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Spatio-temporal pattern of China's rural development: A rurality index perspective

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ABSTRACT

China's rural areas are undergoing considerable spatio-temporal change. To some extent, this change increases the difficulty in our understanding the regional rural development and thus brings about challenges for the making of feasible regional rural development policies and strategic planning. This study establishes an index system to evaluate the degree of rurality in China at county level using national census data of 2000 and 2010, and examines the correlationship between rurality index and major socio-economic and geographical indicators. The results of evaluation and spatial analysis show that the rurality index can largely reflect the spatio-temporal patterns of China's rural development, and the Pearson correlation analysis confirmed that counties with high rurality have been marginalized in the aspects of both geographical location and economic development. As such, the patterns of rural development identified by rurality index analysis significantly improve our knowledge on the recent development of rural China. However, this index is less successful in revealing the agricultural production status quo alone. The authors argue that rurality index is an important tool for measuring rural development, and could provide us with valuable information for local planning and the innovation of rural development policies. Furthermore, integrating rurality studies and rural socio-economic analysis can contribute greatly to the making of integrated and regionalized rural development policies.

1. Introduction

Since the economic reforms and open-door policy were initiated in 1978, China's rural areas have undergone tremendous changes, particularly, changing from a relatively simple, closed peasant economy to a diversified market economy, and the regional disparities of rural development also increased (Liu, 2006; Long et al., 2010). As the central government of China has maintained a comparative advantage and an open door policy that focus on the growth of coastal regions to attract foreign investment and stimulate economic growth, the eastern coastal regions have made remarkable achievements in rapid economic growth and rural development (Liu, 2007; Long and Woods, 2011; Li et al., 2014a). However, the vast central and western regions of China, especially their rural areas, have been lagged behind severely, under the combined effects of the poor economic base and infrastructure, scarcity of human capital endowments, market distortions and poor geographical location (Li and Qiao, 2001; Ying, 2003; Xu and Tan, 2002; Wei and Ye, 2009; Li and Wei, 2010; Li et al., 2013, 2014b, 2014c). In 2010, about 50% of China's population still lived in the rural areas and 36.7% of total employment was working in the agriculture sector which generated a 10% gross domestic product (GDP) (NBSC, 2011a). Promoting the sustainable development of agriculture and rural areas should still be the priority in the agenda of China's central government (Li et al., 2014c). And the innovation of the mechanism and policies of agricultural and rural development to solve the problems related to farmers, agriculture and rural areas (so called "San Nong Wen Ti" in Chinese or three rural issues in English) in various regions is urgently needed (Gu and Li, 2013; Liu, 2007; Liu et al., 2014a; Long et al., 2010).

Rural planning and rural policies need a good understanding of what is rural (Cloke, 1977; Waldorf, 2006). Especially, effective rural development policies must be based on an accurate classification of the essential characteristics of the regional types (OECD, 1994;

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2003; Gülümser et al., 2008, 2009; Madu, 2010). Such a frame work allows the identification of both needs and opportunities in the rural areas (Bogdanov et al., 2008). However, historically rural development and rural areas were intrinsically associated with non-urbanization and agriculture, which is not sufficient to describe today's complex reality (Isserman, 2005). The consequences of lack of proper understanding of rurality on rural development are that the advantages associated with targeting policies to rural areas based on better understanding of the dynamics and sense of identity are not harnessed (OECD, 2005). A full recognition and better understanding of the properties of different rural areas may provide important information for decision-makers and thus have significant reference value for restructuring the framework of rural policies.

So far, the existing policy framework of China concerning rural development is still mainly composed of uncoordinated one-size-fits all policies (Long et al., 2010; Li et al., 2013). Compared with Europe and the North America, the approach of targeting policies to rural areas based on informed knowledge of rurality in current China is still lacking and this to a large extent, has been responsible for the relatively poor and fragmented rural development in China. As for China, more efforts could be made on improving regional policies and rural policies concerning local characteristics (Long et al., 2010; Li et al., 2013, 2014b).

The concept, measurement and application of rurality, which has been proved to be effective in somewhere else may provide a reference for China (Cloke, 1977; OECD, 1994, 1996, 2003; Madu, 2010; Long and Zhang, 2012). In general, the analysis of discourses over rurality is important on two levels: first, in obtaining more adequate explanations of social change by observing changes in attitudes and values regarding 'the rural' (Pratt, 1996); second, it is on a policy level, more knowledge on rurality allows for planning of more inclusive policies (Cloke, 1977; Zografos, 2007). Given this, continuous studies about the evaluation of rurality have been carried out in various countries and regions like England and Wales (Cloke, 1977; Cloke and Edwards, 1986; Harrington and O'Donoghue, 1998), Spain (Ocaña-Riola and Sánchez-Cantalejo, 2005; Prieto-Lara and Ocaña-Riola, 2010), USA(Waldorf, 2006), Turkey (Gülümser et al., 2008, 2009), Serbia (Bogdanov et al., 2008), Nigeria (Madu, 2010), China (Long et al., 2009a; Meng et al., 2013), and so on. It is believed that the index provides a useful tool which is able to give an insight not only into the static distribution of rurality, but also into the processes of rural change over time.

Against this background, this study is intended to evaluate the degree of rurality in recent China at county level, using classical methods and successive national census data, so as to provide a comparable picture of rurality in China and to improve our knowledge about current characteristics of China's rural and regional differences, and thus provide valuable information for local planning and the innovation of rural development policy. This paper is organized in five sections. Following the introduction, we will give a brief background about rurality and China's recent rural development from a spatial perspective. The third section introduces the index, method and data source for evaluating China's rurality at county level. In the fourth section, the index is used to analyze the variations in rurality across space and time. Moreover, the relationship between rurality index and typical socio-economic and geographical indicators will be also addressed. The final section summarizes the results of the analysis and derives a set of policy-relevant conclusions and directions for future research.

2. The research background: rurality and China's rural development

2.1. Rurality and rurality index

An operational definition for 'rural area' is pivotal if proposals, policies and decisions aimed at optimizing the distribution of resources, closing the gap on inequity between areas and raising standards of living for the least advantaged populations are to be put in place (Ocaña-Riola and Sánchez-Cantalejo, 2005). Questions as to what is meant by a rural area, the identification of diagnostic features and attempts at understanding the nature and scope of rurality are continuing themes in the literature (Cloke, 1977; Blunden et al., 1998; Prieto-Lara and Ocaña-Riola, 2010). It is widely acknowledged that rural is a fuzzy concept which is contested in terms of identifying the critical parameters of rural space (Hoggart, 1990; Halfacree, 1993; Shambaugh-Miller, 2007; Wood, 2011). Low population density, abundance of farmland, and remoteness from urban agglomerations are characteristics that people typically associate with rural places. In fact, people frequently use the term "rural" to collectively express their perception of place characteristics that—in one way or another—typify rurality (Zografos, 2007; Duenckmann, 2010). As such, the meaning of rurality depends on the perception of each individual who integrates visions of rurality into everyday life (Ilbery, 1998; Hoggart et al., 1995; Halfacree, 1995). Moreover, the developmental processes of social, economic and political restructuring in many countries are reshaping rural areas (Woods, 2007a, 2011, 2013; Labrianidis, 2006), and rural has also been used in different contexts from developed countries to the underdeveloped ones (Dinis, 2006). Thus, the same as rural, rurality remains an elusive concept (Waldorf, 2006; Woods, 2010), and special attention on rural areas is necessary while focusing on the measurements of the differences in the degree of rurality (Cloke, 1977).

In general, rurality has proved very difficult to define in an all-embracing manner for three important reasons involving functions, dynamics and variation (Cloke, 2006). Moreover, rural areas are undergoing considerable spatio-temporal change due to social, economic and technological developments, and especially the interaction of various non-quantitative elements affecting rural development (Long et al., 2009a). This kind of change, to some extent, increases the difficulty in our understanding of the rural and rurality. In broad terms, Cloke (2006) theoretically discussed functional concepts of rurality, political-economic concepts of rurality and social constructions of rurality, which have been influential in constructing conceptualizations of rurality. In their efforts to impose some order on the diversity of claims and conceptions related to the countryside, Frouws (1998) identifies three major strands of discourses, i.e., agri-ruralism, utilitarianism and hedonism, while López-i-Gelats et al. (2009) identify four discourses of rurality, i.e., the conservationist, entrepreneurial, agriculturalist, and endogenous development.

In empirical studies, researchers and international organizations such as the Organization for Economic Co-operation and Development (OECD) and European Union (EU) have developed several typologies and different rural indicators in order to better understand the dynamics of rural areas and to develop relevant policies for rural areas (Cloke, 1977; OECD, 1994, 1996; 2003; EC, 1988; Woods, 2013). Especially since the influential earlier work of Cloke (1977), several rurality indices have been developed specifically for different countries. The rurality index of England and Wales (Cloke, 1977; Cloke and Edwards, 1986; Harrington and O'Donoghue, 1998), the rural indicator of OECD (OECD, 1994, 1996, 2003), the MSU rurality index and the scale measure of urbanicity of USA (Weinert and Boik, 1995; Dahly, 2007), the

accesibility/remoteness index of Australia (Department of Health and Aged Care (2001)), the general practice rurality index of Canada (Olatunde et al., 2007), and the rurality index for small areas in Spain (Prieto-Lara and Ocaña-Riola, 2010) are some of the complex indices published in the international scientific literature. As in China, the only precedent of a rurality compound index is the rurality degree index for the eastern coastal China (Long et al., 2009a).

Overall, various ways of classification and definition in the literature are derived to measure differences in the degree of rurality, including the level of population density, the rate of population loss or gain, settlement size, local economic structure, accessibility and landscape, etc. (Ballas et al., 2003; Baum et al., 2004; Bryden, 2002; Ilbery, 1998; Labrianidis, 2004). In line with the various perspectives of rurality, evidence abounds in literature that rural areas could be characterized by: specific open landscape; a relatively low population density; the greater part of the population being associated with agriculture and forestry; traditional life styles and habits; agricultural and forest-related use of land; a scarcity of built-up areas and settlement that is dispersed; and a preponderance of inhabitants considering themselves country-dwellers (Madu, 2010). This paper tries to establish a China's rurality index system based on international literature and the basic national conditions of China.

2.2. Spatial perspective of China's rural areas

Since 1978, China has pursued sweeping economic changes in an officially sponsored transition from a centrally planned economy to a market economy. In practice, the economic reforms have set in train a process of potentially fundamental social and institutional change in rural China which is creating new socio-economic forces, shifting power in their direction, and raising the possibility of rural transformation (Xu and Tan, 2001, 2002; Long et al., 2011, 2012). More and more rural young labors out-migrated to eastern coastal China for off-farm work and to a large extent, promoted the development of the counties of destination (Fan, 2005). Rural resident population experienced a process of firstly increase, then decrease, and now come into the period of fast decrease (Li et al., 2010; Long et al., 2012). Specifically, the original counties are suffered more and more from the brain drain and consequent rural hollowing, these counties shows lower rate of economic growth (Liu et al., 2011a; Long et al., 2012; Li et al., 2014a).

The rural development in China has gradually attracted the interest in academic circles both at home and abroad (Long et al., 2009a), ranging from rural–urban migration (Liu, 2008; Ma, 1999; Rozelle et al., 1999; Zhang et al., 2004; Liu et al., 2013), rural industry and employment (Mohapatra et al., 2007; Shen and Ma, 2005; Unger and Chan, 1999), rural associations and state corporatism (Unger, 2006), rural taxation and government regulation (Tao et al., 2004), rural poverty alleviation (Heilig et al., 2006; Unger, 2002a, 2003; Park and Wang, 2010), rural transformation development (Unger, 2002b, 2006; Liu, 2007; Long et al., 2011), rural gentrification (Qian et al., 2013), urban–rural equalized development (Liu et al., 2013), rural land-use change and building new countryside (Liu et al., 2008, 2014b; Long et al., 2009b, 2010). Some studies has also depicted the development stage of China's rural development and explained the driving forces and breaking forces during different period (Xu and Tan, 2001, 2002; Long et al., 2010). Overall, these studies have given more or less a history perspective or structure perspective on China's rural development. Currently, we still have little knowledge about the nature of pattern of rural development at a more fine scale beyond provincial (Liu, 2006; Liu et al., 2013; Long et al., 2011). As such, we will give a brief depict about China's rural and its recent development from a spatial perspective, before analyzing China's rurality index.

The natural environment factor is one of the main indices for evaluating human habitats, sustained economic growth and ecological health status. The vast land expanses of China include plateaus, plains, basins, foothills, and mountains. Defining rugged plateaus, foothills and mountains as mountainous, they occupy nearly two-thirds of the land, higher in the west and lower in the east just like a three-step ladder. The highest step of the typical 'ladder topography' including Qinghai province and Tibet autonomous region is formed by the Qinghai-Tibet Plateau at the average height of over 4000 m. On the second step are large basins and plateaus, most of which are 1000–2000 m high. The Daxing'an, Taihang, Wu and Xuefeng Mountains divide this step and the next lower one. Plateaus including Inner Mongolian, Loess, Yungui Plateaus, and basins such as Tarim, Junggar, and Sichuan Basins are situated here. The third step, abundant in broad plains, is dotted with the foothills and lower mountains, with average altitude of over 500 m. Here are located with famous plains: the Northeast Plain, the Huang-Huai-Hai Plain, and the Middle-Lower Yangtze River Plain, neighboring with each other from north to south. These well-cultivated and fertile lands produce abundant crops. Using natural environment data including climate, hydrology, surface configuration and ecological conditions, Yang and Ma (2009) establish natural environment suitability index (NESI) of China. They find that the value of NESI is higher in the east and lower in the west of China, and the best natural environment area is the Yangtze River Delta region, while the worst are the northwest of Tibet and southwest of Xinjiang. These physical features largely shaped the patterns of local cultural and socio-economic development. Areas with better natural environment are more prone to be regions with higher population density and richer economy.

According to the state of economic development, GDP per capita is one of the most frequently used indicators for measuring economic performance and comparing the state of development of different areas. Li and Qiao (2001) analyzed the economic disparities of China during 1990 and 1998 using nationwide county level data of GDP per capita. They found that the counties with faster growth rates than the national average were spread from several growth centers to outside. Consequently, three growth corridors gradually appeared, namely, the Coastal Corridor (along the nation's coastal line), Beijing–Guangzhou Corridor (along the railway from Beijing to Guangzhou), and the Yangtze River Corridor (along the Yangtze River from Chengdu to Shanghai). Overall, the less developed counties were mainly located in the western part of China. The distribution pattern of less developed counties is consistent with the disadvantageous development conditions in mountainous, cold and dry areas, as well as with the isolation in the provincial border regions. We collected the data of GDP per capita in 2010. As we can see clearly in Fig. 1, which has been divided into five grades by quintile, GDP per capita at county level shows huge regional disparities. Counties in eastern coastal China which have experienced rapid economic growth since the initiation of reform and opening up policies, and counties in north China with rich mineral resources and less population have higher GDP per capita. In contrast, inland counties especially in southwest China with mountainous terrain and central China major in agricultural production have much lower GDP per capita. Furthermore, there are also some counties in eastern coastal China have lower GDP per capita and in west and central China, there are also some counties with higher GDP per capita. This economic development pattern can inevitably affect the local state of rural development.

With the rapid development of industrialization and urbanization as well as enhancement of geographical differentiation and diversity of man-earth areal system, territorial functions and regional development orientations have shown an increasingly

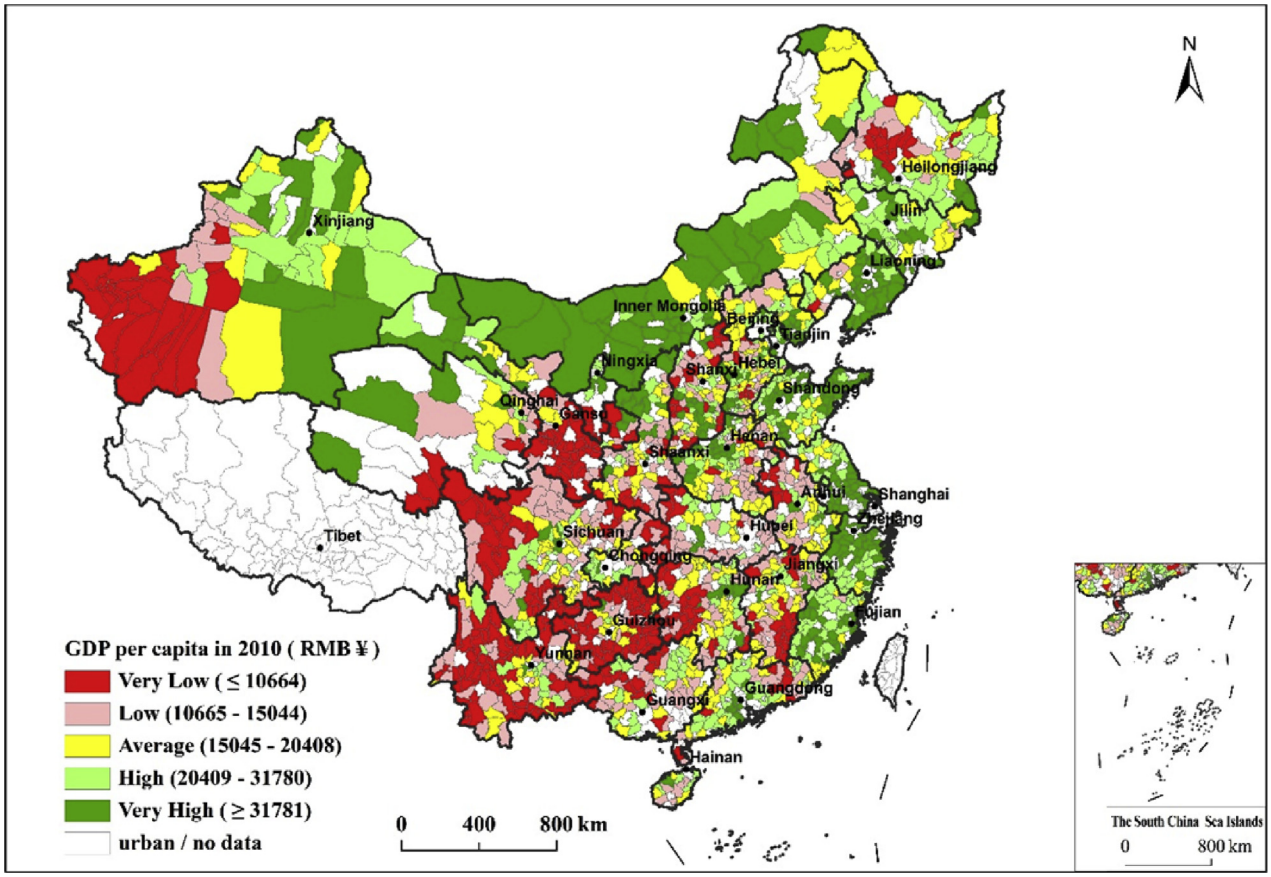

Fig. 1. Spatial pattern of GDP per capita in China at county level in 2010. Note: The GDP per capita is divided into five grades by quintile; exchange rate US$ to RMB¥: 1–6.77.

strong trend towards diversification. Liu et al. (2011b) evaluate and grade the functional areas of economic development, food security, social stability, environmental protection and comprehensive function of China at county level. The results show that economy-oriented functional areas are mainly distributed in eastern coastal developed areas and peripheral areas of the metropolitan regions, such as Pearl River Delta, Yangtze River Delta and Beijing-Tianjin-Hebei region. Grain-oriented functional areas are mainly distributed in the Northeast Plain, the Huang-Huai-Hai Plain, Sichuan Basin, central Hubei, eastern Hunan and other regions covered by a large area of plain. The social security function indexes are gradually weakened from coastal to inland areas and from north to south; Eco-conservation areas are concentrated in the Northeast China and southern Qinling Mountain–Huaihe River Line.

Obviously, the physical conditions and socio-economic development of rural China show great regional disparities, but our knowledge about this pattern is still very inadequate especially when making integrated and regionalized rural policies. So, this paper will calculate China's rurality index at county level using national census data of 2000 and 2010, and reveal the spatial patterns and dynamics of rurality index. Moreover, the Pearson correlation coefficients between rurality index and major socio-economic and geographical indicators will be calculated to examine to what extent the rurality index can characterize the pattern of China's rural areas and to provide scientific support for the making and improvement of rural policies.

3. Methodology

3.1. Index system and data source

When establishing the index system of rurality evaluation, basically, the variables must be representative of the concept of rurality in China in line with the theoretical and empirical background we discussed above. At the same time, they can be both measured and quantified, especially be readily available and accessible for users at a reasonable cost-benefit ratio. Moreover, they must be easy to update at regular intervals (Ocaña-Riola and Sánchez-Cantalejo, 2005). Rural system is complex and hybrid. Rural development can be seen as the outcome of interactions between various rural system components (Lakshmanan, 1982; Marsden, 2010), e.g., geographical and bio-geo-physical conditions, industrial development, rural population, and social and cultural characteristics (Fang and Liu, 2009, 2014; Long et al., 2010, 2011; Ye et al., 2013). However, demographic characteristics are the most important and active factors in reflecting the change of rural development, as evidenced by some studies concerning land use transitions affected by rural migration (Carr, 2009; Chen et al., 2014), the spatio-temporal variations of driving factors of population change in rural, suburban, and urban areas (Chi and Ventura, 2011), population pressure and agricultural intensification in rural systems (Ali, 2007), and implications of rural population change for policymaking in developing countries (Anríquez and Stloukal, 2008). As such, the national census data published every decade was selected as the main source of information for rurality evaluation, since many of the variables it includes meet these criteria (Cloke, 1977; Harrington and O'Donoghue, 1998; Prieto-Lara and

Ocaña-Riola, 2010).

Combining with previous studies and taking into account the basic characteristics of rural China and the availability of data, fifteen variables that could largely reflect the population density, age-structure, education level, employment, migration and housing condition of rural areas, have been chosen for evaluating rurality, so as to explore the spatio-temporal pattern of China's rural development from the perspectives of demographic characteristics and their changes. The fifteen variables are population density, size of household, young children index, senior citizen index, birth rate, mortality rate, in-migration, education level, illiteracy rate, professional and technical personnel, economic dependency index, agricultural employment, share of rural population, housing habitability index and share of self-built housing (Table 1). Our initial judgment is, to a large extent, that counties with higher rurality index may have lower population density, bigger size of household, higher young children index, lower senior citizen index, higher birth rate, higher mortality rate, lower in-migration, lower education level, higher illiteracy rate, lower professional and technical personnel, lower economic dependency index, higher agricultural employment, higher share of rural population, higher housing habitability index and higher share of self-built housing.

The data of the fifteen variables at county level in Table 1 were obtained from the national 2000 census and 2010 census. County-level socio-economic data were obtained from Chinese Counties (Cities) Socio-economic Statistical Yearbook (NBSC, 2001, 2011b), and Chinese Regional Economic Statistical Yearbook (NBSC, 2011c). In order to ensure the accuracy of data, statistic yearbook of each province was used for revising and checking when preparing the dataset. DEM data for calculating relief degree of land surface and transportation data for calculating distance from nearest provincial capital, highway and railway were derived from National Resources and Environmental Database presented by Resources and Environmental Scientific Data Center, Chinese Academy of Sciences.

In terms of the number of counties for evaluation, according to China Statistical Yearbook (NBSC, 2011a), the number of districts under the jurisdiction of cities, cities at county level, counties and autonomous counties are 853, 370, 1461 and 117, respectively. For districts under the jurisdiction of cities could be seen as urban area, so the county level regions used for rurality evaluation would be cities at county level, counties and autonomous counties (in brief, we call the three kinds of administrative districts *counties*), with a total number of 1948. However, due to the adjustment of administrative divisions and a small number of counties lack socio-economic data, 81 counties are removed from the research. Specifically, for data availability, counties of Tibet are all removed. As a result, this research includes 1867 counties. The paper does not include Taiwan, Hong Kong and Macau. Nevertheless, the 1867 counties consist of 96% of China's cities at county level, counties and autonomous counties, and thus have strong representativeness.

Table 1
Variables for measuring rurality index of China's counties.

Variable	Explanation	Unit	Direction
Population density	Number of inhabitants per square kilometer	Persons/km^2	−
Size of household	Average number of inhabitants living in one household	Persons	+
Young children index	Number of people aged 0–14 per 100 inhabitants	%	+
Senior citizen index	Number of people over the age 65 per 100 inhabitants	%	−
Birth rate	Total number of births per 1000 of a population during the year	‰	+
Mortality rate	Total number of deaths per 1000 of a population during the year	‰	+
In-migration	Number of immigrants from outside the county per 100 inhabitants	%	−
Education level	Average years of schooling of adults	year	−
Illiteracy rate	Percent of adults who can't read	%	+
Professional and technical personnel	Proportion of professional and technical personnel in total employment	%	−
Economic dependency index	Number of economically inactive per 100 persons of working age	%	−
Agricultural employment	Share of agricultural employment in total employment	%	+
Share of rural population	Percentage of population residing in rural areas	%	+
Housing habitability index	Percentage of households with exclusive use of running water, bathing facilities and inside W.C.	%	+
Share of self-built housing	Percentage of self-built houses in rural area	%	+

Note: '+' means the higher the value of variable, the higher the rurality index; in contrast, '−' means the higher the value of variable, the lower the rurality index.

3.2. Statistical analysis

Recent China's rurality at county level could be considered as a combination of variables listed in Table 1. Principal component analysis (PCA) is one of the most common methods used by data analysts to provide a condensed description and describe patterns of variation in multivariate data sets. Meanwhile, the PCA is a classic and widely used method in rurality studies (Cloke, 1977; Cloke and Edwards, 1986; Harrington and O'Donoghue, 1998; Ocaña-Riola and Sánchez-Cantalejo, 2005; Madu, 2010; Prieto-Lara and Ocaña-Riola, 2010). As such, PCA was used in this study to summarize the information provided by the characteristics of the counties into a single rurality factor. In detail, the first principle component, which has the most comprehensive capacity (Kendall, 1975; Su, 2000), are chosen for calculating the component score, i.e., rurality index.

Exploratory Spatial Data Analysis (ESDA) has been employed to better reveal the spatial pattern of rurality (Anselin et al., 2007). More specifically, a local spatial autocorrelation analysis using a Local Indicator of Spatial Association (LISA) will help to describe and visualize spatial distribution and discover patterns of spatial association of rurality index (Anselin et al., 2006; Griffith, 2003;

Table 2
Variable loading scores for the index of 2000 and 2010.

Variable	2000		2010	
	Loading score	Revised loading score	Loading score	Revised loading score
Population density	−0.177	–	−0.258	–
Share of rural population	0.820	0.834	0.870	0.871
Size of household	0.614	0.632	0.641	0.656
Young children index	0.622	0.623	0.713	0.702
Senior citizen index	−0.129	–	−0.135	–
Birth rate	0.619	0.590	0.623	0.626
Mortality rate	0.467	–	0.251	–
In-migration	−0.705	−0.728	−0.740	−0.768
Education level	−0.752	−0.715	−0.721	−0.660
Illiteracy rate	0.559	0.520	0.487	–
Professional and technical personnel	−0.645	−0.680	−0.703	−0.738
Economic dependency index	−0.718	−0.725	−0.555	−0.569
Agricultural employment	0.841	0.844	0.805	0.810
Housing habitability index	0.467	–	0.574	0.548
Share of self-built housing	0.714	0.762	0.809	0.839
Percentage of current variance explained	38.84%	49.30%	39.68%	51.17%

Lehtonen and Tykkyläinen, 2010). In addition, across the numerous studies of rurality index, few have quantitatively discussed the correlationship between the rurality index and typical socio-economic variables. In this paper, Pearson correlation coefficient was employed to explore and examine the correlationship between rurality index and main socio-economic and geographical indicators.

As for the realization of above method, SPSS was the software used both for the PCA and correlation analysis. Scores for the rurality index were plotted on the county map of China and ArcGIS (ArcMap) was the Geographic Information System used for this purpose. The LISA analysis was also run in ArcGIS (ArcToolbox).

4. Results

4.1. Performing rurality index using principal components analysis

In the data of 2000, the first component accounts for 38.84% of the total variance. Table 2 demonstrates the loading scores for this combination. It is clear that the variables with large positive loading scores are those which correspond with characteristics which are evidently rural, such as a high level of agricultural employment. Similarly, variables with large negative loading scores are identified with more apparent urban characteristics, such as high levels of professional and technical personnel. Variables with small loading scores (between −0.5 and +0.5), which means little contribution to the regional differentiation, were discarded (Cloke, 1977). As a result, the less important of the population density, senior citizen index, mortality rate, and housing habitability index variables were discarded. And thus eleven variables remained, for which a new principal component was determined, accounting for 49.3% of the current total variance. As for the data of 2010, the same method has been employed to calculate loading score and revised loading score (Table 2). The first component accounts for 39.68% of the total variance. Further, four variables namely population density, senior citizen index, mortality rate and illiteracy rate were discarded because their loading scores are relatively small (between −0.5 and +0.5). And thus also eleven variables remained, for which a new principal component was determined, accounting for 51.17% of the current total variance. Overall, the direction of each variable's affection on rurality index is in line with our initial expectations.

Concerning the loading changes exhibited by each individual variable, there has been a marked decline in the contribution of the education level variable between 2000 and 2010. Recently, the average years of schooling of adults in the most rural areas have increased significantly, so this variable has decreased in value as an indication of rurality distribution. Such change can also be seen on illiteracy rate, economic dependency index and agricultural employment. Other variables have shown increases in differentiation over the intercensal period. Especially, the contribution of variables closely linked with economic development such as in-migration and professional and technical personnel increased significantly. In the meantime, young children index and share of self-built housing also show increasing contribution on the variety of rurality. These opposing trends have tended to counterbalance each other and have had little overall effect on the index. So, it seems that the index could effectively indicate the changing nature of rurality itself, as well as the spatial manifestation of this change. Such an analysis would provide an interesting insight into the reasons behind the varying contributions of different variables to the principal component of rurality.

Overall, share of rural population (0.834), in-migration (−0.728), economic dependency index (−0.725), agricultural employment (0.844) and share of self-built housing (0.762) are the top 5 variables most affecting rurality in 2000. As for 2010, the five variables were share of rural population (0.871), in-migration (−0.768), professional and technical personnel (−0.738), agricultural employment (0.810) and share of self-built housing (0.839). Obviously, from the perspective of social and economic development, education, professional skills, employment and urbanization are main factors contribute to the variety of rurality.

4.2. The spatial pattern of rurality

The index of rurality for 2000 and 2010 was calculated for each county by evaluating the reduced principal component value for each county; that is by substituting the values of the remaining eleven variables in the principal component equation. A highly positive index value denotes an extremely rural area. According to the value of rurality index, the rurality in China have been divided into five grades by quintile ranging from very low, through low, average and high, to very high. The fifth-grade counties have the highest rurality, while the first-grade has the lowest.

In 2000, the values of rurality index are between −4.83 and +3.17. It can be seen from Fig. 2 that constrained by physical conditions and general socio-economic development, China's rurality index shows a gradually increasing spatial pattern from east to west in 2000, except for the northern part, which has a very low rurality index. In term of rurality index in 2010, it ranges between −4.10 and +3.06. Driven by different but consolidated economic development models and rural transformation intensities, the dynamic regional rurality index in China from 2000 to 2010 does not show an obvious spatial pattern. In addition, the patterns of rurality index shown in Figs. 2 and 3 are very similar to the pattern of GDP per capita shown in Fig. 1. These patterns denote persistent spatial structures, and reveal, for instance, that the transition of China's rural policies since 2004 has not visibly altered the landscape of socioeconomic conditions in rural areas.

Three major belts with “very low” rurality index areas are clearly visible from the index distribution (Figs. 2 and 3).

(1) The first belt is eastern coastal China. Due to its special advantages (optimal physical conditions, location, and socio-economic factors for the development of non-agricultural industry and urbanization), this region is the forefront and engine of China's economic development, thus industrialization and urbanization dominate the process of socio-economic development but agriculture and rural landscape and culture are experiencing rapid decline.
(2) The second belt is northeast China. This region is both China's traditional heavy industrial base and national commodity grain base. This region faced economic depression and industrial restructuring during the 1990s, but has been experiencing a process of revitalization since the launch of Economic Rejuvenation Plan for Northeast China (Dunford and Li, 2010). In addition, the level of modernization of agricultural production in this region is rather high and has led to high agricultural output. As such, this region shows more urbanity and remains a low rurality index.
(3) The third belt is northern China. Counties in this region usually have rich mineral resources, and vast resources exploration has dramatically changed local demographic characteristics, socio-economic structure and traditional culture, thus rurality index in this region declined significantly.

Moreover, three belts with “very high” rurality index areas can also be identified from Figs. 2 and 3.

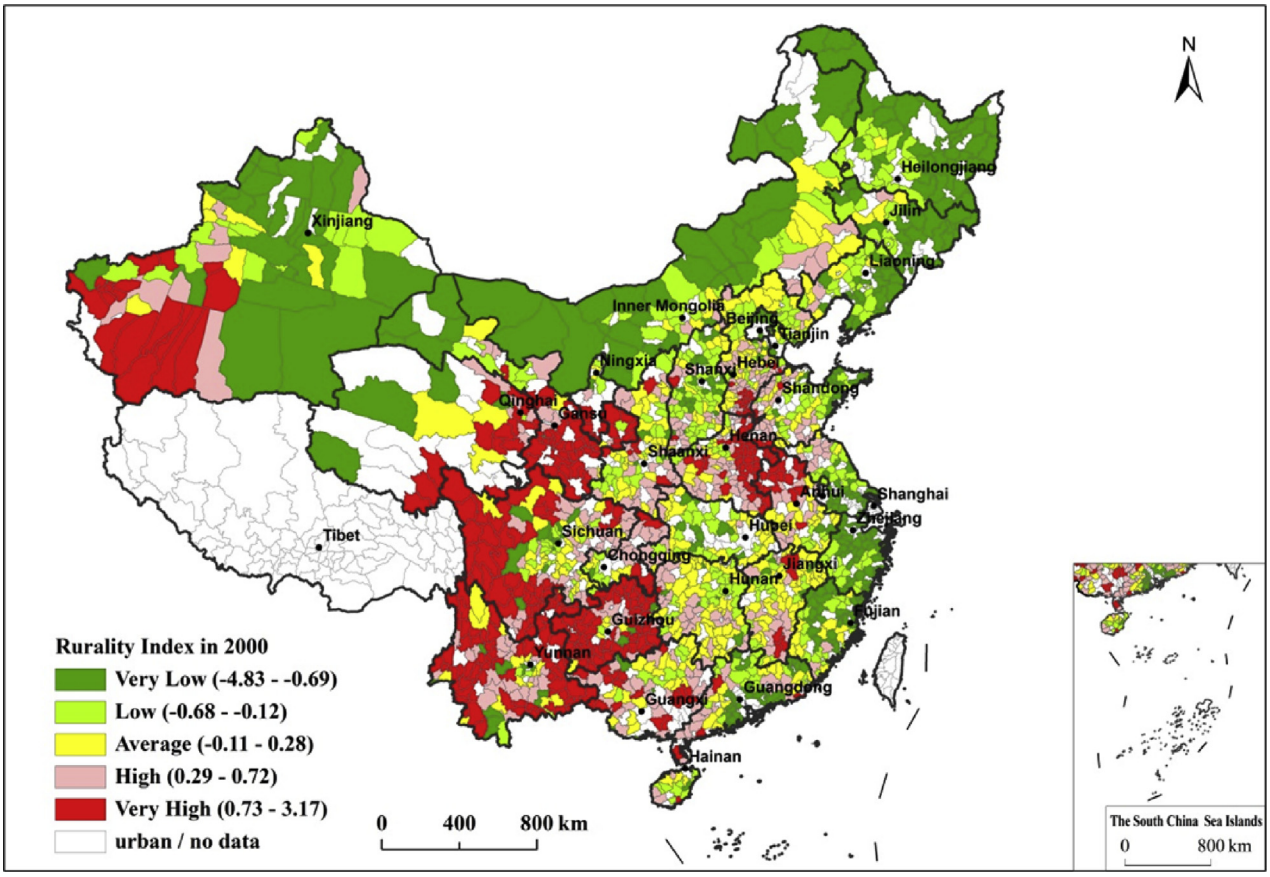

Fig. 2. Spatial pattern of rurality index in 2000.

(1) The first belt is southwest China. The development of non-agricultural industry and urbanization in this region is lagging behind compared to eastern coastal China, for relative poor physical conditions, location, and weak socio-economic foundation. Rural areas in this region are mountainous and current agricultural production is still extremely backward (Li et al., 2013).
(2) The second belt is northwest China, including southwest Xinjiang, northern Gansu and northwest Sichuan. To a large extent, these regions are ethnic minority areas, with remote geographical location, poor accessibility, backward socio-economic development, and are still struggling to transform the traditional subsistence agriculture.
(3) The third belt is the North China Plain, i.e., the Huang-Huai-Hai Plain. This region has long been one of China's most important grain production areas, which has excellent agricultural production conditions, and contributes a lot to national grain security (Li et al., 2011). However, due to growing contradiction between population change and land use, and the strictly control of prices of agro-products under urban-rural dual structure, the socio-economic transition and urbanization of these region lagged behind (Li et al., 2014a), which have contributed to a high rurality index.

Over all, counties with "very low" value of rurality index mainly distribute in the eastern coastal, northeast and northern part of China, while counties with "very high" value of rurality index mainly distribute in the southwest of China and Huang-Huai-Hai plain. Counties with "low", "average" and "high" rurality index show a staggered distribution in the rest regions, especially on the periphery of inland urban areas.

In order to better discover the patterns of spatial association of rurality index, LISA analysis has been carried out based on ArcToolbox of ArcGIS. The LISA groups map of rurality index in 2000 and 2010 are shown in Figs. 4 and 5, respectively.

In 2000, the numbers of High–High counties (the counties with high rurality values surrounded by that with high rurality values), Low–Low counties (the counties with low rurality values surrounded by that with low rurality values), Low-High counties (the counties with low rurality values surrounded by that with high rurality values), High-Low counties (the counties with high rurality values surrounded by that with low rurality values) and Not Significant counties (Areas that are not significant at a default pseudo significance level of 0.05) are 460, 335, 51, 3 and 1018, respectively. It can be seen from Fig. 4, the High–High counties mainly distribute in the southwest of Xinjiang and southern Gansu in northwest China, the most part of Yunnan and Guizhou and western Sichuan in southwest China, and the traditional agricultural areas of central China, namely, eastern Henan, Northern Anhui, southwest Shandong and southern Hebei. While the Low–Low counties mainly distribute in eastern Xinjiang, central Inner Mongolia, east part of northeast China, Shandong Peninsula, southern Jiangsu, the most of Zhejiang, northern Fujian and the Pearl River Delta. The number of Low-High and High-Low counties was relatively small, and they usually distribute in the periphery of High–High counties and Low–Low counties, respectively.

Since 2000, China has experienced different paces of industrialization, urbanization and rural transformation in different kinds of areas, and brought about various impact on demographic and socio-economic structures and thus exerted unequal influences on

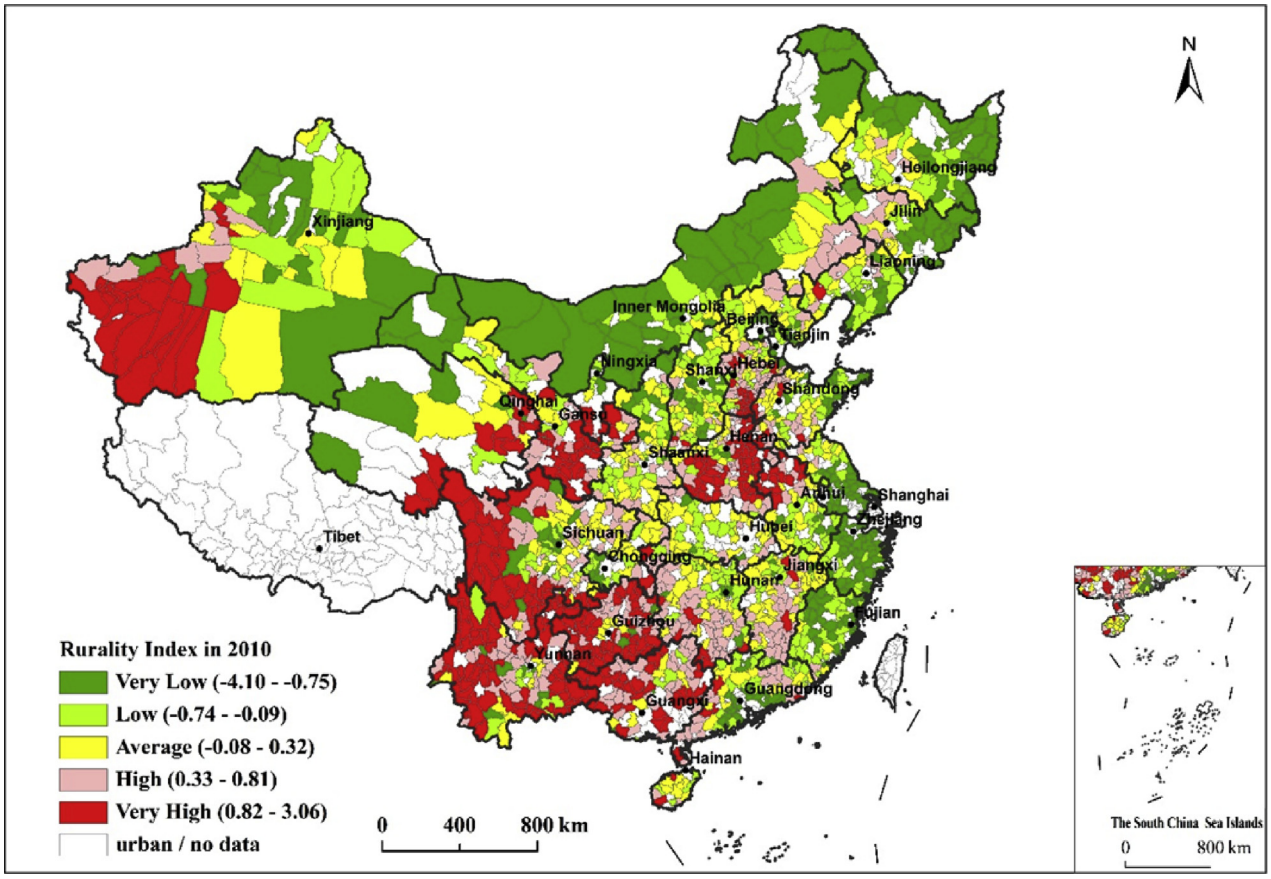

Fig. 3. Spatial pattern of rurality index in 2010.

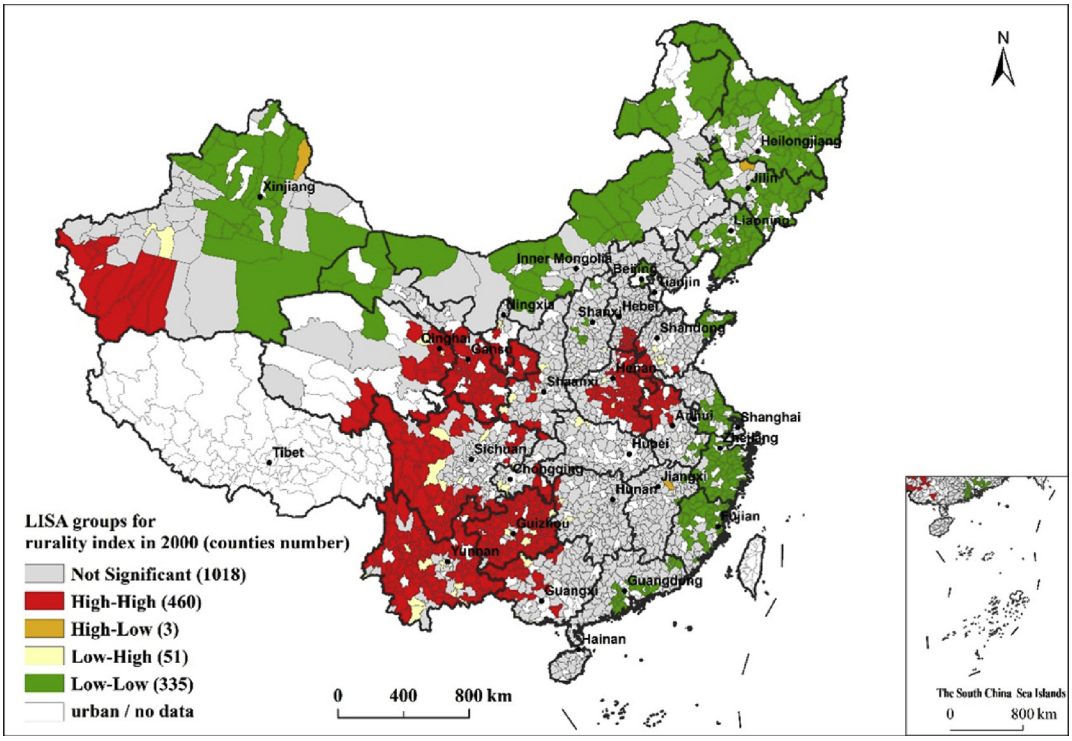

Fig. 4. LISA groups for rurality index in 2000.

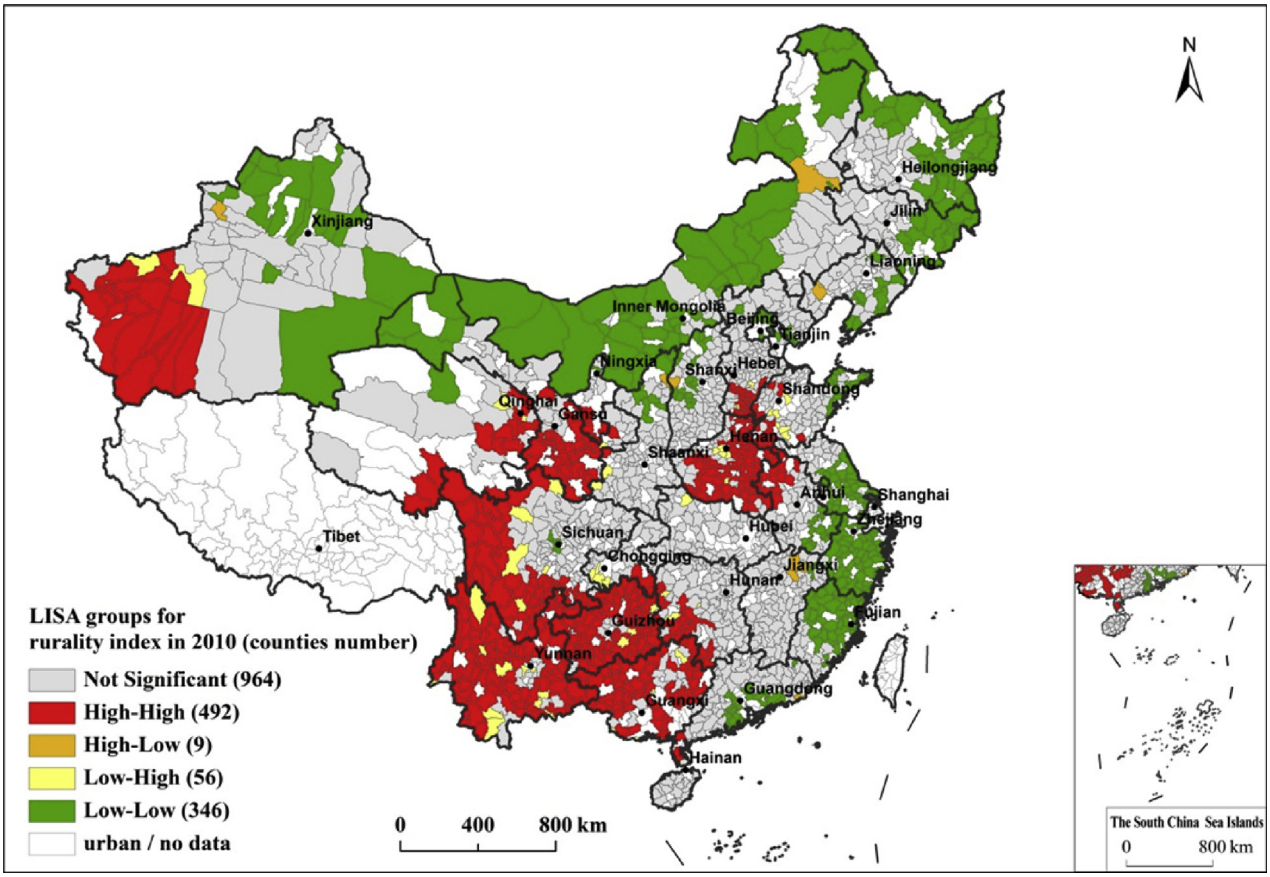

Fig. 5. LISA groups for rurality index in 2010.

the changes of rurality. In 2010, the numbers of High–High counties, Low–Low counties, Low-High counties, High-Low counties and Not Significant counties are 492, 346, 56, 9 and 964, respectively. Compared with that in 2000, the LISA groups are fairly stable over time, and the characteristics of spatial concentration distribution further enhanced.

Roughly, three areas showing significant change can be identified clearly from Figs. 4 and Fig. 5: firstly, the High–High counties in Guangxi expand quite a lot; secondly, the Low–Low counties in Inner Mongolia increased significantly; and thirdly, the number of Low–Low counties in northeast China reduced sharply.

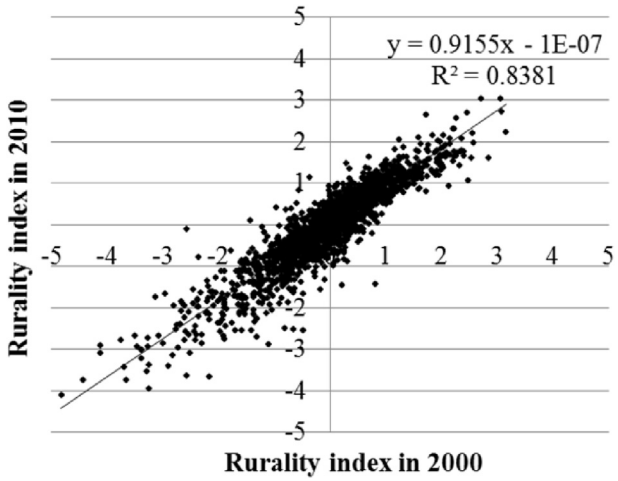

Fig. 6. Temporal persistence of rurality in China's counties.

4.3. The dynamic change of rurality

Areal variation is necessary to gain a widespread pattern of the distribution of rurality, and variation over time is likely to offer an

Table 3
Change matrix of the number of counties with different level of rurality index in 2000 and 2010, and its changes.

Rurality index in 2000	Rurality index in 2010					Total (2000)	Loss	Changes in 2010 (%)
	Very low	Low	Average	High	Very high			
Very low	299	64	8	3	–	374	75	20.05
Low	63	206	91	12	2	374	168	44.92
Average	10	85	168	101	9	373	205	54.96
High	1	18	96	188	70	373	185	49.60
Very high	1	1	10	69	292	373	81	21.72
Total (2010)	374	374	373	373	373	1867	714	38.24
Gain	75	168	205	185	81	714	–	–

Note: According to the value of rurality index, the counties in this study have been divided into five grades by quintile ranging from very low, through low, average and high, to very high. Since the total number of counties in this study is 1867, which is not divisible by 5. So, the numbers of counties with very low, low, average, high and very high rurality both in 2000 and 2010 are 374, 374, 373, 373 and 373, respectively. This table aims to analyze the changes of the number of the counties with different level of rurality index. For example, in the row of "very low", compared to 2000, there were 299 counties remained the level of "very low", 64 counties changed to the level of "low", 8 counties changed to the level of "average", and 3 counties changed to the level of "high" in 2010.

interesting insight into the changing nature of rurality (Cloke, 1977). The dynamics of rurality over time and space are further detected in three ways. Firstly is the correlation analysis. Fig. 6 shows a scatter dot graph representing the rurality index in 2000 on the horizontal axis and that in 2010 on the vertical axis. Both the linear ascending trend in the cloud of dots and the high correlation between the two indices (regression coefficient (0.9155) almost equals 1; $R^2 = 0.838$, and $P < 0.01$) suggest little change in the rurality pattern of China's counties between 2000 and 2010.

Secondly is the changing matrix analysis. As shown in Table 3, in the year of 2000, 374 counties were classified as "very low" rurality. When compared to the year of 2010, among the 374 counties, there are 64, 8 and 3 counties became counties with "low", "average" and "high" rurality, respectively. That is, the rurality category of about 20 percent of the "very low" rurality counties in 2000 changed. In addition, the counties with "very high" rurality experienced nearly the same dynamics. However, the counties with rurality of "average", "high" and "low" experienced much more changes. In general, the rurality state of "very low" and "very high" counties experienced much less change in the category of rurality, while the other counties are more prone to get category of rurality changed.

Thirdly is the change of spatial pattern of rurality index. As shown in Fig. 7, counties with rurality index increased at least one level mainly distribute on Xinjiang, northeast China and the border areas of Henan, Guangxi and Hunan. To a large extent, this well reflects the large scale farmland reclamation and consequent agricultural development in northern China, and the dilemma of nearly stagnant socio-economic development in agricultural counties and mountainous counties of central China. While, counties with rurality index decreased at least one level mainly distribute in agro-pastoral interlaced region around Yulin, periphery of Sichuan Basin, and the most part of Chongqing. This change is due to the vast mineral resources exploration in Yulin of Northern Shaanxi and the ambitious implementation of the Western

Table 4
The correlation between rurality index and typical socio-economic and geographical indicators.

Indicator type	Indicator	2000	2010
The ability to attract investment	Per capita urban fixed asset investment	−0.331**	−0.436**
Output and value-added capabilities	Above-scale industrial output per capita	−0.433**	−0.543**
	Share of non-agro industrial value added	−0.538**	−0.500**
	GDP per capita	−0.612**	−0.597**
Local government financial strength	Local budget revenue per capita	−0.615**	−0.613**
	Local budget expenditure per capita	−0.352**	−0.294**
Residents' income and savings levels	Per capita net income of farmers	−0.567**	−0.653**
	Per capita savings deposits	−0.685**	−0.755**
Agricultural production	Per capita grain output	−0.012	0.014
	Major agro-products output per capita	−0.031	0.017
Relief feature	Relief degree of land surface	0.301**	0.244**
Distance/marginalization	Distance from nearest provincial capital	−0.015	0.090**
	Distance from nearest highway	0.005	0.089**
	Distance from nearest railway	0.156**	0.191**

Note: ** Significant at 0.01 level.

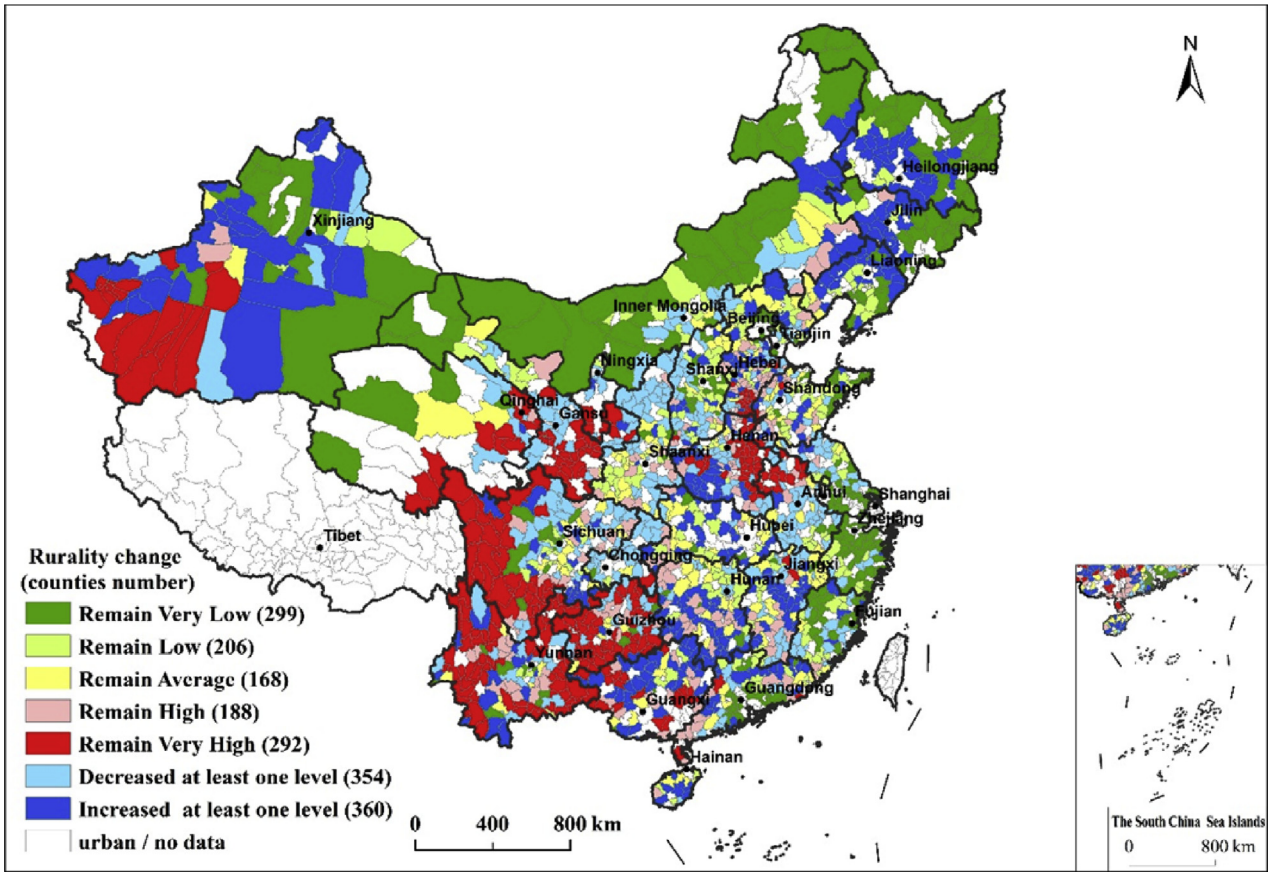

Fig. 7. The changing pattern of rurality index between 2000 and 2010.

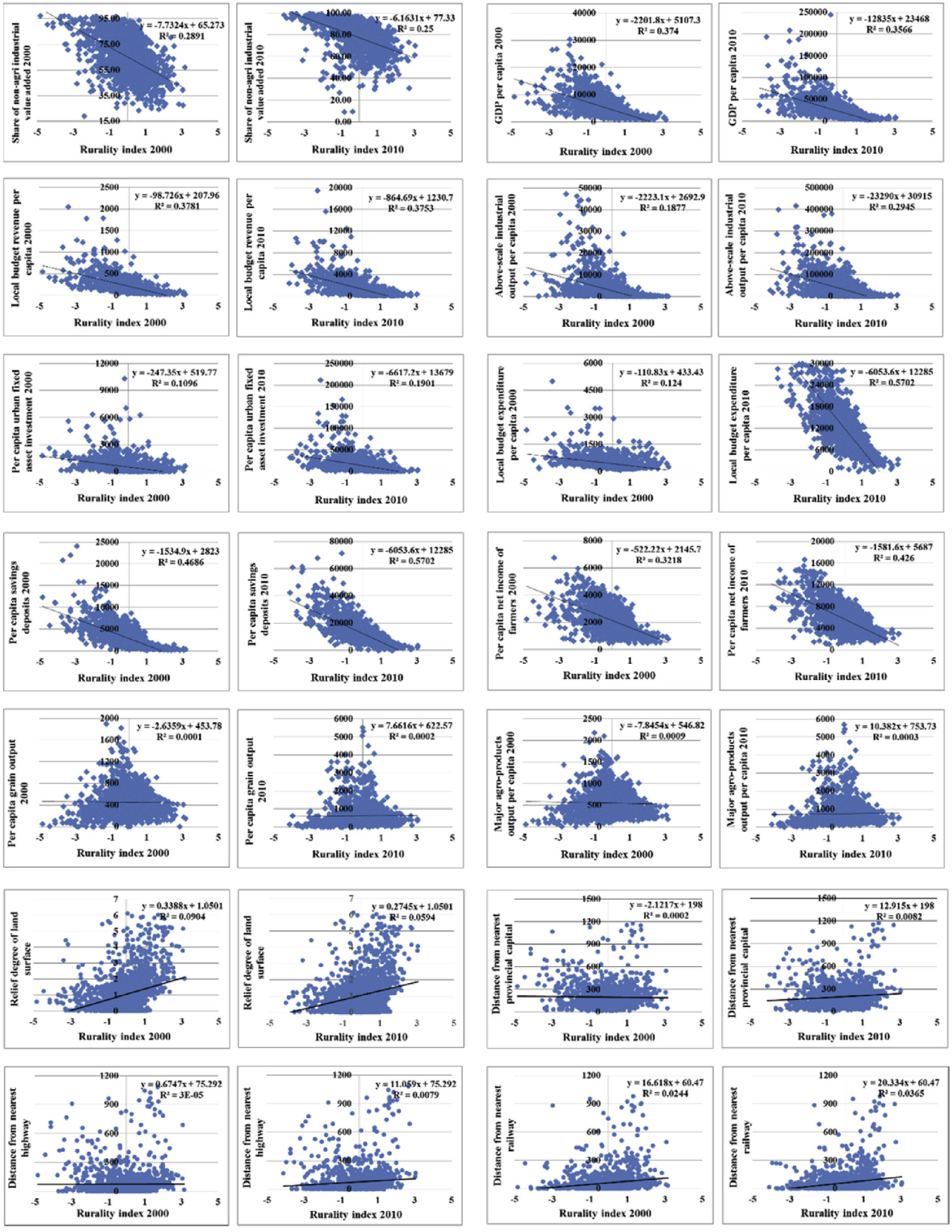

Fig. 8. The scatter map of rurality index and typical socio-economic and geographical indicators.

Development Strategy in Sichuan Basin, which results in the development of non-agricultural economy.

4.4. The correlation between rurality and typical socio-economic and geographical indicators

Rurality index has significant negative correlation with indicators reflecting the local ability to attract investment, output and value-added capabilities, local government financial strength and residents' income and savings levels. In the meantime, counties with higher rurality degree are prone to have higher relief degree of land surface, and have longer distances from nearest provincial capital, highway and railway (see Table 4 and Fig. 8). Therefore, counties with high rurality have been marginalized both geographically and economically. Regional policies devote to promoting rural development and eliminating regional disparities should pay more attention to these marginal counties.

It is worth mentioning that, there was no significant correlation between the rurality index and per capita grain output and major agro-products output per capita (Table 4). As shown in the fifth row of Fig. 8, per capita grain output and major agro-products output per capita are higher in counties with moderate rurality index. In fact, China's major grain producing counties mainly located in the Northeast Plain, the Huang-Huai-Hai Plain, the Sichuan Basin and the Middle-Lower Yangtze River Plain. Compared to the counties with high rurality around them (Fig. 3), many of these counties especially in Sichuan Basin, and the Middle-Lower Yangtze River Plain are experiencing gradually socio-economic transition driven by urbanization and industrialization and thus show a lower rurality. As such, rurality index can help to understand the overall pattern of China's rural development state effectively. However, due to the vast regional difference of physical geography condition and economic location at county level, and China's unique agricultural and rural development policies under urban-rural dual structure, this index is less successful in revealing the agricultural production status quo alone.

5. Conclusions and discussion

To deal with the issues related to agriculture, farmer and rural area in China, it would be rational to modify the current "one fit all" agricultural and rural policies, fully recognize the nature of different regions, and to allow the local attributes of rural areas could be better considered. Unfortunately, we still have little knowledge about the nature of pattern of rural development at a more fine scale. In the light of this, using national census data of 2000 and 2010, this paper establishes an index system to assess the varieties of rurality at county level and thus provide a comparable picture of rurality in China, so as to better identifying and understanding the overall pattern and regional characteristics of rural China. Moreover, the correlationship between rurality index and major socio-economic and geographical indicators has been also discussed based on Pearson correlation coefficient.

Overall, counties with 'very high' rurality index are mainly located in the hilly areas of inner China with socio-economic development seriously lagged behind, and Huang-Huai-Hai traditional agricultural areas which are China's major grain production areas. These counties distribute centralized and contiguously. The rurality index of most counties in other major agricultural areas such as Northeast Plain, Jianghan Plain, Sichuan Basin and Jiangxi province is relatively 'high'. But these areas are in the process of rapid urban-rural transformation development, and their rualilty is changing toward the 'average' type. Counties with low rurality index are mainly around the eastern coastal big cities, northeast national forest and northwest areas with rich mineral and energy resources experiencing large-scale exploitation. Although they are rural areas, the population property, settlement mode, and industry pattern have differed largely from the traditional agricultural areas. It was found that, in most cases, the rurality pattern reflects the impact of physical geography, resource endowment, traffic location, territorial culture, economic foundation and socio-economic policy on the rural system effectively. The rurality index could largely reflect the basic characteristics of the spatio-temporal pattern of China's rural development, and the pattern identified by rurality index significantly improved our knowledge on the recent development of China's rural areas.

As we know, without an in-depth understanding of regional pattern of rural state, feasible rural policies can hardly be mapped out. However, rural system is a complex system that cannot be perfectly demonstrated through only one or two indicators. In terms of the patterns revealed by the rurality index and corresponding regional policy demands, there are two little limitations. Firstly, counties with 'very high' rurality index are located both in the remote hilly areas and Huang-Huai-Hai Plain, which makes it hard to identify target areas relying solely on the rurality to making suitable rural development policy, especially aiming at promoting the agricultural development and grain production. Secondly, regions with low rurality index are either in the rural areas of eastern coastal China with relatively high urbanization and industrialization level or in the energy-mineral resource areas of northern China and forest areas of northeastern China. Different from the relative developed rural areas in eastern coastal China, in the northern China and forest areas of northeastern China, agriculture are still the major source of rural residents' livelihood and these regions are still the key areas in need of preferable rural development policy. Therefore, due to the vast regional difference at county level both in physical geographical conditions and economic location, as well as China's unique agricultural and rural development policies under urban-rural dual structure, this index is less successful in fully revealing the agricultural production status alone.

But even so, important policy implications for China's rural development can be addressed based on our rurality index analysis. As we can see from Tables 2 and 4, the relationship between the major original indicators and rurality index is stable, and the correlationship between rurality index and socio-economic and geographical indicators is significant. Compared with counties with lower rurality index and thus have better economic performance, local residents in counties with higher rurality index are more likely to have lower education level, to be lack of professional skills and to be employed by agricultural sector with less income, and the urban development and urbanization level in these counties are lower. It is confirmed that the counties with high rurality have been marginalized in the aspects of both geographical location and economic development. Apparently, they are the key challenges for China during the course of integrating urban and rural development in the 21st century. As such, in order to accelerate the rural development in counties with high rurality index and thus to reduce China's urban-rural development disparities and regional development disparities, more efforts should be made to change the status of peripheral through local transportation infrastructure construction, to improve the education level and professional skills of local population, and to revitalize the industries and urban development in these marginalized counties.

Theoretically, this study could be seen as an attempt to construct the knowledge about the rural through quantitative data as part of academic and governmental discourses (Woods, 2011), aiming at understanding the rural China. To a large extent, this could also be identified as a functional perspective mainly driven by technological and political factors to statistically categorize rural space (Woods, 2009a). However, this kind of rematerializing rural

depends highly on the definitions of rural areas, the indicators selected and the scale of the territorial units used (Shambaugh-Miller, 2007; Woods, 2011). However, both the non-numerical representations of the rural and the contested hybrid reconstitution of networked rural localities within globalization processes (Woods, 2007a, 2007b, 2009a, 2009b, 2011, 2013), were neglected in this study. As such, we acknowledge the critiques of indices of rurality in Europe & the US by Woods (2009a, 2011). It is worth to mention that, although the quantitative discourses of rurality are problematic in defining the limits of rural space, the lines that they do draw have real effects on policy implementation and funding programmes (Woods, 2011: 48). To this point, rural local government has become concerned not only with advocating local interests, but with advocating particular discourses of rurality, especially in the aspect of strategic planning (Woods, 1998). As for China, is experiencing a period of considerable rural restructuring (Long and Woods, 2011; Long et al., 2012), has implemented various policies and strategic planning (Long, 2014; Long et al., 2010). In this sense, we tend to emphasize the positive role of rurality index. Especially, this index is helpful for us to understand rural space and rural change, and their regional differences, and it could provide important information for the public and government when reexamining the problems and policies of China's rural development. Furthermore, theoretically, successive rurality index studies should further dock with important theoretical point of view of rural geography. Most importantly, we should devote our self to explore the development mechanism of rural areas with different level of rurality, discover the regional disparities of networks of rural development, and build bridges to link the theories, practices and policies of rural development.

Therefore, given the advantages and limitations of rurality index from the perspectives of demographic characteristics and their changes, the following aspects are needed to further study to bridge the gaps between the local features and macro rural development policies. Firstly, indicator system for rurality evaluation may be further improved by adopting the indicators reflecting the accessibility, land use, landscape and culture of rural areas. This may help to improve its precision when identifying various rural areas. Secondly, more efforts should be made to explore the formation mechanism of regional differences of rurality under China's specific physical and socio-economic conditions. Thirdly, the studies on rurality and rural socio-economic analysis should be integrated to formulate better regionalized rural development policies. Only by addressing these studies can we obtain in-depth knowledge and understanding of the rurality and thus lead to more integrated, regionalized and feasible rural development policies.

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