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The Spatio-temporal Pattern of Rural Transformation and Development in County Areas of Henan Province

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Abstract

To construct a rural transition evaluation index system, use the entropy weight TOPSIS model and spatial analysis method to explore the temporal and spatial patterns of county-level rural economic transformation and development of Henan Province in 2000, 2005, 2010 and 2016. The results show that the spatial transformation of county transition in Henan Province is significant, and the spatial distribution of county economy and rural transition development is inconsistent. The rural transformation hot spots are distributed in the central agricultural area and some counties in the southwest of Henan. The county economic growth center is the sub-hot spot and sub-cold spot area of rural transformation.

Keywords

Entropy weight TOPSIS; rural economic transformation; Henan Province.

1. Introduction

The rapid advancement of industrialization and urbanization has made the urban-rural relationship change significantly [1-2]. The urban-rural population movement and the restructuring and interaction of economic and social development factors have accelerated, and local participants have to respond to and adjust to these changes, leading to social problems in rural areas. The reconstruction of economic form and regional spatial pattern, that is rural transformation and development [3-8]. Based on this scholars, a lot of research has been done. Early research mainly focuses on the comparison and reference of domestic and international rural development models [9], the division of rural development types [4, 10], rural transformation models [11], the dynamic mechanism of rural transformation. [12-16]etc. With the deepening of the degree of transformation, rural transformation and main function zoning [17-18], land use transformation [19-20], rural [21-23], rural reconstruction [24], rural revitalization [25], ecology The coordinated symbiotic relationship [27] such as sustainable development [26] has become a research hotspot. China is currently in the new stage of economic development and is turning to the sustainability of economic development [28-29].

Located in the middle and lower reaches of the Yellow River, Henan Province is the country's first agricultural province and plays a pivotal role in the country [31]. Henan Province is in the transitional zone from the second step to the third step. The terrain is complex and diverse. The plains and basins, mountains and hills account for 55.7%, 26.6%, and 17.7% of the total area respectively. [32] The complex geographical environment has formed Zhengzhou. The core-edge economic development pattern centered on Luoyang and Jiaozuo City. In 2016, the per capital GDP, urbanization rate and per capital disposable income of rural residents in Henan Province were 42 575 yuan, 48.50% and 11 697 yuan, respectively, which were lower than the national average of 53,980 yuan, 57.35% and 12,363 yuan respectively. The backward development of urban and rural economic development coexists, and it is particularly important to explore the spatial and temporal pattern of rural transformation in Henan

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Province. Based on the TOPSIS method of entropy weight, this study uses the county of Henan Province as the research unit, and uses spatial analysis and coupling coordination degree model to explore the temporal and spatial patterns of rural transformation with time.

2. Research Data and Methods

2.1. Research Data and Indicator System

2.1.1. Research Data

Henan Province is located in the central part of China. It has 17 prefecture-level cities, 1 province and data of the urban transformation of the municipal and county-level administrative units, In terms of accessibility, the paper uses 108 county administrative regions in Henan Province as research units. The data comes from the 2001 China, 2006, 2011, 2017, China County Statistical Yearbook, Henan Statistical Yearbook, Henan Rural Statistical Yearbook, Henan Survey Yearbook, and statistical publications on national economic and social development in some cities and counties. At the same time, according to the administrative divisions of Henan Province in 2015, some data were processed.

2.1.2. Building an Indicator System

Based on the previous research results, combined with the actual situation of Henan Province and the availability of data, the evaluation index system of rural transformation development level is selected: six indicators from population, industry and land use are selected to reflect the level of rural transformation and development in Henan Province(table 1).

Table 1: Indicator system for the rural transformation development level in Henan Province

Rule layer	Index layer	Index
Rural labor structure	Non-farm population as a percentage of the	+
	The proportion of non-agricultural employment of	+
Rural economic development	Second, the tertiary industry output value occupies the total output	+
	The ratio of agricultural output value to agricultural practitioners (Yuan/person)	+
	Total output value per unit sown area (yuan/hectare)	+
Rural land use	The proportion of the sown area of grain crops in the	-

2.2. Research Methods

2.2.1. Entropy Weight TOPSIS Method

The TOPSIS method of entropy weight is a multi-objective decision-making method. The weight of the evaluation index is determined by the entropy weight method, and the ordering of objects is determined by the TOPSIS method, which can effectively eliminate the influence of subjective factors. The calculation formula is as follows [33-35]:

1.The entropy weight method determines the index weight:

$$\omega_j = \frac{1 - H_j}{\sum_{j=1}^{n}(1 - H_j)} \tag{1}$$

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Among them: $H_j = -k\sum_{i=1}^{m} p_{ij} \ln p_{ij}$; $p_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{m} x'_{ij}}$; $k = \frac{1}{\ln m}$;positive indicators $x'_{ij} = \frac{x_{ij}}{x_{\max}}$; reverse indicators $x'_{ij} = \frac{x_{ij}}{x_{\min}}$.

In the formula: m is the evaluation target, n is the evaluation index of the evaluation target, and $x_{\max}$ is the maximum value and $x_{\min}$ is the minimum value of the index. $\omega_j \in [0,1]$ and $\sum_{j=1}^{n} \omega_j = 1$.

2.The TOPSIS method determines the comprehensive evaluation index:

$$C_i = \frac{sep_i^-}{sep_i^+ + sep_i^-}, \quad C_i \in [0,1] \tag{2}$$

among them: $sep_i^+ = \sqrt{\sum_{j=1}^{n} (s_j^+ - r_{ij})^2}$; $sep_i^- = \sqrt{\sum_{j=1}^{n} (s_j^- - r_{ij})^2}$; $S_j^+ = \max(r_{1j}, r_{2j}, \cdots, r_{nj})$;

$S_j^- = \min(r_{1j}, r_{2j}, \cdots, r_{nj})$; $R = (r_{ij})_{m \times n}, r_{ij} = \omega_j \cdot x'_{ij} (i = 1,2,\cdots,m; j = 1,2,\cdots,n)$.

2.2.2. Coefficient of Variation Method

The coefficient of variation reflects the degree of dispersion of the sample data by the ratio of the standard deviation of the sample to its mean [36]. Calculated as follows:

$$C_V = \frac{1}{y}\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(y_i - \bar{y})^2} \tag{3}$$

Where: C_V is the coefficient of variation; $\bar{y}$ is the average of the regional sample size; y_i is the observed value of the region; n is the total number of research units.

2.2.3. Exploratory Spatial Analysis

1.Global space autocorrelation. Moran's I index is an important indicator of spatial correlation. By calculating numerical variables, the index results can reflect the spatial agglomeration characteristics of variables [37]. Calculated as follows:

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(X_i - \bar{X})(X_j - \bar{X})}{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}\sum_{i=1}^{n}(X_i - \bar{X})^2}, i \neq j \tag{4}$$

Where: I is the Moran's I index; n is the total number of research units; Xi and Xj are the observations of the regions i and j, respectively; the average of the regions; Wij is the neighboring relationship between the spatial positions i and j, if the regions i and j Adjacent, then Wij=1, otherwise Wij=0. Moran's I index is between the values -1 and 1. When I >0, the indicators are purely autocorrelated in space. When I <0, the indicators are purely spatially negative autocorrelation, I =0, between indicators Present an independent random distribution.

2.Local spatial autocorrelation. The local spatial autocorrelation index (LISA) can solve the local spatial clustering significance and the clustering type regional positioning problem; the Getis-Ord Gi* index is used to measure the hotspot and cold spot analysis of geographic unit economic growth [38]. The specific formula is:

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$$I_i = Z_i \sum_{j \neq i}^{n} w_{ij} Z_j \tag{5}$$

$$G_i^* = \frac{\sum_{j=1}^{n} w_{ij} x_j}{\sum_{i=1}^{n} x_i} \tag{6}$$

Where: Zi and Zj are the normalization of the spatial unit observations xi and xj, and wij is the spatial weight.

3. Analysis of Results

3.1. Analysis of Evaluation Results of Rural Transformation

Based on the TOPSIS method of entropy weight, the comprehensive development strength of the rural transformation in henan province was calculated on 6 evaluation indexes of the rural transformation level in 2000, 2005, 2010 and 2016, and the comprehensive scores of the top 10 and the bottom 10 of the rural transformation level (excluding urban areas) in henan province in 4 years were ranked.

The high value area of rural transformation level in henan province is not in the high value area of economic growth level. Within the research period, counties with a higher level of rural transformation are mainly distributed in xinxian, yanling, neihuang, xinye and other areas in southern and southwest henan, which have a higher agricultural component and a lower level of overall economic development. Counties with a lower level of rural transformation are mainly distributed in pingdingshan, xinxiang, puyang and other regions, which are located in the periphery of the economic growth center of henan province and are not obviously driven by economic radiation, and most of them are economically underdeveloped counties. On the whole, the low level of rural transformation in henan province is concentrated in the periphery of the county economic growth center, while the high level of rural transformation is concentrated in the less developed county economy, indicating that the development of county economy in henan province has no significant driving effect on the rural transformation.

3.2. Overall Spatial Correlation Characteristics

Based on the entropy weight TOPSIS method, the comprehensive development strength of county transition in Henan Province in different years is calculated. According to the calculation method of range, C_V and Moran's I, the index value of the overall spatial correlation feature is obtained (Table 3).

Within the scope of the study, the Moran's I index of rural transformation and development level in Henan Province is positive at 0.01 confidence level, indicating that the spatial distribution of high-value rural and low-value counties in Henan Province since 2000 has been concentrated. In terms of time changes, although the Moran's I index of rural transition in Henan Province has declined in some years, it generally shows an increasing trend of volatility, and the corresponding spatial agglomeration is continuously strengthened.

The C_V value of rural transitional development level in Henan Province showed a volatility upward trend, and the regional development imbalance was obvious. Since 2000, the degree of dispersion of the rural development level index in Henan Province has generally expanded, but there are also small fluctuations. However, on the whole, the degree of dispersion of the county-level rural transformation development index still shows an expanding trend. The comparison between the C_V value and the Moran's I index shows that the two are basically consistent, which also confirms the increasing trend of the spatial agglomeration of rural transformation in the county of Henan Province.

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Table 2: The top 10 and the bottom 10 of henan rural transformation level comprehensive score（2000, 2005, 2010, 2016）

2000		2005		2010		2016		
County (city)	Comprehensive evaluation index	County (city)	Comprehensive evaluation index	County (city)	Comprehensive evaluation index	County (city)	Comprehensive evaluation index	Ranking
Xin County	0.688 7	Yanling County	0.718 1	Yanling County	0.715 0	Xixia County	0.784 4	1
Yima City	0.591 2	Xin County	0.669 5	Xin County	0.700 4	Xin County	0.685 6	2
Boai County	0.588 4	Dengzhou City	0.648 7	Zhongmou County	0.673 2	Zhongmou County	0.643 5	3
Changge City	0.530 1	Yanshi City	0.618 3	Xichuan County	0.603 2	Luanchuan County	0.605 3	4
Zhengyang County	0.528 9	Xinye County	0.572 4	Neixiang County	0.597 7	Tongxu County	0.597 1	5
Zhecheng County	0.525 2	Xiping County	0.552 4	Xinye County	0.590 7	Shangcheng County	0.568 0	6
Gushi County	0.519 8	Gushi County	0.537 7	Qi County	0.583 1	Guangshan County	0.566 4	7
Shangcheng County	0.509 1	Xihua County	0.531 4	Dengzhou City	0.582 6	Yanling County	0.559 5	8
Xinxiang County	0.508 9	Mianchi County	0.530 5	Tongxu County	0.578 7	Neihuang County	0.556 8	9
Xinye County	0.506 2	Neixiang County	0.520 4	Luanchuan County	0.574 6	Xichuan County	0.553 7	10
Ye County	0.237 6	Weihui City	0.240 4	Yuanyang County	0.251 3	Taiqian County	0.232 5	99
Wugang City	0.228 7	Taiqian County	0.234 3	Xiuwu County	0.249 4	Dengfeng City	0.230 7	100
Xinan County	0.217 9	Wuyang County	0.232 4	Lushan County	0.246 1	Xi County	0.228 3	101
Xun County	0.209 5	Wugang City	0.228 4	Dengfeng City	0.243 8	Shangcai County	0.225 5	102
Wuyang County	0.203 1	Dengfeng City	0.218 1	Linzhou City	0.243 3	Linzhou City	0.217 8	103
Yuanyang County	0.203 0	Shangcai County	0.217 3	Shangcai County	0.231 4	Wuyang County	0.217 7	104
Lushan County	0.200 1	Lushan County	0.205 0	Xi County	0.210 3	Wugang City	0.214 3	105
Puyang County	0.188 6	Puyang County	0.185 0	Wuyang County	0.188 0	Yuanyang County	0.173 2	106
Song County	0.171 4	Yuanyang County	0.144 1	Taiqian County	0.174 1	Huojia County	0.153 7	107
Luoning County	0.148 8	Fan County	0.115 8	Fan County	0.107 7	Fan County	0.135 7	108

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In terms of the two poles, the rural transition in Henan Province has shown a trend of continuous upward growth. Within the scope of research, the two extremes of rural transformation and development have been increasing, indicating that the gap between the highest and lowest levels of rural transitional development is increasing, and there is a possibility that the spatial agglomeration effect will increase.

Table 3: The general characteristics of rural transformation in different years

Year	2000	2005	2010	2016
Poor	0.542 9	0.608 4	0.609 6	0.651 0
Cv	0.269 4	0.301 6	0.292 2	0.307 5
Moran's *I*	0.298 3	0.297 5	0.361 6	0.357 8

In order to more intuitively analyze the spatial variation characteristics of county-level rural transformation, according to the score of comprehensive strength of county-level rural transformation in Henan Province in 2016, use Arc-GIS software and use the best natural fracture point method to divide the horizontal distribution map of rural transformation development in Henan Province. (figure 1).

The high-value areas of rural transformation and development in Henan Province are distributed in the periphery of the county economic development center and in the Eastern Henan Plain. On the one hand, the region is flat and has a large area of cultivated land. On the other hand, it is affected by the radiation of high-level economic zones. The development of agriculture is becoming larger, ecological and characteristic. The low-value areas of rural transformation and development and the county economy the coincidence of the development centers shows that while developing the county economy, it ignores the attention to rural areas and leads to an imbalance in regional development. On the whole, there is no one-to-one correspondence between the high-value areas of county economy and rural transformation and development in Henan Province, and there is a bias in spatial distribution.

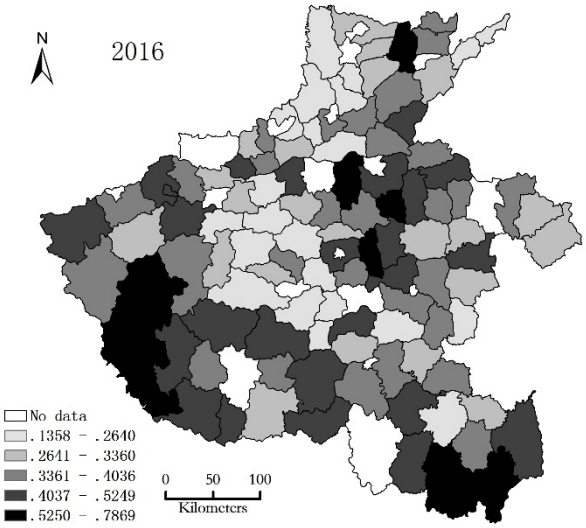

Fig.1 Spatial distribution map of rural transformation in Henan province（2016）

3.3. Local Spatial Association Features

3.3.1. Local Spatial Pattern of Rural Transformation

The level of rural transformation and development in Henan Province showed significant high and low value agglomeration characteristics (Fig. 2). The analysis results are mainly high-high and low-low type agglomeration, and the distribution is relatively scattered and the stability is

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not high; the high-low and low-high agglomeration types are less, and the latter has higher stability. The number of high-high type zones does not change much, but the spatial distribution varies greatly and is more dispersed. From the perspective of spatial correlation, the stable area is concentrated in the southwestern Henan area such as the Nanyang Basin; the change area is transferred from the southeastern Henan to the central plain to the southeastern Henan. The number of low-low type zones is the highest, showing a trend of decreasing first and then increasing. From a spatial perspective, it is mainly distributed in the hilly area of western Henan, and gradually shifts to the central and northern areas of Henan. The number of high-low type zones is small, the changes are frequent, the distribution is scattered, and the stability is poor. The low-high type zone has the fewest number, and the maximum is only 2, and the low-high type zone disappears in 2016. It is mainly distributed in the periphery of the county with a high level of rural transformation and development, that is, the county with a low level of rural transformation and development is surrounded by a county with a higher level of development.

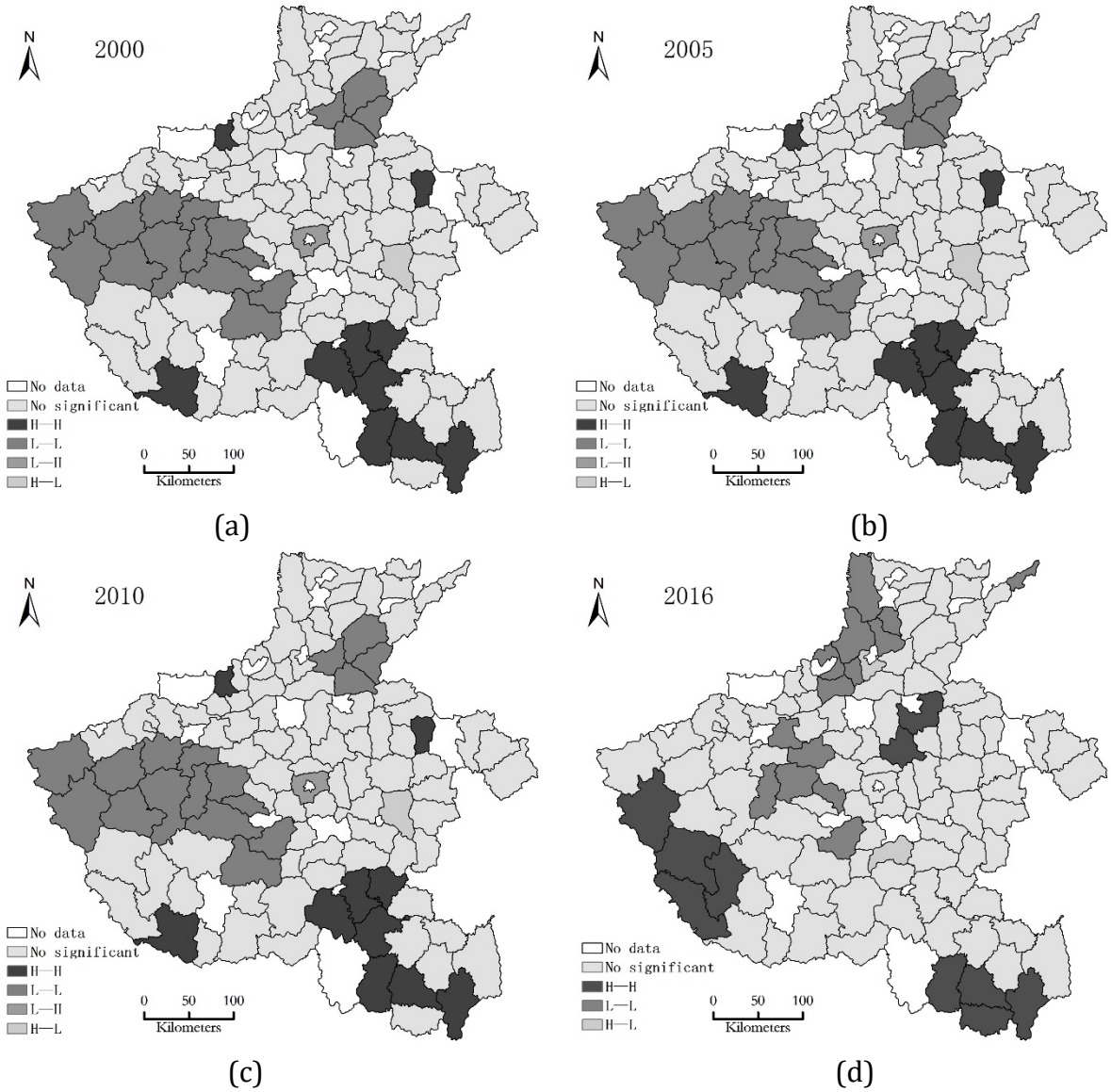

Fig.2 LISA map of rural transformation level of Henan province (2000, 2005, 2010, 2016)

3.3.2. Cold Transition Analysis of Rural Transformation

The distribution of cold hot spots in rural transitional development in Henan Province is roughly the same as its spatial correlation pattern, but there is a certain deviation from the spatial distribution of county economic development level. The rural hot spots are not distributed in economically developed counties, but cold spots. Distributed in sub-developed

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counties on the periphery of the economic development center (Figure 3). Since 2000, the number of rural hot spots in the county area of Henan Province has been increasing, showing a blocky distribution and expanding scope. In 2005, the distribution of hot spots extended from the southeastern part of Henan Province to the northwest and southwest to the central plain and the Nanyang Basin in southwestern Henan. The distribution in the southeastern part of Henan is relatively stable. The number of central plains increases first and then decreases and gradually extends to the north, while the number of southwestern Henan increases and continues to expand westward and northward. The number of cold spot areas is reduced first and then increased, and concentrated in the hilly area of western Henan. From the time change, the cold spot area in western Henan gradually disappeared and gradually extended eastward and northward. The number of secondary hot spots has decreased and the distribution is more scattered. In 2000, it was mainly concentrated in the western Henan and southern Henan areas. After that, the hot spots began to shift to the periphery of the hot spots and concentrated in the southwestern, south, and central regions of Henan. The number of secondary cold spot areas is the largest and presents a concentrated and continuous distribution. Most of them are distributed around the sub-hot spot, indicating that the level of rural transformation and development in the region has not maintained sustained growth.

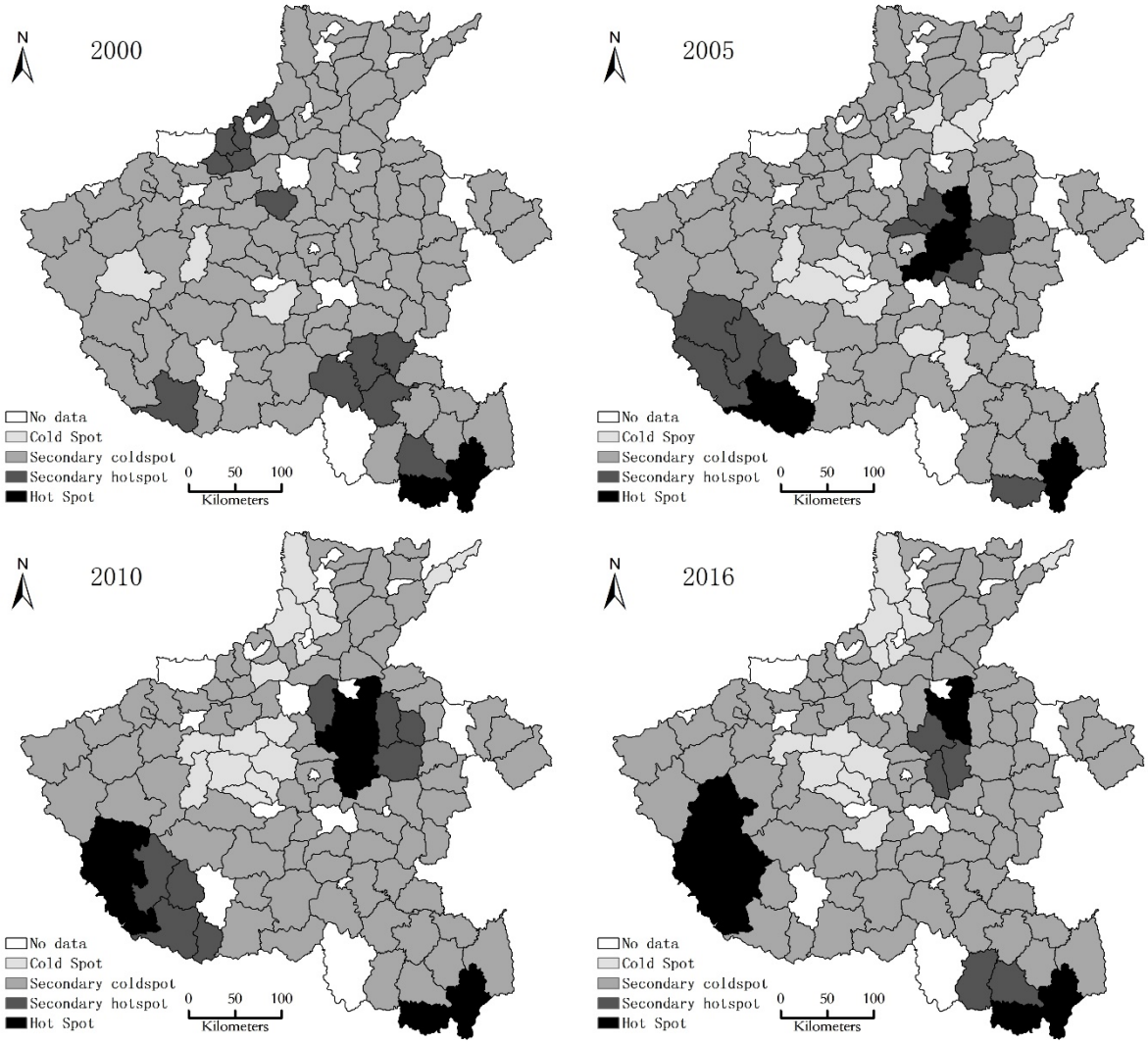

Fig.3 Economic growth hot spot in Henan Province (2000, 2005, 2010, 2016)

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4. Conclusion and Discussion

The spatial distribution of rural transformation in Henan Province is inconsistent with the spatial distribution of county economic development. There is a clear correlation distribution in the rural transformation space, mainly high-high and low-low agglomeration types, but the stability is not high, and the spatial agglomeration type distribution is relatively scattered compared with the county economic development level. The rural transformation hotspots are inconsistent with the county economic hotspots. The county economic growth centers are the sub-hot spots and sub-cold areas of rural transformation, while the new rural transformation hotspots appear in the central agricultural areas and some counties in the southwest of Henan. The export rate and the proportion of rural non-agricultural employment are relatively high, and the rural transformation effect is obvious. The overall development of the village has a significant restrictive effect on rural transformation.

The natural resources and social and economic conditions of different counties in Henan Province are quite different, the imbalance of regional development is prominent, and the rural transition also shows significant differences. Different development policies should be explored. This paper systematically analyzes the coupling and coordination relationship of rural transition in various counties in Henan Province by using multiple indicators and multiple methods, and establishes the spatial development pattern of county-level rural transformation. However, it is worth noting that the rural transition system is complex and the selection of evaluation indicators may have different results. Therefore, it is necessary to further explore the establishment of a more reasonable indicator system. In addition, due to the discontinuity of some data, this study only conducts a preliminary study on the level of rural transformation in Henan Province from the perspective of static cross-section data. In the following study, it will be combined with dynamic analysis.

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