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Spatio-temporal change of urban–rural equalized development patterns in China and its driving factors

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ABSTRACT

The urban–rural equalized development is not only significant theoretically, but also a strategic challenge facing the coordinated development of urban and rural China. In this paper we put forward an innovative theory of URED against the background of China's urban–rural transformation. The spatio-temporal pattern, its change and driving factors of urban–rural equalized development during 1996–2009 were analyzed using principal component analysis, the Markov chain model and exploratory spatial data analysis model based on the data for 31 Chinese provinces (autonomous regions and municipalities). It is found that during the study period URED exhibited an obvious tendency of "club homogenization" in China. However, since 2003 the homogenization of the URED for entire China has weakened. Moreover, URED showed a significant geographic characteristic of "polarization" during 1996–2003. Namely, the spatial units of a high URED level were concentrated in eastern China near the coast, and the spatial units of a low URED level were located mainly in central and western China. However, this spatial polarized structure of URED was destroyed since 2003, and the spatial disparity at the provincial level has decreased. Finally, it is concluded that policies and institutional structure, economic growth and urbanization were the main driving factors of the identified URED spatio-temporal pattern and its change in China. This study may serve as a scientific reference regarding decision-making in coordinating urban and rural development and in constructing the new countryside of China.

1. Introduction

Urban and rural areas are the two entities that interact with and mutually influence each other in regional development. The maintenance of a reasonable equilibrium and interactive relationship between them is the fundamental prerequisite of accomplishing coordinated development of urban and rural areas (Liu et al., 2009; Chen et al., 2010a). In 1950, the Germany Seidel Foundation initiated the concept of urban–rural equalized development (URED), which referred to "Living in the rural areas does not mean a reduced quality of life", or "inhabitants in rural and urban areas may have different life styles, but enjoy an equivalent standard of living" (Billaud et al., 1997; Neander and Schrader, 2000). Benefiting from the concept of URED and the implement of specific rural development program (e.g. land consolidation and rural renovation), rural development in Germany experienced the phase from traditional agricultural to multi-functional and integrated development, which focused on environmental, landscapes and traditional cultural preservation and contributed to keeping people staying in rural areas (Magel, 2007). Through specific spatial planning and financing, this program has more or less transformed rural living in the village into a modern residential community, sped up the process of farmland standardization, industrialized agriculture and socialized services, and entitled villagers with the same right and opportunities on education, employment, social security and other fields as urban citizens. It can be seen that Germany has acted convincingly as a pathfinder in exploring ways of implementing URED in Europe. Germany's experience of URED could be absorbed, which complied with the trend of rural development in many Chinese villages, and gave inspiration to others.

From the foundation of the People's Republic of China in 1949 to the initiation of Deng Xiaoping's reforms in 1978, economic policy in China followed a central planning model (Long and Michael, 2011). The development of agriculture and industry was unbalanced and a "dual track" structure was formalized in the national economy, with industrialization rapidly progressed at the expense

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of agriculture and the rural economy (Gustafsson and Li, 2002; Liu et al., 2010). Since the economic reforms of 1978, agriculture and the countryside have contributed greatly to, and have made substantial sacrifices for, the development of industries and cities in China (Long et al., 2011). This development strategy has caused a series of problems that obstruct China's social and economic development (Wan, 2001; Zhang et al., 2012; Liu et al., 2013a). The most notable issue is a shift in the economic balance and the widening of the prosperity gap between urban and rural areas, which is not only reflected in income difference, but also in non-agricultural employment, infrastructural construction, health insurance, social security and farmers' social status. In order to eliminate the gap between rural and urban areas, and achieve the goal of "urban–rural coordination development" (*chengxiang tongchou*), government should consider mapping out proper policies and strategies. The URED might serve as an important model for coordinated urban–rural development and modern village construction in China.

After more than 30 years of reform and opening up, China's rapid urbanization has caused a huge quantity of cultivated land lost to industrial workshops while rural labor is transformed into workers, resulting in large-scale rural hollowing and depopulation (Liu et al., 2010, 2013b; Sun et al., 2011). Currently, about 250 million rural labors in China shuttle between urban and rural areas. However, it is difficult for them to settle and work permanently. The issue stems from the underlying cause that the Chinese government attaches extreme importance to urban development and beautification without paying adequate attention to creating sufficient employment opportunities in villages and small towns so as to prevent rural people from moving to cities (Long et al., 2009; Leeuwen and van Dekkers, 2013). In 2011, China's urbanization rate has reached 51.3%. However, urban–rural development inequality and industrial-agricultural divergence have worsened due to the dual-track structure of socio-economic development (Zhai and Liu, 2009; Long et al., 2011). What is actually the outlet road for rural area development in China during the urban–rural transformation era—to rush blindly for rapid urbanization or to seek steady URED? This problem is not only a theoretical issue in urgent need of in-depth study in rural geography, but also a strategic challenge facing urban–rural coordinated development and construction of a modern countryside.

Against this backdrop, the fifth plenary session of the sixteenth central committee of the Communist Party of China (CPC) put forward an important long-term development strategy to "build a new socialist countryside", in which China's collaborative construction of physical, spiritual, ecological, political and social civilization was expected to be shaped, and China's modernization was driven by "two engines" of urbanization and new countryside construction. Also proposed were the tactics of highlighting the socio-economic functions and value of rural China, promoting the inter- and intra-regional flow of production elements, cultivating self-innovative and specialized industries of township and villages, and elevating self-supporting capability, productivity and competitiveness of rural areas. In 2012, integration of urban–rural development is put forward as a major strategy of rural sustainable development in the eighteen central committee of CPC. In response to these policy propositions and requirements, the geographic study on the coordinated urban–rural development and construction of modern countryside should be strengthened.

In recent years, numerous studies have analyzed China's urban–rural development from the multidisciplinary perspectives of geography, economics and sociology. Previous studies mainly focused on the essential characteristics (Chen et al., 2010b), dynamic mechanism (Liu et al., 2008; Long et al., 2009), construction modes (Li and Yang, 2011; Song et al., 2012), as well as planning and implementation (Zheng and Yu, 2011) of urban–rural development. However, few studies concentrated on China's urban–rural equalized development. So far researchers have merely focused on the qualitative analysis of the connotation (Stumpf, 1984, 1997; Stroessner, 1986; Ye and Bi, 2010), theory (Wilson and Wilson, 2001; Knickel and Peter, 2005; Wang, 2008a), mode (Jahnke, 1992; Cullingworth and Nadin, 2006; Li, 2007) and approaches (Schrader et al., 2004; Bruckmeier, 2000; Wang, 2008b) of URED. There is still a lack of quantitatively evaluating URED and revealing the spatio-temporal differentiation and driving mechanism of URED. Thus, no breakthrough has been achieved in the theory and practice of URED in China. This paper aims to put forward an innovative theory of urban–rural equalized development against the background of rural–urban transformation. It emphasizes the spatio-temporal pattern, dynamic process and driving forces of URED. This study may serve as a scientific reference regarding decision-making in coordinating urban and rural development and in constructing the new countryside of China.

2. Connotation and evaluation of URED

2.1. Connotation of URED

Currently, both rural development and urban development in China are experiencing a transition period. The traditional agricultural society is being transformed into a modern, industrial and urban society, and the economy is changing from a traditional planned economy to a modern market system (Liu, 2007; Long et al., 2011). This rural and urban transformation comprises urban–rural integrated development as a strategic process, and urban–rural equalized development (*chengxiang dengzhihua*) as a strategic goal. According to the strategy of promoting the integration of urban–rural economic and social development, improving socialist new countryside construction plans, and accelerating the improvement of rural production and living conditions, URED should be put forward. The purpose of URED is to smoothly accomplish the distinctive equalization of urban–rural spatial location, economic investment, social services, ecological environment and quality of life.

(1) The fundamental concept of URED implies that inhabitants in cities and villages may have different life styles, but can still enjoy an equivalent living standard. At present there is a huge disparity between urban and rural areas in terms of level of development in China. It dictates the complexity of urban and rural development characteristics and diversifies their development models. Rather than following the same development models as cities, URED highlights an innovative development model, in which villages are able to not only enjoy the same allocation of infrastructure, public services, social security, and basic rights as cities, but also preserve the traditional cultural landscape with idyllic characteristics (Liu, 2007; Gross et al., 2011). Instead of farmland being lost to factory workshops and villages converted to cities, URED focuses on eliminating urban–rural differences in pursuit of the rural style of production and life by popularizing mechanical farming and creating a favorable rural living environment and employment condition in rural areas (Stroessner, 1986).

(2) URED refers to the collaborative process of urban–rural differential development and urban–rural complementary development, attaching more importance to equalizing urban–rural life quality and functions. URED involves four evolutive implications, evolving from building the concept of URED to

Table 1
Appraisal indicator system of the urban–rural equalization development level.

Target layer	Criterion layer	Index layer	Calculation formula
Spatial location	Transportation	Highway net density (km/10,000 km^2) x_1	Highway mileage (km)/Area of land (10,000 km^2)
	Spatial distribution	Degree of spatial structure concentration (%) x_2	$P = 100 - 1/2\sum_{i=1}^{n}(G_i - R_i)$, where P is the degree of spatial structure concentration, G_i is the ratio of GDP of the ith region in total GDP, R_i is the ratio of population of the ith region in total population at the year-end.
Economic investment	Economic development	Per capita gross domestic product (GDP) (RMB¥/10,000persons) x_3	Gross Domestic Product (GDP) (RMB¥)/Population at the year-end (10,000 persons)
	Industrial division of labor	Proportion of nonfarm payroll employment (%) x_4	Population of rural nonfarm payroll employment (10,000 persons)/ Population of rural employment (10,000 persons)
	Financial investment	Relative proportion of financial support for agriculture (%) x_5	Proportion of the financial support for agriculture in total financial investment (%)/Proportion of the primary industry in GDP (%)
		Ratio of urban–rural fixed-asset investment (%) x_6	Rural fixed-asset investment (RMB¥)/Urban fixed-asset investment (RMB¥)
	Production efficiency	Index of urban–rural productivity of dual track structure (%) x_7	$Q = \sqrt{\frac{V_1/E_1}{V_2/E_2}}$ where Q is the index of urban–rural productivity of dual track structure; V_1 and V_2 are added value of the primary industry (RMB¥), and added value of the secondary and tertiary industry (RMB¥); $E_1$and E_2 are employed population of the primary industry (10,000 persons), and employed population of the secondary and tertiary industry (10,000 persons)
Social services	Education and culture	Average number of university students among each ten thousand people (%) x_8	Population of university students (10,000 persons)/Population at the year-end (10,000 persons)
	Health care	Average number of hospital beds per ten thousand inhabitants (beds/10,000persons) x_9	Number of hospital beds/Population at the year-end (10,000 persons)
Ecological environment	Ecological environment	Ratio of industrial wastewater standards discharge (%) x_{10}	Amount of industrial wastewater standards discharge (10,000 ton)/ total amount of industrial wastewater discharge (10,000 ton)
		Forest coverage(%) x_{11}	Forest cover (10,000 km^2)/Area of land (10,000 km^2)
		Consumption of chemical fertilizer (10,000ton) x_{12}	Amount of chemical fertilizer use (10,000 ton)
Life quality	Income gap	The ratio of urban–rural residents' income (%) x_{13}	Per capita net income of rural households (RMB¥)/Per capita disposable income of urban households (RMB¥)
		Gini coefficient (%) x_{14}	$G = 1.067 - 20.22(1/A) - 0.89 \ln A$, where G is Gini coefficient, A represents gross domestic product (GDP) (RMB¥)
	Distinction of consumption	Ratio of urban–rural residents' Engel coefficient (%) x_{15}	Rural residents' food expenses out of the consumption expenditure (RMB¥)/Urban residents' food expenses out of the consumption expenditure (RMB¥)
		Ratio of urban–rural residents' consumption expenditure (%) x_{16}	Rural residents' consumption expenditure (RMB¥)/Urban residents' consumption expenditure (RMB¥)

achieving equivalent supply of public facilities, then to accomplishing equal social welfare and rights, and finally to realizing equalized individual wealth and social status between urban and rural China. Following the interactivity and dynamics of the urban and rural systems, URED serves to promote industrial–agricultural benign interpenetration and coordinated urban–rural development, thereby achieving substantially equalized rights and benefits, as well as the goal of same-land-same-price for both urban and rural areas. URED should not target "assimilation" or "duplication" of the urban and rural development model. Rather, it seeks to make the city more like a city and the village more like a village (Stumpf, 1997).

(3) URED as a definite measure and operating model is beneficial to gradually eliminating the dual-track structure of urban–rural development, bridging the urban–rural gap, and creating harmonious urban–rural interactions as the long-term strategy. First of all, by implementing the strategy of industry financing agriculture and city supporting village, URED is in favor of developing rural economy, increasing peasants' income, raising labor quality, improving rural living conditions, and reinforcing self-governance by villagers themselves. Moreover, promoting URED satisfies the demand of constructing a new countryside, with the aspiration of advanced production, a wealthy life, civilized local customs, clean and tidy village outlook, and effective and democratic management of village affairs. Furthermore, promoting URED is conducive to suppressing ill planned expansion of cities so as to avoid the disappearance of the unique rural culture and landscape.

2.2. Appraisal indicator system and method

2.2.1. Appraisal indicator system of URED

In the context of urban–rural transformation, URED has been an important model for coordinated urban–rural development and modern village construction in China. However, there is a lack of an appraisal indicator system that can be used to assess the level of URED among the 31 administration units in China. Based upon the consideration of maneuverability, dynamics, scientific validity, and comprehensiveness, a critical indicator system was established using the expert consultation method (Delphi) according to the scientific definition of URED, with reference to related literature, feasibility reports, and official reports (Shen et al., 2012; Zhang et al., 2012; Siciliano, 2012) in this study. Semi-structured interviews with geography and sociology experts at home and abroad and government officials for urban–rural development were conducted to determine the evaluation index system in Table 1. It takes into consideration the multi-scale characteristics and spatial heterogeneity in evaluating the URED level among the 31 Chinese provinces (autonomous regions and municipalities). It consists of the target layer, the criterion layer, and the index layer, and includes 16 identified specific indicators to reflect urban–rural equalized development characteristics of spatial location, economic investment, social services, ecological environment and life quality (Table 1).

2.2.2. Data resources

Due to the difficulty in obtaining data, this study makes use of data in three years, 1996, 2003 and 2009 for the 31 Chinese provinces (autonomous regions and municipalities). The data in these 3 special years-1996, 2003, and 2009 were more complete and comprehensive than others. In 1996, the population in rural China peaked at 859 million. In the same year, Chinese government initially finished detailed land use survey at the national level, and published national-wide land use data. In 2009, the second detailed land use survey was finished at the national level. In terms of 2003, it was not only the year in the middle of 1996 and 2009, but also the first year after the 16th National Congress of CPC initiated rural socio-economic development reform in 2002. In hence, these three years were very significant and typical for us to research the URED in China. Because we aimed to describe and compare all of these data from 1996 to 2009 for the whole country, we made sure that any data used were from unified statistical sources and that the economic data were based on comparable pricing, that is, all of the original economic data from 2003 to 2009 were calculated using the constant price from 1996.

All data were obtained from the Comprehensive Statistical Data and Materials on 50 Years of New China, the annual reports of National Bureau of Statistics of China, Chinese Statistical Yearbooks from 1997 to 2010, Chinese City Statistical Yearbooks, Chinese Statistical Yearbook for Regional Economy, Chinese Population Statistical Yearbooks and the relevant yearbook of 31 Chinese provinces (autonomous regions and municipalities).

2.2.3. Evaluation method

2.2.3.1. Principal component analysis. Principal component analysis (PCA) was carried out to calculate the level of URED using SPSS version 18.0.1 for Windows based on the collected socio-economic data for the 31 Chinese provinces. PCA involves the following seven major steps: (i) the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was employed to test the appropriateness of the data for PCA analysis (Bagozzi and Yi, 1988; Song et al., 2011), (ii) compute the correlation matrix (coefficients) and covariance matrix, (iii) identify the eigenvalues and the corresponding eigenvectors, (iv) discard any components that account for only a small proportion of the variation in datasets (Song et al., 2011), (v) develop the PCA loading matrix and perform a varimax rotation on the factor loading matrix to infer the principal variables, and (vi) calculate the URED (Johnson, 1998; Song et al., 2011).

2.2.3.2. Markov chain model. Markov process is a special random moving from one state to another state at each time step (Guan et al., 2011). A first-order Markov model is the model of a system in which probability distribution over next state is assumed to only depend on current state, but not on previous ones (non-aftereffect) (Veldkamp and Lambin, 2001; Fischer and Sun, 2001; Pijanowski et al., 2002; Guan et al., 2011). It is commonly used in the prediction of geographical characteristics lacking after-effect events, and has become an important prediction method in geographical research (Clancy et al., 2010; Yang et al., 2012). In this paper, Markov chain analysis was used to predict the transition probability between different URED levels. Through integrating GIS software and the Markov chain model, the temporal evolution pattern of URED in the future was also simulated. Markov chain analysis is an effective means in modeling the change of URED levels. This change serves as an indicator of the direction and magnitude of the URED level in the future (Yang et al., 2012). As a robust model, the Markov transition matrix is feasible to not only quantitatively explain the conversion between different URED levels, but also reveal the transfer rate between them.

2.2.3.3. Exploratory spatial data analysis model. Spatial statistical methods are able to reveal the spatial dependence, spatial association and spatial autocorrelation among spatial data by adopting various spatial statistical analytic models (Anselin, 1996; Dai et al., 2010). As a core technique in spatial statistical analysis, the exploratory spatial data analysis (ESDA) technique can be applied to study spatial dependence and heterogeneity by analyzing spatial autocorrelation (Anselin, 1995; Dai et al., 2010). It is able to reveal the characteristics of spatial data, detect singular points or regions, explore spatial association patterns, clusters or hot spots, and make spatial partitions via visualization (Dai et al., 2010). In general, ESDA includes such two aspects as global spatial autocorrelation analysis (e.g. Global Moran's I and Geary's C) and local spatial autocorrelation analysis (e.g. Getis-Ord's Gi* and LISA).

In this paper, the Global Moran's I statistic and Moran scatter plot map are used to measure spatial autocorrelation of URED using GIS and Geoda software. This global Moran's I statistic is essentially a cross-product correlation measure that incorporates "space" by means of a spatial weights matrix W (Jing and Cai, 2010). Significance can be obtained by randomly permuting the observed values, based on analytical derivations, or, more commonly, on a comparison to a reference distribution (Cliff and Ord, 1981; Jing and Cai, 2010). The value of Global Moran's I ranges from -1 to 1. Given a certain significance level, a Moran's I value significantly beyond zero implies spatial positive correlation and obvious spatial clusters of cells with higher attribute values or lower attribute values, and the Moran's I near $+1.0$ indicates a small global spatial difference. On the other hand, a Moran's I value significantly below zero implies spatial negative correlation and an obvious spatial difference in the attribute values between the cells and their adjacent cells, and the Moran's I near -1.0 indicates a large global spatial difference. While a Moran's I value near $-1/(N-1)$ indicates the pattern expressed is spatially random without spatial autocorrelation (Cliff and Ord, 1981; Dai et al., 2010).

The Moran's I statistic can be visualized as the slope in a scatter plot of the spatially lagged variable (W_x) on the original variable (x), or a so-called Moran scatter plot (Anselin, 1995; Jing and Cai, 2010). This provides an easy way to categorize the nature of spatial autocorrelation into four types, corresponding to spatial clusters and spatial outliers. Specifically, observations in the lower left (low–low) and upper right (high–high) quadrants represent potential spatial clusters (values surrounded by similar neighbors), whereas observations in the upper left (low–high) and lower right (high–low) quadrants suggest potential spatial outliers (values surrounded by dissimilar neighbors) (Anselin, 1995; Jing and Cai, 2010).

3. Spatio-temporal pattern changes of URED

3.1. Temporal evolution characteristics of URED

In order to assess the level of URED, principal component analysis was carried out using SPSS software, based on the collected socio-economic data for the 31 Chinese provinces. Kaiser (1974) suggested the common KMO test evaluation criteria. A KMO value over 0.9 indicates strong suitability for PCA; a value of 0.8 means suitability; a value of 0.7 shows moderate suitability; a value of 0.6 signifies poor suitability; while a value of 0.5 implies strong unsuitability" (Shen et al., 2012). According to the results obtained, the KMO value of economic benefit indicators were 0.673 in 1996, 0.670 in 2003 and 0.651 in 2009, respectively, which were all larger than the test threshold of 0.6, indicating that the sample was commonly suitable for PCA. By setting the cumulative variance contributions of no less than 76% as the selection criterion, the first four principal components of PCA were found to have an eigenvalue above 1. These four components, respectively, explained 77.6%, 77.6% and 77.0% of total variance in 1996, 2003 and 2009, which meant that they could substitute reasonably the 16 original indices with little loss of information. These results indicate that PCA is suitable for and effective in evaluating the level of URED.

It can be seen through Table 2 that the 31 Chinese provinces had a gradual regional distribution pattern of URED, dropping from eastern coastal provinces to central China and further to western China. This geographical distribution feature of URED is consistent with the regional economic disparities and rate of urbanization, which suggests that regional economic growth and urbanization may impose a strong effect on URED. The capital of Beijing reached the highest level of URED with an evaluation value of 143.63 in 1996, 126.60 in 2003 and 108.86 in 2009, respectively. Comparatively, the evaluation value of Inner Mongolia (28.05), Guizhou (18.68), Yunnan (3.69) all ranked the lowest with the smallest URED value, which were 5.1times, 26.78 times, and 29.5times lower than Beijing's during 1996–2009, respectively. Furthermore, the variation coefficients of URED amounted to 0.72, 1.14 and 1.63 in 1996, 2003, and 2009, demonstrating that the regional difference of URED was on increase during the study period.

The Markov chain model was used to reveal the temporal evolution pattern of URED for the 31 provinces over 1996–2003 and 2003–2009. Firstly, all the indicators, including spatial location, economic investment, social services, ecological environment, and life quality, were fed into a formula based on GIS that grouped all provinces into four URED levels, i.e., uppermost, high, medium, and low. Then the Markov transition probability matrix for the URED is calculated on the basis of the Markov model to predict the evolutionary transformation pathway and probabilities between different levels for all provinces over the study periods. The temporal evolution characteristics of URED were analyzed by employing the Markov chain model incorporated into GIS as follows:

(1) During 1996–2003, the transition probabilities of different levels of provinces showed the characteristics of uppermost URED level > low URED level > high URED level > medium URED level. Overall, more than 66.67% of provinces stayed at the same level, even though a few regressed or progressed to a higher URED level. All the provinces belonging to the uppermost level remained unchanged at the same level. More provinces (municipalities) that belonged to a low level tended to keep stalled (81.82%) than moved upward to other levels (18.18%). Provinces at high levels of URED were more likely to advance to the uppermost level than to drop to the low level, of which the transition probabilities were 33.33% and 0, respectively. While provinces at the medium URED level were more likely to drop significantly to the low level (16.67%) than jumping up to the high and uppermost levels (0). These results show that the URED of the 31 Chinese provinces exhibited an obvious "club homogenisation" phenomenon. Actually, "club homogenisation" refers to a set of regions with similar geographical proximity, analogous initial conditions and structural features. In essence, the convergence of the URED levels consists of space and time. In the long term, the level of URED would converge to the same steady state. "Club homogenisation" of URED levels among the 31 Chinese provinces (autonomous regions and municipalities) took place not only among eastern coastal China, central China and western China, but also within the eastern, central and western regions as well.

(2) During 2003–2009, the transformation between each level of URED was more frequent and intensified. There existed 45.45% of provinces of a medium level leaping to the high level of URED. Provinces belonging to the medium and low levels still maintaining at the same level decreased by 37.88% and 23.49%, respectively. Provinces of the medium level progressing to the high or uppermost levels, and the low level advancing to the medium, high or uppermost levels of URED rose 45.45% and 23.49%, respectively. By comparison, only 9.10% of provinces belonging to the medium level shifted downward to the low URED level. The meaningful result indicates that URED of the 31 Chinese provinces gradually broke away from the tendency of "club homogenisation" and regional disparity became dwindled.

3.2. Spatial evolution characteristics of URED

3.2.1. Spatial autocorrelation analysis of URED

To explore the spatial evolution of urban–rural equalized development of the 31 Chinese provinces in 1996, 2003 and 2009, the Global Moran's *I* statistic and Moran's *I* scatter plots are adopted to reveal the characteristics of spatial heterogeneity and temporal evolution of URED at different scales and in different periods in China with ESDA. Using GIS and Geoda software, the value of Global Moran's *I* of URED was categorized into four types, corresponding to spatial clusters and spatial outliers. Specifically, observations in the lower left (low–low) and upper right (high–high) quadrants represent potential spatial clusters (values surrounded by similar neighbors); whereas observations in the upper left (low–high) and lower right (high–low) quadrants suggest potential spatial outliers (values surrounded by dissimilar neighbors). Fig. 1 displays the Moran's *I* value and Moran's *I* scatter plot of URED. The spatial autocorrelation of URED is detailed as follows:

Table 2
The value and order of the urban–rural equivalent development of 31 Chinese provinces.

R	V_{1996}	O_{1996}	V_{2003}	O_{2003}	V_{2009}	O_{2009}	*R*	V_{1996}	O_{1996}	V_{2003}	O_{2003}	V_{2009}	O_{2009}
Beijing	143.63	1	126.60	1	108.86	1	*Henan*	51.46	17	36.99	20	33.73	16
Shanghai	136.00	2	120.84	2	108.85	2	*Hunan*	51.23	18	36.52	21	25.38	23
Tianjin	97.80	3	107.13	3	87.22	3	*Heilongjiang*	36.86	27	47.36	14	36.66	14
Jiangsu	75.67	5	65.43	4	75.82	4	*Xinjiang*	46.97	20	35.93	22	12.95	28
Zhejiang	75.56	6	62.28	6	71.25	5	*Shanxi*	52.14	15	41.70	19	26.99	20
Liaoning	75.72	4	64.46	5	53.53	7	*Qinghai*	43.36	23	31.43	25	25.72	22
Guangdong	72.41	7	54.23	8	52.16	8	*Guangxi*	41.55	24	29.76	27	9.94	29
Fujian	66.72	8	56.41	7	43.99	9	*Ningxia*	41.01	25	30.07	26	19.40	24
Hebei	65.43	9	51.12	11	43.74	10	*Sichuan*	44.47	21	34.74	23	25.73	21
Shandong	60.00	10	50.83	12	54.38	6	*Chongqing*	44.47	22	43.82	18	35.08	15
Hainan	56.95	14	48.67	13	16.25	26	*Gansu*	38.00	26	29.08	28	13.78	27
Jilin	57.43	11	52.18	9	36.91	13	*Yunnan*	34.15	28	22.26	30	3.69	31
Shanxi	57.27	12	47.30	15	38.51	12	*Xizang*	32.24	29	26.38	29	17.49	25
Hubei	56.97	13	51.24	10	39.82	11	*Inner Mongolia*	28.05	31	33.73	24	32.31	17
Jiangxi	51.72	16	43.80	16	29.52	19	*Guizhou*	31.72	30	18.68	31	9.86	30
Anhui	50.71	19	43.13	17	31.29	18							

Note: V_{1996}, V_{2003}, V_{2009} indicates the URED value of 1996, 2003, 2009; O_{1996}, O_{2003}, O_{2009} indicates order, respectively.

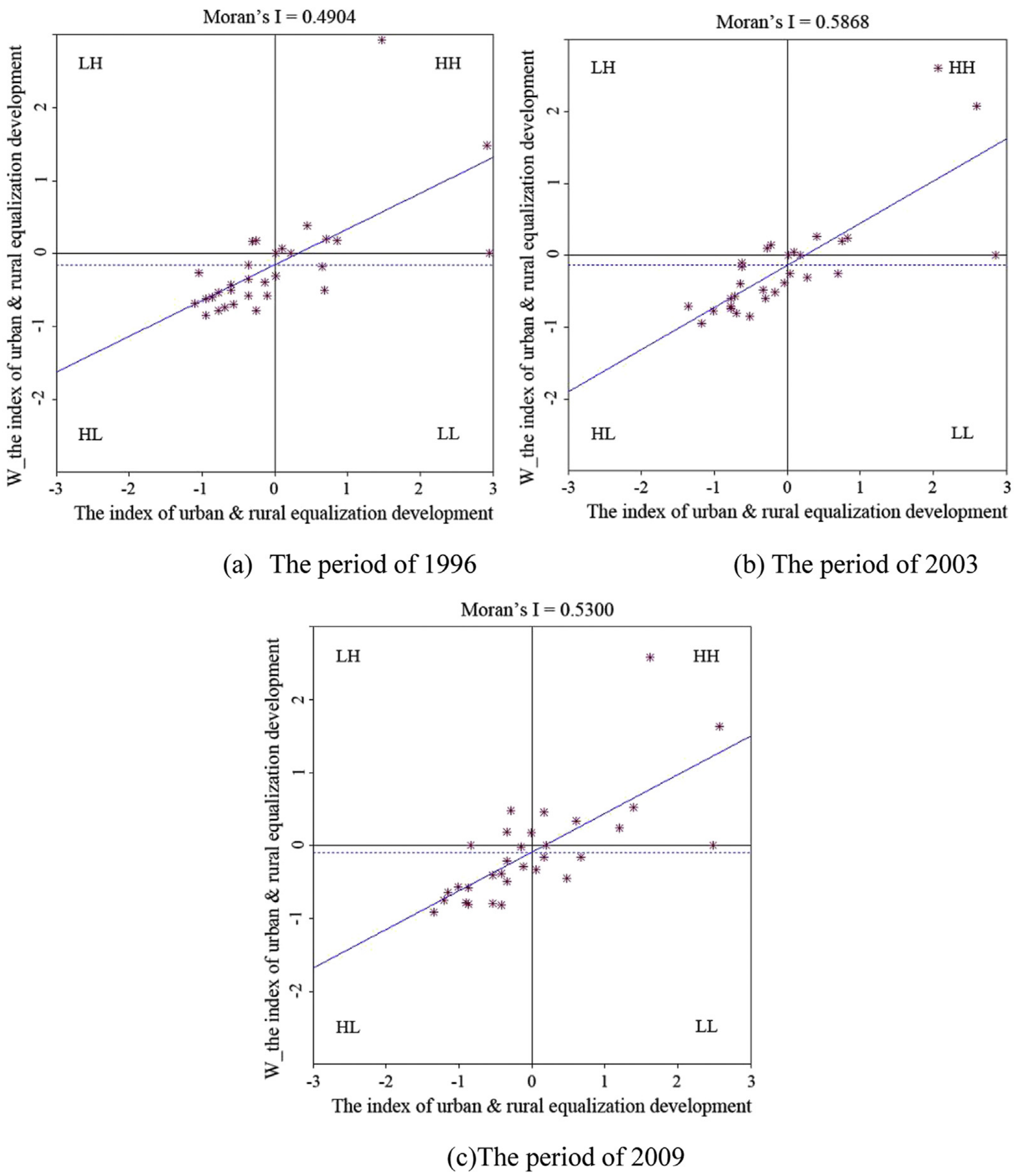


Fig. 1. Moran scatter plot of the urban–rural equivalent development level in China.

(i) Throughout the study periods of 1996, 2003 and 2009, the overall spatial disparities of the URED were large at the national level. The Moran's *I* value of URED for the 31 Chinese provinces were all positive and significantly higher than zero (Fig. 1), indicating a strong spatial autocorrelation and obvious spatial clusters of provinces with higher attribute values or lower attribute values. During 1996–2003, the Moran's *I* value of URED rose from 0.4904 in 1996 to 0.5868 in 2003, which suggests that provinces with a relatively high (low) level of URED tend to be located in close proximity to other high (low) developed provinces. However, the Moran's *I* value showed a declining trend from 0.5868 in 2003 to 0.5300 in 2009, indicating that the overall spatial difference at the provincial level was increasing in that provincial inequality of URED within the eastern, central and western regions themselves has been more serious than inter-regional rural inequalities among the three regions.

(ii) The Moran's *I* value changed by 0.1 from 1996 to 2003, indicating the URED of entire China had a geographic characteristic of spatial aggregation with a significant positive spatial correlation. Comparatively, the Moran's *I* value changed by −0.6 during 2003–2009, demonstrating the spatial aggregation extent of URED tended to decline, resulting in an enlarged spatial disparity of URED at the provincial level.

(iii) The change of the type of spatial autocorrelation. From 1996 to 2003, low–high provinces (provinces of a low URED value surrounded by neighbors with high URED) and high–low provinces (provinces of a high URED value surrounded by neighbors with low URED) accounted for less than 17% of the total, indicating that a small number of provinces had a typical feature of spatial difference with their neighboring provinces. The low–low provinces (cold spots of a low URED value surrounded by neighbors with low URED) made up more than 54% of the total. The high–high provinces (hot spots of a high URED value surrounded by neighbors with high URED) accounted for more than 29% of the total, indicating that the URED of the 31 provinces displayed a significant tendency of "polarization", particularly characterized

(a) The period of 1996

(b) The period of 2003

(c) The period of 2009

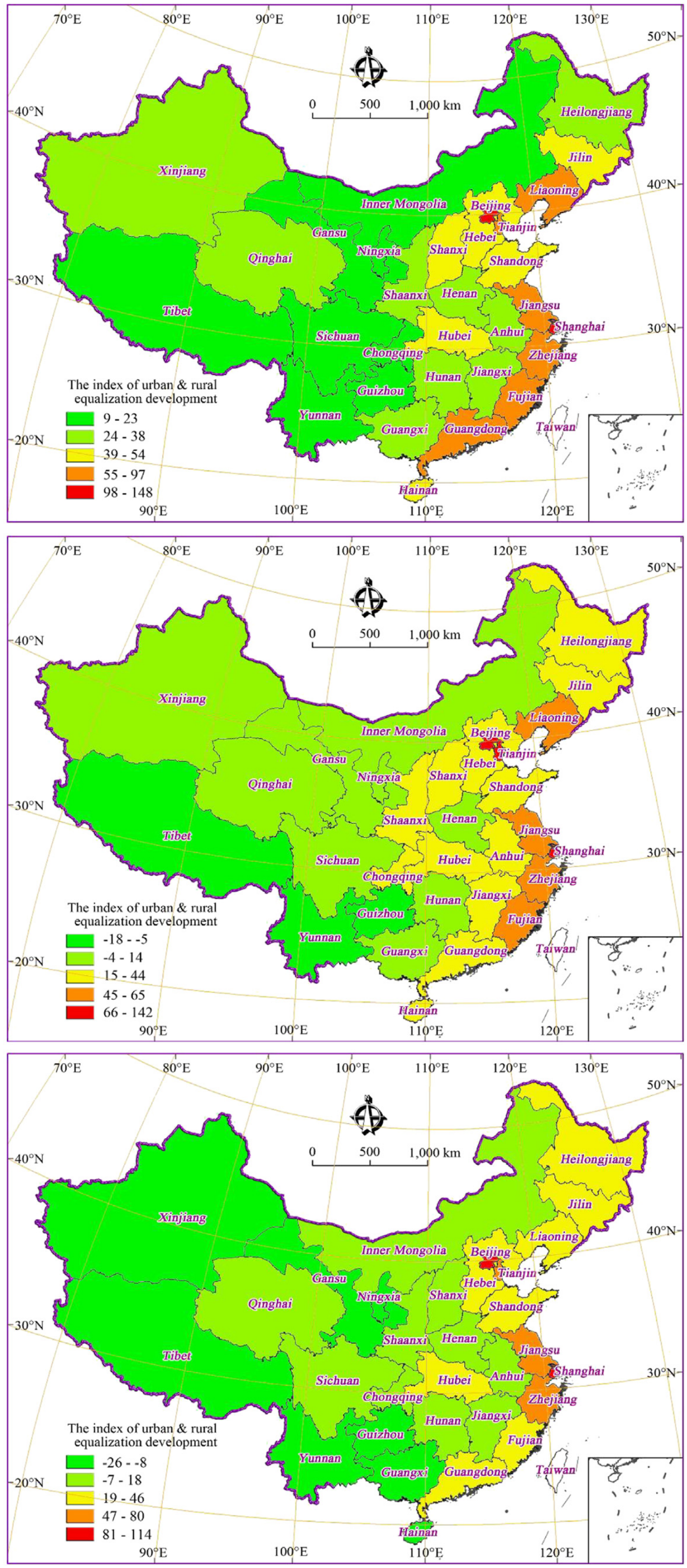
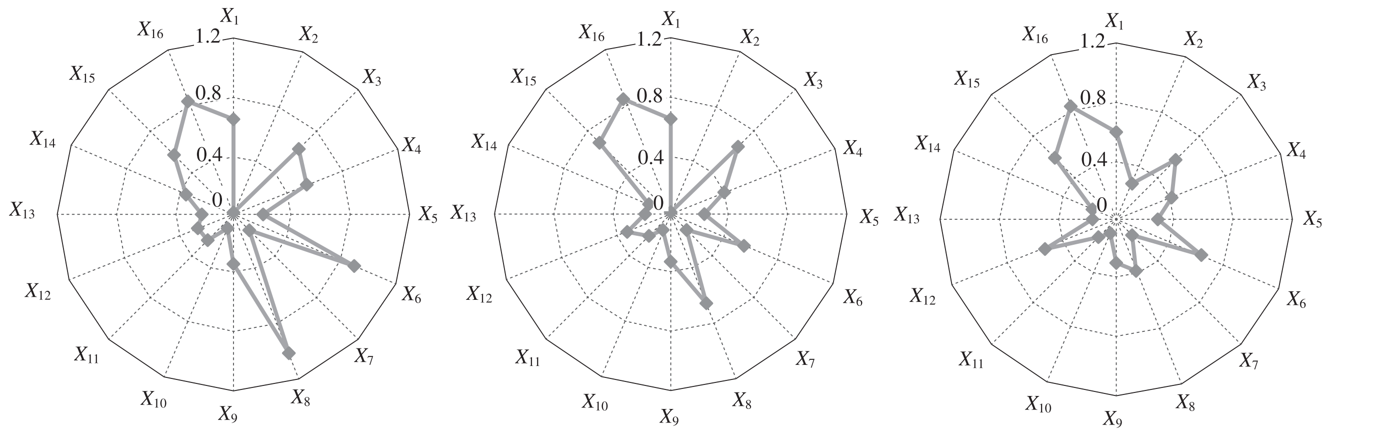


Fig. 2. Spatial pattern change of the urban–rural equivalent development level in China.



(a) The period of1996 (b) The period of 2003 (c) The period of 2009

Fig. 3. Variation coefficients of influencing factors on the urban–rural equivalent development level in China. Note: x_1 = Highway net density (km/10,000 km^2); x_2 = Degree of spatial structure concentration (%) x_3 = Per capita gross domestic product (GDP) (RMB¥/10,000persons); x_4 = Proportion of nonfarm payroll employment (%); x_5 = Relative proportion of financial support for agriculture (%); x_6 = Ratio of urban–rural fixed-asset investment (%); x_7 = Index of urban–rural productivity of dual track structure (%); x_8 = Average number of university students among each ten thousand people (%); x_9 = Average number of hospital beds per ten thousand inhabitants (beds/10,000 persons); x_{10} = Ratio of industrial wastewater standards discharge (%); x_{11} = Forest coverage (%); x_{12} = Consumption of chemical fertilizer (10,000 ton); x_{13} = The ratio of urban–rural residents' income (%); x_{14} = Gini coefficient (%); x_{15} = Ratio of urban–rural residents' engel coefficient (%); x_{16} = Ratio of urban–rural residents' consumption expenditure (%).

with the agglomeration of low URED provinces surrounded by similar neighbors. During 2003–2009 the spatial autocorrelation pattern of URED underwent a larger change than over the previous period. The number of low–high and high–low provinces increased by one each, accounting for 22.58% of the total. The proportion of the low–low and high–high provinces dropped, respectively, to 51.61% and 25.81% in 2009, suggesting that the spatial autocorrelation of URED of the entire 31 provinces had a gradually weakened spatial pattern of "bipolar agglomeration".

3.2.2. Spatial pattern evolution of URED

Based on the ArcGIS spatial analyst module, the URED index for the 31 Chinese provinces was classified into five zones of higher, high, medium, low, and lower in 1996, 2003 and 2009, respectively. Comparison of the three study periods reveals the spatio-temporal pattern of URED (Fig. 2) that shows hardly any variation in the spatial organization and quantity for the higher and high URED zones except that Tianjin shifted from the cluster zones of a high URED value to a higher URED value and Guangdong was degraded from the cluster zones of a high URED value to a medium URED value. However, since 2003 the spatio-temporal patterns of the URED for the medium, low and lower URED zones changed dramatically. To be more precise, the geographic difference characteristics and spatial pattern evolution of URED for the 31 Chinese provinces were analyzed below.

(i) During 1996–2003, the spatial distribution change of URED was attributed predominantly to the change within the medium, low, and lower URED zones. In 1996, the medium URED zone was located mainly in Shandong, Hebei, Shanxi, Jilin, and Hubei provinces; the low URED zone was distributed mainly in Henan, Anhui, Jiangxi, Hunan, Guangxi and Shaanxi, Xinjiang, Qinghai; while Inner Mongolia, Gansu, Ningxia, Sichuan, Chongqing, Guizhou, Yunnan and Tibet belonged to the cluster zones of lower URED values (Fig. 2a).

(ii) In 2003, the spatial distribution pattern of URED within the medium URED zone, low URED zone and lower URED zone tended to be more concentrated together, replacing the relatively decentralized geographic distribution in 1996. Anhui, Jiangxi, Heilongjiang and Jilin all experienced considerable improvement to the medium URED zone, shaping a centralized and continuous distribution pattern in central China. The western region internally underwent an increasingly obvious "polarization" trend in URED. For example, Shaanxi and Chongqing advanced to the rank of the medium hierarchy from the low hierarchy, whereas Gansu, Ningxia, Sichuan, Inner Mongolia also progressed from the lower hierarchy to the low hierarchy. Thus, the lower URED zone significantly shrank with all the cold spots comprising of Tibet, Yunnan and Guizhou, exhibiting a formation of zonal distribution in Southwest China (Fig. 2b). As a result, in 2003 a total of 11 provinces belonged to the medium URED zone, with 6 more than in 1996, but 5 less in the lower URED zone.

(iii) Dissimilar to the former period, the spatial distribution of URED in each grade has not changed noticeably in 2009 (Fig. 2c). The spatio-temporal pattern evolution demonstrated that the URED pattern gradually broke away from the "polarized" trend, the regional difference in the eastern coast, central and western areas has diminished gradually.

4. Driving factors of URED

There is an obvious spatial differentiation of URED in China. A considerable part of the regional differentiation is attributable to the influences of physical conditions, the existing economic development level, historical and cultural backgrounds, together with the location and transportation conditions. In addition, based on the previous analysis of spatio-temporal pattern of URED during 1996–2009, this paper has identified some other contributors to the URED. They include Chinese policies and institution, economic growth and development, and urbanization level. To further reflect the influence of the 16 critical indicators identified and their changes on URED quantitatively, the variation coefficients of the 16 critical indicators are calculated over the study period (Fig. 3). The detail is presented below:

4.1. Policies and institution

The spatio-temporal pattern evolution of URED is related closely to a series of Chinese regional development policies. China had a dramatic urban–rural disparity before 1978 due to many policy biases in favor of urban citizens under the central planning system, including the industrial-agricultural product “price scissors” policy, household registration system (*hukou* policy), hierarchical public finance system and land requisition and compensation system (Gustafsson and Li, 2002; Zhong, 2011). The 1997 Asian financial crisis exerted a destructive impact on domestic economic development. In response to this challenge, the Chinese government exerted tremendous efforts to assist the urban laid-off workers while ignoring the livelihood and well-being of rural population, further enlarging the disparity between urban and rural China (Wan, 2001). Thus, the provincial URED level demonstrated a significant phenomenon of “Polarization”. In 2002, the 16th National Congress of CPC mapped out the implementation of the “five overall arrangements” tactics (balancing urban and rural development, development among regions, economic and social development, development of man and nature, and domestic development and opening up to the outside world) and the strategies of building the new socialism countryside and a moderately prosperous society. Every effort was strengthened in pursuit of industry financing agriculture and city supporting village, which made this period an important turning point in dynamic evolution of URED (Fang and Meng, 2008; Long et al., 2010). During 2003–2009, the proportion of financial support for rural areas dramatically increased from 7.12% to 8.81%, which effectively facilitated the improvement of rural infrastructure, transportation, water supply, electricity, telecommunications, cable television and information network, and intensively reformed the rural household registration system, the social security system, the medical care system, the cultural and educational systems, and the employment management system. As a result, the gap in urban–rural spatial location, economic linkage, public services and ecological environment has been noticeably narrowed.

In order to further reflect the influence of the change of the 16 critical indicators identified above on URED, their variation coefficients during the study period were calculated. It is found that the variation coefficient of the ratio of urban–rural residents' income, the Gini coefficient, and the ratio of the urban–rural residents' Engel coefficient declined from 0.20, 0.18, and 0.12 in 2003 to 0.18, 0.16 and 0.11 in 2009, respectively (Fig. 3). The result indicates that since 2003, the policy of industry financing agriculture and city supporting village has played a beneficial role in effectively resolving problems facing Chinese farmers and agriculture in the countryside and fostered coordinated and harmonious urban and rural development.

4.2. Economic growth

In market economy conditions, economic development variation is the most important driving factor influencing the geographic differences of URED. It can be seen through Fig. 3 that during 2003–2009 the regional difference of the URED diminished due mainly to the decrease in the variation coefficient of per capita GDP, proportion of nonfarm employment, highway net density, average number of hospital beds per ten thousand inhabitants, and the average number of university students among every ten thousand inhabitants. For example, the variation coefficient of the five critical indicators decreased from 0.65, 0.40, 0.64, 0.32, and 0.65 in 2003 to 0.58, 0.39, 0.59, 0.30, and 0.37 in 2009, correspondingly. The result suggests that nation-wide economic growth was conducive to narrowing the gap in transportation, industrial division of labor, education and culture, and health care between urban and rural areas, which entailed the spatial pattern of URED at the provincial level gradually breaking away from the trend of “polarization”, and leading to the homogenization of regional differences since 2003.

In order to further explore the influence of economic development on URED, we computed the correlation coefficient between the URED index and per capita GDP. It was noteworthy that these two variables had a correlation coefficient as high as 0.932. This positive correlation suggests that urban development has a strong side economic effect on increasing rural employment opportunities, improving farmers' income, facilitating rural infrastructure construction (e.g. rural transportations and communications), thus promoting urban–rural interactions and coordination, and narrowing the gap between urban and rural China (Liu, 2007; Goodman, 2008).

The geographical distribution feature of URED is consistent with the regional economic disparities, which are to a great extent due to the adoption of trickle-down growth strategy to inventively develop a few regional centers by the government. (i) The spatio-temporal pattern change of Beijing, Shanghai and Tianjin, all municipalities, is attributable to their incomparable policy privileges and superior socioeconomic development advantages to other regions, thus their URED reached the top level (Fig. 2c). (ii) Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Liaoning along the east coast of China took special advantage of their optimal physical conditions, location, and socioeconomic factors for developing export-oriented economy (e.g. international trade and profit-driven foreign direct investment) and township and village enterprises. These powerful drivers promote eastern regional economic development, generate a great number of employment opportunities and effectively improve productivity and urban–rural people's living standards. Owing to abundant material wealth and flexible rural development policy, indigenous villagers in Jiangsu, Zhejiang and Guangdong can even earn several combined incomes, including land compensations, rents from overbuilt home spaces and dividends from village collective enterprises, which entail local villagers enjoying a comfortable living standard equal to citizens (Zhong, 2011). These factors have contributed to the higher URED than the central and western regions. (iii) In contrast, socioeconomic development in the central and western regions has lagged far behind that of eastern regions because of geographical and historical reasons, which has led to extremely poor public infrastructure and inferior conditions for URED. Although Chinese government has realized the widening regional gap and shifted its focus from the east coast onto the inland, for example, the government implemented the “western development strategy” in 1999, the “reinvigorating old industrial bases of northeast China” in 2003, and the “central China grow-up strategy” in 2006, the efficiency of production and rate of returns on government investment in central and western region remained lower than that in eastern region in terms of market mechanism (Long et al., 2011). Besides, in central and western China, the central city as the growth engine generally exerted quite a weak polarizing effect in absorbing resources and factors of production from adjacent regions, and in distributing beneficial effects in diffusing capital, technology, personnel and other factors to its neighbors, ultimately giving rise to the poor urban–rural interactions and integration performance, which contributed to the lower URED. However, since a series of *Hukou* policy reforms initiated recently, rural-to-urban labor migration in central and western areas has brought some benefits to rural districts through remittances and through the physical and human capital brought back by return migrants, which has more or less narrowed the gap between the urban and rural areas and push forward urban–rural integration (Fan, 2005).

4.3. Urbanization

It is widely recognized that urbanization is a contributing factor to changing China from the former dual-track urban–rural economic structure into an integrated economy that fosters optimized allocation of urban–rural resources (Liu et al., 2009). Since the economic reform starting in 1978, China has been experiencing noticeably rapid urbanization. With an accelerated process of rural industrialization and urbanization, rapid population growth and development of the market economy, the industrial structure, employment structure, and land-use pattern between urban and rural China have been transformed tremendously (Long et al., 2009). As a result of quickened urbanization, in some typical regions urban–rural industrial development has become increasingly interdependent and mutually-beneficial, with urban–rural information exchange more convenient, urban–rural resource allocation more reasonable, and urban–rural interactions and conjunctional development more sustainable (Zheng and Yu, 2011; Song et al., 2012; Liu et al., 2013b). It can be concluded through Chinese developmental trajectories that urbanization was beneficial to providing more incentives and opportunities in support of rural socio-economic transition, and entitling villages with modern industrial civilization.

Regression analysis reveals a correlation coefficient of 0.765 between the URED index and the rate of urbanization, demonstrating that urbanization played a vital role in driving URED. Those provinces with a high level of urbanization also enjoyed a much higher URED level. They showed more steady and healthy interactions between urban and rural areas, and more progress in building the new countryside. In practice, those regions engaged in coordinating and balancing the development of cities of all sizes and strengthening the construction of small towns and central village (community) generally experienced more sustainable urbanization and more harmonized urban–rural linkage (Song and Zhang, 2002). Therefore, under China's current national conditions, scientifically arranging the urban system, planning pivotal villages (communities), and integrating rural organizations, industry and space will enhance the functioning of central village (community) on rural population convergence, industrial agglomeration and spatial intensification, enhancing the integration and equalization of urban–rural spatial location, economic investment, social services, ecological environment and quality of life, and finally achieving URED.

5. Conclusion

This paper put forward an innovative theory of URED against the background of urban–rural transformation. Through the analysis of spatio-temporal pattern, its change and driving factors of URED of 31 Chinese provinces during 1996–2009, this study may provide a good understanding of the formation, regional differences and evolution of urban–rural "dual structure" at the provincial level, and serve as a scientific reference regarding decision-making in coordinating urban and rural development and in constructing the new countryside of China. The layout and implementation of URED will enable the rural overall development at the aspects of economy, society, culture and ecology, which may finally shape a more equitable urban and rural coordination development pattern in China.

This paper establishes indicator systems to assess the level of URED among the 31 administration units in China, which could effectively reflect urban–rural equalized development characteristics of spatial location, economic investment, social services, ecological environment and life quality. Using the Markov chain model and exploratory spatial data analysis model based on the data for 31 Chinese provinces, the spatio-temporal pattern and its change of urban–rural equalized development during 1996–2009 were analyzed. Our results show that: (i) Temporal evolution characteristics of URED. During 1996–2003, the urban–rural equalized development of 31 Chinese provinces (autonomous regions and municipalities) exhibited a significant phenomenon of "club homogenization". The provinces belonging to the low level dominate the dynamic evolution of URED. However from 2003 to 2009, URED gradually broke away from this tendency and the overall regional difference of URED tended to be narrowed. The variation coefficient of the URED was 0.72, 1.14, and 1.63 in 1996, 2003 and 2009, respectively, indicating that geographic difference of URED at the provincial level was universally widening. Under the effect of cumulative causation mechanism, the spatio-temporal differentiation of URED within the eastern, central and western regions of China was further exacerbated instead of differentiation among eastern coastal China, central China and western China. (ii) Spatial evolution characteristics of URED. URED showed a significant spatial characteristic of "polarization" during 1996–2003. The 31 Chinese provinces have a gradual regional distribution pattern of URED, dropping from eastern coastal provinces to central China and further to western China. Provinces in the eastern coastal region had a significantly higher URED than that of the central region, and the URED in central area was higher than its counterpart in the western area. This geographical distribution feature of URED is consistent with the regional economic disparities and rate of urbanization. However, this spatial polarized structure of URED was gradually destroyed since 2003, and the spatial disparity at the provincial level has decreased.

It can be concluded that economic policies, economic growth and urbanization were the main drivers influencing the spatio-temporal pattern change of URED in China. The paper emphasized that Chinese government should devote itself to implementing suitable regional and urban–rural coordination development policies to enhance efficiency of production and increase the rate of returns on government investment. Whether these policies produce good results should ultimately be determined by the satisfaction degree of the people in the dimensions of economy, society, culture and ecology. If the Chinese government can successfully promote for more equitable development not only among eastern, central and western regions, but also between urban and rural areas, China might sustain its sustainable development. On the other hand, under China's current national conditions, scientifically arranging the urban system, planning pivotal villages (communities), and integrating rural organizations, industry and space will enhance the functioning of central village (community) on rural population convergence, industrial agglomeration and spatial intensification, enhancing the integration and equalization of urban–rural spatial location, economic investment, social services, ecological environment and quality of life, and finally achieving URED. In this paper, based on the regression analysis results and the variation coefficient, the spatio-temporal pattern evolution and its driving factors of URED are examined quantitatively. However, the microscopic dynamic mechanism of different influential factors and the geographic distribution of URED for different regions remain to be explored in-depth with a case study in typical areas.

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