmans, 1998; Sun, Tu, and Yu, 2004). Developments in spatial econometrics have addressed the spatial dependence issue and have provided various remedies (Pace, Barry, and Sirmans, 1998; Dubin, Pace, and Thibodeau, 1999; Sun, Tu, and Yu, 2004; Jeanty, 2010). Housing project addresses enable me to identify latitude and longitude. Geographic coordinates allow me to capture the influence of spatial dependence using spatial econometrics.

The studies in general indicate that land-use patterns in a smaller geographic area can influence housing values (Grether and Mieszkowski, 1980; Cao and Cory, 1981; Geoghegan et al., 1997, Song and Knaap, 2004). Chinese literature has suggested that urban land supply policy plays a decisive role in soaring housing prices (Yu, 2010; Wu, Gyourko, and Deng, 2012) but lack of micro evidence. Based on Chinese across-cities data, the findings in Chapter 4 conclude that a city with a larger share of non-residential land has higher housing prices. It is because when a city's government attempt to promote local economic growth by supplying more and cheaper non-residential land, economic growth both calls for a higher demand for labor and generates higher wage rates. Both labor demand and higher wages drive up housing demand and prices. Meanwhile, the land supply policy decreases the supply of residential land, causing a limited housing supply that worsens the already

high price of housing. This implies that local land supply by usage can alter the housing market's supply and demand conditions. Therefore, the equation (5.5) derived above is applicable to estimate the effects of the neighborhood land supply pattern on housing transaction prices in Chinese cities..

There are two issues when specifying the econometric model. First, how to measure neighborhood land supply pattern? Land uses information is needed in developing measures of neighborhood land uses pattern (Geoghegan et al., 1997, Song and Knaap, 2004). Unfortunately, this type of information is unavailable in Beijing. Instead, I use land transaction data between 2000 and 2010. The problem of using land transaction data is it only reflects the new supply, but to a great degree, urban land uses are path-depended. With the rapid urban expansion, land supply in the inner city is increasingly inelastic and new supply of land is more happened suburban areas. To address this problem, instead of area of land supply by uses, I use the shares of commercial, industrial, and public service land in new supply land aggregated at a time span with certain years. While these variables must be an imperfect measure of neighborhood land uses pattern, the similarity between the shares of commercial, industrial, and public service land in new supplied land and that in developed urban area in Beijing suggests that the approximation may not be

too far off[14].

Second, how to define a geographic unit for the land supply pattern? The geographic unit of the neighborhood varies in the studies on neighborhood land-use patterns influences housing prices. It can be a special zone (Grether and Mieszkowski, 1980), a traffic analysis zone (Song and Knaap, 2004), or a census tract (Matthews and Turnbull, 2007). The introduction of the administrative system in section 5.2 suggests that Jiedao is a geographical unit of analysis that allows for research and data collection but is not a political player that uses tax revenues and land resources to provide public services. Thus, the most convenient way is to consider a Jiedao as a local land market and to aggregate micro land transaction data by usage at the Jiedao level. However, the difference in term of geographic size is great between Jiedaos in the inner city and suburban, 9.35 km^2 versus 54.8 km^2. Therefore, for the housing projects in the inner city, I sum up land supply data at the located Jiedao and its neighboring Jiedaos. But for the housing projects in the suburban, only land supply in the located Jiedao is included. When conducting robustness tests, I also calculate variables related to land allocation structure within a circle with a 1-kilometer radius or a circle with 2-kilometer radius

[14] In 2011, after exclude roads and other transportation facility, public infrastructure, and green space, the share of residential land in urban developed area in Beijing was 41.25 percent according to China City Construction Statistical Yearbook 2012. Land supply data applied in this study which underestimate industrial land shows, in average, 48.27 percent of new supply land had been allocated to the residential sector between 2000 and 2011.

centered on each specific housing project.

Therefore, Y_j and Z_j in equation (5.5), the market activities that able to alter housing supply and demand conditions, are specified into three variables, *CommercialLand, IndustrialLand, PublidLand*, representing the shares of commercial, industrial, and public service land in the neighborhood, respectively. Equation (5.5) of is reduced to an estimable function as the following:

$$P_{ij} = \alpha_0 + \alpha_1 X_{ij} + \alpha_{21} CommercialLand_j + \alpha_{22} IndustrialLand_j + \alpha_{23} PublidLand_j + \alpha_3 Others_j + \mu_{ij}. \quad (7)$$

The prices of a housing unit *i* located in neighborhood *j* is a function of of $X_{ij,}$—a vector of hedonic factors, neighborhood land uses, and $Others_j$—other variables of market activity assumed to influence housing supply and demand conditions. μ_{ij} represents the random disturbance term ω_{ij} in equation (5.6). $\alpha's$ are coefficients need to be estimated, and particular interests are placed on α_2. Because commercial land brings job both opportunities and desirable amenities, it is expected that the share of commercial land will have positive effects on housing prices. Industrial land can create job opportunities, but it is associated with an undesirable living environment. The sign of α_{22} depends on a tradeoff between the desire for neighborhood amenities and accessibility

to jobs. For the shares of new land allocated to public service sectors, the effects are likely positive, as this category includes transportation, green space, and other functional facilities in Beijing.

5.4 Data

Two datasets are employed in the present study. One is new housing transaction data between 2006 and 2011 and the other is land transaction data between 2000 and 2010. This section documents the sources of that data and also provides a description of the data.

The new housing transaction data are from Beijing's Study Center of Construction and Development (Beijing Shi Jianshe Fazhang Yanjiu Zhongxin), which is subordinate to Beijing's Municipal Commission of Housing and Urban-Rural Development (Beijing Shi Zhufang he Chengxiang Jianshe Weiyuanhui) and specializes in studying policies related to housing and urban development. The land transaction dataset consists of two parts. The first part, from 1993 to 2004, is available from the Institution of Real Estate Studies at the Central University of Finance and Economics (CUFE). The second part, from 2005 to 2011, is available from the official website of Beijing's Center of Land's Organization and Reservation (Beijing Shi Tudi Zhengli Chubei Zhongxin), which is subordinates to Beijing Municipal Bureau of Land and Resources (Beijing Shi Guotu Ju), takes responsibility for

organizing and implementing the transactions of land-use rights via public auction, or tender, or list, and manages the land market on behalf of the government. As mentioned earlier, because land transactions by negotiation have not been available since 2005, the share of industrial land tends be underestimated. The population data at the Jiedao level are from the Sixth Population Census of Beijing. Other information in this study such as public infrastructure is public and is shown in Figure 5.2.

The spatial distribution of new housing projects and transacted land parcels reflects a pattern of geographic decentralization and urban expansion in Beijing. Figure 5.3 illustrates the spatial distribution of new housing projects. With the increasing scarcity of land in central Beijing, housing has been built further and further away from the city center. The housing transaction data show that, in 2006, 57 percent of new housing transactions occurred outside the fifth ring road; in 2011, the number declined to 23 percent. Figure 5.4 shows the spatial distribution of transacted land parcels in Beijing by usage and grouped into two time periods, 1993-2004 and 2005-2011; it follows the same spatial pattern as the distribution of new housing projects. Compared to the years before 2005, land parcels for all usages have been decentralized due to urban expansion. Moreover, industrial land has been highly decentralized, and the decentralization of housing land has been gradual. Commercial land

was still relatively centralized. This pattern reflects that land-use patterns in the entire city of Beijing have become increasingly market-oriented.

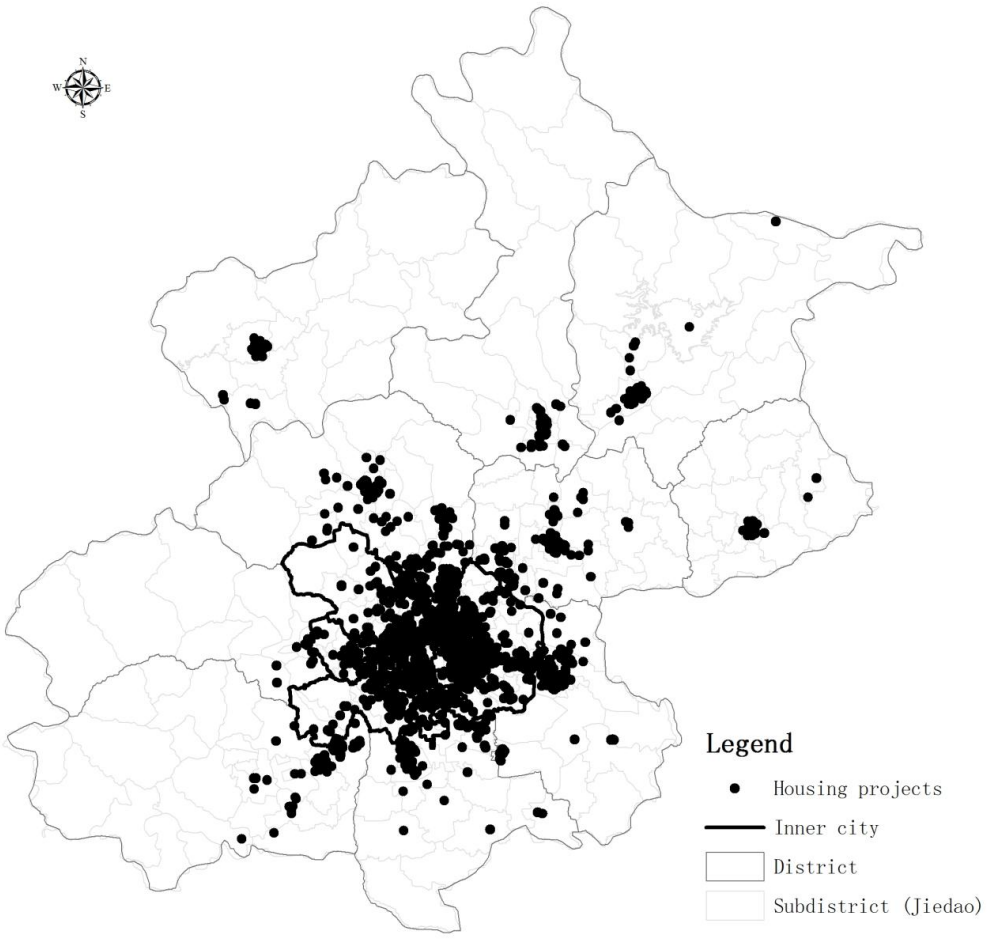
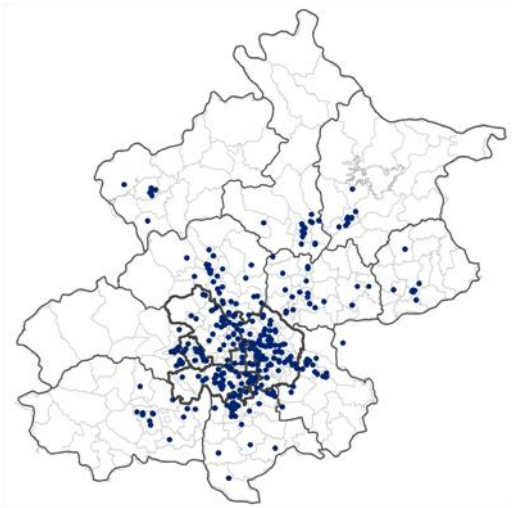
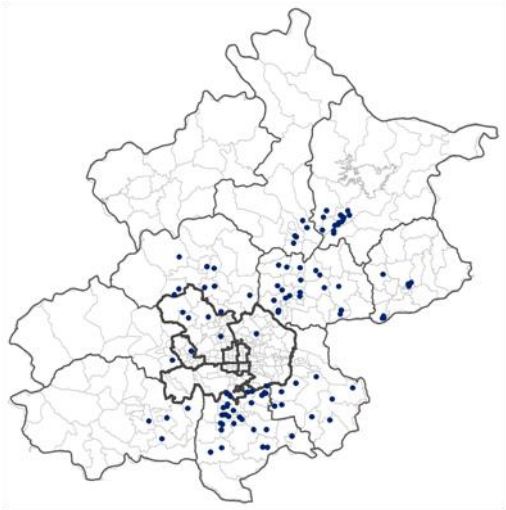


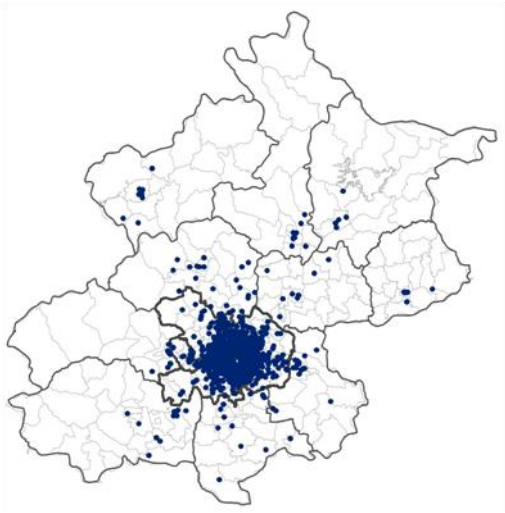
Figure 5. 3 Spatial distribution of new housing projects



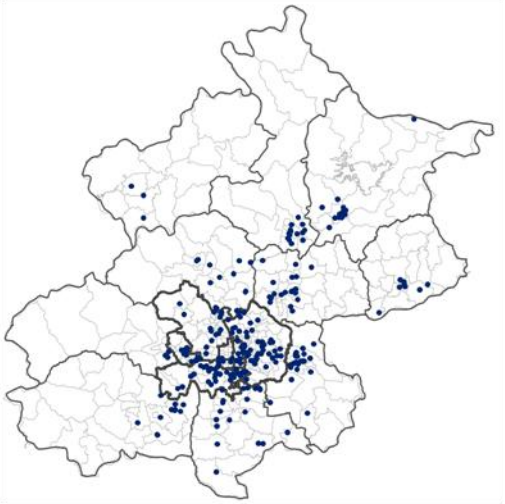
Industrial land 1993-2004



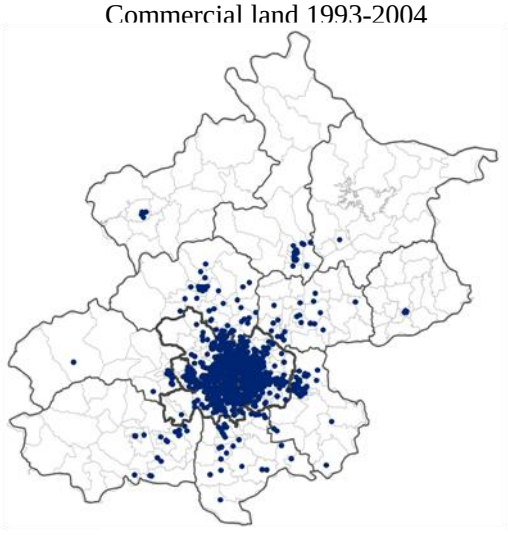
Industrial land 2008-2011



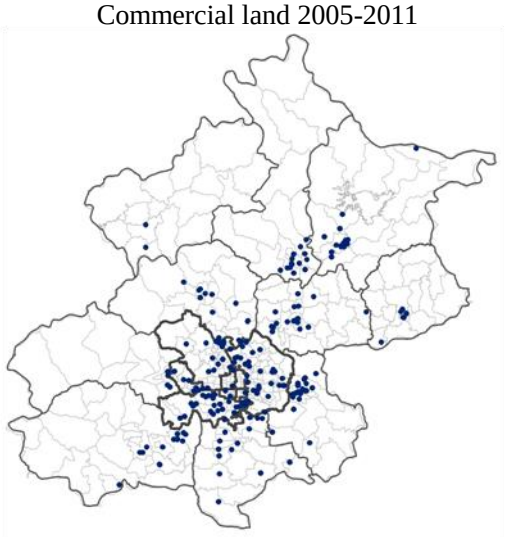
Commercial land 1993-2004



Commercial land 2005-2011



Residential land 1993-2004



Residential land 2005-2011

Figure 5. 4 Spatial distribution of land parcels

From 2006 to 2011, 7,516 housing projects[15] were put on the market, and more than 650,000 housing transactions were conducted. Table 5.3 provides a complete description of the variables used in the regression, and Table 5.4 gives the summary statistics of those variables. The dependent variable is the transaction prices of new housing units. All prices are deflated by the Consumption Product Index, taking 2006 as the base year. As shown in Table 5.4, the real average sale price of a housing unit in Beijing is 1.54 million RMB.

Table 5. 3 Variable list and definitions for hedonic analyses

Variable	Definition
Housing Unit Attributes	
Price	The real price of a housing unit in 2006 price (Thousand RMB).
Area	The area of a housing unit (100 sq. meter).
Floor	The floor level in which a housing unit is located.
Duration	Time on market, from the date on which the project was issued to the sale date (10 month).
Pre_sale	Binary: indicating if the unit was sold by pre_sale or not.
Y06Q1-Y11Q4	A set of quarterly dummy variables that indicate the date of the sell.
Housing Project Attributes	
P_area	The total floor area of the project, indicating the size of the project (10,000 sq. meter).
B_floor	The total number of floor of the building, indicating the size of the project
D_school	The distance from the project to the closest core primary school (kilometers)
D_hospital	The distance from the project to the closest core hospital (kilometers)
D_park	The distance from the project to the closest park (kilometers)
D_CBD	The distance from the project to the closest Central Business District (kilometers).
Subway	Binary: project within 1-kilometer distance from a subway station.

[15] Developers should apply for sale permits to put their projects on the market. Sometimes, especially for large housing projects, developers sell houses in stages. In these cases, one large housing project could have several sale permits. In this study, each sale permit is treated as one housing project.

Table 5.3 Variable list and definitions for hedonic analyses (Continued)

Location	
QD1	Binary: located in the first quadrant (Northeast)(TianAnMen as the origin point).
QD2	Binary: located in the second quadrant (Northwest)(TianAnMen as the origin point).
QD3	Binary: located in the third quadrant (Southwest)(TianAnMen as the origin point).
QD4	Binary: located in the fourth quadrant (Southeast)(TianAnMen as the origin point).
Ring1	Binary: located inside the sencond ring road.
Ring2	Binary: located between the sencond and the third ring road.
Ring3	Binary: located between the third and the fourth ring road.
Ring4	Binary: located between the fourth and the fifth ring road.
Ring5	Binary: located outside the fifth ring road.
Land Supply Pattern in the Located Jiedao and the Neighboring Jiedaos from year t-6 to t-1	
CommercialLand	The share of land allocated to the commercial sector out of the total land supply from year t-6 to t-1 in the neighborhood (the located Jiedao and its adjacent Jiedaos for the inner city and only the located Jiedao for suburban areas).
IndustrialLand	The share of land allocated to the industrial sector out of the total land supply from year t-6 to t-1 in the neighborhood (the located Jiedao and its adjacent Jiedaos for the inner city and only the located Jiedao for suburban areas).
PublicLand	The share of land allocated for public services out of the total land supply from year t-6 to t-1 in the neighborhood (the located Jiedao and its adjacent Jiedaos for the inner city and only the located Jiedao for suburban areas).
Other Housing Supply and demand Factors	
PopulationDensity	Population density (10 thousand/sq. kilometer).
HousingSupply	The planned construction area of housing from year t-6 to t-1 in the located Jiedao (million sq. meter).
N_HousingSupply	The planned construction area of housing from year t-6 to t-1 in the neighboring Jiedaos(million sq. meter).

Table 5. 4 Descriptive statistics

Variable	Mean	Std.dev.	Min	Max
Housing Unit Attributes				
Price	1538.54	2335.29	0.00	346856.60
Area	1.22	0.82	0.06	182.97
Floor	8.16	6.19	-3.00	54.00
Duration	0.71	0.80	-1.50	12.00
Pre_sale	0.84	0.37	0	1
Housing Project Attributes				
P_area	5.12	4.20	0.00	36.35
B_floor	15.21	7.75	1.00	63.00
D_school	3.32	3.57	0.00	48.70
D_hospital	11.99	13.07	0.11	103.00
D_park	2.47	2.52	0.00	45.74
D_CBD	10.87	10.56	0.01	86.16
Subway	0.29	0.45	0	1
Location				
QD1	0.40	0.49	0	1
QD2	0.18	0.39	0	1
QD3	0.25	0.43	0	1
QD4	0.17	0.38	0	1
Ring1	0.04	0.20	0	1
Ring2	0.08	0.27	0	1
Ring3	0.14	0.34	0	1
Ring4	0.18	0.38	0	1
Ring5	0.56	0.50	0	1
Land Supply Pattern in the Located Jiedao and the Neighboring Jiedaos from year t-6 to t-1				
CommercialLand	0.28	0.19	0.00	1.00
IndustrialLand	0.12	0.21	0.00	1.00
PublicLand	0.09	0.12	0.00	1.00
Other Housing Supply and demand Factors				
PopulationDensity	0.97	0.96	0.01	14.45
HousingSupply	1.30	1.39	0.00	7.42
N_HousingSupply	4.30	3.38	0.00	16.33

There are three sets of variables representing conventional hedonic factors. The first set is information related to the sold unit including unit area, floor number, selling date, presale or not, and time on market. As shown in Table 5.4, the average unit size of a typical housing unit in Beijing is 122 square meter. The average time on market (*Duration*) of a new housing unit is 7 months. Beijing's new housing market is dominated by condominiums, leading to an average floor number of approximately 8. Pre-sale is the main type of sale, involving 84 percent of transactions of new housing units. The second set is project-related information, including total built area, number of floors of the building, accessibility, and location variables. A project's total built area, which indicates the project size, can be used to control the size effect. A typical housing project has a built area of 51.2 thousand square meters for a total of approximately 420 average-size housing units. The third set is location attributes. The address of a housing project enables me to identify the latitude and longitude. With these geo-codes, I calculated the distances from each project to the nearest employment center, core primary school, and core hospital via geographic information system (GIS). Access to core primary schools is highly valued because of the compulsory education policy that requires children to attend primary schools in their assigned school zones. Other public services, such as high-quality hospitals and parks (green space), are also included. Two variables measure the accessibility to work places: distance to the nearest CBD and a dummy representing whether there is a

subway station available within 1 kilometer. Finally, location variables can be further categorized into two groups. Deng, Zheng, and Guo (2010) find that, compared to the QD1 (Northeast) region, the QD2 (Northwest), QD3 (Southwest), and QD4 (Southeast) regions have lower average housing prices. Thus, I will include quadrant dummies in the regression. Beijing's transportation system is based on ring roads, which play a very important role in transportation. Regions divided by ring roads have different levels of housing values. Therefore, location indicators represented by ring dummies are introduced into the control variables.

Key testing variables representing the neighborhood land uses are calculated as follows. First, I aggregate micro land transaction data by usage at the neighborhood level, which is the located Jiedao and its adjacent Jiedaos for the inner city and only the located Jiedao for suburban areas. Next, the shares o commercial, industrial, and public service sectors in the neighborhood over the past five years are calculated and chosen as land uses pattern variables[16]. The reason that land supply is summarized by usage over a five-year time span is

[16] There are ten categories of urban land use in Chinese cities: residential, commercial, industrial, storage, intercity transportation, intracity transportation, public functions, green space, special land, and water. Land for the first four categories is supplied via land conveyance, which is a process of leasing land-use rights to users; land for the remaining uses, which this study calls public service land, is usually supplied by administrative allocation, leaving the data unavailable. However, as shown in Table 5.2, it is observed that a very few pieces of land for public service have been transacted via land conveyance. This study merges storage land into industrial land.

because five years are required to attenuate the effect of the shock caused by the supply of a new piece of land[17].

Two other types of factors that can influence housing supply and demand are included in another regression, serving as a test for robustness. The first is population density[18]. As one of the most important demand factors, population should be considered. Because geographic size varies across Jiedaos, it is more appropriate to use population density. The second type is planned housing supply shock. Information related to planned construction area and floor-to-area ratio is available in micro land transaction data. This makes it possible to control the influence of neighborhood planned housing supply.

If a housing project is located at the edge of a Jiedao, the price of its units may be more affected by the neighboring Jiedao rather than the corresponding Jiedao. To address this problem and to conduct robustness tests, a more accurate definition of geographic unit of local land supply is needed. GIS also enabled me to define alternative geographic unit for the land supply. First, I drew circular neighborhoods with a 1- or 2-kilometer radius for each housing

[17] In Beijing, for a medium-size commercial project, such as a shopping mall or an office building, it usually takes at least 1 year from project design to construction permit, and construction takes 2-3 years, leaving 1-2 years for decorating and starting a business. In later empirical tests, we also used time spans of 3 and 10 years. The directions of the effects are not altered but become less significant.

[18] Population data at the Jiedao level are only available for the population censuses of 2000 and 2010. Using these two years of population data, we interpolated each year with linear average values.

project. Next, I placed aggregate land transactions within the circles and calculated shares of the four categories of land with a time span of the past five years at the circular neighborhood level, as I did at the Jiedao level.

5.5 Empirical analysis

I conduct the empirical study in three stages. First, I compare the results of the conventional hedonic model with the results of the disequilibrium hedonic models to show the effects of neighborhood land supply pattern on housing prices. Next, I conduct robustness tests by using alternative definitions of neighborhood, which are circular neighborhoods with a 1- or 2-kilometer radius from the center of the transacted housing unit. Finally, to address the problem of spatial dependence problems, spatial econometric models are applied into the representative sub-samples and the results are discussed.

5.5.1 Results using Jiedao's land supply patterns

The results of a conventional hedonic model, a disequilibrium hedonic model with a land supply pattern, and a disequilibrium hedonic model with both land supply pattern variables and other demand and supply factors are reported in Table 5.5. Several important findings are revealed. Firstly, quarter dummies are included to capture the effects of unobservable macroeconomic and housing market cycles. The performance of the quarter dummies is not reported due to space limitations, but all are both positive and statistically

significant (see the full results in Table A1 in the Appendix). This reflects a strong trend of housing price appreciation during the study period, from the first quarter of 2006 to the fourth quarter of 2011.

As expected, with respect to the physical attributes of a housing unit, both larger units and upper floors tend to have higher total prices. An unexpected result is that both duration (time on market) and pre-sale positively affect transaction prices. The possible explanation is, 84 percent of housing units are sold in the form of pre-sale, with waiting time for those housing unit being shorter when the duration is longer, and the sale price then increases. There are strict regulations when developers apply for pre-sale licenses. For homebuyers, pre-sale per se could be an indicator of a credible developer and a high-quality project. This might be the reason why pre-sale has a positive influence on housing values.

Table 5. 5 Results of hedonic models

	Conventional Hedonic Model (1)			Hedonic Model with Land Supply Pattern Variables (2)			Model (2) + Other Demand and Supply Factors (3)		
	Coef.	S.E.		Coef.	S.E.		Coef.	S.E.	
Housing Unit Attributes									
Area	0.584	0.001	***	0.583	0.001	***	0.583	0.001	***
Floor	0.007	0.000	***	0.007	0.000	***	0.007	0.000	***
Duration	0.005	0.001	***	0.005	0.001	***	0.005	0.001	***
Pre_sale	0.298	0.002	***	0.293	0.002	***	0.292	0.002	***
Housing Project Attributes									
P_area	-0.010	0.000	***	-0.010	0.000	***	-0.009	0.000	***
B_floor	0.001	0.000	***	0.001	0.000	***	0.001	0.000	***
D_school	-0.016	0.000	***	-0.017	0.000	***	-0.016	0.000	***
D_hospital	-0.018	0.000	***	-0.018	0.000	***	-0.018	0.000	***
D_park	0.005	0.001	***	0.006	0.001	***	0.006	0.001	***
D_CBD	-0.003	0.000	***	-0.003	0.000	***	-0.003	0.000	***
Subway	0.013	0.001	***	0.008	0.002	***	0.008	0.002	***
Location									
Quadrant dummies (QD1=0)									
QD2	-0.108	0.002	***	-0.081	0.002	***	-0.084	0.002	***
QD3	-0.193	0.002	***	-0.182	0.002	***	-0.180	0.002	***
QD4	-0.012	0.002	***	-0.005	0.002		-0.009	0.002	***
Ring roads dummies (Ring1=0)									
Ring2	-0.230	0.004	***	-0.234	0.004	***	-0.217	0.004	***
Ring3	-0.133	0.004	***	-0.134	0.004	***	-0.112	0.004	***
Ring4	-0.178	0.004	***	-0.187	0.004	***	-0.154	0.004	***
Ring5	-0.256	0.004	***	-0.267	0.004	***	-0.233	0.005	***
Neighborhood Land Uses Pattern									
CommercialLand				0.129	0.005	***	0.117	0.005	***
IndustrialLand				0.174	0.004	***	0.170	0.004	***
PublicLand				0.491	0.009	***	0.492	0.009	***
Other Housing Demand and Supply Factors									
PopulationDensity							0.016	0.001	***
HousingSupply							-0.001	0.000	***
Constant	5.973	0.005	***	5.922	0.006	***	5.890	0.007	***
Quarter Controls	Yes			Yes			Yes		
R-sq	0.603			0.605			0.605		
Number of observations	622,374			622,374			622,374		

Note: 1. * P < 0.05; ** P < 0.01; *** P < 0.001.

2. All variables are defined in Table 5.3

3. Dependent variable is ln(Price) (unit: thousand RMB)

With respect to the physical attributes of a housing project, homebuyers negatively value larger projects, but they positively value taller buildings. This pattern is consistent with a characteristic aspect of Beijing's housing market: the high-end housing market is dominated by luxury housing in very tall buildings that are small in size. Public services are positively valued in Beijing's housing market, except for parks. People are willing to pay more to be close to high-quality primary schools, high-quality hospitals and workplaces; and the existence of a subway station within one kilometer is also positively valued. The coefficient of the distance to parking is positive in all three models, as shown in Table 5.5. This is inconsistent with the findings by Zheng, et al. (2008) and Liao and Wang (2012), who show that the desire for green space is important in the Chinese housing market. These unexpected results might be because parks might not be a perfect proxy for green space because parks are typically located in Beijing's suburban areas. Location variables play important roles in housing prices. On average, the first quadrant (Northeast region) and the region inside the second ring road are the most expensive areas in Beijing. The fourth quadrant (Southeast region) is the second-most expensive area, followed by the second quadrant (Northwest region). The third quadrant (Southwest region) is the area with the lowest housing prices in Beijing. As indicated by the coefficients of the ring road dummies, housing prices decline when housing is further away from the city center.

Most importantly, a neighborhood's land supply pattern has a significant impact on housing prices. As shown in columns (2) and (3) of Table 5.5, all of the neighborhood land uses variables are positive and significant. This result suggests that an increase in the shares of commercial, industrial, and public service land in newly supplied land could drive up property values. Moreover, the performance of the estimations is slightly improved when the land supply pattern variables are included, as indicated by the R-square of the regressions. Consistent with our expectations, because commercial land will bring job opportunities, desirable amenities and other functional land associated with public facilities, the shares of commercial and other land positively affect housing prices in the next few years. The positive coefficient of industrial land share reflects that the importance of accessibility to work outweighs the desirability of neighborhood amenities in Beijing's housing market. Because the share of residential land is omitted, the positive coefficients of all non-residential land shares also means that the impact of the share of residential land on housing prices is negative. A supply of housing land helps to stabilize housing prices in a small geographic area. Column (3) in Table 5.5 shows the other housing supply and demand factors have expected results. Higher population density associated with higher housing prices. The planned construction area of housing in the neighborhood decreases housing values.

Two representative subsamples are chosen to conduct robustness tests, and the results are reported in Table A2. The first is the subsample of the transactions in a newly developed district, Tongzhou. The first is the subsample of the transactions in a newly developed district, Tongzhou. Both share of commercial land and share of public service land have the expected positive effects on housing prices, providing supportive evidence. However, the effect of the neighborhood industrial land share becomes negative. This suggests that, in Tongzhou district, the importance of accessibility to work cannot outweigh the desirability of neighborhood amenities. In the full sample, some projects have more transactions than others. However, the results could be over-represented by the projects that have more transactions. In an attempt to fix this potential problem, for each project, I only select the transactions with prices per square meter that were reasonably close to the average prices of their corresponding projects, which is the second subsample in Table 6. The results in column (2) of Table A2 show that all three key test variable have positive coefficients and the results are very significant. All other impacts are consistent with the results in column (2) of Table 5.5. In general, the robustness tests using the subsamples provide supportive results.

Overall, the empirical results show that, after controlling for housing characteristics, accessibility to jobs, and neighborhood amenities, the share of non-residential uses in the neighborhood have positive impacts on housing

prices. This finding implies that the land supply pattern plays a role in Beijing's soaring housing prices. Consistent with the explanation of the theoretical framework, the land supply pattern alters a neighborhood's housing market conditions by creating job opportunities and a limited supply of residential land. Both a strong housing demand and a smaller housing supply lead to high housing prices.

5.5.2 Results based on alternative geographic units

As mentioned in the data section, the land allocation variables for Jiedaos might be less accurate than those for a circular neighborhood for some housing projects, especially those located at the edge of a Jiedao. To address this problem and conduct robustness tests, I re-define the geographic unit as a circular neighborhood with either 1- or 2-kilometer radius for each housing project. Only three variables of land supply pattern in the circular neighborhoods are included in the regressions: the shares of commercial, industrial, and other uses in the land supply over the past five years. The results are presented in Table 5.6.

Table 5. 6 Results of disequilibrium hedonic models using alternative definitions of neighborhood

	A circlar neighborhood with a 1 km radius (1)			A circlar neighborhood with a 2 km radius (2)		
	Coef.	S.E.		Coef.	S.E.	
Housing Unit and Project Attributes						
Area	0.619	0.001	***	0.633	0.001	***
Floor	0.008	0.000	***	0.008	0.000	***
Duration	0.014	0.001	***	-0.002	0.001	***
Pre_sale	0.286	0.002	***	0.296	0.002	***
P_area	-0.009	0.000	***	-0.009	0.000	***
B_floor	0.001	0.000	***	0.002	0.000	***
D_school	-0.006	0.000	***	-0.009	0.000	***
D_hospital	-0.019	0.000	***	-0.017	0.000	***
D_park	-0.008	0.001	***	-0.006	0.001	***
D_CBD	-0.002	0.000	***	-0.003	0.000	***
Subway	0.030	0.002	***	0.040	0.002	***
Location						
Quadrant dummies (QD1=0)						
QD2	-0.084	0.002	***	-0.097	0.002	***
QD3	-0.165	0.002	***	-0.191	0.002	***
QD4	0.007	0.002	**	-0.009	0.002	***
Location dummies (Ring1=0)						
Ring2	-0.163	0.004	***	-0.196	0.004	***
Ring3	-0.107	0.004	***	-0.124	0.004	***
Ring4	-0.149	0.004	***	-0.161	0.004	***
Ring5	-0.246	0.004	***	-0.271	0.004	***
Land Supply Pattern in the Neighborhood from year t-6 to t-1						
CommercialLand	0.055	0.003	***	0.027	0.004	***
IndustrialLand	0.029	0.004	***	0.109	0.004	***
PublicLand	0.174	0.006	***	0.166	0.006	***
Planned Housing Supply in the Neighborhood from year t-6 to t-1						
HousingSupply	-0.030	0.001	***	-0.019	0.000	***
Constant	5.871	0.006	***	5.902	0.006	***
Quarter Controls	Yes			Yes		
R-sq	0.623			0.626		
No. of observations	488,069			582,694		

Note: 1. * P < 0.05; ** P < 0.01; *** P < 0.001.

2. All variables are defined in Table 5.3

3. Dependent variable is ln(Price) (unit: thousand RMB)

First, consistent with the results using the Jiedao's land supply pattern, almost all housing unit attributes, housing project attributes, and location attributes have expected coefficients. The transaction price is higher for units that are larger, located on higher floors, and sold via pre-sale. However, the effect that time on market has on housing values is inconsistent in columns (1) and (2) of Table 5.6. It is positive in the regression using a 1-kilometer neighborhood radius yet becomes negative in the regression using a 2-kilometer neighborhood radius. The homebuyers still value positively those projects with relatively small total sizes that are located in taller buildings. Easy accessibility to core primary schools, core hospitals, and parks, and proximity to a subway station raises a housing unit's transaction price. The impact on housing prices of the proximity to a park contradicts the previous finding but is consistent with other studies of the Chinese housing market (Zheng, et al., 2008; Liao and Wang, 2012). All of the quadrant and ring road dummies present the same influence pattern; the results are shown in Table 5.5. The housing price appreciation trend is still strong when using alternative definitions of geographic unit for land supply patterns, as indicated by the positive and significant coefficients of the quarter dummies, which are not reported in Table 5.6 due to space limitations (see the full results in Table A3 in the Appendix).

Moreover, the positive influences of shares of commercial land, industrial land

and other uses in land supply are still significant in Table 5.6. This suggests that, when the share of non-residential land uses increases in an area with a 1- or 2-kilometer radius, housing transaction prices increase in that area because the imbalance between the housing demand and supply is strengthened via the land supply pattern. As expected, planned housing supply in a neighborhood has a negative impact on housing values. Generally, the results of the disequilibrium hedonic model using alternative definitions of geographic unit of land supply pattern are consistent with the basic results when applying Jiedaos' land supply pattern variables.

5.5.3 Results of spatial econometric models

As mentioned before, one special feature of the housing market is spatial dependence. To improve the efficiency of this study's estimations, it is necessary to capture the influence of the spatial dependence problem by applying spatial econometric models. Because the number of micro transactions is too large to apply spatial econometric models, a representative subsample is needed to conduct the estimation. I utilize at least ten subsamples by applying different selection rules, with consistent results. Only the most representative subsample is presented here. This subsample is selected using the following rules. Due to differences in residential density between inner city and suburban areas, the pattern of spatial dependence should be different in different areas. I first exclude housing projects outside the inner city,

leaving 3,849 housing projects. Next, because the condominium is the prevalent form of residential development in Beijing, one transaction in each project carries all information about the housing project, its location attributes, and the neighborhood's land supply pattern. Therefore, I retain one transaction for each project, selecting the transaction with a price per square meter that is the closest to the average price per square meter. This process results in 3,849 observations for spatial econometric models.

A number of spatial-related routines have been written by Stata users, I choose spmlreg by Jeanty (2010) for two reasons. The first reason is that this routine allows for different observations share the same geographic coordinate when constructing the spatial weight matrix. The second reason is that this routine can estimate all four forms of spatial models[19]. A distance decay spatial weight matrix with a cut-off value of 4 kilometers is constructed using the following rules. Let d_{ij} denotes the distance from housing project *i* to project *j* in kilometers:

$$w_{ij} = \begin{cases} \frac{1}{d_{ij}+1} & \text{if } d_{ij} \leq 4, \\ 0 & \text{if } d_{ij} > 4. \end{cases} \tag{5.8}$$

[19] The four forms of spatial models are the spatial lag model, the spatial error model, the spatial durbin model, and the general spatial model. The spatial lag model is $y = \rho Wy + X\beta + \varepsilon$, with ε assumed to be classical. This model says that levels of the dependent variable y depend on the levels of y in neighboring regions. The spatial error model is $y = X\beta + \mu$ and $\mu = \lambda W\mu + \varepsilon$, with ε assumed to be classical. In this model, the spatial influence results only from the error terms. The spatial durbin model is $y = \rho Wy + X\beta + WX\theta + \varepsilon$, which also adds average-neighbor values of the independent variables to the specification. The general spatial model combines the spatial lag model and the spatial error model: $y = \rho Wy + X\beta + \mu$ and $\mu = \lambda W\mu + \varepsilon$.

Table 5. 7 Selected results of spatial econometric models

	Disequilibrium hedonic model (1)			Spatial lag model (2)			Spatial error model (2)			General spatial model (4)		
	Coef.	S.E.		Coef.	S.E.		Coef.	S.E.		Coef.	S.E.	
Neighborhood Land Uses Pattern												
CommercialLand	1.139	0.111	***	1.171	0.111	***	1.252	0.116	***	1.232	0.119	***
IndustrialLand	1.430	0.204	***	1.363	0.204	***	1.354	0.217	***	1.336	0.217	***
PublicLand	2.707	0.142	***	2.736	0.142	***	2.834	0.145	***	2.821	0.147	***
rho				0.201	0.050	***				-0.008	0.016	
lambda							0.364	0.064	***	0.373	0.071	***
Housing unit attributes	Yes			Yes			Yes			Yes		
Project attributes	Yes			Yes			Yes			Yes		
Quadrant controls	Yes			Yes			Yes			Yes		
Ring Roads controls	Yes			Yes			Yes			Yes		
Number of observations	3,849			3,849			3,849			3,849		

Note: 1. * P < 0.05; ** P < 0.01; *** P < 0.001.

2. All variables are defined in Table 5.3

3. Dependent variable is ln(Price) (unit: thousand RMB)

4. roh: measures the intensity of spatial spillover effect, and a positive roh implies that the neighboring housing prices per se positively affect housing prices; lambda: measures the spatial dependece of the error terms. The possible sources of the error spatial dependent problems are unobservable neighborhood characteristics, measure error problems.

Similar to Liao and Wang (2012), an increase or decrease from the 4-kilometer cutoff has a minimal effect on the estimation results. In addition, the maximum value of the distance between the two nearest neighbors in the sample is 3.87 kilometers. To ensure that every observation has at least one effective neighbor (the sum of each row in the matrix not being zero), I use the 4-kilometer cutoff value in the spatial weight matrix.

The disequilibrium hedonic model (2) in Table 5.5 is also applied as a comparison and three spatial econometric models are used to address the spatial dependence problem[20]. The selected results are reported in Table 5.7 (see the full results in Table A4 in the Appendix), and three main findings can be drawn. First, the four models provide consistent results. Second, the results of spatial econometric models provide consistent results with other hedonic models presented in the section 5.5.1 and section 5.5.2. *CommercialLand, IndustrialLand, PublidLand* have significant positive influences in new housing transaction prices in Beijing. Third, the spatial dependence in Beijing's housing market exhibits both spatial spillover and spatially lagged errors, as indicated by the significant values of ρ and λ in columns (2) and (3) of Table 5.7, respectively. In this sense, the general spatial model in column (4) of Table 5.7, which allows for both sources, may be more

[20] The spatial durbin model is not used because it is not suitable for the hedonic price analysis. For example, the average-neighbor values of the unit sizes have no influence on the transaction price of a housing unit.

appropriate. The results of the general spatial model show that, after capturing the spatial-error-dependent influence, the spatial spillover effect becomes insignificant. This suggests that the possible sources of the spatial dependent problems in Beijing's new housing market are unobservable neighborhood characteristics and measure error problems. In addition to these findings, all of the other control variables have reasonable results, as expected, and those results are available on request. Therefore, the results of the spatial econometric models both confirm the notion that supplying more land for non-residential uses drives up housing prices in a small geographic area and support the implication that the land supply pattern by usage contributes to housing price appreciation in Beijing new housing market.

5.6 Summary

The literature on the effects of neighboring land-use patterns on housing prices applying housing transaction data from Western counties provides inconsistent evidence. Aiming to further explore how land-use patterns influence housing transaction prices in small geographic areas, I target Beijing, a city with booming land and housing markets. First, a theoretical framework is developed by modifying the disequilibrium hedonic framework of Anas and Eum (1984) to illustrate how land supply pattern variables could be incorporated into the determination process of housing prices through a price adjustment process. Next, the variables of the land supply pattern by usage are

added into the estimable model specification to reveal the impact of land supply patterns on housing prices. Finally, combining land transaction data over the last decade and housing transaction data from 2006 to 2011 in Beijing enables me to conduct the empirical tests. The empirical analysis is carefully performed by using several model specifications, defining the geographic unit in different ways, and applying spatial econometric models.

This study contains several important findings. First, all of the hedonic factors have the expected signs and are significant in Beijing's new housing market, except for the distance to parks. Second**,** the northeast region and the region inside the second ring road enjoy the highest housing prices compared to other regions. Third, the price appreciation trend is strong, as indicated by the coefficients of quarter dummies, though the results are not reported in the tables due to space limitations. Fourth, and most importantly, all of the coefficients of the shares of commercial, industrial, and other lands in both the examined and neighboring Jiedaos are positive and significant in models using both the Jiedao's land supply pattern and alternative geographic unit definitions. The results suggest that shares of non-residential uses in land supply have a significant impact on housing prices in small geographic areas. After controlling for the influence of the spatial dependence problem, the impact pattern is not altered, though it becomes less significant. Considering that the share of non-residential uses in land supply has increased, especially

since 2004, this last finding implies that land supply patterns could contribute to the soaring housing prices in Beijing.

The above findings also have other important implications. For example, with respect to the housing price index, if information about land supply patterns is capitalized into housing price, as implied by this study's empirical findings, then land supply variables should be considered when constructing the housing price index. Figure 5 shows three price indices in Beijing's new housing market: the real official price index, the conventional hedonic price index (model (1) in Table 5.5), and the hedonic price index considering land supply pattern variables (model (2) in Table 5.5). The third hedonic price index is slightly different from the conventional hedonic price index, though those two indices both grow much faster than the official housing price index reported by Beijing's government. After capturing the influences arising from urban land supply shocks, the growth trend of housing prices appears less strong than that indicated by the conventional hedonic price index. This suggests that, without considering land supply factors, the indices have an upward bias. Moreover, the large-housing transaction data make it possible to construct a housing price index of new building at the Jiedao level, which helps to reveal the dynamic of housing prices at a small geographic level. This estimate is important in its own right.

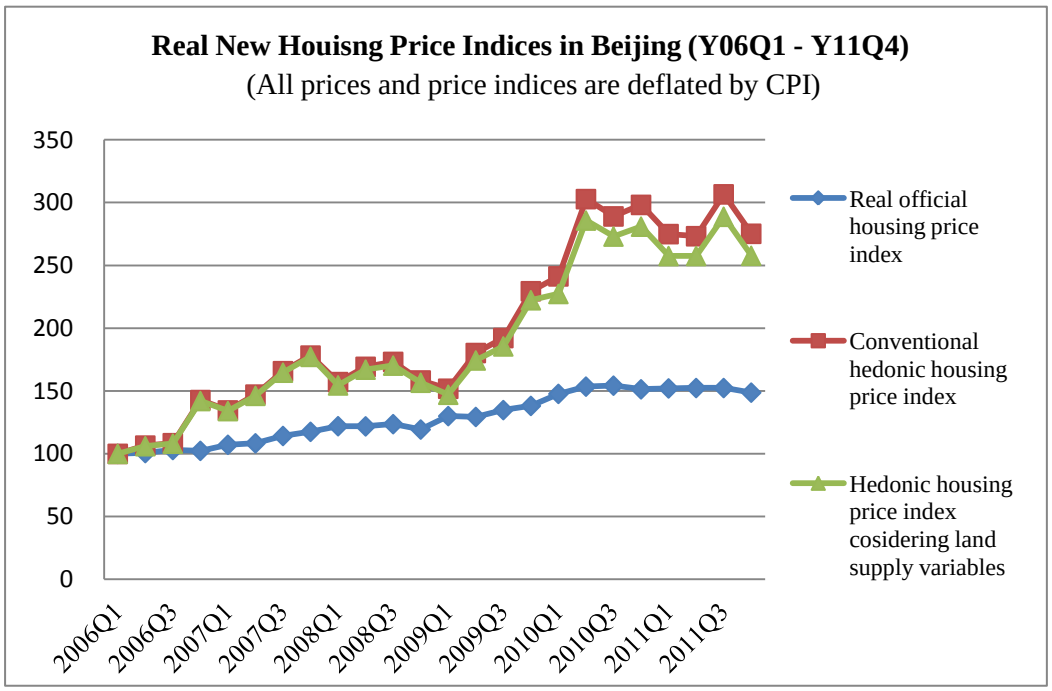


Figure 5. 5 Real new housing prices indices in Beijing from the first quarter of 2006 to the fourth quarter of 2011

The present study provides empirical evidence that land allocation among usages will affect housing values in neighboring areas. More importantly, housing prices tend to increase more rapidly if more new land is supplied to the commercial, industrial, and public service sectors compared to the share of housing land. Therefore, by explaining housing price appreciation in Beijing from the perspective of land supply, this study provides a more empirical basis for urban land supply policy. Land supply policy can help to stabilize housing prices by supplying a proportional share of residential land. Not only do usage shares at the city level matter, but the spatial distribution of all usages matters as well. This study also enriches the existing literature in two dimensions. First, the theoretical model developed in this study is flexible enough to investigate

the influence of any market activity that could alter housing market conditions or housing prices. Second, unlike housing markets in Western counties, where the disequilibrium factors are mainly mortgage interest rates and marginal tax rates, this study provides new empirical evidence from Beijing's housing market, in which disequilibrium could originate from land supply patterns related to different uses.

Chapter 6 Conclusion

This research aims to investigate the impact of urban land supply policy on urban growth and housing prices in Chinese cities, with particular attention to housing prices. Two studies found that the urban land supply policy that prioritizes non-residential land use contributes to both the surge in housing prices and lagging urbanization in China. In this chapter, I first briefly review the research and then highlight the contributions of the research. Finally, I summarize the limitations and future research.

6.1 Review of the research

China's urban land supply policy has one unique characteristic. On the one hand, city governments offer a large amount of low-cost land for non-residential uses to attract investment and stimulate local economic growth. On the other hand, city governments under-supply residential land and collect exorbitant conveyance fees for residential land. As a result, land for housing is under-supplied at a higher price, whereas land for non-residential use is over-supplied at a lower price. I conduct a two-stage test of the hypothesis that this land supply policy contributes to the issues of high housing prices and lagging urbanization in China.

In the first stage, to examine the impact of the land supply policy on some difficulties – in particular, soaring housing prices—in furthering China's urbanization process, the following macro-level questions are investigated:

1. In a city with fixed physical size, how does the share of non-residential land affect urban outcomes, as indicated by urban economic output, population size, wage rates, and housing prices?
2. For each additional unit of land supply, does allocating more land for non-residential uses drive up the growth rates of wages, housing prices, and economic output per capita?

Then if it is true that a higher share of non-residential land is associated with higher housing prices, the next question is how housing prices are affected by land supply patterns. In an attempt to reveal the micro mechanism of this effect, I conduct a micro study in the second stage to investigate the question of how land supply patterns affect housing prices in small geographic areas.

To provide answers to the above questions, the land supply policy in contemporary China is first introduced to reveal one characteristic of land supply policy, which is that priority has been given to non-residential land uses. Two of the problems associated with the land supply policy that motivate this research are justified: housing prices escalation and lagging urbanization in China. Next, I review the related literature to find a theoretical base and methodology applicable to this research. Additionally, through a comprehensive literature review, gaps are identified.

In the macro study, under the concept of spatial equilibrium across cities, a simple two-sector urban economic model that incorporates the competing land uses between urban economic growth and the housing sector has been developed to show how urban outcomes change with the share of non-residential land in a city in the macro study. Three theoretical predictions were derived. Next, a data set covering 284 Chinese cities between 2003 and 2010 is applied in the empirical study to verify the model's theoretical predictions. The following results have are shown:

1. For a city of fixed physical size, increasing the share of non-residential land increases wage rates, housing prices, and output per capita;
2. The relationship between the share of non-residential land and total urban economic output appears to be an inverse U-shape, and the population size decreases;
3. For an additional unit of land supply, allocating more land to non-residential sectors boosts growth rates of wages, housing prices, and output per capita.

To further explore the micro mechanism of the effect of land supply for alternative land uses on housing prices, in the micro study, a framework of disequilibrium hedonic model is first developed by modifying a disequilibrium hedonic framework of Anas and Eum (1984) to illustrate how land supply pattern variables should be incorporated into the determination process of housing prices through a price adjustment process. Next, the 2006-2011transaction data for new housing and the 2001-2010 land

transaction data in Beijing are used to show the impact of land supply patterns in a neighborhood on housing prices in Beijing. After running various model specifications using different measures of land supply variables and even controlling spatial dependence problem, I find the following consistent results:

1. Size, location on an upper floor, newness of a unit, use of pre-sale, and easy accessibility to public goods are positively valued in Beijing's housing market;
2. The northeast region and the region insides the second ring road enjoy higher housing prices comparing to other regions in Beijing;
3. It is shown the housing prices appreciation is very strong in the studied time in Beijing;
4. Most importantly, the shares of commercial, industrial, and public services land in small geographic areas all have positive and significant influences upon property values.

The findings of this research confirm the notion that urban land supply policy contributes to China's high housing prices and lagging urbanization problems. To be more precise, when a larger proportion of land is assigned to non-residential sectors at the macro level, economic growth brings strong demand for housing. An under-supply of housing land further worsens the already severe problem of housing prices. Housing difficulties restrain migrants from settling in cities, resulting in a lagging urbanization problem. At the micro level, in addition to accessibility, housing attributes and neighborhood characteristics, home buyers positively value a housing unit

located in a neighborhood with higher shares of commercial, industrial, and public service land in the previous five years. This is because land supply for alternative land uses in a neighborhood signals changes in job opportunities and neighborhood amenities that result in shock to the housing market.

In sum, the results of this research answer the questions that I attempted to investigate. Although it is impossible to solve the problems of housing prices and lagging urbanization in China through this research, it does provide a better understanding of those problems. The contributions of the present research are summarized in the next section.

6.2 Contributions

This research enriches the literature, provides alternative explanations for real-life problems and sheds lights on policies that are helpful to address these problems.

First, with respect to the literature contributions, the model developed in Chapter 4 is of great significance. It extends the analysis framework of the interactions between urban growth and housing supply to the land sector. This is important because land is a limited resource that is crucial both for housing and for the production functions of other goods. Moreover, the model is a structure form model based on a micro foundation, and it fills the gap of no rigorous theoretical model in the literature of the interactions between urban

growth and housing supply. The model can be generalized to study the urban dynamics arising from any changes in factors. For example, when there is a shock that leads to redistribution of labor forces among different sectors, the urban economic model developed in Chapter 4 can be applied to reveal the impact on urban outcomes.

Second, the new empirical evidence from the emerging Chinese market, as revealed in this research, completes the literature. Essentially, its findings are consistent with theory drawn from Western counties. The inelastic housing supply arising from differential treatments in land supply policy has the result that urban growth arrives in the form of high wage rates and housing prices, but lower population growth. However, China's land supply process differs from that of Western counties. China's process is primarily controlled by the government, especially city government. Therefore, in addition to the market forces that restrain housing land supplies and lead to high housing prices in a liberal economy, the incentive of the local government in land supply is another reason for the findings in China.

Third, the micro study in this research is the first application of the disequilibrium hedonic framework to Beijing's housing market. The existing studies applying disequilibrium hedonic model usually focus on the Unit States housing market and consider factors, such as mortgage interest rate, turnover rate or construction cost, a disequilibrium factors. However, those factors are not the main sources of disequilibrium in the Chinese housing

market. As shown by the findings of the macro study, the urban land supply patterns influence housing prices by altering the housing market conditions. Considering the importance of Beijing's housing market and the fact that high housing prices are such a serious issue, the application of the disequilibrium hedonic analysis to Beijing housing market is of great significance. Moreover, I attempted to improve the estimation of the disequilibrium hedonic approach by address the problem of spatial dependence. Although the results the spatial econometric models are preliminary, they merit further efforts in the future.

For the determinants of housing prices, the existing studies either use the conventional hedonic model, which only decomposes housing prices into the consumption attributes of housing, or wildly modify the hedonic model to incorporate market activity information into housing prices without solid theories. This research shows new developments in value housing, properties for which the value is determined by both consumption attributes and market activity information, as based on the work of Anas and Eum (1984, 1986). This changes the approach studying the determinants of micro prices of owner-occupied housing and constructing housing prices indices. The example given in Section 5.6 of Chapter 5 shows the difference between housing prices indices using the conventional hedonic model and the disequilibrium hedonic model.

This research reveals that land supply policy in favor of non-residential uses contributes to China's soaring housing prices and relatively lagging

urbanization. It provides alternative explanations for the problems in housing prices and lagging urbanization from the prospective of land supply policy. These explanations themselves are of great importance, because the high housing prices in some major cities have become such a critical issue and further economic growth in contemporary China relies on a smooth urbanization process. In this sense, the phenomenon known as “cheap industrialization and expensive urbanization” in China also relates to land supply. Moreover, because the local governments in China rely heavily on urban land supply policy both to pursue its economic growth and to generate revenue to finance local economic growth, it is necessary to reveal the consequences of this type of land supply policy.

This research pays particular attention to housing prices. Its new explanation of housing prices appreciation in China, from the perspective of land supply structure, is helpful for policy makers to formulate more effective government interventions to curb the growth trend in housing prices. The recent rebounding in housing prices despite the efforts and determination of the central government to control housing prices suggests that, to make interventions effective, the central government must give local governments incentives rather than administrative orders to control housing prices. The incentives of local governments in land supply, which leads to prioritizing non-residential uses, are sources—among many others—of the housing prices issue. Top-down reform in urban land supply, which motivates local governments to balance land allocation among different types of usage, could

be one way of stabiliziing housing prices.

In summary, this research achieves its objective. The findings answer my research questions and are meaningful to address the targeted research problems. Therefore, the significance of this research, as mentioned in the introduction chapter, has been realized.

6.3 Limitations and future research

In this section, all of the limitations of this research and their reasons are listed, followed by a description of the future research that I intend to conduct.

The two-sector urban economic model developed in Chapter 4 is based on several assumptions that simplify the derivation and analysis. Although the rationality of these assumptions has been proven by other literature, there are still two concerns. First, in this model, I assume a fixed demand for housing for each worker. Theoretically, this is acceptable. However, it is impractical in the real world for two reasons. One is that housing consumption will increase with income level. In fact, the housing consumption area for urban citizens in China has increased dramatically over the past two decades. For example, in Beijing, the housing consumption area per person was 11.6 square meters in 1990, and almost doubled by 2012, when it reached 21 square meters. Second, to illustrate the effect of new land supply on growth rates, I assume that the reservation utility level is invariable over time. This denies improvements in

quality of life. The example of increasing housing consumption per person, as described above, makes this assumption unrealistic. In future research, I will attempt to relax these two assumptions to exam whether new findings emerge. However, one expectation is that, if these two assumptions are relaxed, the boosting effect of the share of non-residential land on housing prices is likely to be amplified in the presences of increasing demand for housing and increasing reservation utility.

The empirical study in Chapter 4 only provides weak support for the third theoretical prediction, which addresses the impact of land supply on the growth rates of wages, housing prices, and GDP per capita. As justified in that chapter, this is due to the limitation of data. Data constraints, especially related to the reliability of macro statistic data, are traditionally difficulty when studying the Chinese market. This is another reason for conducting a micro study to complete this research. The prediction regarding the impact of land supply on the growth rates of wages, housing prices, and GDP per capita can be empirically tested when high-quality data become available.

Another complicated problem in the macro study is endogeneity. For example, higher housing prices are positively associated with better business environment and higher level of industrialization. Coincidently, the variable non-residential land share is also positively correlated with business environment and level of industrialization. The correlation potentially renders non-residential land share endogenous in the regressions of Table 4.5, Table

4.6, and Table 4.7. In the theoretical model, wages, housing prices and GDP per capital are determined simultaneously. However, the effects of urban land allocation on these three indicators are estimated separately. It is well known that these three variables are highly correlated. To reduce the effect of the endogeneity problem, I chose to exclude the other two variables from the empirical analysis when estimating the effect of urban land allocation on one variable. However, a more sophisticated approach should be used, and the structure model might be a promising approach. The endogeneity problem between economic output and population size in Table 4.8 and Table 4.9 is controlled by a 2SLS estimation.

The micro study in Chapter 5 presents rich findings about Beijing's new housing market. Most of the findings are consistent with the expectations and results of other studies. However, the impact on housing values of the proximity to parks is inconsistent across different model specifications. Although the proximity to parks has been positively valued when using alternative definitions of geographic units for land supply pattern variables, the result is contrary to the base model using a Jiedao's land supply pattern variables. Considering that the desire for green space is important in the housing market (Liao and Wang, 2012; Zheng, et al., 2008), this is worth further study. Parks may not be a perfect proxy for green space because, in Beijing, parks are usually located in suburban areas. I will further explore this question in Beijing's housing market by using different proxies.

Other two issues of the empirical analysis in Section 5.5 are acknowledged. One is omitted variable issue. The micro-level spatial correlations of housing prices may also be driven by omitted variables. For instance, share of commercial land may proxy for this neighborhood's prosperity, which associated with several types of neighborhood interactions including accessibilities to jobs, shopping centers, public facilities, etc., and thus has a positive effect on housing price. While the omitted variable issue is inevitable, the fact that several different approaches to identification arrive at the same conclusion should provide confidence in the main result. The other is how to fully distinguish the desire for accessibility to the workplace from the positive effect of higher shares of commercial, industrial or public service land uses on housing values. I include distance to the nearest employment center to control the impact of accessibility to the workplace. However, non-residential land brings job opportunities. If a homebuyer in a neighborhood with a high share of non-residential land supply works in the neighborhood rather than at the nearest employment center, he or she will bid higher on housing because of the potential savings in commuting-related costs. The lack of information about homebuyers' workplaces makes it impossible to completely isolate this influence.

Land supply in China is an extremely complicated process. Although Chapter 2 introduces a full picture of China's policy, the use structure – i.e., residential

versus non-residential uses—in urban land supply is the focus of this research. Other regulations of land supply, such as height control, and floor-to-area ratio, also influence the elasticity of housing supply and housing prices. For example, Glaeser and Gyourko (2003) reveal that strict building restrictions are highly correlated with high housing prices. Furthermore, local governments pass supplementary regulations to limit types of industry when leasing out non-residential land. This will change the conditions of housing demand, such as income level, and population composition. A fully understanding of the relationship between urban land supply policy and housing prices must consider these influences, each of which can lead to a meaningful study. Unfortunately, information about the details of these regulations is very hard to collect. Further research with a focus on one or two particular regulations can be conducted when this information becomes more readily available.

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Appendix

Table A1 Full results of hedonic models using Jiedaos' land supply patterns

	Conventional Hedonic Model (1)			Model with Land Supply Pattern Variables (2)			Model (2) + Other Demand and Supply Factors (3)		
	Coef.	S.E.		Coef.	S.E.		Coef.	S.E.	
Housing Unit Attributes									
Area	0.584	0.001	***	0.583	0.001	***	0.583	0.001	***
Floor	0.007	0.000	***	0.007	0.000	***	0.007	0.000	***
Duration	0.005	0.001	***	0.005	0.001	***	0.005	0.001	***
Pre_sale	0.298	0.002	***	0.293	0.002	***	0.292	0.002	***
Housing Project Attributes									
P_area	-0.010	0.000	***	-0.010	0.000	***	-0.009	0.000	***
B_floor	0.001	0.000	***	0.001	0.000	***	0.001	0.000	***
D_school	-0.016	0.000	***	-0.017	0.000	***	-0.016	0.000	***
D_hospital	-0.018	0.000	***	-0.018	0.000	***	-0.018	0.000	***
D_park	0.005	0.001	***	0.006	0.001	***	0.006	0.001	***
D_CBD	-0.003	0.000	***	-0.003	0.000	***	-0.003	0.000	***
Subway	0.013	0.001	***	0.008	0.002	***	0.008	0.002	***
Location									
Quadrant dummies (QD1=0)									
QD2	-0.108	0.002	***	-0.081	0.002	***	-0.084	0.002	***
QD3	-0.193	0.002	***	-0.182	0.002	***	-0.180	0.002	***
QD4	-0.012	0.002	***	-0.005	0.002	**	-0.009	0.002	***
Ring roads dummies (Ring1=0)									
Ring2	-0.230	0.004	***	-0.234	0.004	***	-0.217	0.004	***
Ring3	-0.133	0.004	***	-0.134	0.004	***	-0.112	0.004	***
Ring4	-0.178	0.004	***	-0.187	0.004	***	-0.154	0.004	***
Ring5	-0.256	0.004	***	-0.267	0.004	***	-0.233	0.005	***
Neighborhood Land Uses Pattern									
CommercialLand				0.129	0.005	***	0.117	0.005	***
IndustrialLand				0.174	0.004	***	0.170	0.004	***
PublicLand				0.491	0.009	***	0.492	0.009	***
Other Housing Demand and Supply Factors									
PopulationDensity							0.016	0.001	***
HousingSupply							-0.001	0.000	***

Table A1 Full Results of Hedonic Models Using Jiedaos' Land Supply Patterns (Continued)

Quarter dummies (Y06Q1=0)									
Y06Q2	0.063	0.004	***	0.063	0.004	***	0.062	0.004	***
Y06Q3	0.082	0.004	***	0.080	0.004	***	0.078	0.004	***
Y06Q4	0.357	0.004	***	0.354	0.004	***	0.350	0.004	***
Y07Q1	0.297	0.004	***	0.287	0.004	***	0.283	0.004	***
Y07Q2	0.386	0.004	***	0.375	0.004	***	0.372	0.004	***
Y07Q3	0.506	0.004	***	0.496	0.004	***	0.493	0.004	***
Y07Q4	0.578	0.004	***	0.571	0.004	***	0.570	0.004	***
Y08Q1	0.452	0.005	***	0.423	0.005	***	0.421	0.005	***
Y08Q2	0.526	0.004	***	0.497	0.005	***	0.494	0.005	***
Y08Q3	0.549	0.005	***	0.521	0.005	***	0.518	0.006	***
Y08Q4	0.460	0.005	***	0.432	0.005	***	0.429	0.005	***
Y09Q1	0.418	0.004	***	0.322	0.005	***	0.317	0.005	***
Y09Q2	0.589	0.004	***	0.495	0.004	***	0.490	0.004	***
Y09Q3	0.654	0.004	***	0.564	0.004	***	0.559	0.004	***
Y09Q4	0.831	0.004	***	0.739	0.004	***	0.735	0.004	***
Y10Q1	0.881	0.005	***	0.794	0.005	***	0.789	0.005	***
Y10Q2	1.108	0.005	***	1.026	0.005	***	1.021	0.005	***
Y10Q3	1.062	0.005	***	0.979	0.005	***	0.973	0.005	***
Y10Q4	1.093	0.004	***	1.014	0.005	***	1.009	0.005	***
Y11Q1	1.012	0.005	***	0.928	0.005	***	0.924	0.006	***
Y11Q2	1.005	0.005	***	0.916	0.006	***	0.911	0.006	***
Y11Q3	1.121	0.006	***	1.039	0.006	***	1.035	0.006	***
Y11Q4	1.013	0.005	***	0.932	0.006	***	0.928	0.006	***
Constant	5.973	0.005	***	5.922	0.006	***	5.890	0.007	***
R-sq	0.603			0.605			0.605		
Number of observations	622,374			622,374			622,374		

Note: 1. * P < 0.05; ** P < 0.01; *** P < 0.001.

2. All variables are defined in Table 5.3

3. Dependent variable is ln(Price) (unit: thousand RMB)

Table A 2 Full results of hedonic models with Jiedao's land supply patterns by subsamples

	Subsample of the transactions in Tongzhou district (1)			Subsample of the transactions those prices in per square meter are mostly close to the average price of their corresponding projects (2)		
	Coef.	S.E.		Coef.	S.E.	
Housing Unit Attributes						
Area	0.785	0.002	***	0.240	0.004	***
Floor	0.006	0.000	***	-0.008	0.001	***
Duration	0.004	0.002	*	-0.053	0.008	***
Pre_sale	0.143	0.005	***	0.280	0.018	***
Housing Project Attributes						
P_area	0.008	0.000	***	0.015	0.003	***
B_floor	-0.002	0.000	***	-0.006	0.001	***
D_school	0.062	0.002	***	-0.005	0.004	
D_hospital	-0.020	0.002	***	-0.020	0.001	***
D_park	-0.095	0.003	***	0.036	0.005	***
D_CBD	-0.015	0.003	***	-0.002	0.001	***
Subway	-0.117	0.004	***	0.275	0.018	***
Location						
Quadrant dummies (QD1=0)						
QD2				-0.034	0.024	
QD3				-0.233	0.020	***
QD4	0.130	0.005	***	-0.092	0.023	***
Ring roads dummies (Ring1=0)						
Ring2				-0.334	0.041	***
Ring3				-0.479	0.038	***
Ring4				-0.373	0.041	***
Ring5				-0.497	0.042	***
Neighborhood Land Uses Pattern						
CommercialLand	0.062	0.013	*	0.029	0.048	
IndustrialLand	-0.131	0.014	***	0.249	0.047	***
PublicLand	0.458	0.023	***	1.277	0.091	***

Table A2 Full results of hedonic models with Jiedao's land supply patterns by subsamples (Continued)

Quarter dummies (Y06Q1=0)						
Y06Q2	0.055	0.009	***	0.110	0.054	*
Y06Q3	0.073	0.009	***	0.118	0.076	
Y06Q4	0.360	0.009	***	0.528	0.046	***
Y07Q1	-0.114	0.010	***	0.206	0.054	***
Y07Q2	-0.047	0.010	***	0.216	0.048	***
Y07Q3	0.138	0.012	***	0.276	0.046	***
Y07Q4	0.130	0.010	***	0.570	0.050	***
Y08Q1	0.145	0.013	***	0.505	0.053	***
Y08Q2	0.196	0.011	***	0.506	0.051	***
Y08Q3	0.176	0.013	***	0.682	0.057	***
Y08Q4	0.108	0.012	***	0.358	0.058	***
Y09Q1	0.063	0.011	***	0.038	0.050	
Y09Q2	0.137	0.009	***	-0.045	0.046	
Y09Q3	0.241	0.009	***	0.308	0.047	***
Y09Q4	0.412	0.009	***	0.446	0.049	***
Y10Q1	0.499	0.012	***	0.855	0.057	***
Y10Q2	0.728	0.013	***	0.782	0.056	***
Y10Q3	0.710	0.015	***	0.406	0.052	***
Y10Q4	0.811	0.013	***	0.959	0.057	***
Y11Q1	0.885	0.014	***	0.821	0.066	***
Y11Q2	0.571	0.015	***	0.090	0.052	
Y11Q3	0.775	0.016	***	0.491	0.061	***
Y11Q4	0.653	0.014	***	0.748	0.054	***
Constant	5.845	0.033	***	6.649	0.063	***
R-sq	0.763			0.437		
Number of observations	54,927			13,691		

Note: 1. * P < 0.05; ** P < 0.01; *** P < 0.001.

2. All variables are defined in Table 5.3

3. Dependent variable is ln(Price) (unit: thousand RMB)

Table A3 Full results of disequilibrium hedonic models using alternative definitions of neighborhood

	A circlar neighborhood with a 1 km radius (1)			A circlar neighborhood with a 2 km radius (2)		
	Coef.	S.E.		Coef.	S.E.	
Housing Unit and Project Attributes						
Area	0.619	0.001	***	0.633	0.001	***
Floor	0.008	0.000	***	0.008	0.000	***
Duration	0.014	0.001	***	-0.002	0.001	***
Pre_sale	0.286	0.002	***	0.296	0.002	***
P_area	-0.009	0.000	***	-0.009	0.000	***
B_floor	0.001	0.000	***	0.002	0.000	***
D_school	-0.006	0.000	***	-0.009	0.000	***
D_hospital	-0.019	0.000	***	-0.017	0.000	***
D_park	-0.008	0.001	***	-0.006	0.001	***
D_CBD	-0.002	0.000	***	-0.003	0.000	***
Subway	0.030	0.002	***	0.040	0.002	***
Location						
Quadrant dummies (QD1=0)						
QD2	-0.084	0.002	***	-0.097	0.002	***
QD3	-0.165	0.002	***	-0.191	0.002	***
QD4	0.007	0.002	**	-0.009	0.002	***
Location dummies (Ring1=0)						
Ring2	-0.163	0.004	***	-0.196	0.004	***
Ring3	-0.107	0.004	***	-0.124	0.004	***
Ring4	-0.149	0.004	***	-0.161	0.004	***
Ring5	-0.246	0.004	***	-0.271	0.004	***
Neighborhood Land Uses Pattern						
CommercialLand	0.055	0.003	***	0.027	0.004	***
IndustrialLand	0.029	0.004	***	0.109	0.004	***
PublicLand	0.174	0.006	***	0.166	0.006	***
Planned Housing Supply in the Neighborhood from year t-6 to t-1						
HousingSupply	-0.030	0.001	***	-0.019	0.000	***

Table A3 Full results of disequilibrium hedonic models using alternative definitions of neighborhood (Continued)

Quarter dummies (Y06Q1=0)						
Y06Q2	0.057	0.004	***	0.067	0.004	***
Y06Q3	0.084	0.004	***	0.082	0.004	***
Y06Q4	0.354	0.004	***	0.345	0.004	***
Y07Q1	0.329	0.005	***	0.309	0.004	***
Y07Q2	0.417	0.004	***	0.391	0.004	***
Y07Q3	0.532	0.004	***	0.507	0.004	***
Y07Q4	0.595	0.004	***	0.569	0.004	***
Y08Q1	0.501	0.006	***	0.458	0.005	***
Y08Q2	0.574	0.005	***	0.553	0.005	***
Y08Q3	0.574	0.006	***	0.541	0.005	***
Y08Q4	0.462	0.005	***	0.448	0.005	***
Y09Q1	0.401	0.005	***	0.395	0.004	***
Y09Q2	0.608	0.004	***	0.581	0.004	***
Y09Q3	0.678	0.004	***	0.630	0.004	***
Y09Q4	0.854	0.004	***	0.808	0.004	***
Y10Q1	0.813	0.005	***	0.810	0.005	***
Y10Q2	1.113	0.006	***	1.031	0.005	***
Y10Q3	1.104	0.006	***	1.013	0.005	***
Y10Q4	1.045	0.005	***	1.012	0.005	***
Y11Q1	0.970	0.006	***	0.976	0.005	***
Y11Q2	0.960	0.006	***	0.953	0.005	***
Y11Q3	1.128	0.007	***	1.103	0.006	***
Y11Q4	0.981	0.007	***	0.936	0.006	***
Constant	5.871	0.006	***	5.902	0.006	***
R-sq	0.623			0.626		
No. of observations	488,069			582,694		

Note: 1. * P < 0.05; ** P < 0.01; *** P < 0.001.

2. All variables are defined in Table 5.3

3. Dependent variable is ln(Price) (unit: thousand RMB)

Table A4 Full results of spatial econometric models

	Hedonic model with land supply pattern variables			Spatial lag model			Spatial error model			General spatial model		
	(1)			(2)			(2)			(4)		
	Coef.	S.E.		Coef.	S.E.		Coef.	S.E.		Coef.	S.E.	
Housing Unit and Project Attributes												
Area	0.104	0.004	***	0.103	0.004	***	0.102	0.004	***	0.102	0.004	***
Floor	-0.007	0.002	**	-0.007	0.002	**	-0.007	0.002	**	-0.007	0.002	**
Duration	0.059	0.014	***	0.060	0.014	***	0.060	0.014	***	0.059	0.014	***
Pre_sale	0.165	0.030	***	0.171	0.030	***	0.175	0.030	***	0.174	0.030	***
P_area	-0.012	0.005	*	-0.013	0.005	**	-0.012	0.005	*	-0.012	0.005	*
B_floor	-0.015	0.002	***	-0.014	0.002	***	-0.014	0.002	***	-0.014	0.002	***
D_school	0.046	0.010	***	0.036	0.011	***	0.047	0.013	***	0.047	0.013	***
D_hospital	-0.033	0.007	***	-0.027	0.007	***	-0.031	0.009	***	-0.031	0.009	**
D_park	0.008	0.014		0.005	0.014		0.009	0.016		0.009	0.016	
D_CBD	-0.023	0.006	***	-0.020	0.006	**	-0.022	0.008	**	-0.023	0.008	**
Subway	0.054	0.031		0.056	0.030		0.073	0.033	*	0.072	0.033	*
Location												
Quadrant dummies (QD1=0)												
QD2	0.151	0.041	***	0.147	0.041	***	0.180	0.055	***	0.176	0.056	**
QD3	-0.234	0.042	***	-0.155	0.046	***	-0.202	0.057	***	-0.205	0.057	***
QD4	-0.043	0.043		-0.030	0.043		-0.046	0.054		-0.049	0.054	
Location dummies (Ring1=0)												
Ring2	-0.275	0.064	***	-0.254	0.064	***	-0.296	0.073	***	-0.305	0.072	***
Ring3	-0.063	0.063		-0.029	0.063		-0.057	0.076		-0.065	0.076	
Ring4	-0.187	0.070	**	-0.145	0.070	*	-0.169	0.085	*	-0.178	0.086	*
Ring5	-0.220	0.093	*	-0.178	0.093		-0.226	0.111	*	-0.232	0.111	*

Table A4 Full results of spatial econometric models (Continued)

Neighborhood Land Uses Pattern												
CommercialLand	1.139	0.111	***	1.171	0.111	***	1.252	0.116	***	1.232	0.119	***
IndustrialLand	1.430	0.204	***	1.363	0.204	***	1.354	0.217	***	1.336	0.217	***
PublicLand	2.707	0.142	***	2.736	0.142	***	2.834	0.145	***	2.821	0.147	***
Constant	6.917	0.100	***	5.380	0.397	***	6.823	0.115	***	6.905	.	.
rho				0.201	0.050	***				-0.008	0.016	
lambda							0.364	0.064	***	0.373	0.071	***
No.of observations	3,849			3,849			3,849			3,849		

Note: 1. * P < 0.05; ** P < 0.01; *** P < 0.001.

2. All variables are defined in Table 3

3. Dependent variable is ln(Price) (unit: thousand RMB)

4. roh: measures the intensity of spatial spillover effect, and a positive roh implies that the neighboring housing prices per se positively affect housing prices; lambda: measures the spatial dependece of the error terms. The possible sources of the error spatial dependent problems are unobservable neighborhood characteristics, measure error problems.