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Effect of land-centered urbanization on rural development: A regional analysis in China

Weilun Feng[a], Yansui Liu[a,b,*], Lulu Qu[a]

[a] Faculty of Geographical Science, Beijing Normal University, Beijing, 100875, China
[b] Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, 100101, China

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ABSTRACT

Since the late 1970s, China has undergone an unprecedented urbanization process. With land finance as the main driving force, land-centered urbanization has not only greatly accelerated China's economic and social development, but it has also had negative effects on social development and the environment. Amid the concerns regarding China's land-centered urbanization process, there have been growing calls for greater attention to be focused on the decline of rural China. The urban-rural relationship is the most basic social and economic relationship, a topic which has become a hotspot in geography, economics and sociology studies in recent decades. Based on panel data from 298 cities in China, from the 2001–2013 period, this paper uses the extended Cobb-Douglas model to measure the effect of land-centered urbanization on rural development, and its spatial pattern characteristics. The results show that, during the period from 2001 to 2013, China's urbanization level increased steadily, while the level of rural development showed a trend of declining first and then rising. Moreover, land-centered urbanization significantly promoted the development of rural areas nationwide, and urbanization's influence intensity displayed strong regional and particularity characteristics. Generally, compared with the relatively poor areas in the central and western regions, urbanization in the economically developed areas has a stronger driving effect on rural development. The findings have an important reference value for policy-makers in new-type urbanization and rural revitalization strategies for China.

1. Introduction

Most countries around the world have been vigorously promoting urbanization in recent decades, as the urbanization process plays an important role in promoting economic development and social progress (Bloom et al., 2008; Long et al., 2012). From 1960 to 2016, the proportion of the world's urban population rose from 33% to 54% (Liu and Li, 2017). Urbanization itself is a complex process of rural to urban transformation, which is accompanied by a major transformation of the country's economic structure, social structure, mode of production and way of life (Lu and Yao, 2007; Salvati et al., 2013; Tisdale, 1942). The rapid development of urbanization has greatly enrichedthe world's social economy, but it has also brought about many practical problems (Diego and Marshall, 2014; Glaeser, 2011; Haseeb et al., 2017). Meanwhile, China is urbanizing at an unprecedented rate, with the proportion of the nation's population dwelling in cities increasing from 17.9% in 1978, to 58.5% in 2017. This represents perhaps the greatest human-resettlement experiment in history (Bai et al., 2014). As an important driving force behind land-centered urbanization, land finance policies indicate that local governments are leading the way in the process of "land acquisition-urban sprawl, to land revenue-urban construction, to land acquisition again" (Zhang and Xu, 2017). The land-centered urbanization of China has become increasingly important since the 1990s and continues to accelerate the country's urbanization and economic growth. However, it has also brought about many practical problems in terms of the development of the economy and society as a whole. Amid all the concerns related to China's land-centered urbanization process in the 21 st century, there have been growing calls for more attention being focused on the decline of rural China (Li et al., 2016). In March 2014, the government issued the National New-type Urbanization Plan (2014–2020), which proposes that urbanization should be changed from being land-centered to people-oriented, moving from urban development to urban-rural integration, with the objective of taking responsibility for the well-being of peasant workers (Chen et al., 2019). In 2018, the 19th national congress of CPC proposed to implement the rural revitalization strategy, which calls for the establishment and improvement of a sound urban-rural integrated development system, mechanism and policy system. For a long time, the

* Corresponding author at: Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, 100101, China.
E-mail address: liuys@igsnrr.ac.cn (Y. Liu).

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central government has attached great importance to the issue of "agriculture, rural areas and farmers". The implementation of the strategy of new-type urbanization and rural revitalization points the way to further balancing urban and rural development, comprehensively building and maintaining a well-off society and achieving the Chinese dream (Tan et al., 2016).

Urbanization and the rural system are two closely related subsystems in China's overall economic development system. The traditional land-centered urbanization witnessed in the new century has exerted a huge impact on rural development, greatly improving the development of industrial and agricultural production in rural areas and the living standards of farmers (Andersen, 2006; Liu et al., 2009). However, this form of urbanization has also brought about many "rural diseases", such as the high-speed non-agricultural transformation of agriculture production factors, over-fast aging and weakening of rural subjects, the increasingly hollowing-out and abandoning of rural construction land, the severe fouling of rural soil and the water environment and the deep pauperization of rural poverty-stricken areas (Liu and Xu, 2016; Paül and Mckenzie, 2013). At present, the rural system has entered a new stage of transformation and development after long-term accumulation (Long and Liu, 2016). The demand for functions such as food production and environmental protection in rural areas will continue to increase in urban areas. The region's ability to promote agriculture and the ability to bring towns to the countryside will be steadily improved, which will provide solid support for promoting rural development (Zhou et al., 2016). Thus, cities and villages are part of a specific organism, and only two parts of sustainable development can support overall prosperity.

The systematic research into China's urbanization by domestic scholars began in the late 1970s. Since then, relevant researches have been increasingly flourishing, and many important achievements have been made (Normile, 2008; Yang, 2013). Relative research on urbanization mainly includes the connotation and characteristics, the mechanism and quality of urbanization, and the urbanization development process (Chen et al., 2010; Gu et al., 2017; Liu et al., 2015a). On the other hand, rural development is a multi-dimensional phenomenon, made up of various components, including politics, the economy, society, the environment and other factors and actors (Conacher et al., 2004; Mcdonagh, 2014; Murdoch, 2000; Pemberton and Goodwin, 2010; Woods, 2012). Rural development studies should not isolate the relationship between rural and urban areas, looking at this topic solely from the perspective of agriculture and rural areas (Liu et al., 2016b). Instead, the government should take the urban-rural development concept as the guide, and agriculture and rural issues as the core, and pursue the coordinated development of urban and rural integration (Wang et al., 2016). Previous studies on the effect of urbanization on rural development mainly focus on the characteristics of spatial and temporal patterns, evolutionary processes, development modes and influence mechanisms (Deng et al., 2015; Kurkalova and Lyubov, 2005; Liddle, 2014; Poumanyvong and Kaneko, 2010; Su et al., 2015; Zasada, 2011). Moreover, multiple regression models, threshold regression models, panel data analyses, structural equation models and system dynamics models have been used to study the interaction between different variables (Lu et al., 2002; Sha et al., 2017; Su et al., 2018). The term panel data refers to a data sample consisting of selecting sample observations for multiple sections of a time series for a specific area (Wang et al., 2017). Compared to other models and methods, a panel data model has obvious advantages over a simple cross-section data model or simple time series model (Xi Qiangmin, 2015). A panel data model can solve the problem of insufficient sample capacity and significantly reduce the problems caused by difficult observations or metric variables. However, relatively few relevant researches are based on a panel data model (Sun et al., 2011). In addition, the Cobb-Douglas production function has been widely used to measure the effect of land, population and capital investment. The analysis of the effect of urbanization on rural development is of great significance to exploring its internal relations, and to steadily promoting new-type urbanization and an effective rural revitalization strategy for China (Yang et al., 2018).

Due to China's special geographical conditions, economic base and institutional arrangements, the impact of urbanization on rural development is simultaneously complex, phased and regional. As such, there is not only a requirement for an in-depth study of the path, direction, intensity and mechanism of traditional urbanization as it occurred in the past; there is also now an urgent need to clarify the leading, boosting and blocking effects of urbanization on rural development, at different stages and in different regions. This is of great theoretical and practical significance to the implementation of China's new urbanization strategy and modern rural revitalization strategy in the new era, and to the further deepening of the reform and innovation of urban and rural integration development systems. Thus, this paper aims to investigate how China's rural development was previously influenced by its traditional land-centered urbanization policies in the early 21 st century, based on a panel data analysis. Then, the second section establishes an evaluation index system for urbanization and rural development systems. In the third section, the paper systematically analyzes the effect of urbanization on sustainable rural development, as well as urbanization's spatial pattern characteristics, based on a panel data analysis. Then, we analyze the effect of urbanization on the various elements of rural systems, from the factor level. This part is conducted through a correlation analysis of urbanization and rural development indicators. Finally, the paper illustrates the significance of this study to any new urbanization and rural revitalization strategy.

2. Data and methodologies

2.1. Data source

All the data used for the evaluation of urbanization and rural development level are obtained from the China City Statistical Yearbook, the China Statistical Yearbook for Regional Economy, the China Urban Construction Statistical Yearbook, and other statistical yearbooks. The data relate to each city and cover a 13-year period. The sample interval was selected to be from 2001 to 2013, with a cross-section of 289 prefecture-level cities, autonomous prefectures, federations and municipalities directly under central government control (Fig. 1). It should be noted that: 1) the level of population urbanization is the proportion of non-agricultural population, thus reflecting the effect of population urbanization on rural systems. 2) Due to a lack of relevant data for some indicators, the average value of the previous two years is used for the prediction.

2.2. Urbanization and rural development systems

The urban-rural development system is a complex, multi-subjective, multi-element natural-humanistic integrated system that is influenced by multiple factors from both inside and outside the system. The rural development system is a natural-humanistic integrated system, which mainly includes rural rim system and kernel system. The rim system is the result of external macroeconomic policies and institutional measures on rural development, while the urbanization-rural development system is the system of influence measurement of urbanization on rural development systems. Based on the theoretical connotation of urbanization and rural development, and taking into consideration data availability and previous research, this paper constructs an evaluation index system for an urbanization-rural development system, using the Delphi method (Table 1). The Urbanization Development Index (UI) selects three first-level indicators of population urbanization, economic urbanization and land urbanization. The Rural Development Index (RI) selects the three indicators of agricultural production, rural living and ecological environment index. The urbanization system and its population, economic and land subsystem indicators are used as independent variables. The rural development system, on the other hand, forms the

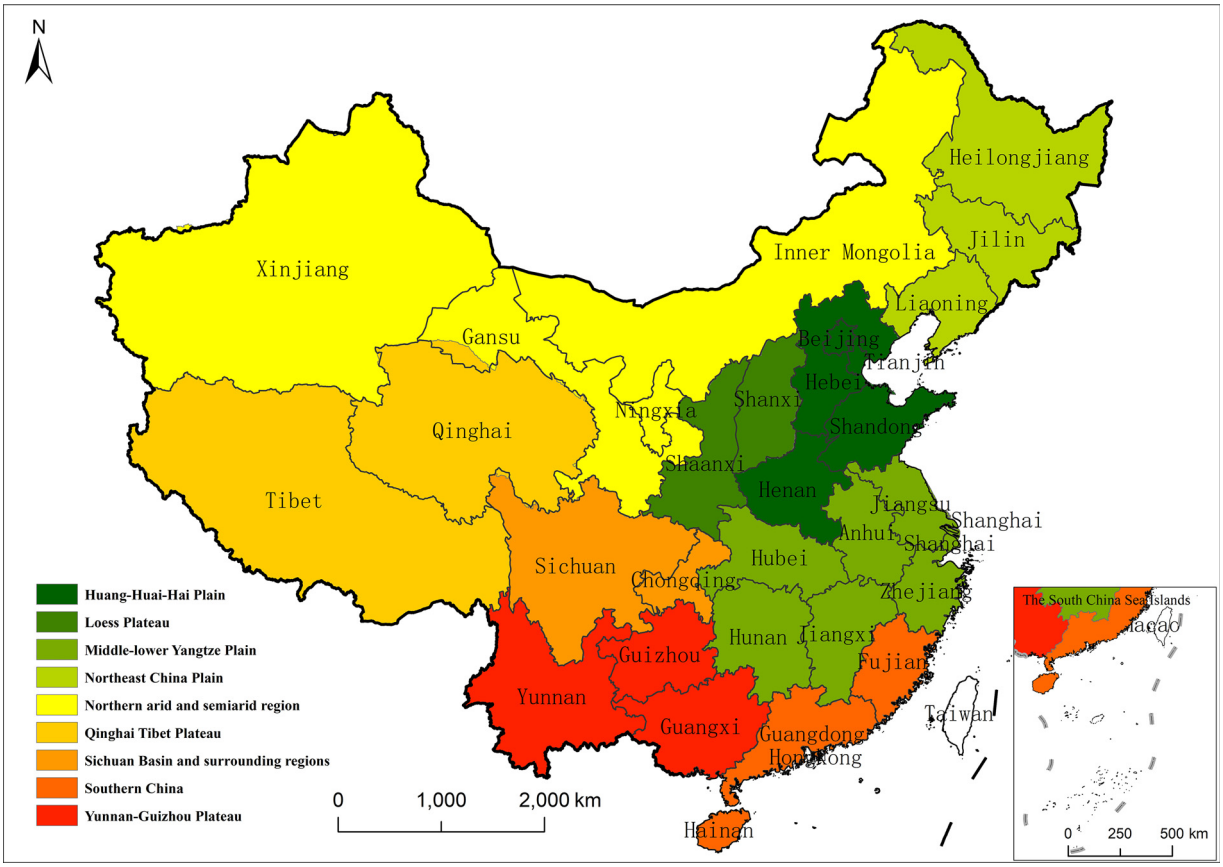

Fig. 1. Provincial-level units and nine agricultural regions in China.

comprehensive development degree of the rural system as a dependent variable by coupling the rural production, living and ecological subsystems.

2.3. Data processing and index calculation

In this study, the extremum standardization method is used to eliminate the difference of different index (Feng et al., 2019). The rural development system indexes are weighted by using the analytic hierarchy process (AHP), and summed up to obtain the development degree of the comprehensive rural system and each subsystem, according to Eqs. (1)–(4):

$$AP_i = \sum_1^3 x_{ij}^{'} * W_j \quad (1)$$

$$RL_i = \sum_4^6 x_{ij}^{'} * W_j \quad (2)$$

$$EE_i = \sum_7^9 x_{ij}^{'} * W_j \quad (3)$$

$$RI_i = AP_i + RL_i + EE_i = \sum_1^3 x_{ij}^{'} * W_j + \sum_4^6 x_{ij}^{'} * W_j + \sum_7^9 x_{ij}^{'} * W_j \quad (4)$$

where i represents the city; j represents the index; $x_{ij}^{'}$ represents the normalized value; AP_i, RL_i, EE_i and RI_i represents the agricultural production, rural living, ecological environment and rural development index of city i, respectively, and W_j represents the weight.

In addition, Pearson correlation method was used to establish the

Table 1
Indicator system for the evaluation of the development of urbanization-rural systems.

Criteria layer	Dimension	Index (weight)	Definition (±)
Urbanization (*UI*)	Population urbanization (*PU*)	The percentage of nonagricultural population in the total population of the city (0.333)	Nonagricultural population/ total population (+)
	Economic urbanization (*EU*)	The percentage of nonagricultural industrial output value in GDP (0.333)	Nonagricultural industry output/ Total GDP (+)
	Land urbanization (*LU*)	The percentage of built-up area in the total city land area (0.333)	Built-up area/ total city land area (+)
Rural development (*RI*)	Agricultural production (*AP*)	Per capita arable land area (0.055)	Cultivated land area/total population (+)
		Total power of agricultural mechanization per unit area (0.180)	Total power/arable land area of agricultural mechanization (+)
		Per capita grain output (0.099)	Total grain output/total population of the region (+)
	Rural living (*RL*)	The per capita net income of farmers (0.191)	Per capita net income of farmers (+)
		Rural per capita electricity consumption (0.095)	Rural electricity consumption/rural population (+)
		Rural per capita housing area (0.048)	Rural per capita housing area (+)
	Ecological environment (*EE*)	Amount of fertilizer applied per unit area (0.067)	Fertilizer application/arable land area (-)
		Industrial wastewater discharge per unit area (0.133)	Industrial wastewater discharge/total area (-)
		Industrial sulfur dioxide emission per unit area (0.133)	Industrial sulfur dioxide emissions/total area (-)

relationships among urbanization and rural development indicators, where the P-values were considered statistically significant at the 0.05 level.

2.4. The extended Cobb-Douglas model

The panel data regression model of the effect of urbanization on rural development is constructed by using the extended Cobb-Douglas model, according to Eqs. (5) and (6).

The extended Cobb-Douglas model is as follows:

$$Y_i(t) = A_i(t)K_i(t)^{\alpha_i}L_i(t)^{\beta_i}R_i(t)^{\gamma_i} \quad (5)$$

To overcome the heteroscedasticity of the extended Cobb-Douglas model (that is, the different variances of the error term), researchers often apply a logarithm on both sides of the model. Take the logarithm of both sides, and the deformation is as follows:

$$lnY_i(t) = lnA_i(t)+\alpha_i lnK_i(t) + \beta_i lnL_i(t)+\gamma_i lnR_i(t) + \varepsilon_i \quad (6)$$

In the model, $Y_i(t)$ represents the comprehensive development degree of the rural system; $lnA_i(t)$ is a constant term; $K_i(t)$represents the level of population urbanization; $L_i(t)$ represents the level of economic urbanization; $R_i(t)$ represents the level of land urbanization, and ε_i represents the vector of residuals. Also, α, β and γ, respectively, represent the coefficient of the panel data model variables, that is, the elasticity coefficient of the effects of population, economic and land urbanization levels on the rural system. According to the principle of rural production function, if the elastic coefficient of α, β, γ is greater than 1, the effect of urbanization on rural development is increasing. If α, β, γ is less than 1, the effect on rural development is decreasing. If α, β, γ is equal to 1, the effect on rural development is unchanged, and if α, β, γ is less than 0, there is a negative effect on rural development.

3. Results

3.1. Model validation results

3.1.1. Panel unit root tests

A unit root test is conducted to ensure that the residual sequence is stable and to avoid false regression. The horizontal and first-order unit root tests were conducted on the urbanization-rural development system and each subsystem, including common unit root and individual unit root. The test methods include Levin, Lin and Chu t (LLC); ADF-Fisher Chi-square, and PP-Fisher Chi-square (Liu et al., 2016a). Results show that many variables are non-stationary in their levels, but most of them become stationary at the 5% significance level after taking first differences (Table 2). This result indicates that urbanization, rural systems and each subsystem form a first-order single integral sequence.

Table 3
Panel co-integration test results.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID?(-1)	−0.38317	0.013958	−27.4507	0.000
D(RESID?(-1))	−0.11648	0.014149	−8.2327	0.000
R-squared	0.42535	Mean dependent var		−0.00507
Adjusted R-squared	0.42518	S.D. dependent var		0.153655
S.E. of regression	0.135253	Akaike info criterion		−1.1629
Sum squared resid	83.49072	Schwarz criterion		−1.16009
Log likelihood	2656.91	Hannan–Quinn criter.		−1.16191
Durbin-Watson stat	1.757058			

Note: The null hypothesis is that the variables are not co-integrated. Lag length is automatically selected based on AIC, with a max lag of 2; ***, ** and * reject the null of no co-integration at the 1%, 5% and 10% significance levels, respectively.

3.1.2. Panel co-integration tests

The purpose of a co-integration test is to determine whether or not there is a long-term stable relationship between model variables and to avoid the phenomenon of pseudo regression. E-views provides two types of panel co-integration test methods: one is the panel co-integration test based on the Engle-Granger two-step method. This method mainly includes the Pedroni test and Kao test. The other type is the panel co-integration test based on the Johansen co-integration test. This paper adopts the widely-used Kao test panel co-integration test method. As can be seen from the test results, the co-integration test statistics of the rural system and each subsystem model all pass the test at confidence levels of 5% and 1% (Table 3).

3.2. Evolution characteristics of urbanization and rural development levels

From 2001 to 2013, China witnessed rapid urbanization, with an annual growth rate of more than 1%. The annual growth rate of land urbanization during this period was far greater than that of population and economic urbanization. The rate of increase of land urbanization moved from 0.25% to 0.49%, while the population urbanization rate increased from 37.66% to 53.73%, and the economic urbanization rate rose from 86.01% to 90.71% (Fig. 2a). China's urbanization and its population, economic and land subsystem index increased steadily during this timeframe. However, the rural development index

Table 2
Panel unit root test results.

	Variable	LLC	IPS	ADF-Fisher	PP-Fisher
Levels	UI	−33.162***	−11.5477***	1524.43***	1714.78***
	RI	45.98	54.42	144.15	157.46
	LU	−15.4197***	−19.4409***	1814.6***	2267.99***
	EU	−44.7758***	−15.5368***	1625.4***	2068.13***
	PU	−15.4197***	−19.4409***	1814.6***	2267.99***
	AP	−8.50236***	−1.69762***	1223.76***	1109.23***
	RL	26.34	47.53	135.24	207.29
	EE	−33.8502***	−9.69936**	1291.34***	1296.38***
First differences	Variable	LLC	IPS	ADF-Fisher	PP-Fisher
	UI	−95.3673***	−52.844***	3400.87***	3853.81***
	RI	−46.3839***	−30.3936***	2385.04***	2830.43***
	LU	−64.4625***	−60.7128***	3516.00***	4593.30***
	EU	−62.5188***	−44.4851***	3220.47***	4016.29***
	PU	−118.586***	−56.7784***	3368.23***	3563.72***
	AP	−76.7593***	−57.9056***	4049.57***	5212.77***
	RL	−62.5266***	−42.6654***	3079.38***	3450.01***
	EE	−101.815***	−41.3334***	2688.31***	3219.98***

Note: The null hypothesis of the LLC, IPS, Fisher-ADF and Fisher PP tests examines non-stationary; ***, ** and * indicate statistical significance at the 1%, 5% and 10% significance levels, respectively.

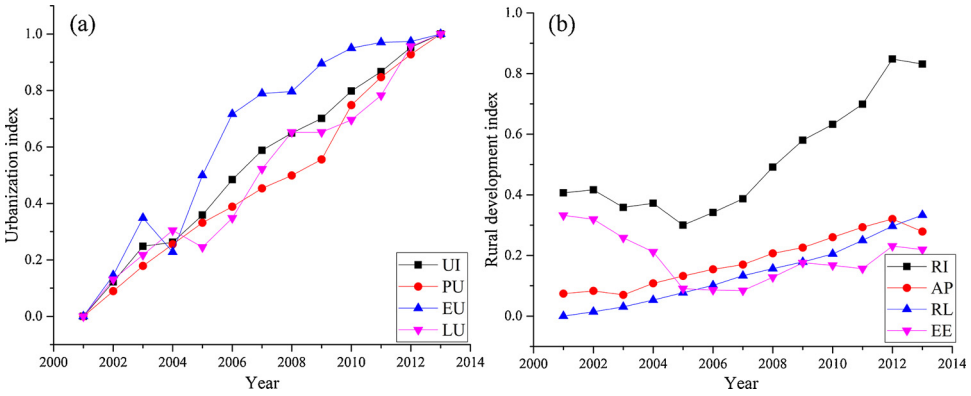

Fig. 2. Evolution characteristics of urbanization and rural development system from 2001 to 2013. Note: UI means urbanization index; RI means rural development index; PU, EU and LU mean population, economic and land urbanization, respectively; AP, RL and EE mean agricultural production, rural living and ecological environment index, respectively. These terms are similar in Figs. 2–6.

experienced a declining trend during the 2001 to 2005 period (Fig. 2b). This was followed by a steadily increasing trend, which eventually peaked in 2012. In terms of the rural development subsystem, the agricultural production and rural living index maintained a steady upward trend from 2001 to 2013. Meanwhile, the rural ecological subsystem decreased sharply from 2001 to 2005 and then slowly increased. As a general rule, China's urbanization has always maintained rapid progress, and the level of rural development has also shown a general, overall upward trend. On the other hand, the rapid progress of urbanization has also polluted the rural water, soil, air and other resources to a certain extent, thus causing damage to the ecological environment.

3.3. Effect of land-centered urbanization on rural development

The coefficient of urbanization for rural development in most areas is greater than 0, indicating that urbanization has a certain promoting effect on rural development. With any improvement in rural development levels, the positive effect of urbanization is gradually enhanced. In addition, the coefficient of land urbanization for rural development is mainly distributed between 0 and 1, which belongs to the stage of diminishing effect. The elasticity coefficient of land urbanization on rural areas is relatively concentrated, while the coefficient of economic and population urbanization is relatively dispersed. According to the spatial distribution results, the areas with coefficients greater than 1 are mainly distributed in southern China, the middle-lower Yangtze Plain and the northeast China Plain (Fig. 3a). These areas have high levels of urbanization and are experiencing rapid development. This can increase rural supply demand and provide an adequate material basis for rural development. In most other regions, the coefficient of elasticity is between 0 and 1, which indicates a stage of decreasing scale. This shows that national urbanization and rural development have gradually entered the transformation stage, moving from focusing on the priority of the development of quantity to focusing on the double improvements of quality and quantity.

As for the urbanization subsystem, the population urbanization coefficient is mainly distributed between 0 and 1 (Fig. 3b). The regions are mainly distributed in the Huang-Huai-Hai Plain, Loess Plateau, Yunnan-Guizhou Plateau, the Sichuan Basin and surrounding regions. With the background of rapid urbanization, the rural population in these areas has rapidly moved to urban areas, obtaining better employment opportunities and higher incomes. The coefficient of economic urbanization is mainly above 0, mainly distributed in the central and eastern plains (Fig. 3c). The effect of non-agricultural industries on rural systems is mainly positive. However, in some regions, the coefficient of subsystems is less than 0; these areas are mainly distributed in the Qinghai Tibet Plateau and the northern arid and semi-arid regions. This may be due to the poor natural resource conditions and lack of infrastructure. With the development of economic urbanization, large numbers of rural people move to cities, leading to a waste of land and grain, as well as the obvious weakening of the rural subject. Therefore, urbanization in these areas has a negative effect on rural development. The elasticity coefficient of land urbanization for rural development is mainly distributed between 0 and 1, which belongs to the stage of diminishing effect (Fig. 3d). The effect of land urbanization on rural development is less affected by population and economic urbanization, and has less effect on rural development.

3.4. Effects of urbanization subsystem on rural development

3.4.1. Population urbanization

Areas with a population urbanization coefficient of greater than 0 on agricultural production systems are mainly distributed in the vast traditional agricultural areas and southeast coastal areas (Fig. 4a). With the rapid development of urbanization, a larger proportion of the rural labor force has shifted to urban areas, and the demand for crops in urban areas has gradually increased. In addition, the level and standard of agricultural science and technology have been continuously developed. As a result, the arable land area per capita continues to increase, the investment in agricultural mechanization continues to increase, and per capita food production also increases, thus greatly promoting agricultural development. The elasticity coefficient of population urbanization on rural living systems is mainly above 0, indicating that population urbanization has a positive effect on rural life (Fig. 4b). With the background of urbanization, the massive construction of infrastructure and the increase in per capita disposable income have all greatly improved farmers' living standards. The coefficient of population urbanization on rural ecological subsystems is mainly distributed below 0 (Fig. 4c). Due to the increase in the level of urbanization, the corresponding levels of the application of industrial wastewater, waste gas and chemical fertilizers also continues to increase, which has a significant effect on the quality of the rural ecological environment.

3.4.2. Economic urbanization

The results show that economic urbanization in the Huang-Huai-Hai Plain, middle-lower Yangtze Plain and in southern China has a positive effect on the agricultural production system, while the economically underdeveloped regions in the central and western regions experience a negative effect (Fig. 5a). The output value of non-agricultural industries in economically developed regions is relatively high. Labor-intensive industries (such as manufacturing and service industries) provide a large number of non-agricultural employment opportunities, which attract the majority of the rural population and their capital to be transferred to cities. The labor force per unit area of rural cultivated land has also increased significantly. The rapid development of the economy has also enabled increased funding for farmers, agricultural technology and machinery to be allocated in rural areas (Fig. 5b). This, in turn, has led to an increase in the mechanization level of rural units, an extensive use of agricultural technology, and more efficient agricultural production. For areas with limited cultivated land resources,

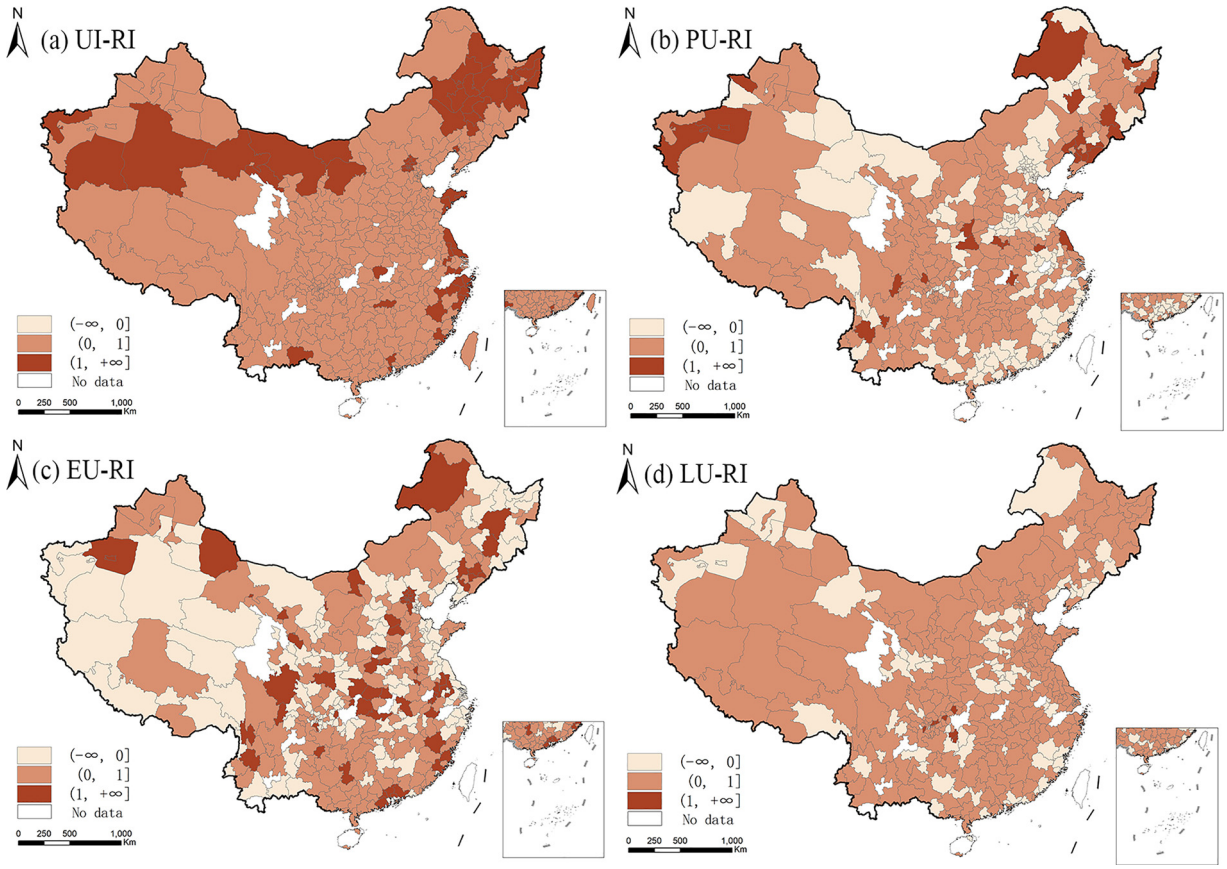

Fig. 3. Effects of urbanization and its subsystems on rural development systems.

such as the southwestern region and the central mountainous area, the non-agricultural industry occupies a large amount of available cultivated land resources. This causes the economic urbanization rate to negatively affect the agricultural production system. In terms of the rural ecosystem, the area where economic urbanization has a positive effect is mainly the southwest region (Fig. 5c). This is mainly due to the relatively small amounts of agricultural fertilizer being applied and low levels of waste water discharge in the region.

3.4.3. Land urbanization

The urbanization of China's first-tier developed cities, such as those in the Huang-Huai-Hai Plain, middle-lower Yangtze Plain and in southern China, has a negative effect on the agricultural production system (Fig. 6a). The main manifestation is that the occupation of cultivated land resources reduces the per capita cultivated land area and per capita grain output. The scale of urban construction land in these areas has been continuously expanded, occupying an ever-increasing amount of cultivated land resources. Areas where land urbanization has a negative effect on rural living are mainly located in the central plains area, as these areas are the main grain producing areas (Fig. 6b). Land urbanization in developed areas has a positive effect on the rural living system. The rural labor force is attracted to the city in large numbers, and the wage level is much higher than for work involving agricultural cultivation. As such, the farmers' income increases. At the same time, an improvement in the urbanization level has a significant corresponding effect on the improvement of rural infrastructure and public service facilities, bringing more convenience to farmers' lives.

3.5. Analysis of urbanization and rural development indicators

The effect of urbanization on rural systems is complex, multi-dimensional and regional. Therefore, it is necessary to return to the factor level to analyze the effect of urbanization on the various elements of rural systems. According to the relevant analysis results in Table 4, this study finds that the influences of urbanization on agricultural production, rural living and rural ecology are significantly different. Population, economic and land urbanization all have significant positive effects on the total power of agricultural mechanization and the living standard of farmers. However, these same factors

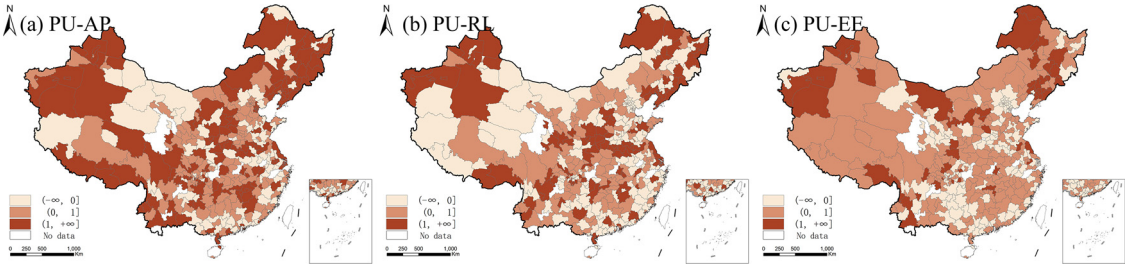

Fig. 4. Effect of population urbanization on rural development subsystems.

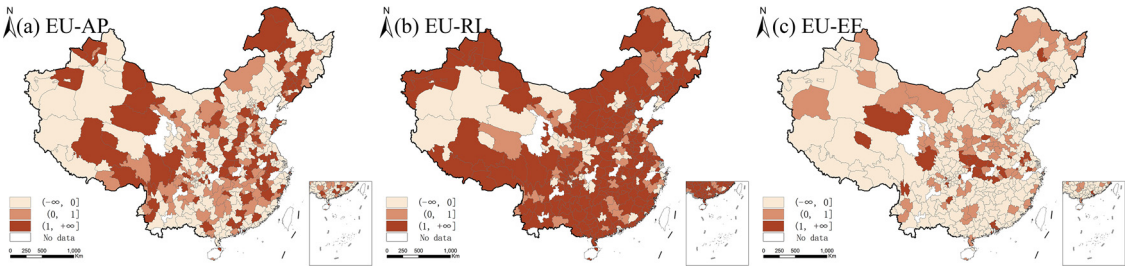

Fig. 5. Effect of economic urbanization on rural development subsystem.

have significant negative effects on per capita arable land area, per capita grain output and rural ecological indicators. Therefore, it can be inferred that an urbanization system has a negative effect on labor and land factors in agricultural production systems, while it has a positive effect on technical factors. At the same time, an urbanization system has a negative effect on material factors (such as grain yield in farm living systems), and a significant positive effect on per capita farmers' incomes and agricultural output value.

4. Discussion

4.1. Spatial pattern of the effect of urbanization on rural development

China is a country with a vast territory and diverse geographical types, and the levels of urbanization and rural development in different regions are quite different. Therefore, the effect of urbanization on rural development is also quite different. Generally speaking, areas with a developed economy and a high urbanization level have relatively high agricultural production and higher living standards for farmers, as urbanization has a positive effect on the development of agriculture and rural areas (Chen and Song, 2014). For example, the elasticity coefficient in the Huang-Huai-Hai Plain, middle-lower Yangtze Plain, in southern China and in some mineral and tourism regions is greater than 1. This indicates that the effect of urbanization on rural development is increasing in scale. In these areas, urbanization has been transformed from land-centered urbanization to people-oriented urbanization, which greatly improves the living standards of farmers and promotes the development of agriculture and rural areas by transferring labor, bringing agricultural science and technology to the countryside and improving the ecological environment (Chen et al., 2016). However, in areas with less-developed economies, such as the broad plains of the Midwest hilly region and the northeast plain region, the elastic coefficient is mainly between 0 and 1. This indicates that the effect of urbanization on rural development is decreasing in scale. These areas are still in the land urbanization stage, which has created some economic and social benefits but which has also created many adverse impacts (Lynch, 2005). For the poor mountainous areas in the central and western regions, urbanization has a relatively low effect on the promotion of agriculture and rural areas. This may be due to the siphon effect of urbanization, whereby rural labor, capital, land and other resource elements are transferred to cities, which in turn makes the level of rural development relatively poor.

For the urbanization subsystem, the average annual growth rate of land urbanization is far higher than that of population and economic urbanization, while the speed of non-agricultural employment transfer is much slower than that of land urbanization. This dynamic is causing social problems for farmers who have lost their land. In addition, population urbanization leads to a large outflow of rural labor force, rural land transfer and improvement of agricultural mechanization (Li et al., 2014a). As a result of economic urbanization, traditional agricultural production has been gradually replaced by new agricultural development models, such as organic agriculture, circular agriculture and leisure agriculture. Land urbanization leads to a decrease in cultivated land resources and a corresponding decrease in per capita cultivated land possession. At the same time, land urbanization also promotes the increase of rural residents' incomes (Li et al., 2015). Succinctly put, the effect of population, economic and land urbanization on agricultural and rural development in different regions presents different patterns (Long et al., 2009).

4.2. The influence mechanism of urbanization on rural development

Urbanization is an inevitable trend of economic and social development, and an important indicator of industrialization and modernization (Li et al., 2014b). Actively promoting urbanization is one of the basic ways used to build a well-off society in an all-round way, as well as a means to solve China's unique problems concerning agriculture, rural areas and farmers (Chen et al., 2018). Since the start of the new century, China's rural areas have developed rapidly, and the agricultural production and living standards of farmers have also been greatly improved. The rapid development of land-centered urbanization, on the whole, has greatly boosted agricultural progress and rural development (Fig. 7). Firstly, population urbanization transforms a large number of suppliers of agricultural products into consumers, which is conducive to increasing farmers' incomes (Liu et al., 2014). Meanwhile, the large amount of consumption demand brought about by urbanization stimulates the development of relevant industries in rural areas and provides opportunities for the development of second and third industries in rural areas (Liu et al., 2010; Long et al., 2010). Secondly, urbanization is conducive to improving agricultural labor productivity. The reduction in numbers of the rural labor force and the increase of rural per capita arable land are conducive to the formation

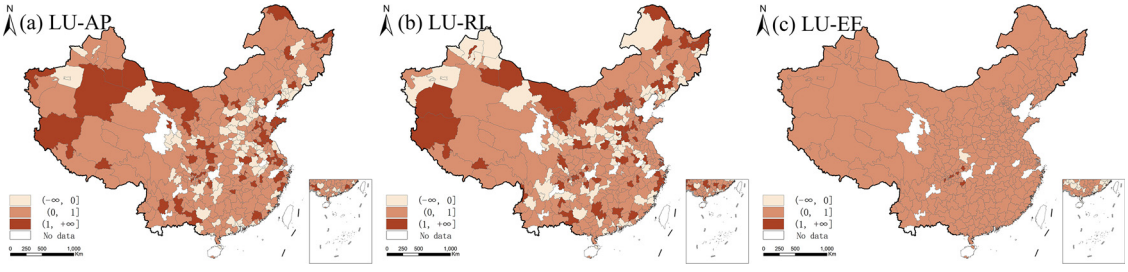

Fig. 6. Effect of land urbanization on rural development subsystem.

Table 4
Correlation analysis of urbanization and rural development indicators.

Primary indicators	Secondary indicators	Population urbanization	Economic urbanization	Land urbanization
Agricultural production	Per capita arable land area	−0.079**	−0.367**	−0.297**
	Total power of agricultural mechanization	0.035**	0.089**	0.026*
	Per capita grain output	−0.222**	−0.412**	−0.359**
Rural living	The per capita net income of farmers	0.592**	0.522**	0.692**
	Rural per capita electricity consumption	0.421**	0.26**	0.561**
	Rural per capita housing area	0.277**	0.43**	0.436**
Ecological environment	Amount of fertilizer applied	0.002*	−0.011**	0.000
	Industrial wastewater discharge	−0.428**	−0.404**	−0.655**
	Industrial sulfur dioxide emission	−0.512**	−0.52**	−0.674**

Note: *Correlation significant at p < 0 05; **correlation significant at p < 0 01.

of large-scale production and the improvement of the mechanization rate (Chen et al., 2013; Seuneke et al., 2013). Additionally, the innovation of technology, products and management methods in cities and towns is brought to the countryside through enterprises, governments, and returning migrant workers, thus increasing the labor productivity of agriculture. Thirdly, urbanization is conducive to changing the income structure of rural areas. The proportion of farmers' property income is increasing through the transformation of land circulation and other mechanisms (Li and Fan, 2010). In terms of the stage of urbanization, the impact of urbanization on rural development in the initial integration stage of urban and rural systems is mainly dominated by the rapid non-agricultural transformation of rural elements. This is manifested as factor agglomeration in most areas, and the polarization effect is greater than the diffusion effect (Ma et al., 2019). However, in the high-level stage of the interactive development of urban and rural systems, the factor flow between urban and rural areas of different levels is accelerated, and the diffusion effect of urbanization on rural development begins to emerge (Liu et al., 2018).

4.3. Implications for strategy of new-type urbanization and rural revitalization

During the process of traditional urbanization in China, cities have long been at the core of growth. Production factors are being concentrated into cities, as rural areas are inferior to cities in terms of human resources, infrastructure, and capital investment environment (Gao et al., 2017). However, China's current urbanization has not yet reached the stage of spontaneously promoting the development of agriculture and rural areas. As such, various “rural disease” problems have become increasingly serious (Liu et al., 2015b; Zhou et al., 2015). Therefore, the sustainable development of rural areas cannot separate the relationship between rural and urban areas. With the background of the new economic normal, a new-type urbanization strategy, one with an emphasis on improving the quality of urbanization and people's well-being, has emerged, as required by the times. The new strategy mainly includes four aspects: people-oriented urbanization, urban and rural shared interests, sustainable development, and harmony and coordination. New-type urbanization is the sublation of traditional urbanization, absorbing the essence and advantages of traditional urbanization, such as giving full play to the macro-control role of the government and paying attention to economic development. On the other hand, new-type urbanization abandons the defects of traditional urbanization, such as the large proportion of land finance and the neglect of the quality of industrial development and human welfare. This new type of urbanization emphasizes putting people first, using the scientific perspective on development as the guide, and focusing on institutional reform and development innovation in the three aspects of "people, land and industry". The implementation of new-type urbanization provides a new development space and element organization platform for rural development, the transformation of urban-rural relations, and the creation of conditions for solving urban-rural problems in the traditional urbanization process (Terluin, 2003).

In addition, China is a vast country, with different conditions for regional development. The differences in natural conditions in the eastern, central, western and northeastern regions, as well as in urban and rural spatial patterns in various regions, determine the complex diversity of rural development. In view of the different types of regions, attention should be paid to the implementation of differentiated new urbanization and rural development strategies. In the urban agglomeration areas along the southeast coast, efforts should be made to strengthen the cultivation of rural industries, promote the comprehensive treatment of urban and rural environment, and implement the new urbanization mode characterized by the integration of urban and rural development. In major grain-producing areas, emphasis should be placed on promoting a new urbanization mode, one which is dominated by central towns and new communities through institutional innovation. The basic premise should be one of not sacrificing farmland and of guaranteeing farmers' land rights and interests. In the mountainous and

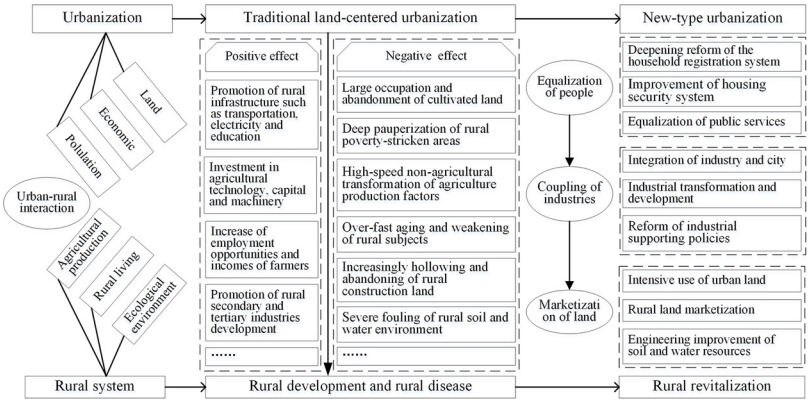

Fig. 7. The influence mechanism of urbanization on rural development.

hilly areas of western China, efforts should be made to implement the urbanization mode suitable for mountainous areas. Here, the basic premise should be one of ecological construction and geological disaster protection, as well as the constraints of the comprehensive bearing capacity of resources and the environment.

Moreover, rural revitalization is a long-term and complicated systematic project. The core of rural revitalization in the new era lies in the primary strategy of accelerating rural transformation and urban-rural integration development, as well as focusing on activating the vitality and endogenous driving forces of the rural population, land, industry and other factors. The ultimate aim should be to improve the sustainable development ability of rural systems. The basic direction of optimizing urban-rural relationships and realizing rural sustainable development should be a path from urban-rural overall planning and urban-rural integration to urban-rural integration and urban-rural equivalence. In the face of the increasingly serious "rural disease" problem, the simultaneous promotion of urbanization and the village-town "two-wheel drive" policy has become the fundamental core of rural revitalization. Only by equalizing urban and rural development strategies, balancing resources and integrating markets can we truly stimulate the vitality and impetus of rural elements, enhance rural development capacity and competitiveness, and then establish and improve the long-term rural revitalization mechanisms and systems. Furthermore, in response to the increasingly severe “village disease” problem, the full implementation of new-type urbanization and rural revitalization is not only a major strategy to promote urban-rural integration and sustainable rural development, but it is also an inevitable requirement for creating and maintaining a comprehensively well-off society.

5. Conclusion

Using the extended Cobb-Douglas model, based on the panel data of 298 cities in China from 2001 to 2013, this study measures the effect of urbanization on rural development, and analyzes urbanization’s spatial pattern characteristics. The results show that urbanization had a certain nationwide promoting effect on rural development in the early 21 st century. China is a vast country, and the effect of urbanization on rural development has significant regional, stage and particularity characteristics. The promotion effect of urbanization on rural development increases with the improvement in rural systems, but the relationship with the urbanization system is not obvious. The effect of land urbanization on rural development gradually weakens with corresponding improvements in urbanization and rural development. The positive effect of population urbanization on rural development is obvious, and the negative effect of economic urbanization on rural development is also obvious.

In terms of the spatial distribution of influence effects, urbanization has strong regionalism and particularity for rural development. Generally speaking, in economically developed regions (such as the southeast coastal areas), the urbanization system often plays a stronger role in promoting rural development. This is due to the higher quality of urbanization and the greater emphasis on people-oriented urbanization. However, the elasticity coefficient of the urbanization system in the underdeveloped central and western regions is often relatively low. This is due to the lower quality of land urbanization and poor resource endowment in these regions. Additionally, urbanization mainly includes population urbanization, economic urbanization and land urbanization, and the effects of these types of urbanization on rural development typically show characteristics of stage and spatial difference. The effect of economic urbanization on rural development is the most obvious and is mainly distributed in the southeastern coastal areas and plain agricultural areas. Meanwhile, the effect of land urbanization and population urbanization is mostly one of diminishing scale.

Furthermore, the findings support the argument that it is difficult to achieve the integration of urban and rural areas by relying solely on urbanization. In general, urbanization plays a significant role in promoting rural development. However, China's current urbanization development has not yet reached the stage of the spontaneous promotion of agricultural and rural development. Also, the problem of “rural diseases” is becoming increasingly serious. Due to China's special geographical conditions, economic foundation and institutional arrangements, the effects of urbanization on rural development are complex, phased and regional. This situation requires not only an in-depth discussion of the historical impact, intensity and mechanism of traditional urbanization on rural development, but also an exploration of how to build a new urban-rural relationship with Chinese characteristics and promote the creation of a new pattern of urban-rural development integration. This is of great theoretical and practical significance to the implementation of China's new urbanization strategy, rural revitalization strategy and further deepening reform and innovation of the urban-rural integration development mechanism in the new era.

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