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Optimization and Application of Comprehensive Environmental-Economic Evaluation Indicator System in Sustainable Development Policies of Chinese Manufacturing Industry

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Abstract:

This paper focuses on optimizing the comprehensive environmental-economic evaluation index system to enhance the sustainable development policy of China's manufacturing industry. The current indicator system, while useful, has notable shortcomings that limit its effectiveness. To address these issues, the paper proposes the inclusion of crucial indicators such as green productivity, carbon footprint, and water footprint, which are essential for providing a more holistic evaluation. These additions aim to capture better the environmental impacts and resource efficiency within the manufacturing sector. The paper also discusses the challenges in data acquisition, emphasizing the need for a standardized national environmental data platform. Such a platform would facilitate the collection of accurate, reliable, and accessible data, thereby improving the precision of evaluations. To further refine the assessment process, dynamic evaluation models, like the system dynamics model, are introduced. These models are designed to provide a more nuanced understanding of the environmental impacts over time, allowing for more responsive and adaptive policy-making. The optimized indicator system is expected to have significant applications in policy formulation, enterprise management, and social oversight. By providing a scientific basis for decision-making, it will play a critical role in advancing the sustainable development of China's manufacturing industry, ensuring that environmental considerations are fully integrated into economic planning and industrial practices.

Keywords: Comprehensive Environmental and Economic Evaluation; Manufacturing Industry; Sustainable Development; Green Productivity; Carbon Footprint; Water Footprint

1. Introduction

With the frequent occurrence of extreme weather, increasing loss of biodiversity, and resource depletion brought about by global climate change becoming increasingly severe, the sustainable development of the manufacturing industry, as a pillar industry of global economic development, has received widespread attention [1]. Especially in China, the world's leading manufacturing country, how to maintain sustained economic growth while effectively responding to environmental challenges and realizing green transformation has become an urgent issue [2]. In recent years, China's manufacturing industry has faced bottlenecks such as environmental pollution and resource constraints while promoting economic development. Therefore, optimizing the comprehensive evaluation index system of the environmental economy is of great practical significance and urgency for guiding China's manufacturing industry toward the path of sustainable development [3]. This study aims to explore the optimization and application of this index system in the sustainable development policy of China's manufacturing industry, with a view to providing the scientific basis for policy formulation and enterprise practice.

1.1 Current Status of the Comprehensive Environmental-Economic Evaluation Indicator System

A comprehensive environmental and economic evaluation index system is a method of comprehensive evaluation of the environmental impact of economic activities through a series of indicators. Currently, China's comprehensive environmental and economic evaluation index system mainly includes resource consumption, pollution emission, ecological efficiency, and other aspects [4]. These indicator systems have played an important role in promoting the green transformation of the manufacturing industry and improving the level of environmental management.

However, the existing system is still deficient in terms of indicator selection, data acquisition, and evaluation methods. The existing comprehensive environmental and economic evaluation index system has certain limitations in the selection of indicators, which are mainly reflected in the following aspects:

1.1.1 Missing key indicators

The existing comprehensive environmental and economic evaluation index system has limitations in the selection of indicators, which are mainly reflected in the absence of key indicators and the controversy over the setting of weights and calculation methods. The existing system fails to comprehensively cover key indicators such as green productivity, carbon footprint, and water footprint, resulting in the evaluation results not being able to comprehensively reflect the actual impact of the manufacturing industry on the environment. Green productivity measures the economic output per unit of resource input, while carbon and water footprints measure greenhouse gas emissions and water consumption, respectively, and these indicators are crucial for evaluating the environmental performance of enterprises [5]. In addition, the weight setting of some indicators lacks scientific basis, and the calculation method is not uniform, which affects the scientificity and fairness of the evaluation. In order to improve the scientificity of the evaluation system, it is necessary to pay attention to the selection of key indicators and to unify the calculation method of each indicator.

1.1.2 Challenges in data acquisition

Data acquisition is the basis for comprehensive environmental and economic evaluation, but China is still facing many challenges in this regard. First of all, the access to environmental data is fragmented and lacks unified standards and platforms, resulting in low data accuracy and accessibility. Environmental data involve multiple sectors and fields, such as industrial production, energy consumption, pollution emissions, etc., which are often dispersed among different management departments and organizations, lacking effective integration and sharing mechanisms [6]. This dispersion not only increases the difficulty of data collection but also makes it difficult to ensure the consistency and comparability of data. Second, some enterprises are opaque in the disclosure of environmental data, which affects the comprehensiveness and authenticity of the evaluation. Some enterprises may be reluctant to disclose detailed environmental data out of commercial confidentiality or fear of reputational damage. Even in environmental reports required to be disclosed by laws and regulations, there may be problems of selective disclosure or whitewashing of data, making it difficult for outsiders to obtain the true environmental performance of enterprises.

1.2 Limitations of the Evaluation Methodology

Existing evaluation methods have several limitations in assessing the sustainable development of China's manufacturing industry. First, most of these methods use static evaluation and rely on historical data, making it difficult to capture dynamic changes in environmental performance, such as the impact of technological advances, market changes, and policy adjustments. Second, they usually lack the ability to predict future trends, which is crucial for developing long-term strategies and addressing environmental risks. In addition, existing methods often fail to fully reflect environmental performance when dealing with complex systems involving multiple dimensions, such as production processes, supply chains, and product life cycles. They also tend to assume that the relationship between variables is linear, ignoring the nonlinear relationships in the actual environment, which may lead to distorted evaluation results [7]. Existing evaluation methods also lack adaptability and are difficult to customize according to the characteristics of different industries, enterprises, and regions. Finally, in practical applications, these methods may be difficult to widely use due to problems such as difficult data acquisition and complex operations.

1.3 International Comparison

There is still a gap between China's comprehensive environmental economy evaluation index system and the advanced international level in terms of scientific and practicality. Internationally, many countries and regions have established mature, comprehensive environmental and economic evaluation systems and have achieved remarkable results in policy formulation, enterprise management, and international cooperation. For example, the EU's Environmental Performance Index (EPI), developed by Yale and Columbia Universities, assesses countries' performance in environmental protection, covering areas such as air quality, water resource management, and biodiversity protection [8]. EPI adopts a standardized and transparent data collection process to ensure the fairness and comparability of the evaluation results and combines both quantitative and qualitative methods to make the results more scientific and have a guiding significance. The U.S. Green Economy Indicator System is based on EPA data and combines economic, environmental, and social indicators to assess economic growth and environmental conditions comprehensively [9]. The system focuses on reflecting the synergistic relationship between the environment and the

economy, such as green employment and green consumption, and ensures the accuracy and timeliness of the data through a perfect data collection and sharing mechanism. The United States also adopts a dynamic evaluation model to effectively predict future development trends and provide support for policy formulation.

2. Overview of Policies for the Sustainable Development of China's Manufacturing Sector

China's sustainable development policies for the manufacturing sector mainly include Made in China 2025 and the Industrial Green Development Plan. These policies emphasize green manufacturing, resource recycling, and pollution control and aim to promote the development of the manufacturing sector towards high quality and greening.

2.1 Made in China 2025

Made in China 2025 is a national strategy released by the Chinese government in 2015, aiming to promote China's transformation from a manufacturing power to a manufacturing power through measures such as innovation-driven, intelligent transformation, strengthening of foundations, and green development [10]. The strategy puts forward nine major tasks, including enhancing manufacturing innovation capability, promoting the deep integration of informatization and industrialization, strengthening industrial basic capabilities, strengthening quality and brand building, comprehensively implementing green manufacturing, optimizing industrial structure, expanding industrial development space, strengthening talent team building and deepening institutional reform. These measures will help promote the transformation and upgrading of China's manufacturing industry, improve its position in the global industrial and value chains, and realize sustainable development. To ensure the realization of the strategic objectives, the government has also introduced a series of supporting policies, such as the Plan for the Green Development of Industry and the Guiding Opinions on Accelerating the Promotion of the Greening of the Manufacturing Industry.

2.2 Industrial Green Development Plan

The Plan for Green Development of Industry is a special plan formulated by the Chinese government to promote the greening of industry, with the aim of responding to resource and environmental constraints, promoting supply-side structural reform, and improving the level of green development of industry [11]. The plan specifies the main goals and tasks to be accomplished by 2025, including establishing a green manufacturing system and upgrading the green development level of major industries. Specific measures include:

(1) Promoting the construction of a green manufacturing system: improving green manufacturing standards and evaluation systems and promoting cleaner production, circular economy, and low-carbon development models.

(2) Strengthening resource recycling: improving the utilization rate of industrial solid waste, wastewater, and waste gas, and developing the renewable resources industry.

(3) Strengthening pollution control: implementing emission reduction of key pollutants and upgrading environmental protection facilities.

(4) Promote green manufacturing technology: support the development of green process technology and green equipment manufacturing.

(5) Improve the policy system: increase financial support, innovate financial policies, and improve legal and regulatory safeguards.

2.3 Latest Policy Trends

In 2024, the Ministry of Industry and Information Technology (MIIT) and seven other departments issued the Guiding Opinions on Accelerating the Greening of the Manufacturing Industry, aiming to promote the greening of the manufacturing industry, build a green manufacturing system, and promote the construction of an ecological civilization [12]. By 2025, the goal is to establish a green manufacturing system, improve energy use efficiency, popularize green technology, and enhance the level of resource recycling. By 2030, the manufacturing industry will realize green and low-carbon transformation, the proportion of non-fossil energy will be increased, the efficiency of resource utilization will reach an internationally advanced level, and the intensity of pollutants and carbon emissions will be significantly reduced. In order to achieve these goals, the opinions put forward are to improve the policy system, increase financial support, strengthen green standards, increase technology research and development and promotion, deepen international cooperation, and implement other safeguard measures. This marks a new stage in the greening of China's manufacturing industry, which is of great significance to high-quality and sustainable development.

3. Optimization of the Comprehensive Environmental-Economic Evaluation Indicator System

3.1 Optimization of Indicator Selection

Some of the indicators in the existing indicator system fail to reflect the environmental impact of the manufacturing industry comprehensively. It is suggested that indicators

such as green productivity, carbon footprint, and water footprint be added to evaluate the environmental performance of the manufacturing industry more comprehensively.

3.1.1 Green productivity

Green productivity is an important indicator for measuring the efficiency of resource utilization and the environmental impact of the manufacturing industry in the production process. It not only takes into account traditional production efficiency but also integrates factors such as resource consumption and environmental pollution. By introducing green productivity, it can more comprehensively reflect how the manufacturing industry can effectively reduce its environmental burden while realizing economic growth.

3.1.2 Carbon footprint

Carbon footprint refers to the amount of greenhouse gas emissions, expressed in carbon dioxide equivalents, produced directly or indirectly by a product, service, or activity over its life cycle. The introduction of carbon footprinting can help assess the manufacturing industry's impact on climate change during the production process. In recent years, with the advancement of global carbon neutrality targets, carbon footprint management has become an important part of international trade. For example, the European Union's Environmental Footprint Methodology (EFM) provides companies with a standardized methodology for calculating carbon footprints and is widely used across multiple industries. The EFM has been used in a variety of industries, such as manufacturing, food, and beverage, as well as in the manufacturing industry.

3.1.3 Water footprint

Water footprint is a measure of the amount of freshwater resources consumed directly or indirectly by a product, service, or activity over its life cycle. The introduction of water footprint helps to assess the manufacturing industry's impact on water resources during the production process. In recent years, the problem of water scarcity has become increasingly serious, and water footprint management has become the focus of attention in various countries. For example, studies based on input-output modeling have shown that there are significant differences in the agricultural water footprints of different provinces and regions in China, indicating that there are large differences in the efficiency of water resource use and environmental impacts between regions.

3.2 Optimization of Data Acquisition

Data acquisition is the basis for comprehensive environmental and economic evaluation. Currently, China faces many challenges in environmental data acquisition, mainly including data fragmentation, non-uniform standards, and uneven data quality. In order to improve the accuracy and accessibility of data, it is recommended that a nationally unified environmental data platform be established.

3.2.1 A nationally unified environmental data platform

Establishing a nationally unified environmental data platform can effectively integrate all kinds of environmental data resources and improve the efficiency of data sharing and utilization. The platform should have the following functions: integrate environmental data from different departments and regions, establish unified data standards and formats, and ensure the comparability and consistency of the data; realize real-time collection and updating of environmental data through IoT and big data technology, and improve the timeliness and accuracy of the data; establish a strict data quality control mechanism to ensure the accuracy and reliability of the data; provide powerful data analysis tools It provides powerful data analysis tools and application interfaces, supports multi-dimensional and multi-level data analysis and application, and provides the scientific basis for comprehensive environmental and economic evaluation.

3.2.2 Optimization measures for data acquisition

In order to optimize data acquisition, the following measures can be taken: formulate unified data collection standards and specifications to ensure data consistency and comparability; establish a cross-sectoral and cross-regional data sharing mechanism to break down data silos and improve the efficiency of data utilization; promote the openness and transparency of environmental data, and enhance the public's and enterprises' ability to access and utilize the data; and strengthen the technical training of data collection and processing personnel to improve their professional level.

3.3 Optimization of Evaluation Methods

Existing evaluation methods mostly use static evaluation and fail to reflect dynamic changes. It is recommended that dynamic evaluation models, such as the system dynamics model, be introduced to reflect the environmental impacts of the manufacturing industry more accurately.

3.3.1 Application of system dynamics modeling

System dynamics modeling is a dynamic modeling method based on feedback control theory, capable of simulating the interactions and dynamic changes among variables in a complex system.1 In comprehensive environmental and economic evaluation, system dynamics modeling can be used to dynamically simulate the environmental impacts of the manufacturing industry by constructing cau-

sality diagrams and flow diagrams for subsystems of the economy, resources, and the environment.2

3.3.2 Optimization measures of evaluation methods

System dynamics modeling plays an important role in manufacturing environmental impact evaluation. It can simulate the environmental impacts under different policy scenarios, predict future development trends, and provide a scientific basis for policy formulation. By integrating economic, environmental, and resource data, the system dynamics model provides a comprehensive evaluation perspective. For example, combined with an improved fuzzy integrated evaluation method, it can dynamically measure the carrying capacity of water resources under different social development scenarios. In addition, the system dynamics model can simulate different policy measures, assess their impacts on environmental performance, and optimize green development policies. By introducing a feedback mechanism, the model can reflect the impact of environmental changes on economic and social systems and improve the scientific and practicality of the evaluation results.

4. Application of the Integrated Environmental-Economic Evaluation Indicator System

4.1 Policy Formulation

The optimized comprehensive environmental-economic evaluation index system comprehensively assesses the environmental performance of the manufacturing industry through careful consideration of resource consumption, pollution emission, and ecological benefits. It also provides a scientific basis for the government to formulate sustainable development policies. The system supports the setting and evaluation of policy objectives, such as carbon footprint and water footprint indicators, to help the government formulate emission reduction and water conservation policies. Through dynamic evaluation models, the government can simulate the environmental impacts of different policy scenarios and make timely adjustments to policy measures to ensure the effectiveness and sustainability of policies. The nationally unified environmental data platform improves the timeliness and accuracy of data and enhances the transparency and credibility of policies. The system is in line with international standards, promoting China's voice and influence in international environmental governance and facilitating international cooperation and exchange.

4.2 Enterprise Management

Enterprises face complex challenges in environmental management, and the optimized Comprehensive Environmental and Economic Evaluation Indicator System provides them with scientific tools to improve environmental performance and promote green manufacturing. By introducing key indicators such as green productivity, carbon footprint, and water footprint, enterprises can comprehensively assess environmental performance, identify weaknesses, and develop improvement measures. A nationally unified environmental data platform supports data-driven decision-making, and dynamic evaluation methods such as system dynamics models help companies simulate the impact of management measures and predict future trends. The optimized indicator system encourages green design and processes, promotes green supply chain management, supports enterprises in applying for environmental management system certification (e.g., ISO 14001), and provides green financial institutions with scientific environmental performance evaluation tools to help enterprises obtain green financial support.

4.3 Social Supervision

The optimized comprehensive environmental and economic evaluation index system plays an important role in social supervision, provides scientific data support for public and social organizations, and enhances the awareness and supervision of the environmental impact of the manufacturing industry. Specific applications include regular disclosure of environmental performance data by enterprises, which is made public through a unified national platform to enhance data transparency and public participation; the introduction of third-party evaluation agencies to conduct independent evaluations and provide a scientific basis; the establishment of a public reporting and feedback mechanism to enhance the efficiency of environmental management; the development of environmental education and publicity campaigns, and the use of big data and artificial intelligence technology to produce visualization reports to help the public more intuitively The media will conduct in-depth investigations and reports by obtaining detailed data to promote social supervision and environmental governance.

5. Conclusion

The optimized comprehensive environmental-economic evaluation index system is of great significance in the sustainable development policy of China's manufacturing industry. Through refined indicator selection, efficient data acquisition, and advanced evaluation methods, the system significantly improves its scientific, accuracy, and practicality, providing solid data support and theoretical basis for the government, enterprises, and society. It not only helps identify environmental bottlenecks in the industry and formulate targeted policies but also promotes

enterprises to shift to a green, low-carbon, and recycling development mode, enhancing the public's awareness of and participation in environmental protection. Overall, the system has injected new momentum into the green development of China's manufacturing industry and provided a useful reference for global environmental governance. In the future, the continuous improvement of this system will help China's manufacturing industry to fulfill its environmental protection responsibilities better and promote the construction of a global ecological civilization while realizing economic benefits.

References

[1] Gao Yang. Analysis of the application of cost in the design engineering of electric power project. Modern industrial economy and informationization, 2014, 4(21): 12-14.

[2] Li Zhiqi. Engineering information. China Engineering Consulting, 2015, (03):72-74.

[3] Zheng Lele. Research on the coupling and coordination of ecological environment and economic high-quality development in Gansu Province. Gansu Science and Technology, 2021, 50(10): 51-57.

[4] Yuan Jingjing, YUAN Guangda, PENG Daju. Evaluation of integrated environmental and economic performance of metallurgical enterprises under environmental carrying capacity. Finance and Accounting Newsletter, 2021, (24):108-111.

[5] Yu Xiangping, Liu Dong. Comprehensive evaluation of coordinated development of ecological environment-economy-tourism in Inner Mongolia. Statistics and Consultation, 2021, (06): 34-37.

[6] Li Haidan. Research on the Measurement and Evaluation of Comprehensive Utilization Efficiency of Clean Energy Based on Environmental and Economic Benefits. Zhengzhou University, 2022.

[7] Li Yanlin. Research on the evaluation of coordinated development of resource-environment-economy system and driving factors of coal industry. China Academy of Environmental Sciences,2022.

[8] Yang, Kexin, Qi Zhang, Ge Wang, Hailong Li, and Benjamin McLellan. A new model for comprehensively evaluating the economic and environmental effects of vehicle-to-grid (V2G) towards carbon neutrality. Journal of Energy Storage, 2024, 98(PB): 113067-113067.

[9] El-Gazar, E. F., Mohamed S. Yousef, Abdelrahman M. Elshaer, Mahmoud A. Khattab, T. A. Mouneer, and A. A. Hawwash. Enhancing solar still performance with hybrid nanofluid: a comprehensive assessment of energy, exergy, economics, and environmental impact using a novel fractional model. Environment, Development and Sustainability, 2024, (prepublish): 1-28.

[10] "Made in China 2025" Interpretation: manufacturing strong country "three-step" strategy. Industrial Furnace, 2024, 46(04): 29.

[11] Wang Zheng. The "14th Five-Year" Industrial Green Development Plan puts forward to comprehensively enhance the level of green manufacturing. Enterprise Observer, 2023, (04): 41.

[12] Editorial Board of the Journal. The Ministry of Industry and Information Technology and other seven departments jointly issued "on accelerating the promotion of the development of manufacturing green guidance". Rubber Science and Technology, 2024, 22(05): 276.