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Exploring the urban-rural development differences and influencing factors in the Huang-Huai-Hai Plain of China

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Abstract: Uneven urban and rural development is one of the main reasons for the decline of the countryside. This imbalance could be measured by the urban-rural difference index (URDI). Existing studies on urban-rural differences have focused on single dimension between urban and rural areas, and lack a systematic multi-dimensional measurement. Based on the construction of an index system and model for measuring urban-rural differences, this study took the Huang-Huai-Hai Plain (HHHP) as the study area, explores the spatial pattern of urban-rural differences in the area, and used geographical weighted regression models to identify the factors affecting urban-rural development differences. Results show that the mean value of URDI in the HHHP was 0.295, and the URDI in its western region was higher than that in the east. The average URDI was relatively high in the western counties along the Beijing–Guangzhou Railway. The low level of urban-rural "population-land-industry" development in the HHHP is an important reason for the small differences between urban and rural areas. Improvements in road transportation infrastructure have led to an increase in the urban-rural development gap. However, the driving force of the road network on urban development is greater than that on rural areas. The role of county economic agglomeration is gaining strength. In the process of rapid economic development, more attention should be paid to the development of the rural economy and the overall revitalization of the countryside. The equivalent allocation of social service facilities is an effective way to solve the problem of urban-rural imbalance. Further analysis demonstrated that terrain factors have relatively little influence on the URDI. This study provides a new perspective and measurement method for understanding the integration of urban and rural development, and provides a useful reference for guiding the urban-rural integration development and the rural revitalization.

Keywords: urban-rural difference index (URDI); population-land-industry; urban-rural relationship; rural revitalization; Huang-Huai-Hai Plain (HHHP); China

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1 Introduction

China has implemented a strict urban and rural household registration system since the founding of the People's Republic of China in 1949. With the implementation of the reform and opening policy in 1978, China's urban and rural household registration system was gradually broken, but the urban-rural dual track system still has a profound impact on China's economy and society (Liu *et al.*, 2010). Since 2003, China has begun to implement a strategy of urban-rural integration, and as a result, rural development has begun to attract attention. However, urban areas still dominate in regional development, while rural areas are increasingly in decline (Liu and Li, 2017). The gap between urban and rural areas makes cities fail to establish a good relationship with the countryside, which exacerbates the decline of the countryside (Haas and Westlund, 2018).

The HHHP (also called the North China Plain), which is one of the country's main grain-producing areas, is facing serious problems of rural decline, marginalization of agriculture, weakening of the population, hollowing of villages and environmental pollution. The development model of rural areas supporting cities and agriculture supporting industries has made rural areas unsustainable and aggravated the urban-rural development gap (Li and Liu, 2013). The deepening of the urban-rural development gap has in turn made urban-rural segregation severely affecting regional sustainable development. This uncoordinated urban-rural relationship affects the sustainable development of the region and the national food security to some extent (Liu, 2018). Against this background, the differences between urban and rural areas in the main grain-producing areas in China have become an important topic of discussion and an essential part of theoretical studies into urban-rural relationships.

Urban-rural relationships include the fundamental economic and social relationships of an area (Li *et al.*, 2011). In all countries of the world, these relationships have gone through the creation of new cities in the countryside, the separation of urban and rural areas, antagonism between urban and rural areas and integration of urban and rural areas (Zheng and Zheng, 2013). City and the countryside are an organism and should not be separated from each other (Yu and Jiang, 2016). Extensive and in-depth research has been done around urban-rural relations, urban-rural development, and urban-rural integration (Henderson and Wang, 2005; Gren and Andersson, 2018; Yan *et al*., 2018). At the same time, changes in urban and rural factors are also the focus of attention (Makita *et al.*, 2010; Magnani and Zhu, 2012). Sociology, economics, geography and other disciplines have conducted extensive studies around urban-rural relations and fruitful results have been obtained (Liang *et al.*, 2004; Shi *et al.*, 2004). However, existing studies have mainly focused on the difference of single factor between urban and rural areas, and few studies have systematically considered the gap between multiple factors. In fact, there is a clear gap between urban and rural areas in terms of health, medical services, education and social welfare (Qian and Smyth, 2008; Yi *et al.*, 2008; Fang *et al.*, 2009; Tam, 2015).

An urban-rural regional system is a comprehensive system composed of different subsystems. Urban-rural disparity is an important part of urban-rural relationships. The incoordination between urban and rural areas affects regional sustainable development and exacerbates the decline of rural areas. The question of how to measure the differences between urban and rural areas from a comprehensive perspective remains many challenges. Therefore, the main

aims of this study are to establish the index system and model of urban-rural development differences, and identify the leading factors affecting the urban-rural development differences. This study provides a new and appropriate concept for understanding urban-rural integrated development and rural revitalization.

2 Materials and methods

2.1 Study area

The HHHP (32°–40°N, 114°–121°E) is one of the largest grain-producing areas in China. The plain spans seven provinces and cities, including Beijing, Tianjin, Hebei, Shandong, Henan, Anhui and Jiangsu, covering an area of about 0.30 million km^2 (Figure 1). The average annual temperature of the HHHP is 8 to 15℃, and the annual rainfall is 500 to 900 mm. In 2015, the HHHP produced about 24% of China's grain. The average disposable income of urban residents and rural residents was 25,237 yuan and 12,056 yuan, respectively. The average population density in urban built-up areas and rural settlements was 7400 person·km^{-2} and 3700 person·km^{-2}, respectively. The average secondary and tertiary industrial output value per km^2 in urban built-up areas was 1 billion yuan·km^{-2}, but the average value of grain output per km^2 of cultivated land was just 1.4 million yuan·km^{-2}. The average urban per capita output value of secondary and tertiary industries was 94,000 yuan/person, but the average value of rural per capita output value of primary industry was just 9000 yuan/person. Rapid urbanization and industrialization have increased the uneven development of urban and rural areas in the HHHP, which has received widespread attention.

Figure 1 Location of the Huang-Huai-Hai Plain of China

2.2 Data and methods

The imbalance between urban and rural development in the HHHP is one of the main driving forces of rural decline. The URDI is a feasible method to measure the development gap between urban and rural areas. Population, land and industry (PLI) are the core elements of the urban-rural system. People is the main body of the system, and their behavior can promote or slow down urban-rural development. Land is the basic element of production and provides a space carrier for development, and industry is the core driving force behind regional economic development. Thus, this study used these three indicators of population, land and industry to analyze the URDI. We constructed an evaluation model for the ur-

ban-rural difference based on the concept of Euclidean distance (Equation 1). In this study, the values of the URDI range from 0 to 3. The greater the difference between urban and rural areas is, the greater the URDI is. URDI=0 implies no obvious urban-rural development difference, whereas URDI=3 indicates the existence of a clear difference.

$$\mathrm{URDI}_i = \sqrt{\left(\mathrm{RP}_i - \mathrm{UP}_i\right)^2 + \left(\mathrm{RL}_i - \mathrm{UL}_i\right)^2 + \left(\mathrm{RI}_i - \mathrm{UI}_i\right)^2} \quad (1)$$

where i is the evaluated unit (county); URDI_i is the urban-rural difference index; RP_i is the rural population index; UP_i is the urban population index; RL_i is the rural land index; UL_i is the urban land index; RI_i is the rural industry index I; and UI_i is the urban industry index.

The indicators for measuring the URDI include multiple sub-indicators. Urban population (UP) includes the proportion of workers to the total urban population in secondary and tertiary industries and the disposable income of urban residents. Urban land (UL) includes the intensive level of land use in urban built-up areas and the secondary and tertiary industrial output value per km^2 in the urban built-up areas. Urban industry (UI) includes the urban per capita output value of secondary and tertiary industries. Rural population (RP) includes the proportion of rural workers to the total rural population and the disposable income of rural residents. Rural land (RL) includes the intensive level of land use in rural settlements and the grain output value per km^2 of cultivated land; the grain output value was calculated using the grain price of 2015. Rural industry (RI) includes the rural per capita output value of primary industry. These social and economic data were obtained from the Statistical Yearbook of China's Counties (NBS, 2016) and the individual provincial statistical yearbooks. The data on urban and rural disposable income came from the annual reports of the county governments. In addition, land data came from the Earth System Science Data Sharing Platform of the Chinese Academy of Sciences (CAS) (http://www.gscloud.cn/). All data were standardized to facilitate the elimination of dimensional effects (Equation 2). The UP, RP, UL, RL, UI and RI were obtained by adding sub-indicators with different weights. The indicators were assigned weights using the entropy weight method, whereby the objective weight was determined according to the magnitude of the index variability. Generally, if the information entropy index weight of an index was small in a system, this indicated that the index value could provide much information (Xu *et al.*, 2018). This method eliminates subjective influences (Table 1).

$$X_i' = \left(X_i - \min X_i\right) / \left(\max X_i - \min X_i\right) \quad (2)$$

where X_i' is the value of the normalized index variable; X_i is the original value of the index variable; min X_i is the minimum value of the original value of the index variable X_i; and max X_i is the maximum value of the original value of the index variable X_i.

In general, the level of road network coverage, as well as natural, economic and social factors, are the factors influencing the development of urban and rural areas. The four indicators include different sub-indicators (Table 2). Road network data were obtained from road maps of China (2015) on the Earth System Science Data Sharing Platform, CAS (http://www.gscloud.cn/). These four indicators were also obtained by adding different sub-indicators with different weights, and the weights were obtained by the entropy weight method (Table 2). In order to measure the influence of different factors on URDI, geographical weighted regression (Equation 3), which can be calculated using ArcGIS10.2, was

applied to analyze the effects. The regression coefficients can be demonstrated using the display function in ArcGIS10.2.

$$\mathrm{URDI}_i = \beta_0\left(u_i, v_i\right) + \sum_k \beta_k\left(u_i, v_i\right) x_{ik} + \varepsilon_i \tag{3}$$

where $\beta_0(u_i, v_i)$ is a constant, $\beta_k(u_i, v_i)$ is the spatial weight matrix; x_{ik} represents different influencing factors; and ε_i the residual error.

Table 1 Indicators of the urban-rural difference index

Destination layer	Criteria layer	Index layer	Weights
Urban development	Urban population	Proportion of workers to the total urban population in secondary and tertiary industries	0.50
		Disposable income of urban residents	0.50
	Urban land	Intensive level of land use in urban built-up areas (person/km^2)	0.51
		Secondary and tertiary industrial output value per km^2 in urban built-up areas	0.49
	Urban industry	Urban per capita output value of secondary and tertiary industries (yuan per capita)	1.00
Rural development	Rural population	Proportion of rural workers to the total rural population	0.50
		Disposable income of rural residents	0.50
	Rural land	Intensive level of land use in rural settlements (person/km^2)	0.51
		Grain output value per km^2 of cultivated land	0.49
	Rural industry	Output value per capita of rural primary industry	1.00

Table 2 Indicators of the factors influencing urban-rural development

Factors	Index layer	Weights
Road network coverage level	Highway length per km^2	0.20
	National road length per km^2	0.26
	Provincial road length per km^2	0.23
	County road length per km^2	0.28
	Railway length per km^2	0.13
Natural factors	County average slope	
Economic factors	County per capita GDP	0.40
	County per capita public finance income	0.30
	County per capita taxes	0.30
Social factors	County per capita social welfare homes	0.31
	County per capita medical and health beds	0.36
	Proportion of students to the county population	0.33

3 Results

3.1 Spatial pattern of the urban-rural difference index

The mean value of the URDI in the HHHP was 0.295, which shows that there is a low level of urban-rural differences. The URDI was relatively high in the western counties of the HHHP along the Beijing–Guangzhou Railway. In this area, the values of most counties'

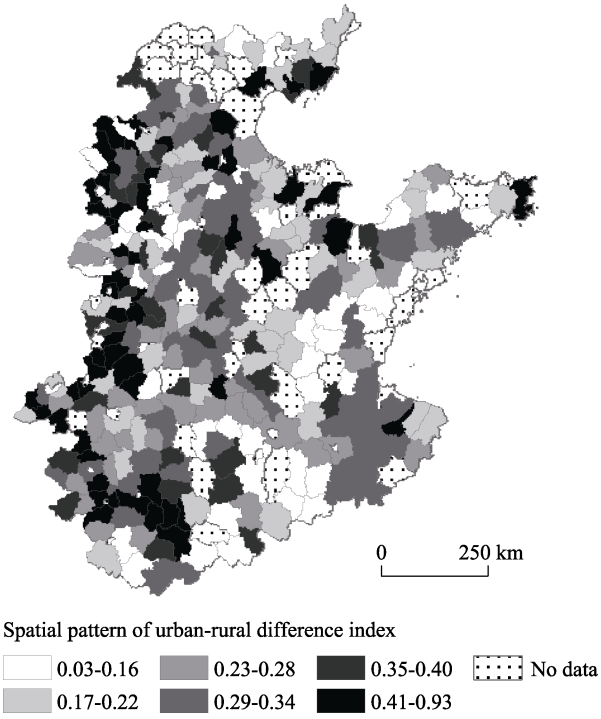

Figure 2 Spatial pattern of urban-rural difference index values in the Huang-Huai-Hai Plain in 2015

URDIs were greater than 0.350, while some even exceeded 0.410. In contrast, the URDIs of the middle area along the Beijing–Kowloon Railway were lower than those of the west. Most of the URDI values were below 0.340. Although the URDI values of some counties were high, such as the coastal areas of Tangshan City, the counties in Dongying City, most of the counties in the economic circle around the Bohai Sea were relatively low. On the whole, the URDI values in the western part of the HHHP were higher than those in the eastern (Figure 2).

Different types of PLI are shown in Figure 3. For the sake of clarity, the development index of urban-rural population (UP_i, RP_i), land (UL_i, RL_i) and industry (UI_i, RI_i) are defined as a low development level in the range [0, 0.3], the development index is defined as a medium development level in the range (0.3, 0.6], and the development index is defined as a high level of development in the range (0.6, 1] (Table 3).

Table 3 Grading standards for urban-rural development

Urban-rural population		Urban-rural land		Urban-rural industry		Development level
UP_i	RP_i	UL_i	RL_i	UI_i	RI_i	
[0, 0.3]	[0, 0.3]	[0, 0.3]	[0, 0.3]	[0, 0.3]	[0, 0.3]	Low
(0.3, 0.6]	(0.3, 0.6]	(0.3, 0.6]	(0.3, 0.6]	(0.3, 0.6]	(0.3, 0.6]	Medium
(0.6, 1]	(0.6, 1]	(0.6, 1]	(0.6, 1]	(0.6, 1]	(0.6, 1]	High

The UP and RP were all low or medium in most parts of the HHHP, and spatial differentiation was obvious. The proportions of low-level and medium-level urban-rural population were 9.33% and 49.67%, respectively. In contrast, the proportion of low-level UP and medium-level RP was 28.67% (Table 4). These three types accounted for 87.67% of the total. This shows that most of the HHHP has a large population and relatively few jobs, which leads to lower income levels in both urban and rural areas. This means that there is a large population base, but there are no corresponding jobs in the local area, which leads to people leaving their hometowns in order to earn higher payment and produces "double drifting in urban and rural areas." Meanwhile, this also indicates that the gap between urban and rural population is small. As rural areas are engaged mainly in agricultural production and other labor-intensive industries, rural areas can bring more jobs than cities. But compared with the secondary and tertiary industries in cities, the rural industries often do not bring too much

incomes. Urban-rural population development in the western region was relatively low, while that of the eastern region was mainly at the medium level.

Table 4 Proportion of different types of urban-rural population-land-industry in the Huang-Huai-Hai Plain in 2015

Development type	Urban-rural population (%)	Urban-rural land (%)	Urban-rural industry (%)
Low-level urban-rural development	9.33 (28)	13.33 (40)	83.67 (251)
Low-level urban development and medium-level rural development	28.67 (86)	48.00 (144)	6.00 (18)
Low-level urban development and high-level rural development	0.33 (1)	7.33 (22)	0.33 (1)
Medium-level urban development and low-level rural development	5.00 (15)	6.33 (19)	7.00 (21)
Medium-level urban-rural development	49.67 (149)	18.00 (54)	1.33 (4)
Medium-level urban development and high-level rural development	6.33 (19)	4.33 (13)	0.67 (2)
High-level urban development and low-level rural development	0	1.00 (3)	1.00 (3)
High-level urban development and medium-level rural development	0.33 (1)	1.67 (5)	0
High-level urban-rural development	0.33 (1)	0	0

Notes: The value in parentheses is the number of counties at the level of development of this type. Cell 9.33 (28) represents the proportions of both urban and rural population at low level is 9.33%, cell 13.33 (40) represents the proportions of both urban and rural land intensification at low level are 13.33%, and so on.

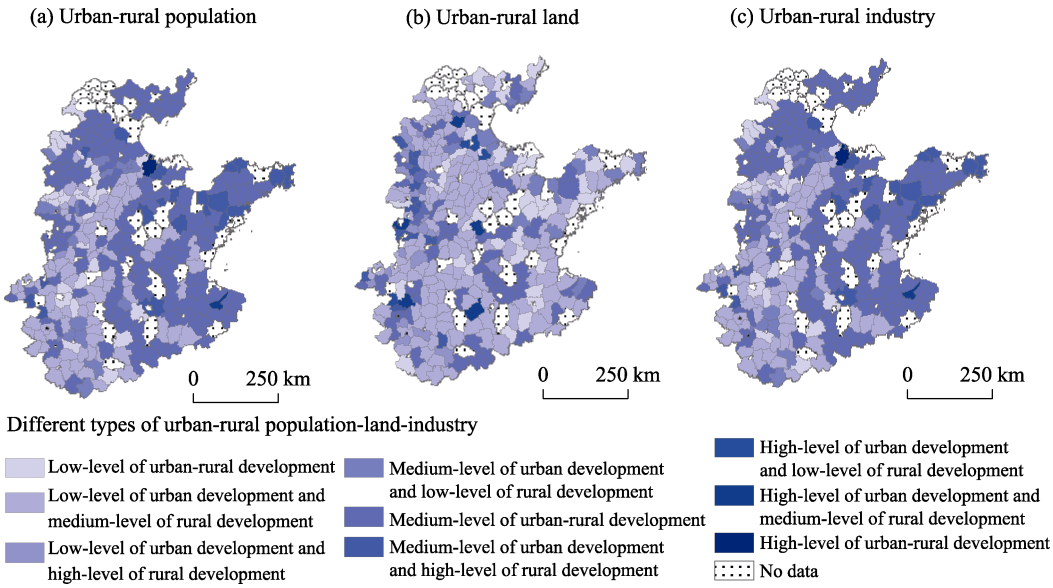

Figure 3 Different types of urban-rural population-land-industry in the Huang-Huai-Hai Plain in 2015

Compared with the spatial pattern of urban-rural population, the spatial differentiation of urban-rural land was not obvious. The medium and low levels of RL and UL were the main types. The proportions of low-level UL and RL, low-level UL and medium-level RL were 13.33% and 48.00%, respectively. Meanwhile, the proportion of medium-level UL and RL

was 18.00% (Table 4). These three types accounted for 79.33% of the total. This shows that the intensity of land use in the HHHP is not high. In other words, per unit area of land can not carry enough population or produce enough output value in most parts of the HHHP. The UL development level was high while RL was relatively low in the western part of the HHHP along the Beijing–Guangzhou Railway. The urban-rural land development of counties in the economic circle around the Bohai Sea was mainly medium-level UL and low-level RL.

Similar to urban-rural population development, the spatial differentiation of urban-rural industry was also obvious. The overall level of urban-rural industrial development was low. The proportion of low-level UI and RI was 83.67% of the total. Although urban-rural industrial development was low, urban industrial development was greater than its rural counterpart in the HHHP. The differences in the urban-rural industrial development of some counties in the economic circle around the Bohai Sea presented medium-level UI and low-level RI types, as for some counties in Jiangsu Province in the HHHP (Table 4).

3.2 Factors influencing the urban-rural difference index

From the development of the four factors including the road network coverage level as well as natural, economic and social factors, we can see that each factor presented different spatial patterns (Figure 4). At the road network coverage level, the overall regional development level was low and that of the highest value was no more than 0.83. A high-density road network coverage area has formed around Zhengzhou, which is a traffic hub city on the Beijing–Guangzhou Railway, with the Longhai (Lianyungang–Lanzhou) Railway and some other important highways passing through it. Several high-density road network coverage areas have formed around cities on the Beijing–Guangzhou Railway as well, including Baoding, Shijiazhuang, Handan, etc. The coverage level of the road network in the counties surrounding Xuzhou, which is the intersection of the Longhai Railway and the Beijing–Shanghai Railway, was also high. The counties in the economic circle around the Bohai Sea also had high road network coverage levels.

In general, the HHHP has relatively flat terrain, with an average slope below 0.251 in most of this area. In the western part of the plain, the terrain is steeper and its altitude is higher than other parts, as is the area around Shandong. The spatial pattern of economic development in counties was obvious in the HHHP. Economic development in the eastern counties was higher than that in the west. This is also consistent with the decline in China's economic development from the east coast to the central and western parts of the country. The central region showed a typical low-value area of economic development, while the level of development in both eastern and western parts of the area was high. The high-value areas formed an L-shaped spatial pattern for social development. From Baoding to the northern part of Zhengzhou, the extension of the Beijing–Guangzhou Railway has formed a high-development-level axis of social factors, as has the extension of the Longhai Railway from Jiaozuo to Lianyungang. The index of social factors in the economic circle around the Bohai Sea was also high.

In order to explore the factors affecting the URDI, we used geographically weighted regression to analyze the road network coverage level, as well as natural, economic and social factors. By using the Akaike information criterion (AIC) method, the optimal bandwidth was

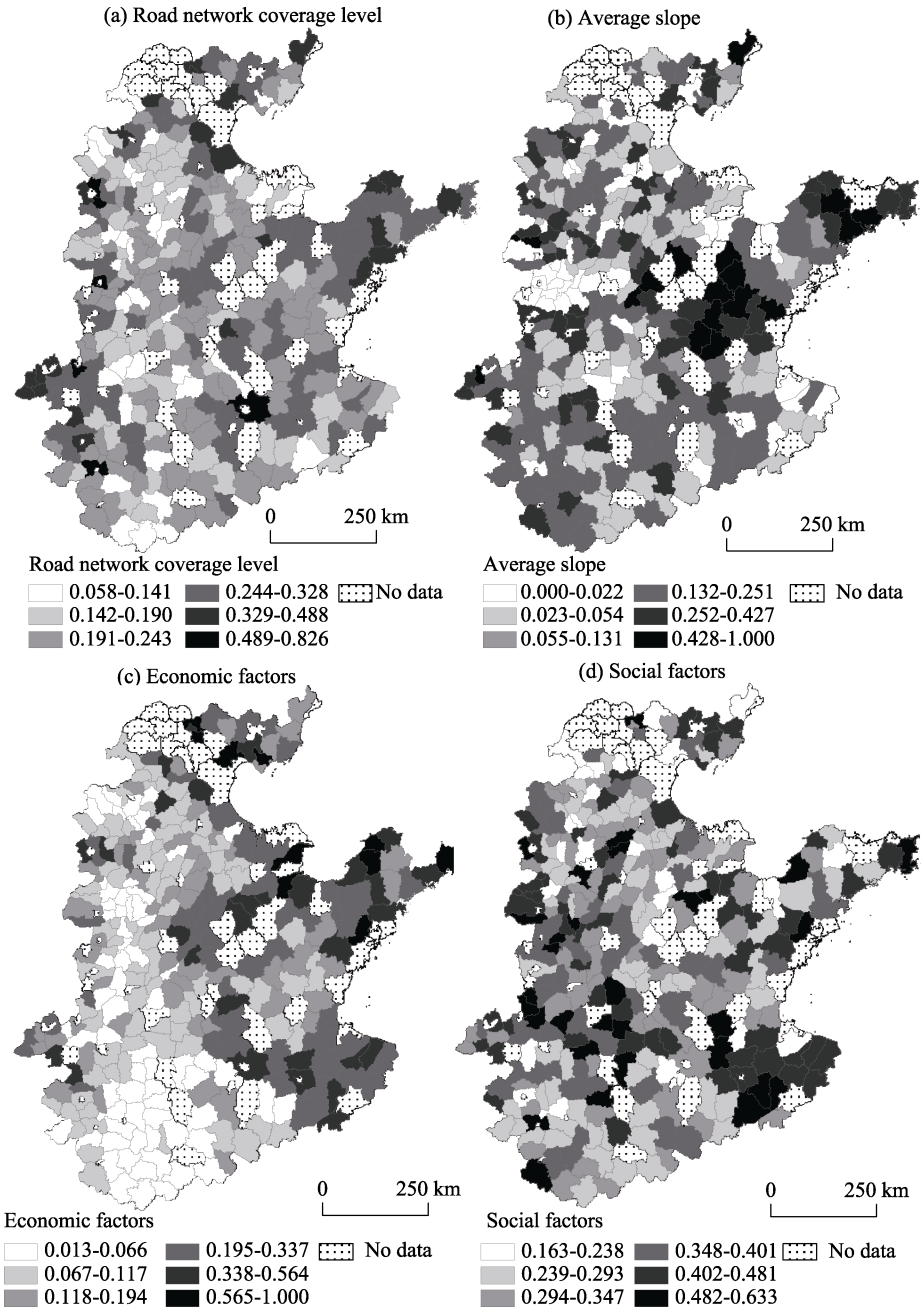

Figure 4 Spatial patterns of road network coverage level, natural, economic and social factors in the Huang-Huai-Hai Plain in 2015

208151.72 m. The results show that AIC was −378.62 and the R^2 was 0.29 and the adjusted R^2 was 0.20. The regression coefficients of the various factors, which can be used to analyze the intensity of the influencing factors in the different regions, are shown in Figure 5.

In general, the road network coverage level has a positive effect on the regional URDI of western counties and a negative effect on eastern counties, although there are fewer of the latter. That is to say, the greater the density of the road network is, the greater the URDI is in

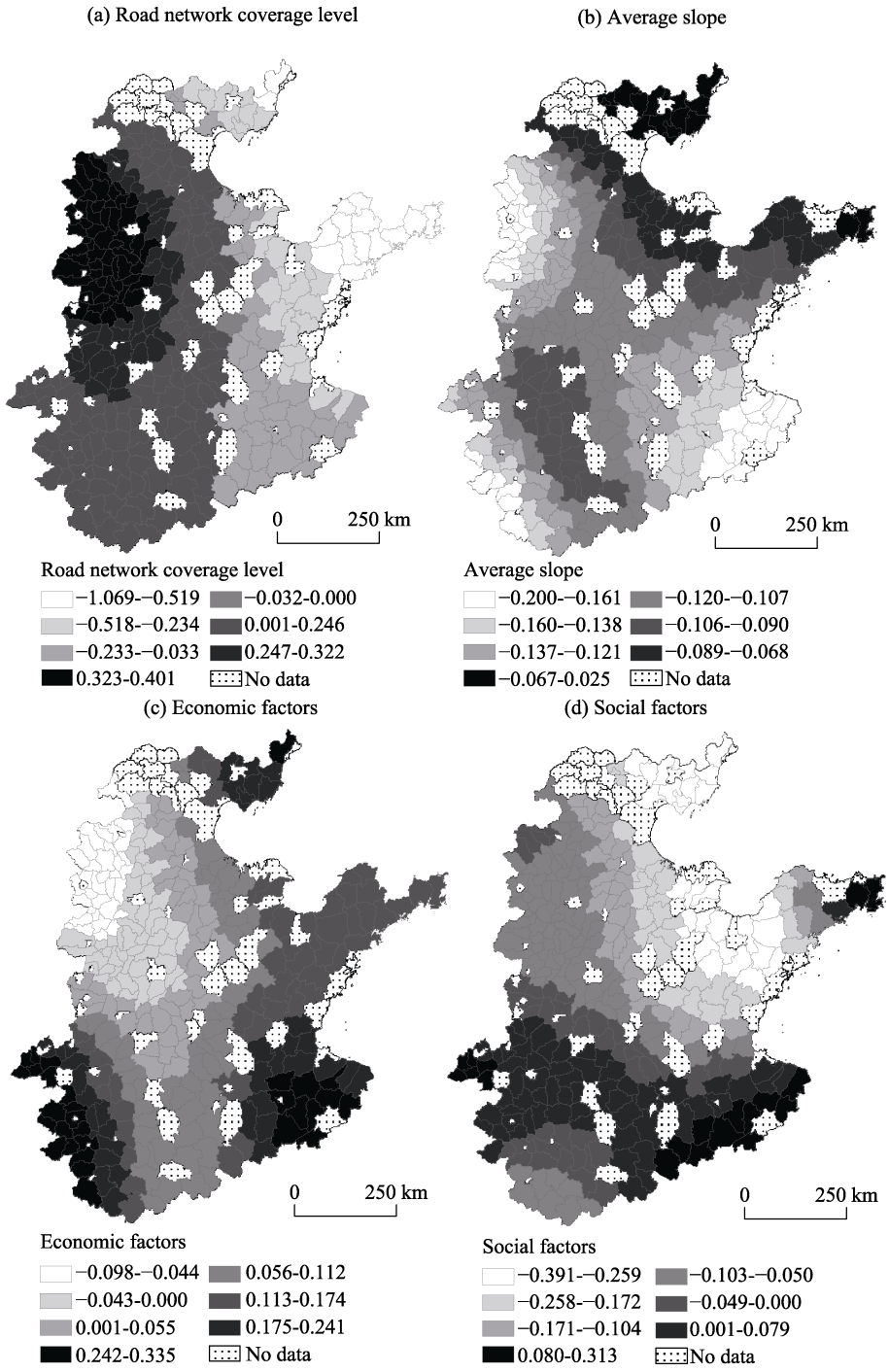

Figure 5 Geographically weighted regression coefficients of the urban-rural difference index in the Huang-Huai-Hai Plain in 2015

the western part of the HHHP. The regression coefficients reflect that the degree of influence declines from west to east. In the western part of the HHHP along the foothills of the Taihang Mountains, the positive influence of traffic factors on the URDI is large over the whole

area. The absolute values of the negative regression coefficients in the economic circle around the Bohai Sea are also large, and all they are greater than 0.234.

The degree of the average slope has a negative effective on the URDI in the HHHP. This means that the greater the average slope is, the smaller the URDI is. The areas with strong influence are mainly in the western part of Henan and Hebei provinces and the southeast part of the HHHP. The impact of slope on the URDI is small in the economic circle around the Bohai Sea. Overall, the regression coefficients of the average slope are lower than other factors, and their absolute values are less than 0.201.

Economic factors have a positive effect on the URDI, which shows that economic development has exacerbated the difference between urban and rural areas in the HHHP. The influence of economic factors gradually decreases from the south and east to the north and west. The counties with a high positive influence are distributed mainly in the eastern and southwestern parts of the HHHP. Economic factors in some counties of Hebei Province have a negative impact on the URDI, but the absolute values of the regression coefficients are very small. In general, the greater the index of economic factors is, the larger the URDI is.

Although social factors have a negative effect on the URDI in most of the HHHP, they have a positive effect on the URDI in counties that surround cities along the Longhai Railway, such as Zhengzhou, Shangqiu and Xuzhou. However, the regression coefficients of their positive influence are relatively small. This shows that the development of social factors can reduce the URDI, and negative impacts in many counties are obvious (the absolute value of the regression coefficient is large). Therefore, the allocation of social infrastructure can effectively narrow the gap between urban and rural areas.

4 Discussion

Previous studies have focused on a single aspect of urban-rural differences, such as income inequality (Yang and Zhou, 1999; Yun, 2011), educational opportunities (Hao *et al.*, 2014) and healthcare (Fang *et al.*, 2009). But few studies have focused on the imbalance between the urban and rural systems. This study can fill this gap. Here, the HHHP was selected as a typical case area, a quantitative model for measuring the urban-rural development difference was constructed, and the spatial pattern of the URDI in the study area in 2015 was investigated, and the leading factors affecting this difference were identified. Our findings can help to reveal the urban-rural relationship in the HHHP.

(1) Urban-rural PLI development is at a low level in the HHHP, which is the main reason for small URDIs in this area. The proportions of urban-rural population, land and industry both at high-level are only 0.33%, 0% and 0%, respectively. Urban-rural development is at a low level in most counties of the HHHP. The development of urban-rural population and industry is relatively low, which reflects that industrial development and job opportunities in the counties are relatively meagre. This is also one of the important reasons for “residential and industrial separation”, that is, the low level of industrial development has not brought sufficient jobs to local residents. Therefore, the habitants of the area are forced to leave home to work in other cities for higher payment. In addition, more attention should be paid to avoiding blind urban expansion.

(2) Natural factors have less influence on the URDI than other factors. The negative in-

fluence of the road network coverage level on the URDI in the economic circle around the Bohai Sea and the positive influence of economic factors are both considerable, while the negative influence of social factors is large, too. This means that this area has achieved better coordinated development between urban and rural areas in the development of society and road facilities. In the process of regional development, economic differences between urban and rural areas should be coordinated. The positive influence of economic and social factors on the URDI in Jiangsu Province is relatively large, whereas the negative influence of road coverage level is obvious. This reflects that the relationship between urban and rural areas has not been coordinated effectively in this region. That means that the overall development of urban and rural areas needs to be strengthened, especially economically and socially. For counties along the Beijing–Guangzhou Railway, the advantages of the transportation infrastructure should continue to be exploited. Meanwhile, attention should also be given to the allocation of social facilities in order to avoid the intensification of these differences.

(3) For most areas, the greater the road network coverage level is, the higher the URDI is. Yang (2016) explored the relationship between urbanization and transportation and proved that the development of counties' urbanization and transportation superiority affected each other significantly. That is to say, the higher the accessibility of transportation is, the more beneficial to a county's urbanization development is. However, the driving force of road network expansion on urban development is greater than that in rural areas. This is the reason why the road network coverage level has a relatively large and positive impact on the URDI. Meanwhile, improvements in transportation can promote the development of rural areas, too. Filani (1993) explored the relationship between transportation and rural development in Nigeria and found that transportation development can improve farmers' productivity and accessibility of the countryside. Although the current transportation system has a positive impact on the URDI in most counties, it still plays an important role in the regional development.

(4) The better the development level of the county economy is, the greater the difference between urban and rural areas is. The town is the growth pole in rural areas around which the economy develops in China. According to growth pole theory, the development of the county economy extending from the urban center to the periphery is a universal phenomenon. In fact, the urban economy is often given priority for development. Under the traditional urban-rural dual track system, rural development is often neglected (Long *et al.*, 2010). So far, urban centers are still the focus of economic development (Chen *et al.*, 2014). Therefore, economic development will lead to an increase in urban-rural differences over time. According to this research, we can see that the development of counties in the HHHP occurred also like this. The agglomeration of urban development is very strong, while the development of the rural economy is relatively backward. So, rural economic development in the HHHP needs to be revitalized urgently, and more attention should be paid to balanced development of urban and rural areas.

(5) The greater the development level of regional social factors is, the smaller the difference between urban and rural areas is. Chen (2015) explored the urban-rural equivalence of China's cities and found that the influence of social factors on urban-rural equivalents is not significant. However, the study showed that the development of social factors can reduce the

differences between urban and rural areas. In the future of urban-rural development, the rational allocation of social factors is an effective way of narrowing the differences between urban and rural areas. Specifically speaking, welfare, medical and education levels are important factors related to the development of people's livelihoods at the county level, and their development can further narrow the urban-rural gap.

5 Conclusions

This study built a quantitative model for measuring the urban-rural development gap from a comprehensive perspective, and analyzed the spatial pattern of the URDI in the HHHP in 2015 based on this, and identified the dominant factors affecting this gap. The results show that this index can reflect the differences in urban-rural development in the HHHP. In general, the URDI in the HHHP was low and its mean value was 0.295. A high value axis has been formed along the Beijing–Guangzhou Railway. The URDI in the western region of the HHHP was higher than that in the eastern area, indicating the existence of an obvious urban-rural development difference in the western region.

The low level of urban-rural PLI development in the HHHP was an important reason for the small differences between urban and rural areas. The proportions of urban-rural population, land and industry both at high-level are only 0.33%, 0% and 0%, respectively. There is a serious separation between rural housing and industry in the whole area. In the future, land use needs to be further developed more intensively. In the HHHP, only the economic circle around the Bohai Sea has achieved a balance between urban and rural areas in both transportation and social development.

The development of the transportation has led to an increase in differences between urban and rural areas. The development of road network has improved the conditions for development of the whole area. However, the rural areas cannot rely on the road network to obtain rapid development because of a lack of rural growth poles, which leads to widening of the URDI. Meanwhile, the role of economic agglomeration in the development of the county is still gaining strength. In the process of economic development, more attention should be paid to the development of the rural economy in the future in order to achieve rural revitalization. The equivalent allocation of social service facilities is an effective way to solve the problem of urban-rural development imbalance. In the HHHP, terrain factors have relatively little influence on the URDI.

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