NINETEENTH ANNUAL PACIFIC-RIM REAL ESTATE SOCIETY CONFERENCE
MELBOURNE, AUSTRALIA, 13-16 JANUARY 2013

THE IMPACT OF GOVERNMENT LAND SUPPLY ON HOUSING STARTS

SIQI YAN, and XIN JANET GE
University of Technology, Sydney

ABSTRACT

This paper investigates the impact of government land supply on new residential construction. By estimating a housing supply equation using a panel data set covering 35 major Chinese cities for the period of 1999 to 2010, it is found that the quantity of the land sold by the government is tightly associated with the number of housing starts. Two- or three-year lag of land sales has a larger impact on new construction than one-year lag, which is consistent with the fact that there is normally a two- to three-year interval between the date of land transaction and the date when construction is initiated. It is also found that the decrease in land sales accounts for a large proportion of the decrease in new construction in Beijing, Shanghai and Shenzhen. The estimates of city-specific supply elasticities are provided based on the housing supply model, it is found that housing price appreciation tends to be more considerable in cities with inelastic supply.

Keywords: land supplies, building activity, house prices, elasticities, China

Email contact: siqi.yan@student.uts.edu.au

1. Introduction

New residential construction plays a crucial role in the economy. Property investment accounts for a noticeable proportion of GDP across countries, and provides considerable employment opportunities in the building industry. The interaction of housing demand and supply determines housing market outcomes, with potential implication for housing affordability. There has been a large body of research that studies the determinants of building activities and attempts to model new housing supply. While researchers have found that factors such as housing prices, construction costs, land use regulation and weather affect new construction, most of the existing studies tend to ignore the impact of residential land supply. Since land is an essential input to housing production, it is reasonable to expect that the supply of developable land should be of critical importance in explaining the levels of building activities. In general, land supply is restricted by geographic and regulatory constraints (Saiz 2010). Many physical features such as oceans, lakes, rivers and other water bodies serve as natural barriers to residential construction, and areas with steep slopes are difficult to develop, or at least, face higher development costs (Meen & Nygaard 2011; Saiz 2010). The number of developable land parcels within a certain period of time can be reduced by the imposition of zoning, urban containment strategies and other land use policies. Under

the leasehold land tenure system, because the governments own all the land and lease out land use rights to private developers under long-term contracts, the flow of new developable land is under direct government control. As the data for annual land sales is readily available, it is easier to investigate the effects of land supply on new construction under this system.

In this paper, we develop an econometric model for new construction to explore the impact of government land supply on new housing supply and provide estimates of city-specific supply elasticities. Estimates are based on a panel data set covering 35 major Chinese cities for the period of 1999 to 2010. The volumes of land sales and housing starts and their changes vary substantially across regional housing markets in China. Thus our data set has the advantage that it provides diverse regional experience which is not available from the data for Hong Kong and Singapore. The reminder of the paper has the following structure. In section 2, we provide theoretical analysis regarding the relationship between land supply and new construction and review the literature on this topic. Section 3 is a brief review of the literature on housing supply. Section 4 is introduction to China's housing and land system. Section 5 describes the econometric model and the data used in this study. The empirical result is reported in section 6 and section 7 concludes.

2. Land supply and new construction

Since any housing unit has to be built on a parcel of land, given a certain building density, the quantity of developable land parcels set a maximum limit on the number of new housing units. In addition, land supply can also exert indirect effects on new construction by influencing land price and the cost of housing production. In the face of increased demand for housing, a decrease in the amount of land supply will lead to higher land price. To minimize the costs of housing production, developers will substitute the now relatively cheaper structural capital for the relatively more expensive land, i.e. build higher-density housing units. Although the effect of a rise in land price can be partially offset by the factor substitution, higher land price will inevitably translate into higher cost of housing production and lower level of new construction eventually. In reality, the presence of density regulation reduces the degree of factor substitution, and further ensures that higher land price results in higher cost of new construction. It is noteworthy that not only the amount of, but also the location of land supply affects new residential construction (Tse 1998). In areas with well-developed infrastructure and better accessibility, the demand for housing tends to be relatively higher and the construction cost tends to be lower, thus home builders are more likely to be motivated to produce housing units in those areas.

Under the leasehold land tenure system, although the new land available for housing development is directly provided by the government through land sales, whether land supply can be translated into actual housing supply may depend on the developers' behaviours. If the developers hold a substantial amount of undeveloped land, the variations in land sales would have little effect on new construction. In that case, when the government releases more residential land, the new land may not be developed immediately, but simply absorbed by the developers' land banks. When the government reduces the amount of land sales, the developers can make use of the land parcels from their inventory of developable lots to maintain a stable level of housing production.

Several studies regarding the impacts of restrictive land supply on new housing supply have been conducted in the British context. Using data at local authority district level for the period 1986-1988, Bramley (1993) estimates a cross-sectional model of new construction , and finds that the stock of land with outstanding planning permission (the land supply variable) has a significantly positive effect on housing output. Also using district level data, Pryce (1999) compares the elasticities of housing supply with respect to land supply between boom (1988) and bust (1992). He finds that land supply elasticity is slightly greater in boom (0.75) than in the bust (0.71).

To the best of our knowledge, there are only a few studies that have investigated the impact of government land supply on new construction. Peng and Wheaton (1994) estimate models of housing supply and housing price using data of 1965 to 1990 to examine the effects of government land supply on housing market outcomes in Hong Kong. They find that the amount of the land sold by the government has no bearing on the numbers of housing completions but is significantly associated with housing prices.

3. China's housing and land system

3.1 Housing reform

During the last three decades, China's urban housing reform has transformed the welfare-oriented housing system into a market-oriented one. Under the traditional welfare-oriented system, housing was treated as a component of social welfare, and renting public rental housing is the only housing tenure choice available for urban households. While Municipal housing bureau were responsible for providing public housing for the employees of small and street-level enterprises, work units (state-owned enterprises and government institutions) are the primary provider of public housing (Logan, Fang & Zhang 2009; Wu 1996). The work

units which are at a higher level of administrative hierarchy or which are good at making a profit are more capable of providing public housing for their employees (Huang 2004a; Huang & Clark 2002; Wu 1996). Within the work units, the public rental housing was allocated to the employees according to their occupational rank, seniority, marital status, family number, current housing conditions, etc. at very low rents (Ho & Kwong 2002; Wu 1996). Since the costs of construction and maintenance for the public housing couldn't be recouped under the heavily subsidised rental system, housing investment became a heavy burden on the state budget. The lack of funding led to severe housing shortage and poor living conditions. According to the first national housing survey conducted between 1985 and 1986, 3.3% of urban households were clarified as homeless, about 11.5% were living in overcrowded conditions with one or two families in a single room, and the average per capital living space for all households was merely 6.4 m^2 (Fong 1989; Wang 1995). The survey also revealed that a large percentage of housing units were not well-equipped. Approximately one-third of housing units had no kitchen or running water, and two-thirds had no flush toilet (Fong 1989; Ho & Kwong 2002).

In order to provide adequate housing for the urban residents and relieve the state of the extensive fiscal burden of public housing provision, the Chinese government launched the housing reform in the late 1970s. In the initial stage of the reform, a series of experiments were carried out in pilot cities to encourage the commodification of public housing. In 1982, new housing units were allowed to be sold to the individuals in four selected cities (Zhengzhou, Changzhou, Siping and Shashi). According to the selling policy, the local governments and the work units provided the potential homebuyers with a subsidy equal to two thirds of the stipulated housing price, and the homebuyers only had to pay one third of the housing price. The trial was terminated in 1985 for two reasons. First, although the payment for the new home was pretty low compared with the annual household income, since the heavily subsidized rental system in the public housing sector remained intact, there was no substantial incentive for most of the households to enter into homeownership. Secondly, the local governments and the work units were reluctant to provide the huge subsidies for home purchase. Based on the lessons learned from the previous reform trial, new measures were implemented in three pilot cities (Yantai, Tangshan and Bengbu) in 1986 to raise public housing rent and sell public housing to the individuals at the same time. The public housing rent was increased from 0.07-0.08 yuan/m^2 to more than 1 yuan/m^2, and the new rent could largely cover maintenance fee, management fee, depreciation expense, investment interest

expense and real estate tax. In order to alleviate the impact of the upward rent adjustment, housing voucher which can be used to pay the rent was provided to urban households. The public housing was sold at a price which consisted of the construction costs and the compensation fee for land expropriation. In 1988, the State Council issued an important document, *Implementation Plan for a Gradual Housing System Reform in Cities and Towns,* which marked the commencement of the nationwide housing reform. After that, many cities formulated local reform plans following the national guideline to adjust public housing rent and sell public housing units to urban residents (Deng, Shen & Wang 2011; Ho & Kwong 2002; Wang & Murie 1996). In 1994, the Chinese central government issued a more comprehensive policy document, *The Decision on Deepening the Urban Housing Reform*, which set goals for the housing reform and laid out the overall strategies. It is claimed that the reform aimed at realising the commercialization of the urban housing sector, boosting residential construction, improving the housing conditions and satisfying the growing demand for housing. The new strategies was comprised of four aspects: (1) establishing a dual housing provision system in which middle- and low-income households would purchase subsidized affordable housing and high-income households would purchase commercial housing; (2) Setting up a compulsory housing saving programme called Housing Provident Fund (HPF); (3) establishing a housing insurance system and a housing finance system within which both policy-oriented loans and commercial loans are provided; (4) establishing a regulated market system of housing exchange, maintenance and management.

During the 1990s, although housing development companies had begun to shoulder the responsibility of housing construction, work units still played a significant role in housing provision. First, low-rent public housing or heavy rent subsidies were still provided by work units until the late 1990s. In Chongqing, public housing rent was less than 5% of the household income in 1998. In Beijing, although public housing rent had increased from around 1 yuan/m^2 in 1995 to 3.05 yuan/m^2 in 2000, rent subsidies had been raised to the average level of 90 yuan/person (Huang 2004a). Secondly, a large percentage of commercial housing (the housing which are developed by housing development companies and sold at the market price) were not bought by the individual buyers but by the work units. The work units then resold the housing units at discounted prices to their employees. In 1992, only 5.9%, 18.9% and 22.3% of the commercial housing were sold to the individuals in Beijing, Tianjin and Shanghai, respectively. The percentage of the commercial housing bought by the individuals was also low for the whole country, at 38.2% that year (Wu 1996). It is suggested

that the deep involvement in housing provision by work units is attributable to the persistence of traditional wage and work-units system (Huang & Clark 2002; Wu 1996). Under these systems, while the cash salary received by the labours was too low to cover the costs of purchasing commercial housing, work units continued to provide low-rent public housing or sell new and existing housing units to the employees at heavily discounted price so that the managers of the work units could be support by the employees. Hence, it is argued that housing reform must be conducted in tandem with the wage and work-unit reform to realize the commercialization of urban housing sector (Fong 1989; Wang & Murie 1996; Wu 1996).

In 1998, with the issue of a milestone document, *Notice on Further Deepening the Reform of the Urban Housing System and Accelerating Housing Construction*, China has eventually established the market mechanism in both housing production and consumption. According to the document, work units were prohibited from providing public rental housing for their employees from the second half of 1998, but in cities where the ratio of housing price to income was greater than 4, work units were allowed to provide home purchase allowance for the employees who didn't own a home or who lived in a home whose size was below the stipulated standard. In the document, promoting housing industry as a new engine of economic growth has been stated as one of the main purposes of housing reform for the first time. An affordable housing programme called low-Rent Housing (LRH) programme which aimed at providing low-rent public housing for lowest-income households was also first introduced in the document.

Based on the above analysis, 1998 is taken as the first year when a fully commercialized housing market begins to emerge in China. In the following empirical work, we choose 1999 (one year after the abolition of welfare housing allocation) as the starting point of the sample period.

3.2 Land system

Urban land is owned by the state while rural land is owned by the collectives. The state is endowed with the right to expropriate collectively-owned rural land in the name of public interest. Land use rights (LURs) are separated from land ownership, and only the former are transferable and tradable. All the urban development has to be conducted on the state-owned urban land, and rural collectives are legally denied the right to trade rural land with developers. Government expropriation is the only way for the rural land to be converted to urban use.

A dual-track land use system, which is characterized by the coexistence of market and non-market mechanisms for land allocation, exists in urban China. The approaches used to allocate land are determined by the purposes of land use. When land is used for government and military activities, urban infrastructure and public service, and government-supported major energy, transport and water-resource facilities, administrative allocation (characterized by free, unlimited and non-transferable land use) is still used to grant LURs to land users. When land is used for commercial purposes, market approach is used to convey LURs to land users. The municipal governments, as a representative of the state, convey the LURs to land users for a certain period of time (70 years for residential land use, 50 years for industrial land use, 40 years for commerce, tourism and entertainment land uses) through negotiation, auction and tender.

4. Review of housing supply literature

Since the empirical work in this paper is based on the estimates of a housing supply equation, in this section we provide a brief review of the key literature on housing supply.

As summarized by Dipasquale (1999), existing studies employ two basic approaches to modelling new housing supply and estimating housing supply elasticities: structural modelling approach and reduced form modelling approach. In the structural approach, housing supply is regressed against housing prices (or the changes in housing prices), a set of construction cost variables (or the changes in construction costs), as well as some other variables influencing building activities (non-price measures of market conditions, weather, regulatory constraints, geographic factors, etc.). Supply elasticities can be obtained directly through model estimation. In the reduced form approach, housing price is expressed as a function of determinants of housing demand and supply. Supply elasticities are unidentified but can be calculated under assumptions regarding the demand elasticities.

4.1 Structural approach

The theoretical underpinnings of most of the studies using structural approach come from one of the two sources: the literature on investment and Tobin's *q* (Tobin 1969) or the literature on urban growth theory. In the *q* theory approach, new housing investment is generally expressed as a function of the levels of housing prices and construction costs, while in the urban-growth theory approach, new residential construction is generally specified as a function of changes in housing prices and construction costs.

(1) *q* theory approach

The *q* theory of investment implies that the decision to produce new housing units is based on the expected profitability of residential construction. According to the theory, housing will be built when *q* (the ratio of housing prices to construction costs) is greater than 1, hence new housing supply should be positively associated with the levels of housing prices and negatively associated with the levels of construction costs.

In 1980s, two widely cited studies conducted by Poterba (1984) and Topel and Rosen (1988) applied the *q* theory approach to explaining new housing investment. Poterba (1984) takes account of the effects of alternative use of construction resources and credit availability on new construction. In his model, the driving forces behind new construction include the real housing prices, the real prices of alternative construction projects, the credit availability and the wage rate in construction industry. Topel and Rosen (1988)'s model is built on dynamic marginal cost pricing considerations. They argue that, if short- and long-run investment supply coincides, housing investment decision would be myopically determined by comparing current asset prices with current marginal costs of housing production. If short-run supply is less elastic than long-run supply (the reason for that is that construction costs are affected by the rate of changes in building activities, leading to investment being spread over a longer period of time to reduce the overall construction costs), current asset prices would be no longer the sufficient statistics for investment decision, and current investment decision would be made based on the expectation of future prices. In the empirical work, they develop both a myopic model and a dynamic enriched model with expectation and internal adjustment costs. The empirical results rejected the myopic model in favour of the internal adjustment cost model.

Most of the measures of construction costs do not have a statistically significant effect on housing starts in Topel and Rosen's model and Poterba's model. Grimes and Aitken (2010) suggest that, the reason for that is that land prices are not included as a component of construction costs. They further argue that, since land supply is substantially less elastic than the supply of other inputs to housing production, it is not reasonable to expect that land prices will rise at the same rate as other construction costs. Thus the ratio of housing prices to building costs (excluding land prices) is not a sufficient statistics for the decision making in housing production. They develop a model of new housing supply in which the ratio of housing starts to the current housing stock is explained as a linear combination of the ratio of house prices to building costs (excluding land prices) and the ratio of building costs (excluding land prices) to land prices.

(2) Urban-growth theory approach

As suggested by some researchers (Dipasquale & Wheaton 1994; Mayer & Somerville 2000b), since land, which is one of the most important inputs to housing production, is distinct from other factors of production, treating residential construction like other types of investment can be problematic. While the prices of construction materials and labour depend on the levels of building activities, according to the urban growth theory developed by Anas (1978), Fujita (1976), Wheaton (1982), Capozza and Helsley (1989) et al., land price is closely associated with the city size or the size of housing stock. In a static analysis of urban spatial structure, as land rent decreases with the distance to a city's CBD to offset increasing transportation costs, given that land price at the urban fringe equals the value of agricultural land plus the costs of converting the land from agricultural to urban use, ceteris paribus, a larger city tends to have higher average land price. In a dynamic analysis of urban growth, following a positive demand shock, new residential construction occurs, housing stock moves from one equilibrium to another, leading to a permanent rise in land prices at all interior locations within a city. To take into account the unique characteristics of land as an input to housing production and better characterize the process of new construction, some studies have attempted to model new housing supply based on the urban growth theory.

Dipasquale and Wheaton (1994) suggest that treating new housing starts as a function of the levels of housing prices implies that an increase in housing price leads to a permanent increase in the level of building activities, which is not likely to happen given that land price is positively related to the city size. They argue that, following a positive demand shock, although increased housing price will initially generate excess return and bring about higher level of new construction, since land price will rise significantly with the increase in the size of housing stock, the marginal costs of housing production will eventually equal housing price, resulting in new construction returning to its normal level. Thus housing starts respond to a growth in housing price only temporarily, until the existing housing stock adjusts to the long-run equilibrium level. Based on this consideration, they incorporate a stock adjustment process into the modelling of new housing supply. They specify new construction as a function of the levels of housing prices and construction costs, and the lagged housing stock. In the model, the levels of prices and costs determine the long-run equilibrium housing stock, housing price levels generate new construction only when the current housing stock differs from the long-run equilibrium level.

Mayer and Somerville (2000b) formally derive the relationship between housing starts and the changes in housing prices and construction costs from the Capozza-Helsley urban growth model (Capozza & Helsley 1989). In this model, housing price at an interior location of a city is regarded as the sum of agricultural land price, structure costs, the present value of location rent and the present value of the expected increase in house rent. After a simple derivation, the distance from the city centre to the border (which defines the city size) can be expressed as a function of the levels of housing prices and construction costs. Housing stock, which is another index of city size, is also determined by the levels of prices and costs. Housing starts, which is equal to the changes in the stock of housing units when ignoring abandonment and demolition, then can be taken as a function of the changes in housing prices and construction costs. As proposed by Mayer and Somerville, using changes in prices and costs rather than their levels to explain new housing supply is also more consistent with the time series properties of housing market data. Since housing price series is non-stationary and price change series is stationary, regressing housing starts (stationary) on the changes in housing prices can avoid the problem of spurious correlation.

Although Dipasquale and Wheaton's housing supply equation differs from Mayer and Somerville's specification in using the levels of housing prices and construction costs in conjunction with the lagged housing stock, the two specifications do share a high degree of similarity. As the lagged housing stock is determined by the levels of lagged prices and costs, the changes in housing stock can essentially be described by the changes in prices and costs. As suggested by Mayer and Somerville (2000b), applying Dipasquale and Wheaton's approach has the disadvantage that it require a measure of the housing stock, which is normally difficult to obtain. Recent studies have been increasingly using changes in prices and costs as independent variables in the housing supply equation (Ball, Meen & Nygaard 2010; Blackley 1999; Green, Malpezzi & Mayo 2005; Hwang & Quigley 2006; Meen & Nygaard 2011; Riddel 2000).

4.2 Reduced form approach

Malpezzi and Maclennan (2001) draw inference about housing supply elasticities based on estimates of housing demand parameters from the literature and their estimates of elasticity of housing price with respect to income. According to a three-equation model of housing market developed by them, housing supply elasticity can be taken as the sum of the ratio of income elasticity of housing demand to income elasticity of housing price and the price elasticity of

housing demand. By estimating a reduced-form equation for housing price which is derived from the model, they get the estimates of the income elasticity of housing price. Combining the estimates with the assumption about the elasticities of housing demand with respect to housing price and income based on the literature, they finally get the estimates of supply elasticity. Given the durable nature of housing and the existence of construction lags and transaction costs, they develop both a flow model and a stock adjustment model.

Following Malpezzi and Maclennan, Harter-Dreiman (2004) also obtains estimates of supply elasticity based on the estimates of income elasticity of housing price and the assumption about the income and price elasticites of housing demand. The unique feature of her approach is that she gets the estimates of the elasticity of housing price with respect to income by examining the long-run cointegrating relationship between income and housing prices.

5. Econometric framework

5.1 A model of new housing supply

Since to the best of our knowledge, there is a lack of convincing estimates of the income and price elasticites of housing demand for China's housing markets, we choose the structural approach rather than the reduced form approach to modelling new housing supply. Furthermore, we choose to include the changes in housing prices and construction costs as the explanatory variables in the housing supply equation based on the following considerations. First, as mentioned before, following a favourable demand shock, an increase in housing price will lead to a temporary rather than a permanent increase in the level of building activities. As increased land price moves the cost of housing production towards housing price, existing housing stock will gradually adjust to the equilibrium level and building activities will eventually return to its normal level. Using changes in prices and costs as independent variables is more consistent with the temporary response of new construction to price growth. Secondly, as proposed by Mayer and Somerville (2000b), housing starts is a flow variable, and thus should be taken as a function of other flow variables, such as the changes in prices and costs. Thirdly, as suggested by Grimes and Aitken (2010), a fully specified *q* theory model in which prices and costs appear in the level forms should contain all the relevant cost variables (including land prices). However, good measures of land prices are often lacked across countries, making using the changes in prices and costs to explain new construction a more feasible approach.

Our equation of new residential construction takes the following form:

$$In(Q_{it}) = \beta_0 + \beta_1 \Delta In(P_{it}) + \beta_2 \Delta RINT_{it}$$
$$+ \beta_3 In(LS_{it-1}) + \beta_4 In(LS_{it-2}) + \beta_5 In(LS_{it-3}) + \varepsilon_{it} \quad (1)$$

where, Q is the quantity of housing starts; P is the average housing price; $RINT$ denotes the real loan interest rate; LS denotes the area of the land sold by the government; ε denotes an error term; Δ denotes the first difference of the variable; the subscripts i and t refer to city i and year t, respectively.

Potential cost variables include interest rate, labour rate and prices of land and construction materials. However, as we are not able to get a good measure of most of the input prices, only the price of financial capital is included in our equation. The land sales variable is included to examine the impact of government land supply on new construction. Since it is a flow variable which measures the flow of new developable land, it appears in the level form. Zheng (2008) suggests that the developers normally initiate construction two or three years after the date of land transactions in China. First, there is a more-than-half-year interval between the date of land transaction and the date when developers have made the full payment and finally acquired the land parcels. Secondly, it takes one year or more for the developers to complete the design of housing projects, obtain the development approval, and decide the building contractor through bidding. Thirdly, some planning parameters such as lot coverage, building height and floor space ratio is subject to unexpected adjustment by the planning authorities, which can result in a substantial delay in construction projects. Hence we include up-to-three-year lags of land sales to investigate the lagged effects of this variable. We also expect that, compared with one year lagged value, two- or three-year lag of land sales will have a more substantial impact on new construction.

5.2 Data

Our empirical analysis uses an annual data set covering China's 35 major cities for the years 1999 to 2010. The 35 cities include 4 municipalities directly under the central government (Beijing, Tianjin, Shanghai and Chongqing), 22 capitals of provinces and autonomous regions, and 5 sub-provincial cities which are not provincial capitals (Dalian, Qingdao, Ningbo, Xiamen and Shenzhen).

The measure of new housing supply is the housing starts (including new construction for ECH, ordinary commodity housing and luxury properties) in terms of floor area, which is sourced from China Real Estate Statistics Yearbook (CRESY, 2000-2011). We obtain the

average housing prices in 2010 from CRESY, and then calculate the average prices in other years using the housing price index available from China Statistical Yearbook (CSY, 2000-2011), thus all the prices are in real term. We obtain the medium- and long-term official loan interest rate from CSY (2000-2011), and then calculate the city-specific real loan interest rates using the city-specific consumer price indexes sourced from Statistical Yearbook for each city. The quantity of government land supply is measured as the area of the land sold by the government through auction or tender, which is sourced from CSY (2000-2011). Table 1 gives the descriptive statistics for the key variables used in the empirical work by cities.

Table 1 Descriptive statistics

City	Average annual housing starts ($10000m^2$)	Average housing price (yuan/m^2)	Average annual land sales ($10000m^2$)	Average real loan interest rate (%)	Housing price growth rate between 1999 and 2010(%)
Beijing	1839.83	12097.02	940.06	4.56	72.77
Tianjin	1179.23	5741.79	661.67	4.54	78.44
Shijiazhuang	363.45	2970.73	182.52	4.15	53.95
Taiyuan	197.32	5855.22	119.82	4.1	44.32
Huhhot	324.09	2818.08	212.88	4	62.33
Shenyang	1210.86	3754.42	831.1	4.74	85.83
Dalian	694.6	5106.18	345.7	5.2	56.37
Changchun	567.5	4237.59	313.49	4.43	36.42
Harbin	543.03	4063.45	271.01	4.72	50.74
Shanghai	2053.36	10615.84	629.09	4.29	100.1
Nanjing	694.33	6869.55	348.98	4.45	83.71
Hangzhou	786.33	10236.73	552.95	4.75	106.6
Ningbo	553.16	8254.36	299.65	4.45	144.22
Hefei	594.68	4286.49	415.27	4.64	52.92
Fuzhou	527.21	6543.54	336.68	4.58	38.43
Xiamen	316.82	8977.69	141.8	4.53	62.11
Nanchang	302.56	3202.24	195.57	4.05	91.78
Jinan	347.71	4642.67	235.48	4.75	69.11
Qingdao	802.09	4548.08	472.59	4.18	120.64
Zhengzhou	670.41	3557.75	410.6	3.97	51.49
Wuhan	913.55	4332.2	614.23	4.62	63.8
Changsha	751.57	3262.01	527.41	4.43	54.08
Guangzhou	908.31	8928.03	521.38	4.9	28.02
Shenzhen	607.28	13362.75	152.93	4.42	78.15
Nanning	369.6	3894.76	169.87	4.19	51.48
Haikou	117.49	4816.95	93.57	4.49	103.08
Chengdu	1180.49	4538.39	643.85	4.27	60.13
Guiyang	397.44	3303.47	298.93	4.73	51.96
Kunming	461.6	2851.89	373.11	3.97	27.52
Chongqing	2115.25	2945.02	1209.33	4.62	81.57
Xian	639.03	3279.78	261.98	4.84	57.87
Lanzhou	169.89	2890.83	111.33	4.53	79.26
Xining	180.03	2529.76	74.63	3.4	46.26
Yinchuan	316	2704.33	127.71	3.95	65.57
Urumqi	333.53	3206.63	137.94	4.59	50.86

(Source: China Statistical Yearbook, 2000-2001)

6. Empirical results

Table 2 sets out the estimates of equation (1). The equation is estimated with a cross-section fixed effect. To control for the possible cross-section specific heteroskedasticity, the equation is also estimated using generalized least squares (GLS) with cross-section weights. Previous studies have provided strong evidence that there are significant variations in supply elasticities across cities (Green, Malpezzi & Mayo 2005; Grimes & Aitken 2010; Mayer & Somerville 2000a; Saiz 2010). The cross-section differences in the housing supply responsiveness can be attributable to the differences in the stringency of planning constraint (Green, Malpezzi & Mayo 2005; Mayer & Somerville 2000a; Mayo & Sheppard 1996), the differences in local geographic land constraints (Ball, Meen & Nygaard 2010; Meen & Nygaard 2011; Saiz 2010) and the differences in the existing land use patterns (Ball, Meen & Nygaard 2010; Meen & Nygaard 2011). Based on the above considerations, β_1 (the supply elasticity) is allowed to vary across cities in our specification, and the coefficients on other variables are restricted to be identical across cities. White period standard errors, which are robust to arbitrary serial correlation and time-varying variances in the disturbances, are reported with the estimates of coefficients.

The central issue in the empirical work is the impact of government land supply on new construction. It is evident from table 2 that coefficients on the quantities of land sales are all highly significant. The effect of three-year lag of land sales is approximately twice that of two-year lag, and four times that of one-year lag, with a 1% increase in current year's land sales leading to a 0.25% increase in housing starts three years later. The result is consistent with the previous analysis that two- or three-year lag of land sales would have a larger impact on housing starts.

Since the year 2003, owing to more stringent restriction on rural-urban land conversion and strengthened government monopoly on the supply of new developable land, the quantities of land sales have declined substantially in many Chinese cities. As government land supply is closely associated with new construction according to our estimates, it is expected that the decrease in land sales have exerted downward pressure on new construction. Between 2004 and 2010, the number of housing starts has experienced a downward trend in Beijing, Shanghai and Shenzhen. We use the following formula to calculate what percentage of the decline in building activities in these cities is attributable to the decline in land sales:

$$\alpha_i = \left[\beta_3 * \Delta_{03/09} LS_i(\%) + \beta_4 * \Delta_{02/08} LS_i(\%) + \beta_5 * \Delta_{01/07} LS_i(\%)\right] / \Delta_{04/10} Q_i \quad (2)$$

Where, α is the percentage of the decrease in new construction attributable to the decrease in land sales; β_3 , β_4 and β_5 are taken from equation (1), denote the elasticities of new construction with respect to one year-, two year- and three year- lag of land sales, respectively. $\Delta_{03/09} LS_i(\%)$, $\Delta_{02/08} LS_i(\%)$, $\Delta_{01/07} LS_i(\%)$ denote the percent change in land sales between 2003 and 2009, 2002 and 2008, and 2001 and 2007, respectively. $\Delta_{04/10} Q_i$ denotes the percentage change in the number of housing starts between 2004 and 2010; the subscripts *i* refers to city *i*.

Table 2 Estimates of housing supply equation (dependant variable: $In(Q_t)$)

Variable	Coefficient	Variable	Coefficient
Constant	13.05 (0.26)		
$In(LS_{t-1})$	0.06 (0.03)		
$In(LS_{t-2})$	0.12 (0.03)		
$In(LS_{t-3})$	0.25 (0.04)		
$\triangle RINT_{t-1}$	-0.02 (0.00)		
$\triangle In(P_t)$ *Beijing*	-4.58 (0.52)	$\triangle In(P_t)$ *Qingdao*	-3.32 (0.16)
$\triangle In(P_t)$ *Tianjin*	1.47 (0.36)	$\triangle In(P_t)$ *Zhengzhou*	8.12 (0.35)
$\triangle In(P_t)$ *Shijiazhuang*	9.34 (0.65)	$\triangle In(P_t)$ *Wuhan*	2.01 (0.43)
$\triangle In(P_t)$ *Taiyuan*	-20.69 (1.00)	$\triangle In(P_t)$ *Changsha*	8.31 (1.71)
$\triangle In(P_t)$ *Huhhot*	5.42 (0.22)	$\triangle In(P_t)$ *Guangzhou*	1.73 (0.54)
$\triangle In(P_t)$ *Shenyang*	0.1 (0.15)	$\triangle In(P_t)$ *Shenzhen*	-0.23 (0.18)
$\triangle In(P_t)$ *Dalian*	2.46 (0.3)	$\triangle In(P_t)$ *Nanning*	-1.68 (0.67)
$\triangle In(P_t)$ *Changchun*	9.46 (0.88)	$\triangle In(P_t)$ *Haikou*	-0.6 (0.26)
$\triangle In(P_t)$ *Harbin*	9.64 (0.84)	$\triangle In(P_t)$ *Chengdu*	1.78 (0.36)
$\triangle In(P_t)$ *Shanghai*	1.38 (0.21)	$\triangle In(P_t)$ *Guiyang*	8.3 (1.22)
$\triangle In(P_t)$ *Nanjing*	0.44 (0.22)	$\triangle In(P_t)$ *Kunming*	16.19 (0.38)
$\triangle In(P_t)$ *Hangzhou*	-2.12 (0.42)	$\triangle In(P_t)$ *Chongqing*	-0.45 (0.20)
$\triangle In(P_t)$ *Ningbo*	0.21 (0.25)	$\triangle In(P_t)$ *Xian*	14.16 (0.34)
$\triangle In(P_t)$ *Hefei*	4.33 (0.4)	$\triangle In(P_t)$ *Lanzhou*	9.14 (0.49)
$\triangle In(P_t)$ *Fuzhou*	-4.09 (0.5)	$\triangle In(P_t)$ *Xining*	11.91 (0.66)
$\triangle In(P_t)$ *Xiamen*	1.49 (0.47)	$\triangle In(P_t)$ *Yinchuan*	4.03 (0.34)
$\triangle In(P_t)$ *Nanchang*	-0.51 (1.05)	$\triangle In(P_t)$ *Urumqi*	8.27 (0.31)
$\triangle In(P_t)$ *Jinan*	-0.72 (0.25)		
Total pool observation	315	Adjusted R-square	0.84
F-statistic	22.94		

According to our calculation, the decrease in land sales accounts for 444.19%, 160.69% and 25.87% of the decrease in building activities in Beijing, Shanghai and Shenzhen, respectively (Since other factors such as the increase in housing prices and the decline in interest rates lead to the increase in building activities, the calculated percentage can be greater than 100%). Variation in land sales plays an essential role in explaining the variation in new construction in these cities.

For the majority of the cities, the coefficients on the changes in housing prices are significant at the 1% or 5% levels (only the coefficients for Shenyang, Ningbo, Nanchang and Shenzhen are insignificant). Estimates of supply elasticities range from -20.69 to 11.91, imply that the responsiveness of new housing supply to price changes exhibit significant variations across cities. Theoretical analysis has indicated that housing price adjustment following a demand shock is heavily influenced by supply responsiveness (Glaeser, Gyourko & Saiz 2008; Glaeser, Gyourko & Saks 2006). The greater the supply elasticity, the greater is the increase in new construction in response to an increase in the demand for housing, and the lower is the corresponding price appreciation. Thus price volatility tends to be lower in regions with more elastic supply. It is evident from the results that cities which have experienced the most considerable housing price booms all have very low supply elasticities. Among the cities who rank at the top 5 of the list of cities by housing price growth rates (see table 1), three cities have a supply elasticity less than 0 (Hangzhou, Qingdao and Haikou), and other two cities have an elasticity close to 0 (Ningbo and Shanghai). By contrast, the cities where housing prices have risen at a more moderate rate, such as Shijiazhuang, Changchun, Kunming, Xian, Urumqi, etc. tend to have a large supply elasticity.

7 Conclusion

Under the leasehold land tenure system, since new developable land is directly provided by the government, the supply side of housing market is subject to significant government intervention. The results in this paper indicate that the quantity of the land sold by the government is tightly associated with the number of housing starts. As there is normally a two- to three-year interval between the date of land transaction and the date when construction is initiated, two- or three-year lag of land sales has a larger impact on new construction than one-year lag. It is also found that the decrease in land sales accounts for a large proportion of the decrease in new construction in Beijing, Shanghai and Shenzhen.

Since the variable of land sales is highly significant in our model, it is reasonable to expect that housing supply models for China's housing markets which leaves out this variable may be subject to omitted variable bias. In other words, taking into account the influence of government land supply allows for a more accurate modelling of new construction and thus a more accurate estimate of supply elasticites. According to the estimates of city-specific supply ealsticities based on our housing supply model, it is found that housing price appreciation tends to be more considerable in cities with inelastic supply.

In this paper, the investigation is focus on the impact of government land supply on the static-state level of new construction. Whether the variations land sales affects the responsiveness of housing supply is a testable assumption for further studies.

Reference

Anas, A. 1978, 'Dynamics of Urban Residential Growth', *Journal of Urban Economics*, vol. 5, no. 1, pp. 66-87.

Ball, M., Meen, G. & Nygaard, C. 2010, 'Housing supply price elasticities revisited Evidence from international, national, local and company data', *Journal of Housing Economics*, vol. 19, no. 4, pp. 255-68.

Blackley, D.M. 1999, 'The long-run elasticity of new housing supply in the United States: Empirical evidence for 1950 to 1994', *Journal of Real Estate Finance and Economics*, vol. 18, no. 1, pp. 25-42.

Bramley, G. 1993, 'The Impact of Land-Use Planning and Tax Subsidies on the Supply and Price of Housing in Britain', *Urban Studies*, vol. 30, no. 1, pp. 5-30.

Capozza, D.R. & Helsley, R.W. 1989, 'The Fundamentals of Land Prices and Urban-Growth', *Journal of Urban Economics*, vol. 26, no. 3, pp. 295-306.

Deng, L., Shen, Q.Y. & Wang, L. 2011, 'The Emerging Housing Policy Framework in China', *Journal of Planning Literature*, vol. 26, no. 2, pp. 168-83.

Dipasquale, D. 1999, 'Why don't we know more about housing supply?', *Journal of Real Estate Finance and Economics*, vol. 18, no. 1, pp. 9-23.

Dipasquale, D. & Wheaton, W.C. 1994, 'Housing-Market Dynamics and the Future of Housing Prices', *Journal of Urban Economics*, vol. 35, no. 1, pp. 1-27.

Fong, P.K.W. 1989, 'Housing Reforms in China', *Habitat International*, vol. 13, no. 4, pp. 29-41.

Fujita, M. 1976, 'Spatial Patterns of Urban-Growth - Optimum and Market', *Journal of Urban Economics*, vol. 3, no. 3, pp. 209-41.

Glaeser, E.L., Gyourko, J. & Saiz, A. 2008, 'Housing supply and housing bubbles', *Journal of Urban Economics*, vol. 64, no. 2, pp. 198-217.

Glaeser, E.L., Gyourko, J. & Saks, R.E. 2006, 'Urban growth and housing supply', *Journal of Economic Geography*, vol. 6, no. 1, pp. 71-89.

Green, R.K., Malpezzi, S. & Mayo, S.K. 2005, 'Metropolitan-specific estimates of the price elasticity of supply of housing, and their sources', *American Economic Review*, vol. 95, no. 2, pp. 334-9.

Grimes, A. & Aitken, A. 2010, 'Housing Supply, Land Costs and Price Adjustment', *Real Estate Economics*, vol. 38, no. 2, pp. 325-53.

Harter-Dreiman, M. 2004, 'Drawing inferences about housing supply elasticity from house price responses to income shocks', *Journal of Urban Economics*, vol. 55, no. 2, pp. 316-37.

Hwang, M. & Quigley, J.M. 2006, 'Economic fundamentals in local housing markets: Evidence from US metropolitan regions', *Journal of Regional Science*, vol. 46, no. 3, pp. 425-53.

Lee, J. & Zhu, Y.P. 2006, 'Urban governance, neoliberalism and housing reform in China', *Pacific Review*, vol. 19, no. 1, pp. 39-61.

Malpezzi, S. & Maclennan, D. 2001, 'The long-run price elasticity of supply of new residential construction in the United States and the United Kingdom', *Journal of Housing Economics*, vol. 10, no. 3, pp. 278-306.

Mayer, C.J. & Somerville, C.T. 2000a, 'Land use regulation and new construction', *Regional Science and Urban Economics*, vol. 30, no. 6, pp. 639-62.

Mayer, C.J. & Somerville, C.T. 2000b, 'Residential construction: Using the urban growth model to estimate housing supply', *Journal of Urban Economics*, vol. 48, no. 1, pp. 85-109.

Mayo, S. & Sheppard, S. 1996, 'Housing supply under rapid economic growth and varying regulatory stringency: An international comparison', *Journal of Housing Economics*, vol. 5, no. 3, pp. 274-89.

Meen, G. & Nygaard, C. 2011, 'Local Housing Supply and the Impact of History and Geography', *Urban Studies*, vol. 48, no. 14, pp. 3107-24.

Peng, R. & Wheaton, W.C. 1994, 'Effects of restrictive land supply on housing in Hong Kong: An econometric analysis ', *Journal of Housing Research*, vol. 5, no. 2, pp. 263-91.

Poterba, J.M. 1984, 'Tax Subsidies to Owner-Occupied Housing - an Asset-Market Approach', *Quarterly Journal of Economics*, vol. 99, no. 4, pp. 729-52.

Pryce, G. 1999, 'Construction elasticities and land availability: A two-stage least-squares model of housing supply using the variable elasticity approach', *Urban Studies*, vol. 36, no. 13, pp. 2283-304.

Riddel, M. 2000, 'Housing market dynamics under stochastic growth: An application to the housing market in Boulder, Colorado', *Journal of Regional Science*, vol. 40, no. 4, pp. 771-88.

Saiz, A. 2010, 'The Geographic Determinants of Housing Supply', *Quarterly Journal of Economics*, vol. 125, no. 3, pp. 1253-96.

Tobin, J. 1969, 'A General Equilibrium Approach To Monetary Theory', *Journal of Money, Credit and Banking*, vol. 1, no. 1, pp. 15-29.

Topel, R. & Rosen, S. 1988, 'Housing Investment in the United-States', *Journal of Political Economy*, vol. 96, no. 4, pp. 718-40.

Wang, Y.P. 2001, 'Urban housing reform and finance in China - A case study of Beijing', *Urban Affairs Review*, vol. 36, no. 5, pp. 620-45.

Wang, Y.P. & Murie, A. 1996, 'The process of commercialisation of urban housing in China', *Urban Studies*, vol. 33, no. 6, pp. 971-89.

Wheaton, W.C. 1982, 'Urban Spatial Development with Durable but Replaceable Capital', *Journal of Urban Economics*, vol. 12, no. 1, pp. 53-67.

Wu, F.L. 1996, 'Changes in the structure of public housing provision in urban China', *Urban Studies*, vol. 33, no. 9, pp. 1601-27.

Zheng, J.E. 2008 'Study on the effects of land supply mode and land suply amount on real estate price', PhD thesis, Zhejiang University, Hangzhou, Zhejiang.