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Green innovation performance measurement and international comparison of ceramic industry clusters

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Abstract: Green innovation is considered as an effective way to build a resource-saving and environment-friendly society and improve production efficiency and environmental quality. For China's industrial enterprises, it is a general trend to change from crude production to green and low-carbon production. It is necessary to promote the green development of China's ceramic industry cluster by further improving China's green innovation performance evaluation system.

1. Introduction

1.1 Research background and Significance

The Fifth Plenary Session of the 18th Central Committee has put forward the development concept of "innovation, coordination, green, openness and sharing", and the report of the 19th National Congress points out that China's economic development has shifted from a stage of high-speed growth to a stage of high-quality development. In this paper, we measure the green innovation performance of China's ceramic industry clusters and further analyze the factors influencing green innovation performance as well as its evaluation system so as to further optimize it.

1.2. Research ideas and methods

This question focuses on green innovation performance measurement and constructs an appropriate evaluation system to measure green innovation performance. The first step is to measure the green innovation performance of the eight ceramic industry clusters using the super-efficient DEA model and to conduct an empirical study using Tobit regression model.

2. Literature Review

2.1. Research on green innovation performance

Scholars at home and abroad have conducted a lot of researches on the measurement of green

innovation performance, mainly on the evaluation system and influencing factors of green innovation performance.

2.1.1. Evaluation system of green innovation performance

First, green innovation outcomes are often measured by selecting the number of patent applications received. The number of patents applied by enterprises is used to measure the level of innovation, and the impact of green technological knowledge stock and non-green technological knowledge stock on technological innovation is studied within and outside the region[1].

Second, the green innovation performance of firms was evaluated using principal component analysis. The green technology innovation performance evaluation index system was constructed from four aspects: product design, production process, organization and management, and marketing, and the green innovation capability of enterprises was measured by using factor analysis[2].

Third, based on Tobit regression analysis, the innovation efficiency of each regional industry cluster was measured by measuring the green innovation performance of the Yangtze River Delta city cluster from 2012-2018 using data envelopment analysis-Malmquist index, classifying the clusters according to the efficiency characteristics[3-4].

2.1.2. Regional differences in green innovation development

Both traditional and innovative green development efficiency was highest in the east; innovative green development efficiency was not improved to a greater extent in the central region; and innovative green development efficiency was improved in the west[5].The East is the most efficient in both traditional and innovative green development, followed by the central region and the western region has the lowest[6]. Provincial capitals, first-tier cities and some coastal cities have absolute advantages due to the scale of economic development[7]. The difference in the contribution of each factor to the green innovation efficiency of industrial enterprises shows a weakening trend from east to west[8]. By using the non-expectation Minds model, it is found that there is more room for improvement of green innovation efficiency in each province and region, and the regional differences are obvious[9].

2.2 Research on factors influencing green innovation performance

2.2.1. Internal drivers affecting green innovation performance

The most important aspect of green innovation performance is internal R&D investment, and executive environmental awareness is an important antecedent of the internal resources and capabilities of the organization being used for green innovation[10]. The more advanced the human resource structure of a company, the stronger its ability to innovate or absorb green technology[11]. Green organizational identity influences green innovation performance through environmental organizational legitimacy[12]; green organizational identity influences green innovation performance through green absorptive capacity[13]. Green organizational identity, environmental commitment and sustainable use practices constitute important internal drivers of corporate green innovation performance[14].

2.2.2 External Environmental Factors Affecting Green Innovation Performance

The motivation of firms to innovate green technology is influenced by local government environmental regulations; increased competition forces firms to initiate green innovation activities

to gain market advantage[15-16]. Increased IPR protection positively affects regional green innovation performance[17].

3. Theoretical overview of green innovation performance of ceramic industry clusters

3.1 The concept of green innovation

In 1997, James first introduced the concept of green innovation: first, green innovation is an innovative activity that can reduce the impact on the environment, and second, such activities can bring some value to customers and companies. Sustainability emphasizes intergenerational equity and efficiency issues[18]; green innovation can relieve resource pressure and promote healthy and sustainable economic development[19]. Chinese manufacturing companies urgently need to use green innovation to break through institutional and efficiency dilemmas to achieve sustainable development[20].

3.2. The concept of green innovation performance

In 1995, Terry Fenrick proposed the "3E" evaluation criterion. Economy refers to achieving performance goals; Efficiency refers to achieving a given output with less input or achieving greater output with a given input; Effective Performance refers to the degree to which the output transformed by resource input can achieve the performance goal.

4. Theoretical Analysis and Research Hypothesis of Green Innovation Performance Measurement of Ceramic Industry Clusters

4.1 Sample selection and data sources

The sample of this paper is the data of eight ceramic industry clusters in China from 2011 to 2020, and the original data are obtained from China Statistical Yearbook, China Science and Technology Statistical Yearbook, and China Environmental Statistical Yearbook.

4.2 Research model design

Data envelopment analysis (DEA) uses a linear programming approach. Compared with the traditional CCR and BBC models, which cannot measure the full range of relaxation slack variables, the non-radial, non-angular super-efficient SBM model uses a non-ray-type approach to introduce the slack variables into the objective function, and it can evaluate the efficiency more accurately.

4.3 Analysis of Green Innovation Performance Measurement Results of Ceramic Industry Clusters

Table 1: Green innovation performance of China's ceramic industry cluster from 2016 to 2020.

Ceramic cluster	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Jingdezhen, Jiangxi	0.713	0.796	0.661	1.143	1.046	0.909	1.149	0.938	1.181	0.952
Foshan, Guangdong	0.661	0.732	0.959	1.270	1.223	1.215	1.138	1.008	1.019	1.036
Zibo, Shandong	0.532	0.585	0.604	0.660	0.850	0.872	1.024	0.660	0.742	0.718
Dehua, Fujian	0.528	0.788	0.807	0.900	1.051	1.115	0.915	0.553	0.662	0.825
Liling, Hunan	0.599	0.646	0.709	0.747	0.823	0.826	0.967	0.908	0.792	0.780
Chaozhou,Guangdong	0.716	0.669	0.939	0.935	0.938	0.916	0.924	0.907	0.909	0.878
Tangshan, Hebei	0.459	0.477	0.498	0.748	0.693	1.032	0.872	1.008	1.0573	1.441
Yixing, Jiangsu	0.588	0.533	0.733	0.830	0.366	0.478	0.349	0.423	0.597	0.549

Based on the panel data from 2011 to 2020 in the provinces and cities where my country's ceramic industry clusters are located, this paper uses the super-rate SBM model to measure the green innovation performance of my country's ceramic industry clusters. The results are shown in Table 1:

5. Conclusions

First, from the perspective of the overall industrial enterprise green innovation performance of China's ceramic industry cluster, the overall green innovation performance of China's ceramic industry cluster is at a moderately high level, and there is a significant gap between provinces and regions. Second, Guangdong industry has been positioned in the processing trade link for a long time, resulting in a low innovation conversion efficiency of Guangdong industry, and there is room for further improvement of the innovation conversion efficiency in Guangdong Province.Third, it is necessary to introduce green innovation-related high and new technologies and improve the utilization efficiency, focusing on green innovation resources, while paying attention to the performance of green innovation. Fourth, the government needs to guide the enterprises towards the model of green innovation, support the R&D activities of green innovation technologies, but the government should not interfere excessively in the market, and should adopt reasonable and rational macroeconomic instruments to achieve a win-win situation for economic development and environmental protection.

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