

Research on the Interaction Measurement Method of Urbanization and Greenization

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Abstract. This paper directed the limitation of the research on the interaction between urbanization and greenization, constructed an interaction measurement method of urbanization and greenization based on the coupling theory in physics; and gave an empirical test and analysis on the support of Chinese provincial regional data for the year 2014. Study results confirms: the urbanization and greenization comprehensive development indicator of this paper constructed can accurately reflect the comprehensive development of China's urbanization and greenization; and the interaction measurement method of urbanization and greenization of this paper constructed is a scientific and comprehensive measurement method of coinciding the idea of sustainable development. The method has considerable significance theoretical innovation and practical application, can measure and analyz availably the interaction between urbanization and greenization, provide decision references and theory supports for a nation or a region to develop the green economy, build green city, realize sustainable development.

Keywords: urbanization; greenization; coupling coordination degree; sustainable development; green city.

1. Introduction

Urbanization is a necessary stage for all countries around the world to realize the process of modernization. With the rapid development of industrialization, the urbanization process has been rapidly developed since the industrial revolution. In the process of urbanization, a series of ecological environmental problems have been produced, and how to promote the interaction development of urbanization and greenization is the problem that every country needs to face. But the research about the greenization has just begun, and the research about the interaction and coordination development of urbanization and greenization is very little, it is difficult to guide the formation of practice. Therefore, it has a significant theoretical and practical significance to research theory and practice of the interaction of urbanization and greenization, for human society to create green city, and to realize sustainable development finally. Based on the above considerations, this paper constructed an interaction measuring method of urbanization and greenization based on the coupling theory in physics; and gave an empirical test and analysis on the support of Chinese provincial regional data for the year 2014.

2. The related research review

2.1 The literatures review of related problems

The related literatures review of urbanization and greenization are as follows. Lin and Liu studied influence factors of carbon emission during the urbanization of China, and gave the suggestion of reducing carbon emissions [1]. At present, the concept of green growth with the highest citation rate is given by OECD [2]. Campiglio [3] explored green growth in the service industry. Mathews and Reinert [4] researched the role of renewable energy, clean technology and resource recycling systems on the green economy. Jakob and Edenhofer [5] considered green growth is the economic growth model of enhancing "social welfare" and "human happiness". Dercon [6] studied the role of green

growth on climate change and aiding poor countries. McKendry and Janos [7] discussed green growth and sustainable development of industrial cities in developed countries. Feng etc. [8] explored the concept of greenization. Ding etc. [9] give a general introduction on progress of coordinated development of industrialization, urbanization, agricultural modernization, informationization, and greenization in China, and other literatures, etc.

2.2 Limitations of existing research

- (1)The research on the urbanization needs to be further deepened at home and abroad.
- (2)The research on the greenization is at the initial stage, and the research is not deep enough, and the research has not formed theoretical system.
- (3)The interaction research of urbanization and greenization is less, and it is difficult to guide the practice.

3. Interaction measuring method of urbanization and greenization

This paper directed the limitation of the research on the interaction between urbanization and greenization, constructed an interaction measurement method of urbanization and greenization based on the coupling theory in physics.

3.1 Interaction measurement indicators system of urbanization and greenization

This paper constructed an interaction measurement indicator of urbanization and greenization, Table 1 is the measurement indicators system. In this paper, we use the factor analysis method to synthesize 5 indicators (proportion of urban population etc.) into urbanization comprehensive index. Similarly, we use the factor analysis method to synthesize 5 indicators (renewable energy power generation ratio etc.) into greenization comprehensive index.

Table 1 Interaction measurement indicators system of urbanization and greenization

	Urbanization and greenization	Evaluation indicator	Concrete representation
Interaction degree of urbanization and greenization	Urbanization comprehensive index	Proportion of urban population	Urban population /total population (ratio)
		Urban employment population accounts for the proportion of total employed population	The number of urban employed population/total employed population (ratio)
		proportion of non-agricultural industry	Second and third industry added value/GDP(ratio)
		Engel coefficient of urban residents	Residents food expenditure gross/total personal consumption expenditure (ratio)
		Per capita disposable income of urban residents	(yuan/person)
	Greenization comprehensive index	Renewable energy power generation ratio	Renewable energy power generation accounts for the proportion of total energy power generation (percentage)
		Per capita sulfur dioxide emissions	Annual average sulfur dioxide emissions per capita(ton/person)
		Investment proportion of environmental pollution government	Environmental pollution government investment accounted for GDP (percentage)
		GDP energy intensity	Ten thousand yuan GDP energy consumption(tons of standard coal)
		Forest coverage	Regional annual average forest coverage (percentage)

3.2 Coupling degree model and coupling coordination degree model

In this paper, the coupling theory of physics subject is introduced, which is used to explore the interaction degree measurement of urbanization and greenization. The model of coupling theory used in this paper is as follows.

3.2.1 Coupling degree model

Coupling degree model of physics subject is as follows:

$$C_n = \left\{ \frac{(U_1 \times U_2 \times \dots \times U_n)}{\prod(U_i + U_j)} \right\}^{1/n} \quad (1)$$

In the above formula, U_1, U_2, \dots, U_n represent n systems, C_n represent Coupling degrees of the n systems.

There are two systems (urbanization and greenization) in this paper, so, the coupling degree of the two systems is as follows:

$$C = C_2 = \left\{ \frac{(U_1 \times U_2)}{(U_1 + U_2)^2} \right\}^{1/2} \quad (2)$$

In the above formula, U_1 represent urbanization comprehensive index, and U_2 represent greenization comprehensive index, and C_2 represent coupling degree index C of the two systems, $0 \leq C < 1$.

3.2.2 Coupling coordination degree model

Coupling degree index C express two system coupling degree, but it can't reflect the actual interaction and coordination degree of the two systems. Therefore, we need to introduce coupling coordination index D to measure the degree of interaction between the two systems.

$$D = \sqrt{C \times T} \quad (3)$$

$$T = \alpha u_1 + \beta u_2 \quad (4)$$

Among them, D represent coupling coordination index, expresses the degree of interaction of the systems. T represent comprehensive evaluation index of two systems, reflect the overall efficiency of the two systems. α and β represent undetermined coefficients. Generally speaking, we think that urbanization and greenization are equally important. So, α and β values are the same, both are 0.5.

3.3 Interactive degree measurement standard of urbanization and greenization

Coupling coordination index D is the indicator which measures the degree of interaction and coordination between urbanization and greenization, the measuring standard is in Table 2.

Table 2 Interactive degree measurement standard of urbanization and greenization

Interactive development phase	Coupling coordination degree of D value	Interaction type	Interactive development phase	Coupling coordination degree of D value	Interaction type
Low level interaction: very little contact	0.0000-0.0999	Extreme lack of interaction	Strengthen interaction: running in contact	0.5000-0.5999	Reluctant interaction
	0.1000-0.1999	Serious lack of interaction		0.6000-0.6999	Primary interaction
	0.2000-0.2999	Moderate lack of interaction		0.7000-0.7999	Intermediate interaction
Start interaction: contend with each other	0.3000-0.3999	Slight lack of interaction	High level interaction: fusion and symbiosis	0.8000-0.8999	Good interaction
	0.4000-0.4999	On the verge of lack of interaction		0.9000-1.0000	High quality interaction

4. Measurement and analysis of the interactive degree of China's urbanization and greenization

Specific data of each indicator which is showed in table 1, of interactive measurement between China's urbanization and greenization in 2014, is derived from *China Statistical Yearbook (2015)*, Statistical Yearbook of Chinese various provincial regions in the year 2015, *China economic information network statistics database*, CNKI “*Statistical database of China's economic and social development*”, People's Republic of China “*national statistical database*” and other relevant statistical data. According to the interaction measurement method of urbanization and greenization presented above, we got interactive degree measurement results of China's urbanization and greenization in 2014, the results are shown in table 3.

Table 3 Interactive degree measurement results of urbanization and greenization of Chinese provincial regions in 2014

Geographical district	Provincial region	Coupling degree index C	Comprehensive evaluation index T	Coupling coordination index D	Interactive degree measurement
North China	Beijing	0.4975	0.8924	0.6663	Primary interaction
	Tianjin	0.4961	0.8761	0.6593	Primary interaction
	Hebei	0.4513	0.7483	0.5811	Reluctant interaction
	Shanxi	0.4452	0.6142	0.5229	Reluctant interaction
	Inner Mongolia	0.4480	0.6259	0.5295	Reluctant interaction
Northeast China	Heilongjiang	0.4741	0.7328	0.5894	Reluctant interaction
	Jilin	0.4763	0.7695	0.6054	Primary interaction
	Liaoning	0.4862	0.8147	0.6294	Primary interaction
East China	Shanghai	0.4993	0.8973	0.6693	Primary interaction
	Jiangsu	0.4918	0.8560	0.6488	Primary interaction
	Zhejiang	0.4926	0.8592	0.6506	Primary interaction
	Anhui	0.4825	0.6534	0.5615	Reluctant interaction
	Fujian	0.4894	0.8429	0.6423	Primary interaction
	Shandong	0.4870	0.8365	0.6383	Primary interaction
	Jiangxi	0.4857	0.6791	0.5743	Reluctant interaction
Central China	Henan	0.4782	0.6974	0.5775	Reluctant interaction
	Hubei	0.4671	0.7582	0.5951	Reluctant interaction
	Hunan	0.4758	0.7146	0.5831	Reluctant interaction
South China	Guangdong	0.4932	0.8631	0.6524	Primary interaction
	Guangxi	0.4815	0.6328	0.5520	Reluctant interaction
	Hainan	0.4839	0.7224	0.5912	Reluctant interaction
Southwest China	Chongqing	0.4791	0.7819	0.6121	Primary interaction
	Sichuan	0.4653	0.6835	0.5639	Reluctant interaction
	Guizhou	0.4475	0.5626	0.5018	Reluctant interaction
	Yunnan	0.4592	0.5942	0.5224	Reluctant interaction
	Tibet	0.3991	0.5294	0.4597	On the verge of lack of interaction
Northwest China	Shaanxi	0.4778	0.7610	0.6030	Primary interaction
	Gansu	0.4294	0.4835	0.4556	On the verge of lack of interaction
	Qinghai	0.4317	0.5491	0.4869	On the verge of lack of interaction
	Ningxia	0.3972	0.4927	0.4424	On the verge of lack of interaction
	Xinjiang	0.4381	0.5748	0.5018	Reluctant interaction

The data in table 3 are analysed as follows. In the interactive degree of China's provincial regional urbanization and greenization in 2014, Shanghai, Beijing, Tianjin, Guangdong, Zhejiang, Jiangsu, Fujian, Shandong, Liaoning, Chongqing, Jilin, Shaanxi belong to the primary interaction. Hubei, Hainan, Heilongjiang, Hebei, Hunan, Henan, Jiangxi, Sichuan, Anhui, Guangxi, Inner Mongolia, Shanxi, Yunnan, Guizhou, Xinjiang belong to reluctant interaction. Qinghai, Tibet, Gansu, Ningxia belong to on the verge of lack of interaction. Overall, there are interactions in China's provincial regional urbanization and greenization in 2014, but the degree and level of interaction is not high. The interactive degree of urbanization and greenization is determined by the comprehensive factors, and generally speaking, the developed region of economy, science and technology, social development, urbanization degree, green economy, the interaction between urbanization and greenization is relatively high. At present, the urbanization and greenization strategy which is implemented in China's national level, is an opportunity for the China's provincial region. Every province should hold this opportunity, vigorously promote the local area of urbanization and greenization, and promote the interaction between urbanization and greenization; This is a necessary way which is used to narrow

the regional gap, to make China as a whole realize modernization, and to achieve sustainable development.

5. Conclusion

This paper directed the limitation of the research on the interaction between urbanization and greenization, constructed an interaction measurement method of urbanization and greenization based on the coupling theory in physics; and gave an empirical test and analysis on the support of Chinese provincial regional data for the year 2014. Study results confirms: the urbanization and greenization comprehensive development indicator of this paper constructed can accurately reflect the comprehensive development of China's urbanization and greenization; and the interaction measurement method of urbanization and greenization of this paper constructed is a scientific and comprehensive measurement method of coinciding the idea of sustainable development. The method has considerable significance theoretical innovation and practical application, can measure and analyz availably the interaction between urbanization and greenization, provide decision references and theory supports for a nation or a region to develop the green economy, build green city, realize sustainable development.

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