Spatial Distribution of Residential Land Price in Cangzhou City Based on DLPM

Hongjie Liu¹, Yuan Meng¹, Jing Ma¹ and Yu Su¹

¹ Urban Construction School, Beijing City University, Beijing, 101399, China

Abstract. This paper mainly takes Cangzhou City as an example to study spatial distribution of residential land price. Through the exploratory spatial data analysis of the land price in Cangzhou City, the land price distributed as inverted u-shaped, and the land price decreases from the center of the city to surroundings. The residential land price in north-south direction changes more dramatically than that in east-west direction. The land price in the east-west direction is low in east and high in west. Through the GIS spatial analysis tool, the digital land price model (DLPM) of residential land price in two stages of Cangzhou City was established respectively. Through the model analysis, the spatial variation characteristics of land price in Cangzhou City from 2007 to 2013 were revealed: (1) The distribution of residential land price was presented obviously centripetal and location relevant, and the land price decreases from the center of the city to the surroundings. (2) The residential area of high land price is transferred from the east to the west. (3) The residential land price develops from a single center pattern to multi-center pattern, and the regional sub-center appears. (4) The railway has barrier effect on residential land price.

1. Introduction
In recent years, urban residential land prices have shown an upward trend nationwide, and there are many factors that form this trend. However, specific to a certain city, the land price presents different spatial correlation and heterogeneity, and many scholars pay attention to the spatial distribution of residential land price within the city. Colwell P studied the spatial distribution of land price in the CBD area of Chicago by using the piecewise parabolic multiple regression analysis method. The non-parametric method was used to study the spatial distribution of land price for the first time, and the existing space method was improved. The study of residential land prices through GIS analysis can not only reveal the spatial distribution of land prices, but also effectively explain the reasons for residential land price changes. Li L et al. used the Kriging optimal interpolation method in GIS to reveal the spatial distribution of different types of land prices in Beijing, and found that the spatial adjacent effect between commercial, residential, industrial and comprehensive land prices is more obvious. Jiang F et al. used the combination of GIS spatial analysis and statistical methods to analyze the spatial distribution and cause of residential land transfer price in Beijing. The results show that the spatial distribution of land price has the characteristics of continuity and variability. Through the empirical analysis of the land price in Hangzhou, Wu Y et al. revealed that the land price distribution map formed by Kriging interpolation has a high consistency with the land price distribution map established by the actual market data. Based on the land price data of Jinan City in 1998 and 2001, Zheng X et al. established a digital land price model (DLPM) by IDW method, and made profile analysis. Many scholars have applied GIS spatial analysis methods combined with geostatistical research methods to study the spatial distribution of different types of land prices in different regions,
such as the spatial distribution of residential land prices in Yuyao City, spatial distribution of residential land prices in Lanzhou City, spatial distribution of residential land prices in the main urban area of Nanjing, spatial distribution of industrial land prices in the Beijing-Tianjin-Hebei urban agglomeration, spatial distribution of land price in Xi’an City.

This paper takes Cangzhou City as an example to construct the Digital Land Price Model (DLPM) of residential land price, analyzes the spatial distribution characteristics of residential land price and proposes land price control measures, in order to enrich the research case of land economics from the method and practice, and provide a powerful reference for land management in similar areas.

2. Research area overview and basic data

2.1. Overview of the study area
Cangzhou City is located in the southeast of Hebei Province, in the center of the Bohai Bay. It is located between 115°06’ and 117°08’ east longitude and between 37°04’ and 38°09’ north latitude. It is only 200 km away from Beijing. It is one of the economic open areas and open coastal cities defined by the State Council. Since 2007, the land market in Cangzhou has developed rapidly and the transaction cases are rich. It has strong representation in small and medium-sized cities in North China.

2.2. Research data sources and pretreatment
According to the distribution of the survey data, the research area of this paper selects the built-up area of the main city: Yingbin Avenue in the west, Changlu Avenue in the east, Haihe Road in the south, and Bohai Road in the north, with an area of about 55 km². The research data collected in this paper spans from 2007 to 2013, mainly from the survey data of benchmark land price update of 2014. A total of 147 valid data samples were collected in this study. Due to the limited number of plots sold in the built-up area within the study time range, the research area data mainly comes from the second-hand housing market transaction data and commercial housing sales data. According to the “Urban Land Valuation Regulations” (GB/T 18508-2014), the second-hand housing transaction data and commercial housing sales data can be measured by the income method. Since the land price level in the land market changes from time to time, in order to ensure the consistency of the transaction time of the sample data, the transaction time of all residential land price samples was revised to December 2013 in this study. The land price of all sample sites is revised to the land price corresponding to 70 years’ land use right. All land price samples will be uniformly revised to the seven access and site leveling. Correct the plot ratio of all land price samples to 2.5.

3. Analysis of the overall trend of land price data samples
In order to study the overall spatial distribution trend of land price data samples, the data was analyzed using trend analysis tool of ArcGIS. The analysis results are shown in Figure 1.

Figure 1. Spatial trends of residential land price in Cangzhou City
As can be seen from Figure 1, the land price of the sample presented reverse "u" shape in the east-west direction and the north-south direction. The land price is the highest in the center of the city and gradually decreases toward the periphery. The shape of the two projection curves shows that the land price varies in the east-west direction and the north-south direction. The land price curve in the east-west direction is relatively flat, and the land price change is relatively small. The land price curve in the north-south direction is steep, and the land price change is relatively large. The east-west curve shows a significant imbalance at the edge, and the land price is characterized by an imbalance between the west and the east.

The spatial distribution law of land price is more consistent with the urban development status of Cangzhou City. At present, the geological conditions in the northeastern part of Cangzhou City are poor, the soil bearing capacity is low, and it is not suitable for large-scale urban development land. The separation effect of Beijing-Shanghai Railway on urban areas is more significant. The TDI chemical enterprises established in the eastern part of the city also affected the expansion of the city to the east, resulting in a lower level of land prices in the east. On the contrary, the development of the city to the west has a series of favorable conditions. First, the western part of the city is the main entrance and exit direction of important cities in the Beijing-Tianjin-Hebei region. It has unique advantages in gateway location and transportation advantages. Secondly, the completion of the Beijing-Shanghai high-speed railway station will extremely drive the urban development to the west. Third, the urban geology of the western area is good, suitable for urban construction land, and a series of factors have led to the rising trend of land prices in the western part of the city. The southward and northward development of the city has been restricted to varying degrees. The high-voltage line network in the south of the 307 national highway is relatively dense, which is not conducive to urban construction. The south is separated by rivers, railways, highways, etc., and the land use structure is incomplete. The amount of house demolition is large in south area, and the cost of urban construction is relatively high. In the north, due to the penetration of the Shuo-Huang Railway, the space is relatively fragmented and scattered, the traffic connection is not smooth, and the lack of external driving leads to insufficient development momentum. Due to the low development, the price of land in the south and north of the city has been at a low level, and the upside potential is relatively small.

4. Spatial distribution of residential land price in Cangzhou City based on DLPM

4.1 Introduction of DLPM
The Digital Land Price Model (DLPM) is a surface model that uses a set of ordered numerical arrays to represent the land price. It is a branch of the Digital Terrain Model (DTM) and a derivation of digital elevation model (Digital Elevation). In the digital land price model, the land price surface is a binary continuous function with the spatial price point coordinates as the independent variable and the land price as the dependent variable. It is a continuous curved surface formed by spatial interpolation of the land sample, which can describe the overall trend of land price changes more intuitively and accurately. A vertical section is formed on the surface of the land price in a certain direction, and a land price profile is formed. The tangent line intersecting the surface of the land price is the land price section line, which can visually reflect the trend of land price change in a certain direction. Before the urban land price profile study, the base point needs to be selected. The base point can be selected in the city center to reflect the land price change from the center to the edge of the city. It can also be selected at the edge of the city to obtain the land price curve throughout the study area.

4.2 Spatial distribution of residential land price in Cangzhou City based on DLPM
The ordinary Kriging interpolation method for interpolation is used in this paper. The time span of the research data in this paper is from 2007 to 2013. During the seven years, the social economy of Cangzhou City grew rapidly and the real estate market developed rapidly. At the same time, according to the overall layout plan of Cangzhou City, the main city of Cangzhou City gradually expanded to the west and gradually formed a regional sub-center. The spatial changes in economic and urban
development have directly affected the spatial evolution of urban residential land prices. In order to reflect the time evolution of residential land price in Cangzhou City, this paper divides the data into two stages, including 2007-2009 as the first stage and 2010-2013 as the second stage. The two-stage digital land price model is shown in Figure 2, 3.

Comparing the two-stage digital land price model, we can find the time and space differentiation law of residential land price in Cangzhou City:

4.2.1 The distribution of residential land price is obviously centripetal and location-related. Both Figures 2 and 3 show that the residential land price in Cangzhou City generally shows a trend of decreasing from the center to the periphery, and the land price change reflects a certain spatial continuity. The traditional business center of Cangzhou City is located in the area surrounded by Qingchi Avenue, Xinhua Road, Jiefang Road and Shuiyuesi Street in Xinhua District. The area is densely distributed with shopping malls such as Huabei Commercial Building, Yihe Mall and Cangzhou Mall. The transportation and livelihood are convenient, which largely raise the housing price. The two-stage digital land price models show that the land price decreases from the center to the surrounding. The farther away from the city center, the lower the land price is, reflecting the spatial centripetality and location relevance of the land price, in line with bid rent theory of Alonso. The land price is a function of the location, where the spatial elements are concentrated, the external effect is stronger, and the location advantage is obvious. The land user must pay the high rent, and the peak price area is formed. The peak residential land price in Cangzhou City is concentrated in the business center area, indicating that the residential structure of Cangzhou City is currently in a stage of mixed allocation with residential and commercial buildings. The commercial center formed for a long time has a profound impact on the distribution of residential structure.

4.2.2 The residential area with high land price is transferred from the east to the west. In Figure 2, the residential area with high land price is mainly concentrated in the old city business center, which extends to surroundings. The extent of high land price extending westward is slightly higher than the eastward, and the westernmost end of the extension is Yong'an Avenue. In Figure 5, the high land price has obviously expanded and shifted to the west, and its westward extension is close to the Yingbin Avenue. There is no significant change in land prices in the east. This trend of change is related to the evolution of urban planning in Cangzhou.

The city of Cangzhou is divided into the Xinhua District in the east and the Canal district in the west by the Canal. The current business center of Cangzhou City is located in Xinhua District, which is the historical reason for the development of the city. In the early 1990s, according to the urban planning of Cangzhou City, the direction of urban development focused on the east. In the mid-1990s, the commercial center such as Cangzhou Mall opened, forming the rudiment of the current urban center in the Huabei commercial area, and the surrounding residential area with high value gradually
formed. Since 2000, with the reform and opening up and economic development, due to the influence of the Beijing-Shanghai Expressway in the western part of the city, the development of land use in the city has clearly shifted westward, and the driving force for urban development of the old Beijing-Shanghai railway has gradually weakened. Since 2005, Cangzhou City has planned to locate the Beijing-Shanghai high-speed railway station in the western part of the city, which has accelerated the development of the city to the west to a greater extent, and the land price in the west has gradually increased. Figure 2 and 3 show that, from 2007 to 2009, the land price in the west is basically the same as the land price in the east. At this time, the planning museum, library and museum in Cangzhou are under construction. In 2013, the planning hall and library have been put into use, and other public facilities are under construction, which further raised the surrounding land price. In Figure 5, the residential land price in the western part of the city is significantly higher than that in the east.

4.2.3 The distribution of residential land price changes from single center to multi-center, and regional sub-center appears. Figure 2 shows that during the period of 2007-2009, the peak price of the whole city was concentrated in central business district (Xinhua District) of the old city, including the west side of Qingchi Avenue, the east side of the Canal, and the area around the Xinhua Road. The land price gradient in the west is lower than that in the east. Figure 3 shows that during the period of 2010-2013, the original peak land price area remained unchanged. At the same time, in the Canal District, a new land price peak area centered on the Tongtian shopping mall area appeared. The land price of the surroundings shows that the influence of the Tongtian shopping mall is not as good as that in the Yihe Mall. However, the highest land price around the Tongtian shopping mall has reached 3270 yuan/m², which is close to the highest price of the old city business center of 3383 yuan/m². From the trend of rising land prices in the west, the degree of influence of the sub-center may be further expanded.

4.2.4 The barrier effect of railway on land price. Both Figure 2 and 3 show that the residential land price is continuously distributed as a whole. The decrease of land price in westward is slower, and the land price in the west and urban center are more continuous. The land price in the east is decreasing layer by layer, and the decline is more severe in the east of the railway, and the land prices on the two sides of the railway show more obvious differences. This change shows that the railway has a certain degree of barrier to land price, and the change in land price actually reflects the changes in urban development. In the process of urban development to the east, due to the barrier of the railway, the development speed of the area in the east of the railway is relatively slow. Compared with the western new urban area, the infrastructure and public facilities of the old urban area in the east are at a low level, which has a certain impact on the land price level.

In summary, the surface map of the digital land price model intuitively reflects the main characteristics of the overall space distribution of residential land price in Cangzhou City. In order to further study the local characteristics of residential land price distribution in Cangzhou City, it can be analyzed through the land price profile. The key to the profile analysis is to select the appropriate base point. According to the above, the the city center (peak area of land price) is generally selected as the central base point. In this paper, the western and northern margins of the study area is selected as the base point, and makes the hatching line to the east and the south. The west east direction is along the old city business center Huabei Commercial Building, and the north-south direction is along the new city business center Tongtian Shopping Center. The result is shown in Figure 4.

Figure 4(a) and Figure 4(b) are profile maps of the west-east direction including the Old City Business Center in two stages. From the curve shape in the two figures, it can be seen that compared with the land price level of 2007-2009, the land price in the west of the city has increased significantly in 2010-2013, reaching a high level 2km away from Yingbin Avenue. This point is located at the north side of Tongtian Shopping Center, the regional sub-center, indicating that after the formation of the regional sub-center, the surrounding land price, especially the western land price, is risen to some
extent. In contrast, the land price in the eastern part of the Canal (Xinhua District) did not change significantly.

![Figure 4. Profile map of residential land price in Cangzhou](image)

Figures 4-c and 4-d are profile maps of the north-south direction including the sub-centers of the new city in two stages. It can be seen that compared with the land price level of 2007-2009, the Tongtian shopping mall has formed a sub-center, and the central land price has risen considerably in 2010-2013. At the same time, the decline in the land price curve in the north of Tongtian Mall has slowed down, indicating the regional sub-center has a greater impact on the land price in the north than that in the south.

5. Conclusions and discussion
Through the exploratory spatial data analysis of the land price in Cangzhou City, the land price in the east-west direction and the north-south direction of the city are inverted u-shaped, and the land price decreases from the center of the city to surroundings. The shape of the projected curve shows that the residential land price in north-south direction changes more dramatically than that in east-west direction. The price trend in the east-west direction is low in east and high in west. The overall trend of land price reflects the spatial dependence of land prices, and the difference in the four directions reflects a certain spatial heterogeneity. Through the GIS spatial analysis tool, the digital land price model of residential land price in two stages of Cangzhou City was established respectively. Through the model comparison, the spatial variation characteristics of land price in Cangzhou City from 2007 to 2013 were revealed: (1) the distribution of residential land price was presented obviously centripetal and location relevant, and the land price decreases from the center of the city to the surrounding area. (2) The residential area of high land price is transferred from the east to the west. (3) The residential
land price develops from a single center pattern to multi-center pattern, and the regional sub-center appears. (4) The railway has barrier effect on residential land price.

The research in this paper inevitably has some shortcomings that need to be further explored. In terms of data acquisition, due to the limited transaction data of land market in Cangzhou City, the number of land parcels is small, mostly mixed with commercial and residential transfer, and the spatial distribution is not balanced. Considering the availability of research data, this paper selects second-hand housing transaction data and housing sales data as the basis for research. The land price of residential transaction samples is mainly calculated by the residual method. Compared with the directly obtained land transfer data, there is a certain measurement error.

References
[1] Colwell P. (1998) A Primer on Piecewise Parabolic Multiple Regression Analysis via Estimations of Chicago CBD Land Prices. The Journal of Real Estate Finance and Economics, 17(1): 87-97.
[2] Moller J. (2009) Regional variations in the price of building land: a spatial econometrics approach for West Germany. The Annals of Regional Science, 43(1): 113-132.
[3] Li L, Gu S, Hu K. (2003) Analysis method and application of urban land price—a case study of Beijing. Resources Science, (04): 85-92.
[4] Jiang F, Zhu D. (2005) Study of regularities of spatial distribution of land price based on GIS—a case study of residential land price in Beijing. Economic Geography, (02): 199-202.
[5] Wu Y, Wu C. (2001) Study of evaluation of urban benchmark land price based on Kriging technology. Economic Geography, (05): 584-588.
[6] Zheng X, Wang J, Yan H. (2004) Application of DLPM in time-space analysis of urban land price. Resources Science, (01): 14-21.
[7] Lou L, Xu R, He J et al. (2005) Spatial analysis technology and its application in study of land price. Zhejiang Land Resources, (09): 48-51.
[8] Du J, Sun P. (2011) GIS analysis of regularities of spatial distribution of residential land price in Lanzhou City. Hunan Agricultural Sciences, (10): 41-42+44.
[9] Cao T, Huang K, Li J et al. (2012) Time-space evolution of residential land price in main urban area of Nanjing City. Geographical Research, (06): 1029-1038.
[10] Liu L, Hu Y, Zheng X et al. (2014) Study of regularities of spatial distribution of land price in Xi’an City based on GIS. Guangdong Land Science, (02): 43-47.
[11] Zhou X, Wang D. (2013) Study of regularities of spatial distribution of industrial land price in city cluster of Beijing-Tianjin-Hebei, (03): 80-84.