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Green Manufacturing Evaluation of Guangdong and Policy Suggestions

Huashen Cao[1, 2, *]

[1]School of Business, Lingnan Normal University, Guangdong, Zhanjiang, China

[2]Guangdong Coastal Economic Belt Development Research Center, China

Abstract

This paper defines green manufacturing based on the situation of manufacturing industry in Guangdong, and constructs green manufacturing evaluation system from four aspects, thoese are, green input, green emission, green cycle and green performance. Based on the manufacturing data of Guangdong from 2011 to 2020, this paper calculates green manufacturing index by using the entropy method and TOPSIS method, and it is found that the green manufacturing level in western Guangdong is increasing, and the green manufacturing level in the Pearl River Delta (PRD) region is good but has a decreasing trend in recent years. For the cross-sectional comparison based on each Guangdong city in 2020, the green manufacturing of cities in the PRD region mainly comes from the contribution of green emissions, the western Guangdong region mainly comes from green inputs, and the northern Guangdong region mainly comes from green recycling. Last, this paper also provides three main policy suggestions to improve development of green manufacture in Guangdong

Keywords

Green Manufacture; Topsis Method; Entropy Method; Evaluation System.

1. Introduction

At present, although the manufacturing industry in Guangdong maintains a fast growth rate, it also faces problems such as high production cost and pollution, which restrict the further upgrading of the manufacturing industry. Therefore, the manufacturing industry in Guangdong needs to get rid of the rough development of high energy consumption and high pollution as soon as possible, and accelerate the improvement of industrial competitiveness, gradually realize the ecological manufacturing industry, to achieve the harmonious development of economy, society and ecology. Therefore, the exploration of green manufacturing model and mechanism should be carried out in conjunction with the characteristics of Guangdong's economic environment and manufacturing industry, and the guiding policies of green manufacturing should be optimized to promote the effective upgrading of industrialization and ecologization of Guangdong's economy and realize the high-quality development of Guangdong's economy.

Green economy has been widely concerned by scholars in recent years, and the study of green manufacturing is also a topic of interest for scholars. A large number of scholars have carried out research related to green manufacturing from the perspectives of government regulation [1,2], industry competition [3], technological innovation [4,5], and human capital [6,7]. However, the existing results mainly focus on some specific micro factors to study green anufacturing, and seldom carry out research on green manufacturing from the macro-regional perspective. Moreover, the definition and level measurement methods of green manufacturing at home and abroad have not yet been unified, and the development of society has constantly put forward new requirements for the connotation of green manufacturing, which leads to the

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fact that the research on green manufacturing countermeasures often ignores the characteristics of industries in the region and most of the proposed policy recommendations lack operability. Therefore, green manufacturing evaluation methods should be further clarified by combining regional characteristics.

2. Definition of Green Manufacture

Green manufacturing is a modern manufacturing model that takes into account people's needs, environmental impact, resource efficiency and enterprise efficiency, and is a sustainable manufacturing model with social responsibility. The research group of Green Manufacturing Development Strategy Research of Chinese Academy of Engineering defines that green manufacturing is to minimize the impact on the natural environment during the whole life cycle of products from design, manufacturing, use to end-of-life, to be harmless to nature, to maximize the utilization of resources and to minimize energy consumption.

Some scholars integrate the technology and benefit perspective to cognize green manufacturing more comprehensively[8,9,10]. They all point out that green manufacturing is to minimize environmental pollution and energy consumption with the help of various advanced technologies under the premise of guaranteeing product quality and function, so as to achieve coordinated development of economic and social benefits.

In this paper, combined with the green manufacturing development model of Guangdong, this paper believe that green manufacturing is to use green factor inputs (green inputs), focus on energy utilization efficiency and pollution reduction in the production process (pollution emissions), focus on resource recycling (resource cycling), and finally improve the production efficiency of enterprises (green growth)

3. Green Manufacture Evaluation of Guangdong

3.1. Evaluation Framework

Based on the above definition of green manufacturing, this paper selects 15 indicators from four sub-objective levels of green input, pollution emission, resource recycling and green growth to build the evaluation indexes of green manufacturing system and measure the construction level of green manufacturing system of 21 cities in Guangdong (see Table 1).

Green input. Green input is the primary factor for the full implementation of industrial green manufacturing, and its goal is to use new energy-saving and consumption-reducing technologies and new clean production processes to maximize the utilization of traditional energy and reduce the energy consumption of manufacturing production, while increasing the use of clean new energy and reducing the environmental pollution caused by the use of energy in manufacturing production from the source. Specifically, three indicators were selected: the reduction rate of energy consumption of 10,000 yuan added value in manufacturing industry, the proportion of fossil energy consumed in manufacturing industry, and coal consumption per unit of industrial added value. Coal accounts for a relatively large proportion of the total energy consumption, so coal consumption is listed as a separate indicator.

Pollution emission. The goal is to minimize the emission of pollutants through the application of wastewater, waste gas, waste efficient management of new technologies and new equipment. Specifically, three indicators are selected to measure the emissions of waste gas per unit of manufacturing value added, wastewater emissions per unit of manufacturing value added, waste emissions per unit of manufacturing value added and carbon dioxide emissions per unit of manufacturing value added. The first three indicators measure the basic situation of daily production emissions of manufacturing industry, and can reflect the environmental impact of manufacturing waste emissions comprehensively. On this basis, considering that China is

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already the world's largest carbon emitter and manufacturing is the main industry leading to the increase of carbon emissions, carbon dioxide emissions per unit of industrial value added are included to measure the impact of manufacturing on the climate environment.

Resource recycling. Circular economy responds to the strategic idea of sustainable development, and is a way to achieve win-win economic and ecological benefits, as well as an important way to solve the resource tension in China. At present, the level of recycling in the manufacturing industry of Guangdong has gradually started, and certain applications have been realized in such industries as automobile and steel, and there is still great room for development in the future. In order to understand the situation of resource recycling in manufacturing industry in Guangdong, therefore, this paper selects five indicators to measure the centralized treatment rate of manufacturing wastewater, the comprehensive utilization rate of manufacturing solid waste, the reuse rate of manufacturing water, the percentage of financial environmental protection budget expenditure and the investment in industrial pollution control. The first three indicators mainly measure the recycling of manufacturing waste, while the last two indicators measure the level of investment in recycling in the manufacturing industry.

Green growth. Although the manufacturing industry in Guangdong is at a leading position in the country, its development in recent years has been plagued by factors such as rising raw material prices, rising labor costs and changes in the exchange rate of RMB, which have further restricted the sustainable development of Guangdong's manufacturing industry by serious resource consumption and escalating pollutant emissions. Therefore, manufacturing enterprises in Guangdong have been increasing the development of independent innovation capability and resource utilization efficiency in recent years, trying to achieve sustainable upgrading of manufacturing industry through green innovation. In this paper, three indicators, namely, the output per unit of construction land in manufacturing industry, the proportion of total manufacturing output value to total industrial output value combined with the growth rate of manufacturing output value, are selected to measure the performance of green transformation and upgrading of manufacturing industry from the perspective of output efficiency of manufacturing industry.

3.2. Data Sources

This paper selects panel data from 2011-2020 for evaluation, and the main sources are China Statistical Yearbook, China Industrial Statistical Yearbook, Guangdong Provincial Statistical Yearbook, and the environmental status bulletins published by the Environmental Protection Department of each city in Guangdong and government websites. Missing data for individual years were calculated by the statistical processing method of missing values. Carbon dioxide data are mainly calculated by referring to the energy carbon emission coefficients of IPCC2006 and multiplying by the input amount of coal, coke and crude oil. There are many kinds of energy inputs in manufacturing industry, but three main energy inputs are these energy sources in China's manufacturing industry, so the carbon emission calculation by selecting the above three energy sources can basically measure the carbon emission volume of manufacturing industry. Finally, due to the different index levels of the original data, it is necessary to carry out dimensionless processing, and this paper selects the extreme difference standardization method to eliminate the difference of the levels and the resulting deviation to the analysis results.

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Table 1. Green Manufacturing Level Evaluation Index System

Level 1 Index	Level 2 Index	Level 3 Index	Weights	Relation
Green Manufacture Index	Green Input	Energy consumption reduction rate of 10,000 yuan added value	0.112	+
		The proportion of fossil energy consumed	0.351	-
		Coal consumption per unit of industrial value added	0.216	-
	Pollution Emission	Emission of waste water per unit of manufacturing value added	0.449	-
		Emission of waste gas per unit of manufacturing value added	0.172	-
		Emission of waste solid per unit of manufacturing value added	0.098	-
		Carbon dioxide emission per unit of manufacturing value added	0.312	-
	Resource Recycling	Centralized sewage treatment rate of manufacturing industry	0.111	+
		Comprehensive utilization rate of solid waste in manufacturing industry	0.192	+
		Water reuse rate in manufacturing industry	0.478	+
		Financial environmental protection budget expenditure ratio	0.114	+
		Investment in industrial pollution control	0.444	+
	Green Growth	Unit construction land output in manufacturing industry	0.312	+
		The proportion of total manufacturing output value to total industrial output value	0.214	+
		Growth rate of manufacturing output value	0.323	+

3.3. Evaluation Methods

In this study, the entropy value method and TOPSIS method are used to calculate the green manufacturing level index. Firstly, the entropy method is used to determine the weights of the index level. The entropy method uses the information entropy to calculate the index weights, which avoids the subjective arbitrariness of the index weights and increases credibility of the index weights and more focused on the comparison between objects. This paper calculates the score indices of green input, green emission, green cycle and green performance indicators based on the determined weights. Finally, the green manufacturing system index is obtained by summing up the scores of each index through TOPSIS method.

4. Empirical Results

4.1. Time Series Comparision Analysis

According to the evaluation method and evaluation index of green manufacturing system, this paper selects representative cities of manufacturing industry in Guangdong according to the

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geographical area of Guangdong, and selects Guangzhou, Shenzhen, Foshan, Zhanjiang, Shantou, Yangjiang and Maoming from Guangdong East and West and PRD respectively for comparison (See Figure 1). The green manufacturing indices of these cities from 2011 to 2020 are calculated and plotted into a dynamic trend as shown in the above figure. It can be seen that the overall green manufacturing system index of these cities shows an upward trend from 2011 to 2020. Among them, the green manufacturing system index of Zhanjiang, Shantou and Maoming has been increasing year by year, and the development speed is faster. This may be related to the vigorous development of clean energy industries and the strengthening of environmental protection policies in these cities. The green manufacturing index of the PRD cities basically remains at a certain level, but in recent years there has been a downward trend.

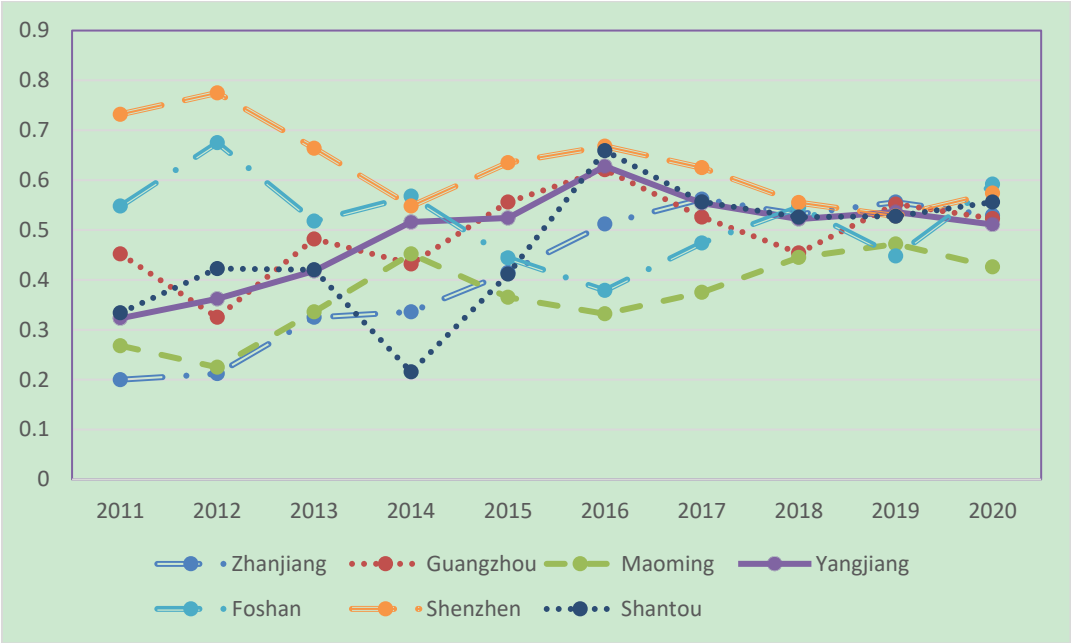

Figure 1. Green Manufacture Index Trending of Representative City of Guangdong

4.2. Cross Section Comparision Analysis

According to the evaluation results and grading criteria of the 2020 Guangdong Green Manufacturing System Index (See Table 2), it can be seen that the cities at a high level are Foshan, Zhanjiang and Guangzhou, and the cities at a low level are Heyuan, Jiangmen and Zhongshan. From the perspective of regional distribution, the level of industrial green manufacturing system construction in northern Guangdong is generally low, the level of industrial green manufacturing system construction in the PRD region is generally high, and the western and northern regions of Guangdong are the second.

From the perspective of constituent elements, the main contribution to the development of green manufacturing system in Foshan, Yangjiang and Yunfu in 2020 comes from green inputs. Secondly, the main contribution to the effectiveness of green manufacturing system construction in Guangzhou, Shenzhen and Dongguan comes from green emissions. Overall, the contribution of green input index and green cycle index in the PRD region are low, the green performance index is relatively high in Shenzhen, Dongguan, Zhanjiang and Maoming, and the contribution of Shaoguang, which has the highest cycle development index, has the highest percentage.

ISSN: 2688-9323

Table 2. Green Manufacture Index Comparison of Guangdong Cities based on Year 2020

City	Green Input	Pollution Emission	Resource Recycling	Green Growth	Green Manufacture Index
Zhanjiang	0.367	0.365	0.112	0.393	0.529
Guangzhou	0.233	0.493	0.351	0.242	0.523
Maoming	0.231	0.182	0.216	0.352	0.426
Yangjiang	0.438	0.359	0.449	0.456	0.511
Foshan	0.477	0.213	0.17	0.211	0.592
Shenzhen	0.203	0.414	0.098	0.458	0.574
Shantou	0.407	0.247	0.312	0.324	0.556
Zhongshan	0.115	0.152	0.111	0.281	0.229
Zhuhai	0.244	0.19	0.192	0.123	0.28
Shaoguang	0.118	0.265	0.478	0.112	0.245
Zhaoqing	0.323	0.227	0.114	0.428	0.361
Jiangmen	0.256	0.184	0.444	0.12	0.221
Huizhou	0.225	0.247	0.312	0.412	0.323
Meizhou	0.209	0.431	0.214	0.051	0.376
Heyuan	0.122	0.111	0.323	0.112	0.149
Qingyuan	0.167	0.175	0.092	0.374	0.407
Dongguan	0.271	0.396	0.346	0.497	0.382
Chaozhou	0.224	0.49	0.271	0.228	0.26
Chaoyang	0.422	0.337	0.212	0.174	0.429
Yunfu	0.404	0.178	0.173	0.27	0.399
Shanwei	0.157	0.276	0.432	0.187	0.24

5. Conclusion and Policy Suggestions

This paper first defines green manufacturing based on the previous literature and the manufacturing industry in Guangdong. Based on the definition, the green manufacturing evaluation system is constructed from four aspects: green input, green emission, green cycle and green performance, and 15 indicators are selected for calculation. Based on the calculation of entropy value method and TOPSIS method, it is found that the level of green manufacturing in western Guangdong is increasing, and the level of green manufacturing in the Pearl River Delta (PRD) region is good but has a decreasing trend in recent years. For the cross-sectional comparison based on each city in 2020, the green manufacturing of cities in the PRD region mainly comes from the contribution of green emissions, the western Guangdong region mainly comes from green inputs, and the northern Guangdong region mainly comes from green cycles.

Based on the above research, this paper provides the following suggestions to promote the green transformation of manufacturing industry in Guangdong.

First, develop green manufacturing knowledge system helps to enhance the cognition and awareness of green development of enterprises, and moreover helps enterprises to find the path of green development, which is the core support to realize green development. The green manufacturing knowledge system focuses on the technological innovation and application related to the production process and energy-saving and environmental protection equipment, especially to increase the research and development of intelligent and efficient clean production technology, so that the products have the characteristics of harmless, lightweight, low energy consumption, low water consumption, low material consumption and easy recycling. Focus on the deep integration of green manufacturing and intelligent manufacturing,

use big data technique to promote the implementation of green manufacturing standardization and visualization to highlight its role in supporting the green transformation of the manufacturing industry.

Second, green development as the guide to improve the traditional advantageous industries in Guangdong. Give full play to the respective advantages of industrial authorities, industry associations, energy-saving service institutions and enterprises, adopt a promotion model combining government guidance and market mechanisms, vigorously develop the energy-saving service market, promote energy-saving service companies and industrial enterprises to dock precisely, promote the application of a number of energy-saving, low-carbon, water conservation, comprehensive utilization of resources and other areas of advanced and applicable processes, technologies and equipment, promote energy conservation and consumption reduction in enterprises, and reduce costs and increase efficiency, drive the rapid and healthy development of the energy-saving service industry, and make new breakthroughs in industrial green development and energy conservation and consumption reduction.

Third, encourage a number of qualified enterprises to carry out green design, produce green products, build green supply chains and guide green consumption in accordance with the requirements into the green manufacturing system. Through the national and provincial support for green factories, green parks, green design products and green supply chain management enterprises and other industrial policies, to create a provincial green manufacturing demonstration benchmark enterprise. Also, this paper suggests the government should increase the replication and promotion efforts. Refine the results of the creation of green enterprises form development experience, strengthen the public opinion propaganda of green factories and green parks benchmark enterprises, and vigorously promote the replication of development paths and the promotion of development experience.

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