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Effect of land prices on the spatial differentiation of housing prices:
Evidence from cross-county analyses in China

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Abstract: This study analyzes the spatial patterns and driving forces of housing prices in China using a 2,872-county dataset of housing prices in 2014. Multiple theoretical perspectives on housing demand, supply, and market, are combined to establish a housing price model to explore the impact of land prices on housing prices. The relative impacts of land prices on housing prices at different administrative levels are then analyzed using the geographical detector technique. Finally, the influencing mechanism of land prices on housing prices is discussed. The main conclusions are as follows. (1) Housing prices have a pyramid-ranked distribution in China, where higher housing prices are linked to smaller urban populations. (2) Land prices are the primary driver of housing prices, and their impacts on housing prices vary over different administrative levels. To be specific, the effect of land prices is the strongest in the urban districts of provincial capital cities. (3) The internal influence mechanisms for land prices driving housing prices are: topographic factors, urban construction level, the agglomeration degree of high-quality public service resources, and the tertiary industrial development level. The urban land supply plan (supply policies) is the intrinsic driver that determines land prices in cities; through supply and demand, cost, and market mechanisms, land prices then impact housing prices.

Keywords: housing prices; land prices; influencing factors; spatial differentiation; county unit; China

1 Introduction

Since the economic reform, China has generated a spectacular economic growth with an annual growth rate of more than 9% (Wang *et al*., 2014a, 2014b; Wang *et al*., 2015). However, China also faces serious challenges arising from imbalanced housing prices. Housing

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prices generally vary spatially at the national or regional scale (Kim and Bhattacharya, 2009; Kuethe and Pede, 2010), and this observation had been the focus of human geography and regional economic research. In China, since the implementation of housing system reform in 1998, housing prices have risen rapidly and show increasingly significant spatial differences in regions and cities (Shih *et al*., 2014; Chen *et al*., 2011; Zhang *et al*., 2015). Furthermore, new patterns and trends in the regional real-estate market are gradually emerging (Wang *et al*., 2015), which are manifested as inter-provincial differences and inter-urban differences (Shih *et al*., 2014; Wang *et al*., 2013). Uneven housing prices have affected the habitation decisions of urbanized immigrants in China and have become a key factor determining the flow of labor in the region (Zhang *et al*., 2015; Wang *et al*., 2016a, 2016b).

Significant inequality in domestic housing prices has several causes. Supply and demand and cost theories are the two most commonly accepted analytical perspectives (Fortura and Kushner, 1986). Regional land prices are a significant factor determining housing prices in the region. From the perspective of housing supply, the shortage of land supply will reduce the housing supply (Bramley, 1993; Quigley and Rosenthal, 2005; Green *et al*., 2016), and promote a corresponding increase in housing prices (Peng and Wheaton, 1994; Ihlanfeldt, 2007; Zabel and Dalton, 2011). From the housing cost perspective, as the most important component of housing cost, land prices are bound to influence housing prices (Wen and Goodman, 2013). Therefore, land prices can either reflect the supply of housing in the region or directly determine the cost of housing, which drives housing prices in terms of the housing supply and costs. Using the annual housing survey data from 58 U.S. metropolitan areas (MSA) from 1974 to 1983, Potepan (1996) quantified the impact of land prices on housing prices. After establishing simultaneous equations for housing prices, land prices and rent, the elasticity of housing prices to land prices was estimated as 0.32. Compared to the cost of housing construction, government regulation, and other factors in the U.S., Glaeser *et al*. (2003) found that land restrictions and consequent land costs are the primary drivers of high housing prices in Manhattan, New York. Using 21 provincial cities in China from 2000 to 2005 as sample data, Wen and Goodman (2013) found that housing price and land price have an endogenous interrelationship. Wang *et al*. (2017) examined the relationship between housing prices and their potential determinants. Their results showed that land prices can predominantly explain the spatial differences in housing prices at the county level in China. Using panel data from 45 research units for 2002–2012 in Israel, Rubin and Felsenstein (2017) found that land control is the core mechanism for land prices affecting housing prices. From the existing literature, it is apparent that land prices play a decisive role in determining housing prices.

In addition to land prices, many other factors also have an impact on disparate housing prices. From the perspective of housing demand, income and demographic variables are two significant determinants (Mankiw and Weil, 1989). Income affects the purchasing power for housing, which in turn determines housing demand (Holly *et al*., 2010). Population growth drives the growth of residential demand and further affects housing prices (Capozza and Schwann, 1989). Moreover, a city's economic structure has an influence on such indicators as income, population, unemployment rate, and vacancy rate, which affects housing prices through supply and demand mechanisms (Shen and Liu, 2004). From the perspective of housing supply, land supply and housing construction costs have a direct impact on housing

supply, which is reflected in housing prices (Holmes *et al*., 2011; Bischoff, 2012). The supply elasticity of housing will be limited by the affordability to buyers (Quigley and Swoboda, 2010), which is closely related to their income level. In addition, wage level can determine the cost of housing construction, which then affects housing supply. Based on the supply and demand framework, the impact of housing market environment on housing prices cannot be ignored (Smith, 1974; Malpezzi, 1996). Research has shown that the transactional friction in real-estate markets (Caplin and Leahy, 2011), market turnover, and proportion of the population working in the real-estate industry are key factors in determining housing prices (Ortalomagné and Rady, 2001; Hwang and Quigley, 2006). These demand, supply, and market factors, which are the key in differentiating regional housing prices, are used as control variables to analyze the impact of land prices on housing prices in this study.

The significant spatial variability in land prices in China inevitably results in corresponding differences in housing prices (Qin *et al*., 2016; Zhang *et al*., 2017). The existing literature that has addressed the impact of land prices on housing prices in China included the following research cases. The levels of income, construction costs, impending marriages, user costs, and land prices were concluded to be the primary determinants of housing prices in China's 29 provinces (Li and Chand, 2013). Housing prices and land prices in 21 provincial cities in China have an endogenous interrelationship (Wen and Goodman, 2013). Housing prices have risen more significantly in coastal China under the construction land use quota system (Liang *et al*., 2016); therefore, land policy drives differences in housing prices between the coastal and inland provinces of China (Han and Lu, 2017). The research units in these studies are province or city. However, refining the analysis unit can lead to more information and precise conclusions (Cohen *et al*., 2015). Counties, large in number and with significantly different characteristics, are the basic administrative unit in China. Therefore, more accurate conclusions could be drawn using the county as the basic unit to analyze the impact of China's land prices on the spatial variability in housing prices. In addition, there is notably regional inequality in China (Wang *et al*., 2012), which means that housing sub-market characteristics may differ across regions and administrative levels. Therefore, we can separately analyze the impact of land prices on housing prices in the regional housing sub-market and compare the differences between various regions, providing the basis for differentiating between policies regulating housing prices and real-estate market development.

This study uses China's 2,872 counties (county-level cities and districts) as the basic research units to analyze the spatial variation patterns in China's housing prices in 2014. We investigate the impact and magnitude of land prices on housing prices, and examine the different characteristics and mechanisms of influencing factors at different administrative levels by combining the theoretical perspectives of demand, supply, and market. This paper provides new research perspectives on research sample, supporting data, and driving forces. The basic unit of research includes almost all administrative units at the county level, which provides a detailed analysis. Housing prices are acquired from a large amount of actual listing data, which provides a realistic survey of the current housing status. The selected factors cover the main indicators from the perspective of housing supply, housing demand, and market environment. The extensive dataset provides a mechanism for investigating geographical differences in the influencing factors. Therefore, this paper provides a new empirical research reference for this field, and also has important academic significance.

2 Data and methodologies

2.1 Data description

This study takes 2872 county administrative units in China as the basic research units, including districts, county-level cities, banners, autonomous banners, and special districts, and excluding Hong Kong, Macao, and Taiwan. Housing prices data were obtained from the following three sources: "Xitai Data", "Haowu Data", and "58Tongcheng Data". "Xitai Data" is the national cities real-estate database, constructed by the Xitai Data Company, which is currently the largest online real-estate transaction database in China, covering 947 county-level units in 118 major prefecture-level cities with 113.3 million sets of housing data (http://www.cityre.cn/cityCenter.html). All housing data were obtained in May 2014, and the unit price of housing was automatically calculated by the database according to the monthly sales data. "Haowu Data" was collected from the network data platform (http://jia.haowu123.com/). Compared to "Xitai Data", the "Haowu Data" covers more counties, with 62.21 million sets of second-hand housing data. Therefore, the housing data from the 719 counties not covered by the "Xitai Data" was obtained from the "Haowu Data;" the collection period remained May 2014. The "58Tongcheng Data" was obtained by mining the artificial data from the "58Tongcheng" website (http://*.58.com/), which is currently one of China's most important real-estate information platforms, covering the most extensive geographical areas, including almost all of China's county units. Thereby, all the counties not covered by the "Xitai Data" and "Haowu Data" were acquired from the "58Tongcheng Data". The data mining method obtained the average housing prices in June 2014 for each county using the average price of the most recent 500 second-hand housing units sold. For counties with less than 500 units in the month, all the data for 2014 were used to calculate the average price. Given this method, we calculated the average real-estate prices for 1094 counties. In addition, there was limited real-estate transaction data for 112 counties, primarily located in the Qinghai-Tibet Plateau, which could skew the average housing prices not to reasonably reflect the true housing prices in this region. Therefore, these 112 counties were treated as "no data" areas in this study. The data source distribution is shown in Figure 1.

In terms of the distribution characteristics of the three data sources, the "Xitai Data" contains housing information for the coastal urban agglomerations and inland major urban agglomerations. The "Haowu Data" covers the secondary important districts in each province. The housing information for the remaining areas was obtained from the "58Tongcheng Data". The number of counties covered by the "Xitai Data," "Haowu Data," and "58Tong-

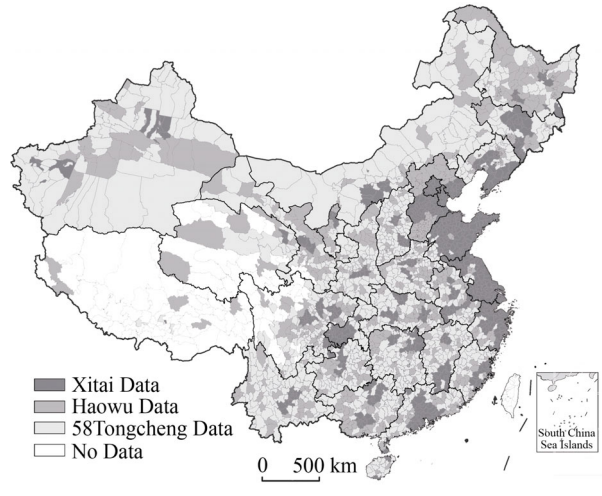

Figure 1 The spatial distribution of the three sources of housing price data in China

cheng Data" respectively accounted for 32.97%, 25.03%, and 38.09% of the total number of counties. The proportion of "no housing data" counties accounted for 3.90% of the total, and are concentrated in Tibet, Qinghai, western Sichuan, and southern Gansu. The three data mining sources employed reflect the following changing characteristics: amount of housing price data, ease of data acquisition, and activity in the real-estate market. Compared with statistics from the National Bureau of Statistics or local housing department, these data more accurately reflect the status of local housing prices. For example, the National Bureau of Statistics provides a price index, which is calculated through actual sales price statistics based on similar housing in similar areas for the sample. Moreover, the data released by local housing departments are the weighted average of monthly housing net prices, easily affected by structural changes in trading volume. Therefore, second-hand housing listing prices, based on large sample data, are more stable and representative.

Five socio-economic factors, the average cost of land, proportion of renters, floating population, average wage of urban employees, and the proportion of the population working in the real-estate industry were selected, to account for the spatial differences in housing prices in China. These data were collected from the Population Census of the People's Republic of China by County (2010), the China City Statistical Yearbook (2011), the China Statistical Yearbook of Land Resources (2011), the China Statistical Yearbook for the Regional Economy (2011), and the China County Statistical Yearbook (2011). All data were selected from 2010 because the Sixth National Population Census of China was conducted in that year, so they were most comprehensive. In addition, Zhang (2008) showed that the impact of housing demand, housing purchasing power, and land prices on housing prices tends to lag about three years. Therefore, it is reasonable and feasible to collect data from 2010 on the influencing factors for housing prices in 2014.

2.2 Methodologies

2.2.1 Kernel density estimation

Kernel density estimation captures the distribution shape information from housing prices while retaining its overall structure, avoiding the error caused by pre-specifying a particular distribution pattern, such as a normal distribution (Chen and Wang, 2011). Given this feature, the kernel density estimation was employed to estimate the overall distribution characteristics of housing prices. The formula can be expressed as follows (Wang *et al*., 2013):

$$f_n(x) = \frac{1}{nh_n} \sum_{i=1}^{n} k\left(\frac{x - x_i}{h_n}\right) \tag{1}$$

where $k\left(\frac{x - x_i}{h_n}\right)$ is the Gaussian Kernel function, n represents the number of counties, h_n is the bandwidth, and x refers to the county housing prices.

2.2.2 Multivariate linear regression model

The Multivariate Linear Regression Model has been widely used to analyze the factors influencing housing prices (Wang *et al*., 2017). The significance level for each factor in the model can be used as the criterion to identify the primary influencing factor (Wang *et al*., 2014). The general form of the multivariate linear regression model is provided as follows:

$$P = a_0 + a_1F_1 + a_2F_2 + \cdots + a_nF_n \quad (2)$$

where F_1, F_2,…, F_n are the various factors that affect housing prices, a_1, a_2,…, a_n denote the regression coefficients for each factor, P refers to housing prices, and a_0 is the intercept for all factors.

2.2.3 The geographical detector technique

The existence of several important determinants of housing prices necessitates using the geographical detector technique, first applied by Wang *et al.* (2010) to the study of the risk of endemic diseases and related geographical factors. The advantage of the geographical detector technique lies in the fewer constraints on assumptions (Hu *et al*., 2011). The core assumption in this method for exploring the strength of the influencing factors is that housing prices take on a spatial distribution consistent with the most significant factors. The power of the influencing factors $D=\{D_i\}$ on the housing prices effect U can be expressed as:

$$P_{D,U} = 1 - \frac{1}{n\sigma_U^2}\sum_{i=1}^{m} n_{D,i}\sigma_{U_{D,i}}^2 \quad (3)$$

where $P_{D,U}$ refers to the power of influencing factors D, m is the number of sub-regions, n represents the number of counties in the regions of the study area, $n_{D,i}$ denotes the number of counties in sub-regions, $\sigma^2{}_U$ stands for the variance in the housing prices in the regions of the study area, and $\sigma_{U_{D,i}}^2$ is the variance in the housing prices in the sub-regions. In general, $P_{D,U}$ takes values in the interval [0,1]. The value of $P_{D,U}$ tends to be 1, indicating that the U factor has a greater impact on housing prices.

3 Patterns of spatial variability in housing prices

Using cluster analysis and accounting for the principle of taking integers, the housing prices for all county-level units in China in 2014 were divided into six levels; from low to high, these are: 3000, 5000, 8000, 10,000, and 25,000 yuan/m^2. According to the classifications, counties were further divided into six categories: low price area (791), medium-low price area (1250), medium price area (464), medium-high price area (109), high price area (115), and extremely high price area (31). Figure 2 shows the spatial variability in housing prices according to the described classification method; the spatial pattern of housing prices has the dual characteristics of administrative level and spatial agglomeration. Generally, the administrative level is positively related with housing prices: higher prices are found at higher adminis-

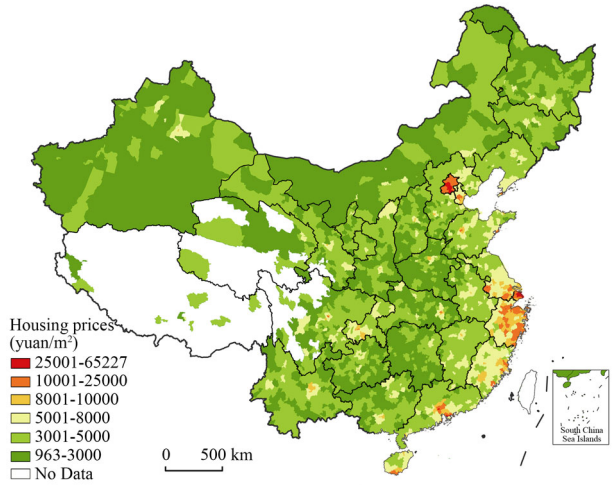

Figure 2 The pattern of spatial variability in housing prices in China

trative levels. Provincial capital cities maintain higher housing prices, followed by prefecture-level cities and counties, or county-level cities. Furthermore, high housing price areas tend to be concentrated in the three urban agglomerations in China's southeast coasts, i.e., the Pearl River Delta, Yangtze River Delta, and western coast of the Straits, and the Beijing–Tianjin region, whereas the medium-low housing price areas are mainly concentrated in inland regions.

According to the classifications of housing prices, the number of counties in each price range and the urban population in each region were calculated and the distribution of housing prices in China is depicted in Figure 3. In general, the number of administrative regions and urban population negatively correlated with housing prices, presenting a pyramid-shaped distribution. Housing prices have three dominant characteristics: the prices in high-level administrative cities are higher than in lower-level cities, prices in coastal cities are higher than in inland areas, and prices in the central area are higher than those in the peripheral areas. Moreover, the 146 high-price areas, with housing prices more than 10000 yuan/m^2, include a population of 117 million, accounting for 17.44% of the total urban population in China. In contrast, the 2041 areas with housing prices lower than 5000 yuan/m^2 account for 73.95% of the country's total population. Approximately 400 million urban residents live in those regions, accounting for 59.75% of the urban population in China. Therefore, the issue of high housing prices in China is a regional issue rather than a national one, both in terms of scope and population. However, cities and counties with high housing prices are often the political, economic, and cultural centers of the region, and also the major agglomeration points for migrants. Therefore, the social influence of the high housing prices cannot be ignored.

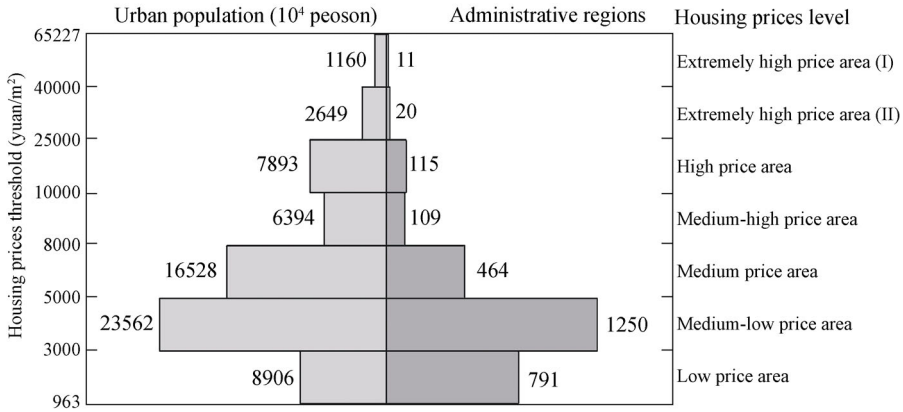

Figure 3 The pyramid-shaped distribution of housing prices in China

According to the kernel density estimate, the housing price distribution characteristics of capital cities, including municipality and sub-provincial cities; prefecture-level cities, including prefectures and counties, and cities where autonomous prefectures are located; and counties, including county-level cities, are illustrated in Figure 4. As shown, regions with higher administrative level host a wider price range, flatter distribution, and more significant absolute differentiation in housing prices. In contrast, the distribution curve for regions of

lower administrative level is sharper. The kernel density estimates for different administrative levels indicate that housing prices decrease from capital cities, to prefecture-level cities, and then to counties. Furthermore, each curve has a significant "long tail," revealing that each administrative level has few units with higher housing prices. Regions with higher administrative levels have longer "long tails," indicating that higher administrative districts contain more high-price areas and larger price differences.

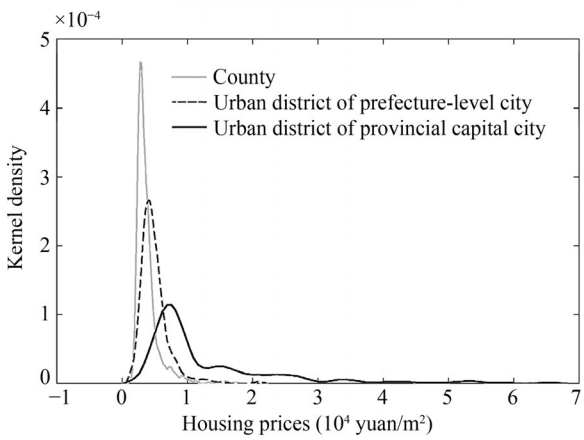

Figure 4 Kernel density estimates of housing prices in China

4 The effects of land prices on China's housing prices differentiation

4.1 The impact of land prices on China's housing prices

In this study, the direction and strength of determinants driving differences in China's housing prices were analyzed, taking into consideration land prices, housing supply, housing demand, and housing market. Housing supply and bottom-line construction costs are represented by land prices. Housing demand and purchasing power are expressed through the following factors: the proportion of renters, floating population, and housing affordability. The housing market is characterized by its relative activity. These factors are measured using the average land price, proportion of renters in the total number of households, urban floating population, average wage of urban employees, and proportion of the population working in the real-estate industry. The statistical descriptions and expected directions of selected factors are compiled in Table 1. We chose those factors for the following reasons. First, land prices are the core determinants affecting housing supply, and are highly correlated with the cost of housing. Second, the vast majority of renters belong to the floating population, and most of them cannot afford to buy local houses but have a rigid demand for housing purchases. Meanwhile, when renters increase in proportion, this usually leads to higher housing demand, and hence higher housing prices in those regions. Third, the floating population is also an important indicator reflecting comprehensive housing demand and overall attractiveness of the city because of their strong intention to settle down. The housing purchasing power and affordability are measured by the average wage of urban employees, which influences both housing demand and housing supply flexibility. Finally, housing market activity can directly reflect the demand for housing investment and the maturity of the real-estate market.

To further analyze the strength and directions of the selected factors' influence on housing prices, excluding the extremely high-price areas, scatter diagrams of associations between impact factors and housing prices are provided in Figure 5. The results show that positive relationships exist between each impact factor and housing prices, which further support the choice of these five influencing factors. The value of R^2 for land prices, proportion of renters,

Table 1 Statistical summary of the variables

Variables	Definition	Expected direction	Min	Max	Mean	S.D.
Land price	Cost of land (10^4 yuan/ha)	+	27.76	6127.08	783.02	829.99
Proportion of renters	Proportion of renters (%)	+	0.00	84.94	9.50	10.45
Floating population	Urban floating population (10^4 person)	+	0.00	243.41	10.58	15.79
Wage level	Average wage of urban employees (yuan)	+	5128.74	125949.00	30286.80	9161.17
Housing market	Proportion of the population working in the real-estate industry (%)	+	0.00	8.06	0.56	0.89

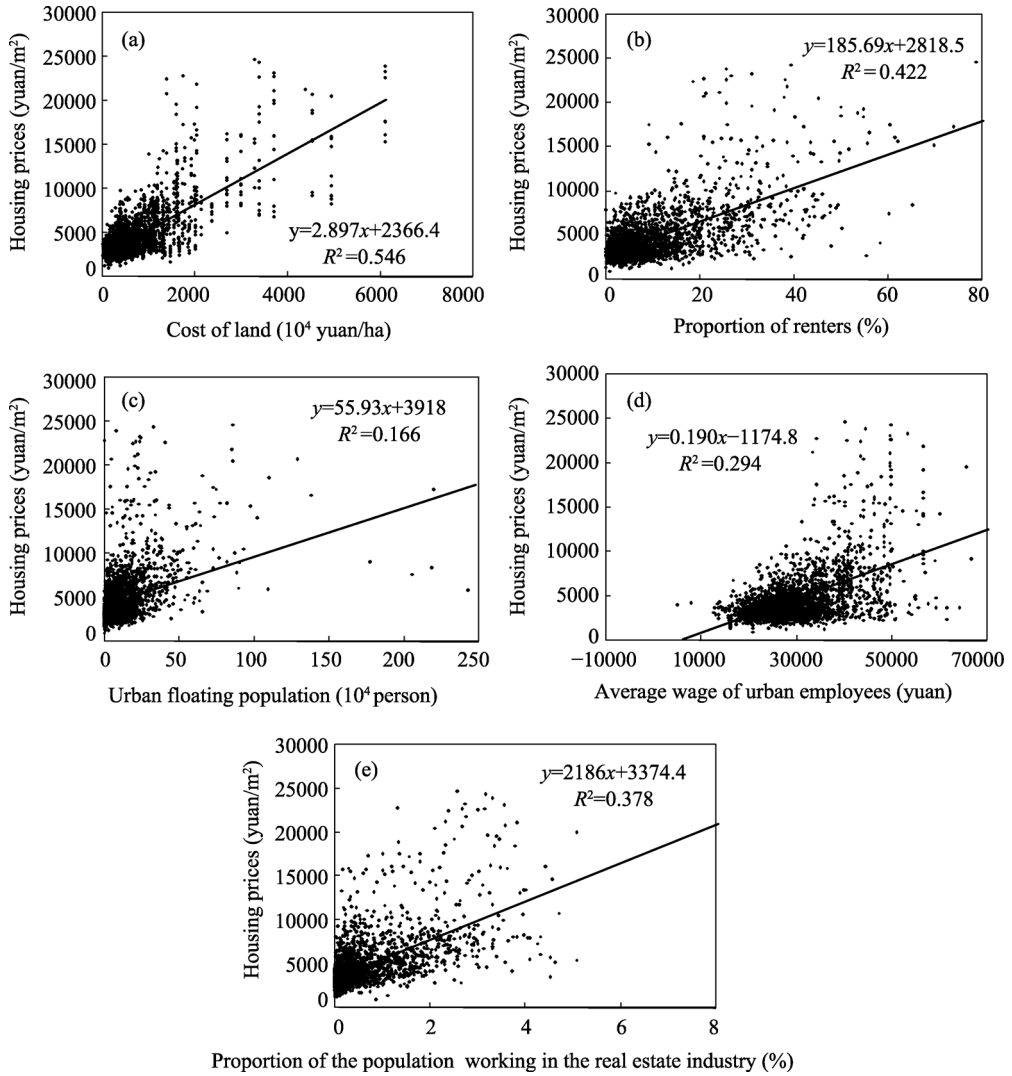

Figure 5 Scatter diagrams of relationships between impact factors and housing prices in China

and housing market activity were higher than for other factors, indicating that these three factors clearly control the spatial distribution of housing prices. Due to the limitations of land price data acquisition at the county-level, land prices at the prefectural-level unit were

applied. Land prices tend to be more distinct at the large-scale, and thereby land price differences between prefectural-level units are more significant (Song *et al*., 2011; Gao *et al*., 2010). Therefore, this data processing method has no significant impact on the conclusions.

A regression model of housing prices was constructed using the above-described five influencing factors as independent variables (Table 2). Using this model, the directions and strength of the influence of the primary elements can be verified. As reported in Table 2, the goodness-of-fit statistic R, the adjusted R^2, and the *df* value were 0.855, 0.731, and 5, respectively, indicating that the regression model is well fitted. The F value is 1502.289, while the significance level is 0.0000, which means that the model is extremely significant. The significance levels for each of the five factors are lower than 0.01, indicating that all factors have a significant positive impact on housing prices, which is consistent with our hypothesis.

Table 2 Regression coefficients for the housing price model for China

Variables	Non-standardized coefficient	Standard error	Standardized coefficient	*t-value*	Significance	Model parameters
Coefficient (α_0)	–1103.623	178.337	–	–6.188	0.000	R = 0.855
Land price	2.702	0.068	0.488	39.482	0.000	R^2 = 0.732
Proportion of renters	28.680	6.657	0.065	4.308	0.000	Aj–R^2 = 0.731
Floating population	0.001	0.000	0.033	2.882	0.007	F = 1502.289
Wage level	0.089	0.007	0.178	12.947	0.000	*Sig.* = 0.000
Housing market	1448.468	72.222	0.281	20.056	0.000	*df* = 5

Based on the non-standardized coefficients and intercepts in Table 2, the regression model for housing prices in China's counties was constructed as follows:

$$P=-1103.623+2.7022x_1+28.680x_2+0.001x_3+0.089x_4+1448.468x_5 \quad (4)$$

The model reveals that with other factors unchanged: an average land price increase of 1 yuan results in a housing price increase of 2.702 yuan; a 1% increase in the proportion of renters results in a housing price increase of 28.680 yuan; a floating population increase of 1% results in a housing price increase of 0.001 yuan; an average wage of urban employees increase of 1 yuan results in a housing price increase of 0.089 yuan; and a 1% increase in the proportion of the population working in the real-estate industry results in a housing price increase of 1448.468 yuan.

Land prices are a crucial factor and are the basis for determining residential housing prices. The first step in residential construction is developers obtaining a leasehold for state-owned land through bidding, auction and listing. Therefore, land costs become the basis and bottom-line for housing prices. According to previous research, the proportion of urban land prices in total housing prices in China rose from 9.0% in 1998 to 24.3% in 2011. Unequal land cost has become an important factor in housing cost differences, and land price changes in China are also Granger causes of housing price changes (Zeng and Zhang, 2013). According to the four-quadrant model established by Wheaton (1996), increases in land prices will result in a corresponding decrease in land supply. Under the premise of a constant plot ratio, the supply of housing will decrease, and with demand unchanged, housing prices will increase. Therefore, from the perspective of housing supply, land costs are positively correlated with housing prices.

The proportion of renters reveals the level of non-home ownership. Chinese culture embraces a strong philosophy of home ownership, and renting is considered as a transitional solution to housing issues. Therefore, renters are the largest group driving housing needs in China. As a result, the proportion of renters in a city is higher, which leads to a greater contradiction between supply and demand of housing, and a greater difficulty in purchasing houses. There is a positive relationship between the size of the floating population and residential prices. The floating population plays an important role in the regional labor market, and is also an important manifestation of the popularity of a region. The flow of young people into areas results in a substantial demand for housing, which is reflected in the spatially consistent distribution of population inflows and housing prices in eastern and central China. The level of wages reflects the affordability of home buyers in the region, which is the foundation for determining whether housing prices will continue to rise. Thus, the level of wages determines the effective demand for housing. Regional wage levels, as a significant factor attracting labor, could determine regional competitiveness. In the absence of competitive wages, the regional labor supply will gradually decrease, thereby reducing housing demand (Wheaton, 1996). Housing market activity directly reflects the housing investment demand in the region and real-estate market maturity, which has a positive impact on housing prices; this relationship is primarily caused by the friction in trading transactions in the real-estate market and market turnover (Caplin and Leahy, 2011; Ortalomagné and Rady, 2011). Generally, higher city administrative levels are associated with more active real-estate markets, which is consistent with the spatial differences in housing prices.

4.2 The magnitude of the land price impact on housing prices

The geographical detector technique was used to analyze the strength of the influencing factor impacts. Based on the pyramid-level distribution characteristics of county-level housing prices in China, the original values of the five factors were divided into five categories, from high to low: high (10%), middle-high (20%), middle (40%), middle-low (20%), and low (10%) levels. Based on the classifications, value thresholds for the five factors were determined, and their spatial distributions are plotted in Figure 6.

In China, there is significant inequality in urban size, population attraction, stage of urban development, real-estate market development, and land market conditions between different administrative levels of a city (county). Cities at a higher administrative level are usually attractive to the population, have scarce land availability, show a greater contradiction between supply and demand for housing, and have a more active real-estate market (Wang *et al*., 2013; Wang *et al*., 2015). Therefore, each factor has varying impact strength on different administrative cities. Table 3 shows the intensity differences for the potential determinants on housing prices in the capital cities, prefecture-level cities, and counties (county-level cities), based on the geographical detector technique.

The results indicate that significant differences in detection power exist among the detection factors. Specifically, the P value of the cost of land is the highest (0.3837), indicating that land prices are the core driving forces in uneven housing prices at the county scale in China. The P values for the proportion of renters (0.3291) and housing market activity (0.3214) are also relatively high, while the P value for the floating population is the lowest.

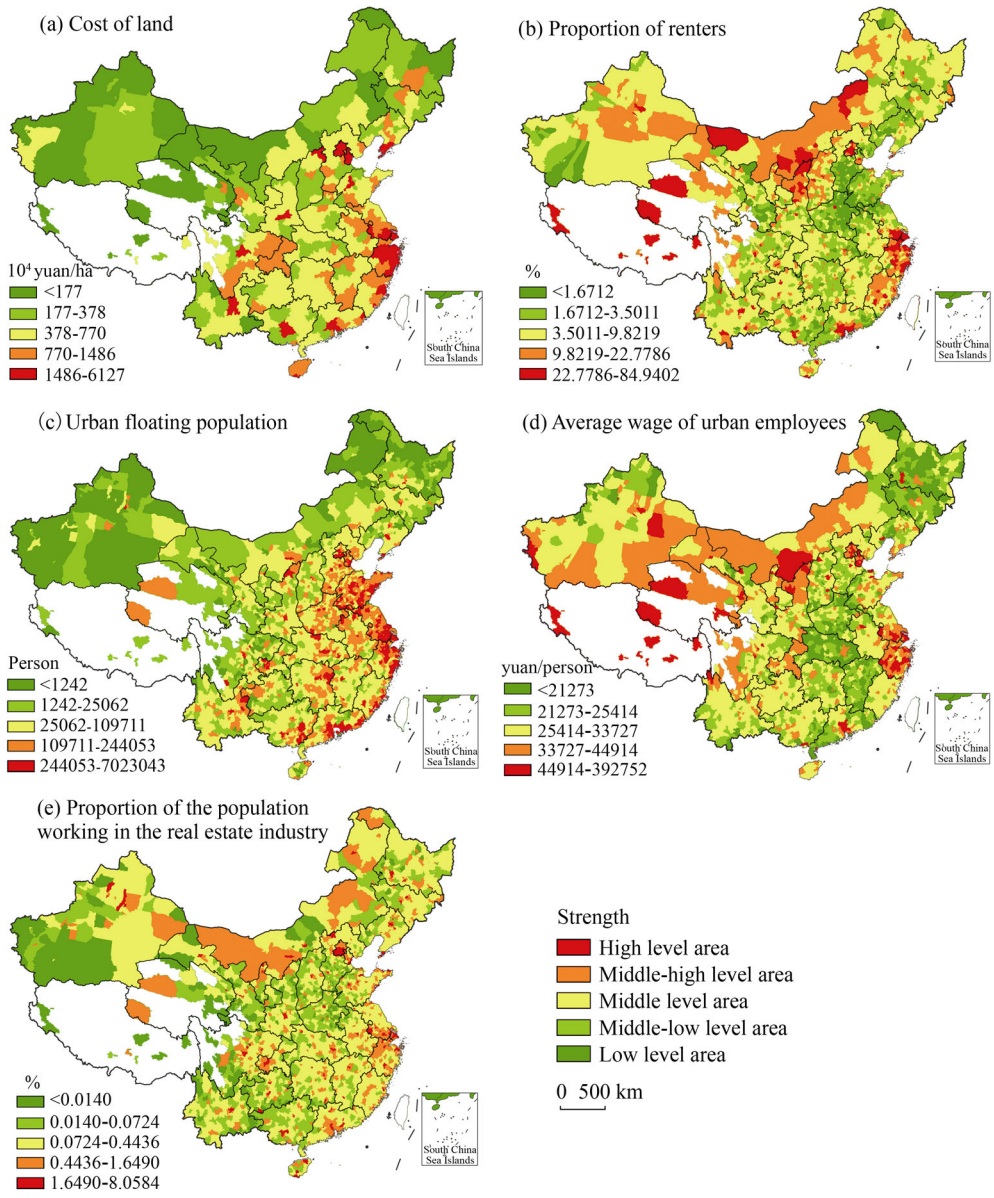

Figure 6 The spatial distribution of the strength of the five factors influencing housing prices in China

The P values for the internal impact factors of the three housing sub-markets classified by administrative level are much higher than that at the national level, which once again indicates that there is a housing sub-market in China at the administrative level. There are also differences in the strength of influencing factors for different administrative sub-markets: in the urban district of provincial capital cities, the impacts of housing market activity, proportion of renters, and land costs are the most significant. In the urban district of prefecture-level cities, housing affordability exerts the most significant impact on housing prices, while the floating population has a weak influence. In counties and county-level cities, housing affordability has the weakest impact, while the remaining four factors have some influence on housing prices.

There are regional differences in the impact of land prices on housing prices. Specifically, the effect of land prices on housing prices is the strongest in urban areas of capital cities. In the prefecture-level cities, counties, and county-level cities, the impact of land prices on housing prices is relatively weak, but cannot be ignored.

Table 3 Geographical detection results for potential determinants of housing prices in China

	Land prices	Proportion of renters	Floating population	Wage level	Housing market
Nation	0.3837	0.3291	0.1664	0.2816	0.3214
Urban district of provincial capital city	0.9070	0.9069	0.6452	0.8307	0.9244
Urban district of prefecture-level city	0.7141	0.8790	0.0095	0.9108	0.8166
County	0.7022	0.7844	0.7382	0.2829	0.7489

4.3 The mechanisms of land price influence on housing prices in China

The impact of land prices on housing prices also has its own internal influence mechanisms. Topographic factors, urban construction level, degree of agglomeration of high-quality public service resources, tertiary industrial development, and urban land supply plan (supply policies) are intrinsic drivers that determine land prices in the city. Through supply and demand, cost, expected growth, and market mechanisms, these factors then affect housing prices. Furthermore, residential prices will exert a feedback on land prices, driving land prices higher or lower.

Districts with a varied topography usually have higher land development costs and housing construction costs, resulting in the short supply of construction land, which is directly reflected in higher land prices, increasing the fixed cost of housing construction and thus housing prices.

High urban construction level significantly affects activity and competition in a city, attracting high-end industries and high floating populations, which increases the demand and price for land. However, high land prices are also an important prerequisite for maintaining a high level of urban construction. Through the supply and demand mechanism and the cost mechanism, land prices exert a positive influence on housing prices.

High-quality public service resources, including quality education, medical care, culture, science, and technology, are important factors in attracting migrants, while increasing the demand for housing for a large number of temporary residents. Regions with high-quality public resources are usually at higher administrative levels, such as the central cities in provinces, which incorporate vibrant real-estate markets; therefore, these regions are characterized by a high demand for land. In addition, a large amount of urban land is occupied by public resources, which exacerbates the demand for urban land and further increases the difference between land supply and demand, which drives housing prices higher.

Regions with highly developed tertiary industry are usually characterized by better urban development, and most traditional industries have been relocated, implying that those regions have strong comprehensive competitiveness and high urban quality. The proportion of high value-added formats, such as research and development, finance and business center economies, high-level industrial structure, and urban consumption structure, drive strong employment absorption, high employment quality, and large land demand. Moreover, urban residents' relatively high capacity to afford high land prices, the active real-estate market,

and higher expectations of rising housing prices directly promote higher land prices and, subsequently, housing prices.

The urban land supply plan is controlled and influenced by urban comprehensive planning and general land use planning, as well as the annual land supply policy. Because the government strictly controls the size and development boundaries for mega-cities, the large difference between land supply and demand in urban areas in capital cities will persist for a long time. Land becomes the object of many developments' bidding and land prices continue to rise as a result of the short supply and high demand. This further increases the expectation for rising housing prices, which continues to drive increases in housing development costs and further price increases.

5 Conclusions

(1) The spatial variability in housing prices across China is characterized by distinct administrative level and spatial agglomeration differences. Regions with higher administrative levels maintain larger price ranges, more significant absolute differentiation within sub-markets, and more high-price areas.

(2) From the multiple perspectives of land prices, housing supply, housing demand, and housing market, we find that land prices, proportion of renters, floating population, housing affordability, and housing market activity all significantly affect regionally different housing prices in China. Land prices are the primary driver of housing prices at the county level; specifically, the effect of land prices on housing prices is the strongest in the urban areas of capital cities. In prefecture-level cities, counties, and county-level cities, the impact of land prices on housing prices is relatively weak.

(3) Land prices influencing housing prices are as follows: topographic factors, urban construction level, degree of agglomeration of high-quality public service resources, tertiary industrial development, and urban land supply plan (supply policies). These are the intrinsic drivers that determine land prices in the city, and through supply and demand, cost, expected growth, and market mechanisms, together they affect housing prices. The internal drivers also partially affect the other four factors, the proportion of renters, floating population, housing affordability, and housing market activity, leading to the distinct spatial variability in housing prices across China.

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