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Spatially non-stationary relationships between urban residential land price and impact factors in Wuhan city, China

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ABSTRACT

Land price plays an important role in guiding land resource allocation for urban planning and development, particularly in big cities of fast developing countries where infrastructures and populations change frequently. Therefore, detecting spatially implicit information in the spatial pattern of relationships between land price and related impact factors is critical. Geographically weighted regression (GWR) analysis was conducted in this study for the purpose in Wuhan, China, by using a 10-year panel data set of residential land price. Based on twelve factors in three aspects (land attributes, location factors and neighborhood attributes), an evaluation index system of resident land price was established. The spatial distributions of estimated coefficients and pseudo t-values of three major explanatory variables (floor area ratio, distance to nearest center business district (CBD) and distance to nearest lake), obtained from GWR analysis, indicated that their relationships of the impact factors with land price are spatially non-stationary. The positive impact of floor area ratio on land price is more significant in highly developed areas than in less developed areas. Conversely, the negative impact of distance to nearest CBD on land price is larger in highly developed areas than in less developed areas. Moreover, wealthier dwellers may be willing to pay a higher price for a good lake view (especially views of small lakes), but infrastructure barriers (near some large lakes) cause negative effect. The outputs of this study, which provide detailed information on the relationships between land price and impact factors in local areas, are promising for urban planners to scientifically evaluate land price and make area-specific strategies.

1. Introduction

Urbanization is one of the most significant changes occurred in contemporary human society. China, like some other countries, has witnessed the urbanization process with a variety of changes in many aspects, such as urban population, land resource, economy and environment. Particularly, China is urbanizing at an unprecedented rate. It is perhaps the greatest human-resettlement experiment in history (Bai, Shi, & Liu, 2014). The current sizes and number of cities in China are showing a growing trend, and the rapid change in urban land use has impressed the world. As we have seen, urban land use change is known as a complex interactional product of natural, economic, environmental and social factors, while land price as an important driving force affects the direction and strength of urban land use change expressed by urban horizontal expansion and vertical development (Hu, Cheng, Wang, & Xu, 2013; Morris & Michael, 2008).

Urban land price, as an indicator for the land market development degree of a city or region, is an important reference to guide the planning authority to make land use policy and home buyers to purchase their houses. During the past several years, the issues

Abbreviations: GWR, geographically weighted regression; OLS, ordinary least squares regression; R^2, coefficient of determination; AICc, corrected Akaike Information Criteria; EBK, Empirical Bayesian kriging; VIF, Variance Inflation Factor; CBD, central business district; D_CBD, distance to nearest CBD; D_lake, distance to nearest lake.

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associated with the spatial distribution of urban land price have been of interest to investigators for optimizing land use management. There is growing literature on the temporal and spatial distributions of land price and the underlying driving mechanism (McMillen, 2003; Wen & Goodman, 2013). In most studies, inverse distance weighting (IDW), kriging interpolation and some other mathematical methods were popularly used to describe the temporal and spatial distributions of land price. Recently, the multifractal interpolation method was used to explore the distribution of urban residential land price, and proved to be suitable for characterizing the local anomalies of land price (Hu, Cheng, Wang, & Xie, 2012).

It is obvious that the complexity of the spatial difference of the land price results from the combined effects of many driving factors. Thus, driving factors of the spatial-temporal variation of land price become another hot research topic. As we all know, all factors that affect the distribution of urban land price are intricate and uncertain. These factors include not only international environment, national policies, and social and economic development at the macro level, but also traffic conditions, community stability, and land speculation at the micro level. So far, many researches have been done to explore the influencing factors of land price from different perspectives. At the macro-level, for example, McDonald and McMillen (1998) carried out a comparison study of the land prices in Chicago before and after the land-use zoning system was adopted in 1923 in order to explore the influence of policy; Atack and Margo (1998) discussed the influence of the American Civil War to land price in New York. Factors are much easier to be detected quantitatively at the micro-level than at the macro-level. Many studies at the micro-level were focused on the floor area ratio, parcel area, and distance to nearest CBD (Colwell & Munneke, 1999), among others. However, it was found that good outdoor environment, including green space provision, proximity to parks, and views of green space and water, carried significant hedonic values (Bond, Seiler, & Seiler, 2002; Jim & Chen, 2007; Lansford & Jones, 1995). Thus, increasing researches began to focus on landscape and infrastructure factors, such as sea (Benson & Hansen, 1998), lake (Bond et al., 2002), forest (Sharma, 2013), and park (Tian & Jim, 2012). A very popular method is the hedonic price method, which was used to measure the hidden values of driving factors. But the existing literature has also suffered from a lack of consideration of regional variations of land price in the rapidly changing land market.

Geographically weighted regression (GWR), a local spatial statistical method, emerged in recent years for evaluating how the relationships between a dependent variable and one or more explanatory variables change spatially (Brunsdont, Fotheringham, & Chariton, 1998). Since the study of Brunsdont et al. (1998), there has growing literature concentrating on residual analysis (Zhang, Gove, & Heath, 2005), stationary test (Leung et al., 2013), arithmetic exploration (Mei, He, & Fang, 2004) and other related theoretical studies for GWR. Because of the obvious superiorities of GWR, it has been widely utilized in many fields in recent years. For example, the Geographic variation and impact factors of land use change (Tu & Xia, 2008), deforestation (Jaimes, Sendra, Delgado, & Plata, 2010), burglary (Breetzke, 2012), childhood drowning (Dai, Zhang, Lynch, Miller, & Shakir, 2013), residents' recreation demand (Lee & Schuett, 2014), urban space (Nilsson, 2014), male suicide (Trgovac, Kedron, Bagchi-Sen, 2015), municipal water consumption (Connolly and Hagelman, 2015) and mapping of population (Cockx and Canters, 2015) have been investigated using GWR.

Although many studies indicated that the influencing factors of land price are complex and their impacts on land price are difficult to be identified accurately, the research in spatial heterogeneity of influence factors of land price has received little attention so far. More importantly, land price plays an important role in guiding land resource allocation for urban planning and development, particularly in big cities of developing countries where infrastructures and populations change frequently. In addition, spatially implicit information on the spatial pattern of relationships between land price and related impact factors is critical and should be detected. Therefore, the general purpose of this paper is to detect the spatially non-stationary relationships between land price and related impact factors using the GWR approach, so that we can better characterize the spatial distribution of land price, analyze related local impact factors and their influencing mechanisms, improve the forecast level of urban land price, and optimize the allocation of land resources.

The whole paper is arranged as follows: Section 2 presents the methods for data collection and processing. Section 3 discusses the spatial variation of urban residential land price, examines the advantages of geographically weighted regression in exploring the spatially varying relationships, and analyzes the spatially varying correlations of the three main factors (floor area ratio, distance to nearest CBD and distance to nearest lake) with land price. Finally, the conclusions and discussion derived from this analysis are given in Section 4.

2. Materials and methods

2.1. Study area

As shown in Fig.1, this study was carried out in the Wuhan metropolis, which lies in the east-central Hubei Province in central China (at 29°58′–31°22′N and 113°41′–115°05′E). The Yangtze River, the largest river in China, and the Han River both cross this city. The central region of the city is divided by these two rivers into three geographical parts, namely Hankou, Wuchang, and Hanyang. In view of functional zoning, Wuchang is the provincial administrative and educational center, Hankou is the commercial, financial and city administrative center, and Hanyang is the industrial base. The main city area of Wuhan is divided into seven administrative districts: Jianghan, Jiang'an, Qiaokou, Hanyang, Wuchang, Hongshan, and Qingshan. This city possesses abundant water resources and typical water landscape. There are 166 lakes in the administrative region, among which 65 lakes are bigger more than 5 km^2. The East Lake is the largest one, with an area of 33 km^2. The total water area accounts for a quarter of the whole city land area. According to the Great Wuhan Development Strategy towards 2049 (WMG, 2012), Wuhan will focus on the development of its water network, and strive to build a livable water landscape city. All of the natural factors play a key role in the land price distribution. Therefore, considering the rate of city expansion of Wuhan, the distribution of samples and the scale requirements of the methods, the area within the third ring road of Wuhan was chosen as our study area.

2.2. Data collection and processing

2.2.1. Land price

In China, residential, commercial and industrial lands are the three main land use classes, and they are located in different areas. Residents get their land use rights mainly through land transfer in the primary land market by four ways, namely, auction, bidding, listing and leasing. Since 1990s, after the tangible real estate market began to appear on the Chinese economic stage, the statistical, analytical and releasing information of residential land price has been always an important part of urban land management. Therefore, based on the sample distributions of price features in