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Construction and application of carbon performance evaluation system for strategic emerging industries in the Guangdong-Hong Kong-Macao Greater Bay Area

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Abstract. Under the background of China's dual carbon goals and the high-quality development of the Guangdong-Hong Kong-Macao Greater Bay Area (GBA), strategic emerging industries (SEIs) have become pivotal to low-carbon transformation. However, there is lacking a targeted carbon performance evaluation system. This paper constructs a carbon performance evaluation system for GBA's SEIs based on publicly disclosed data, adhering to the principles of validity, availability, and relevance. The system comprises three core dimensions: emission reduction efficiency, green manufacturing and innovation, and green information disclosure. Besides, the paper takes ZTE Corporation, a GBA listed SEI company, as a case study, collecting its relevant data from 2022 to 2024 to verify the applicability of the evaluation. This study enriches the theoretical framework of carbon performance evaluation for SEIs and provides a practical tool for companies' low-carbon management.

Keywords: carbon performance evaluation system, strategic emerging industries, Guangdong-Hong Kong-Macao Greater Bay Area

1. Introduction

As climate change has a deepening impact on people's lives, carbon reduction has become an important issue of concern for businesses and society. China's proposed dual-carbon goals reflect its active fulfillment of its international obligations to address climate change. To achieve dual-carbon goals, businesses need to improve their carbon performance. Improving corporate carbon performance not only reduces carbon emissions but also lowers debt costs [1] and improves financial performance [2].

Strategic emerging industries are high-tech and low-resource-consumption sectors, but their rapid expansion presents new challenges to carbon reduction in supply chain activities and product manufacturing processes. The Guangdong-Hong Kong-Macao Greater Bay Area (GBA) is leading the development of strategic emerging industries. According to the "2024 Research Report on the Development of New Quality Productive Forces of Guangdong Companies" released by the Guangdong Provincial Investigation and Research Center, as of June 5, 2024, nearly 40% of listed companies in Guangdong Province are in strategic emerging industries, and over 95% of Guangdong's listed companies in strategic emerging industries are concentrated in the nine mainland China cities of the GBA [3].

Therefore, this paper constructs a carbon performance evaluation system for strategic emerging industries and selects a GBA-listed company in a strategic emerging industries for a carbon performance case study. This paper enriches the literature in the field of carbon performance assessment by combining carbon reduction-related data with regional industrial characteristics. In practice, this paper provides GBA's strategic emerging industries with a clear, data-driven carbon performance evaluation tool and offers a reference for other companies by summarizing the best practices of the case study company.

2. Principles for constructing a carbon performance evaluation system for strategic emerging industries

The first principle is validity. The selection of carbon performance evaluation indicators is based on carbon accounting standards and ESG information disclosure norms to ensure the validity of both theory and practice.

The second principle is availability. All indicators, such as greenhouse gas emissions and green certifications, come from publicly disclosed ESG or sustainability reports. The use of difficult-to-obtain data, such as internal production process data,

should be avoided to ensure its broad applicability.

The third principle is relevance. The carbon performance evaluation system needs to reflect the characteristics of strategic emerging industries. A single emission reduction efficiency indicator cannot reflect the carbon performance of strategic emerging industries because these industries are typically high-tech. This means they must not only passively control carbon emissions in the short term but also lead the long-term low-carbon transformation through development and production of low-carbon products.

According to the "Report on Statistical Analysis of Green and Low-Carbon Patents 2024" released by the China National Intellectual Property Administration, GBA's green and low-carbon patent grants grew rapidly from 2020 to 2023, with an average annual growth rate of 24.7% [4]. This indicates that green innovation has become a development trend for GBA companies to improve their future carbon performance. Therefore, it is necessary to combine emission reduction measures with perspectives such as green manufacturing and innovation to measure the carbon performance of strategic emerging industries more comprehensively.

3. Construction of a carbon performance evaluation system for strategic emerging industries

This paper focuses on using measurable and comparable indicators to reflect the carbon emission performance of enterprises from multiple dimensions. Therefore, the data in the evaluation indicators comes from companies' ESG reports or sustainability reports. This helps researchers evaluate carbon performance through publicly available information when it is difficult to obtain internal carbon-related data from companies. Table 1 shows the carbon performance evaluation system for strategic emerging industries constructed. This evaluation system includes three dimensions: emission reduction efficiency, green manufacturing and innovation, and green information transparency. The selection of indicators may vary slightly depending on the specific sub-sector of strategic emerging industries when evaluating their carbon performance.

The first core evaluation dimension is emission reduction efficiency. This is a direct reflection of whether companies' carbon reduction measures are effective. In this dimension, firstly, the evaluation system measures the overall scale and effectiveness of companies' GHG (Greenhouse Gas) emissions using two indicators: GHG emissions and decrease in GHG emissions. Secondly, GHG emission intensity and decrease in GHG emission intensity reflect GHG emissions relative to economic output. Electricity is also a contributor to carbon emissions. Strategic emerging industries, especially the electronics and information technology industry, typically require and consume large amounts of electricity. Therefore, electricity consumption is also an evaluation indicator. Moreover, we need to measure whether companies have achieved their emission reduction targets under the Science Based Targets (SBTi) initiative. The SBTi is a global organization addressing climate change, whose purpose is to advocate for companies to set carbon reduction targets and implement the targets

The second core dimension is green manufacturing and innovation. First, we need to understand whether the company has obtained any new national or provincial green factory, green industrial park, or green supply chain management enterprise certifications this year. This reflects the government's recognition of the company's green production. Second, we need to evaluate the company's carbon performance from the perspectives of product carbon footprint and supply chain carbon footprint. Because low-carbon development in strategic emerging industries should be guided by low-carbon practices throughout the entire product lifecycle. It may overlook the high-carbon risks associated with raw materials if companies simply reduce carbon emissions within the production facility. Besides, the evaluation system would measure the company's clean energy, such as solar or photovoltaic power generation or generation capacity. Optimizing energy consumption structure remains a key challenge in achieving low-carbon production [5]. Therefore, it is necessary to measure the extent to which companies produce and use clean energy.

The third core evaluation dimension is green information transparency. Although transparent disclosure of carbon-related information does not equate to outstanding carbon performance [6], it is reasonable to incorporate the level of information disclosure into the carbon performance evaluation system at this stage. Because the number of Chinese A-share listed companies currently disclosing sustainability reports or ESG reports is limited, making it difficult to distinguish high-carbon-performing companies from low-carbon-performing ones due to a lack of transparency. Incorporating information transparency into the carbon performance evaluation system not only encourages high-carbon-performing companies to signal their strong carbon management capabilities to the market but also compels companies with relatively low carbon performance to establish sophisticated carbon accounting systems, thereby identifying emission reduction potential.

In this dimension, firstly, the evaluation system examines whether companies comply with the "Governance-Strategy-Impact, Risk and Opportunity Management-Indicators and Targets" disclosure framework proposed in the "Guidelines for Sustainability Reporting of Listed Companies." The "Guidelines for Sustainability Reporting of Listed Companies" is a document officially released on April 12, 2024, by the Shanghai Stock Exchange, Shenzhen Stock Exchange, and Beijing Stock Exchange under the guidance of the China Securities Regulatory Commission. This guideline provides a standardized and clear criteria for the disclosure of sustainability reports by A-share listed companies in China. In the future, an increasing number of A-share listed companies in China will comply with the requirements of this guideline.

Second, this dimension examines whether the company's sustainability report has been audited or assured by a third-party organization. Unlike financial reports, sustainability reports are not mandatory to be audited by a third-party professional organization before disclosure. This makes the veracity of the information disclosed in sustainability reports potentially questionable. Furthermore, some scholars suggests that companies may use ESG information disclosure as a tool for "greenwashing" [7]. Sustainability assurance could increase the credibility of companies' disclosed carbon reduction information to some extent.

Table 1. Carbon performance evaluation system for strategic emerging industries

Category	Evaluation Index	Evaluation Index Definition
Emission Reduction Efficiency	GHG Emissions	Total GHG Emissions (Tons of CO2 Equivalent)
	Decrease in GHG Emissions	Year-on-year Decrease in Total GHG Emissions
	GHG Emission Intensity	Total GHG Emission Intensity (Tons of CO2 equivalent / Million Revenue)
	Decrease in GHG Emission Intensity	Year-on-year Decrease in Total GHG Emission Intensity
	Electricity Consumption	Total Electricity Consumption (kWh)
Green Manufacturing and Innovation	SBTi Achievement	Whether the company has met its current SBTi emission reduction target. If yes, code 1; if no, code 0.
	Green Manufacturing Certification	New National or Provincial-Level Certifications for Green Factories, Green Industrial Parks, and Green Supply Chain Management Enterprises
	Product Carbon Footprint	Total Number of Products that Have Completed Carbon Footprint Assessment
	Supply Chain Carbon Footprint	Number of Suppliers that the Company Promotes Carbon Inventory or Dual-carbon Audits
	Clean Energy: Solar Power	Solar Power Generation (kWh)
	Clean Energy: Photovoltaic Power	Newly Installed Photovoltaic Power Generation Capacity (MW)
Green Information Transparency	Disclosure Framework	Whether the company's sustainability report follows the "Governance-Strategy-Impact, Risk and Opportunity Management-Indicators and Targets" framework of the "Guidelines for Sustainability Reporting of Listed Companies". If yes, code 1. If no, code 0.
	Sustainability Reporting Audit and Assurance	Whether the company's sustainability report has been audited or assured by a third-party organization. If yes, code 1; if no, code 0.

Source: Designed by the Authors

4. Application of carbon performance evaluation system for strategic emerging industries: taking ZTE corporation as an example

To apply the carbon performance evaluation system for strategic emerging industries described above, this paper selects ZTE as a case study. ZTE's core businesses include wireless networks, optical transmission, and computing infrastructure. It is a leading company in the next-generation information technology industry in GBA, listed in Chinese Hong Kong and Shenzhen. ZTE's sustainability reports are relatively complete, and its carbon-related information is readily available. Therefore, this company can serve as a typical case study for carbon performance research. This paper uses relevant data from ZTE's sustainability reports from 2022 to 2024 [8-10] to evaluate its carbon performance. Table 2 shows the evaluation results for ZTE.

In terms of emission reduction efficiency, both GHG emissions and GHG emission intensity showed significant decreases in 2023 and 2024, with a more pronounced decrease in 2024. GHG emissions and GHG emission intensity decreased by 21.87% and 19.97% respectively in 2024. Similarly, electricity consumption also decreased year by year. This indicates that ZTE has

implemented a series of effective energy-saving and emission-reduction measures in recent years. ZTE achieved its SBTi emission reduction target in 2024. Data for this indicator is missing for 2022 and 2023 because ZTE only applied to join SBTi in May 2023.

In green manufacturing and innovation, ZTE obtained two and three national or provincial green manufacturing certifications in 2023 and 2024, respectively. Specifically, in 2023, ZTE was awarded the title of "National Green Supply Chain Management Enterprise" by the Ministry of Industry and Information Technology (MIIT), and its Heyuan manufacturing base received the title of "National Green Factory" from the MIIT. In 2024, ZTE added provincial green factory certifications to its Xi'an, Changsha, and Nanjing Binjiang bases. This demonstrates ZTE's continuous investment and efforts in green manufacturing, and that its production processes and supply chain management have been recognized by authoritative institutions, which will help enhance the company's overall green image and competitiveness.

In 2023 and 2024, ZTE conducted carbon footprint assessments on 101 and 154 products, respectively. ZTE can better understand the carbon emissions throughout the product lifecycle by assessing the carbon footprint of more products. From 2022 to 2024, ZTE encouraged its core suppliers to conduct carbon inventory or dual-carbon audits, with the largest number of suppliers involved in 2023. According to ZTE's Net-Zero Strategy White Paper, ZTE's carbon emissions are relatively low in scopes 1 and 2, but higher in scope 3 [11]. In other words, carbon emissions in high-end information and communication technology (ICT) manufacturing are mainly reflected in the upstream and downstream value chains. ZTE's assistance for suppliers in conducting carbon inventory reflects its focus not only on low-carbon production but also on the green development of the entire supply chain. Regarding clean energy, ZTE's solar power generation saw significant growth between 2022 and 2024. Specifically, the solar power generation in 2024 was approximately 6.16 times that of 2023. ZTE added 22 MW of photovoltaic power generation capacity in 2023. Although ZTE did not disclose this figure for 2024, the investment in 2023 laid the foundation for subsequent solar power generation.

In terms of green information transparency, ZTE's 2024 sustainability reports follow the "Governance-Strategy-Impact, Risk and Opportunity Management-Indicators and Targets" framework of the "Guidelines for Sustainability Reporting of Listed Companies." These guidelines were issued in April 2024, indicating that ZTE is one of the first companies to comply with these new guidelines. ZTE's sustainability reports from 2022 to 2024 have all been verified by third-party organizations. This increases the credibility of the carbon performance data and information in the reports, enabling investors, regulators, and the public to more confidently assess and monitor a company's carbon performance based on the report's content.

Overall, ZTE performed well in terms of carbon performance between 2022 and 2024. ZTE made positive progress in all three dimensions: emission reduction efficiency, green manufacturing and innovation, and green information transparency.

Table 2. Carbon performance evaluation for ZTE

Category	Evaluation Index	2022	2023	2024
Emission Reduction Efficiency	GHG Emissions (Tons of CO2 Equivalent)	72498089.25	65455341.76	51137975.29
	Decrease in GHG Emissions	-	9.71%	21.87%
	GHG Emission Intensity (Tons of CO2 Equivalent)	589.634	526.7997	421.59
	Decrease in GHG Emission Intensity	-	10.66%	19.97%
	Electricity Consumption (kWh)	828928417.4	800734820	755564388.6
Green Manufacturing and Innovation	SBTi Achievement	-	-	1
	Green Manufacturing Certification	-	2	3
	Product Carbon Footprint	-	101	154
	Supply Chain Carbon Footprint	109	150+	100
	Clean Energy : Solar Power (kWh)	2689124	4820300	29702700
	Clean Energy : Photovoltaic Power (MW)	-	22	-
Green Information Transparency	Disclosure Framework	-	-	1
	Sustainability Reporting Audit and Assurance	1	1	1

Source: ZTE 2022-2024 Sustainability Reports [8-10]

5. Conclusion

This paper designs a carbon performance evaluation system for companies in strategic emerging industries. This paper takes ZTE, a next-generation information technology company in GBA as an example and uses data from the company's sustainability reports from 2022 to 2024 to evaluate the trend of its carbon performance during these years. The contribution of the paper is to enrich the literature on carbon performance evaluation, especially for strategic emerging industries. This paper summarizes ZTE's practices in improving carbon performance, providing a reference for other companies in the same industry.

This paper has two limitations. First, the evaluation system is primarily based on publicly disclosed sustainability reports from companies. However, currently, A-share listed companies in China are not required to disclose ESG reports, which may result in the lack of structured data for some companies. This issue may be resolved in the future as the Chinese securities market becomes more strict in its requirements for environmental information disclosure by listed companies. Second, this paper only analyzes a single case within the information industry. Future research could evaluate the carbon performance of companies in other sub-sectors of strategic emerging industries and make comparisons across different industries.

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