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Analysis on the Spatial-temporal Evolution and Driving Factors of Urban Land Price in Kunming City, Southwest of China

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Abstract:

With the acceleration of urbanization, the distribution of land prices in many cities around the world has undergone rapid changes. It is necessary to simulate the evolution of urban land prices and analyze the change in driving factors. Choosing Kunming City as a case study, this study highlights a dynamic analysis process of land price distribution and its driving factors between 2008 and 2018 using variogram, Kriging valuation and GeoDetector. The results show that the distribution of residential and commercial land prices in Kunming is single-center, and that the center of gravity of high-value areas has shifted to the west. The spatial regularity of land price has weakened. The driving factors of land price include: floor area ratio, distance to the central business district, and distance to the nearest: subway station, public school, hospital, and park. The impact of well-known general hospitals on land prices has increased significantly, while the impact of other factors has declined. Influenced by school enrollment policies and the transformation of the business district, the impact of public primary schools on land prices has remained high, while the impact of public secondary

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schools has weakened.

Keywords: *Residential land price, Commercial land price, Spatial-temporal evolution, Driving factors, Kunming City.*

I. INTRODUCTION

The land market is an important factor market, which has the function of stabilizing society and the economy. Land price is not only a barometer reflecting the economic development of a region, but also an important lever for the government to regulate the land market. Land price has been widely linked to issues of government regulation [1], land use [2], economic growth [3], and real estate market [4]. With the development of the economy, urban land prices in many countries have experienced rapid growth and stable fluctuations. In order to grasp the level of urban land prices, governments and research institutes have monitored prices for commercial, residential, industrial and other types of land. However, there is insufficient research on the spatial-temporal evolution of urban land price and the change in driving factors, which makes it difficult for central and local governments to make urban land spatial planning and land supply policies more effective. In addition, industrial lands are basically located in industrial agglomerations, which are greatly influenced by policy factors. Spatial planning and management are relatively easy. However, the driving factors behind residential and commercial land prices are multiple and it is thus difficult to formulate policies. This paper presents research on a spatial-temporal distribution simulation and on the analysis of change in the driving factors of urban residential and commercial land prices.

With the deepening of land price research, the analysis of spatial-temporal evolution [5] and driving factors have become “hot spots”. Box-counting algorithm [6], digital land price model [7], GIS spatial analysis [8], and other methods are applied to the study of land price evolution. In the analysis of driving factors, the research objective has involved single factor [9] and multi-factors [10]. Research methods have developed from a linear model [11] to some complex models, including a geographically weighted regression (GWR) model [12], a gravitation model [13] and a feature price model [14]. However, changes in the degree of influence of driving factors are often neglected.

GeoDetector (founded in 2010 [15]) offers the advantage of having considerably fewer constraints on the hypothesis. This can effectively overcome the problem of traditional analysis methods in dealing with driving factors geospatially [16]. This study attempts to use GeoDetector to analyze the change in driving factors of land price.

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Although each of the aforementioned methods have in-depth applications, each method alone is insufficient. An integration of spatial-temporal evolution and driving factors analysis is necessary to accurately analyze the reasons for the evolution of land prices to promote the stable development of regional land prices. Kunming is a regional international central city based in southwest China, which radiates to South and Southeast Asia. In recent years, the economy of Kunming has developed rapidly and in 2019 became a new Chinese first-tier city. To a certain extent, the city represents the developmental trend of Southwest China and as such was selected as a research case in this study. Through the collection of data relating to urban land price between 2008 and 2018, and the investigation of the change processes and driving factors associated with urban land price, we aim to explore the following three issues using variogram integrated with Kriging assessment and GeoDetector:

1) What is the change in the spatial correlation and distribution of urban land price over the past ten years?

2) What are the main driving factors of urban land price changes?

3) How do the driving factors affect the change in urban land price?

II. STUDY AREA AND DATA ANALYSIS

2.1 Study Area

The study area covers an area of approximately 320 km^2 in the central region within the four districts of Kunming (Wuhua, Panlong, Xishan, and Guandu District) in Fig 1. The monitoring range of residential and commercial land, i.e., the study area, has not changed. The northeast and northwest of Kunming are mountainous areas, and the southwest is Dianchi Lake. The monitoring points basically cover the central urban area of Kunming.

Promoted by the national strategy, the economy has developed rapidly and the urbanization process has sped up in Kunming. From 2008 to 2018, the residential land price increased from 2776 yuan/m^2 (\$396/m^2) to 7334 yuan/m^2 (\$1047/m^2) and the commercial land price increased from 5993 yuan/m^2 (\$855/m^2) to 16604 yuan/m^2 (\$2369/m^2). This represents the speed of development of potential cities. These tremendous changes make Kunming a good case study for analyzing changes in the distribution and driving factors of urban land prices.

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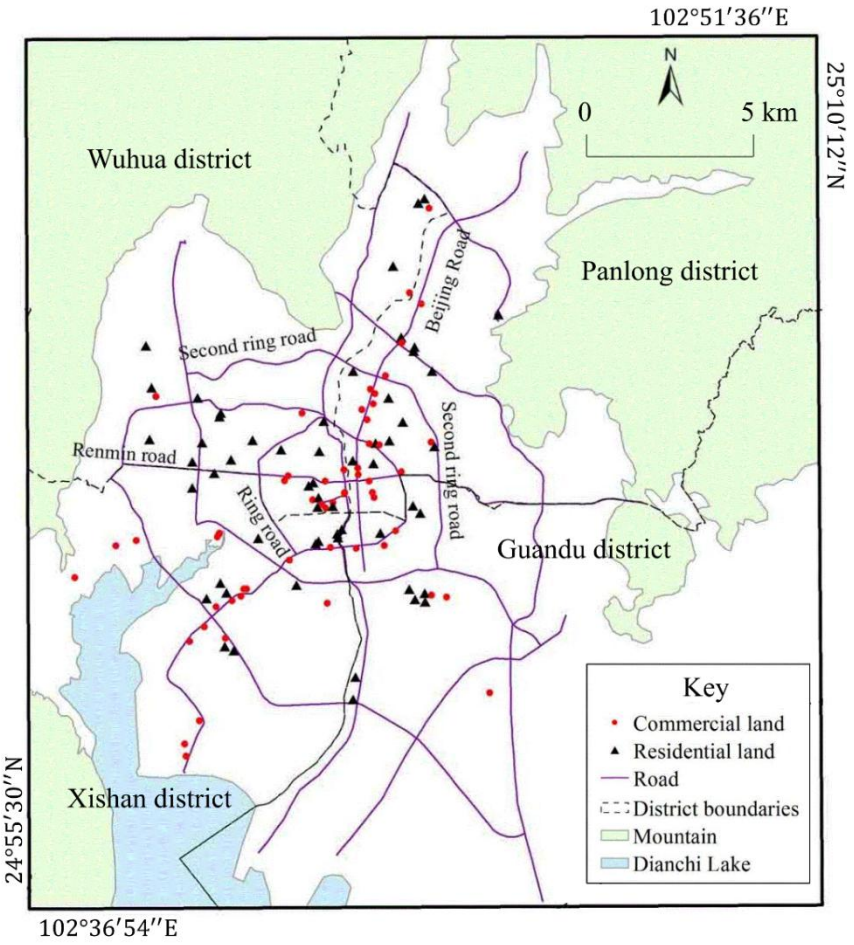

Fig 1:The study area and monitoring points distribution.

2.2 Data Analysis

Dynamic monitoring of land prices was carried out in 2008 in Kunming, and annual monitoring data of residential and commercial land prices was collected from 2008 to 2018. This study collected 11 years of data from 43 commercial land price and 44 residential land price monitoring points in Kunming.

From the perspective of data changes, the accuracy of data is affected because the growth rate is calculated using pushback data instead of time monitoring data in 2008. There was a rapid rise in land prices between 2009 and 2011. The annual growth rate of the residential land price increased from -2.67% to 94.51%, and the commercial land price increased from 22.48%

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to 52.25%. Between 2012 and 2018, a period of stable fluctuation of land prices was observed, with the range in price fluctuations being less than 7% with an overall upward trend.

Combined with relevant research literature, the land price driving factors include: land structure factors (land area and floor area ratio), location traffic factors (distance to the central business district (CBD), distance to the nearest subway station, distance to the nearest bus station, distance to the nearest main road), and neighborhood factors (distance to the nearest: commercial district, recreational water area, university, primary and secondary school, park and hospital). The land structure factor data is derived from the monitoring point recorded data, the location of traffic factors and the neighborhood factors are obtained through vector data established by ArcGIS. The location of traffic and neighborhood factors changes with the development of social economy, and we checked the relevant data for each year to ensure that all facilities were established and in a state of use.

III. METHODS

3.1 Variogram Simulation

The variogram is a geostatistical method. It is commonly used in geology [17,18], and the land market [19], and has been widely used in housing and land price research in recent years [20]. Under the condition of the second-order stationary hypothesis, the calculation of the variogram $\gamma(h)$ is defined by Eq. 1 [21]:

$$\gamma^*(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [Z(x_i) - Z(x_i + h)]^2 \quad (1)$$

Where $\mathrm{N}(h)$ is the logarithm of the data pair $\{Z(x_i), Z(x_i + h)\}$, and h is the distance of the land price monitoring point. $\mathrm{Z}(x_i)(i = 1,2, \ldots, n)$ is the observation of the stationary regionalization variable $\mathrm{Z}(x)$ at the spatial position x_i. The data pair $\{Z(x_i), Z(x_i + h)\}[i = 1,2,\ldots,Nh$ is an observation on point pair xi, $xi+h$ separated by h in a certain direction.

The variogram is generally represented by a variation curve. The spherical model is the most widely used, and is represented by Eq. 2:

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$$\gamma(h) = \begin{cases} 0 & h = 0 \\ C_0 + C\left(\frac{3h}{2a} - \frac{h^3}{2a^3}\right) & 0 < h \le a \\ C_0 + Ch > a \end{cases} \quad (2)$$

Where C_0 is the nugget constant, $C_0 + C$ is the base value, C is the arch height, and a is the range of influence of the land price. When used for spatial variability analysis of urban land price, C_0 indicates the degree to which land price is affected by uncertain factors, and $C_0 + C$ indicates the amount of fluctuation in land price. The spatial correlation of land price can be measured by $C_0/(C_0 + C)$, that is, the nugget effect. When the value is < 25%, the land price has a strong spatial correlation, when between 25% and 75%, it has a medium correlation, and when > 75%, the spatial correlation is weak. The variogram starts from the origin in the range of 0–a and increases as $|h|$ increases. When $|h|$> a, the two-point land prices have no effect on each other.

3.2 Spatial-temporal Distribution Estimation

The spatial-temporal distribution of land prices was simulated using the Kriging estimate. It is a mathematical method for finding optimal, linear, and unbiased interpolation estimators [21], and is expressed by Eq. 3:

$$Z(x_0) = \sum_{i=1}^{n} \lambda_i Z(x_i) \quad (3)$$

Where $Z(x_i)$ is the land price of the monitoring point x_i, n is the number of monitoring points, $\lambda_i$is the weight, and $Z(x_0)$ is the land price of the unknown point. The principle of Kriging's valuation is to ensure that the estimator is unbiased and obtain n weights λ_i on the premise that the estimated variance is the smallest.

3.3 GeoDetector

Driving Factors were selected by GeoDetector and further analyzed for their degree of influence. GeoDetector can detect spatial heterogeneity, spatial distribution of driving factors of research objects, and multi-factor interaction [15]. Its core idea based on the assumption that if an independent variable X has an important influence on a dependent variable Y, the spatial distribution of X and Y should be similar [22]. The method is widely used in disease research [23], population distribution [24], renewable energy [25], and other fields.

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When GeoDetector is used to analyze the driving factors of various phenomena, it can detect to what extent the driving factor, X, explains the spatial heterogeneity of the land price, Y, using Eq. 4:

$$q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2} \quad (4)$$

where, q is the detection force index of the land price driving factor, $h = 1, \ldots, L$ is the classification of the driving factors,N_h is the number of samples in the h layer, N is the number of samples in the study area, and σ_h^2 and $\sigma^2$are the variance of the h layer and the entire research area. The value interval of q is $[0, 1]$, which means that the independent variable X explains the land price Y of 100 × q%. The larger the value of q, the stronger the explanatory power of the driving factor to the land price.

IV. RESULTS AND DISCUSSIONS

4.1 Simulation and Analysis of the Spatial-temporal Evolution of Land Price

4.1.1 Variogram Calculation

According to the principle of variogram, the variogram of residential and commercial land prices for 11 years from 2008 to 2018 was calculated and fitted. Due to space constraints, we list the fitting parameters for the representative five years in TABLE I, which includes the rapid rising period of land prices in 2009 and 2011, and the stable fluctuating periods of land prices in 2013, 2015, and 2018. The variogram shows three of the years in Fig 2, 2009, 2013, and 2018.

TABLE I. Fitting parameters of the variogram for residential and commercial land prices

Use	Year	C_0 (yuan/m^2)^2	C (yuan/m^2)^2	a km	$C_0/(C_0+C)$
Residential land price	2009	0	2.52×10^6	5.84	0
	2011	0	6.74×10^6	5.07	0
	2013	0	1.78×10^7	2.47	0
	2015	0	1.88×10^7	1.88	0
	2018	0	1.80×10^7	1.72	0

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Commercial land price	2009	1.02×10^{7}	5.10×10^{7}	3	0.167
	2011	0	1.16×10^{8}	2.63	0
	2013	4.10×10^{7}	9.57×10^{7}	4.36	0.3
	2015	0	9.56×10^{7}	1.65	0
	2018	4.69×10^{6}	9.42×10^{7}	2.03	0.047

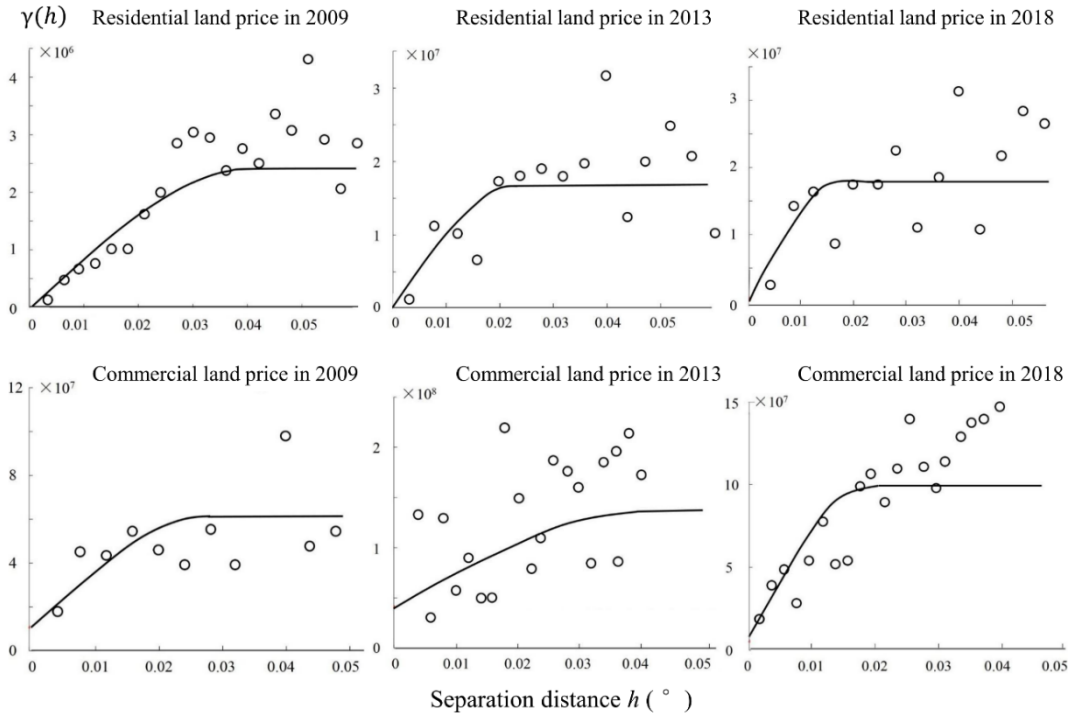

Fig 2: Variogram of residential and commercial land price in Kunming City.

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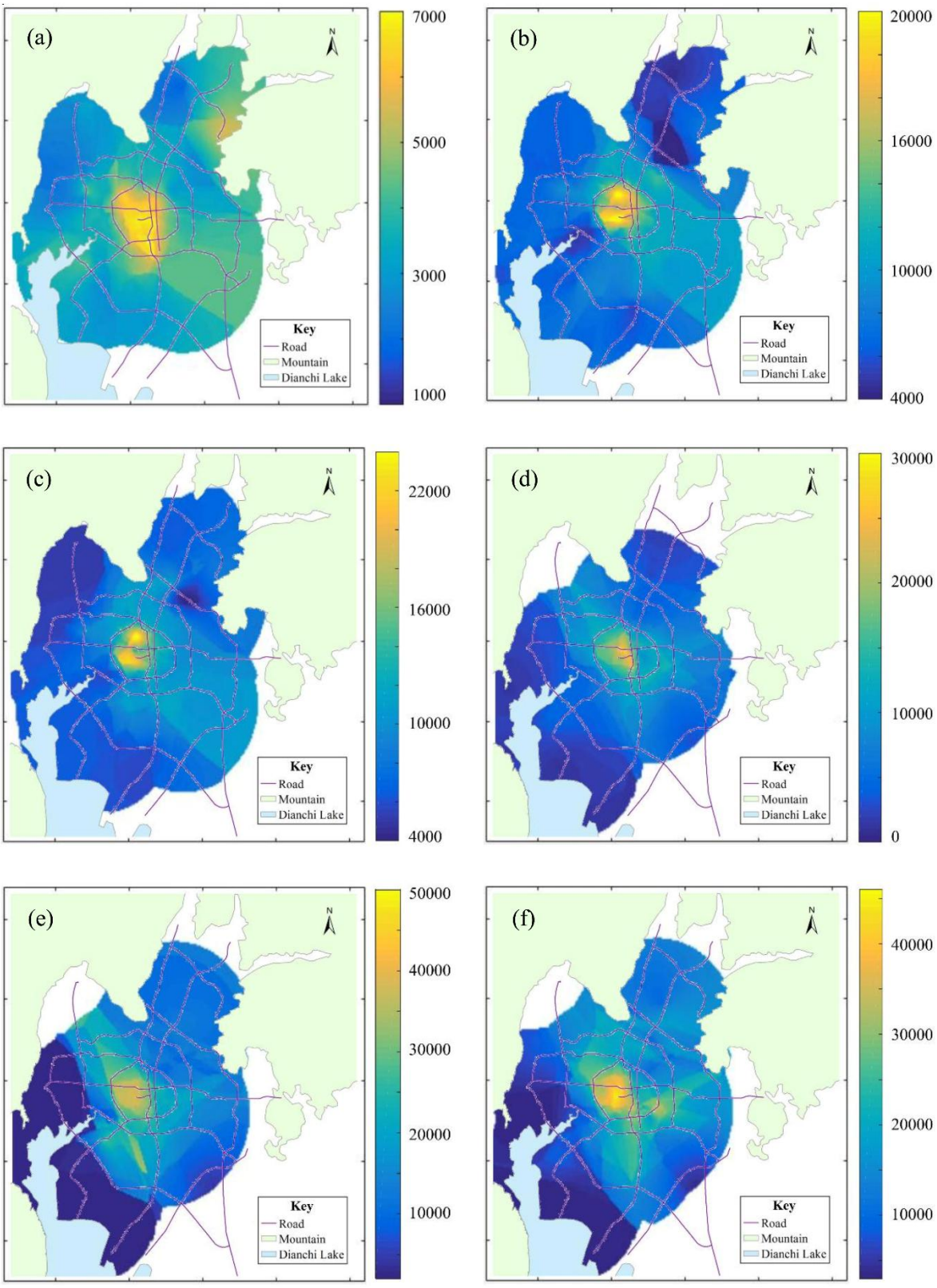

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Fig 3: Distributions of residential and commercial land price in Kunming City. (a) Residential land price in 2009, (b) Residential land price in 2013, (c) Residential land price in 2018, (d) Commercial land price in 2009, (e) Commercial land price in 2013, (f) Commercial land price in 2018.

It can be seen from the fitting parameters in TABLE I that the nugget constant and the nugget effect of the residential land price are all 0, and that the range of the influence of the land price (a) is between 1.72 km and 5.84 km, showing a gradual downward trend. The commercial land price nugget constant and nugget effect are between 0-0.3, with 0 in 2011 and 2015, and a large gap between different years. The range of the influence of the land price (a) is between 1.65 km and 4.36 km, showing a downward trend, but with great differences between different years.

4.1.2 Spatial-temporal Distribution Estimation of Land Price

Based on the principle of Kriging's valuation, the distribution of residential and commercial land prices between 2008 and 2018 was simulated. Due to space constraints, we list three representative years in Fig 3.

From the perspective of the spatial-temporal evolution of land price, the range of high-value and higher-value areas of residential land prices is shrinking. After 2013, the high value area was divided into two parts by Renmin Road in Fig 1. The northern part became the highest value residential area in Kunming in 2018, and the southern center of gravity shifted westward. In 2009, the higher-value areas of residential land price located in the north of the city, the north bank of Dianchi Lake, and the southeastern part of the study area. It only covered the radiation area of the city center to the southeast by 2018. The low-value area of residential land is inconsistent in the annual distribution, but it is basically located at the foot of the mountain.

The range of high-value area commercial land prices has expanded and the center of gravity has shifted westward. The higher-value areas have continued to move to the southeast. Commercial low-value areas are mainly located in the north bank of Dianchi Lake, but the scope is shrinking.

4.1.3 Spatial-temporal Evolution Analysis of Land Price

The residential land price fitting effect is better in TABLE I and Fig 2, and that the test variogram of commercial land price has a large fluctuation around the theoretical variogram. The area of residential land is the largest, evenly distributed area in Kunming, and the distribution of monitoring points is relatively scattered. Commercial lands are mainly

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concentrated in the city center and some commercial districts, thus causing the overall fluctuation of the commercial land price variability.

The nugget constant of the residential land price is 0, indicating that there is a strong spatial correlation, and that spatial variability is all structural variation. The regularity of the range change is very strong. The range decreases gradually and the decreasing rate slows down between 2009 and 2018. This shows that the influence range of residential land price gradually narrowed and that the spatial regularity became worse. On the one hand, due to the influence of land conditions, location, school district, etc., the adjacent land often has a large price gap, and the gap has an expanding trend. Furthermore, with the increasing population of Kunming, the floor area ratio and building density of newly supplied residential land increased. These factors shortened the distance to which the residential land price stabilized.

In different years, the nugget effect and range of commercial land price in Kunming are quite different. The nugget effect was largest in 2013 at 0.3, but was <0.17 in other years. Commercial land price has a strong spatial correlation in most years. The influence of structural factors on commercial land prices is more than 70%, while the influence of random factors was small. The range of commercial land prices shows an overall downward trend, but it fluctuates greatly in different years. On the one hand, within the scope of monitoring, residential land accounts for 63% of the monitored land and commercial land for 11%. Commercial land is concentrated in the city center. It gradually decreases towards the periphery and is mainly concentrated in the commercial areas. On the other hand, the commercial land price in Kunming is relatively high, and about twice the residential land price. It is more susceptible to market and policy factors than the residential land price, which increases the complexity of land price changes. Even in similar years, the distance that commercial land prices tend to stabilize is still quite different.

According to the simulated results for the spatial distribution of residential and commercial land prices (Fig 3), both residential and commercial land prices in Kunming show a single-center spatial distribution pattern, and prices gradually fall towards the periphery of the city. There are some old residential districts and historically formed commercial districts in the city center. In recent years, some mixed commercial and residential land has been built to the west of the city center. Land price has been raised because of convenient transportation, good living, offices, and shopping environments, and the center of gravity of the high-value area of residential and commercial land price has shifted. In 2018, the high-value area of residential land price was located around the Green Lake because of better parks, schools, hospitals, and transportation facilities.

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The Municipal Government and the branch campuses in Kunming moved to the Chenggong District in the southeast of the study area after 2011. The urban built-up area continues to extend to Chenggong, and the residential and commercial land prices along this line has grown fast to become a higher land price. Housing prices in Kunming began to rise in 2006. As the northern city was one of the earliest areas for development, there were more and more high-rise buildings, and land prices increased rapidly. With development in recent years, residential ”hot spots” in Kunming have increased. Dianchi bay has formed a new pattern of wealthy areas, where the living environment is better, and the price of residential land has been relatively high. Commercial land price near Dianchi Lake is low because of fewer commercial districts.

In order to analyze in depth the reasons for the evolution of land prices, it is necessary to use GeoDetector to further analyse the change in driving factors of land prices.

4.2 Change of Land Price Driving Factors

The spatial distribution of land price is mainly affected by structural factors. According to the characteristics of land price in Kunming and the related research results [23,34], this paper uses GeoDetector to select the main driving factors according to the collected three categories of twelve factors (Section 2.2).

4.2.1 Driving Factors Selection

There are few studies on the application of GeoDetector to land price driving factors. Since the sample size of residential and commercial land is small, no more than forty-five, this paper divides each driving factor into three categories. The classification of each driving factor is based on the natural discontinuous point grading method by using ArcGIS 10.2 software.

An annual detection of twelve factors affecting residential and commercial land prices from 2008 to 2018 shows that a significance level of 0.05, seven factors (land area, and distances to the nearest: bus stop, main road, business district, recreational water area, university, primary and secondary school) have no significant impact on residential and commercial land prices, and were eliminated. Firstly, the bus system and the main road system in the urban area are relatively perfect, and the number of high-quality primary and secondary schools has gradually increased, which reduces the impact of these indicators on land prices. Secondly, the impact of land area on land price is not significant, which is due to a large range in land areas, from 64 m^2 to 248565 m^2, with a distribution pattern that is not obvious. Thirdly, the distance to the nearest business district is within 3.0 km, and the distance to the recreational water area is within 4.5

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km. There are also more than ten public colleges in Kunming. These factors have not shown the expected significance, and have no obvious added value for the land price.

However, in terms of the motivation of the public to buy a house or a shop, the distance to schools has become a key factor. It is necessary to further analyze the high-quality primary and secondary schools in Kunming into public primary schools, public secondary schools, private primary schools, and private secondary schools. Among them, people make a greater distinction between public primary schools. These are divided into high-quality public primary schools (top 25) and better public primary schools (top 60). The influence of these factors on land price is detected separately, and whether they can pass the null hypothesis test is observed.

Finally, seven driving factors affecting residential land price are determined: floor area ratio (FAR), D_{CBD}, D_{subw}, D_{sch1} (D_{sch2}), D_{sch3}, D_{hosp}, and D_{park}. Six driving factors affecting commercial land price were determined: FAR, D_{CBD}, D_{subw}, D_{sch1} (D_{sch2}), D_{sch3}, and D_{hosp} in TABLE II.

TABLE II. Main driving factors of residential and commercial land prices

Determinants	Factors	Parameter representation	Symbol	Land use
Land structure factor	floor area ratio	FAR	+	R, C*
Location traffic factor	distance to CBD	D_{CBD}	-	R, C
	distance to the nearest subway station	D_{subw}	-	R, C
Neighborhood factor	distance to the nearest high-quality public primary school	D_{sch1}	-	R, C
	distance to the nearest better public primary school	D_{sch2}	-	R, C
	distance to the nearest high-quality public secondary school	D_{sch3}	-	R, C
	distance to the nearest 3-A-grade general hospital	D_{hosp}	-	R, C
	distance to the nearest park	D_{park}	-	R

*Note: “R” stands for residential land price and “C” stands for commercial land price.

4.2.2 Analysis on the Influence Degree

GeoDetector was used to detect seven selected indicators, and the impact of these (FAR, D_{CBD}, D_{subw}, D_{sch1} (D_{sch2}), D_{sch3}, D_{hosp} and D_{park}) on residential and commercial land prices was

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analyzed. The principle of GeoDetector ensures that it is collinearly immune to multiple independent variables and can be processed without treatment. We calculate the q statistics of the driving factors of residential and commercial land prices from 2008 to 2018. Due to space constraints, we list five representative years in TABLES III and IV, which are consistent with the years of the variogram analysis.

TABLE III. Driving factors of residential land price from 2009 to 2018 in Kunming City

Year	Index	FAR	D_{CBD}	D_{subw}	D_{sch1}	D_{sch2}	D_{sch3}	D_{hosp}	D_{park}
2009	q statistic	0.065	0.415	/	0.246	0.333	0.371	0.193	0.440
	p-value	0.882	0.000	/	0.004	0.000	0.000	0.025	0.000
	Rank	/	2	/	5	4	3	6	1
2011	q statistic	0.231	0.460	/	0.269	0.118	0.215	0.202	0.457
	p-value	0.453	0.000	/	0.003	0.078	0.026	0.013	0.000
	Rank	/	1	/	3	/	4	5	2
2013	q statistic	0.248	0.373	/	0.227	0.140	0.228	0.211	0.322
	p-value	0.006	0.000	/	0.006	0.047	0.031	0.015	0.002
	Rank	3	1	/	5	7	4	6	2
2015	q statistic	0.204	0.388	0.209	0.164	0.055	0.108	0.318	0.357
	p-value	0.095	0.000	0.014	0.027	0.337	0.108	0.005	0.000
	Rank	/	1	4	5	/	/	3	2
2018	q statistic	0.240	0.403	0.176	0.220	0.093	0.135	0.311	0.340
	p-value	0.018	0.000	0.027	0.007	0.148	0.054	0.006	0.000
	Rank	4	1	6	5	/	/	3	2

TABLE IV. Driving factors of commercial land price2 from 2009 to 2018 in Kunming City

year	index	FAR	D_{CBD}	D_{subw}	D_{sch1}	D_{sch2}	D_{sch3}	D_{hosp}
2009	q statistic	0.384	0.594	/	0.347	0.347	0.341	0.350
	Rank	2	1	/	4	4	5	3
2011	q statistic	0.485	0.546	/	0.428	0.426	0.429	0.400
	Rank	2	1	/	4	5	3	6

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2013	q statistic	0.454	0.426	/	0.369	0.374	0.225	0.483
	Rank	2	3	/	5	4	7	1
2015	q statistic	0.466	0.527	0.457	0.496	0.446	0.365	0.572
	Rank	5	2	4	3	6	7	1
2018	q statistic	0.378	0.495	0.303	0.477	0.377	0.310	0.549
	Rank	4	2	7	3	5	6	1

*Note: The P value of all driving factors of commercial land price is below 0.05.

There were six main driving factors of residential land price in 2018. With D_{CBD}, D_{park}, and D_{hosp} having the top three impacts on residential land price. The land location and the quality of life are the most important factors for residential land price, which are also considered by most buyers.

Furthermore, FAR, D_{sch1}, and D_{subw} also influence the residential land price. FAR is positively correlated with residential land price, that is, the larger the building area, the lower the degree of comfort of residents, and the higher the residential land price. On the one hand, the number of land supplies in the Second Ring Road of Kunming City has been relatively small in recent years. Most of them are fragmentary lands and village-in-city lands. Land scarcity is obvious. The supply of land near the city center shows a trend of increasing FAR. On the other hand, when there are parks, hospitals, and convenient transportation nearby, the unit price is higher than the surrounding area when the land is sold. Real estate developers also integrate the proximity of high-quality schools to increase land prices. In order to narrow the gap between house prices in the surrounding areas, it is necessary to increase the floor area ratio. From the perspective of the impact of schools on residential land prices, only D_{sch1} has an impact. Purchasers with school age children will mainly consider high-quality public primary school district housing, and they can also directly go to the corresponding public secondary school. D_{subw} is an important factor for office workers to consider when buying a house. Due to traffic congestion during commuting in Kunming, many people choose to travel by subway. The land price near the subway station is therefore higher than other areas.

D_{sch1} and D_{subw} only affect part of the population. D_{park} and D_{hosp} have a wide range of impacts, the q statistics of which are larger than other factors, and the impact on residential land prices is great.

There were six driving factors for commercial land prices in 2018. With D_{hosp}, D_{CBD}, and D_{sch1} (D_{sch2}) having the top three impacts on commercial land prices. General hospitals are a driving factor for attracting many people around them. When choosing the location of

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commercial districts, the densely populated areas are considered. The commercial land in Kunming is mainly concentrated in the city center. The closer to CBD, the faster the land price increases. In recent years, an increasing number of training schools have been established in commercial districts. Public primary schools have more extra-curricular time and more training needs. Among them, the higher the ranking of a school, infers more requirements for the comprehensive development of students, and a greater impact on commercial land prices.

FAR, D_{sch3}, and D_{subw} also impact commercial land prices. The influence of FAR on the commercial land price is similar to that of the residential land price. On one hand, land resources are scarce in the Second Ring Road. On the other hand, commercial land around parks, hospitals, and subway stations concentrates a flow of people, with higher land prices and a larger FAR. Recently, the influence of D_{sch3} on commercial land price has been shown in so much as secondary school students need intensive learning for major courses, but due to lesser extracurricular time in comparison with primary school students, the impact on the commercial land price is weaker than D_{sch1}. Commercial land is usually located in places that have convenient transportation. Self-driving, bus, and the subway are all convenient modes, thus D_{subw} has less impact.

4.2.3 Analysis on Driving Factor Change

It can be seen from the q statistic of the residential price driving factors for the selected five years, that all factors except D_{hosp} generally show different degrees of decline. With the continuous development of the urban economy, the continuous improvement of living facilities, and the continuous extension of high-quality resources, the impact of transportation, education, and leisure on the residential land price has weakened.

FAR affected the residential land price in 2013 and 2018. The q statistics in these two years are approximately coincident, but other years have nothing to do with residential land price.

The q statistic rankings of D_{CBD} and D_{park} remain in first and second place. The formation of the CBD in Kunming is due to historical reasons. It has not changed much over the years, and the price of land has gradually declined from the center to the periphery. D_{park} reflects the living environment. Life moved slowly and the climate is comfortable in Kunming, and is very suitable for living, including elderly people. Citizens pay more attention to the living environment and air quality. The number of migrant populations who come to Kunming to buy houses has increased. Many of them buy retirement homes, and the important factor they consider is the living environment.

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The q statistics of D_{sch1} (D_{sch2}), D_{sch3}, D_{subw}, and D_{hosp} vary greatly. Firstly, the impact of schools on residential land price is reflected in D_{sch1} and D_{sch2}, which have a greater impact on residential land price than D_{sch3}, D_{subw}, and D_{hosp}, whereas the nearest distance to private primary schools and private secondary schools has no impact. It can be seen from the change and ranking of q statistics from 2009 to 2018 that D_{sch1} has always had a large influence on the residential land price. D_{sch2} and D_{sch3} had a greater impact in previous years and have had no impact on residential prices in recent years. From the analysis of the willingness to buy a house, families preparing to buy a house who also require a school will give priority to the nearby high-quality public primary schools. They will subsequently consider the counterpart public secondary school. In public schools, people focus on the top public schools in Kunming. This phenomenon is influenced by the enrollment policies of public and private schools in Kunming. The public primary schools adopt the district enrollment methods, and the public secondary schools generally adopt the corresponding public primary school direct promotion method. If you choose a public primary school, then for the secondary school one can choose the counterpart public school or a private school. If private primary schools are chosen, then only a private secondary school can be chosen. This policy has led to a significant increase in land prices around high-quality public primary schools. Many families prefer high quality public primary schools so that there is more choice for secondary schools. After 2010, universities and high-quality high schools gradually opened subsidiary primary and secondary schools, and the quality of education has been relatively high. These schools select the best students for admission, alleviating the pressure of high-quality education resources. Secondly, the influence of D_{subw} on the residential land price is obviously reduced. In 2014, Kunming opened subway lines 1 and 2, and subway line 3 was opened in 2017. With the increase of subway lines, the convenience of travel has been enhanced, and dependence on it declined. Thirdly, D_{hosp} is the only factor that has a growing impact on residential land prices. Initially, the vector data of the nearest 3-A-grade hospitals in Kunming was used. It was found that there is no direct relationship with the residential land price. After further data processing, D_{hosp} was found to be the main driving factor of residential land price. With the development of society and the improvement of living standards, people pay more attention to health.

From the q statistics of the driving factors of commercial land price in the selected five years, it can be seen that the fluctuation of FAR is relatively stable, and that the overall change is not obvious. Other factors show different degrees of decline or rise.

The q statistics and ranking of D_{CBD} and D_{subw} declined. With an increasing number of migrants in Kunming, the number of commercial districts is increasing. These are mainly distributed in densely populated areas, rather than being concentrated in the city center.

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Although the distance from the city center determines commercial land prices, its influence is declining. With the continuous improvement of the subway lines, the impact of D_{subw} on the commercial land price will continue to weaken in the same way as the residential price.

It can be seen from the q statistic and ranking of D_{sch1}, D_{sch2}, and D_{sch3}, that the position of public primary schools had a greater impact on commercial land prices than public secondary schools, while private schools have no influence. Among the public primary schools, the higher the ranking, the greater the impact on the commercial land price. The impact of D_{sch1} on commercial land prices has increased, whereas D_{sch2} remained stable and the impact of D_{sch3} has weakened. With the popularity of e-commerce, shops have been greatly impacted. Many business districts are constantly transforming and developing in the direction of training. Public school students leave school early, especially pupils who have more time after class. There is a great demand for diversified training. Secondary school students mainly focus on intensive learning of major courses. There are various kinds of training and counseling in high-quality private schools, and the demand for training courses outside school has become smaller.

The impact of D_{hosp} on commercial land prices is increasing. As for the capital city of Yunnan Province, there is a concentration of high-quality medical resources in the province in Kunming. With the improvement of people's living standards and health care, high-quality general hospitals have led to a significant increase in the flow of people around. When choosing the location of commercial districts, the densely populated areas are taken into account, which will have an increasing influence on the commercial land price.

V. CONCLUSION

In this paper, the variogram and Kriging valuation method were used to analyze the evolution of residential and commercial land prices between 2008 and 2018 in Kunming. GeoDetector was used to determine the main driving factors. The study found that:

1. From the spatial variation law, the residential and commercial land prices in Kunming are distributed in a single center. The center of gravity of high-value areas of land price is cheaper to the west, and the higher-value areas continue to develop toward the southeast of the city center. Residential land prices are completely affected by structural factors. The scope of influence is shrinking continuously, and the spatial regularity has weakened. Commercial land prices are mainly affected by structural factors.

2. The driving factors of residential price in Kunming mainly include: floor area ratio, distance to CBD, and distance to the nearest: subway station, high-quality public primary school, high-quality public secondary school, hospital, and park.

3. Due to the continuous improvement of living standards and more attention to health, the flow of people around well-known general hospitals has increased. The impact of D_{hosp} on residential and commercial land prices has increased significantly. With the progress of society and the increase of transportation and public facilities, people's dependence on them decreases, and the impact of D_{CBD}, D_{park}, and D_{subw} on land price (commercial land price excluding D_{park}) decreases. Affected by the school enrollment policy, the impact of D_{sch1} on residential land price remained at a high level, while the impact of D_{sch2} and D_{sch3} on residential land prices has weakened. With the transformation of some commercial districts into training centers, the impact of D_{sch1} on commercial land price has increased, whereas D_{sch2} maintained a stable fluctuation and the impact of D_{sch3} has weaken.

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