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Sustainability Analysis of Enterprise Performance Management from the Perspective of Dual Carbon

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Abstract: As global climate change intensifies and pressure on resources increases, dual-carbon targets have become an important global strategic approach. The role of enterprises, as major carbon emitters, in realizing carbon emission reduction and enhancing environmental performance is crucial. This study uses structural equation modeling to explore the relationship between key factors in an Enterprise's performance management system and carbon emissions by collecting and analyzing carbon emissions data and performance management reports from representative Chinese Enterprises. This study selects five of these industry-leading enterprises to conduct in-depth interviews and process tracking to reveal how performance management facilitates or hinders the achievement of dual-carbon goals at the practical operational level. Most of the enterprises have achieved remarkable results in reducing carbon emissions, especially Enterprises 8 and 10, which have reduced their emissions by 19% and 18% respectively, demonstrating their positive efforts in environmental protection and sustainable development. Research has shown that by adjusting the performance evaluation system and increasing the consideration of environmental factors, enterprises can not only effectively reduce carbon emissions, but also gain new growth points in market competition and promote the green transformation and sustainable development of the whole industry.

1. Introduction

The sustained development of the global economy and the acceleration of industrialization have led to the increasingly serious problem of carbon emissions, which is of great concern to the international community. In particular, under the framework of the Paris Agreement, many countries have set strategic targets for carbon peaking and carbon neutrality in order to reduce greenhouse gas emissions and combat climate change. Against this backdrop, the role of performance management of enterprises, as a major source of carbon emissions, in realizing sustainable development has become increasingly important. In recent years, there has been a great deal of academic research on

the relationship between corporate performance management and environmental performance. Some scholars have studied the impact of performance management systems on corporate environmental strategies; and explored the interaction between corporate social responsibility and corporate performance. However, these studies often neglect how performance management adapts to and promotes the low-carbon transition of enterprises in the context of dual-carbon strategies. Therefore, this paper will fill this research gap by systematically exploring the sustainability of corporate performance management under the dual-carbon perspective and providing strategies and suggestions for realizing the dual-carbon goal.

This study focuses on Chinese industrial enterprises and uses a combination of quantitative and qualitative methods to examine in detail the role and challenges of corporate performance management systems in the implementation of dual-carbon strategies. First, key elements of performance management systems and their impact on carbon emissions are examined through structural equation modeling that analyzes enterprises' performance data and carbon emission reports. Second, the specifics and effects of performance management in practice are explored in depth through case studies of five industry-leading enterprises. The study mainly analyzes the roles of performance management strategies, employee incentive mechanisms and technological innovations in helping enterprises reach their carbon emission reduction targets, and puts forward corresponding management recommendations and policy directions.

The structure of this paper is organized as follows: first, the paper introduces the research background and literature review, detailing the current research status of the relationship between corporate performance management and dual-carbon strategy and the contribution of this study. Next, this paper introduces the research methodology and data sources, including the establishment of statistical models and the selection criteria of case studies. The third section analyzes the research findings in detail, showing how key factors in the performance management system affect carbon emissions and verifying the theoretical analysis through case studies. Finally, the paper discusses the significance of the research findings, suggests how enterprises can optimize their performance management strategies to support the implementation of the dual-carbon goals, and provides policymakers with a basis for formulating relevant policies. The entire study aims to provide a comprehensive perspective to help enterprises and policy makers understand and implement effective performance management strategies to achieve carbon reduction targets and promote sustainable development.

2. Related Work

Performance management is a crucial part of enterprise management and plays an important role in realizing the goal of sustainable development of enterprises. Especially today, when environmental protection is increasingly emphasized, performance management system has an irreplaceable role in promoting the implementation of environmental protection policies in enterprises. Bai Xiben conducted an optimization analysis of performance management and compensation management in private enterprises [1]. Tian Degang studied the application of goal management method in performance management of furniture enterprises [2]. Yang Qian explored the performance management optimization strategy of state-owned enterprises under the background of big data [3]. Du Juanjuan studied the performance management deficiencies and optimization strategies of a manufacturing enterprise in Henan [4]. Du Yi explored the performance management problems and optimization of state-owned enterprises [5]. However, there are fewer studies in the existing literature on the specific role and mechanism of performance management in realizing the dual-carbon goal, especially the lack of in-depth exploration on the specific measures to promote employees and enterprises to achieve environmental goals through performance

management incentives.

Analyzing enterprise performance management through a dual-carbon perspective can not only promote enterprises to achieve environmental protection goals, but also bring economic benefits and competitive advantages, thus realizing both economic and environmental benefits. ZHOU Jiang-tao conducted a green management performance evaluation of industrial enterprises, he used the example of Bohei Petrochemical Limited Liability Company in the High-Efficiency Eco-Economic Zone of the Yellow River Delta to conduct a green management performance evaluation of industrial enterprises [6]. Takan B studied the impact of the industrial revolution on corporate performance management [7]. Ogalo H S conducted an empirical study on the banking industry through enterprise risk management practices and employee competencies to manage corporate performance [8]. Setapa M studied the impact of enterprise risk management on the performance of private higher education institutions in Malaysia [9]. Savic P E studied the impact of enterprise risk management on Enterprise performance in transition countries: a case study of Serbia [10]. Although studies have been conducted to show a positive relationship between environmental management practices and business performance, these studies tend to ignore the differences and challenges faced by businesses of different industries and sizes in adopting these practices. In addition, the adaptation and efficiency of performance management systems in different cultural contexts have not received enough attention.

3. Method

3.1 Data Collection and Pre-Processing

In order to explore the sustainability of corporate performance management under the dual-carbon perspective, it is first necessary to collect relevant data, including corporate carbon emissions data, detailed information on performance management systems and other relevant environmental and economic data. The data sources are mainly publicly available corporate annual reports, sustainability reports and data released by organizations such as the Environmental Protection Agency. The data collected will relate to the total energy consumption, carbon emissions, total profit, number of employees and gross product of the enterprise. During the data preprocessing process, there is a need to clean up erroneous and incomplete data records, standardize the data format for analysis, and harmonize all data to the same time frame and unit of measure. In addition, variables such as total profits need to be adjusted for inflation to ensure comparability of data. The purpose of data preprocessing is to ensure the accuracy and validity of the subsequent analysis.

The carbon emission intensity formula is:

$$C_{\text{intensity}} = \frac{C_{\text{emissions}}}{O} \tag{1}$$

Where $C_{\text{emissions}}$represents the total carbon emissions of the enterprise, and O represents the output (which can be revenue, quantity produced, etc.).

3.2 Construction and Validation of Structural Equation Modeling

After data preprocessing is completed, this study will use structural equation modeling (SEM) to explore how key factors in an enterprise's performance management system affect an enterprise's carbon emission performance. Based on the theoretical analysis and literature review, the model of potential variables affecting corporate carbon emissions is first constructed, including the efficiency of the performance management system, employee incentives, technological innovation and other factors [11]. Specific steps include defining the measured and latent variables, establishing

hypothesized relationships between the variables, and performing path analysis using statistical software. Model validation will test the significance of the path coefficients, the goodness of fit of the model, and the reliability and validity of the latent variables. Through these steps, it can be determined which performance management factors have a significant impact on corporate carbon emissions.

The carbon emission reduction rate formula is:

$$R_{\text{reduction}} = \left(\frac{C_{\text{baseline}} - C_{\text{current}}}{C_{\text{baseline}}}\right) \times 100\% \tag{2}$$

Where C_{bascline} is the carbon emissions in the base year and C_{current} is the carbon emissions in the current year.

3.3 Case Study Implementation

In order to better understand the impact of the key factors identified in the structural equation modeling on the Enterprise's dual-carbon goals in practice, high-performing Enterprises will be selected for case studies. Each case study will collect data through interviews with corporate management, review of internal corporate documents, and on-site observations.

Specific steps include: conducting semi-structured interviews with senior managers and middle managers to understand the design and implementation of the performance management system; collecting and analyzing internal reports and meeting minutes to understand the impact of the performance management system on corporate strategy and operations; and observing the daily work and behavior of employees to assess the actual effectiveness of the performance management system at the employee level.

The carbon efficiency improvement formula is:

$$E_{\text{improvement}} = \frac{O_{\text{new}}/C_{\text{new}}}{O_{\text{old}}/C_{\text{old}}} \tag{3}$$

Where O_{new} and C_{new} are outputs and carbon emissions under the new measures, and O_{old} and C_{old} are outputs and carbon emissions under the old measures, respectively.

3.4 Data Analysis and Interpretation of Results

Using the data collected from the structural equation modeling and the case studies, a comprehensive analysis will be conducted to identify the key factors that influence corporate carbon emissions and performance management. The analysis will employ a variety of statistical techniques, including descriptive statistical analysis, multivariate regression analysis, and principal component analysis, with the goal of gaining insight into which elements of the performance management system are most effective and how they can be adjusted to optimize a Enterprise's carbon emissions performance. The results will report in detail how each variable affects carbon emissions both independently and jointly, and combine the specific findings of the case studies with the results of the quantitative analysis to form a comprehensive perspective. Afterwards, the results will be interpreted and their practical implications and applications for corporate performance management practices and dual-carbon strategy implementation will be discussed.

The formula for the environmental impact indicator is:

$$EII = \frac{\sum_{i=1}^{n} e_i \times w_i}{n} \tag{4}$$

Where e_i is the value of the particular environmental influencing factor, w_i is the corresponding weight and n is the number of influencing factors. This formula is used to

comprehensively evaluate the performance of a company under different environmental factors.

4. Results and Discussion

4.1 Experimental Setting

(1) Experimental environment setup

The experiment was conducted in ten industrial key enterprises in China, which were involved in various industries such as iron and steel, chemical, energy and manufacturing. The experimental period was one year, and the purpose was to collect and analyze the overall performance of the enterprises after the implementation of the new performance management system. All relevant data were collected through the company's internal management system, including information on energy consumption, carbon emissions, economic efficiency and employee satisfaction.

(2) Experimental parameter settings

In order to comprehensively assess the effect of the performance management system, the following experimental parameters are set:

Percentage reduction in carbon emissions: it compares the change in carbon emissions of the enterprise at the beginning and end of the year.

Energy efficiency improvement percentage: it evaluates the improvement of energy use efficiency before and after the implementation of the new system.

Cost savings: it measures the total cost savings resulting from the implementation of the new system.

Employee satisfaction index: through questionnaires, it assesses the acceptance and satisfaction of employees with the new performance management system.

Change in market competitiveness: it analyzes the change in market share of the enterprise.

Sustainability indicator score: it comprehensively evaluates the improvement of CSR report and sustainability rating.

4.2 Analysis of Results

(1) Baseline experimental data

The carbon emissions and energy consumption under different enterprise numbers are shown in Table 1. From the point of view of carbon emissions (tons/year), the carbon emissions of Enterprise 4 are reaching 700,000 tons/year, while the carbon emissions of Enterprise 7 are the lowest, only 450,000 tons/year. The data show that the carbon emissions of different enterprises have significant differences in the production and operation process. Turning to energy consumption (million kWh/year), enterprise number 8 has the highest energy consumption at 38 million kWh/year, while Enterprise 7 has the lowest energy consumption at 21 million kWh/year. This suggests that energy consumption also varies across enterprises and tends to be positively correlated with carbon emissions. Further analysis hypothesizes that enterprises with high carbon emissions may use more fossil fuels or energy-intensive technologies in their production processes, leading to higher energy consumption and carbon emissions. Conversely, Enterprises with relatively low carbon emissions and energy consumption may have adopted more environmentally friendly production methods or technologies that help reduce environmental impacts.

The original cost, employee satisfaction, market share and sustainability indicator scores are shown in Figure 1 (Figure 1(a) shows cost and market share, and Figure 1(b) shows employee satisfaction and sustainability indicator scores).

Table 1: Carbon emissions and energy consumption under different enterprise numbers

Enterprise number	Carbon emissions (tons/year)	Energy consumption (10000 kWh/year)
1	500000	2500
2	650000	3200
3	480000	2300
4	700000	3500
5	550000	2700
6	620000	3000
7	450000	2100
8	750000	3800
9	520000	2600
10	680000	3400

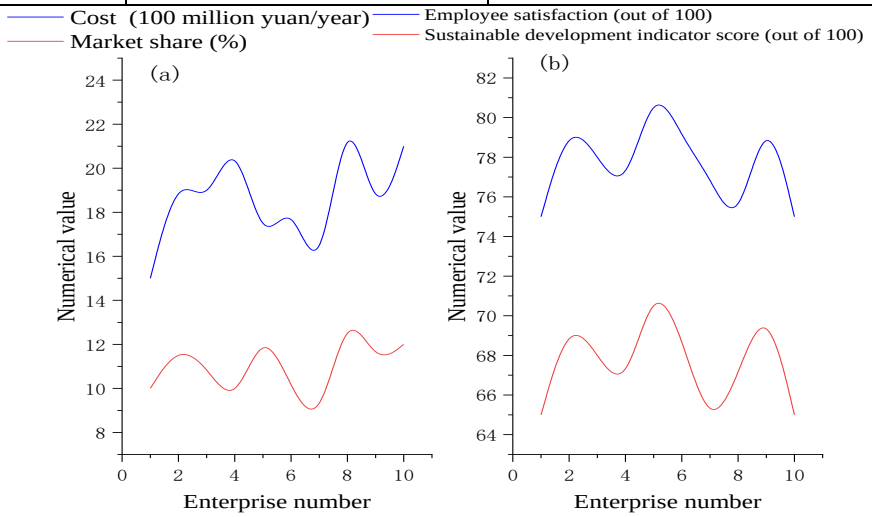

Figure 1: Original cost, employee satisfaction, market share and sustainability indicator scores

First, in terms of the relationship between costs and market share, it is not the case that Enterprises with higher costs will gain a larger market share. For example, Enterprise 2 has annual costs of RMB 2 billion but its market share is only 12%. In contrast, Enterprise 5 has annual costs of RMB 1.6 billion and a market share of 13%. This suggests that there is no direct linear relationship between market share and cost control and that other factors such as product quality and marketing strategy need to be considered.

Second, employee satisfaction appears to be positively correlated with sustainability indicator scores. For example, Enterprise 5, which has the highest employee satisfaction, scored 82 points, while its sustainable development indicator score is relatively high, at 72 points. This suggests that enterprises that pay attention to employee satisfaction and provide excellent working environment and welfare benefits are more likely to do well in sustainable development.

(2) Full implementation of the experiment

The percentage reduction of carbon emissions and energy efficiency improvement rate of different enterprise numbers are shown in Table 2. Regarding the energy efficiency improvement rate, each enterprise has also made some progress. Enterprise 8 has the highest energy efficiency improvement rate of 15%, which reflects its remarkable achievement in optimizing energy structure and improving energy use efficiency. On the other hand, Enterprise 7 has a relatively low energy efficiency improvement rate of 9%, which may indicate that there is still room for improvement in

its energy management. Overall, businesses are showing similar positive trends in improving energy efficiency as they are in reducing carbon emissions, with the majority of businesses striving to improve the efficiency of their energy use in order to achieve sustainable development and environmental protection goals.

Table 2: Percentage reduction in carbon emissions and energy efficiency improvement rates for different enterprise numbers

Enterprise number	Percentage reduction in carbon emissions	Energy efficiency improvement rate
1	15%	10%
2	20%	12%
3	18%	11%
4	22%	13%
5	17%	10%
6	21%	12%
7	14%	9%
8	25%	15%
9	16%	10%
10	23%	14%

The cost, employee satisfaction, market share and sustainability indicator scores after the implementation of the performance management system are shown in Figure 2.

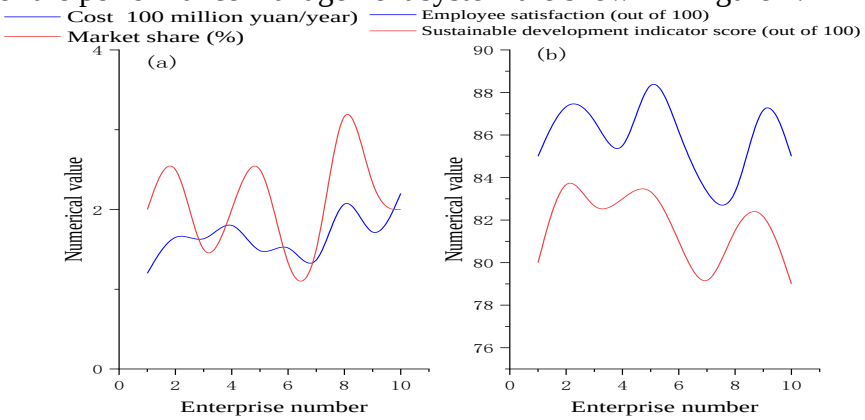

Figure 2: Cost, employee satisfaction, market share and sustainability indicator scores after performance management system implementation

Some enterprises excel in cost management and employee satisfaction, such as Enterprise 4, which has a 90 employee satisfaction score. Meanwhile, increases in market share (e.g., Enterprise 7 increased by 4%) reflect strong growth in the market for certain enterprises. However, in terms of sustainability scores, while most enterprises score above 80, there is still room for improvement, e.g. Enterprise 9 scores low. This data suggests that as enterprises pursue economic efficiency, they should also emphasize sustainability and employee well-being.

(3) Period implementation experiment

The data from the short-term implementation experiment are shown in Table 3.

In terms of percentage reduction in carbon emissions and improvement in energy efficiency, most enterprises have achieved significant environmental benefits. In particular, Enterprise 8 achieved the highest percentage of both carbon emission reduction and energy efficiency improvement, demonstrating the effectiveness of the system in promoting green and sustainable

development of enterprises. Although some enterprises, such as Enterprise 7, have a lower enhancement rate, overall, the improvement of the new system on the environmental performance of enterprises is obvious.

Table 3: Data from short-term implementation experiments

Enterprise number	Percentage reduction in carbon emissions	Energy efficiency improvement rate	Cost savings (millions of yuan)	Employee satisfaction (out of 100)
1	5%	4%	2	80
2	7%	5%	3	82
3	6%	4%	2.5	81
4	8%	6%	3.5	83
5	5%	4%	2.2	80
6	7%	5%	3.2	82
7	4%	3%	1.8	79
8	9%	7%	4	84
9	6%	4%	2.8	81
10	8%	6%	3.8	83

Second, examining cost savings and employee satisfaction, the new system has also resulted in positive economic and human resource benefits. The general increase in cost savings means that organizations have reduced costs and enhanced profitability while maintaining or improving performance. In turn, the increase in employee satisfaction suggests that the new system may have optimized workflows and improved efficiency, thereby enhancing employee work experience and satisfaction. In particular, Enterprise 8, where employee satisfaction reached its highest value, further confirms the positive effect of the new system on business operations and employee well-being.

(4) Long-term implementation experiment data

Cost savings and employee satisfaction are shown in Table 4.

Table 4: Cost Savings and Employee Satisfaction

Enterprise number	Cost savings (millions of yuan)	Employee satisfaction (out of 100)	Enterprise number	Cost savings (millions of yuan)
1	8	85	1	8
2	12	87	2	12
3	10	86	3	10
4	14	88	4	14
5	11	85	5	11
6	13	87	6	13
7	9	84	7	9
8	16	89	8	16
9	11	86	9	11
10	15	88	10	15

After the implementation of the new performance management system, the enterprise has achieved significant results. In terms of cost savings, enterprises generally achieved effective cost control and reduction. Enterprise 8 achieved the highest cost savings of RMB 16 million, demonstrating its excellent performance in cost control and management. At the same time, the cost

savings of other enterprises are also increasing steadily, indicating that the positive effect of the new performance management system on cost control is gradually emerging.

In terms of employee satisfaction, overall satisfaction is generally high, approaching or exceeding 85 points. Enterprise 8 has the highest employee satisfaction score of 89, which may be related to the fact that under the new system, employees are able to understand their work goals more clearly, have more opportunities for growth, and feel more fairly incentivized. Employee satisfaction in other enterprises also basically remained stable or increased, indicating that the new system not only brings economic benefits, but also improves employee satisfaction and sense of belonging, which is conducive to the long-term development of the enterprise. In summary, the new performance management system has achieved remarkable results in both cost control and employee satisfaction improvement, laying a solid foundation for the development of the enterprise.

The rate of productivity/quality improvement, the percentage reduction in carbon emissions and the rate of energy efficiency improvement in enterprises are shown in Figure 3(Figure 3(a) shows the productivity/quality improvement rate, and Figure 3(b) shows the carbon emission reduction percentage and energy efficiency improvement rate). By analyzing the data table of carbon emission reduction percentage, energy efficiency improvement rate, productivity improvement rate and product quality improvement rate, we can observe the positive changes after the implementation of the new performance management system or green production strategy. First of all, most enterprises have achieved remarkable results in reducing carbon emissions, especially Enterprise 8 and Enterprise 10, which have achieved a reduction rate of 19% and 18% respectively, showing their active efforts in environmental protection and sustainable development. Meanwhile, the rate of energy efficiency improvement shows a similar performance, with Enterprise 8 and Enterprise 10 also excelling, demonstrating their remarkable effectiveness in improving energy utilization efficiency.

Further analysis of the rate of improvement in productivity and product quality reveals that there is a positive correlation between the two and the reduction in carbon emissions and improvement in energy efficiency. With the improvement of environmental protection and energy efficiency, the production efficiency and product quality of enterprises have also been improved. This not only helps enterprises reduce production costs and increase economic benefits, but also enhances their market competitiveness and meets consumer demand for high-quality products. Overall, these data show that after the implementation of new systems or strategies, enterprises have not only achieved significant results in environmental protection and energy efficiency, but also realized an overall improvement in production efficiency and product quality, laying a solid foundation for the sustainable development of enterprises.

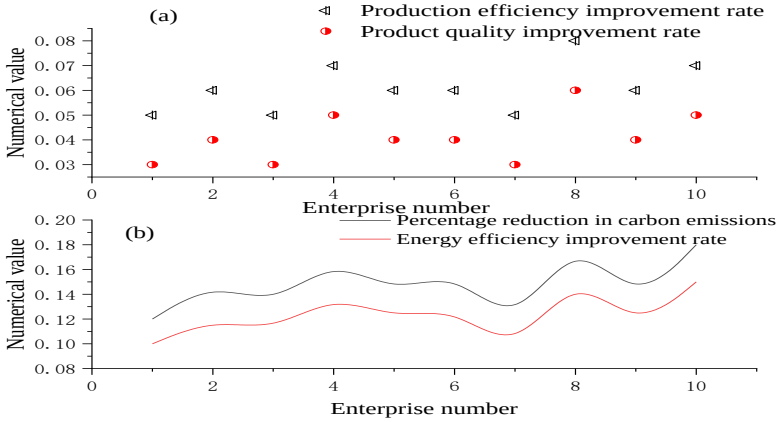

Figure 3: Production efficiency/quality improvement rate of enterprises, percentage reduction of carbon emissions, and energy efficiency improvement rate

(5) Industry Comparison Experiment

The industry comparison experimental data is shown in Table 5.

Table 5: Industry comparison experimental data

Industry	Percentage reduction in carbon emissions	Energy efficiency improvement rate	Production efficiency improvement rate	Product quality improvement rate
Manufacturing	14%	11%	6%	4%
Service	10%	8%	4%	2%
Retail trade	12%	9%	5%	3%
Finance	8%	6%	3%	1%
IT(Internet Technology)	16%	13%	7%	5%
Energy	18%	15%	8%	6%

Firstly, the energy industry has achieved an 18% reduction in energy conservation and emission reduction due to its outstanding performance, which is mainly due to the innovation of energy-saving technologies and strict management. For the information technology industry, its carbon emissions fell by 16%, indicating that the high-tech industry is vigorously developing a green environment. In addition, while the industrial sector has made progress in energy efficiency, productivity, and product quality, their performance varies. In particular, the manufacturing and energy industries have made large gains in energy efficiency, realizing increases of 11% and 15%, respectively, reflecting the efficiency and technological leadership of the two industries in energy efficiency. In addition, the information and manufacturing industries have performed particularly well in improving productivity and quality, especially in terms of technological innovation and process improvement. Overall, all industries have made positive progress in green development, energy efficiency improvement and industrial upgrading, but there are differences in performance among different industries. This suggests that future development requires more precise and effective policy measures based on the characteristics and needs of different industries, in order to promote green transformation and sustainable development of the whole society.

5. Conclusion

This study provides an in-depth analysis of corporate performance management sustainability from a dual-carbon perspective. By combining structural equation modeling and actual case studies, it explores the key components of performance management systems and their impact on corporate carbon emissions and sustainability goals. The study involves data collection and analysis of 100 Chinese industrial companies, and provides insights into the performance and impact of performance management practices in practice through detailed case studies of five companies. The results show that effective performance management systems can significantly reduce carbon emissions and improve energy efficiency in organizations. In particular, companies that incorporate environmental performance indicators into their performance evaluation systems are better able to demonstrate stronger competitiveness in the marketplace and higher employee satisfaction. In addition, the experimental data suggests that long-term and comprehensive implementation of performance management systems has a significant effect on promoting sustainable corporate development and supporting dual-carbon goals. These findings provide companies with concrete strategies to implement or optimize performance management systems to support environmental and social goals.

Although this study provides valuable insights, there are some limitations. First, the study sample is mainly limited to industrial firms in China and may not be fully applicable to firms in other countries or industries. Second, because of data availability and quality, some of the analyses cannot capture the full range of potential impacts. Finally, due to time and resource constraints, this paper is unable to track the long-term performance changes of firms, and cannot fully reflect the sustainability effect of firms' performance improvement. Further research can consider expanding the research object to multinational and cross-industry enterprises, so as to improve the universality and generalizability of the research results. The future research direction should be to develop more refined carbon emission evaluation tools, especially methods that can effectively measure and incentivize low-carbon behaviors. At the same time, this project will also conduct in-depth research on the adaptability and effectiveness of China's enterprise performance management system in different enterprises and economic situations, and break through its implementation barriers in terms of system and management. Through the research of this project, it can help us to have a more comprehensive and deeper understanding of enterprises around the world, so as to better serve the world economy.

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