Evaluation and Policy Optimization of Inclusive Green Growth of City Clusters Along the Middle Reaches of the Yangtze River

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Abstract: Under the background of the transformation of the main social contradictions and the new stage of improving the quality and efficiency of the economy, it is of great significance for the regional high-quality development to promote the inclusive green growth of city clusters along the middle reaches of the Yangtze River. Based on SBM-Malmquist-Luenberger model, this paper measures the real performance of inclusive green growth of city clusters along the middle reaches of the Yangtze River, and corresponding policy optimization suggestions are put forward.

Keywords: city clusters along the middle reaches of the Yangtze River; inclusive green growth

1. Introduction

The 19 th National Congress of the Communist Party of China held in October 2017 repeatedly stressed the importance of adhering to the harmonious coexistence of economy, society and ecological environment, marking that the construction of socialism with Chinese characteristics has entered a new stage of high-quality development, and the concept of inclusive green growth has gradually risen to the national consensus. However, for a long time, the level of inclusive green growth in urban agglomerations in the middle reaches of the Yangtze River has been greatly different due to imbalances in resource endowments, technical conditions, and economic development levels. At the same time, inclusive green growth among cities has a strong spatial correlation, making it difficult to formulate targeted policy paths. Under the background of the transformation of the main social contradictions and the new stage of improving the quality and efficiency of the economy, the scientific measurement of the inclusive green growth level of the urban agglomeration in the middle reaches of the Yangtze River is of great significance for optimizing the existing development policies and promoting regional inclusive green growth.

The theory of inclusive green growth was proposed at the United Nations Conference on Sustainable Development in 2012 [1]. Subsequently, in order to adapt to the changes of the times and better promote their economic and social development, countries have integrated the idea of " inclusive green growth " and formulated new development strategies, which is a good beginning to actively promote the continuous development of inclusive green growth theory. Although different scholars have put forward different opinions on the connotation of inclusive green growth, there are two views that are generally recognized by the academic community. One is based on the idea of development economics, which is defined as a sustainable growth model with comprehensive and coordinated development of economy, society and environment. Specifically, it is to pursue economic growth while taking into account social inclusion and environmental friendliness [2-3]; the other is to combine the perspective of welfare economics and argue that the foothold of inclusive green growth lies in the enhancement of social development sustainability and the improvement of social welfare [4-6]. By summarizing these two statements, we can see that the essence of inclusive green growth theory is the organic combination of green growth theory and inclusive economic growth theory. Its core goal is to promote the sustainable realization of " three wins " in economy, society and environment. Therefore, inclusive green growth mode is of great significance to solve the problems of unbalanced economic growth, social injustice and resource and environmental constraints.

As the theory of inclusive green growth has attracted worldwide attention, experts and scholars around the world have conducted in-depth research on inclusive green growth. The existing research mainly focuses on two aspects. The first is measurement research. For example, Xu Baoliang et al. established an inclusive green growth evaluation index system from multiple dimensions, and used factor analysis (FA) to measure the comprehensive score of factors to illustrate the dynamic changes of China 's inclusive green growth [7]. Wu Wulin et al. combined qualitative and quantitative analysis methods to screen out evaluation indicators, and used the entropy weight method to quantitatively evaluate China 's inclusive green growth performance from 2000 to 2015

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[8]; the second is the study of influencing factors. Some scholars use spatial panel models and other models to identify the influencing factors of inclusive green growth, and find that the level of scientific and technological innovation, infrastructure level and environmental governance efficiency can effectively promote inclusive green growth [3,9-10].

Most of the existing literature directly measures the level of inclusive green growth by constructing a comprehensive index, which can not fully reflect the changes in the efficiency of economic growth, and there are problems such as one-sidedness and lack of effectiveness. Based on the SBM-Malmquist-Luenberger index, this paper measures the inclusive green growth level of the urban agglomeration in the middle reaches of the Yangtze River, comprehensively evaluates the inclusive green growth status of the urban agglomeration in the middle reaches of the Yangtze River, and helps to evaluate the development status of the urban agglomeration in the middle reaches of the Yangtze River more objectively, so as to put forward targeted policy optimization suggestions to promote regional inclusive green growth.

2. Measure methods and models

2.1 Measurement method of inclusive green growth

In this paper, SBM-Malmquist-Luenberger index is used to measure the inclusive green growth level of urban agglomeration in the middle reaches of the Yangtze River, so as to reflect its changing law more objectively and truly. Drawing on the research results of most experts and scholars, and following the idea of geometric mean of Malmquist productivity index, the SBM-Malmquist-Luenberger index can be divided into technical efficiency change (MLEFFCH) and technological progress change (MLTECH). The basic form can be expressed as follows :

$$ML = (x^{t+1}, y^{t+1}, u^{t+1}; x^t, y^t, u^t) = \left(\frac{\vec{S}_C^t(x^{t+1}, y^{t+1}, u^{t+1})}{\vec{S}_C^t(x^t, y^t, u^t)} \times \frac{\vec{S}_C^{t+1}(x^{t+1}, y^{t+1}, u^{t+1})}{\vec{S}_C^{t+1}(x^t, y^t, u^t)}\right)^{\frac{1}{2}}$$

$$= \frac{\vec{S}_C^{t+1}(x^{t+1}, y^{t+1}, u^{t+1})}{\vec{S}_C^t(x^t, y^t, u^t)} \times \left(\frac{\vec{S}_C^t(x^{t+1}, y^{t+1}, u^{t+1})}{\vec{S}_C^{t+1}(x^{t+1}, y^{t+1}, u^{t+1})} \times \frac{\vec{S}_C^t(x^t, y^t, u^t)}{\vec{S}_C^{t+1}(x^t, y^t, u^t)}\right)^{\frac{1}{2}}$$

$$= MLEFFCH(x^{t+1}, y^{t+1}, u^{t+1}; x^t, y^t, u^t) \times MLTECH(x^{t+1}, y^{t+1}, u^{t+1}; x^t, y^t, u^t)$$

The above formula shows that if ML>1, then it shows that the level of inclusive green growth from t to t+1 is rising, and vice versa ; similarly, its split item>1 indicates that the technology has improved or improved, and vice versa.

2.2 Spatial autocorrelation test

In order to further reveal the spatial differences of inclusive green growth in urban agglomerations in the middle reaches of the Yangtze River, this paper uses Moran's I index and Moran scatter plot to analyze the spatial correlation of inclusive green growth in urban agglomerations in the middle reaches of the Yangtze River from both global and local aspects. The calculation formula of Moran's I index is :

$$Moran\ 'sI = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}\left(X_i - \overline{X}\right)\left(X_j - \overline{X}\right)}{\sum_{i=1}^{n}\left(X_i - \overline{X}\right)^2}$$

In the formula, the total number of observations of variables in the whole study area is represented ; for the city and urban space weight matrix ; if the city and the city are adjacent, then = 1; otherwise, = 0 ; represents the observed values of variables in the city ; represents the observed values of the corresponding variables of the city ; denotes the average number of observations of the same variable for all cities. When the Moran's I index is between-1 and 1, the positive and negative values and the absolute value indicate that the positive and negative values of the spatial correlation of the variables are weaker. If it is used to represent the expected value and variance of the Moran's I index, it represents the total number of research samples, and the statistics are used to test whether the spatial autocorrelation is significant. There are:

$$E(I) = -\frac{1}{n-1}, \quad Z = \frac{I - E(I)}{\sqrt{Var(I)}}$$

In addition, this paper adopts Moran's I scatter plot to test the local autocorrelation of inclusive green growth in urban agglomerations in the middle reaches of the Yangtze River, and further explores the spatial agglomeration rules of cities in urban agglomerations in the middle reaches of the Yangtze River. Among them, the first and third quadrants belong to the spatial positive correlation area, that is, the cities with high (low) observations are surrounded by cities with high (low) observations, while the second and fourth quadrants are spatial negative correlation areas, indicating that cities with low (high) observations are surrounded by cities with high (low) observations.

3. Results

3.1 Data source

This paper selects the urban agglomeration in the middle reaches of the Yangtze River as the research object. The data used are mainly from the China Urban Statistical Yearbook from 2010 to 2021, the statistical yearbooks of relevant provinces (Jiangxi, Hubei, Hunan) over the years and the statistical bulletins of relevant prefecture-level cities from 2009 to 2020.

3.2 Measurement results of inclusive green growth

In terms of time series evolution, it can be seen from table 1 that the inclusive green growth level of the urban agglomeration in the middle reaches of the Yangtze River reached the maximum value in the sample period from 2013 to 2014, but the technological progress was always less than 1 at the end of the period or at the beginning of the period, and the technical efficiency at the end of the period was also lower than that at the beginning of the period. Therefore, the ML index result must be less than 1, which may be that the accelerated deepening of capital

in the urban agglomeration in the middle reaches of the Yangtze River has led to an increase in the ratio of input to output of each city, which in turn has caused the best frontier to sink, resulting in the measurement result of frontier technology regression, which means that the inclusive green growth level of most cities in the urban agglomeration in the middle reaches of the Yangtze River still has a large room for improvement.

In terms of regions, during the sample period, only the inclusive green growth level of Wuhan city circle is greater than 1, and the remaining urban agglomerations are between 0.9-1, indicating that the inclusive green growth level of Wuhan city circle is in an advantageous leading position in the urban agglomerations in the middle reaches of the Yangtze River. The specific analysis found that the inclusive green growth level of the remaining urban agglomerations is generally low mainly because of insufficient technological progress, indicating that technological progress changes play an important role in inclusive green growth ; although changes in technical efficiency can also affect the level of inclusive green growth, the effect is not as significant as the former. Therefore, the region should take effective measures to actively promote technological progress in the future.

Table.1. ML index and its decomposition index of urban agglomeration

Period / Urban agglomeration	ML index	MLEFFCH index	MLTECH index
2009-2010	0.965	1.010	0.953
2010-2011	0.967	0.987	0.979
2011-2012	0.926	1.021	0.910
2012-2013	1.041	1.004	1.043
2013-2014	1.114	0.969	1.154
2014-2015	0.997	1.003	0.995
2015-2016	0.931	0.995	0.936
2016-2017	1.006	1.006	1.003
2017-2018	0.992	1.046	0.957
2018-2019	0.999	0.995	1.005
2019-2020	0.952	0.966	0.993
Mean	0.990	1.000	0.993
Poyang Lake city group	0.933	1.001	0.933
Wuhan city circle	1.096	1.004	1.093
Chang-Zhu-Tan urban agglomeration	0.942	0.997	0.954
Urban agglomeration in the middle reaches of the Yangtze River	0.994	1.002	0.993

3.3 Spatial autocorrelation analysis

（1）Global autocorrelation analysis. By calculating the Moran's I index of the inclusive green growth level of the urban agglomeration in the middle reaches of the Yangtze River from 2010 to 2020, it can be seen that the Moran's I index from 2010 to 2020 is all greater than 0, and the Moran's I index of other years except 2012 has passed the significance test at different levels (Table 2), indicating that the inclusive green growth of the urban agglomeration in the middle reaches of the Yangtze River basically shows a strong spatial positive correlation, which may be due to the active regional cooperation in the urban agglomeration in the middle reaches of the Yangtze River. The linkage of economic, social and environmental systems in each city is strengthened. With the spillover effect of economy, the level of inclusive green growth in different regions shows a trend of convergence. In addition, the Moran's I index reached its lowest value in 2012, and showed a sharp decline before 2012. After 2012, it fluctuated year by year, and showed a slow decline since 2018. During the whole study period, the global Moran's I index decreased from 0.628 in 2010 to 0.463 in 2020, showing an overall decline, indicating that the regional differences among cities in the urban agglomeration in the middle reaches of the Yangtze River have weakened over time, which may be related to the remarkable achievements of regional coordinated development in recent years.

（2）Local autocorrelation analysis. According to the spatial local distribution of the inclusive green growth level of the urban agglomeration in the middle reaches of the Yangtze River sorted out by the Moran scatter plot, it can be seen that there are two main positive spatial agglomeration forms of inclusive green growth in the urban agglomeration in the middle reaches of the Yangtze River.Among them, in 2018 and 2019, only 4 and 1 of the 28 sample cities fell in the second and fourth quadrants, accounting for 14.3 % and 3.6 % of the total sample, respectively, which means that the number of cities in the first and third quadrants is much larger than that in the other quadrants, which further supports the research conclusion that there is a clear spatial positive correlation between the inclusive green growth of the urban agglomeration in the middle reaches of the Yangtze River.

Table.2. The Moran 's I value and related statistics of IGG in the urban agglomeration in the middle reaches of the Yangtze River and the statistical analysis of the spatial local distribution of IGG in each city.

Year	Moran's I	E	sd	Z	p	First Quadrant	Second Quadrant	Third Quadrant	Fourth Quadrant
2010	0.628	-0.037	0.198	3.354	0.003***	7	2	15	4
2011	0.426	-0.037	0.192	2.418	0.015**	8	4	12	4
201	0.183	-0.	0.	1.	0.127	8	4	12	4

2		037	187	176					
2013	0.407	-0.037	0.198	2.244	0.014**	12	3	10	3
2014	0.294	-0.037	0.200	1.656	0.058*	7	5	10	6
2015	0.436	-0.037	0.193	2.446	0.010***	7	4	13	4
2016	0.235	-0.037	0.190	1.433	0.095*	10	2	12	4
2017	0.234	-0.037	0.187	1.450	0.069*	7	4	13	4
2018	0.515	-0.037	0.178	3.108	0.001***	8	1	16	3
2019	0.497	-0.037	0.185	2.882	0.002***	12	1	15	0
2020	0.463	-0.037	0.191	2.620	0.003***	8	4	12	4

Note: The level of inclusive green growth in 2007 represents the level of inclusive green growth in 2009-2020, and so on in the remaining years; *, * *, * * * are statistically significant at 10 %, 5 % and 1 %, respectively.

4. Conclusion and suggestion

4.1 Conclusion

This paper selects 28 cities in the urban agglomeration in the middle reaches of the Yangtze River from 2009 to 2020 as the research object, measures the real performance of inclusive green growth in the urban agglomeration in the middle reaches of the Yangtze River based on the perspective of total factor productivity, and then carries out specific analysis from two aspects of time series evolution and spatial pattern. At the same time, the spatial correlation is tested by econometric methods. The study finds that: In terms of time series evolution, the level of inclusive green growth in the urban agglomeration in the middle reaches of the Yangtze River generally shows a decreasing trend ; in terms of regions, the inclusive green growth level of Wuhan metropolitan area is in a leading position in the urban agglomeration in the middle reaches of the Yangtze River. In terms of spatial distribution, the inclusive green growth of the urban agglomeration in the middle reaches of the Yangtze River basically shows a positive spatial correlation that weakens with time, and most cities in the urban agglomeration in the middle reaches of the Yangtze River have obvious spatial stability.

4.2 Suggestion

Each region needs to choose the appropriate path according to local conditions. Specifically, urban agglomerations with a high level of inclusive green growth should accelerate the shift of their focus from achieving rapid economic growth to improving the quality of economic growth. Cities should pay attention to the orderly development of internal space, the effective use of energy resources and the comprehensive management of the ecological environment. Combined with regional economic characteristics, they should further take advantage of location, capital, infrastructure and other advantages to promote the quality of economic growth. The regions with medium level of inclusive green growth should fully combine their own characteristics and give full play to the advantages of industrial development. For example, cities such as Pingxiang and Yueyang can fully tap the advantages of natural resources, vigorously develop tourism and related industries, and promote industrial optimization and upgrading. At the same time, cities should strengthen the investment of regional scientific and technological innovation funds to provide financial support for scientific and technological innovation activities ; regions with low levels of inclusive green growth should continue to promote the process of urbanization, and rationally introduce foreign direct investment projects on the basis of protecting, governing and improving the ecological environment. At the same time, cities should give full play to their comparative advantages, accelerate the pace of "going out" and promote the sustained and rapid development of regional economy.

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