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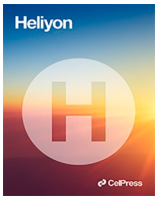

Research article

Identifying the spatial heterogeneity of housing financialization in China: Insights from a multiscale geographically weighted regression

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ABSTRACT

With the deepening linkage between housing and finance, the financial attributes of housing have been increasing. Thus, housing financialization has become a worldwide phenomenon that is gradually emerging in China's real estate market and thus cannot be ignored. The amount of urban capital is an important manifestation of financialization, but only a few studies have considered the spatial heterogeneity of impact of urban capital amount—represented by loan balances (LOAN) on housing prices. To fill this gap, this study builds a dataset of housing prices and influencing factors for county-level units using 2109 counties in China and analyzes the spatial scope and heterogeneity of housing financialization. Results show that globally, LOAN has a significant positive effect on housing prices, and the impact direction is in line with theoretical expectations. Locally, spatial heterogeneity exists for the impact of LOAN on housing prices, and the phenomenon of housing financialization is mainly observed in China's eastern coastal area. This study can help enhance the understanding of the spatial constraints on the impact of LOAN on housing prices and the spatial heterogeneity of housing financialization in China. Moreover, it provides a theoretical basis for policymakers to formulate spatially differentiated housing policies.

1. Introduction

As the link between housing and finance deepens, various types of capital have penetrated real estate through financial markets, resulting in an increase in the financial attributes of housing products and a self-perpetuating cycle of asset values in a closed system of "housing finance" [1]. Housing has been increasingly regarded as a tool to acquire wealth and increase investment, rather than as a social good [2]. Financialization is understood by Aalbers as "the increasing dominance of financial actors, markets, practices, and measurements, and narratives, at various scales, resulting in a structural transformation of economies, firms (including financial institutions), state, and households [3]." The global capital surplus has triggered housing financialization ("Great Wall of Money") to flow into the real estate sector due to financial deregulation in various countries [4]. The financialization of housing as a channel for

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absorbing surplus capital in the main capital cycle has become ubiquitous and has evolved into a common feature of national financial systems. In contrast to other countries, housing in China has transformed from a state-allocated nontradable commodity to a tradable commodity and subsequently to an investable asset [5]. The financialization of housing in China has also become an important form of capital accumulation. Thus, housing financialization has become a novel topic in national and regional housing price studies.

Absorbing funds by housing is an unbalanced process, with investment in housing assets requiring enormous amounts of capital, often accompanied by high borrowing behavior [6]. Loans, one of the main driving forces of growth in the financial industry, have historically been regarded as a means of increasing the number of homeowners in a country [7]. In consideration of housing's consumer and capital good attributes, it is generally recognized as a fresh demand item for residents, and most households are faced with the problem of purchasing their first fresh home. Moreover, if housing is considered a high-yield investment product in household asset allocation, a rise in housing prices leads residents to expect a large increase in future housing prices, thus increasing housing investment demand. For consumers and investors, personal income alone often cannot meet the demand for housing, and individuals and families inevitably have to borrow from financial institutions to purchase homes. In addition to a family's financial resources (savings), credit loans and mortgages (direct bank loans) become the main source of funds for home purchases [8]. Addae-Dapaah argues that high housing prices, both real and expected, encourage more housing loans [9]. This finding has been confirmed by Muellbauer [10], who found that a decline in consumer spending is associated with a decline in asset prices. In other words, low housing prices reduce consumer spending and correspondingly housing loans. Therefore, the impact of loans on housing prices becomes an important manifestation of the financialization of housing. The amount of personal loans, contract loans, loans from specialized depository savings institutions, and bond issues represents to some extent the amount of funds available to a given city. The amount of urban capital represents a city's ability to adsorb funds and the level of financial development. The amount of capital is then related to the value of housing and the extent to which financialization works for housing. Loans from financial institutions provide financial support for the development of various sectors of the city's economy [11], and are the fundamental support for the city's financial development, i.e., the level of the city's financial development can be measured by the balance of loans from financial institutions, as reflected in existing studies [12,13]. Therefore, we use the amount of personal loans, contractual loans, loans from specialized deposit savings institutions and bond issuance to represent the amount of urban finance.

The determinants of housing prices have plagued policymakers and researchers for many years. Typically, when researchers attempt to explain deviations of housing prices from the mean, they focus on fundamental shocks [14]. Currently, studies on the factors influencing housing price differences within countries have concentrated on urban population [15,16], employment [17,18], economy [19,20], industry [21–23], land prices [24,25], and other urban fundamentals. In addition to these aforementioned factors, housing financialization has an important influence on housing price differences and cannot be ignored. Indeed, housing commoditization is closely related to financial policies [26], and financialization has a considerable impact on housing prices [26,27]. The increased level of financialization objectively accelerates capital accumulation activity through real estate, leading to higher asset allocation in the real estate sector [28]. In other words, financialization and related issues are indispensable factors that affect housing prices [29], and the impact of the amount of capital in cities on housing prices cannot be underestimated. In China, loans have an important impact on housing prices [30–32]. Thus, analyzing the impact of urban loan balances on housing prices will facilitate the exploration of regional housing financialization. However, there is still a gap in case studies of housing financialization at fine spatial scales (e.g., county) in China. Therefore, this study verifies that housing financialization in China is innovative in scale by using county-scale units.

However, when the level of development varies considerably within countries or regions (as in China) [33,34], attention needs to be paid to the spatial scope of housing financialization and its spatial heterogeneity. That is, housing financialization is likely to occur only in some regions (e.g., those with more developed real estate and financial markets) rather than in all regions. In other words, there may be spatial heterogeneity in housing financialization. From this perspective, the extant literature has paid little attention to this issue. The existing literature focuses solely on housing financialization at a global scale and ignores its local variability, that is, spatial heterogeneity. To address the gaps in existing research, the spatial heterogeneity of housing financialization needs to be investigated by examining the regional scope and spatial heterogeneity of the impact of loan balances on housing prices. This aspect represents an important and innovative contribution of this study.

The existence of housing financialization in China has been partially documented by previous research. Over the past two decades, housing prices in China have been rising rapidly [35,36] and have increased at nearly twice the rate of national income [37]. Along with this rapid increase, there are increasing differences in housing prices across regions and cities [38–40]. There are also large regional inequalities not only in housing prices but also in the amount of capital [41], level of economic development [42], and land expansion [43], among many others. Given China's vast size, development conditions vary widely across regions, including differences in the level of development of real estate and financial markets; this variation likely leads to the spatial heterogeneity of housing financialization in China, which exhibits local rather than global characteristics. That is, the phenomenon of housing financialization is likely to occur only in some regions. Thus, the spatial scope and heterogeneity of housing financialization in China must be studied.

To respond to these current needs, this study examines the spatial scope of housing financialization in China and its spatial heterogeneity in terms of the impact of loan balances on housing prices. This is also the goal of this study. This is because existing studies have paid little attention to this element, and most of them focus on China's housing financialization only on a global scale, ignoring the spatial heterogeneity of housing financialization. Local regression models (e.g., geographically weighted regressions [GWR]) are a more effective way to analyze the spatial heterogeneity of housing price influences [44,45]. To measure the spatial scope and heterogeneity of housing financialization in China, we constructed a cross-sectional dataset covering seven influencing factors—capital amount, population, employment, economy, and industry—for 2109 counties (cities and districts) in China. In analyzing the local characteristics of the impact of capital amount on housing prices, we used a multiscale geographically weighted regression (MGWR) model to explore the spatial heterogeneity of the strength and direction of the impact of loan balances on housing prices in 2109

counties (cities and districts) in China. In contrast to the existing research, this study concentrates on exploring the spatial scope of housing financialization and the differences in its global and local effects on housing prices in China. These findings contribute to our understanding of the spatial constraints on the impact of loan balances on housing prices and the spatial heterogeneity of housing financialization in China. Furthermore, this study deepens the understanding of China's housing market and provides a reference for the government to make targeted and differentiated housing regulatory policies in different regions.

The rest of this paper is organized as follows. In Section 2, we design the research framework, construct the index system of influencing factors, describe the data sources, and determine the method. Section 3 constitutes the analysis of the research results, including the spatial differentiation pattern of housing prices and loan balance distribution in Chinese county-level units, the strength and direction of the influence of loan balances on housing prices, and the spatial heterogeneity of housing financialization. Section 4 includes a related discussion and conclusions of this research.

2. Material and methodology

In China, housing financialization is centered on assetization as part of an overarching strategy to deal with the overaccumulation of the Chinese economy, helping to release pressure and capital accumulation. By contrast, housing has become a means of investment for Chinese households, who regard housing as a form of asset-based welfare and owning a home as a way of coping with future financial risks. Thus, the financialization of housing has contributed to the transformation of owner-occupied housing into a financial asset for household wealth, with the dual role of government and the private sector [8]. On the basis of this background, research on the financialization of housing in China must be conducted.

2.1. Research design

To analyze the spatial scope and heterogeneity of housing financialization in China, a research design is developed for the study process. The specific analysis process is as follows: First, we choose the impact of the total loan balances in financial institutions at year-end on housing prices to represent the strength of housing financialization. Therefore, this study quantitatively measures housing financialization by examining the impact of loan balances on housing prices. On the basis of data from 2109 counties (cities, districts) in China, we construct a model of impact factors for housing prices corresponding to funds (expressed as loan balances), population, employment, economy, and industry. Second, from a global perspective, we run the ordinary least squares (OLS) model to verify whether the factors selected are significant and whether their direction of influence is in line with theoretical expectations. We particularly focus on verifying the significance and direction of the impact of loan balances on housing prices. Finally, the research results are analyzed, and the conclusions are drawn and discussed. In view of the conclusions of this study, we propose targeted policy suggestions (Fig. 1).

2.2. The indicator system of factors affecting house prices

To study the effect of loan balances on housing prices, a regression model must be contructed. The housing prices of each county in

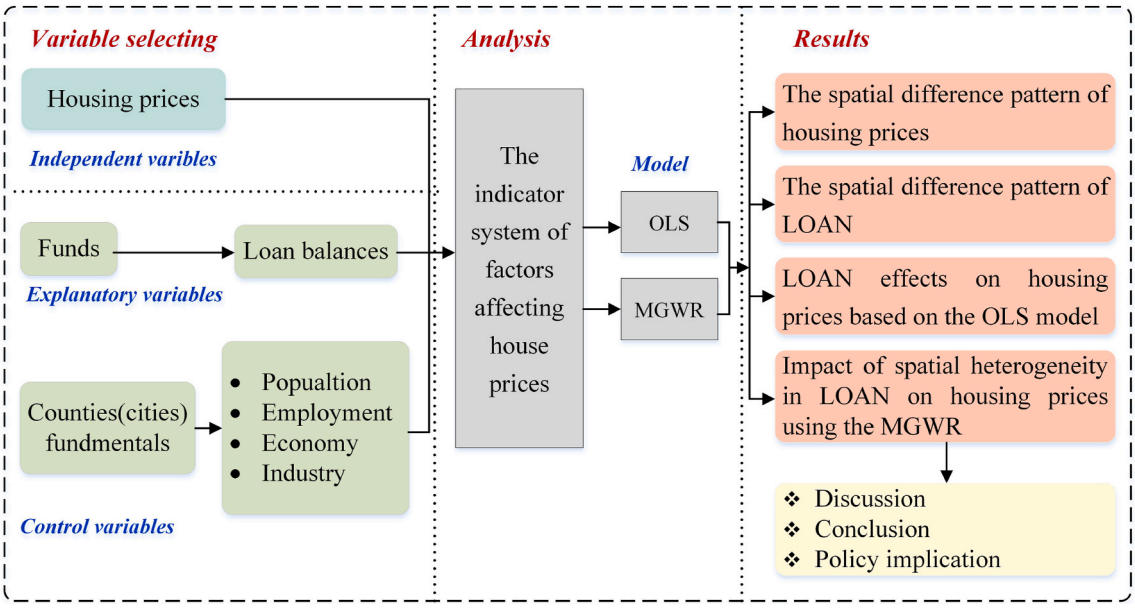

Fig. 1. Research design.

China are used as the dependent variable in the regression model, which is expressed as the average listing price of second-hand houses in yuan/m^2; the independent variable (explanatory variable) in the regression model is the loan balance. Housing prices and loan balances are closely linked, and housing financialization is an important factor in housing price differentials. Existing studies [5,46,47] have used loan balances to represent the amount of capital in cities; the independent variable (control variable) in the regression model includes six factor indicators covering four aspects—population, employment, economy, and industry—that are the fundamental factors of cities and influence the differences in housing prices there (Table 1). Table 2 presents descriptive statistics on the data for these seven independent variables.

Loan balances is denoted by total loan balances in financial institutions at year-end. Many studies have been conducted to analyze the relationship between financial factors and housing prices [48–50], and results showed that financialization is a central factor affecting house prices. The growth of loans in the banking system is a suitable indicator of financialization [26]. Research shows that a 10% increase in available credit leads to a 1.5% increase in the value of purchased properties [51]. Ayberk and Önder examined the relationship between mortgages, consumer loans, construction loans, commercial loans, and industrial loans and housing price growth rates using Turkey, an emerging market country, as an example. As housing prices rise, commercial loans, as well as some specific industrial loans that promise to increase private sector employment, are squeezed out by mortgage, consumer loans, and construction loans, and the positive relationship between loans and housing prices observed in developed markets also appears in this emerging market [52]. Thus, we choose loan balances to verify the spatial heterogeneity of their impact on housing financialization in China. Theoretically, the larger the loan balance is, the higher the strength of housing financialization.

Population attractiveness is expressed as the proportion of the migrant population in the permanent population. The higher the proportion of the migrant population is, the stronger the population attractiveness of the city becomes. Migrant population is a major means of achieving population growth in cities, and a continuous influx of people creates a constant demand for housing. Relevant studies have demonstrated that the migrant population is positively associated with housing demand [53] and housing prices [36,54]. Therefore, cities or counties with a higher proportion of migrant population have higher housing prices.

Population density is mainly used to measure the distribution of the population in a country or region. People are the main buyers of housing, and the higher the population density is, the higher the demand for housing. As China has historically been a populous country, population issues are related to the development of the national housing market; changes in population size lead to changes in housing demand, and population density naturally affects the health and stability of the real estate industry. Miles developed a housing market model to argue that the main determinant of house price inflation relative to income is the evolution of population density, which affects housing construction and housing values [55]. Furthermore, Prüser and Schmidt showed that the higher the population density is, the tighter the real estate market and that population density is a key factor that determines housing prices, having a significant positive correlation with them [56].

The composition of employment reflects the allocation or changing characteristics of labor resources [57,58] and is an essential factor affecting housing prices. The proportion of employment occurring within the tertiary sector is generally used to represent the composition of employment. As the industry with the highest employment potential and the most promising development, the proportion of employment within the tertiary sector indicates a better industrial structure, a better urban living environment, and a stronger housing demand. Generally, a correlation exists between the composition of employment and housing price changes.

The economic development level is denoted by per capita gross regional product (GRP). Per capita GRP is the most important indicator of urban fundamentals. Cities with a high level of economic development have high urban vitality, greater population attractiveness, and an active real estate market. Economic competitiveness and housing prices have an interactive relationship [59]. Further, Hossain and Latif showed that the economic level is an important variable that determines housing prices, indicating their positive correlation [60].

The service level is denoted by the tertiary industry's percentage of GRP. The level of urban service is a core element of urban attractiveness and competitiveness. Roback found that the local service level influences residents' quality of life [61]. Furthermore, Shen and Liu indicated that the development level of the service industry is one of the important indicators for measuring urban economic fundamentals [23]. Thus, the tertiary industry's share of GRP is used to denote the level of urban service.

The industrial development level is denoted by the number of industrial enterprises above a designated size. Industry refers to those

Table 1
Description, measures, and expected direction of the variables.

Explanatory perspectives	Variables	Definition	Symbol	Expected directions
Funds	Loan balances	Total loan balances in financial institutions at year-end (100 million yuan)	LOAN	+
Population	Population attractiveness	The proportion of migrant population in the permanent population (%)	PMPPP	+
	Population density	Population density (person/sq.km)	PD	+
Employment	Composition of employment	The proportion of employment occurring within the tertiary sector (%)	PEOTS	+
Economy	Economic level	Per capita Gross Regional Product (yuan/person)	PCGRP	+
Industry	Service level	Tertiary industry as percentage to GRP (%)	TIAPTGRP	+
	Industrial development level	Number of Industrial Enterprises above Designated Size(unit)	NNEDS	+

Table 2
Descriptive statistics.

Symbolized variables	Min	Max	Mean	Std.Dev
Housing prices	1251.0000	60487.0000	5792.5411	3614.3675
LOAN	0.0578	63382.5000	532.1472	2881.7066
PMPPP	0.0000	67.4873	6.6952	8.3734
PD	0.2291	40722.8916	464.3305	1111.4401
PEOTS	0.0909	115.2989	13.7165	7.4023
PCGRP	4822.8859	339117.8676	41243.5961	31412.8285
TIAPTGRP	6.3800	87.8858	41.9163	10.7482
NNEDS	0.0100	8122.0000	179.5956	475.7894

involved in resource extraction, processing, and manufacturing [62], and the level of industrial development reflects the level of regional industrial production capacity, production base, and production efficiency [63]. Construction and industry belong to the same secondary industry, and housing construction cannot be bifurcated from industrial construction. Zhou and Zhang examined housing prices around the Shanghai–Suzhou and Beijing–Langfang high-speed railway stations and found that house price premiums exist in industrial parks in these two pairs of important core–periphery cities in China [21]. In general, high housing prices can promote the development of real estate and related industries, which in turn can boost economic growth [64]. To a certain extent, the number of industrial enterprises above a designated size reflects the level of regional industrial development. Therefore, we choose the number of industrial enterprises above a designated size to reflect the relationship between the industrial development level and housing prices.

2.3. Data

The research unit consists of 2109 counties (cities, districts). Housing data were collected in March 2019; the housing price data of 1948 counties (cities, districts) mainly came from the "Jiwu" real estate trading platform, which covers the entire country (http://www.jiwu.com/). The price data of the remaining 161 counties (cities, districts) were taken from 10 real estate data platform websites (Table 3).

Data for the seven impact factors for cities (municipal districts) mainly come from the *China City Statistical Yearbook 2017*, while the data for counties come from the *China Statistical Yearbook (County-level) 2017*. Data that could not be obtained from these two sources were supplemented by the *Statistical Communiqué of the 2017 National Economic and Social Development* for counties (cities, districts). The statistical year of the above data is 2016. It should be noted that according to existing research, the impact of housing-related factors on housing prices has a lag period of two to three years [36,65,66]; therefore, to use impact factor data from 2016 is appropriate.

2.4. Methods

2.4.1. Global regression using OLS model

The OLS model is run to estimate the global impact factors of housing price differences in China. Using this model not only validates the plausibility of the selected seven independent variables but also tests the significance of their effect on housing prices. OLS is often used as a traditional global regression model for the study of factors influencing housing prices. The model expression is as follows in Equation (1):

$$y_s = \sum_{i=1}^{n} \beta_i x_{si} + \beta_0 + \varepsilon_s, \left[\varepsilon_s \sim N\left(0, \delta^2\right)\right] \tag{1}$$

where $s = 1,2, \ldots, 2109$ denotes the county (city) in China, y_s is housing prices in the county (city) of s_{th}, β_i is the regression coefficient of the i_{th} variable in the model, x_{si} ($i = 1, \ldots,7$) represents the observed value of the variables for the impact factors of housing prices,

Table 3
Data source.

Name of platform or website	Number of cities (counties)	Website
Jiwu website	1948	http://www.jiwu.com/
Xitai data	89	https://m.creprice.cn/
Anjuke Website	25	https://*.anjuke.com/
58Tongcheng	22	https://*.58.com/ershoufang/
Fang-tianxia	7	https://*.esf.fang.com/
Gotohui Data	6	https://fangjia.gotohui.com/
Baidu	6	https://www.baidu.com/
Fangduoduo website	2	https://*.fangdd.com/esf/
Baixing website	2	https://*.baixing.com/ershoufang/
Leju website	1	https://*.leju.com/
Zhenhouse website	1	http://*.zhenhouses.com/

β_0 is a constant term, ε_s denotes the error term of the model, and $\varepsilon_s \sim n\ (0,\delta^2 I)$ indicates that the error term has a normal distribution and consistent variance, that is, the product of the error and covariance matrix is 0; I is an identity matrix.

2.4.2. Multiscale geographically weighted regression

The OLS model can calculate the strength and significance of the statistical relationship between housing prices and its influencing factors, and requires only a single equation for all data [36]. In addition, the assumption is that such a statistical relationship does not change in any location; however, in reality, it would experience changes locally with differences in spatial location. In contrast, the GWR model allows for local variations in the relationship between independent and dependent variables across the whole space and reflects the spatial-smoothness of the parameters in different regions [67,68]. Therefore, we can use the GWR model to analyze the spatial heterogeneity of factors affecting housing prices [69,70]. The MGWR model is based on classical GWR and can take into account the difference in the bandwidth of each variable parameter to create a GWR model in which different variables have different bandwidths. This is a more refined treatment of the scaling problem than traditional GWR, as traditional GWR models have a fixed bandwidth for all variable parameters. MGWR was proposed by Fotheringham et al. [71], but statistical inference methods to implement the model were lacking at that time. Yu et al. refined these methods for MGWR in 2019 which allows MGWR to be used in a large range of case application studies [72]. The MGWR in this study is expressed as in Equation (2):

$$y_s = \beta_0(u_s, v_s) + \sum_{i=1}^{n} \beta_{bwi}(u_s, v_s)x_{si} + \varepsilon_s, \left[\varepsilon_s \sim N\left(0, \delta^2 I\right)\right] \tag{2}$$

where (u_s, v_s) is the geographical location of the city (county) s; $\beta_0\ (u_s, v_s)$ is the constant of the city (county) s regression model; $\beta_{bwi}\ (u_s, v_s)$ is the regression coefficient of the i_{th} variable in the city (county) s regression model, which varies with location; and bwi denotes the bandwidth of the regression coefficient of the i_{th} variable. The bandwidth of the regression coefficient for each variable is not fixed but varies with the regression coefficient; in other words, the local regression has a "multiscale" character, which is the difference between MGWR and classical GWR.

The MGWR model defines a spatial weight matrix (W_{sk}) for each city (county) s. The spatial weight matrix defines the "neighboring" cities (counties) used in the MGWR run. The definition of each value (w_{sk}) of the spatial weight matrix (W_{sk}) requires a kernel function. In this study, a quadratic kernel function with adaptive bandwidth is used, which can be expressed as follows in Equation (3) [71]:

$$w_{sk} = \begin{cases} \left[1 - (d_{sk}/b_s)^2\right]^2, k \in N_q(s) \\ 0, k \notin N_q(s) \end{cases} \tag{3}$$

In the formula, w_{sk} refers to the spatial weight value between county (city) s and county (city) k; d_{sk} is the distance between county (city) s and county (city) k; b_s is the bandwidth used in the regression for s_{th} county of the model; $N_q(s)$ denotes the set of q nearest housing units to city (county) s, and w_{sk} is decreasing with increasing d_{sk}, $w_{sk} = 1$ when $d_{sk} = 0$.

Since the spatial distribution of counties (cities) in China tends to be uneven, some regions have a denser housing distribution, while others are sparser. Therefore, when counties (cities) are densely distributed, the bandwidth distance will become smaller, whereas when counties (cities) are sparsely distributed, the bandwidth distance will be larger. Thus, how determining the size of the adaptive bandwidth in the kernel function to obtain the optimal bandwidth is one of the key issues in determining the effectiveness of MGWR. We use the corrected Akaike information criterion (AICc), and its expression is shown in Equation (4) [73,74]:

$$AIC_C = 2n\ln\hat{\sigma} + n\ln(2\pi) + \frac{n + tr(S)}{n - 2 - tr(S)'} \tag{4}$$

where σ denotes the maximum likelihood estimate of the variance of the random error, and tr(S) is the trace of matrix S.

Unlike the classical GWR, MGWR uses a generalized additive model (GAM) to estimate the elasticity coefficients [75]. The expression of the model is as follows in Equation (5) [72] :

$$y = \sum_{i=1}^{n} f_i + \varepsilon\ (f_i = \beta_{bwi}x_i) \tag{5}$$

The above model can be fitted to the model using the backfitting algorithm for the smoothing terms. This method requires initialization settings for all smoothing terms, that is, the coefficients of the MGWR model need to be estimated for initialization. Classical GWR is used as the initialization method. Once the initialization method is determined, the difference between the actual value and the initialized predicted value—the initialized residual ($\hat{\varepsilon}$)—can be expressed as follows in Equation (6) [75]:

$$\hat{\varepsilon} = y - \sum_{i=1}^{n} \hat{f}_i \tag{6}$$

When classical GWR is used as the initialization method, the initialization residual error $\hat{\varepsilon}$ plus $\hat{f}_i$ and the first independent variable are subjected to classical GWR, and the optimal bandwidth $bw1$ is searched, with the new parameter estimates $\hat{f}_1$ and $\hat{\varepsilon}$ replaced with the previous estimates. Subsequently, the residual error plus the second additive term $\hat{f}_2$ is regressed with the second variable, and the

parameter estimates $\widehat{f}_2$ and $\widehat{\varepsilon}$ of the second variable are updated. This is repeated analogously until the n_{th} independent variable. The above process constitutes a completion step, and these steps are repeated for estimation until the convergence criterion is met. In this study, the proportional change in the smoothing term (smoothing *f*) method is used to determine the convergence criterion.

3. Results

3.1. Spatial difference pattern of housing prices

The housing prices of China's county-level units are shown in Fig. 2. The lowest housing price is 1251 yuan/m^2, and the highest is 60,487 yuan/m^2. Significant spatial differences in housing prices are found among China's county-level units. The housing prices in the eastern coastal area are significantly higher than those in other regions. The higher housing price regions include the Beijing–Tianjin–Hebei urban agglomeration, the Yangtze River Delta, the urban agglomeration on the west side of the Taiwan Strait (the surrounding areas of Fuzhou and Xiamen), the Pearl River Delta in Guangdong Province, the southern coastal areas of Hainan Province, and provincial capital cities. We also find that the housing prices of provincial capital cities are generally higher than those of other county-level cities. On the basis of the pattern of spatial differences in China's housing prices, we can determine that spatial heterogeneity of housing prices in China exists.

3.2. Spatial difference pattern of LOAN

The pattern for LOAN in China is shown in Fig. 3. LOAN in Chinese counties ranges from 0.05 to 63,382.50 hundred million yuan, which indicates significant variability in LOAN among China's county units. Counties with high LOAN are mainly located in the eastern coastal area of China; the Beijing–Tianjin–Hebei, Yangtze River Delta, and Pearl River Delta urban agglomerations are the main high-value cluster areas, and the provincial capital cities also have high LOAN. Comparing the spatial difference patterns between housing prices and LOAN reveals that the pattern can be considered the same for both. This spatial pattern provides initial evidence of a close relationship between housing prices and LOAN.

3.3. LOAN effects on housing prices based on the OLS model

We run the OLS model to explore whether LOAN has an overall effect on housing prices andto examine the strength and direction of

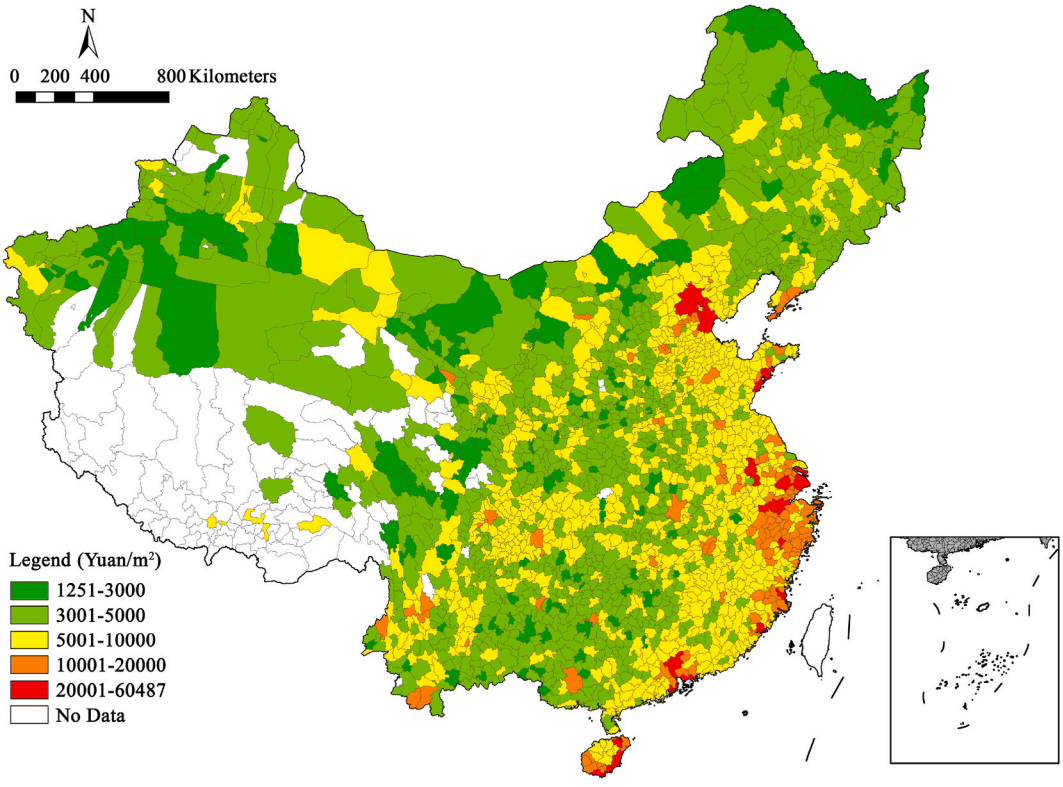

Fig. 2. Spatial difference pattern of housing prices in China.

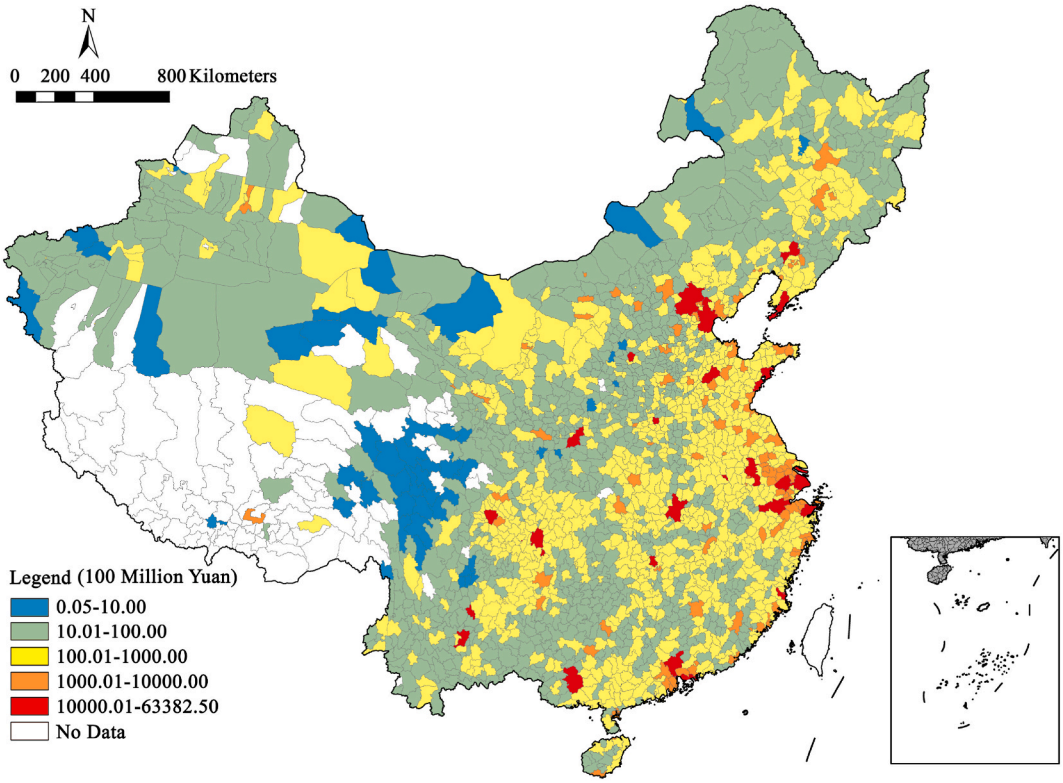

Fig. 3. Spatial difference pattern of loan balances in China.

this effect. First, the seven variables were tested for multicollinearity using SPSS 19.0; the results showed that all the variance inflation factor values were less than 10, indicating that none of the seven variables had multicollinearity; thus, all variables were included in the OLS model. In addition, we conducted normality tests on the standardized residuals of the OLS model, and the results showed that all the residuals followed the normal distribution pattern, indicating that the OLS model was highly accurate. We ran the OLS model using MGWR 2.2.1 software with variable standardization settings turned on. The results are shown in Table 4.

Table 4 shows that the OLS model has an adjusted R^2 of 0.508 and an AICc value of 4501.43 at the 95% confidence level, and all seven variables are positively correlated with housing prices, with the direction of influence matching theoretical expectations. A comparison of the coefficients of the variables shows that LOAN has the largest coefficient value of 0.429, indicating that LOAN has the most significant effect on housing prices. This result indicates that the effect of LOAN on housing prices is positively correlated at a global scale and reaches a 99% confidence level, in line with the theoretically expected direction.

The remaining six control variables have a significant positive impact on housing prices. At 99% confidence level, comparison revealed that NNEDS has the strongest impact on housing prices with a regression coefficient of 0.204, followed by PMPPP with a coefficient of 0.101 and PCGRP and TIAPTGRP with coefficients of 0.076. PD and PEOTS have an impact on housing prices at 95% confidence level, with PD's impact being greater than that of PEOTS. The influence direction of these variables is consistent with the theoretical prediction.

Table 4
OLS model results.

Variables	Coefficient	Std. error	t/z-value	*P*	Tolerance	VIF
Intercept	0.000	0.015	0.000	1.000	–	–
LOAN	0.429**	0.023	18.271	0.000	0.424	2.359
PMPPP	0.101**	0.019	5.361	0.000	0.652	1.533
PD	0.035*	0.016	2.179	0.029	0.932	1.073
PEOTS	0.031*	0.016	1.984	0.047	0.931	1.074
PCGRP	0.076**	0.019	3.947	0.000	0.630	1.586
TIAPTGRP	0.076**	0.016	4.716	0.000	0.896	1.115
NNEDS	0.204**	0.025	8.223	0.000	0.378	2.644

R^2: 0.509; adjusted R^2: 0.508; log likelihood: 2241.67; AICc: 4501.43.
**, and * represent the 0.01, and 0.05 significance levels, respectively.

3.4. Impact of spatial heterogeneity in LOAN on housing prices using the MGWR

Considering that the influences of these variables differ spatially, we applied the MGWR 2.2.1 software to run the GWR and MGWR models, keeping the parameter settings consistent for both models. We chose spherical coordinates and used the Gaussian model. The spatial kernel type is determined using the adaptive bi-square method, and the golden section search algorithm was used to calculate the bandwidths. For optimal bandwidth criterion, we choose the AICc criterion, and variable standardization settings were turned on. By comparing the regression results of the OLS, GWR, and MGWR models (Table 5), the R^2 and adjusted R^2 of the MGWR model are 0.819 and 0.794, respectively, which are higher than those of the traditional OLS and classical GWR model. The MGWR model also has the smallest AICc value and the largest log-likelihood value. These results suggest that the MGWR model is superior to the OLS and classical GWR models and is more suitable for exploring the spatial heterogeneity of the effect of LOAN on housing prices.

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MGWR has a greater advantage over classical GWR in terms of scale, and different bandwidths can be used for each variable in MGWR, whereas the bandwidth for each variable in GWR is the same. The bandwidth obtained using the classical GWR model is 147, which is only 6.98% of the sample size, whereas the MGWR results show that all seven variables and one constant of the model have different bandwidths, which vary significantly. As shown in Table 6, the bandwidth of the constant is the smallest, with an effect scale of 46, accounting for 2.18% of the total sample. The bandwidth of LOAN is 142, accounting for 6.73% of the total sample, and high spatial heterogeneity is observed, indicating that LOAN has a considerable influence on the housing prices in China's counties when space is accounted for. The bandwidth of PMPPP is 645 and accounts for 30.58% of the total sample, which is a large share, with the coefficient relatively smooth in terms of spatial variation. The scale of PD is smaller, with a bandwidth of 214, which indicates an evident spatial heterogeneity in the effect of population density on housing prices in counties. The action scales of PEOTS and PCGRP are 2107 and 2,098, respectively, which are global scales with almost no spatial heterogeneity, indicating that PEOTS and PCGRP have the same impact on housing prices in all counties in China. The bandwidths of TIAPTGRP and NNEDS are 132 and 69, respectively, accounting for 6.25% and 3.27% of the total sample, both of which have high spatial heterogeneity. Overall, the effect of the five variables on housing prices is spatially heterogeneous, except for PEOTS and PCGRP, which have a global impact.

Table 7 presents a descriptive statistical analysis of the coefficients of the seven variables based on the results of the MGWR model. The coefficients of LOAN range from 0.009 to 1.331, indicating that LOAN has a positive effect on housing prices. The mean value is 0.383, and the standard deviation is 0.253. After further analysis of the MGWR model results and setting $p < 0.05$ as the statistical significance level, the sample size for the explanatory variable LOAN to meet $p < 0.05$ is 54.53%, indicating that the effect of LOAN on housing prices shows a significant positive correlation in 54.53% of counties in China.

For the MGWR model, we visualized the local R^2 values of the regression results in ArcGIS, as shown in Fig. 4. The higher the local R^2 value for the county is, the stronger the degree of influence of these variables in the model on housing prices. Local R^2 values range from 0.1894 to 0.9553, which can be divided into five intervals. Overall, the local R^2 values are larger in the eastern coastal area and smaller in the western region. Specifically, the regions with higher local R^2 values (>0.7) are the Beijing–Tianjin–Hebei urban agglomeration and its surrounding areas, Shandong Peninsula, Yangtze River Delta (including Shanghai, Jiangsu, northeastern Zhejiang Province, and eastern Anhui Province), the urban agglomeration on the west side of the Taiwan Strait, and Guangdong Province. The local R^2 values of the three major regions, namely, Beijing–Tianjin–Hebei and surrounding areas, Yangtze River Delta, and Guangdong Province, are greater than 0.8. These regions are also the most dynamic in China's real estate market. These results demonstrate that the impact factors used in this study have a stronger explanatory power for housing prices in counties in the eastern coastal area of China than in other areas.

We analyzed the spatial distribution pattern of the strength and direction of the impact of LOAN on housing prices in China's counties, and the results are shown in Fig. 5. LOAN coefficients are classified into five categories, with areas that do not meet statistical significance ($p < 0.05$) and areas with local R^2 values < 0.6 shown in gray. Fig. 5 shows that the direction and strength of the effect of LOAN on housing prices are strong spatially heterogeneous in Chinese counties. LOAN has a significant positive impact on housing prices in cities along the eastern coastal area of China, including the Beijing-Tianjin-Hebei urban agglomeration and its surrounding areas, the Shandong Peninsula, the Yangtze River Delta (Shanghai, Jiangsu, Zhejiang, and the eastern part of Anhui Province), the urban agglomeration on the west side of the Taiwan Strait, Guangdong Province, and the eastern part of Hainan Province. Among

Table 5
A comparison of the results of the OLS、GWR and MGWR models.

	R^2	Adjusted R^2	AICc	Log likelihood
OLS	0.509	0.508	4499.35	−2241.67
GWR	0.791	0.762	3273.88	−1371.02
MGWR	0.819	0.794	2963.00	−1190.35

Table 6
Bandwidths of MGWR.

Variable	Bandwidth	ENP_j	Adj *t*-val(95%)	DoD_j
Intercept	46.00	116.446	3.527	0.377
LOAN	142.00	21.225	3.045	0.600
PMPPP	645.00	7.673	2.723	0.733
PD	214.00	14.492	2.928	0.650
PEOTS	2107.00	1.486	2.126	0.948
PCGRP	2098.00	1.322	2.078	0.963
TIAPTGRP	132.00	39.193	3.226	0.520
NNEDS	69.00	52.992	3.312	0.480

Table 7
Statistical description of MGWR coefficient.

Variable	Mean	STD	Min	Median	Max
Intercept	0.017	0.395	−0.593	−0.090	1.643
LOAN	0.383	0.253	0.009	0.312	1.331
PMPPP	0.072	0.050	−0.026	0.071	0.174
PD	0.080	0.209	−0.317	0.014	0.677
PEOTS	0.004	0.001	0.001	0.004	0.006
PCGRP	0.062	0.005	0.043	0.063	0.070
TIAPTGRP	0.079	0.086	−0.179	0.073	0.370
NNEDS	−0.179	0.446	−3.430	0.199	1.252

R^2: 0.819; adjusted R^2: 0.794; log likelihood: 1190.35; AICc: 2963.00.

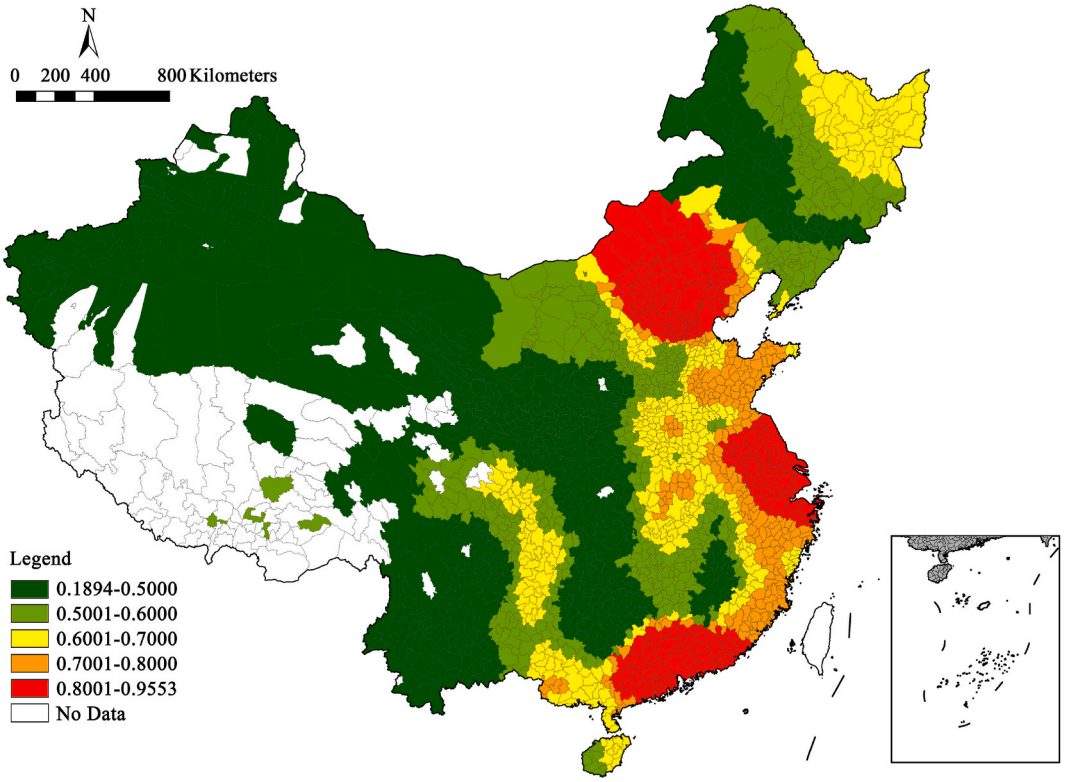

Fig. 4. Spatial pattern of local R.^{2}.

them, the influence of the urban agglomeration on the west side of the Taiwan Strait is the most significant. In the Beijing-Tianjin-Hebei urban agglomeration, Pearl River Delta, and the Shandong Peninsula, the impact of LOAN on housing prices is also high. The results demonstrate that there is significant spatial heterogeneity in LOAN impact on housing prices in Chinese counties.

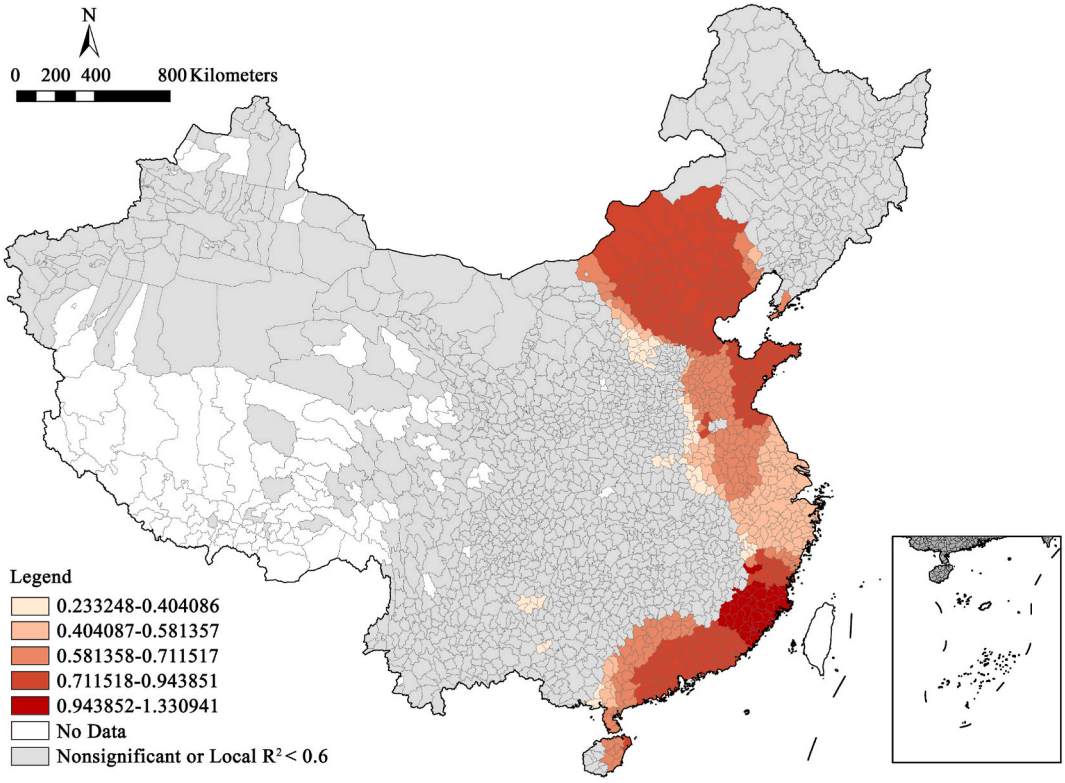

Fig. 5. Local regression coefficient pattern of loan balances.

4. Discussion and conclusions

4.1. Discussion

The characteristics of the pattern of spatial variation in county-level housing prices in China suggest a close link between housing prices and LOAN. The county-level units with higher housing prices are mainly located in urban agglomerations in the eastern coastal area and provincial capital cities in the central and western regions of China. Similarly, for counties with higher LOAN, the spatial variation patterns for LOAN are comparable with those for housing prices. The eastern coastal urban agglomerations, as the most economically prosperous region in China, attract a large influx of people and thus have an increased demand for housing, making the already limited land resources scarce. Coupled with increased land investment and development, the entry of financial capital and the gradual transformation of land into a financial asset [76] have further contributed to higher housing prices in this region, deepening the link between finance and real estate.

We reveal spatial heterogeneity in housing prices and LOAN by analyzing the pattern of spatial variation and further determine the factors and directions of differences in housing prices at the county level through global regression analysis. LOAN, PMPPP, PD, PEOTS, PCGRP, TIAPTGRP, and NNEDS all have a positive effect on housing prices. Thus, capital in combination with aspects concerning population, employment, economy, and industry can account for housing price changes at the global level. Through local regression analysis, we find that LOAN makes the greatest contribution to housing prices; at the $p < 0.05$ level, the effect of LOAN on housing prices shows a significant positive correlation in 54.53% of counties in China. Thus, LOAN is the main contributor to regional differences in housing prices in China, affects the largest number of regions, and is the most suitable for explaining regional differences in China's housing prices, validating the most important direct effects of China's financial markets on the real estate market [77]. This finding also suggests that the effect of LOAN on housing prices does not apply to all regions but is concentrated in certain areas. Moreover, the scope of LOAN's influence and the strength of its effect vary across counties, with a distinct housing financialization impact in the eastern coastal region and the highest degree of housing financialization in the urban agglomeration on the west side of the Taiwan Strait. In other words, spatial heterogeneity exists in the financialization of housing in China. Against the background of the urban real estate economic boom, our results indicate that the view of housing as an investment good has strengthened, and financial capital represented by LOAN has penetrated the real estate industry in the economically developed eastern coastal area. According to the principle of the financial "gas pedal," the application of LOAN in the financing and investment cycle at the supply and demand sides of the housing market has intensified, and the "real estateization" of the local economy has deepened. Furthermore, the financialization of housing (or rather the financial market) has become more dominant in the housing sector [78]. Thus, in the new economic development phase, the regional dimension of housing financialization becomes more pronounced, and the extent of its role becomes

stronger.

The noticeable phenomenon of housing financialization in particular areas (eastern China) is due to several factors. First, housing financialization requires a large amount of capital, as well as a more mature real estate market environment and a climate for housing investment, eastern China surpasses central and western China in terms of capital availability, real estate market development, and financial services, which renders housing financialization more likely in eastern China. Second, the phenomenon of housing financialization is more likely to occur in regions where housing prices have risen more rapidly or where there are expectations of greater housing price increases, housing prices in eastern China are higher, and their upward trend is more pronounced, which forms a demonstration effect for real estate investment. When real estate is considered an investment, it often relies on financial services (e.g., loans). Third, housing financialization needs to be supported by a large number of people who need to buy homes, which means that a large number of immigrant population with purchasing power need to move in to support the local real estate market. From a demographic perspective, eastern China experiences a significant influx of population, while central and western China witness population outflows. This influx of population drives local housing demand and contributes to the prosperity of the housing market, which provides a fundamental basis for housing financialization. By contrast, in the central and western regions where the population is flowing out, the investment appeal of housing is comparatively weak, which causes difficulty in promoting the development of housing financialization. In addition, income levels are higher in eastern China than in the central and western regions. Housing financialization tends to occur at higher income levels because housing is considered an expensive commodity, and greater liquidity exists in areas with higher income levels.

The regression model results suggest the existence of housing financialization in China, which is consistent with Wu et al. [8]. Although the housing loan level is relatively low in China, the absolute number of loans and their share of GDP are rising, and the appreciation of housing prices has led to a significant increase in multichannel housing consumption financing. Furthermore, except for PEOTS and PCGRP, the remaining four control variables in the study are spatially heterogeneous in their effects on housing prices. This result indicates the existence of differences in the effects among the factors influencing house prices, with different indicators having different ranges and regions of influence on housing prices. The composition of employment and economic level play a role in all regions but have nonsignificant effects in some. China's real estate market is characterized by complexity and diversity [79] and has distinct regional submarkets. Urban fundamentals, such as population, employment, economy, and industry, play an important role in housing prices. Among all the urban fundamentals included in our analysis, we find that LOAN has the most impact on housing prices. In contrast to previous studies, the current study not only explores the direction and extent of the global influence of LOAN on housing prices in 2109 counties (cities and districts) in China but also probes more deeply into the different local effects of LOAN in various regions. To eliminate the errors introduced by different models, the study selected the model with the best fit by comparing three models, i.e., OLS, GWR, and MGWR, to analyze in depth the local regression results of housing financialization in China. These findings help quantitatively identify the spatial scope of housing financialization in China, as well as the factors affecting housing prices; they also quantify the mechanism of action of key factors affecting housing prices and clarify their spatial heterogeneity (especially LOAN). The current study can also increase the understanding of China's housing market and can serve as a reference for the government's formulation of differentiated housing regulation and control policies.

From a methodological and theoretical point of view, this study constructs a multivariate integrated indicator system that includes factors related to capital, population, employment, economy, and industry to consider the spatial scope and spatial heterogeneity of housing financialization in China comprehensively. The study highlights the application prospects of using multivariate perspectives based on OLS, GWR, and MGWR techniques to understand the factors influencing housing prices. This approach provides greater potential value in further research on these issues. Compared with existing research, which is mainly global in scope, our empirical analysis examines local differences in the factors influencing housing financialization, thus providing a more accurate and specific reference that the government can use to establish housing policies for different regions that well correspond to their characteristics.

Loans and housing prices are a two-way interactive process. On the one hand, credit expansion is the main driver of house price appreciation [30], i.e., lending drives up housing prices; real estate requires a large amount of capital investment and relies on credit funding, and when large amounts of credit funds flow into real estate, housing prices rise. On the other hand, urban housing is gradually becoming a financial product and available collateral, real estate prices affect the availability of loans through wealth effects, and the belief in the high-profit margins offered by real estate has spawned lending behavior and more aggressive financial institution lending programs, facilitating the investment of more credit funds into the real estate market [80–82].

Some factors in the real estate market are considered to have a certain time lag in their impact on housing prices. To address the endogeneity of reverse causality, we select variable data with inconsistent timing, with the independent variable data being earlier than the dependent variable. Given that obtaining panel data at the county scale in China is difficult, this study adopts cross-sectional data, which is a shortcoming of this study. This study focuses on the impact of loans on housing prices, and thus, we select the most typical and representative control variables in the principle of limited objectives. From the perspective of regression modeling, the number of control variables should not be too large, and thus, we do not put more indicators into the model. In addition, given that this study uses macroscale statistics, i.e., each county and district is represented by only one statistic, the content of the above basic demographic characteristics is difficult to refine. In the future, the conclusions of this study can be supported by the use of large-scale sample survey data that are more micro and detailed.

This study is limited because we used only one indicator, i.e., LOAN, to represent the amount of urban capital and reflect housing financialization through the impact of LOAN on housing prices. Thus, the indicators related to the scale, degree, and investment efficiency of housing financialization (e.g., incremental social financing scale, incremental social financing scale as a share of GDP, etc.) are ignored. Therefore, more indicators that can reflect housing financialization should be considered in future research to verify the spatial heterogeneity of housing financialization in China from the perspective of multiple indicators. This study shows that spatial

heterogeneity exists in the financialization of housing in China, behind which is the complexity of China's housing market, which is affected by internal geospatial, as well as economic mechanisms, such as integrated geography, urban-rural differences, economic policy uncertainties, urban facilities, land management systems, and the number and location of financial institutions, which may be an important direction for subsequent research. In addition, this study used MGWR2.2.1 software to construct a multi-scale geographically weighted regression model, which only supports cross-sectional data to analyze the spatial heterogeneity problem, resulting in a lack of evidence of spatio-temporal scales in the study; and the study did not construct a dynamic panel model or a dynamic spatial model, which ignored the spatial spillover effect. This limitation applies not only to this study but also to studies utilizing MGWR. In the future, we plan to consider the spatio-temporal scales and spatial spillover effects of housing financialization by referring to relevant studies, such as Tomal [83], Le Sage and Pace [84,85] when we obtain panel data.

4.2. Conclusions

This study created a dataset of LOAN and urban fundamentals related to population, employment, economy, and industry to determine their impact on housing prices in 2109 counties (cities and districts) in China. By using OLS and MGWR models, the study identified the spatial scope of housing financialization in China globally and locally and further analyzed the direction and strength of the impact of LOAN on housing prices. The key findings of the study are as follows:

The spatial distribution of housing prices in China is significantly heterogeneous. In general, housing prices in urban agglomerations in the eastern coastal area and provincial capitals in central and western China are significantly higher than those in other regions, namely, the Yangtze River Delta, Beijing–Tianjin–Hebei urban agglomeration, the urban agglomeration on the west side of the Taiwan Strait (around Fuzhou and Xiamen), the Pearl River Delta in Guangdong Province, and Hainan Province. The spatial distribution characteristics of LOAN are similar to those of housing prices, and the high values are mainly concentrated in the eastern coastal city cluster and the capital cities of the central and western provinces.

A global regression model (OLS) was used to verify the relationship between LOAN and housing prices and its significance. The results showed that LOAN has a significant positive influence on housing prices, with a much higher intensity than the other factors selected in this study; this finding is in line with theoretical expectations.

The spatial heterogeneity of the effect of LOAN on housing prices was analyzed through local regression. After testing the geographical variability of local coefficients, the results showed that LOAN, PMPPP, PD, TIAPTGRP, and NNEDS have a spatially heterogeneous effect on housing prices, whereas PEOTS and PCGRP do not. Meanwhile, the MGWR model performed better than the OLS and GWR models; moreover, it could better capture the spatial heterogeneity of housing price drivers. Thus, housing financialization in China exhibits spatial heterogeneity and spatial limitations. The phenomenon of housing financialization in China is mainly reflected in the eastern coastal area of China, including the Beijing–Tianjin–Hebei urban agglomeration and its surrounding area, Shandong Peninsula, Yangtze River Delta (Shanghai, Jiangsu, Zhejiang, and the eastern part of Anhui Province), the urban agglomeration on the west side of the Taiwan Strait, Guangdong Province, and the eastern part of Hainan Province.

In summary, this study examines the spatial scope and spatial heterogeneity of housing financialization in China from the perspective of the impact of loan balances on housing prices. Compared to previous studies, this study focuses on exploring the spatial scope of housing financialization and the differences in the global and local impacts of financialization on housing prices in China. The findings of this study will contribute to our understanding of the spatial limits of the impact of loans on housing prices and the spatial heterogeneity of housing financialization in China. It will also help to further deepen the understanding of China's housing market, provide reference for the government to formulate differentiated housing regulation policies in different regions, prevent the phenomenon of excessive housing, and ensure the smooth operation of the housing market.

4.3. Policy implications

The current housing financialization in China is a prominent issue, and it is urgent to introduce relevant policies and measures to control it. This study proposes the following policy recommendations: first, adhere to the policy of "housing without speculation", weaken the property of housing investment, curb the rapid rise of real estate market prices, guide residents to rationally purchase houses, and supervise real estate enterprises to reasonably operate. In particular, real estate speculators and speculators can be restrained by adjusting the ratio of housing loans and increasing the down payment ratio. Secondly, the government needs to formulate differentiated housing control policies and implement relevant policies in a targeted manner according to the city. Especially for the housing problem in the eastern region, it is necessary to focus on control and prevent the excessive financialization of housing in the eastern region; third, give full play to the government's management function. The relevant departments and local governments need to increase the financial supervision of the housing market, which can be guided by policy and financial support, the construction of a perfect housing rental and purchase information resources sharing service platform, to ensure the normality of financial support, and promote the healthy and stable development of the real estate market.

Data availability statement

The data used in this study are publicly and available. The data involved in the study and their sources have been stated in 2.3 Data.

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Ethics declarations

Review and approval by an ethics committee was not needed for this study because this study does not involve animal experiments, human and behavior studies.

Additional information

No additional information is available for this paper.

CRediT authorship contribution statement

Yang Wang: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Xiaoli Yue:** Writing – original draft, Software, Methodology, Data curation. **Min Wang:** Writing – original draft, Data curation. **Gengzhi Huang:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] J. Li, The Theory of Financialization of Urban Housing in China, Economy & Management Publishing House, Beijing, 2020.
[2] I. Leijten, K. de Bel, Facing financialization in the housing sector: a human right to adequate housing for all, Neth. Q. Hum. Rights 38 (2) (2020) 94–114.
[3] M.B. Aalbers, Corporate Financialization, International Encyclopedia of Geography: People, the Earth, Environment and Technology, Wiley, Oxford, England, 2016.
[4] M.B. Aalbers, The financialization of home and the mortgage market Crisis, in: The Financialization of Housing, Routledge, New York, 2016.
[5] J. Chen, F. Wu, Housing and land financialization under the state ownership of land in China, Land Use Pol. 112 (2022) 104844.
[6] J. Li, Y. Dong, Z. Ren, The financialization of housing, decline of depositto-ioan ratio and transformation to housing capital: the more you save, the more houses you buy? Modern Finance and Economics-J of Tianjin University of Finance and Economics 41 (10) (2021) 68–83.
[7] S. Kohl, More mortgages, more homes? The effect of housing financialization on homeownership in historical perspective, Polit. Soc. 46 (2) (2018) 177–203.
[8] F. Wu, J. Chen, F. Pan, N. Gallent, F. Zhang, Assetization: the Chinese path to housing financialization, Ann. Am. Assoc. Geogr. 110 (5) (2020) 1483–1499.
[9] K. Addae-Dapaah, Housing loan and t\he price of housing in Singapore, J. Bus. Econ. 5 (9) (2014) 1513–1524.
[10] J. Muellbauer, The assessment: consumer expenditure, Oxf. Rev. Econ. Pol. 10 (2) (1994) 1–41.
[11] Y. Liu, Y. Guo, D. Xie, X. Xiao, W. Hu, Research on the impact and mechanism of financial development on new urbanization: a case study of the Yangtze River Economic Belt, PLoS One 18 (8) (2023) e0289758-e0289758, https://doi.org/10.1371/journal.pone.0289758.
[12] W. Ding, J. Du, Y. Kazançoğlu, S.K. Mangla, M. Song, Financial development and the energy net-zero transformation potential, Energy Econ. 125 (1) (2023) 106863, https://doi.org/10.1016/j.eneco.2023.106863.
[13] A.K.M. Mohsin, M.D. Rashidul Islam Sheikh, H. Tushar, M. Masum Iqbal, Syed Far Abid Hossain, Md Kamruzzaman, Does FinTech credit scale stimulate financial institutions to increase the proportion of agricultural loans, Cogent Econ. Finance. 10 (2022) 2114176, https://doi.org/10.1080/23322039.2022.2114176.
[14] D. Anastasiou, P. Kapopoulos, K.M. Zekente, Sentimental shocks and house prices, J. Real Estate Financ, Econ. Times 67 (2021) 627–655.
[15] W. Kuang, Expectation, speculation and urban housing price volatility in China, in: Advances in Management of Technology, 2010, pp. 148–160. PT 1.
[16] Y. Wang, T. Kinugasa, The relationship between demographic change and house price: Chinese evidence, Int. J. Econ. Policy Stud. 16 (1) (2022) 43–65.
[17] M. Adelino, A. Schoar, F. Severino, House prices, collateral, and self-employment, J. Financ. Econ. 117 (2) (2015) 288–306.
[18] N.K. Kishor, H.A. Marfatia, G. Nam, M.H. Rizi, The local employment effect of house prices: evidence from US States, J. Hous. Econ. 55 (2022) 101805, https://doi.org/10.1016/j.jhe.2021.101805.
[19] M. Sahoo, House price bubbles and its predictive capacity on inflation and economic growth: some Indian evidence, J. Publ. Aff. 22 (2022) e2464.
[20] S. Vogiazas, C. Alexiou, Determinants of housing prices and bubble detection: evidence from seven advanced economies, Atl. Econ. J. 45 (1) (2017) 119–131.

[21] Z. Zhou, A. Zhang, High-speed rail and industrial developments: evidence from house prices and city-level GDP in China, Transp. Res. Pt. A-Policy Pract. 149 (2021) 98–113.
[22] V. Karlsson, Modern Industrial Structure and Development of House Price Spatial Disparity: A General Case for Iceland-a Large but Thinly Populated European Country, 2007, pp. 96–116.
[23] Y. Shen, H. Liu, Housing prices and economic fundamentals: a cross city analysis of China for 1995–2002, Econ, Res. J. 6 (7) (2004) 78–86.
[24] S.H. Lee, J.H. Kim, J.H. Huh, Land price forecasting research by Macro and micro factors and real estate market utilization plan research by landscape factors: Big data analysis approach, Symmetry 13 (4) (2021) 616.
[25] R. Wang, J. Hou, Land finance, land attracting investment and housing price fluctuations in China, Int. Rev. Econ. Finance 72 (2021) 690–699.
[26] G.C. Lin, A. Smart, X. Li, F.Z. Hu, Financializing Chinese cities: state–capital nexus and the uneven geography of housing speculation, Area Dev. Policy 4 (4) (2019) 435–453.
[27] M.B. Aalbers, The Financialization of Housing: A Political Economy Approach, Routledge London, England, 2016.
[28] A. Smart, J. Lee, Financialization and the role of real estate in Hong Kong's regime of accumulation, Econ, Geogr 79 (2) (2003) 153–171.
[29] R. Fernandez, M.B. Aalbers, Financialization and housing: between globalization and varieties of capitalism, Compet. Change 20 (2) (2016) 71–88.
[30] D.J. Huang, C.K. Leung, B. Qu, Do bank loans and local amenities explain Chinese urban house prices?, China Econ, Rev 34 (2015) 19–38.
[31] M. Liu, Q.P. Ma, Determinants of house prices in China: a panel-corrected regression approach, Ann. Reg. Sci. 67 (1) (2021) 47–72.
[32] Z. Su, J.T. Huang, A.J. Lin, House price expectations, mortgages, and subjective well-being in urban China, J. Consum. Aff. 55 (4) (2021) 1540–1562.
[33] W. Li, Z. Cai, S. Cao, What has caused regional income inequality in China? Effects of 10 socioeconomic factors on per capita income, Environ. Dev. Sustain. 23 (9) (2021) 13403–13417.
[34] X. Qin, Y.D. Wei, Y. Wu, X. Huang, Regional development and inequality within city regions: a study of the Yangtze River Delta, China, Geogr. Rev. 113 (3) (2021) 359–385.
[35] K. Rogoff, Y. Yang, Has China's housing production Peaked? China World Econ. 29 (1) (2021) 1–31.
[36] Y. Wang, S. Wang, G. Li, H. Zhang, L. Jin, Y. Su, K. Wu, Identifying the determinants of housing prices in China using spatial regression and the geographical detector technique, Appl. Geogr. 79 (2017) 26–36.
[37] K. Chen, Y. Wen, The great housing boom of China, Am. Econ. J. Macroecon. 9 (2) (2017) 73–114.
[38] Y. Cai, Y. Zhu, M. Helbich, Club convergence of regional housing prices in China: evidence from 70 major Cities, Ann. Reg. Sci. 69 (1) (2022) 33–55.
[39] Y. Zhao, R. Wei, C. Zhong, Research on spatial spillover effects and regional differences of urban housing price in China, Econ. Comput. Econ. Cybern. Stud. 55 (2) (2021) 211.
[40] Y. Lin, M. Shi, Impact of the irrational rise of housing prices on the mechanism of advanced industrial structure, J. Urban Plann. Dev. 148 (1) (2022) 05021068.
[41] D. Wang, T. Ye, S. Tian, X. Wang, Reexamining spatiotemporal disparities of financial development in China based on functional data analysis, Math. Probl Eng. 2021 (2021) 5539035.
[42] H. Du, R.B. King, What predicts perceived economic inequality? The roles of actual inequality, system justification, and fairness considerations, Br. J. Soc. Psychol. 61 (1) (2022) 19–36.
[43] F. Xu, Z. Wang, G. Chi, D. Wang, Z. Zhang, D. Zuo, Differentiation and progress of urban regionalization in China: perspectives of land use and geography, Appl. Geogr. 137 (2021) 102600.
[44] N. Liu, J. Strobl, Impact of neighborhood features on housing resale prices in Zhuhai (China) based on an (M) GWR model, Big Earth Data 7 (1) (2022) 146–169.
[45] X. Liao, M. Deng, H. Huang, Analyzing multiscale spatial relationships between the house price and visual environment factors, Appl. Sci. 12 (1) (2021) 213.
[46] Y. Ji, X. Guo, S. Zhong, L. Wu, Land financialization, uncoordinated development of population urbanization and land urbanization, and economic growth: evidence from China, Land 9 (12) (2020) 481.
[47] J. Migozzi, Selecting spaces, classifying people: the financialization of housing in the south African city, Hous. Policy Debate 30 (4) (2020) 640–660.
[48] G. Kalman-Lamb, The financialization of housing in Canada: intensifying contradictions of neoliberal accumulation, Stud. Polit. Econ. 98 (3) (2017) 298–323.
[49] A.L.D.S. Pereira, Financialization of housing in Brazil: new frontiers, Int. J. Urban Reg. Res. 41 (4) (2017) 604–622.
[50] G. Wijburg, M.B. Aalbers, The alternative financialization of the German housing market, Hous. Stud. 32 (7) (2017) 968–989.
[51] R. Kelly, F. McCann, C. O'Toole, Credit conditions, macroprudential policy and house prices, J. Hous. Econ. 41 (2018) 153–167.
[52] İ. Ayberk, Z. Önder, House prices and bank loan portfolios in an emerging market: the role of bank ownership, Econ, Model 106 (2022) 105683.
[53] S.A. Gabriel, F.E. Nothaft, Rental housing markets, the incidence and duration of vacancy, and the natural vacancy rate, J. Urban Econ. 49 (2001) 121–149.
[54] J. Chen, F. Guo, Y. Wu, One decade of urban housing reform in China: urban housing price dynamics and the role of migration and urbanization, 1995–2005, Habitat Int. 35 (1) (2011) 1–8.
[55] D. Miles, Population density, house prices and mortgage design, Scott, J. Polit. Econ. 59 (5) (2012) 444–466.
[56] J. Prüser, T. Schmidt, Regional composition of national house price cycles in the US, Reg. Sci. Urban Econ. 87 (2021) 103645.
[57] B. Yu, Urban spatial structure and total-factor energy efficiency in Chinese provinces, Ecol. Indicat. 126 (2021) 107662.
[58] M. Syrquin, Resource reallocation and productivity growth, Econ. Struct. Perform. (1984) 75–101.
[59] X. Liu, Housing renewal policies, house prices and urban competitiveness, Appl. Geogr. 30 (2) (2010) 221–228.
[60] B. Hossain, E. Latif, Determinants of housing price volatility in Canada: a dynamic analysis, Appl. Econ. 41 (27) (2009) 3521–3531.
[61] J. Roback, Wages, rents, and the quality of life, J. Polit. Econ. 90 (6) (1982) 1257–1278.
[62] F. Krausmann, C. Lauk, W. Haas, D. Wiedenhofer, From resource extraction to outflows of wastes and emissions: the socioeconomic metabolism of the global economy, 1900–2015, Glob. Environ. Change-Human Policy Dimens. 52 (2018) 131–140.
[63] C. Liu, M. Gao, G. Zhu, C. Zhang, P. Zhang, J. Chen, W. Cai, Data driven eco-efficiency evaluation and optimization in industrial production, Energy 224 (2021) 120170.
[64] P. Healey, Urban policy and property development: the institutional relations of real-estate development in an old industrial region, Environ. Plann. 26 (2) (1994) 177–198.
[65] G.D. Jud, D.T. Winkler, The dynamics of metropolitan housing prices, J. R. Estate Res. 23 (1/2) (2002) 29–46.
[66] X. Chen, H. Yang, An empirical analysis on relationship between housing price and land price in China, Journal of WUT (Information & Management Engineering) 35 (2013) 440–443.
[67] C. Bitter, G.F. Mulligan, S. Dall'erba, Incorporating spatial variation in housing attribute prices: a comparison of geographically weighted regression and the spatial expansion method, J. Geogr. Syst. 9 (1) (2007) 7–27.
[68] D.M. Hanink, R.G. Cromley, A.Y. Ebenstein, Spatial variation in the determinants of house prices and apartment rents in China, J. Real Estate Financ, Econ. Times 45 (2) (2012) 347–363.
[69] D. Yu, Y.D. Wei, C. Wu, Modeling spatial dimensions of housing prices in Milwaukee, WI, Environ. Plann. Plann. Des. 34 (6) (2007) 1085–1102.
[70] H. Li, Y.D. Wei, Z. Yu, G. Tian, Amenity, accessibility and housing values in metropolitan USA: a study of Salt Lake County, Utah, Cities 59 (2016) 113–125.
[71] A.S. Fotheringham, W. Yang, W. Kang, Multiscale geographically weighted regression (MGWR), Ann. Am. Assoc. Geogr. 107 (6) (2017) 1247–1265.
[72] T. Shen, H. Yu, L. Zhou, H. Gu, H. He, Hedonic price of second-hand houses in Beijing based on Multi-scale Geographically Weighted Regression: scale law of spatial heterogeneity, Econ, Geogr 40 (3) (2020) 75–83.
[73] Y. Mou, Q. He, B. Zhou, Detecting the spatially non-stationary relationships between housing price and its determinants in China: guide for housing market sustainability, Sustainability 9 (10) (2017) 1826.
[74] Y. Wang, K. Wu, L. Jin, G. Huang, Y. Zhang, Y. Su, H.O. Zhang, J. Qin, Identifying the spatial heterogeneity in the effects of the social environment on housing rents in Guangzhou, China, Appl. Spat. Anal. Policy 14 (4) (2021) 849–877.
[75] T.J. Hastie, R.J. Tibshirani, Generalized Additive Models, Routledge, New York, 2017.
[76] F. Wu, Land financialisation and the financing of urban development in China, Land Use Pol. 112 (2022) 104412.
[77] Y. Jiang, L. Zheng, L.X. Wang, Research on external financial risk measurement of China real estate, Int. J. Financ. Econ. 26 (4) (2021) 5472–5484.

[78] G. Wijburg, The de-financialization of housing: towards a research agenda, Hous. Stud. 36 (8) (2021) 1276–1293.
[79] N. Aveline-Dubach, China's housing booms: a Challenge to bubble theory, in: D. Pumain (Ed.), Theories and Models of Urbanization. Lecture Notes in Morphogenesis, Springer, Cham, 2020, pp. 183–208, https://doi.org/10.1007/978-3-030-36656-8_11.
[80] D.B. Sae Park, Y. Park, Price run-up in housing markets, access to bank lending and house prices in Korea, Int. J. Financ. Econ. 40 (3) (2010) 332–367.
[81] G. Chen, K. Dong, S. Wang, X. Du, R. Zhou, Z. Yang, The dynamic relationship among bank credit, house prices and carbon dioxide emissions in China, Int. J. Environ. Res. Publ. Health 19 (16) (2022) 10428, https://doi.org/10.3390/ijerph191610428.
[82] R. Gimeno, C. Martínez-Carrascal, The relationship between house prices and house purchase loans: the Spanish case, J. Bank. Finance 34 (8) (2010) 1849–1855, https://doi.org/10.1016/j.jbankfin.2009.12.011.
[83] M. Tomal, Exploring the meso-determinants of apartment prices in Polish counties using spatial autoregressive multiscale geographically weighted regression, Appl. Econ. Lett. 29 (9) (2022) 822–830.
[84] J.P. LeSage, R.K. Pace, Introduction to Spatial Econometrics, Chapman & Hall/CRC, Boca Raton, Florida, USA, 2009.
[85] J.P. LeSage, R.K. Pace, Spatial Econometric models, in: Handbook of Applied Spatial Analysis, Springer, Berlin and Heidelberg, Germany, 2020, pp. 355–376.