



# New housing construction and market signals in urban China: a tale of 35 metropolitan areas

Honghao Ren<sup>1,2</sup>  · Henk Folmer<sup>3</sup>

Received: 19 March 2019 / Accepted: 14 January 2022 / Published online: 18 March 2022  
© The Author(s), under exclusive licence to Springer Nature B.V. 2022

## Abstract

This paper investigates the equilibrium adjustment mechanism of new housing construction in urban China after the 1998 housing market reform. This analysis is based on a panel of 35 metropolitan areas over the period 2001–2015. The new housing supply function is specified in terms of changes rather than levels to capture the disequilibrium state of the Chinese housing market. In addition, current, one-year and two-year lags of the controls are used to capture the impact of the state control of construction land permits (Land Regulation Act). The main outcome is that new housing construction in the metropolitan areas under study responded to market signals but with relatively long time lags. In particular, during the period 2007–2015, new housing construction positively responded to the one-year and two-year lagged changes in housing prices and construction land supply, negatively responded to the current, one-year and two-year lagged changes in the interest rate, and negatively responded to the one-year lagged changes in construction material costs. The main conclusion is that China's housing marketization has started to work, although it is still subject to its historical footprints and typical Chinese characteristics, notably state control of the construction land supply.

**Keywords** New housing construction · Urban housing reform · State-controlled supply of construction land · Metropolitan China · Post-socialist economy

---

✉ Honghao Ren  
honghaoren@hotmail.com

Henk Folmer  
h.folmer@rug.nl

<sup>1</sup> Department of Real Estate Management, School of Management Science and Engineering, Shanxi University of Finance and Economics, Taiyuan 030006, China

<sup>2</sup> Real Estate Center, University of Groningen, 9747 AD Groningen, The Netherlands

<sup>3</sup> Department of Economic Geography, University of Groningen, 9747 AD Groningen, The Netherlands

## 1 Introduction

New housing construction plays an important role in a country's macroeconomic and socioeconomic development. As argued by Mayer and Somerville (2000a), new housing construction significantly influences overall output, both directly and indirectly. This is particularly the case in so-called construction-driven economies such as Spain (Bielsa & Duarte, 2011) and China (Ren et al., 2014). Furthermore, new housing construction has a strong impact on the business cycle of a (regional) economy (Davis & Heathcote, 2005; Glaeser et al., 2008). For instance, the excess construction of new housing during a housing price bubble can lead to a sharp decline in (regional) housing prices and induce or strengthen a (regional) economic recession (Johnson, 1998; Kuethe & Pede, 2011).

The response of new housing construction to market signals has drawn widespread attention, particularly in mature market economies such as the USA, the UK and the Netherlands (see, among others, Mayer & Somerville, 2000a; Vermeulen & Van Ommeren, 2009). More specifically, new housing construction has been found to positively respond to house prices and negatively to construction material costs and builders' financial costs. In addition, land use regulation has been identified as a main determinant of new housing construction (see, among others, Bramley, 1999; Caldera & Johansson, 2013; Green et al., 2016; Mayer & Somerville, 2000b; Mayo & Sheppard, 1996; Monkkonen, 2013; Vermeulen & Rouwendal, 2007).

Although the response of new housing construction to market signals has been intensively studied in market economies, less is known about it in socialist and post-socialist economies. In the former, housing construction and housing allocation to consumers are controlled by state institutions (Gentile & Sjöberg, 2010). In the latter, particularly in China, state involvement in housing construction has declined sharply, and private housing development companies began to emerge rapidly after the breakdown of the central planning system (Herbst & Muziol-Weclawowicz, 1993; Petrović, 2001; Sunega & Lux, 2007). However, housing construction is still affected by the legacy of the socialist era (Gentile & Sjöberg, 2010). For instance, post-socialist countries tend to have more restrictive land use regulations, which have led to shortages in the housing supply (Mayo & Stein, 1995). Although the developments of house prices in post-socialist countries have been extensively addressed (see, e.g., Égert & Mihaljek, 2007; Posedel & Vizek, 2009; Stepanyan et al., 2010), the response of new housing construction to market signals after the transition in general is an under researched topic and therefore still unclear.

This paper examines new housing construction in urban China where construction land for new development is still owned by the national government and regulated by the national and provincial governments (Chen & Wen, 2017; He et al., 2014; Yan et al., 2014). In particular, via the Land Regulation Act, the national and provincial governments indirectly affect where when and how much farmland will be converted into construction land and put on the market. As farmland in China is scarce, the national and provincial governments face the trade-off of supplying construction land versus preserving farmland (Wu et al., 2011; Ding & Lichtenber, 2011; see Sect. 2 for details). The involvement of the government in construction land supply has led to lengthy and complicated procedures to obtain construction permits (Tian & Ma, 2009). Consequently, lagged and current market signals that can explain new housing construction in China need to be identified. For instance, Deng and Chen (2019), Wang et al. (2012) and Wang

and Liu (2009) indicated that housing construction responds to current and one-year lagged house prices rather than only current house prices. However, they ignored longer lags. They also ignored longer lags for the other housing market signals.

China has experienced massive rural–urban migration since 1978. In particular, during the 1998–2015 period, the population of the 35 major metropolitan areas under study increased by 63.01 million (27.86%) (China City Statistical Yearbook, 1999–2016). This massive rural–urban migration led to a considerable increase in the demand for housing in the major metropolitan areas. In addition, the demand for more spacious dwellings increased because of growth in both employment and disposable income. Per capita disposable income in urban China increased from RMB 5,425 (Euro 683.53) in 1998 to RMB 31,195 (Euro 3,930.48) in 2015, that is, by 575.02%. As a result, per capita living space in metropolitan China increased from 18.7 square meters in 1998 to 36.0 square meters in 2015. As rural–urban migration and disposable income were growing, China’s housing market was all but in equilibrium. For instance, the average real house price increased from RMB 1,854 per square meter in 1998 to RMB 6,473 in 2015, i.e., by almost 249.14% (China Statistical Yearbook, 2016). To accommodate the disequilibrium state of the housing market, a model specifying new housing construction in China should consider changes rather than levels (see Caldera & Johansson, 2013; Hwang & Quigley, 2006; Mayer & Somerville, 2000a).

China’s new housing construction during the period 2001–2015 bears other typical Chinese characteristics. In particular, the national government invested heavily in the development of public housing and intervened in housing construction plans. The government’s investment in public housing shifted the housing supply curve up, and its intervention narrowed the gap between the supply of and demand for this type of housing. Thus, the response of new housing construction to housing market signals in China has tended to differ from that in developed countries.

Due to its Land Regulation Act, China offers a unique opportunity for analyzing the equilibrium adjustment mechanism of new housing construction in the presence of controlled construction land supply. The construction boom and the absorption of marketed housing since the housing reform in 1998 indicate that the Chinese housing market has responded positively to housing demand. Nevertheless, little is known about the specific responses to market fundamentals such as house prices, the costs of construction material and builders’ financial costs. The purpose of this paper is to further address the responses to market fundamentals and to quantify them.

In this paper, data on 35 main metropolitan areas in China during the 2001–2015 period are analyzed. The focus is on metropolitan areas because the housing market reform was implemented in urban housing markets only. The urban housing markets thus structurally differ from other housing markets, notably rural markets (Hanink et al., 2012). The 35 major metropolitan areas include four municipalities, 26 provincial capitals and five prefecture-level cities. Because of greater land scarcity, their size and political and economic importance, the four municipalities (Beijing, Tianjin, Shanghai and Chongqing) are directly under the national government. The five prefecture-level cities (Dalian, Tsingtao, Ningbo, Xiamen and Shenzhen) have developed rapidly, govern surrounding counties and have a specific development status in the National Plan. All the 35 metropolitan areas are subject to the same institutional setting, i.e., construction land regulation and housing policy, but they are allowed to impose additional own regulations (see Sects. 2, 4.1 and 4.3 for further details). Because the population of the 35 main metropolitan areas is approximately 21% of the total Chinese urban population and these areas are the main drivers of the Chinese

economy (Dhakal, 2009), insight into the working of the main metropolitan housing markets is a major step toward a more comprehensive understanding of the response of the Chinese housing market to market signals.

The remainder of the paper is organized as follows. Section 2 presents a synopsis of the Chinese metropolitan housing market, including the construction land supply. The empirical model and the data are described in Sect. 3, and the empirical results are presented in Sect. 4. Section 5 presents a discussion of the results and Sect. 6 concludes and discusses policy implications.

## 2 Features of the Chinese housing market

China started reforming its metropolitan housing supply system in 1982. Before 1982, the provision of housing in metropolitan areas was part of the socialist welfare system (Chen et al., 2011). In this system, typically, the rent did not cover the construction costs and basic maintenance outlays. Hence, it was a heavy burden for state-owned enterprises to construct sufficient new housing and maintain the existing housing stock. The housing supply in metropolitan China was quantitatively and qualitatively insufficient and failed to meet demand (Lee, 2000; Wu, 1996; Zhao & Bourassa, 2003). As a result, China experienced continuously deteriorating urban living conditions and widespread housing shortages (Lee, 2000).

To improve the living conditions of urban residents and supply sufficient housing for immigrants from rural areas, the Chinese government launched its housing market reform. In 1982, real estate trade was introduced, and the housing market was started through pilots in selected metropolitan areas. Based on successful experiments, the National Council abolished the collective housing allocation system and implemented measures to commercialize the provision of urban housing in the entire country in 1998 (Wang & Murie, 1996; Zhu, 2002). Public housing was sold to urban residents who obtained user rights for a maximum of 70 years. Furthermore, private real estate enterprises were allowed to construct new houses that were allowed to be traded on the market (Wang & Murie, 1999). Median and high-income households had to buy houses, whereas public housing was provided to low-income households by the municipal government.

The urban housing reform turned the socialist housing system into a market-oriented system (Yi & Huang, 2014). The reform created considerable demand for housing, and house prices rapidly increased, boosting new housing construction. Due to rapid economic growth, large numbers of people found jobs in urban areas, resulting in a massive rural–urban migration (Yang & Dunford, 2017). The housing reform offered households the chance to obtain more comfortable houses. The demand for more comfortable housing pushed up house prices further, which attracted more investment in new housing construction, and so on. As a result, more new real estate enterprises were established, and numerous new housing construction projects were started in urban China.

The present urban housing system in the 35 metropolitan areas still bears historical footprint and typical Chinese characteristics (Deng et al., 2011), affecting the responsiveness of new housing construction to market signals. These characteristics include (i) regulations for the new construction of public housing for low-income households, (ii) the marketization of housing for medium-income households and (iii) construction land regulation.

## 2.1 Public housing for low-income households

One of the main principles of the housing market reform was that municipal governments were obliged to supply low-rent housing to low-income households, while median- and high-income households were required to purchase houses at market prices. Because supply did not catch up with demand, house prices started increasing dramatically in 2005 and 2006. In addition, the number of median-income households that were not able to obtain housing through the housing market started increasing sharply. These households started buying affordable low-rent houses, which led to the crowding out of low-income households. In response to this unwanted development, the central government initiated a low-rent housing construction plan and started providing rent subsidies to low-income households. Municipal governments provided most of the development subsidies and made construction land for low-rent housing available for free or at a low cost. The implementation of the public housing program further boosted new housing construction (Murray, 1999; Sinai & Waldfoegel, 2005). By the end of 2006, 512 cities, including all 35 metropolitan areas, had public housing and rent subsidies programs in place. In addition, the national government invested 7.08 billion RMB in public housing construction, and 547 thousand households obtained low-rent housing (MOHURD, 2007). After 2006, the national government continued the rent subsidy programs and continued to invest in developing public housing for low-income households.

## 2.2 Housing for medium-income households

The central government also regulated the construction plans of real estate companies in a bid to increase new housing construction for medium-income households and rural–urban migrants.<sup>1</sup> As house prices increased, these groups of consumers could not obtain affordable housing. To meet their housing demand, the central government issued construction plans aimed at increasing the supply of relatively small houses in 2006. The regulation implied that housing of less than 90 square meters should account for at least 70 percent of each new housing construction project.

The regulation benefitted medium-income households in two ways. First, the regulation made it possible for medium-income households to make the necessary down payment. Second, more medium-income houses were developed even when the construction land supply remained unchanged.

## 2.3 Construction land control

Land in China is owned by the national government. Stringent regulations have been imposed on land use, especially farmland, to secure sufficient food for China's population of 1.3 billion, which is expected to reach a maximum of 1.396 billion in 2026 (United Nations Population Divisions, 2013). For this purpose, the national government

---

<sup>1</sup> To control its rural–urban migration system, the provincial government applies the Hukou system, i.e., a residence permit system. The Hukou system specifies the conditions that prospective migrants should meet to convert their rural Hukou to an urban Hukou (Zhang and Treiman, 2013). Individuals who fail to obtain an urban Hukou can stay in the city but have limited access to affordable housing, public schools, health care and insurance.

has preserved 120 million hectares of high-quality farmland. Farmland is only allowed to be converted to construction land under the following conditions. First, based on its regional socioeconomic development, each municipal government is obliged to develop a ten-year land use plan every tenth year and a one-year-ahead plan every year. These plans inter alia specify how much farmland the municipal government plans to convert to construction land. Ten-year land use plans that determine where when and how much farmland is to be converted need to be submitted to the central government for approval. After the plan has been approved, the municipal government expropriates the farmland designated for housing construction and leases the land use rights to real estate development companies by auction or tender (Lichtenberg & Ding, 2009).

Because of more than two decades of extensive urban growth, substantial land use conversions have taken place in metropolitan China (Ding, 2007). Construction land has become scarce, and more intensive use of this land has become necessary (c.f. Wheeler (2009)). The availability of construction land is regulated by regulations such as the 'Regulation of Construction Land Contraction' and the 'Land Market Regulation' and the 'Enhancement of Land Management' issued by the Shenzhen municipal authority in 2001 and 2004, respectively, and the 'Regulation of State-owned Construction Land Supply' issued by the Beijing government in 2005. As new housing construction depends on the availability of construction land, new housing construction is indirectly controlled by the municipal and central governments.

As a consequence of the planning structure involving both municipal and central governments in the supply of construction land, housing development companies have faced considerable time lags in obtaining construction land. According to The World Bank (2015), in China, it took on average 266 workdays in 2015 to obtain a construction permit, whereas in a market economy such as the USA, it took 78.6 workdays. Hence, we hypothesize that new housing construction in China responded to market signals with longer delays and responded to the land supply more intensively than in a market economy such as the USA.

### 3 Model and data

The empirical model employed to analyze the responsiveness of new housing construction is the stock-flow model, which captures residential investment as a function of housing prices and the interaction between housing prices and the housing supply. The first versions of the model were developed in the 1960s (see Huang, 1966; Smith, 1969). Since then, various additional determinants of housing construction have been added. Specifically, construction material cost and construction financing cost were added as factors with negative impacts on housing construction (Mayer & Somerville, 2000a), and construction land supply was added as a variable with a positive impact (DiPasquale & Wheaton, 1994; Harter-Dreiman, 2004; Riddel, 2004; Van der Vlist et al., 2011). In addition, DiPasquale (1999) and Follain et al. (1993) enlarged the model by adding housing policy as a determinant.

The stock-flow model specifies that when a housing market is in equilibrium, new housing construction in area  $i$  at time  $t$  ( $C_{it}$ ) is a function of the house price ( $P_{it}$ ), construction material cost ( $MC_{it}$ ), construction financing cost ( $KC_{it}$ ), construction land supply ( $LS_{it}$ ) and housing policy ( $HP_t$ ) (with the expected sign under every coefficient). That is,

$$C_{it} = \beta_0 + \beta_1 P_{it} + \beta_2 MC_{it} + \beta_3 KC_{it} + \beta_4 LS_{it} + \beta_5 HP_t + u_{it} \tag{1}$$

(-/+)
(+)
(-)
(-)
(+)
(-/+)

The above model (1) fails to consider the typical features of China’s housing market discussed in Sect. 2 in two ways. First, the model considers levels and thus is unsuitable for capturing the state of disequilibrium of the Chinese housing market due to massive rural–urban migration and increasing per capita disposable income (see, e.g., Hanweck, 2018; Riddell, 2004; Velupillai, 2006). To consider this disequilibrium, we specify the model in terms of changes rather than levels (see inter alia Caldera and Johansson (2013), Gonzalez and Ortega (2013) and Hwang and Quigley (2006)). Second, as explained in the previous section, construction land supply is controlled by the national and municipal governments. As a consequence, it takes on average 266 workdays to acquire construction permits to convert farmland into construction land (The World Bank, 2015). Therefore, we consider both lagged changes and current changes. We use one-term and two-term lags of the explanatory variables given the short observation time period. In summary, the empirical model is calculated as follows (expected sign under every coefficient):

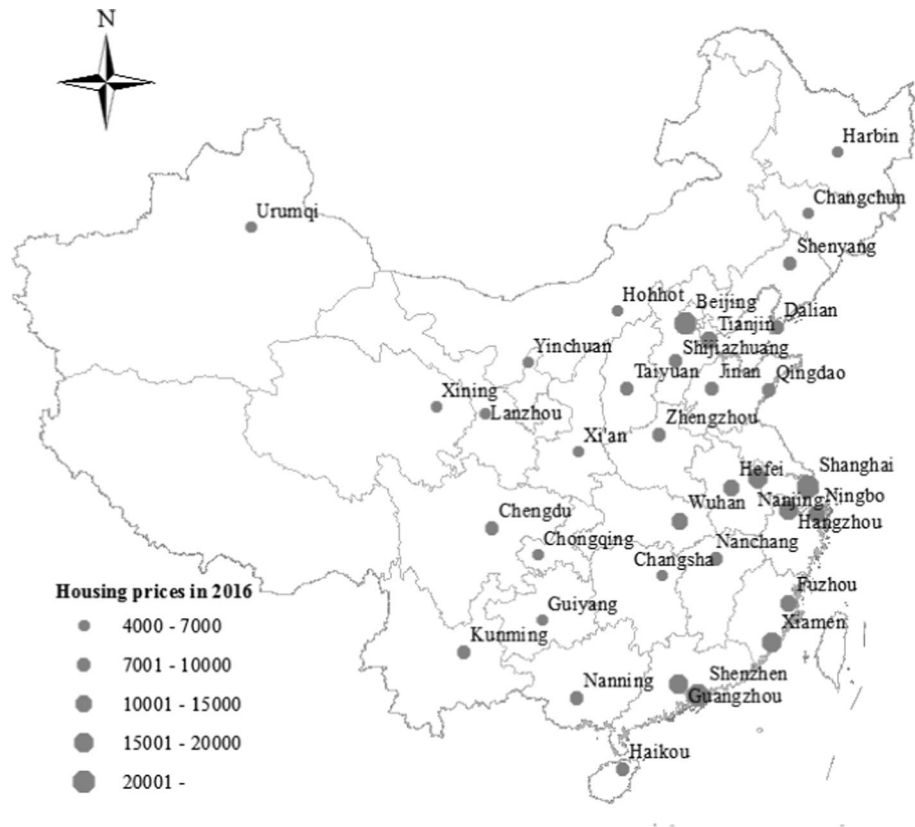
$$\begin{aligned}
 Start_{it} = & \beta'_0 + \beta'_1 \Delta P_{it} + \beta'_2 \Delta P_{it-1} + \beta'_3 \Delta P_{it-1} + \beta'_4 \Delta MC_{it} + \beta'_5 \Delta MC_{it-1} + \beta'_6 \Delta MC_{it-1} \\
 & + \beta'_7 \Delta KC_{it} + \beta'_8 \Delta KC_{it-1} + \beta'_9 \Delta KC_{it-1} + \beta'_{10} \Delta LS_{it} + \beta'_{11} \Delta LS_{it-1} \\
 & + \beta'_{12} \Delta LS_{it-1} + u_{it},
 \end{aligned}$$

(-/+)
(+)
(+)
(+)
(-)
(-)
(-)
  
(-)
(-)
(-)
(+)
(+)
  
(+)

where *Starts* denotes new housing construction,  $\Delta$  denotes the first difference operator,  $\beta'_0$  is the intercept,  $\beta'_j$  ( $j=1,2,\dots,13$ ) is the coefficient of explanatory variable  $j$  (defined above), and  $u_{it}$  is the error term.

Since the stock-flow model captures the interaction between house prices and the housing supply, house prices are likely to be endogenous in model (2). See, among others, Gonzalez and Ortega (2013), Hwang and Quigley (2006), Mayer and Somerville (2000a) and Riddell (2004). To account for this, we follow Gonzalez and Ortega (2013) and Hwang and Quigley (2006) and apply an instrumental variable (IV) approach with the following variables as instruments for  $\Delta P_{it}$ : change in the population ( $\Delta POP_{it}$ ), change in the per capita disposable income ( $\Delta INC_{it}$ ), change in the mortgage interest rate ( $\Delta M_{it}$ ), change in non-construction employment ( $\Delta EM_{it}$ ), and change in the energy price ( $\Delta EP_{it}$ ). Note that the one-term lagged variable  $\Delta P_{it-1}$  is determined prior to *Start<sub>it</sub>* and is exogenous.

Another possible endogenous variable is land supply. As discussed in Sects. 1 and 2, the municipal government is the monopoly supplier of construction land in urban China; thus, this context is basically different from a standard competitive land market. Particularly, in the Chinese situation, the municipal government determines the construction land supply and land price, which are based on the need to preserve agricultural land, a municipality’s socioeconomic development and the incentive to increase revenue. Guo (2013) pointed out that the conversion of agricultural land to construction land accounted for more than 40% of the total revenues of municipality governments during the research period. Hence, construction land demand has little impact on the construction land supply and its price. Therefore, the paper employs land supply as an exogenous variable. Further econometric aspects are discussed in Sect. 4.2.



**Fig. 1** 35 metropolitan areas in China

The analysis presented below is based on observations for China's 35 major metropolitan areas over the period 2001–2015.<sup>2</sup> This information is presented in Fig. 1.

Data were collected from public sources. Data on housing starts, construction land supply and average real house price per square meter for each metropolitan area were collected from the China Real Estate Statistics Yearbooks 2002–2016. Monetary values were deflated by the consumer price index for each metropolitan area and obtained from each metropolitan area's statistics yearbook. Changes in the construction material cost were proxied by changes in the construction material price index collected from each metropolitan area's statistics yearbook. The construction financing cost was measured as the interest rate of commercial bank loans, and this information was obtained from the People's Bank of China.<sup>3</sup> Data on the urban population were obtained from the China City Statistics

<sup>2</sup> The Chinese housing reform started in 1998. However, for the period 1998 to 2000 not all 35 major metropolitan areas published data on housing prices and new housing construction. Thus, the paper considers only the period 2001–2015.

<sup>3</sup> Following Grimes and Aitken (2010), the analysis is based on the interest rate of commercial bank loans for 0.5 year. We also conducted a sensitivity analysis by estimating model (2) with the interest rate of commercial bank loans for 0.5–1 year, 1–3 years, 3–5 years and more than 5 years.



Yearbooks 2002–2016. Data on the per capita disposable income, deflated by the consumer price index, were collected from each metropolitan area's statistics yearbook. We employed changes in the interest rate of the Housing Providence Fund, set by the People's Bank of China, as a proxy for changes in the mortgage cost. Although only a limited proportion of borrowers apply for loans from this fund and there is competition from commercial banks, the two institutions compete by way of the interest rate, and this proxy is acceptable because changes in the interest rates of the various institutions are closely linked (Yeung & Howes, 2006). We obtained nonconstruction employment data by subtracting construction employment from total employment. Data on construction employment and on total employment were collected from the China City Statistics Yearbooks 2002–2016. Data on the energy price index were obtained from each metropolitan area's statistics yearbook.

## 4 Empirical results

### 4.1 Descriptive statistics

We estimate model (2) for the 35 major metropolitan areas for (i) the period 2001–2006 and (ii) the period 2007–2015. The rationale for the two separate regressions is to capture the structural changes in the market signals due to the introduction of the public housing policy aimed at stimulating the construction of houses less than 90 square meters in 2006 (see Sect. 2). Note that All 35 metropolitan areas had introduced this policy by 2006.

Table 1 displays the descriptive statistics of all the variables used in the empirical analysis. The table shows that during the periods 2001–2006 and 2007–2015, the average number of new housing starts across the metropolitan areas reached 6.10 and 11.18 million square meters per year, respectively. New housing starts strongly varied across the metropolitan areas, ranging from 0.49 million square meters in Haikou in 2002 to 53.88 million square meters in Chongqing in 2013. Housing prices, construction land and incomes increased substantially in both periods. The increase in construction land from 2001–2006 was greater than that from 2007 to 2015. The construction material price index and the energy price index increased during the 2001–2006 period but declined from 2007 to 2015. The interest rate of commercial bank loans and the interest rate of long-term loans from the housing providence fund were virtually constant during the 2001–2006 period but declined from 2007 to 2015. The change in the urban population was the same in both periods. Non-construction employment increased in both periods.

The change in construction land across the metropolitan areas averaged 4.34 and 3.42 million square meters per year from 2001 to 2006 and 2007–2015, respectively. Although all metropolitan areas in China were subject to land use regulations implemented by the national government, the stringency of the regulations imposed varied. Land use regulation in the four mega areas (Beijing, Shanghai, Guangzhou and Shenzhen) was more stringent than in the other metropolitan areas because of greater land scarcity (Hou, 2010). Under their strict land use regulations, the change (growth rate) in construction land declined while the construction land price increased (see "Appendix A"). In the other 31 metropolitan areas, the construction land supply and prices fluctuated. Since the land market in the mega areas differed from the land markets in the other 31 metropolitan areas, we estimated a model for all 35 metropolitan areas and one for the metropolitan areas without the four mega areas.

**Table 1** Descriptive statistics

Statistics	2001–2006					2007–2015				
	Mean	S.D.	Min.	Max.		Mean	S.D.	Min.	Max.	
<i>Dependent variable</i>										
$Starts_{it}$	6.10	5.52	0.49	26.69		11.18	7.94	1.35	53.88	
<i>Independent variables</i>										
$\Delta P_{it}$	0.26	0.34	-0.34	1.77		0.38	0.84	-2.16	6.63	
$\Delta MC_{it}$	0.47	7.43	-26.20	38.75		-0.67	10.90	-42.31	32.00	
$\Delta KC_{it}$	0.00	0.30	-0.54	0.36		-0.08	0.75	-1.71	1.00	
$\Delta LS_{it}$	4.34	3.88	0.21	20.93		3.42	3.28	0.14	21.83	
$\Delta POP_{it}$	0.12	0.13	0.00	0.74		0.12	0.18	-0.26	1.02	
$\Delta INC_{it}$	0.90	0.50	-1.39	3.02		1.47	0.70	-0.65	6.15	
$\Delta M_{it}$	0.00	0.34	-1.65	2.01		-0.09	0.59	-1.35	0.85	
$\Delta EM_{it}$	0.05	0.10	-0.28	0.50		0.10	0.15	-0.17	0.98	
$\Delta EP_{it}$	0.01	0.07	-0.49	0.22		-0.02	0.14	-0.60	0.56	

**Table 2** The Harris–Tzavalis (HT) panel unit-root test

Periods	2001–2006		2007–2015	
	Z	p-Value	Z	p-Value
<i>Dependent variable</i>				
<i>Starts<sub>it</sub></i>	- 3.38	0.00	- 5.80	0.00
<i>Independent variable</i>				
$\Delta P_{it}$	- 3.60	0.00	- 18.70	0.00
$\Delta MC_{it}$	- 12.50	0.00	- 23.85	0.00
$\Delta KC_{it}$	- 4.05	0.00	- 18.14	0.00
$\Delta LS_{it}$	- 5.07	0.00	- 9.12	0.00
$\Delta POP_{it}$	- 5.93	0.00	- 5.10	0.00
$\Delta INC_{it}$	- 3.67	0.00	- 11.13	0.00
$\Delta M_{it}$	- 6.34	0.00	- 16.17	0.00
$\Delta EM_{it}$	- 4.91	0.00	- 11.99	0.00
$\Delta EP_{it}$	- 2.99	0.00	- 15.85	0.00

### 4.2 Estimation results

Before going into detail, we observe that the interest rate of commercial bank loans (*KC*), which was employed as a proxy for the financial costs of housing construction, was absent in the 2001–2006 model because the interest rate of bank loans was strictly controlled by the monetary authorities and hardly changed during this period. This rate changed in 2002, 2004 and 2006 only. Moreover, the changes were very small: - 0.54%, 0.18% and 0.36%, respectively. Hence, this interest was a very weak market signal and deleted from the analysis.

As a first step, we tested the time series for stationarity to avoid inconsistent estimators (Wooldridge, 2016). As the panels are balanced and the size of the panels is small, we used the Harris–Tzavalis (HT) panel unit-root test. Table 2 shows that the hypothesis of a unit root is rejected for the dependent and independent variables at the 1% level.

Next, we estimated the prediction of  $\Delta P_{it}$  to control for its endogeneity. The IV model was calculated as follows:

$$\Delta P_{it} = \alpha_0 + \alpha_1 \Delta POP_{it} + \alpha_2 \Delta INC_{it} + \alpha_3 \Delta M_{it} + \alpha_4 \Delta EM_{it} + \alpha_5 \Delta EP_{it} + v_{it}$$

The estimated models are reported in “Appendix B.”

The third step involved testing for fixed effects (FE) versus random effects (RE) to control for unobserved heterogeneity by means of the Hausman test.<sup>4</sup> For the period 2001–2006,  $\chi^2$  equals 289.33 with degrees of freedom (*df*)=9, and p-value=0.00. For the period 2007–2015,  $\chi^2$  is 257.39 with *df*=12, and p-value=0.00. Hence, we rejected the random effects hypothesis and continued the analysis based on the results of the FE specification.

<sup>4</sup> The RE estimator has smaller variance than the FE estimator, provided that the unobserved heterogeneity is exogenous. If this assumption does not hold, the FE estimator should be used (see Wooldridge (2010) for a detailed discussion).

**Table 3** Response of new housing starts to market signals in the 35 major metropolitan areas

Dependent variable: $Starts_{it}$			
Independent variables			
Periods	2001–2006	2007–2015	
$\Delta P_{it-1}$	3.06*** (0.47)	0.36* (0.19)	
$\Delta P_{it-2}$	1.04** (0.52)	0.41** (0.19)	
$\Delta MC_{it}$	-0.02** (0.01)	– –	
$\Delta MC_{it-1}$	– –	-0.04*** (0.01)	
$\Delta KC_{it}$	– –	-0.33** (0.15)	
$\Delta KC_{it-1}$	– –	-0.63*** (0.16)	
$\Delta KC_{it-2}$	– –	-0.64*** (0.17)	
$\Delta LS_{it}$	0.34*** (0.05)	0.76*** (0.09)	
$\Delta LS_{it-1}$	0.46*** (0.04)	0.46*** (0.09)	
$\Delta LS_{it-2}$	0.43*** (0.04)	0.42*** (0.09)	
Constant	0.32* (0.18)	3.39*** (0.46)	

See Table 1 for definitions. Standard errors appear in parentheses. \*, \*\* and \*\*\* indicate significance at the 10%, 5%, and 1% levels, respectively. The estimates are based on the 0–0.5 year interest rate. Feasible generalized least squares estimates

The hypothesized full model (2) for the period 2007–2015 and the reduced model 2 (without the KC variables) for 2001–2006 were estimated by FE ordinary least squares. Column 2, “Appendix C,” shows that for the period 2001–2006, the coefficients of  $\Delta P_{it}$  and  $\Delta MC_{it-1}$  have unexpected signs but are not significant at the 10% level. Hence, these variables were deleted from the model. For the period 2007–2015, the coefficients of  $\Delta P_{it}$  and  $\Delta MC_{it}$  have unexpected signs and are highly statistically insignificant. Hence, they were deleted. The results are presented in Appendix C columns 3 and 5.

Next, we tested both reduced models for serial correlation and heteroskedasticity. For the period 2001–2006, the Wooldridge test ( $F=4.30$ ,  $df=(1, 34)$ ,  $p\text{-value}=0.04$ ) led to the rejection of the hypothesis of no serial correlation, while the modified Wald test ( $\chi^2=1877.11$ ,  $df=35$ ,  $p\text{-value}=0.00$ ) led to the rejection of the hypothesis of homoskedasticity. Similar results were obtained for the period 2007–2015: Wooldridge test  $F=61.10$ ,  $df=(1, 34)$ ,  $p\text{-value}=0.00$ , and modified Wald test  $\chi^2=934.68$ ,  $df=35$ ,  $p\text{-value}=0.00$ . Thus, we reestimated the models using feasible generalized least squares (F-GLS) and deleted the variables with insignificant coefficients one by one (backward stepwise elimination) (see Tang et al., 2016). The results are reported in Table 3.

The results in Table 3 show that one-year lagged and two-year lagged house price changes had significant, positive impacts on housing starts in both periods. The impacts during the 2001–2006 period were substantially larger than those in the 2007–2015 period. In particular, a one RMB increase in the real house price per square meter at  $t-1$  had a contemporaneous effect on housing starts of 3,060 square meters<sup>5</sup> during the first period and 360 square meters during the second. For house prices at  $t-2$ , the impacts were 1040 and 410, respectively. There are differences between both periods because the national government gradually reduced the construction land supply after 2006. As a consequence, there were fewer opportunities for building new houses such that housing starts could not grow as much as before despite the higher price. Yan et al. (2014) attributed the lower price elasticity of housing construction after 2006 to a decrease in the construction land supply. See also Caldera and Johansson (2013), who pointed out that a limited land supply leads to lower price elasticity. In addition, the low-rent and affordable housing programs implemented by the national government in 2006 further reduced the availability of construction land for houses to be sold at market prices, which further reduced the price elasticity of housing construction (Chen & Nong, 2016; Yuan & Hamori, 2014).

The response of new housing construction to changes in house prices in China is stronger than that in the USA. In the USA, a one dollar increase in real house price increases housing starts by 57 houses which accounts for approximately 0.06% of annual starts (Mayer & Somerville, 2000a).<sup>6</sup> In China, however, a one RMB increase in real house prices drove housing construction up by 4100 (3060 + 1,040) square meters during the 2001–2006 period, which accounts for 0.67% of the average annual starts. From 2007 to 2015, the increase was 770 (360 + 410) square meters, accounting for 0.09% of the average annual starts.

Table 3 shows that the current change in construction material costs had a significant negative impact on housing starts during the 2001–2006 period. A one percentage point increase in  $\Delta MC_{it}$  reduced total new housing starts by 0.02 million square meters. For the second period,  $\Delta MC_{it}$  had an unexpected sign and was statistically insignificant; thus, it was deleted. For the period 2001–2006, the impact of  $\Delta MC_{it-1}$  had an unexpected sign and was statistically insignificant. For the second period, the impact of  $\Delta MC_{it-1}$  was 0.04 million square meters. For both periods,  $\Delta MC_{it-2}$  had the correct sign but was statistically insignificant and deleted.

In contrast to Hwang and Quigley (2006), we find that for the second period, the impacts of the change in capital costs measured by the change in the commercial interest rate for all lags are significant. Specifically, a one percentage point increase in the interest rate of bank loans at  $t$ ,  $t-1$  and  $t-2$  decreased total new housing starts by 0.33, 0.63 and 0.64 million square meters, respectively. The impacts of current, one-year lagged and two-year lagged construction land supply are positive and significant for both periods. A one million square meter increase in the construction land supply increased total new housing starts by 1.23 (0.34 + 0.46 + 0.43) million square meters from 2001 to 2006 and by 1.64 (0.76 + 0.46 + 0.42) million square meters from 2007 to 2015. The impact from 2007 to

<sup>5</sup> This is calculated as  $Starts_{it} = 1 \times 3.06 \times (1,000,000/1,000)$ . Note that the house price change is reported in 1000 RMB.

<sup>6</sup> Information on new housing construction in the US is measured by the number of houses rather than square meters. Since the number of houses is more heterogeneous than square meters, the comparison is crude.

**Table 4** Responsiveness of new housing starts at varying interest rates, 2007–2015

Dependent variable: $Starts_{it}$					
Independent variable					
Interest rate	0–0.5 year	0.5–1 year	1–3 years	3–5 years	> 5 years
$\Delta P_{it-1}$	0.39** (0.19)	0.36* (0.19)	0.37** (0.19)	0.38** (0.19)	0.36* (0.18)
$\Delta P_{it-2}$	0.45** (0.19)	0.41** (0.19)	0.42** (0.19)	0.43** (0.19)	0.43** (0.19)
$\Delta MC_{it-1}$	-0.03*** (0.01)	-0.04*** (0.01)	-0.04*** (0.01)	-0.03*** (0.01)	-0.03*** (0.01)
$\Delta KC_{it}$	-0.32* (0.18)	-0.33** (0.15)	-0.28* (0.15)	-0.27* (0.16)	-0.27* (0.16)
$\Delta KC_{it-1}$	-0.78*** (0.20)	-0.63*** (0.16)	-0.65*** (0.16)	-0.72*** (0.17)	-0.74*** (0.18)
$\Delta KC_{it-2}$	-0.62*** (0.20)	-0.64*** (0.17)	-0.58*** (0.17)	-0.61*** (0.17)	-0.62*** (0.17)
$\Delta LS_{it}$	0.75*** (0.10)	0.76*** (0.09)	0.75*** (0.09)	0.76*** (0.09)	0.75*** (0.09)
$\Delta LS_{it-1}$	0.46*** (0.09)	0.46*** (0.09)	0.46*** (0.09)	0.47*** (0.09)	0.47*** (0.09)
$\Delta LS_{it-2}$	0.41*** (0.09)	0.42*** (0.09)	0.42*** (0.09)	0.43*** (0.09)	0.42*** (0.09)
Constant	3.48*** (0.47)	3.39*** (0.46)	3.46*** (0.46)	3.40*** (0.46)	3.43*** (0.46)

Notes: See Table 1 for definitions. Standard errors appear in parentheses. \*, \*\* and \*\*\* indicate significance at the 10%, 5%, and 1% levels, respectively. Feasible generalized least squares estimates

2015 is larger than that from 2001 to 2006 since intensive construction land use was promoted by the national government such that the floor area ratio increased after 2006.

We note that new housing construction significantly responded to changes in housing prices and the construction land supply from 2001 to 2006 and to all market signals from 2007 to 2015 except for the current and two-year lagged changes in construction material costs. Compared with the Western housing market, in urban China's market, the price elasticity of new housing construction was larger. Meanwhile, new housing construction was still restrained by government-controlled construction land supply in urban China. Due to the government's regulation on construction land supply, new housing construction in urban China responded to market signals with longer lags.

### 4.3 Robustness

In this section, we examine the robustness of our main results. First, we examine whether our results are robust to different interest rates. Next, we analyze the extent to which our results hold for the 31 metropolitan areas, with the mega areas excluded.

**Table 5** Responsiveness of new housing starts to market signals in the 31 metropolitan areas

Dependent variable: $Starts_{it}$				
Independent variable				
Periods	2001–2006		2007–2015	
	35	31	35	31
$\Delta P_{it-1}$	3.06*** (0.47)	1.70*** (0.30)	0.36* (0.19)	0.44* (0.24)
$\Delta P_{it-2}$	1.04** (0.52)	1.41*** (0.37)	0.41** (0.19)	0.43* (0.24)
$\Delta MC_{it}$	-0.02** (0.01)	-0.04*** (0.01)	-	-
$\Delta MC_{it-1}$	-	-	-0.04*** (0.01)	-0.04*** (0.01)
$\Delta KC_{it}$	-	-	-0.33** (0.15)	-0.41*** (0.15)
$\Delta KC_{it-1}$	-	-	-0.63*** (0.16)	-0.64*** (0.16)
$\Delta KC_{it-2}$	-	-	-0.64*** (0.17)	-0.61*** (0.17)
$\Delta LS_{it}$	0.34*** (0.05)	0.40*** (0.05)	0.76*** (0.09)	0.77*** (0.10)
$\Delta LS_{it-1}$	0.46*** (0.04)	0.32*** (0.05)	0.46*** (0.09)	0.46*** (0.10)
$\Delta LS_{it-2}$	0.43*** (0.04)	0.31*** (0.05)	0.42*** (0.09)	0.40*** (0.10)
Constant	0.32* (0.18)	0.91*** (0.20)	3.39*** (0.46)	3.16*** (0.45)

See Table 1 for definitions. Standard errors appear in parentheses. \*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels, respectively. The estimates are based on the 0–0.5 year interest rate. Feasible generalized least squares estimates

Regarding sensitivity to interest rates, we reestimated the model only for the period 2007–2015 and the interest rates of commercial bank loans for 0.5–1 year, 1–3 years, 3–5 years and more than 5 years. The results are presented in Table 4. The different interest rates have only minor impacts on the responsiveness of new housing starting to market signals. The signs of the coefficients do not change. Moreover, the magnitudes vary slightly. The largest change is  $\Delta KC_{it-1}$ , which ranges from -0.78 to -0.63.

Regarding the 31 metropolitan areas, Table 5, column 2 shows that for the 2001–2006 period, the responses in the 31 metropolitan areas to the one-year lagged change in housing prices is weaker than in the 35 metropolitan areas. A possible explanation is that, the demand for housing in the full sample was stronger than in the restricted sample because of the strong in-migration and income growth, especially in the megacities. For the period 2007–2015, the impacts of the changes in housing prices between the two samples are approximately equal because in-migration into megacities declined because of tighter hukou restrictions while the 31 metropolitan areas eased their hukou restrictions to attract

more migrants (Zhan, 2017). Second, for the first period, the impact of the change in the current land supply for the 31 sample is larger than in the 35 sample while for the one- and two-year lagged changes, the reverse holds. For the second period, the impacts are virtually equal for the two groups of areas. These results indicate that the national government gradually implemented more stringent land use regulations nationwide.

## 5 Discussion

The above results, especially those after 2006, are partly in line with the findings obtained by inter alia Caldera and Johansson (2013), DiPasquale and Wheaton (1994), Gonzalez and Ortega (2013), Hwang and Quigley (2006), Mayer and Somerville (2000a) for the USA, UK and EU countries. However, there are also substantial differences which are related China's historical footprints and housing policy.

First, as discussed in Sect. 2, the Chinese national government implemented stringent land use regulation to preserve 120 million hectares of high-quality farmland. To this end, it controls construction land supply. As a consequence, it takes on average 266 work days to obtain a construction permit to convert farmland into construction land. Hence, housing development companies face considerable time lags in obtaining construction land. Since housing price varies along with construction land availability (Yan et al., 2014), its impact on housing construction in China lasts longer than in mature market economies such as the USA (Caldera & Johansson, 2013). Specifically, the one-year and two-year lagged change in housing price have significant positive impacts on new housing construction in China whereas in the USA the impact lasts no longer than one year (Kuethe & Pede, 2011).

Second, the public housing program and medium-income housing policy have stimulated new housing construction in China. Specifically, municipal governments provided development subsidies and low-cost construction land for the public housing program (Sinai & Waldfoegel, 2005). Meanwhile, to meet the demand of medium-income households and rural–urban migrants the national government regulated the construction plans of housing development companies to stimulate the construction of houses that are less than 90 square meters. As a consequence of the stimulation programs, the price elasticity of new housing construction in China is larger than in a market economy such as the USA. For details, we refer to Sect. 4.2.

Third, the abolishment of the collective housing allocation system in 1998 brought about a sudden demand shock which boosted housing construction and increased the prices of inputs, including construction material costs and financing costs. In contrast to Hwang and Quigley (2006), who found that the impact of the construction material cost and financing is statistically insignificant, the present study shows that the one-year lagged change in the construction material cost and the current and lagged change in the financing cost had significant negative impacts on housing starts in the 35 metropolitan areas after 2006.

## 6 Summary and conclusions

This paper explores the equilibrium adjustment mechanism of new housing construction in urban China after the 1998 housing market reform based on a panel of the 35 major metropolitan areas over the period 2001–2015. We analyzed the periods 2001–2006 and



2007–2015 separately to address the impact of the 2006 housing policy, which aimed to stimulate the construction of houses smaller than 90 square meters.

The empirical model was estimated as a regional fixed effects model employing new housing construction as the dependent variable and changes in housing prices, the construction material cost, the construction financing cost and the construction land supply as determinants. Since house prices are endogenous, we applied an instrumental variable approach that employed changes in the population, per capita disposable income, mortgage interest rate, nonconstruction employment and energy price as instruments of the change in house prices.

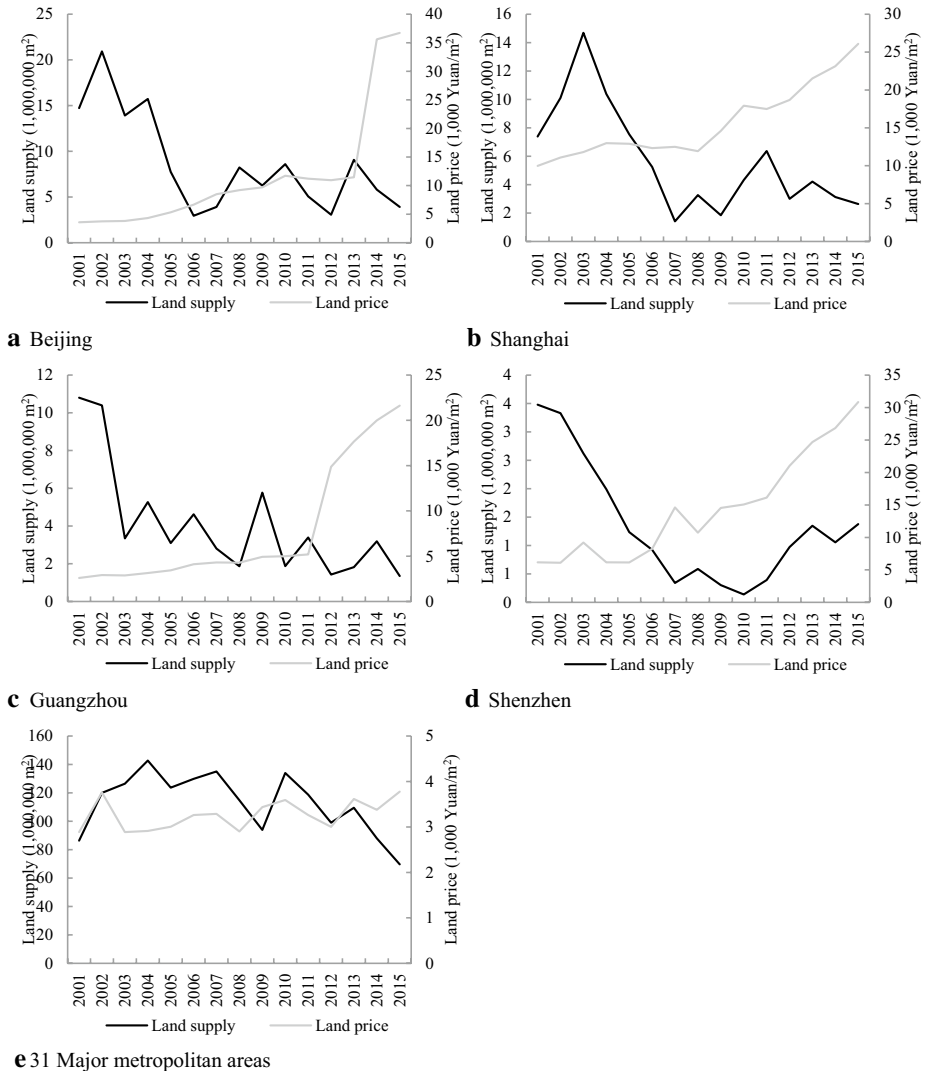
The main result shows that from 2001 to 2006, new housing construction significantly responded to one-year and two-year lagged changes in housing prices, changes in construction material costs and current and lagged changes in the construction land supply. From 2007 to 2015, new housing construction significantly responded to one-year and two-year lagged changes in housing prices, current and lagged changes in the construction financial cost and construction land supply and one-year lagged changes in construction material costs. The different responses between the two periods indicate that the market-oriented housing supply system responded increasingly to market signals.

The comparison between China's newly established housing market and more mature western housing markets indicates that the Chinese housing market has started to work in the 35 metropolitan areas during the study period. However, because of its historical footprints and typical housing policy, the response of the Chinese housing market to market signals needs further improvement. This applies particularly to the land market, which responds more slowly than in mature housing markets. This reform is urgently needed because of the continued high demand created by rural–urban migration and the rising per capita income.

This paper gauges the equilibrium adjustment mechanism of new housing construction and sheds light on how the Chinese housing market works. However, it is subject to limitations. The analysis in the paper is based on data collected from 2001 to 2015, and thus provides no information on how the equilibrium adjustment mechanism has worked after 2015. Although construction land supply is still controlled by national government and public housing programs have continued after 2015, the housing market conditions have changed. Particularly, the outbreak of Covid-19 has led to delays of housing construction. In addition, it has become more difficult to raise capital for housing companies as the People's Bank of China implemented a new policy in which a housing loan is not allowed to exceed 40% of a borrower's total bank loan. Further studies are needed to address how these factors affect new housing construction in urban China.

## Appendix A

See Fig. 2.



**Fig. 2** The change in construction land and land prices in the four mega metropolitan areas and in the 31 major metropolitan areas in China (2001–2015). Source: The China Real Estate Statistics Yearbook (2002–2016) and Land Value Monitor (<http://www.landvalue.com.cn/lvmonitor>, Accessed 26 June 2018)

## Appendix B

See Table 6.

**Table 6** The estimated IV models

Dependent variable: $\Delta P_{it}$				
Independent variables				
Periods	2001–2006		2007–2015	
Model	FE	RE	FE	RE
$\Delta POP_{it}$	1.06*** (0.40)	0.44** (0.20)	1.14*** (0.46)	1.04*** (0.29)
$\Delta INC_{it}$	0.07* (0.04)	0.19*** (0.05)	0.02* (0.01)	0.08** (0.04)
$\Delta M_{it}$	-0.15** (0.07)	-0.11* (0.07)	-0.23** (0.09)	-0.22** (0.09)
$\Delta EM_{it}$	0.24 (0.28)	0.64*** (0.23)	0.63 (0.45)	0.41 (0.35)
$\Delta EP_{it}$	-0.59* (0.30)	-0.51* (0.30)	-0.03 (0.40)	-0.01 (0.40)
Constant	0.07 (0.07)	0.02 (0.05)	0.13 (0.15)	0.08 (0.07)
$R^2$	0.34	0.56	0.32	0.35

See Table 1 for definitions. Standard errors appear in parentheses. \*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels, respectively

## Appendix C

See Table 7.

**Table 7** Response of new housing starts to market signals in the 35 major metropolitan areas

Dependent variable: $Starts_{it}$				
Independent variables				
Periods	2001–2006		2007–2015	
	Full model	Reduced model	Full model	Reduced model
$\Delta P_{it}$	-1.67 (1.28)	–	-0.98 (0.78)	–
$\Delta P_{it-1}$	2.78** (0.69)	2.29*** (0.62)	0.17 (0.36)	0.38 (0.30)
$\Delta P_{it-2}$	1.04 (0.89)	0.93 (0.88)	0.41 (0.35)	0.63** (0.30)
$\Delta MC_{it}$	-0.01 (0.02)	-0.04** (0.02)	0.03 (0.03)	–
$\Delta MC_{it-1}$	0.02 (0.04)	–	-0.07** (0.03)	-0.06** (0.03)
$\Delta MC_{it-2}$	-0.01 (0.05)	-0.01 (0.29)	-0.01 (0.03)	-0.00 (0.02)
$\Delta KC_{it}$	–	–	-0.24 (0.32)	-0.36 (0.28)
$\Delta KC_{it-1}$	–	–	-0.96*** (0.32)	-0.74*** (0.26)
$\Delta KC_{it-2}$	–	–	-0.92*** (0.30)	-1.00*** (0.29)
$\Delta LS_{it}$	0.36*** (0.10)	0.31*** (0.09)	0.47*** (0.12)	0.45*** (0.11)
$\Delta LS_{it-1}$	0.29*** (0.08)	0.31*** (0.08)	0.05 (0.11)	0.04 (0.11)
$\Delta LS_{it-2}$	0.34*** (0.07)	0.32*** (0.07)	0.06 (0.11)	0.09 (0.11)
Constant	0.96 (1.05)	2.01** (0.75)	10.04*** (0.69)	9.68*** (0.61)

Estimator: FE-OLS. For an explanation of the absence of the  $\Delta KC$  variables for the period 2001–2006, please see Sect. 4.2

## References

- Bielsa, J., & Duarte, R. (2011). Size and linkages of the Spanish construction industry: Key sector or deformation of the economy? *Cambridge Journal of Economics*, 35(2), 317–334.
- Bramley, G. (1999). Housing market adjustment and land-supply constraints. *Environment and Planning A*, 31(7), 1169–1188.
- Caldera, A., & Johansson, Å. (2013). The price responsiveness of housing supply in OECD countries. *Journal of Housing Economics*, 22(3), 231–249.
- Chen, J., Guo, F., & Wu, Y. (2011). One decade of urban housing reform in China: Urban housing price dynamics and the role of migration and urbanization, 1995–2005. *Habitat International*, 35(1), 1–8.
- Chen, J., & Nong, H. (2016). The heterogeneity of crowding effect of public housing on market housing: Empirical evidence from China. *Journal of Housing Economics*, 33(1), 115–127.

- Chen, K., & Wen, Y. (2017). The great housing boom of China. *American Economic Journal: Macroeconomics*, 9(2), 73–114.
- Construction Land Price in 70 Cities. (2014). Available at <http://www.landvalue.com.cn/>. Retrieved June 26, 2018 (in Chinese).
- Davis, M. A., & Heathcote, J. (2005). Housing and the business cycle. *International Economic Review*, 46(3), 751–784.
- Deng, L., & Chen, J. (2019). Market development, state intervention, and the dynamics of new housing investment in China. *Journal of Urban Affairs*, 41(2), 223–247.
- Deng, L., Shen, Q., & Wang, L. (2011). The emerging housing policy framework in China. *Journal of Planning Literature*, 26(2), 168–183.
- Dhakal, S. (2009). Urban energy use and carbon emissions from cities in China and policy implications. *Energy Policy*, 37(11), 4208–4219.
- Ding, C. (2007). Policy and praxis of land acquisition in China. *Land Use Policy*, 24(1), 1–13.
- Ding, C., & Lichtenberg, E. (2011). Land and urban economic growth in China. *Journal of Regional Science*, 51(2), 299–317.
- DiPasquale, D., & Wheaton, W. C. (1994). Housing market dynamics and the future of housing prices. *Journal of Urban Economics*, 35(1), 1–27.
- DiPasquale, D. (1999). Why don't we know more about housing supply? *The Journal of Real Estate Finance and Economics*, 18(1), 9–23.
- Dong, Y. (2016). A note on geographical constraints and housing markets in China. *Journal of Housing Economics*, 33, 15–21.
- Égert, B., & Mihaljek, D. (2007). Determinants of house prices in Central and Eastern Europe. *Comparative Economic Studies*, 49(3), 367–388.
- Food and Agriculture Organization of the United Nations (FAO). (2008). Available at <http://faostat.fao.org/site/291/default.aspx>. Retrieved June 26, 2018.
- Follain, J. R., Leavens, D. R., & Velz, O. T. (1993). Identifying the effects of tax reform on multifamily rental housing. *Journal of Urban Economics*, 34(2), 275–298.
- Gentile, M., & Sjöberg, Ö. (2010). Soviet housing: Who built what and when? The case of Daugavpils, Latvia. *Journal of Historical Geography*, 36(4), 453–465.
- Glaeser, E. L., Gyourko, J., & Saiz, A. (2008). Housing supply and housing bubbles. *Journal of Urban Economics*, 64(2), 198–217.
- Green, K. P., Filipowicz, J., Lafleur, S., & Herzog, I. (2016). *The impact of land-use regulation on housing supply in Canada*. Vancouver: Fraser Institute.
- Gonzalez, L., & Ortega, F. (2013). Immigration and housing booms: Evidence from Spain. *Journal of Regional Science*, 53(1), 37–59.
- Grimes, A., & Aitken, A. (2010). Housing supply, land costs and price adjustment. *Real Estate Economics*, 38(2), 325–353.
- Guo, K. (2013). The relationship between land financial dependence, fiscal income gap and house price. *Economic Review*, 23, 69–75. (in Chinese).
- Hanink, D. M., Cromley, R. G., & Ebenstein, A. Y. (2012). Spatial variation in the determinants of house prices and apartment rents in China. *The Journal of Real Estate Finance and Economics*, 45(2), 347–363.
- Hanweck, G. A. (2018). Identifying house price booms, bubbles and busts: A disequilibrium analysis from chaos theory. Available at SSRN: <http://dx.doi.org/https://doi.org/10.2139/ssrn.3271953>
- Harter-Dreiman, M. (2004). Drawing inferences about housing supply elasticity from house price responses to income shocks. *Journal of Urban Economics*, 55(2), 316–337.
- He, C., Huang, Z., & Wang, R. (2014). Land use change and economic growth in urban China: A structural equation analysis. *Urban Studies*, 51(13), 2880–2898.
- Herbst, I., & Muziol-Weclawowicz, A. (1993). Housing in Poland: Problems and reforms. *Cities*, 10(3), 246–256.
- Hou, Y. (2010). Housing price bubbles in Beijing and Shanghai: A multi-indicator analysis. *International Journal of Housing Markets and Analysis*, 3(1), 17–37.
- Hsing, Y. T. (2006). Global capital and local land in China's urban real estate development. In F. Wu (Ed.), *Globalization and the Chinese City* (pp. 167–189). Routledge.
- Huang, D. S. (1966). The short-run flows of nonfarm residential mortgage credit. *Econometrica*, 34(2), 433–459.
- Hwang, M., & Quigley, J. M. (2006). Economic fundamentals in local housing markets: Evidence from US metropolitan regions. *Journal of Regional Science*, 46(3), 425–453.
- Johnson, C. (1998). Economic crisis in East Asia: The clash of capitalisms. *Cambridge Journal of Economics*, 22(6), 653–661.

- Kueth, T. H., & Pede, V. O. (2011). Regional housing price cycles: A spatio-temporal analysis using US state-level data. *Regional Studies*, 45(5), 563–574.
- Lee, J. (2000). From welfare housing to home ownership: The dilemma of China's housing reform. *Housing Studies*, 15(1), 61–76.
- Lichtenberg, E., & Ding, C. (2009). Local officials as land developers: Urban spatial expansion in China. *Journal of Urban Economics*, 66(1), 57–64.
- Mak, S., Choy, L., & Ho, W. (2012). Region-specific estimates of the determinants of real estate investment in China. *Urban Studies*, 49(4), 741–755.
- 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*, 10(3), 278–306.
- Mayer, C. J., & Somerville, C. T. (2000a). Residential construction: Using the urban growth model to estimate housing supply. *Journal of Urban Economics*, 48(1), 85–109.
- Mayer, C. J., & Somerville, C. T. (2000b). Land use regulation and new construction. *Regional Science and Urban Economics*, 30(6), 639–662.
- Mayo, S., & Stein, J. (1995). Housing and labor market distortions in Poland: Linkages and policy implications. *Journal of Housing Economics*, 4(2), 153–182.
- Mayo, S., & Sheppard, S. (1996). Housing supply under rapid economic growth and varying regulatory stringency: An international comparison. *Journal of Housing Economics*, 5(3), 274–289.
- McLaughlin, R. B. (2012). New housing supply elasticity in Australia: A comparison of dwelling types. *The Annals of Regional Science*, 48(2), 595–618.
- Ministry of Housing and Urban-Rural Development of the People's Republic of China (MOHURD). (2007). Report of the construction of low-rent housing supply system. [http://www.mohurd.gov.cn/zxydt/200804/t20080424\\_162808.html](http://www.mohurd.gov.cn/zxydt/200804/t20080424_162808.html). Retrieved June 26, 2018 (in Chinese).
- Monkkonen, P. (2013). Urban land-use regulations and housing markets in developing countries: Evidence from Indonesia on the importance of enforcement. *Land Use Policy*, 34(12), 255–264.
- Murray, M. P. (1999). Subsidized and unsubsidized housing stocks 1935 to 1987: Crowding out and cointegration. *The Journal of Real Estate Finance and Economics*, 18(1), 107–124.
- Peng, L., & Thibodeau, T. G. (2012). Government interference and the efficiency of the land market in China. *The Journal of Real Estate Finance and Economics*, 45(4), 919–938.
- Petrović, M. (2001). Post-socialist housing policy transformation in Yugoslavia and Belgrade. *European Journal of Housing Policy*, 1(2), 211–231.
- Posedel, P., & Vizek, M. (2009). House price determinants in transition and EU-15 countries. *Post-Communist Economics*, 21(3), 327–343.
- Poterba, J. M. (1984). Tax subsidies to owner-occupied housing: An asset-market approach. *The Quarterly Journal of Economics*, 99(4), 729–752.
- Ren, H., Folmer, H., & Van der Vlist, A. J. (2014). What role does the real estate-construction sector play in China's regional economy? *The Annals of Regional Science*, 52(3), 839–857.
- Riddell, M. (2004). Housing-market disequilibrium: An examination of housing-market price and stock dynamics 1967–1998. *Journal of Housing Economics*, 13(2), 120–135.
- Shen, Y., & Liu, H. (2004). Relationship between real estate development investment and GDP in China. *Journal of Tsinghua University*, 44, 1205–1208. (in Chinese).
- Sinai, T., & Waldfoegel, J. (2005). Do low-income housing subsidies increase the occupied housing stock? *Journal of Public Economics*, 89(11), 2137–2164.
- Smith, L. B. (1969). A model of the Canadian housing and mortgage markets. *The Journal of Political Economy*, 77(5), 795–816.
- Stepanyan, V., Poghosyan, T., & Bibolov, A. S. (2010). House price determinants in selected countries of the former Soviet Union. IMF Working Papers, 1–15.
- Sunega, P., & Lux, M. (2007). Market-based housing finance efficiency in the Czech Republic. *European Journal of Housing Policy*, 7(3), 241–273.
- Tang, J., Folmer, H., & Xue, J. (2016). Adoption of farm-based irrigation water-saving techniques in the Guanzhong Plain, China. *Agricultural Economics*, 47(4), 445–455.
- The World Bank. (2015). *Doing business 2015: Comparing business regulation in 190 economies*. The World Bank Group.
- Tian, L., & Ma, W. (2009). Government intervention in city development of China: A tool of land supply. *Land Use Policy*, 26(3), 599–609.
- Topel, R., & Rosen, S. (1988). Housing investment in the United States. *The Journal of Political Economy*, 99(6), 718–740.
- United Nation Population Divisions. (2013). *World population prospects: The 2011 revision*. [http://www.mohurd.gov.cn/zxydt/200804/t20080424\\_162808.html](http://www.mohurd.gov.cn/zxydt/200804/t20080424_162808.html). Retrieved June 26, 2018.

- Van der Vlist, A. J., Czamanski, D., & Folmer, H. (2011). Immigration and urban housing market dynamics: The case of Haifa. *The Annals of Regional Science*, 47(3), 585–598.
- Velupillai, K. V. (2006). A disequilibrium macrodynamic model of fluctuations. *Journal of Macroeconomics*, 28(4), 752–767.
- Vermeulen, W., & Rouwendal, J. (2007). Housing supply and land use regulation in the Netherlands”. Tinbergen Institute Discussion Paper.
- Vermeulen, W., & van Ommeren, J. (2009). Does land use planning shape regional economies? A simultaneous analysis of housing supply, internal migration and local employment growth in the Netherlands. *Journal of Housing Economics*, 18(4), 294–310.
- Wang, S., Chan, S. H., & Xu, B. (2012). The estimation and determinants of the price elasticity of housing supply: Evidence from China. *Journal of Real Estate Research*, 34(3), 311–344.
- Wang, S., & Liu, H. (2009). The impact of land supply policy on housing supply and prices. *Journal of China Civil Engineering*, 42, 116–121. (in Chinese).
- Wang, Y., & Murie, A. (1996). The process of commercialisation of urban housing in China. *Urban Studies*, 33(6), 971–989.
- Wang, Y., & Murie, A. (1999). Commercial housing development in urban China. *Urban Studies*, 36(9), 1475–1494.
- Wang, Y., Wang, Y., & Bramley, G. (2005). Chinese housing reform in state-owned enterprises and its impacts on different social groups. *Urban Studies*, 42(10), 1859–1878.
- Wheeler, S. (2009). Regions, megaregions, and sustainability. *Regional Studies*, 43(6), 863–876.
- Wooldridge, J. (2010). *Econometric analysis of cross section and panel data*. The MIT Press.
- Wooldridge, J. (2016). *Introductory econometrics: A modern approach*. Cengage Learning.
- Wu, F. (1996). Changes in the structure of public housing provision in urban China. *Urban Studies*, 33(9), 1601–1627.
- Wu, Y., Zhang, X., & Shen, L. (2011). The impact of urbanization policy on land use change: A scenario analysis. *Cities*, 28(2), 147–159.
- Yan, S., Ge, X. J., & Wu, Q. (2014). Government intervention in land market and its impacts on land supply and new housing supply: Evidence from major Chinese markets. *Habitat International*, 44, 517–527.
- Yang, Z., & Dunford, M. (2017). City shrinkage in China: Scalar processes of urban and hukou population losses. *Regional Studies*, 52(8), 1111–1121.
- Yeung, S. C. W., & Howes, R. (2006). The role of the housing provident fund in financing affordable housing development in China. *Habitat International*, 30, 343–356.
- Yi, C., & Huang, Y. (2014). Housing consumption and housing inequality in Chinese cities during the first decade of the twenty-first century. *Housing Studies*, 29(2), 291–311.
- Yuan, N., & Hamori, S. (2014). Crowding-out effects of affordable and unaffordable housing in China, 1999–2010. *Applied Economics*, 46(35), 4318–4333.
- Zhan, S. (2017). Hukou reform and land politics in China: Rise of a tripartite alliance. *The China Journal*, 78(1), 25–49.
- Zhang, Z., & Treiman, D. J. (2013). Social origins, hukou conversion, and the wellbeing of urban residents in contemporary China. *Social Science Research*, 42(1), 71–89.
- Zhao, Y., & Bourassa, S. C. (2003). China’s urban housing reform: Recent achievements and new inequities. *Housing Studies*, 18(5), 721–744.
- Zhu, J. (2002). Urban development under ambiguous property rights: A case of China’s transition economy. *International Journal of Urban and Regional Research*, 26(1), 41–57.