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The Spatial Distribution Characteristics of Resident Population Growth Rate in Henan Province, China

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Abstract

Population is an important strategic resource for national development, a fundamental element of socio-economic development. The coordinated development of population and economy is an effective way to achieve rapid economic growth. Based on the population statistics data of counties (districts) in Henan Province, China, from 2006 to 2021. The paper firstly uses the logistic population growth mathematical model to calculate the resident population growth rate of counties (districts), then utilizes the hotspot analysis and spatial semi-variogram analysis, to research the spatial distribution characteristics of the resident population growth rate in Henan Province. The research results show that the evolution of the regional resident population in the province basically conforms to the logistic natural growth model. The resident population growth rate shows the characteristics of high in the north and low in the south, high in the center and low in the surrounding regions. The resident population growth rate is positively correlated with the level of economic development; the urban built-up areas, especially the new regions in urban planning, have a fast growth rate of resident population, which has a significant siphon effect on the population of surrounding regions. The hotspots of resident population growth rate in the province are mainly distributed in the urban built-up areas and surrounding regions of Zhengzhou, Luoyang, and Xinxiang, accounting for about 3.51% of the total area of the province. The cold spots are mainly distributed in the eastern part of the province, forming zonal distribution, which spans across Shangqiu City, Zhoukou City, and Zhumadian City, accounting for about 8.61% of the total area of the province. The area with negative growth of resident population accounts for approximately 53.47% of the total province. The spatial distribution of the growth rate of the resident population in the whole province basically conforms to the spherical model, with a small dispersion degree and a short range. In the range, there is a high degree of variability in resident population growth rate.

Keywords

Resident Population Growth Rate, Logistic Natural Growth Model, Cold and Hot Spot Analysis, Semi-Variogram Function, Spatial Interpolation, Henan Province

1. Introduction

Population is the destiny of a country, an important strategic resource for national development, and a fundamental element for socio-economic development (Ma et al., 2022; Deng et al., 2017). The regional population distribution is influenced and constrained by various factors, such as social production mode, economic development level, regional resource environment, transportation accessibility, and history (Deng et al., 2017; Yan & Li, 2017; Cao, 2022; Song et al., 2022). The socio-economic development of a region largely depends on population security. The coordinated development of population and economy is an important way to achieve rapid economic growth and effectively solve population problems. Population growth leads to an increase in the size of the labor force, and demographic bonus generated could promote regional economic development. At the same time, rapid economic growth also could provide a relatively favorable living environment for regional population, attract more migrants, and effectively promote regional population growth (Huang & Duan, 2022; Hu et al., 2020).

In recent years, driven by factors such as location, natural endowment, and policies, the large-scale population migration brought by regional development differences, not only promotes rapid urbanization, but also profoundly affects the regional macroeconomic pattern. The uneven distribution pattern of regional population brings about uneven spatial allocation of social factors, and on the other hand, the uncoordinated distribution pattern of population and economy leads to the widening of regional development gap, and restricts the coordinated development of regional economy. In the process of China's economy shifting from high-speed growth to high-quality development, solving the problem of "imbalance and insufficiency" in development has become an important research contents for improving the quality of development (Ma et al., 2022; Yan & Li, 2017).

Studying the population distribution pattern and its evolution laws, revealing the dynamic mechanism of population spatiotemporal evolution, have important practical significance for scientifically guiding the rational layout of population, achieving regional coordination and high-quality development (Ma et al., 2022; Deng et al., 2017; Yan & Li, 2017), has also been becoming a focus of scholars' attention. In recent years, the researches on population distribution have mainly focused on two aspects: one is the analysis of spatiotemporal pattern evolution characteristics, which, based on sampling survey data, using the methods, as centroid model, spatial autocorrelation model, concentration index and imbalance index, offset sharing model, and network analysis etc., explore the characteristics of population distribution, population mobility, and population pattern evolution in different regions and scales. The second is the study of driving factors for the spatiotemporal patterns evolution, which, based on qualitative analysis or quantitative exploration using diversified models, study the impact on the evolution of population distribution patterns of natural environment, economic and social development factors, economic development level, industrial structure, employment opportunities and income levels, the basic pattern of population distribution, economic and social development factors, infrastructure and public service capabilities, etc. These researches have obtained many practical conclusions, providing scientific guidance for regional socio-economic development (Ma et al., 2022; Yan & Li, 2017; Cao, 2022; Song et al., 2022).

The growth of resident population in a region mainly comes from natural population growth within the region and population migration between regions (Sun & Zhang, 2015; Liu et al., 2017). In a similar overall environment for economic development, the regions should have the same natural population growth rate, and the differences in regional population growth rates mainly come from the migration of population between regions. The social living environment and economic development level of a region play an important role in the migration of population between regions (Xiao, 2010; Sun & Zhang, 2015; Liu et al., 2017).

The growth rate of regional population fundamentally reflects the degree of difference in regional population growth. Based on the population statistics data of counties in Henan Province from 2006 to 2021, this paper, firstly uses the logistic population growth mathematical model to calculate the resident population growth rates of counties, and then utilizes the spatial analysis methods, such as the hotspot analysis and spatial semi-variogram analysis, to research the spatial distribution characteristics of the resident population growth rate in the province, in order to provide meaningful references for formulating reasonable provincial economic and social development policies.

2. Data and Research Methods

2.1. Research Area Overview

Henan is located in 31˚23'N - 36˚22'N, 110˚21'E - 116˚39'E, with a total area of 1.67×10^5 km^2, with 17 prefecture-level cities, 21 county-level cities, 82 counties, and 54 municipal districts. The terrain is high in the west and low in the east, and the regional terrain relief gradually decreases with the increase of longitude, the distribution density of resident population is inversely proportional to the terrain relief. From 2006 to 2020, the number of registered population and resident population increased gradually. In 2021, the number of registered population and resident population shows a negative growth for the first time. In 2014, China began to adjust from the one-child policy to two children free policy. Driven by the population policy, how to ensure the coordinated development of provincial economy and population is one of the important issues currently facing by the local government (Zhang et al., 2020).

2.2. The Growth Rate of Resident Population

Theoretically, resident population change in a certain region is a self-organized evolution process, influenced by the regional resource environment, terrain distribution characteristics, geographical location, socio-economic development level, and development policies.

The change of resident population mainly comes from natural population growth and inter regional population migration, which basically conforms to the characteristics of logistic curve,

$$P_t = \frac{P_0}{1+\exp\{a-rt\}} \tag{1}$$

where, P_t is as the discrete variable of resident population data. t is the sequence of time, a is a regional constant, r represents the natural growth rate of resident population, P_0 is as the environmental load capacity. a and r are the regression coefficient of the linear regression equation,

$$y = \ln(P_0 - P) - \ln(P) = a - rt \tag{2}$$

The significance level of the equation is tested using the test

$$F = \frac{SSR/1}{SSE/(n-1)} \tag{3}$$

where SSR and SSE are the regression squared sum and residual squared sum of Equation (2), n is the number of observed years. Giving a significance level α, based on the critical value F_α of the F distribution, as $F > F_\alpha$, a and r are significant.

The environmental load force P_0 is the function of the regional environment (Li et al., 2019; Yang et al., 2022). For ease of calculation, the inflexion of Equation (1) is used, and where the tangent slope reaches the maximum, the curve changes from concave to convex. Its value is fitted with the maximum slope of the measured curve (Yin, 2002)

$$P_0 = 2\max\{P_2 - P_1, P_3 - P_2, \cdots, P_n - P_{n-1}\}. \tag{4}$$

2.3. The Cold and Hot Spot Analysis of Resident Population Growth Rate

The cold and hot spot analysis is an effective method for exploring the local spatial aggregation characteristics of the growth rate of resident population. If there is a strong spatial correlation between the growth rate of resident population, it indicates that the spatial process factors of resident population growth are affecting the growth of the regional resident population. Studying the regions with strong correlation and exploring the significant aggregation characteristics of resident population growth rate in spatial patterns, could help to arrange social resources reasonably, ensure the balance of regional population distribution, and guarantee reasonable changes in regional population (Getis & Ord, 1992; Lu et al., 2023).

Under the second stationary assumption (Zhang et al., 2020), the hot and cold spots analysis utilizes the Getis-ord $Gi*$ statistical analysis model

$$Gi* = \frac{\sum_{k=1}^{n} w_{ij} r_k - \bar{r} \sum_{k=1}^{n} w_{ik}}{S \sqrt{\frac{n \sum_{k=1}^{n} w_{ik} r_k - \left(\sum_{k=1}^{n} w_{ik} \right)}{n-1}}} \tag{5}$$

where, $\bar{r}$ and S represent the mean and variance of the growth rate of the resident population, respectively. $W = \left(w_{ij} \right)_{n \times n}$ is the spatial relationship matrix of the counties, $w_{ij} = 1$ if and only if the county i and j are connected by edges (edge), otherwise $w_{ij} = 0$. $Gi* > 0$ means the weighted average of the resident population growth rates in the surrounding i county is greater than the overall average, indicating where is hot spot region with higher resident population growth rates. The larger $Gi*$, the more obvious the hot spots are. In other words, $Gi* < 0$ means the weighted average of the resident population growth rates in the surrounding i county is less than the overall average, indicating where is cold spot region with lower resident population growth rates. The smaller $Gi*$, the more obvious the cold spots is.

The overall aggregation characteristics are described by the deviation multiple from the overall theoretical standard deviation of the mean of the sample and the mean of the overall theoretical mean

$$Zscore = \frac{\bar{r} - \mu_0}{\sigma / n} \tag{6}$$

The significance level of the aggregation characteristics is based on hypothesis testing, as $\bar{r}$ and $\bar{r}_i$ converge in probability to a normal distribution $N\left(\mu, \sigma^2 \right)$ (Getis & Ord, 1992; Lu et al., 2023; Huang & Xu, 2020).

2.4. Spatial Heterogeneity Characteristics of Resident Population Growth Rate

The resident population growth rate $r(P) = r(x, y)$ is a regionalized variable, which is different from an ordinary random variable, which conforms to a certain probability distribution, while a regionalized random variable takes a value according to its location in a region. In other words, the regionalized random variable is the specific value of the ordinary random variable at a certain time and a specific location. It is a random function based on the position, an ordinary random variable in one place (Zhang et al., 2020; Li et al., 2014; Chen et al., 2019; Liao et al., 2016).

The resident population growth rate has two significant characteristics: randomness and structural. Firstly, it is a random variable, and has the characteristics of locality, randomness, and abnormality; secondly, it has average structural properties, which not only reflects the natural population growth level in the location, but also reflects the attractiveness of partial advantages to population migration, to some extent, resulting in the spatial correlation characteristics between the resident population growth rate $Z(P_0)$ at P_0 and $Z(P_i)$ at P_i, where P_1 is h away from P_0. These spatial correlations depend on the distance h between the two points and the characteristics of the resident population growth rate itself.

Under the second stationary assumption, the covariance between two points is defined as

$$c(h)=\frac{1}{N(h)}\sum_{i=1}^{N(h)}\left[r(P_i)-\overline{r}(P_i)\right]\left[r(P_i+h)-\overline{r}(P_i+h)\right] \tag{7}$$

where $N(h)$ is the number of observation value pairs, $\overline{r}(P_i)$ is the mean of the observation value ,which has nothing to do with the position of P_i.

In order to conveniently study the overall changes in the resident population growth rate in different places, explore the differences in the resident population growth rate at different distances, the distribution of the resident population growth rate at specific distances, and the relationship between the resident population growth rate and distance changes, the semi-variogram function of the resident population growth rate $\gamma(h)$ is defined as half of the covariance of the resident population growth rate for all pairs of observation points (P_i, P_i') at the distance of h

$$\gamma(h)=\frac{1}{2N(h)}\sum_{i=1}^{N(h)}\left[r(P_i)-\overline{r}(P_i)\right]\left[r(P_i+h)-\overline{r}(P_i+h)\right] \tag{8}$$

which reflects the resident population growth rate variation of all point pairs at the distance of h in the discrete point group, as well as its spatial distribution characteristics.

The semi-variogram function, calculated based on the observed values of discrete resident population growth rate is a discrete function, in order to study the overall characteristics of regional changes in resident population growth rate, using curve fitting method to transform it into a continuous function to obtain a mathematical model of semi-variogram function. Commonly used fitting functions include exponential model, spherical model, Gaussian model, and linear model, etc.

The mathematical model of a continuous semi-variogram function could be described by four parameters, namely, the localized discontinuity value or nugget value $C_0=\lim_{h\to 0}\gamma(h)$, which reflects the spatial variation caused by random factors, is determined by the variance of observed values at a single location; As the interval distance h increases, $\gamma(h)$ from C_0 gradually tends to a constant $C_0+C=\lim_{h\to\infty}(h)$, called the sill value, which reflects the largest variation in resident population growth rate; when $\gamma(h)$ reaches near the sill value and tends to stabilize, the corresponding value h is called the range (a), which reflects when

$h \geq a$, the spatial correlation of resident population growth rate disappears (Zhang et al., 2020; Li et al., 2014; Chen et al., 2019; Liao et al., 2016).

Based on the fitting semi-variogram model, using spatial interpolation analysis could calculate the resident population growth rate at unknown points, which could present the overall spatial distribution and variation characteristics of resident population growth rate in the whole area.

The Kriging interpolation method is based on the data of known points in the finite neighborhood of an unknown point, taking into their spatial position relationship and the structural information provided by the fitting semi-variogram model, using unbiased optimal estimation to calculate the value of the unknown point

$$Z^*(P) = \sum_{i=1}^{n} \lambda_i Z(P_i), \lambda = K_{n \times n}^{-1} D_{n \times 1}, \tag{9}$$

where λ_i is the contribution of the resident population growth rate of the known point P_i to the unknown point P. n is the number of points within the specified distance neighborhood of P. K is the augmented matrix of the semi-variogram values on the known points, D is an augmented column vector of the semi-variogram values from the known points to the unknown point (Zhang et al., 2020; Liao et al., 2016).

3. Analysis of the Evolution Characteristics of Spatial Distribution of the Resident Population in Henan Province

3.1. Growth Rate of Resident Population in Henan Province

Using Equation (1)-(4) to calculate the growth rate of the resident population in the units of county (district), city and province, under the confidence level of 90%, by the test of F, the resident population growth rates show significant characteristics. The results for the province and each city are shown in Table 1 and Figure 1, and the county (district) are shown in Figure 2.

Table 1. The characteristic of city population growth rates from 2006-2021 in Henan.

City	$r \times 10^4$	Confidence Level	City	$r \times 10^4$	Confidence Level
Province	86.49	100.00			
AnYang	66.52	100.00	ZhengZhou	1132.84	100.00
PuYang	114.77	100.00	ShangQiu	33.48	89.13
HeBi	114.27	100.00	XuChang	25.3	99.79
XinXiang	206.15	100.00	ZhouKou	−141.59	99.88
JiaoZuo	43.00	100.00	PingDingShan	29.7	99.97
Jiyuan	124.36	100.00	LuoHe	−85.31	100.00
KaiFeng	39.79	100.00	NanYang	−52.37	99.23
SanMenXia	−171.14	100.00	ZhuMaDian	−133.65	100.00
LuoYang	162.97	100.00	XinYang	−85.52	98.86

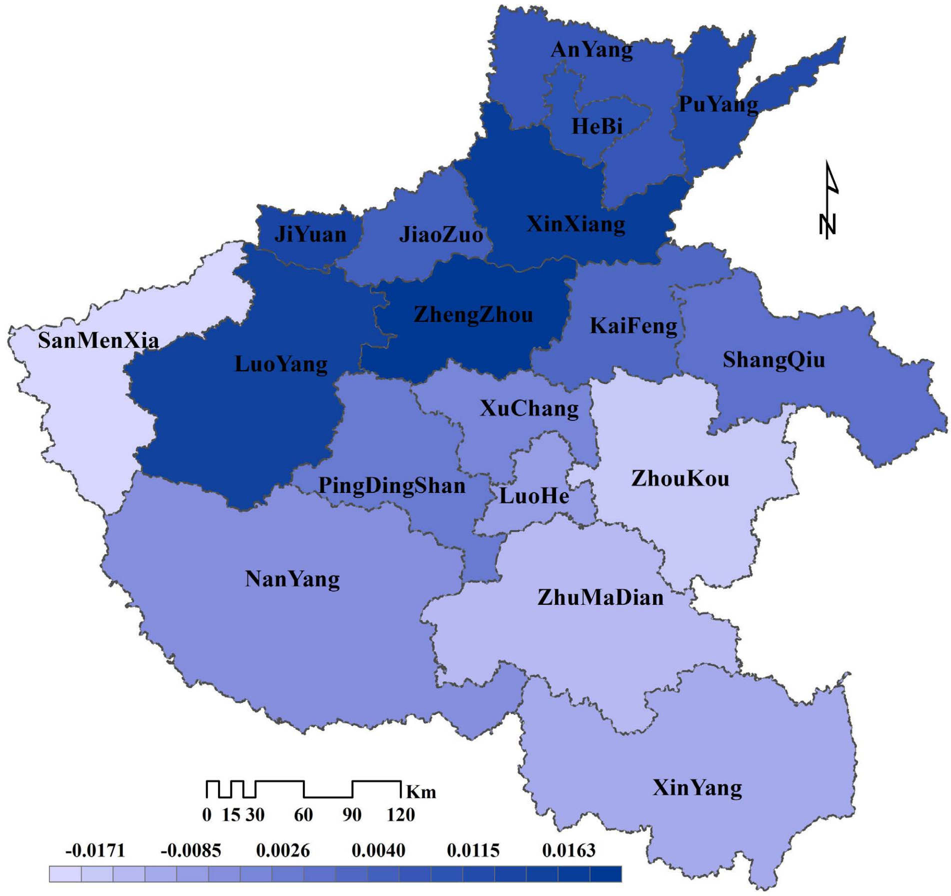

Figure 1. The distribution of city resident population growth rates in Henan.

The growth rate of the resident population in the province is about 86.5×10^{-4}. In the city level, there are six cities with the resident population growth rate higher than the provincial average, namely Zhengzhou, Xinxiang, Luoyang, Jiyuan, Puyang, and Hebi in descending order. The resident population growth rate in Zhengzhou has reached 13.10 times the provincial average, while the resident population growth rates in Xinxiang and Luoyang are about 2 times the average. In terms of urban scale and city economic output, Zhengzhou and Luoyang rank among the top two in the province, while Xinxiang urban scale and city economic output are relatively lagging behind in the provincial ranking, where the population growth might be attributed to its regional location (**Figure 1**).

There are six cities with negative resident population growth rates, with an average growth rate of -111.60×10^{-4}, namely Sanmenxia, Zhoukou, Zhumadian, Xinyang, Luohe, and Nanyang in ascending order, which indicates that the resident population here is gradually decreasing, and under the assumption of the same natural growth rate of populatio in the province, where shows the significant population outflow characteristics. The resident population growth rate in Sanmenxia is lowest, about 1.53 times of the negative average, while Zhoukou and Zhumadian are slightly higher than the negative average level, and Xinyang and Luohe are about 0.77 times the negative average level.

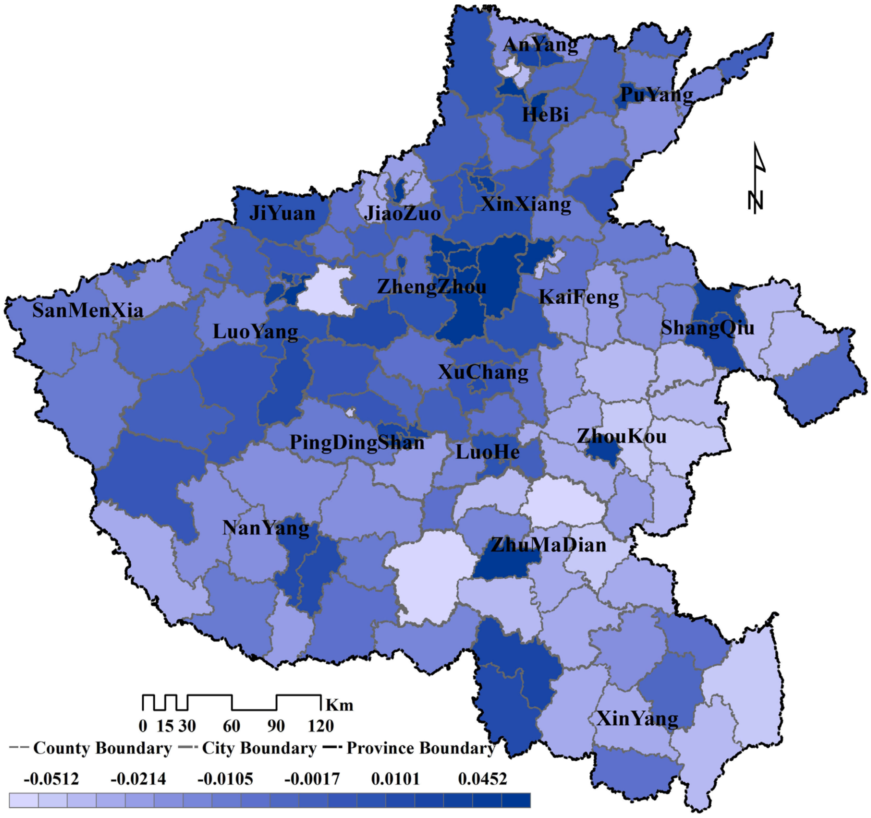

Figure 2. The distribution of county resident population growth rates in Henan.

In geographical distribution perspective, the resident population growth rate shows a characteristic of higher in the north and lower in the south, higher in the center and lower in the surrounding regions. The resident population growth rate is positively correlated with the level of economic development.

Among the 158 counties (districts) in the province, 71 counties (districts) have a positive resident population growth rate of, where the resident population is gradually increasing; 51 counties (districts) have a resident population growth rate higher than the provincial average, of which 30 urban built-up areas, 3 county-level cities, namely Xinzheng City, Dengfeng City, and Xinmi City, 8 counties, as Zhongmu County, Ruyang County, Qi County, Xinxiang County, Weishi County, Yuanyang County, Changyuan County, and Song County, of which Zhongmu County is adjacent to Jinshui District of Zhengzhou Urban to the west and Fuxiang District of Kaifeng urban to the east, Qi County is adjacent to Qibin District of Hebi urban to the north, and Xinxiang County is adjacent to the three built-up areas of Xinxiang urban. The remaining 5 counties are relatively far away from urban built-up area. Among the 51 counties (districts), there are 10 counties (districts) with a resident population growth rate more than 10 times of the average level, including Jinshui District, Guancheng District, Huiji District, Xinzheng City, and Zhongmou County in Zhengzhou City; Luolong District in Luoyang City, Longting District in Kaifeng City, Qibin District in Hebi City, Yicheng District in Zhumadian City, and Shanyang District in Jiaozuo City. There are 11 counties (districts) with a resident population growth rate of 5 to 10 times of the average level, including Zhongyuan District, Erqi District, and Shangjie District in Zhengzhou City; Jianxi District and Laocheng District in Luoyang City; Hongqi District and Weibin District in Xinxiang City; Chuanhui District in Zhoukou City; Hualong District in Puyang City; Zhanhe District in Pingdingshan City; and Liangyuan District in Shangqiu City. From a local geographical distribution perspective, Chuanhui District in Zhoukou City exhibits local heterogeneity characteristics, with a negative resident population growth trend in the urban built-up area at a rate of approximately -141.60×10^{-4}, while the population growth rate in the egion is 652.72×10^{-4}.

Among the 158 counties (districts) in the province, 87 counties (districts) have a negative resident population growth rate, where the resident population is gradually decreasing, with an average population growth rate of -150.17×10^{-4}, which includes 12 urban built-up areas, namely Xigong District in Luoyang City, Shaanzhou District in Sanmenxia City, Shunhe District, Gulou District and Xiangfu District, as well as Yuwangtai District in Kaifeng City, Shilong District in Pingdingshan City, Zhongzhan District and Macun District in Jiaozuo City, Yindu District in Anyang City, Shancheng District and Heshan District in Hebi City , at the same time, Heshan District is also the region with the largest population decline in the province, with a resident population growth rate of -512.12×10^{-4}, which is −5.92 times of the resident population growth rate in the province, and 3.41 times the average in population negative growth region. Except for Shaanzhou District in Sanmenxia City, the resident population of the cities, where these built-up areas are located in, is showing a positive growth trendency.

The resident population of 11 county-level cities, including Yongcheng, Weihui, Wugang, Mengzhou, Yuzhou, Xingyang, Qinyang, Dengzhou, Lingbao, Xiangcheng, and Yanshi, show a negative growth trendency. Except for the three county-level cities, as Dengzhou, Lingbao, and Xiangcheng, the resident population of the cities, where they are located in, is showing a positive growth trendency. The resident population growth rate of Yanshi City is only higher than that of Heshan District, ranking second to last in the province with -482.19×10^{-4}, from the perspective of regional location and economic development level, which should be greatly affected by the population siphon effect of adjacent Luolong District of Luoyang urban. The resident population growth rate of Xingyang City, which is adjacent to three built-up areas in Zhengzhou, is about -287.17×10^{-4}, from the perspective of regional location and economic development level, it should be greatly affected by the population siphon effect of neighboring Zhengzhou urban built-up area. Among the remaining 66 counties (districts) with negative resident population growth, there are 3 in Kaifeng city, 2 in Luoyang city, 3 in Pingdingshan city, 3 in Anyang city, 1 in Hebi city, 1 in Xinxiang city, 2 in Jiaozuo city, 4 in Puyang city, 1 in Xuchang city, 2 in Luohe city, 2 in Sanmenxia city, 9 in Nanyang city, 6 in Shangqiu city, 8 in Xinyang city, 8 in Zhoukou city, and 9 in Zhumadian city.

In the geographical distribution perspective, most of these counties (districts) with negative population growth are located in the eastern, southern, and western border regions of the province. In the eastern part of the province, there is only one built-up area, Hualong District, in Puyang City, apart from this, only Taiqian County has shown positive resident population growth, while the other four counties (districts) have shown negative resident population growth; Shangqiu City only has two built-up areas, as Liangyuan District and Suiyang District, while all other counties (districts) show negative resident population growth; Zhoukou City has only one built-up area (Chuanhui District), while all other counties (districts) are experiencing negative resident population growth; Zhumadian City has only one built-up area (Yicheng District), while all other counties (districts) are experiencing negative resident population growth. In the southern part of the province, Xinyang City only has two built-up areas, as Pingqiao District and Shihe District, while all other counties (districts) show negative resident population growth; Nanyang City only has two built-up areas, as Wanping District and Wolong District. Except for Xixia County, the resident population of the other 10 counties (districts) has shown negative growth; Sanmenxia City has two built-up areas, as Shanzhou District and Hubin District, except for Hubin District and Yima City, all other 4 counties (districts) have negative resident population growth.

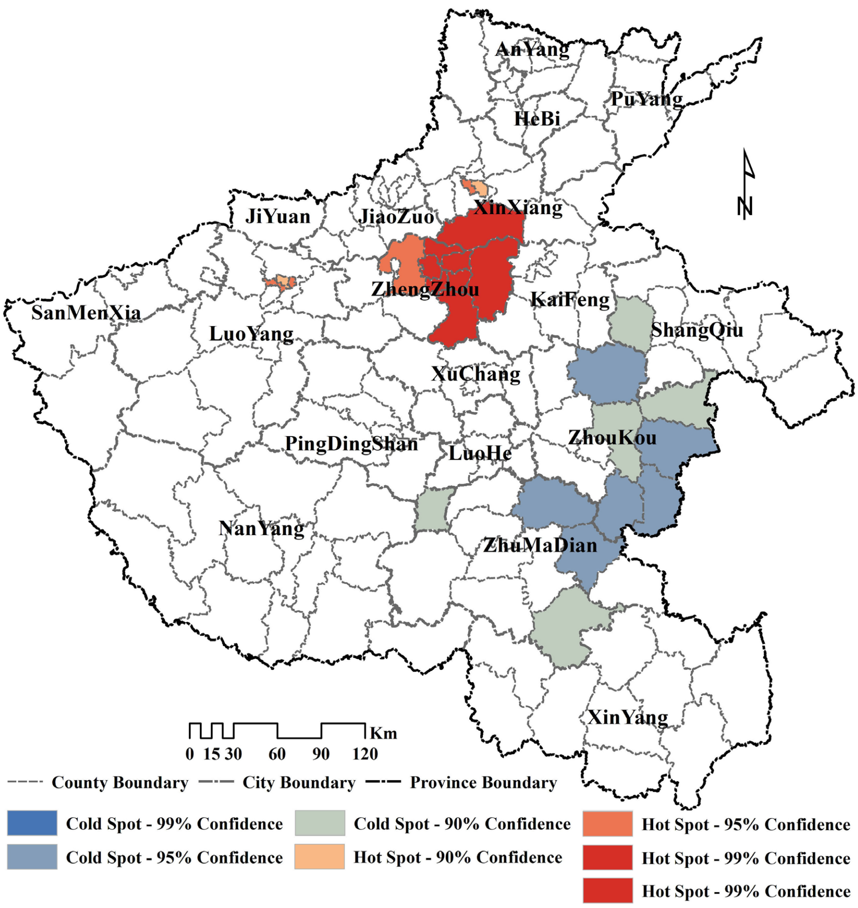

Figure 3. The Hot Spot and Cold Spot distribution of resident population growth rate in Henan.

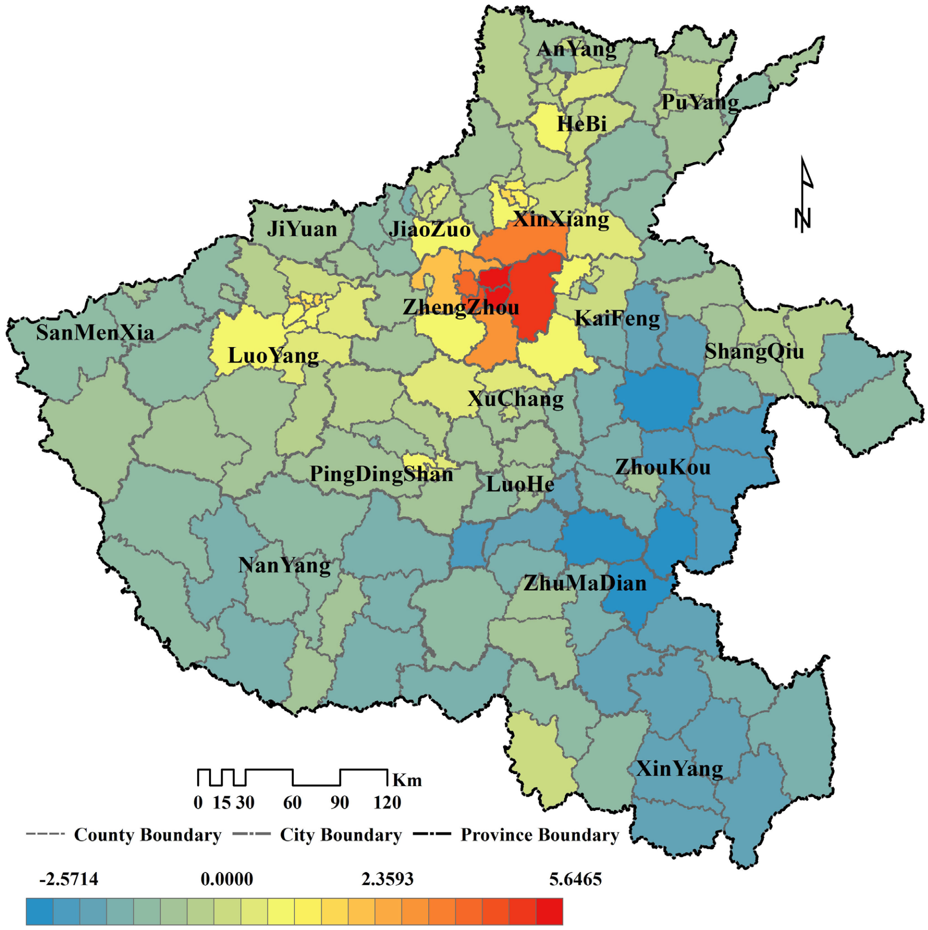

Figure 4. The Z-score distribution of resident population growth rate in Henan.

3.2. Hotspot Analysis of Resident Population Growth Rate in Henan Province

Using Equations (5) and (6) to calculate the Getis-ord Gi* index and the corresponding $Zscore_i$ for each county (district), and the results are shown in **Figure 3** and **Figure 4**, The resident population growth rate in the province exhibits clear distribution characteristics of hot and cold spots. Under the confidence level of 90%, the hotspot regions are mainly concentrated in and around the built-up areas of Zhengzhou, Luoyang, and Xinxiang, accounting for 3.5068% of the total area of the province; the cold spot regions are mainly concentrated in the eastern part of the province, spanning Shangqiu City, Zhoukou City, and Zhumadian City. Wuyang City, located at the junction of Zhumadian City, Nanyang City, Pingdingshan City, and Luohe City, also exhibits the distribution characteristics of cold spot. Under the confidence level of 90%, its area accounts for 8.6102% of the total area of the province. Under the confidence level of 99%, the hotspot area includes all built-up areas of Zhengzhou City, as well as the north adjacent Yuanyang County, east adjacent Zhongmu County, and south adjacent Xinzheng City, with a total area of 4671.10 km^2, accounting for approximately 2.7971% of the total area of the province, and there are no cold spot regions.

3.3. Spatial Heterogeneity Characteristics of Resident Population Growth Rate in Henan Province

Using Equations (7) and (8) to calculate the semi-variogram function values of the resident population growth rate $\gamma(h)$, then utilize the exponential model, spherical model, Gaussian model, and linear model to fit the function curve, under maximum the coefficient of determination and minimum residual, obtain the optimal semi-variogram function, a spherical model.

$$\gamma(h)=\begin{cases}0 & h=0\\ 1.8700\times10^{-4}+1.0410\times10^{-3}\times\left(\dfrac{3h}{2.3400\times10^{4}}-\dfrac{h^{3}}{3.2032\times10^{12}}\right) & 0<h\le1.17\times10^{4}\\ 1.22800\times10^{-3} & h>1.17\times10^{4}\end{cases} \quad (10)$$

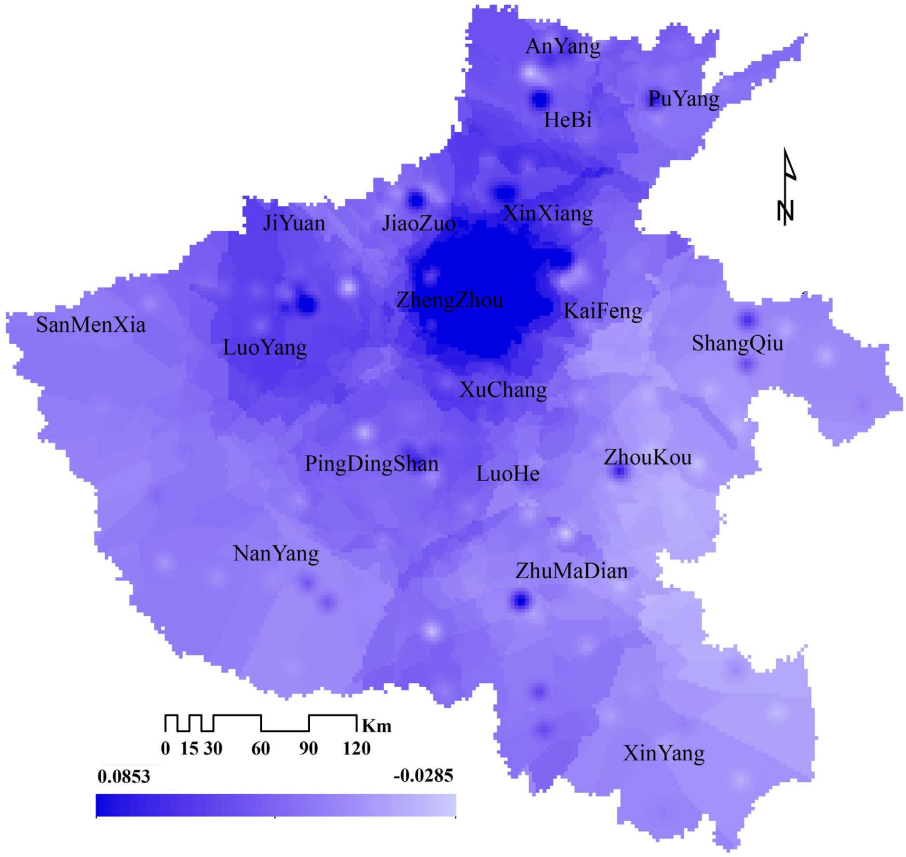

Figure 5. The interpolation distribution of resident population growth rate in Henan.

The parameters corresponding to the semi-variogram function are the nugget $C_0=1.8700\times10^{-4}$, the sill value $C+C_0=1.2280\times10^{-3}$, and the range $a=11.700$ km. The average distance between 158 sampling points is about 124.746 km, and the average nearest distance is about 20.2014 km. The nugget and the sill value shows that the dispersion of resident population growth rate is relatively small. In the range, the spatial heterogeneity of resident population growth rate $C/(C+C_0)=84.77\%$ is large, but the range is relatively small.

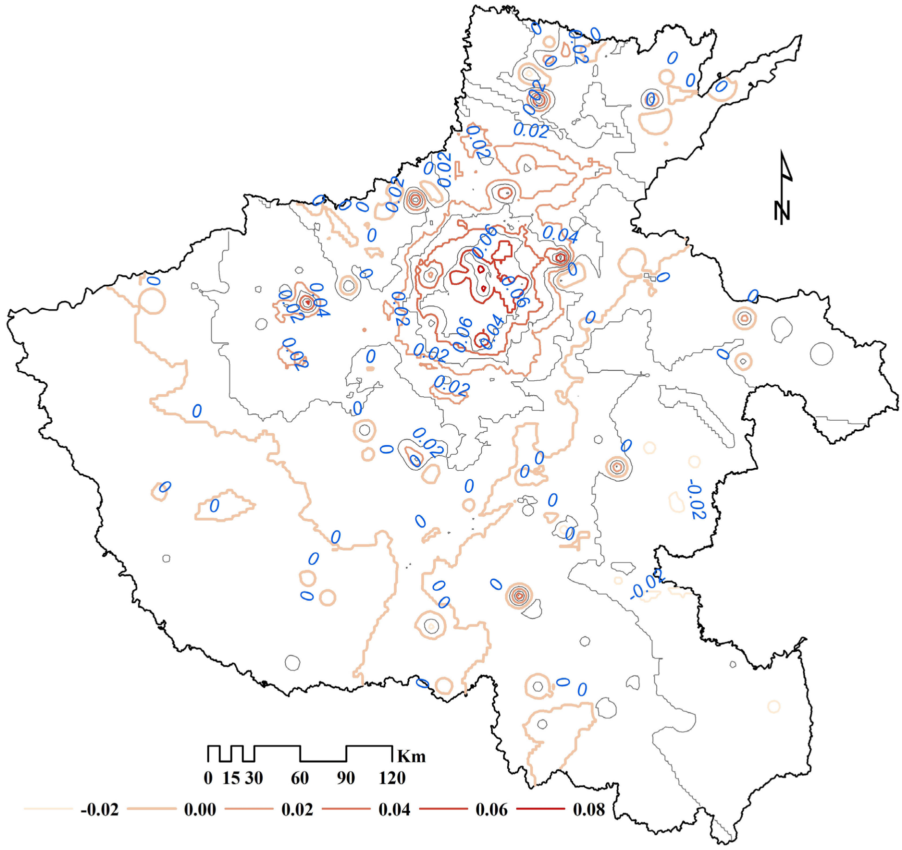

Figure 6. The contour distribution of resident population growth rate in Henan.

Based on the spherical model and Using Equation (9), to perform Kriging interpolation analysis on the province, the results are shown in **Figure 5**. Calculating the contour lines of **Figure 5**, the distribution of contour lines with the interval of 0.01 for the resident population rate is shown in **Figure 6**. Statistics show that the area with negative resident population growth is about 8.92×10^4 km^2, accounting for approximately 53.47% of the total area of the province.

4. Conclusion

This paper is based on the population statistics data of counties in Henan province from 2006 to 2021, taking counties (districts) as the basic unit, using a logistic population growth mathematical model to calculate the growth rate of the resident population in counties (districts), then utilizing the spatial analysis methods, as hotspot analysis and semi-variogram function analysis to study the spatial distribution characteristics of the growth rate of the resident population in the province. The research results show that: 1) the evolution of the resident population in the province basically conforms to the logistic natural growth model, the resident population growth rate shows the characteristics of high in the north and low in the south, and high in the center and low in the surrounding areas. The resident population growth rate is positively correlated with the level of economic development. 2) Urban built-up areas, especially new regions in urban planning, have a rapid growth rate of resident population where have a significant siphon effect on the population of surrounding regions. Under the confidence level of 90%, the hot spots of resident population growth are mainly distributed in the built-up areas and surrounding regions of Zhengzhou, Luoyang, and Xinxiang, accounting for 3.51% of the total area of the province. The cold spots are mainly distributed in the eastern part of the province, spanning across Shangqiu City, Zhoukou City, and Zhumadian City, accounting for 8.61% of the total area of the province. 3) The spatial distribution of the resident population growth rate in the whole province basically conforms to the spherical model, and the dispersion of the resident population growth rate is small and the range is short. Within the range, the spatial heterogeneity of resident population growth rate is large, but the range is relatively small.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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