An Empirical Study on Housing Supply in Chinese Cities: Using the Urban Growth Model

Ping GAO*
Kazuo INABA**
Jie QIN***

Abstract

This paper employs the urban growth model to explore the relationship between urban growth, land use control and housing supply. Using the panel data for 35 Chinese cities over the year 2002 to 2010, the result shows that housing price and land supply are the main factors that affect housing supply. With an increase in housing price or in land supply, housing supply increases. However, land price and urban characteristics have no impact on housing supply.

Keywords: urban growth model, housing supply, Chinese cities
JEL Classification: R31

1. Introduction

In the last two decades, China experienced a rapid economic growth and drastic urbanization which caused a huge demand for housing. As a consequence, housing price jumped from 1854 RMB/Sq.m in 1998 to 4725 RMB/Sq.m in 2010. The Chinese government implemented a series of regulations to control the high price, including the latest regulatory notification No. 26 released by the Ministry of Land and Resources in 2012. It is hard to evaluate the effects of these regulations if we do not have a full understanding of the nature of the housing market, especially the supply-side which has mentioned few in the previous literatures.

The previous examination on the housing supply elasticity across cities suggest there is a large variation in housing supply across cities. Our former study estimated housing supply elasticity, the result of which shows housing supply in China is not perfect elastic, and it is a slightly lower comparing to developed countries.[1] The purpose of this paper is

* PHD Student, Graduate School of Economics, Ritsumeikan University. Email: gr0079ee@ed.ritsumei.ac.jp
** Professor, Department of Economics, Ritsumeikan University. Email: inabak@ec.ritsumei.ac.jp
*** Professor, Department of Economics, Ritsumeikan University. Email: khata@ec.ritsumei.ac.jp

to examine the variation in housing supply across Chinese cities with our focus on urban development and land use control. The urban growth model is employed to capture the relationship among land-use control, urban characteristics, and housing supply. Using panel data for 35 Chinese cities over the year 2002 to 2010, the result shows that land supply and housing price are the main factors that affect housing supply. However, the impacts of land price and urban attributes are insignificant.

Chapter 2 begins with a brief summary of both the previous empirical studies and the development of the theoretical model on housing supply. Chapter 3 discusses the model derived from the urban growth model. The model captures the impact of urban growth and land-use controls on housing supply. The chapter also includes data description. The estimated results are reported and discussed in Chapter 4. Chapter 5 is the conclusion with the main findings and a further plan for future study.

2. Literature review

Two approaches, the reduced-form and structural approaches are often used to estimate the relationship between housing construction and housing price. In the former approach, housing supply and demand function is combined into a single reduced equation form. The price elasticity of housing supply is derived from the coefficients on supply and demand shift parameters in the reduced regression form. Earlier empirical studies on housing supply tend to use this approach such as Muth (1960), Follain (1979), Stover (1986), and Olsen (1989). Most of their studies failed to reject the hypothesis that housing supply is perfectly elastic. Thus, the researchers inferred that the supply curve for new housing is perfectly elastic.

On the other hand, recently there have been several attempts to build a structural model of housing supply. The theoretical underpinning of such literature comes from one of two sources: the investment theory and urban spatial theory. The main difference in these approaches lies in treating land, which is the most important factor (Denise Dipasquale, 1999). The studies based on investment theory, which treats land the same as other variables such as capital and labor, but ignore the special characteristic of land. Meanwhile, studies based on urban theory explicitly incorporate the land market into the theory. In this approach, land is treated as different one from others as the supply is limited even in the long-run. This section is not an overall review of empirical researches on housing supply, but a particular focus on the literatures based on urban growth and land development theory.

2.1 Variations in housing supply and its alternative explanations

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

What is true across countries may also be true across cities, with significant local variation in land use and other regulatory practices (Green, Malpezzi and Mayo, 2005). Studies of Goodman (1998) and later literatures such as Richard and others (2005) provide strong evidence to prove that supply conditions to vary from place to place even within the country.

2.2 Urban growth and housing supply

Richard K. Green et al. (2005) examine how urban form can influence supply elasticities. They first estimate supply elasticities for 44 U.S. metropolitan areas following a model based on the theory of urban form suggested by the work of Capozza and Helsley (1989), and Mayer and Somerville (2000). They find that estimates of the price elasticity of housing supply varied substantially from place to place. Richard et al. (2005) similarly believe that metropolitan areas, that were heavily regulated, exhibit lower elasticities. In addition, they also find that while regulation and density (urban form) play essential roles in explaining variation in elasticities, urban growth rates and city size do not in predictions of the model.

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

2.3 Land-use regulations and housing supply

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

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

Contrast to the prior research, the latter add land-use controls on their model concept, and the result shows that housing starts in cities with more extensive land-use regulations is the lower 45 percent than cities are less regulated. Panel data reveal collected national data may slightly overestimate the price elasticity of new construction and underestimate the time needed to respond to price shocks. Likewise, we also have Braid (2001), in which the urban growth model is extended by taking land redevelopment and housing deterioration into account, and develop a method for tracing perfect-foresight growth paths for an urban area. Computer simulation for growth with myopic expectations is also conducted, and the results show significant differences between myopic growth and perfect-foresight growth.

Their study shows that housing supplies are significantly correlated to urban form and local land use controls. However, in China, there is an obvious lack of studies on reuniting housing supply and urban growth. They are treated as two separate ideas and land control is normally ignored in analyzing housing supply for a long period. Furthermore, most of the studies focus on the relationship between the housing price and land price in China. Limited studies combine land use control with housing supply. Nevertheless, we still have a couple of exceptions. Wang Bin and Gao Bo (2009) present an influential discussion of housing supply elasticity variation in China. They find that credit, land supplying and construction costs elasticity of supply were significantly different by region. Besides, the study of Yuming Fu et al. (2007) uses a structural model to explain housing supply elasticity across Chinese cities. They found that supply elasticity increases with fixed investment and urban area expansion in the city while it is independent of urban size and density, cities experiencing stronger growth tend to have lower housing supply elasticity. In fact, the previous studies on Chinese housing market have not addressed whether land-use controls will lead to a significant variation in housing supply across cities. Moreover, the studies have not fully considered the role of distinctive urban features and urban housing climates in affecting housing supply. It would thus be of interest to learn how different urban features and local land-use controls will affect housing supply.

2.4 The urban growth model

This section introduces original concepts of the urban growth model first developed by Richard J. Arnott（1980）and afterwards advanced by Capozza and Helsley（1989）.

2.4.1 A general urban growth model with durable housing

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

2.4.2 Urban growth and land development model

The model assumes that an urban area is located on a homogeneous plain 2ϕ radians of which is suitable for construction use. The urban area available for housing construction is not only related to the landform, but also related to the household density in the interior of the city. It is obvious that a larger ratio of the hilly area to the total urban area will put the city at a serious disadvantage for developing new constructions. Furthermore, the higher the population density is, the more difficult for developers to acquire land for new constructions. The utility function U(X, L) is homogeneous of degree 1, continuous and increasing in X and L. Lot sizes are fixed at $\overline{L}$ units per household. Separate households live on annular lots at different distance from the central business district (CBD) a point in space at which all non-residential activity takes place. Every day, each household commutes to and from CBD to work and go to shopping, and locations are indexed by their distance z from the CBD. The cost of commuting a unit of distance is a positive constant T. If a household lives at a distance z, he has a commuting cost Tz.

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

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

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

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

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

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

$$z(t)=\left[\frac{N(t)\bar{L}}{\phi}\right]^{1/2}. \tag{3}$$

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

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

where the land price mainly consists of four items. The first item in Equation (4) is the agricultural rent; the second item is the construction cost; the third item is the location advantage rent for household indexed by $z(t)$, and the final term is the value of the anticipated future rent increase at location $z(t)$ when the urban areas expand exponentially.[2] Chapter 3 discusses our model developed based on the urban growth theory and describes the data for estimation.

3. Methodology and data

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

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

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

$$HS_t=N(t)\cdot\bar{L}, \tag{6}$$

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

After taking consideration of adding the assumption that urban city grows exponentially at a constant rate g, the equilibrium housing stock can be described as follow:

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

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

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

Thus, housing stock changes can be treated as a function of the changes in housing price, urban growth, construction cost and other variables as described in Equation (9).

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

where ΔHS is a flow variable usually measured by the new constructions. Unlike developed countries such as the United States and the United Kingdom, China is not possessed of data directly related to the housing stock. Thus, this specification helps us to overcome the difficulty in collecting housing stock data.[3] Implications of this expression are as follows: as the city size expands, the more outputs are supplied. The theories based on the previous studies also suggest that as population, housing price and its changes rise, so do the new constructions. Furthermore, ϕ, the radians of the plain, implying the area available for construction use, is assumed negatively related to the population density since area with densely populated tends to increase the difficulty for developers to conduct new construction. The higher the population density is the more difficulties developers face to conduct new constructions.

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

Hence, we design our empirical model to examine housing supply determinants for cities with change of housing construction as a dependent variable and include population density (*den,* with an expected negative sign), urban population (*pop,* with an expected positive sign), urban sprawl (*bua* used to grasp the changes in commute cost, with an expected positive sign), and urban land-use regulation as explanatory variables. Two indicators of land-use regulations, land supply (*ls,* with an expected positive sign) and land price (*lp,* with an expected negative sign) are both included into the empirical model.

Panel data on 35 Chinese cities for the years 2002 to 2010 are provided by the National Bureau of Statistics in China: the *Main Indicators of Real Estate Projects in 35 Large and Medium-sized Cities,* published by the Press of China Statistics.[4] For each of the cities, we have observations of housing prices, housing construction, land availability and some other observations on urban characteristics such as the density, urban built-up areas and urban populations. While most existing studies on housing supply use national data, the present paper use panel data for empirical analysis. Since there are significant variations in the local housing market among the Chinese cities, the panel data can help us to overcome the biases caused by using national data.

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

***New housing construction* (Housing completions)**

Two residential construction measures: the real value of residential construction in each country and either starts or completions are often used to estimate housing construction. We have complete data for space of housing completions. Series of housing completions from the year 2002 to 2010 is provided by the Main Indicators of Real Estate Projects in 35 Large and Medium-sized Cities (China Statistical Yearbook, 2011[5]).

Housing Prices

Literatures on developed countries like the U.S. often use repeat sales price index and a hedonic house price series as a price variable in the supply equation. However, such data is not available in China. Thus, we measure housing prices with the average selling price of residential housing in each city, which is calculated by dividing the aggregate sales value by the total space housing sold. This housing price measure cannot reflect quality improvements in housing stock, a quality-adjusted housing price index or a repeated-sales housing price index is not available for Chinese cities as argued in Liu Hongyu and Shen Yue (2005).

Land-use regulations

We include two measures of land control, including land supply and land price. Land supply and land price are the two most important ways for local government to regulate the land market. We use the land space purchased by the developers in one year as a land supply measurement. Data on land supply come from "the Main Indicators of Real Estate Projects in 35 Large and Medium-sized Cities", China Statistic Yearbook (2011), compiled by the National Bureau of Statistics of China. Land price is measured by the land price for residential construction use and sources from "China Urban Land Price Dynamic Monitor" released by the China Land Price Information Dynamic Publishing Platform.

Urban attributes

We use built-up area in one year to measure urban sprawl, and use urban population to measure the size of the city, and we also have data of urban population density. Data of urban attributes mainly come from "the City Statistic Yearbook (2011)" and "the China Real Estate Statistic Yearbook (2011)".

Table 1 reports descriptive statistics for all the variables used in the empirical analysis. The coefficient of variance (Standard.Dev/Mean) is also included in Table 1 to show the dispersion of variables mentioned in our paper.

Table 1 Descriptive Statistics for Variables

Variable	Mean	Median	Maximum	Minimum	Standard. Deviation	Coefficient of Variation
Housing completions (10 000 Sq.m)	586.885	414.34	3380.12	41.10	561.24	0.956
Housing price (RMB/sq.m)	4057.89	3197.00	18954.00	1202.00	2739.93	0.675
Urban Population (0, 000)	646.66	571.02	33.3.45	64.10	508.92	0.787
Built up area (0, 000 Sq.m)[6]	325.16	234.50	1350.00	33.64	262.00	0.806
Density (Person/Sq.m)	635.44	578.68	2253.00	105.12	408.74	0.643
Land supply (0, 000 Sq.m)[7]	418.39	313.33	2092.50	13.87	370.36	0.885
Land price (RMB/Sq.m)	3911.64	2210.00	22927.00	432.00	4411.134	1.128

Note. Housing stock changes are measured by new completions of residential constructions. Measures for urban attributes include urban population, built-up area and population density. Two indicators for land regulation are land supply and land price.

4. Estimated results

Several regressions are conducted to find out the causes that lead to housing supply variations across the Chinese cities. The main focus is on whether variations in urban characteristics and local land-use regulations are the principal causes of discrepancies of housing supply among different cities. We estimated the housing supply function suggested by the urban growth model, in which housing supply is mainly correlated to housing price, urban growth and land-use regulation. We construct a double logarithmic model to explore the determinants in affecting housing supply elasticity. All the variables are expressed as natural logarithms. Thus, the estimated coefficients of housing price can be interpreted as housing supply elasticity. Our regression model is described by Equation (10),

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

where $i=25$ cities, and $t=2002, 2003\cdots 2010$. The dependent variable is the changes in housing stock, which we measure as space of housing completions (*completions*). The urban attributes are characterised by density, population, and by city built-up area. Alternatively, land-use regulation is characterized by land space purchased by the developers in one year (*ls*) and land price (*lp*).

It should be noted that using panel data may encounter the problem of heteroskedasticity and autocorrelation. In that case, the OLS (Ordinary Least Square) estimator will be

Table 2 Regression results with the dependent variable of

Variable	I	II	III
$Ln(P)$	0.638*** (9.164)	0.672*** (11.042)	0.557*** (6.707)
$Ln(pop)$	0.082 (1.311)	0.075 (1.261)	−0.110 (−1.533)
$Ln(den)$	−0.252* (−1.944)	−0.247* (−1.968)	−0.917 (−0.847)
$Ln(bua)$	−0.171 (−1.569)	−0.181* (−1.861)	−0.118 (−0.929)
$Ln(ls)$	0.352*** (10.728)	0.356*** (10.895)	0.159*** (4.787)
$Ln(lp)$	−0.001 (−0.009)		
AR(1)			0.461*** (9.821)
Constant	0.844 (0.909)	0.587 (0.657)	2.747** (2.363)
DW-statistic	1.389	1.400	2.451
R^2	0.831	0.834	0.901

Note. t-values in parenthesis. ***1% significance **5% significance *10% significance. Dependent variable is the natural log of completed housing constructions *Ln* (*completions*).

not efficient. To avoid these problems, generalized least squares (GLS) method, is employed instead of OLS estimation method. Furthermore, an AR(1) item is included to avoid autocorrelation. The estimation results are presented in Table 2.

The first regression includes all the main variables. In all three cases housing price is the most notable factor affecting housing supply. The estimated coefficient of housing price is significantly greater than zero. It implies that space housing completions increase significantly as housing price increases. However, the effects of urban attribute which are characterized by the population, density, and the built-up area are uncertain. Case II reports negative estimations of the coefficient of built-up area and density at 10% significance level after excluding the variable of land price. The results are consistent with the fact that a city with a higher population density makes it more difficult to available additional land to develop new construction for developers.

The estimated coefficients of land supply in all cases is significant. However, the estimated coefficient of land price is not significant. AR(1) is used to correct for autocorrelation. The estimated results show land supply is a significant factor in influencing housing supply for Chinese cities, while the variable of land price is not significant. Furthermore, this finding is similar to Wang and Liu (2009) in which they concluded that land supply increase moves the action to the housing supply very apparent, while the effect of the land price on housing supply is insignificant. The result can be interpreted that land supply is strictly controlled by local government in China and may lead to an inefficient land market. Although the estimated coefficient of the population is insignificant, Case III shows housing price, urban attributes and land supply can explain more than 80% percent of the variation in housing supply.

Table 3 Estimation results for three regions

Independent variables	Eastern cities	Middle cities	Western cities
Method	FE, Pooled EGLS	FE, Pooled EGLS	FE, Pooled EGLS
$Ln(P)$	0.521*** (0.093)	0.864*** (0.152)	0.720*** (0.118)
$Ln(pop)$	0.172* (0.102)	−0.005 (0.116)	−0.749*** (0.172)
$Ln(bua)$	0.105 (0.132)	−0.501** (0.233)	−0.060 (0.205)
$Ln(den)$	0.509* (0.273)	−0.688 (0.587)	−0.823*** (0.102)
$Ln(ls)$	0.406*** (0.050)	0.213*** (0.067)	0.200*** (0.059)
R^2	0.871	0.811	0.831
Observations	140	81	81

Note. t-values are in parentheses. ***1% significance **5% significance *10% significance
Cities are divided into three regions according to their geographic position.

Previous studies by Yuming Fu et al (2007), Wang Bin and Gao Bo (2011), and Wong Songbo et al. (2012) argued that the geographical constraint plays critical roles in determining housing supply elasticity. To examine the above argument, we divide these cities into three regions and conduct regressions in each region.

The results are reported in Table 3. For each of these three regions, the estimated coefficients of housing price and land supply are still all significant. Moreover, the results reveal that the magnitude of the estimated coefficients of housing price and land supply are different. The results also imply that housing price plays a vital role in affecting housing supply in the midland cities and western cities, while land supply has the greatest power in influencing housing supply in the eastern area. The space of land available to conduct new construction is limited in eastern city, which is experiencing a rapid urban growth and are usually with a higher density of population. In contrast, it is less difficult to obtain additional land for construction use in western and the midland regions with lower population density. The population which may indirectly reflect the huge demand in the eastern region affects housing output. Unlikely, the estimated coefficient of population in the western and the midland region is not significant.

In general, the results reported in Table 3 reveals that geographical position is also a significant factor in determining housing supply elasticity. The estimated coefficient of housing price can be interpreted as the elasticity of housing supply, which reflects the response speed of developers in front of the changes in housing price. It implies that housing developers in the midland cities and the western cities are more sensitive to housing price than those in the eastern cities. In contrast, developers in eastern cities seem to more sensitive to land supply than those in the midland cities and the western cities. Hence, based on the estimated results, several suggestions are given to policy makers. For the eastern cities, land use control is the most effective method to control housing supply, while housing price is the biggest determinant in affecting housing supply for middle and western areas. Housing market regulations should be correspondingly based on the changed climate of the housing market in different regions.

5. Summary and conclusions

Investigations on housing supply variation across cities and regions find that housing price and land supply are two predominant effective factors in influencing housing supply for developers. Housing supply is significantly related to the change of housing price. Furthermore, land supply plays a more crucial role in affecting housing supply than land price. This is related to the fact that land supply is strictly controlled by the local government. Land price does not play its due diligence in regulating land market. Further, regressions are performed to find out the determinants of housing supply for diverse regions. The results suggest that housing price and land supply are significantly positive to housing supply in all cities. However, the degree of influence may be different. For middle and western cities, housing price is the most significant determinant in affecting housing supply, while for eastern cities, land supply is almost equally important as housing price. Thus, regulations suitable for local housing market conditions are strongly suggested to local government. Although the variation in housing supply across cities has been examined, further research on housing supply variation among different housing type is also needed. In the next research, we intend to investigate housing supply variation between housing types considering that housing is mainly consisted of residential housing, office housing, business use housing and others. We need further work to explore the effect of the local government regulations on housing construction.

Notes

1) The results of relative work were presented on the 8th Annual Conference of Asia-Pacific Economic Association (APEA), Singapore, June 28, 2012.

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

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

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

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

supplied.

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

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

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