

Article

Effects of Affordable Housing Land Supply on Housing Prices: Evidence from 284 Cities in China

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Abstract: The policy objectives of affordable housing programs in China are two-fold: on the one hand, they are designed to assist low- and moderate-income families and reduce inequality; on the other hand, they are intended to lower commodity housing prices. However, the effects of affordable housing land on housing prices, particularly the between-city variation and the mechanisms behind the market effects, have not been sufficiently examined, making it difficult to evaluate the housing policy and improve it accordingly. In this study, we address these gaps by using a prefecture-level panel dataset covering 2009–2020, obtained from national land and housing transaction information platforms. We use a threshold model to investigate the threshold effect of population size and a mediating model to uncover the channels through which the supply of affordable housing land affects housing prices. The results confirm that the affordable housing land supply can have a beneficial influence in terms of slowing down the increase in housing prices. The population size plays a significant role in explaining the between-city market effect variations. In cities with a population greater than 10.78 million, increasing the supply of affordable housing land would cause the housing prices to increase. Meanwhile, in cities with smaller populations, increasing the supply of affordable housing land could lower the housing prices. The underlying mechanisms of the market effects vary across cities with different population sizes. Although affordable housing land crowds out commodity housing land in all cities, housing demand diversion only exists in cities with a smaller population. At present, China is experimenting with city-specific housing policies; our findings imply that decision makers should explore additional policy options, besides building on incremental construction land, in order to make housing more affordable in supercities in China.

Keywords: affordable housing; crowding out effect; diversion effect; threshold regression model; mediating effect; China



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1. Introduction

In the wake of the 2008 financial crisis, the issue of housing affordability has posed an increasing challenge in cities worldwide, particularly over the past few years [1,2]. With the privatization and residualization of affordable housing programs, there has been a new emphasis on supply as housing policy becomes a concern in regions such as Australia, the United States, Europe, and Singapore [3–8]. Since the 1998 housing reform, China has made many attempts to build and supply housing to low-income families through affordable housing policies. Although these policies are formulated and issued by the central government, they lead to distinct market impacts once they are implemented [9,10]. The diverse real estate market settings and their resulting impacts may serve as valuable guidance for other countries as they develop supply-side policies.

Housing prices in Chinese cities have experienced rapid increases as a result of the urbanization process and the housing system reform [11–13]. According to data from the Chinese National Bureau of Statistics, the average sales price of commercial housing has

increased from 1948 CNY/square meter in 2000 to 10,158.94 CNY/square meter in 2020, an increase of over 500%. In particular, the housing prices in large cities are generally unaffordable to the ordinary working class [14]. The surge in housing prices has not only caused financial stress among individuals who wish to own a home; it has also led to wealth inequalities, a real estate market bubble, and increasing labor costs [15]. In the design of housing policies in China, affordable housing, especially economic and suitable housing (ESH), has a dual purpose. On the one hand, it improves the housing supply structure, solves the housing difficulties of middle- and low-income families, and reduces housing inequality; on the other hand, the policy aims to suppress the prices of commodity housing [16,17]. Various measures implemented by the central government seek to expand the supply of affordable housing supply in locations where property values are excessively high and are increasing at an accelerated rate.

Before the 1998 housing reform, China had started the construction of an affordable housing system. From 1994 to 2007, more than 10 million units of affordable housing were built, including cheap rental housing (CRH) and economic and suitable housing (ESH). Approximately 22 million units of affordable housing were constructed from 2008 to 2018, including approximately 16 million units of CRH and approximately 5,730,000 units of ESH. The amount of money spent on housing subsidies via China's national budget grew from CNY 447.9 billion in 2012 to CNY 680.6 billion in 2018, with an average increase of 8.9% [18]. Given the massive fiscal expenditure and land resources invested in affordable housing programs, research on their influence on the local residential market is quite limited, particularly regarding the disparity in the market effects across cities. To address this gap, this study investigates the effects of affordable housing on local housing markets, emphasizing the varying impacts observed in cities of differing population sizes.

2. Literature Review

2.1. Affordable Housing System and Land Supply for Affordable Housing

In 1994, for the first time, the central government of China proposed the establishment of an affordable housing supply system targeted at middle- and low-income families, with the goal of social security. At that time, such government-subsidized housing was referred to as the "Anju Project"; the construction land for the housing project was supplied by the local government through administrative allocation, and the related taxes and fees were reduced or waived [19]. During the "Anju Project", the government-led construction of affordable housing focused primarily on owner-occupied housing, which was eligible for policy loans from the central government, tax deductions, and free land allocation by local governments and required developers to make a profit of no more than 3 percent [20].

In June 1998, the State Council issued the "Notice on Further Deepening the Reform of Urban Housing System and Accelerating Housing Construction", which proposed to "establish and improve the multi-level urban housing supply system with mainly economic and suitable housing". It required that "the lowest income families rent cheap rental housing (CRH) provided by the government or employers; low-medium-income families buy economic and suitable housing (ESH); and high-income families buy and rent commodity housing" [21]. The "Anju Project" transitioned towards focusing on economic and suitable housing (ESH), maintaining the same land allocation and financial arrangements but with an expanded range of eligible families. The CRH program was dedicated to the lowest-income urban families and was later expanded to cover low-income families. The local governments, particularly the municipalities, are responsible for the construction, funding, and management of CRH. In 2009, in order to deal with the housing challenges faced by middle-income families, public rental housing (PRH) was officially incorporated into the housing supply system. This is an affordable type of rental housing with wider coverage than CRH, while its land and funding sources are essentially the same as those of CRH. PRH was integrated into the housing programs in 2014. Thus, ESH, PRH, and CRH were the main forms of affordable housing in China before 2020 [22]. Affordable housing initiatives require large amounts of land, and many local governments rely on

land lease revenues due to this financial expenditure [23,24]. In the context of the limited development of urban land, affordable housing could consume the construction resources reserved for commodity housing.

2.2. Land Supply and Housing Prices

China enforces stringent regulations on the use of land for construction purposes. The central government distributes total construction land use quotas to provincial governments according to the Land Administration Law. The provinces and municipalities are then required to prepare an overall land use plan according to the plans for national economic and social development, making more detailed arrangements for local construction land use [25]. Each year, the central government issues an annual land use plan, which is formulated according to the current overall land use plan and allocates incremental construction land quotas to each province. Then, the provincial governments allocate quotas to the lower-level governments within their jurisdiction. The local government then determines the structure, layout, timing, and method of the annual incremental land supply according to the construction land use quotas allocated by the provincial government [26]. The annual limit on the supply of construction land available in cities is decided by the higher-level government, while the supply of residential land is decided by the local government. Since local governments have a strong incentive to designate large amounts of land as industrial land to improve the local taxation and GDP, attracting industrial investments, the share of residential land is quite limited [22]. In order to ensure that local governments construct sufficient affordable housing, the land intended for affordable housing has been required to be listed separately in the annual land use plan since 2009.

A substantial body of research has shown that the scale of the residential land supply has a significant impact on housing prices [27–32]. Under the strict construction land use quota system, on the one hand, the yearly land supply directly determines the maximum amount of construction carried out by real estate enterprises; on the other hand, when the residential land decreases and cannot satisfy the potential market demand, the increase in land prices increases the direct costs of housing construction, which ultimately causes a reduction in the overall housing market supply. An empirical study by Hilber and Vermeulen (2016) analyzed the impact of land supply restrictions on housing prices in the UK [33]. They found that a low supply of land can lead to higher house prices, especially in areas with high demand elasticity. In terms of the duration of the impact, Ren et al. (2011) studied 35 large- and medium-sized cities in China and found that the land supply two years before the study had a positive impact on the supply of new commodity housing in the studied year, and it had a negative impact on the average price of new commodity housing [34].

2.3. The Impact of the Affordable Housing Policy on the Housing Market

The existing literature mainly discusses affordable housing from the perspectives of institutional transformation, the efficiency and equity of different programs, and the impact on the participant households [35–40], while studies on affordable housing programs' market effects are relatively rare. One reason for this scarcity is the lack of robust affordable housing provision in many developing economies [41–44], while social housing stock instead of new constructions predominates as the affordable housing supply measure in developed economies such as the European countries. However, supply-side housing initiatives and legislative measures can influence the entire housing sector or substantial parts of it. Some scholars have already attempted to address the affordable housing policy's impacts on the housing stock or private housing investment, suggesting that affordable housing programs will reduce the supply of commodity housing [45–47]. Murray (1983) pointed out that the affordable housing policy may affect the commodity housing market through two channels: firstly, the increase in government-subsidized housing will divert part of the demand for commodity housing; secondly, the construction of affordable housing will occupy some of the production factors of commodity housing, increasing the

construction cost of the latter and causing a price increase or reducing the supply scale. Some scholars suggest that the degree of influence of public housing on the commodity housing market is dependent on the existence of direct competition between the two. This competition is influenced by the extent to which the intended buyer demographic and the methods of funding for both public and commodity housing are similar [48].

Empirical evidence of the crowding out effect can be found in many countries. Eriksen and Rosenthal (2010) analyzed the impact of American LIHTC construction at the levels of the MSA, county, and a 10-mile radius, finding that LIHTC development may strongly affect the number of newly built unsubsidized rental units [45]. Sau Kim Lum (2002) studied the impact of Singaporean market fundamentals and public policy variables on the price of private housing by constructing a Structural Equation Model and Dynamic Error Correction Model. They found that the affordable housing sector could influence the private housing market through the scale of land and the affordable housing supply [49]. Lee (2007) built a panel VAR model to study the interaction of affordable housing investment and private housing investment in South Korea from 1988 to 2003. It was found that public housing investment stimulated private housing investment during a housing shortage, and the two will crowd each other out when housing is relatively abundant. Furthermore, the crowding out effect will be magnified with an increase in the rate of homeownership [50].

In 2009, China's central government announced an affordable housing construction plan involving a government fund of CNY 167.6 billion, and studies on the market effects of affordable housing are increasing. However, existing studies predominantly adopt a macroscopic approach, with a primary emphasis on the national and provincial levels [51,52], lacking in-depth analysis at a more granular level. Moreover, Chinese scholars have not yet reached a consensus regarding whether the provision of affordable housing has led to a decrease in housing prices. Wang and Gao (2011) tested the dynamic impact of affordable housing on housing prices by constructing a Structural Vector Autoregression (SVAR) model, and they found that the construction of affordable housing has a restraining effect on the increase in housing prices [51]. At the same time, increasing housing prices will prompt local governments to increase their investments in affordable housing. Zhou and Lin (2011) employed a Vector Autoregression (VAR) model to determine whether there exists a Granger causal relationship between investment in commercial housing prices and investment in affordable housing. The study revealed a bidirectional Granger causal relationship between these two variables. The analysis of impulse response functions showed that the suppression effect of the increased investment in affordable housing on the prices of commodity housing is temporary. In the long run, investment in affordable housing may actually contribute to an increase in the prices of commercial housing [53]. Yu et al. (2015) utilized panel data from 11 cities in Zhejiang Province, covering the period of 2003 to 2012, and found that, with the exception of a few cities, the crowding out effect of affordable housing on commercial residential housing in this region was not significant [54].

The market impact of China's affordable housing policy can provide a valuable reference for other countries that are currently experiencing rapid urbanization and large-scale affordable housing construction. This study aims to contribute to the literature on the impact of the affordable housing policy on the commodity housing market as follows: Firstly, this study not only investigates the effect of affordable housing on commodity housing prices but also focuses on the role of the population size of the local market, which offers an innovative explanation for the non-linear relationship between affordable housing land and urban housing prices. The scope of the study is extended from the existence of market effects to the effect of variations between cities. Secondly, instead of using the traditional geographical zones used by most studies to divide the sample groups and perform a regression analysis, we employ a threshold regression model that allows for the endogenous determination of the sample partition criteria, resulting in a more objective and impartial approach. Thirdly, this study analyzes the mediation effect of the commercial housing demand and residential land supply and tests the working mechanism of the

affordable housing market effect with panel data from 284 Chinese cities, so as to provide a stronger basis for housing policymaking.

3. Data and Model Specification

3.1. Overview of Data

There are three main sources of data considered in this study. The average housing prices in prefecture-level cities were obtained from “Anjuke”, which is one of the major city-level online housing listing platforms in China. The average housing price in each city is posted on the website (<https://www.anjuke.com/fangjia/> (accessed on 1 August 2022)) based on the previous year’s real estate transaction information. Data on the commercial housing land supply, the affordable housing land supply, and land prices were obtained from the China Land Market Network (CLMN), which was founded and launched by the Natural Resources and Real Estate Registration Center in October 2003. It is a platform for the provision of national land transaction information, and it is the most comprehensive information source regarding land transactions, including land areas, lease prices, and land use types. Among the control variables, the gross domestic product, the average salary of employees on duty, and the urban population were derived from the *China Urban Statistical Yearbook*, which is an annual publication that provides comprehensive statistics on urban development and management in China. The sales areas of commodity housing were obtained from the CEIC database, and the population density was obtained from the WorldPop website.

Based on the data of the CLMN, this study constructed the panel data of 284 cities, covering the period of 2009 to 2020. In China, according to the administrative division codes released on the website of the Ministry of Civil Affairs of the People’s Republic of China (<https://www.mca.gov.cn/mzsj/xzqh/2020/20201201.html> (accessed on 1 November 2022)), there were 297 prefecture-level cities as of 2020, excluding those in Hong Kong, Macao, and Taiwan. Among them, six cities are located in the Tibet Autonomous Region; there are data only covering 2016 to 2018 for five of these cities in the *China Urban Statistical Yearbook*, while there are no data for the other city regarding commodity housing sales and the average wages of urban workers. Thus, the cities in the Tibet Autonomous Region were removed from the database. Seven other cities were merged into or separated from others due to administrative adjustments that occurred between 2009 and 2020, resulting in incoherent city data; thus, they were also removed from the database.

The dependent variable was the logged house price (lnHP), denoted by the average house price of each city in the Anjuke database. The missing data were filled in by using the linear interpolation method. Linear interpolation assumes a linear relationship between the data points. It is a straightforward method for the estimation of values between two known data points, but it has several potential limitations and biases that can affect its accuracy and reliability. Firstly, it is sensitive to outliers. A single outlier can significantly influence the interpolated curve, leading to biased results. Secondly, it is not suitable for datasets with rapid changes or discontinuities. The method smooths out these changes, potentially leading to inaccuracies in representing the true data pattern. Thirdly, the results of linear interpolation can be influenced by the values at the end points of the interpolation range. If the end points are extreme or unusual, they can bias the interpolation. In summary, linear interpolation is best suited for relatively flat or smoothly varying data. The literature on housing shows that house prices are consistent over time [55,56]; the use of the average values of the adjacent years to replace missing values works well when there is a small number of missing data (96 out of 3408). The main independent variable is the scale of the land supply for affordable housing (lnAFF), which is the sum of land designated for ESH, RPH, and CRH construction in each city.

Control variables representing urban characteristics are included in the model based on theoretical reasoning and previous empirical work. The demand-side factors encompass variables such as GDP, the wage level of urban workers, the size of the urban population, and the population density. Gross Regional Product (lnGDP) is used to represent the

general level of macroeconomic development of the city and is closely related to the average housing prices [57]. The wage of urban workers (lnWAGE) is used as a proxy for the buying power of a city. The wage increase brought about by urban economic growth increases the housing price through the demand effect. The wage data used in this study were obtained by dividing the total wages of employees on the job by the average number of employees on the job in the *China Urban Statistical Yearbook* over the studied years. Urban population (lnPOP) and population density (lnPDENSE) are used to capture the housing demand in a city. Population agglomeration will bring about a large housing demand, thus increasing the housing prices. It is widely believed that cities expand in conformity with the law of proportional effect, which is also referred to as the rank-size rule or Gibrat's law [58,59]. Since the annual provincial population figures are readily accessible, the missing data for the urban population can be estimated by multiplying the average proportion of the urban population within the provincial total over the past three years by the current provincial population count. The supply scale of commercial residential land serves as a supply-side factor in the mediating model. A constrained supply of land will lead to a decrease in the availability of housing, which in turn will likely result in an increase in housing prices [60,61]. The production cost of housing is represented by the commercial residential land leasing price (lnLLP). Several studies have found that the price of urban residential land accounts for a large part of the housing cost, and the land supply situation has a direct impact on the housing price [62,63]. The leasing price of commercial residential land is calculated from the residential land leasing revenue and the total leasing area after excluding the affordable housing land. The data of residential leasing revenue and total residential land within a city were obtained from the CLMN by adding up leasing revenue and land area of each transaction. To eliminate the impact of dimensionality and heteroscedasticity, the model fitting process incorporates logarithmic transformations for all continuous variables. By compressing the range of values of a variable and making the data more consistent across the range, logarithmic transformations can help to stabilize the variance and make the data more suitable for regression analysis. The descriptive statistics are shown in Table 1.

Table 1. Definitions and descriptive statistics of variables.

Variable	Description	N	sd	Mean	Min	Max
lnHP	Logged average housing price	3408	0.486	8.601	7.474	11.03
lnLAFF	Logged and lagged affordable housing land	3408	3.879	2.246	−11.51	7.168
lnGDP	Logged urban GDP	3408	1.196	6.413	3.243	10.56
lnWAGE	Logged average wage of urban workers on the job	3408	0.392	10.86	9.451	13.26
lnPOP	Logged urban population	3408	0.705	5.868	3.049	8.074
lnPDENSE	Logged urban population density	3408	0.966	5.770	1.891	8.942
lnLLP	Logged and lagged average residential land price	3408	0.937	7.563	3.233	11.74

3.2. Model Specification

3.2.1. Baseline Regression Model

First, we estimated the housing price as a function of the affordable housing land supply and the above-mentioned control variables; the model is as follows:

$$\ln\text{HP}_{it} = a_0 + a_i + a_1 \ln\text{AFF}_{it-2} + a_2 Z_{it} + \varepsilon_{it} \quad (1)$$

where i is the city, t is each year from 2009 to 2020, and $\ln\text{HP}_{it}$ is a proxy for the average price of commodity housing in city i at time t in logarithmic form. $\ln\text{AFF}_{it-2}$ is the main explanatory variable in this model. According to the relevant literature (Zou et al., 2021), we calculated the construction period of affordable housing by subtracting the time of contract signing from the agreed completion time. Thus, the average construction period of

affordable housing is 26–30 months, based on data from the China Land Market Network. Considering that affordable housing projects can apply for sales licenses after obtaining a construction permit in many cities, it is believed that there is an approximately two-year lag from the signing of the land leasing contract to the sale of affordable housing. In other words, the affordable housing that is built is assumed to enter the housing market two years after its leasing contract is signed, thus impacting the housing prices in the market. Therefore, the data on affordable housing land, used to estimate the model, are lagged by two years. One benefit of this approach is that it reduces the possibility of housing prices influencing the supply of affordable housing land in reverse. Z_{it} represents a series of control variables that capture city characteristics, with specific explanations provided in the previous section. a_0 is the intercept term, a_i captures city-fixed effects, and a_2 denotes the coefficients to be estimated, corresponding to the impact of the control variables on the dependent variable. ε_{it} is a random disturbance term.

3.2.2. Generalized Method of Moments Model

Since there is a dynamic inter-period influence in housing price data [64], the lagged housing price was used as the endogenous instrumental variable. In order to overcome the endogeneity of variables and the heteroscedasticity problem of residual differences, the systematic GMM method, developed by Arellano and Bond (1991) and Arellano and Bover (1995), was used to estimate the relationship between affordable housing land and housing prices [65,66]. The dynamic panel model is as follows:

$$\ln HP_{it} = b_1 \ln HP_{it-1} + b_2 \ln AFF_{it-2} + b_3 Z_{it} + \lambda_{it} + \mu_{it} \quad (2)$$

where λ_{it} is the unobservable city-fixed effect and μ_{it} is a random disturbance term. The necessary conditions for the effectiveness of systematic GMM estimation are that the tool variable must be valid and the residual difference term must have no sequence correlation. Therefore, Hansen statistics were used to test the reliability of the tool variables, and Arellano–Bond statistics were used to test whether the model had sequence correlations.

3.2.3. Threshold Regression Model

In the extant literature, there is no consistent conclusion on the relationship between the supply of affordable housing and the urban real estate market. Sinai and Waldfohal (2005) pointed out that the impact of housing subsidies on local housing consumption depends on regional characteristics such as the housing burden and the scale of population mobility. Artificially creating gradients and incorporating interaction or quadratic terms for explanatory variables are frequent approaches for conducting group heterogeneity analyses. However, many of these methods have drawbacks, including varying criteria for variable grouping, subjectivity, and ambiguous interpretability. To tackle these concerns, we used the threshold regression model, which chooses the quantity and values of thresholds in an "endogenous" manner, to study the possible asymmetric effects of the affordable housing supply on housing prices in different types of cities. Cities with different population sizes have housing markets with different characteristics; for example, in large cities, the average living space is relatively smaller and the housing vacancy rate is lower [67]. We used urban population as a threshold variable to capture the housing characteristics of a city. The threshold regression estimation method developed by Hansen (1999) was used to set up a threshold model as follows:

$$\ln HP_{it} = \alpha_i + I(\ln POP_{it} \leq \gamma_1) \ln AFF_{it-2} \beta_1 + I(\ln POP_{it} > \gamma_1) \ln AFF_{it-2} \beta_2 + Z_{it} \delta + \varepsilon_{it} \quad (3)$$

where the indication function is $I(\cdot)$.

$$I(q_{it} \leq \gamma_1) = \begin{cases} 1 & \text{if } q_{it} \leq \gamma_1 \\ 0 & \text{if } q_{it} > \gamma_1 \end{cases} ; I(q_{it} > \gamma_1) = \begin{cases} 0 & \text{if } q_{it} \leq \gamma_1 \\ 1 & \text{if } q_{it} > \gamma_1 \end{cases} \quad (4)$$

where $\ln\text{HP}_{it}$ is the dependent variable, $\ln\text{AFF}_{it-2}$ is the independent variable, $\ln\text{POP}_{it}$ is the threshold variable, and γ is the estimated threshold parameter, which was obtained by using STATA 14.0 during the process of establishing the threshold model for the panel data.

3.2.4. Mediating Effect Model

Lastly, we used mediation analysis to investigate the channels by which the affordable housing land supply affects housing prices. Mediation analysis aims to delve deeper into understanding the mechanism through which an independent variable influences a dependent variable. This type of analysis is used to determine whether a variable (the mediator) helps to explain the relationship between another variable (the independent variable—in this case, affordable housing land supply) and a third variable (the dependent variable—in this case, average housing price). A two-step procedure is used to test the mediation effect, and the model is as follows:

$$\text{Mediator}_{it} = c_0 + c_1 \ln\text{AFF}_{it-2} + c_2 Z_{it} + \lambda_{it} + \mu_{it} \quad (5)$$

$$\ln\text{HP}_{it} = d_0 + d_1 \text{Mediator}_{it} + d_2 \ln\text{aff}_{it-2} + d_3 Z_{it} + \lambda_{it} + \mu_{it} \quad (6)$$

where Mediator_{it} is the mediating variable, which represents the urban commodity housing land supply ($\ln\text{NONAFF}_{it}$) and the commodity housing sales area ($\ln\text{COMH}$) in terms of the land crowding out effect and the demand diversion effect, respectively. In line with Baron and Kenny (1986), Mackinnon (2007), and Wen et al. (2004), a_1 in Equation (1) is the total effect of the affordable housing land supply on housing prices; d_2 is the direct effect of the affordable housing land supply on housing prices; $c_1 d_1$ is the size of the mediation effect; and $c_1 d_1 / a_1$ is the percentage of the mediation effect in the total effect, used to reflect the importance of the mediating variables in the impact of the affordable housing land supply on housing prices. If a_1 , c_1 , and d_1 are all statistically significant, but d_2 is smaller than a_1 , this indicates that there is a partial mediation effect; if c_1 and d_1 are both statistically significant, but d_2 is not significant, there is a full mediation effect [68–70].

4. Results

4.1. Baseline Regression Results and Robustness Test

In order to test for multicollinearity, the Variance Inflation Factor (VIF) was constructed before estimating the model. The VIF values of each variable were between 1.09 and 2.43, and the mean of the VIFs was 1.62. In general, a model does not exhibit multicollinearity when the maximum VIF value is no greater than 10. Therefore, it can be determined that the model does not exhibit serious multicollinearity problems.

Then, ordinary least squares (OLS), fixed effects, and random effects regression analyses were conducted on the variables. The Hausman test results indicate that the null hypothesis of random effects can be rejected; thus, only the OLS and fixed effects results are reported here. The estimated results are shown in columns (1)–(2) of Table 2. By controlling for other influencing factors, the estimated coefficients for the two lagged periods of the affordable housing land area in columns (1)–(2) were found to be both significantly negative at the 1% level, indicating that an increase in the supply of affordable housing land will have a negative impact on the average urban house price two years later. By replacing the main explanatory variable with the logarithm of the per capita area of affordable housing land ($\ln\text{LAFFPP}$), a robustness test was conducted on the original model. The result is shown in column (3). The estimated coefficient was -0.009 , which was still significantly negative at the 1% level.

Column (4) lists the GMM estimation results. The parameter results show that the p -value of AR (1) was less than 0.001, and the p -value of AR (2) was greater than 0.1, while the p -value of the Hansen test was 0.111, which is greater than 0.1, indicating that the instrumental variables passed the Hansen test and the empirical estimation results are valid. In the GMM model, the coefficient of affordable housing land supply was significant

at the 1% level, and it was also negative; thus, taking the dynamic nature of housing prices into consideration, the estimated results are still robust.

Table 2. Baseline estimation results and robustness tests.

Variable	(1) lnHP	(2) lnHP	(3) lnHP	(4) lnHP
lnLHP				0.569 *** (0.056)
lnLAFF	−0.005 *** (−2.71)	−0.005 *** (−5.99)		−0.030 *** (0.005)
lnLAFFPP			−0.009 *** (−7.15)	
lnLLP	0.079 *** (5.90)	0.045 *** (6.91)	0.046 *** (7.10)	0.016 (0.017)
lnWAGE	0.374 *** (9.95)	0.395 *** (26.36)	0.394 *** (26.35)	0.138 (0.093)
lnGDP	0.149 *** (11.07)	0.151 *** (11.95)	0.154 *** (12.21)	0.117 (0.084)
lnPOP	0.030 (0.96)	0.014 (0.30)	0.007 (0.15)	0.369 ** (0.151)
lnPDENSE	0.069 *** (2.64)	0.543 *** (7.08)	0.529 *** (6.91)	−0.236 (0.231)
Constant	2.448 *** (6.96)	−0.190 (−0.47)	−0.128 (−0.32)	0.649 (0.959)
Observations	3408	3408	3408	3405
R-squared		0.694	0.696	
Number of id	284	284	284	284
ar1p				0
ar2p				0.315
Hansenp				0.111

Robust z-statistics in parentheses; *** $p < 0.01$ and ** $p < 0.05$

4.2. Threshold Effect Test and Results

By using 284 cities at the prefecture level and above, covering the period of 2009 to 2018, and based on Hansen's (1999) panel threshold regression model [71], model estimations were obtained under the assumptions of no threshold, only one threshold, two thresholds, and three thresholds. The bootstrap method was employed to draw samples 500 times to obtain the p -values of the test statistics, in order to determine whether there was a threshold effect. According to the test results presented in Table 3, the model passed the significance test under the assumption of a single threshold. This single-threshold parameter divides the size of the urban population into two intervals, indicating that the influence coefficient of the affordable housing supply on the housing price was significantly different in cities with different population sizes.

Table 3. Results of threshold effect test and threshold value estimation.

Model	BS-reps	Fstat	Threshold	Lower	Upper
Single	500	20.76 **	6.9828	6.9626	7.0312

** $p < 0.05$.

In accordance with Equation (3), the data were subjected to a regression analysis, and related robustness tests were conducted. The regression results are shown in Table 4. Model (1) represents the panel threshold regression results with the lagged natural logarithm of affordable housing land as the main explanatory variable and the natural logarithm of housing prices as the dependent variable. Model (2) represents the estimation results based on the clustered robust standard deviation method for data from Model (1), serving to eliminate heteroscedasticity. Meanwhile, to avoid the impact of extreme values on the model coefficients, Model (3) represents the panel threshold regression results after the 1% winsorizing treatment of all variables.

As can be seen from the regression results listed in Table 4, the coefficients of each variable in the three panel threshold models presented in columns (1)–(3) are similar. Most of them were significant at the 1% level, which indicates, to some extent, that the model devised in this study is relatively stable and the research conclusion is also reliable. Here, mainly based on Model (1), the impact of the affordable housing land supply on housing prices is analyzed. As can be seen from the estimation results of Model (1), the impact of the land scale of affordable housing on the urban commercial housing price is significantly different when the size of the urban resident population changes, while the housing price

and the city with the large resident population increase the housing price. In the model, the threshold value was 6.9828, i.e., when the urban population size is less than 10.78 million, the impact of the scale of affordable housing land on the housing price is negative and significant at the level of 1%. This shows that when the size of the urban population is within this threshold, the affordable housing supply restrains the city's housing prices. When the urban population size is greater than 10.78 million, the coefficient of the scale of land for affordable housing is positive and significant at the level of 1%, indicating that when the size of the permanent resident population is within this range, the supply of affordable housing increases the housing price.

Table 4. Threshold regression results.

Variable	(1)	(2)	(3)
	lnHP	lnHP	lnHP
lnLLP	0.044 *** (6.78)	0.044 *** (4.59)	0.037 *** (4.40)
lnGDP	0.149 *** (11.81)	0.149 *** (5.31)	0.127 *** (5.60)
lnPOP	−0.010 (−0.22)	−0.010 (−0.16)	0.002 (0.04)
lnWAGE	0.396 *** (26.52)	0.396 *** (10.49)	0.434 *** (15.48)
lnPDENSE	0.507 *** (6.60)	0.507 ** (2.55)	0.248 * (1.70)
lnLAFF-I(lnPOP ≤ 6.9828)	−0.005 *** (−6.20)	−0.005 *** (−5.11)	−0.005 *** (−5.14)
lnLAFF-I(lnPOP > 6.9828)	0.020 *** (3.75)	0.020 ** (2.39)	0.021 ** (2.37)
Constant	0.154(0.38)	0.154 (0.15)	1.353 * (1.79)
Observations	3408	3408	3408
R-squared	0.696	0.696	0.704
Number of id	284	284	284

t-Statistics in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Why does the impact of the affordable housing land supply on house prices vary positively and negatively across cities of varying population sizes? To answer this question, the sample was divided into two groups according to the above population size threshold. There were 113 data denoting populations greater than 10.78 million and 3295 data denoting populations less than 10.78 million. Table 5 presents the data statistics of the full sample, the sample of the cities below the threshold, and the sample of the cities above the threshold. It can be seen that the cities that were below the threshold had an average population size that was lower than the national average, with an average net outflow of population and a salary level slightly lower than the average of the full sample. The average per capita supply of commercial housing land was slightly higher. However, the cities that were above the threshold had an average population of over 10 million, were primarily net inflow cities, and had an average wage level for on-the-job employees that was far higher than the average of the full sample, while the per capita area of the commercial housing supply was lower than the average of the full sample. In other words, the cities that were above the threshold had a strong demand for housing but a relatively insufficient supply of urban residential land. Based on the land supply system and the theoretical analysis presented earlier, it can be reasonably inferred that increasing the supply of affordable housing land in cities with a tight residential land supply may restrict the supply of commercial housing land, leading to a reduction in the amount of developable residential land, thus driving up housing prices.

Table 5. Summary statistics of subsamples.

Variable	All Cities (3408 Observations)			Lower Regime (3295 Observations)			High Regime (113 Observations)		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
POP	449	21	3209	405	21	1078	1735	1078	3209
Migrant	0.23	−418.50	1211.00	−13.74	−354.51	827.22	407.55	−418.45	1211.12
WAGE	56,121	12,721	576,545	55,169	12,721	576,545	83,877	28,084	196,567
lnNONAFFPP	0.65	0.00	11.44	0.66	0.00	11.44	0.52	0.03	2.11

4.3. Results of Mediation Analysis and Robustness Test

To investigate the mechanisms by which the affordable housing land supply impacts housing prices, mediation effect models were constructed and analyzed. Table 6 reports the results of the mediation analysis. The mediation effect of commodity housing land was significant in both sample groups. Columns (1)–(2) and (5)–(6) show the mediation effect model results for commercial housing land in the two sets of cities. The regression coefficients of the affordable housing land in columns (1) and (5) were significantly negative against the commodity housing land in the same period, and the regression coefficients of the two-period-lagged commodity housing land on the housing price were also significantly negative. This indicates that the supply of affordable housing land crowds out the supply of commercial housing land in the same period, thereby leading to an increase in housing prices in both sets of cities. In cities with a population of less than 10.78 million, the mediation effect of land crowding out accounted for 14.4% of the total effect. In cities with a population of more than 10.78 million, the regression coefficient of the affordable housing land on housing prices was not significant after adding the mediating variable of housing land into the model, indicating that, in this sample, the land crowding out effect constitutes a complete mediation effect. The crowding out effect of commodity housing land confirms that the construction of affordable housing consumes a fraction of the resources intended for commercial housing [46]. Under the premise that the total amount of construction land in China is fixed within a certain period, land is a crucial resource in residential construction that cannot be replaced by capital. Reducing the quantity of the land supply decreases the elasticity of the housing supply, thereby leading to an increase in housing prices [72].

Table 6. Regression results of mediating analysis.

Mediator Variable	Cities with Urban Population < 10.78 Million				Cities with Urban Population > 10.78 Million			
	Housing Land		Housing Demand		Housing Land		Housing Demand	
	lnLNONAFF (1)	lnHP (2)	lnCOMH (3)	lnHP (4)	lnLNONAFF (5)	lnHP (6)	lnCOMH (7)	lnHP (8)
lnLAFF	−0.027 *** (−12.04)	−0.002 *** (−3.30)	−0.008 ** (−2.44)	−0.002 *** (−2.77)	−0.028 *** (−2.95)	−0.007 (−0.33)	0.020 (0.40)	0.004 (0.20)
lnLNONAFF		−0.016 *** (−5.74)				−0.075 * (−1.99)		
lnCOMH				0.06 *** (2.81)				−0.027 (−0.68)
Constant	3.095 *** (2.67)	0.591 (1.62)	−4.023 ** (−2.05)	−0.667 * (−1.88)	2.993 (1.20)	−0.563 (−0.22)	5.742 (0.87)	−3.204 (−1.29)
Control variables	YES	YES	YES	YES	YES	YES	YES	YES
Observations	3295	3016	2980	2991	113	96	93	94
R-squared	0.739	0.800	0.646	0.809	0.887	0.888	0.432	0.878
Number of id	278	278	278	278	16	14	13	14

t-Statistics in parentheses; *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Columns (3)–(4) and columns (7)–(8) show the mediation effect model results for the housing demand in the two sets of cities. The mediation effect for the housing demand was significant only in the group with a smaller population size. In column (3), the regression coefficient of the two-period-lagged affordable housing land on the housing demand was significantly negative, indicating that the construction of affordable housing has diverted a portion of the demand for housing among urban residents, thereby reducing the demand for commodity housing. In column (4), the regression coefficient of the housing demand on housing prices was significantly positive, indicating that the demand was positively correlated with the housing price, which is in line with the expected impact of the supply and demand relationship on price. The results suggest that in cities with a population of less than 10.78 million, the construction of affordable housing had a negative impact on housing prices by diverting the demand for commercial housing. The mediation effect of this diversion accounted for 16% of the total effect, indicating that, in this subset of cities, the mediation effect of the housing demand diversion was slightly greater than the mediation effect of land crowding out, and the combined effect aligns with the negative

impact of affordable housing land on the average housing price. However, in the sample of cities with a population greater than 10.78 million, it can be seen from the regression results in column (7) that the regression coefficient of the affordable housing land on the housing demand was not significant, indicating that affordable housing could not satisfy the demand of urban residents for commercial housing. On the one hand, this may be due to the high demand for housing in populous cities themselves, where the supply fails to satisfy the demand [67]. The construction of affordable housing satisfies the unmet demand for housing, thus not affecting the sales volume of commercial housing. On the other hand, there is a problem associated with the location of affordable housing in remote areas, which is particularly prominent in large cities [73,74]. The inconvenience of the spatial location makes it difficult for affordable housing to provide an effective substitute for ordinary commercial housing.

The bias-corrected percentile bootstrap CI method was used to test the robustness of the mediation analysis. The bootstrap technique is a valuable tool for estimating and assessing the significance of direct and indirect effects in statistical analysis and is particularly useful when dealing with non-normal distribution of mediator variables. Bootstrap methods provide an empirical approach to establish the statistical significance of the estimated effects. Shrout and Bolger suggest that researchers should present the 95% confidence interval (CI) for the median indirect effect derived from bootstrap resampling [75]. If this confidence interval excludes the zero value, it indicates that the indirect effect is statistically significant at the 0.05 significance level. First, 500 samples were generated from the original dataset by using random sampling with replacement. Second, Model (5) and (6) were tested using these 500 samples, yielding 500 estimates of each path coefficient. Last, the results from these 500 estimates of path coefficient were utilized to compute the estimates of the indirect effect of commercial housing land or housing demand. The results of bootstrap analysis are shown in Table 7. It can be seen that the mediation effects of commercial housing land were statistically significant in both sets of samples, but the mediation effects of housing demand was only statistically significant in cities with urban population less than 10.78 million, which is consistent with the regression results of the mediating analysis. Therefore, the mediation analysis is robust.

Table 7. Bootstrap analysis of the significance of indirect effects.

	Independent Variable	Mediator Variable	Dependent Variable	Indirect Effect	95% CI (Lower and Upper)
Cities with urban population < 10.78 Million	lnLAFF	lnLNONAFF	lnHP	0.0008	0.0004, 0.0015
	lnLAFF	lnCOMH	lnHP	−0.019	−0.0669, −0.0036
Cities with urban population > 10.78 Million	lnLAFF	lnLNONAFF	lnHP	0.0489	0.0207, 0.1086
	lnLAFF	lnCOMH	lnHP	0.0001	−0.0002, 0.0003

CI = confidence interval.

5. Discussion and Conclusions

China serves as a valuable case in contributing to theories on affordable housing policy that extend beyond the contexts of capitalist market economies, particularly when considering the coexistence of state regulations and market forces. As a supply-side policy, affordable housing in China is implemented and supported by the government, which provides construction land and partial financial support. The impact of the affordable housing policy on the commodity housing market is mainly exerted through the construction land supply, which is very different from that effects of housing policies such as tax incentives. While the displacement of private rental housing construction as a result of the LIHTC program is substantial [45], the crowding out of commercial land due to affordable housing supply is comparatively minor. And the influence of the crowding out on housing prices could be mitigated by the demand diversion effects of affordable housing. Moreover, the variability of the housing market conditions offers the opportunity to explore the working mechanisms of the housing policy's effects in cities with different real estate market charac-

teristics. In this study, we sought to extend the previous literature on the Chinese housing policy by examining the between-city variability in affordable housing's market effects in cities with different population sizes. Firstly, our findings confirm that the supply of affordable housing land has a certain positive effect on controlling the increase in housing prices two years later. Secondly, we find that housing prices show an asymmetric response to the supply scale of affordable housing land under housing markets with different population sizes. The relationship between the supply of land for affordable housing and housing prices exhibits a single-threshold effect that correlates with the size of the city's population. Additionally, the mechanisms by which affordable housing land affects cities of varying sizes differ significantly. These findings indicate that the consideration of the variations between cities is crucial when formulating and implementing affordable housing policies.

From a policy perspective, it has been observed that in order to ensure access to affordable housing and to direct the housing market towards the preferred state, future affordable housing development and construction land allocation plans need to tackle the challenges of the differing dynamics between affordable and market-priced housing in various urban settings. Since 2003, China's land supply policies have been characterized by "supporting the central and western regions and restricting large cities" [26]. As a result, the increments in residential land in coastal and large cities have been quite limited. The promise of better job prospects, superior infrastructure and amenities, and various economic and social advantages offered by major cities prove to be a significant source of attraction for individuals who wish to relocate. As a result of this migration, an increase in the demand for housing and in housing prices is anticipated. Given the results of this study, the construction of affordable housing in these cities will consume commodity housing land and further increase housing prices. This, in turn, will exacerbate the issue of housing affordability in cities. By contrast, affordable housing constructed in smaller cities will compete with market-priced housing for the demand, which will worsen the situation in cities where there is oversupply of housing.

The varying market effects of affordable housing across cities of different population sizes will significantly influence China's urbanization process and the structure of its urban systems in the coming years. The continuous increase in housing prices will not only increase the living costs of urban residents and restrict household consumption [76] but also increase labor costs and damage urban competitiveness [61]. Concurrently, if housing prices escalate faster than wage growth, it will be increasingly challenging for individuals to purchase homes, leading to an increased demand for affordable housing and a desire to move away from large cities. After 2010, the population growth in supercities, namely Beijing, Shanghai, Guangzhou, and Shenzhen, dropped sharply due to soaring housing prices [77]. If large cities wish to maintain their status and attract and retain human capital, it is essential for them to promote supply-side structural reforms to change the current supply strategies for affordable housing land and to adjust the allocation structure of affordable housing.

Our findings offer practical policy suggestions. While increasing investment in affordable housing programs, policymakers should pay close attention regional disparities. Firstly, in supercities with a population size greater than 10 million, it is crucial to prevent the construction of affordable housing from occupying too much commercial residential land. It would be beneficial to take advantage of existing developed land and empty plots for the purpose of building affordable housing. Moreover, it is essential to develop policies that optimize the use of land resources in the construction of new affordable housing. While there is a standardized national criterion for the floor area of affordable housing, the floor area of affordable housing should be adjusted based on the average per capita housing space of local residents in supercities, thereby increasing the quantity of affordable housing that can be provided per unit of land. This will help to alleviate the crowding out effect of affordable housing on commodity housing. Secondly, in smaller cities, it is shown in this study that the supply of affordable housing can divert the housing demand from the commodity housing market in these cities, which might cause housing surplus and

waste of resources. It is recommended that the local government acquire vacant residential properties to serve as affordable housing, thereby reducing the time it takes to provide these accommodations and addressing the excess housing inventory in smaller and mid-sized cities. Lastly, policymakers should evaluate the performance of the affordable housing policy regularly. Although there have been studies examining resident satisfaction and the affordability of affordable housing, there is no comprehensive report available that covers all these aspects. The fluctuations in the housing market and shifts in social needs necessitate a comprehensive review and revision of these policies every few years to ensure their relevance and to effectively address the current challenges.

In this study, we examined the impact of affordable housing land supply on housing prices, the variation in these impacts across cities, and the underlying mechanisms that drive these effects. It is crucial to note that there may be other factors that could explain the market effect variations. In addition to differences in urban real estate market characteristics, there are also local discrepancies in the implementation of affordable housing policies, which can also contribute to variations in the market effects. For example, do the influences on the housing market differ between economic and suitable housing (ESH) and public rental housing (PRH)? Furthermore, do cities with varying amounts of land allocated for ESH (economic/suitable housing) and PRH (public rental housing) experience distinct market impacts? We call for further research on the heterogeneous market effects of affordable housing within and between cities. China is currently planning to launch a new round of affordable housing construction and implement differentiated affordable housing policies in cities. Studies on affordable housing's market effect and its variations between cities are especially valuable for efficient and effective housing policy formulation and implementation in China.

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