

THE IMPACT OF GREEN SUPPLY CHAIN MANAGEMENT ON THE VALUE OF NEW ENERGY VEHICLE ENTERPRISES: A CASE STUDY OF BYD

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Abstract: With the increasing environmental pollution and climate deterioration, the new energy vehicle industry plays a vital role in coping with the challenges of emission pollution and resource depletion brought by the traditional automobile industry. As an environmentally friendly and sustainable business practice, green supply chain management has a profound impact on the value of new energy vehicle enterprises. This paper takes BYD as the research subject, measures the degree of green supply chain management using the green supply chain management evaluation index published by the Ministry of Industry and Information Technology, collects and normalizes the enterprise value represented by the return on net assets, and finally employs the gray correlation analysis method to explore the relationship between the two, thereby confirming that BYD's green supply chain management has a positive impact on its enterprise value and provides corresponding suggestions. The research in this paper provides some guidance for new energy vehicle enterprises to formulate and implement green supply chain management strategies, and helps enterprises achieve a win-win situation of environmental and economic benefits.

Keywords: Green supply chain management; New energy vehicle; Corporate value; Grey relevance

1 INTRODUCTION

In the context of climate change and environmental problems, governments and enterprises are gradually recognizing the urgency and importance of addressing climate change, and there is a broad global consensus on the development of a "low-carbon economy", which emphasizes reducing energy consumption, reducing environmental pollution and controlling greenhouse gas emissions. China has also responded positively, adhered to the path of green and sustainable development, and integrated green supply chain management into the development strategy of enterprises [1].

In order to mitigate the negative impact of corporate activities on the atmospheric environment, renewable energy solutions such as solar, hydro and wind are being actively sought in addition to traditional energy sources. These emerging industries will gradually become the dominant force in China's economy, and among these industries, the new energy field has been identified as one of the seven strategic emerging industries for China's future development [2]. In order to build a clean, safe and reliable energy system and reduce carbon emissions, many companies have begun to set foot in the new energy industry, especially in the field of new energy vehicles, and the development momentum of related enterprises is particularly rapid. As a global leader in the field of new energy vehicles, BYD actively responds to the national goal of "carbon peak before 2030 and carbon neutrality before 2060", and promotes carbon emission reduction through technological innovation and green supply chain management.

Green supply chain management is a modern management method that integrates the concepts of green manufacturing and supply chain technology, which emphasizes the integration of environmental protection and sustainability principles into supply chain operations to achieve energy conservation, emission reduction and pollution reduction. Corporate value encompasses the resources and capabilities of the company, as well as the beliefs, philosophies and goals behind it, while reflecting the company's social responsibility, environmental impact and impact on various stakeholders. Fadhel found that green supply chain management practices can not only improve the environmental performance of enterprises [3], but also indirectly affect financial performance, improve operational efficiency and enhance corporate image by enhancing competitive advantage, and bring competitive advantages to enterprises. Zhang Lingfu et al. found that the green supply chain affects the improvement of enterprise value through the level of risk-taking, and the technological innovation ability and supply chain concentration further regulate this process [4].

The three traditional methods of asset valuation are divided into the cost approach, the market approach and the income approach. On the basis of these three methods, many scholars use a variety of evaluation methods to analyze the performance or value of enterprises. Sujit et al. used the balanced scorecard theory to divide enterprise performance into four dimensions [5]: finance, customer, internal process, and learning and growth, and comprehensively evaluated the performance of small and medium-sized manufacturing enterprises through questionnaire survey and data analysis. Arjuna et al. comprehensively used tools such as analytic hierarchy process [6], target matrix, and traffic light system to construct an evaluation system for green supply chain management for an agricultural product marketing company, and carried out a quantitative analysis of the environmental impact and performance of the enterprise's operation process.

The above relevant literature shows that green supply chain management can significantly improve enterprise value. Current research on green supply chain management mainly focuses on manufacturing, retail, food and beverage, and chemical and pharmaceutical industries, while the new energy vehicle industry is far from paying enough attention [7].

Therefore, this paper selects BYD enterprises in the new energy vehicle industry as the research object, and uses the gray correlation method to study the correlation degree of green supply chain to its enterprise value, so as to provide guidance for new energy vehicle enterprises to formulate and implement green supply chain management strategies. In addition, the practice of green supply chain management can not only enhance corporate value, but also promote the sustainable development of the new energy vehicle industry, and achieve the dual benefits of environmental protection and economic benefits.

2 ANALYSIS OF THE CURRENT SITUATION OF THE NEW ENERGY VEHICLE INDUSTRY AND THE RELEVANT GENERAL SITUATION OF BYD

2.1 Analysis of the current situation of the new energy vehicle industry

As a pioneer in the innovation of the automotive industry, the new energy vehicle industry not only brings together cutting-edge technologies in many fields such as energy, transportation and computers, but also provides new development opportunities for China's transformation from imitation to transcendence, from a "big automobile manufacturing country" to a "strong automobile manufacturing country".

In terms of production capacity, China's annual output of new energy vehicles has climbed from 84,000 units in 2014 to 9.587 million units in 2023, ranking first in the world for nine consecutive years. China's rapid growth in the field of new energy vehicles, the significant increase in technology patents, and the leading position in battery manufacturing clearly demonstrate the significant progress that China has made in the transformation of the automotive industry to green and electrification [8]. The following table shows the top 10 retail sales of China's new energy vehicle manufacturers from January to November 2024:

Table 1 From January to November 2024, China's New Energy Vehicle Manufacturers will be Ranked TOP10 in Retail Sales

Rank	The name of the business	Sales volume (10,000 units)	Year-on-year growth	Market share
1	BYD Auto	331.52	37.80%	34.50%
2	Geely Automobile	75.41	94.30%	7.90%
3	Tesla China	57.42	8.80%	6.00%
4	SAIC GM-Wuling	55.71	42.60%	5.80%
5	Changan Automobile	55.03	60.60%	5.70%
6	Ideal car	44.20	35.70%	4.60%
7	Cialis Motors	35.58	379.20%	3.70%
8	Chery Automobile	35.39	252.30%	3.70%
9	GAC Aion	33.08	-24.80%	3.40%
10	Great Wall Motors	25.33	21.30%	2.60%

From Table 1, it can be seen that BYD, as the new energy vehicle manufacturer with the highest sales volume and market share, has great reference value for other car companies in the same industry when studying its corporate value. Moreover, BYD has repeatedly obtained A-level ESG ratings over the years, indicating that BYD has performed well in promoting sustainable development strategies. So we take BYD as the research object to explore the impact of green supply chain on the value of new energy vehicle enterprises.

2.2 BYD Green Supply Chain Management

BYD Co., Ltd., abbreviated as "BYD", was established in February 1995. After more than 20 years of rapid development, it has established more than 30 industrial parks worldwide, and its business scope includes multiple fields such as electronics, automobiles, new energy, and rail transit.

BYD is committed to ecological innovation, implementing climate commitments with leading green solutions and practical actions, advocating for "cooling the earth by 1 °C". In 2022, BYD announced the discontinuation of fuel vehicles and focused on pure electric and plug-in hybrid vehicle businesses, becoming the world's first car company to officially announce the discontinuation of fuel vehicles. In terms of green supply chain management practices, BYD actively promotes green transformation through innovative practices in four areas: green suppliers, green products,

green logistics, and green packaging. The company requires suppliers to fully consider environmental impacts in product design and production processes, and take continuous improvement measures to reduce these impacts [9]. In addition, BYD has strengthened the transparency and compliance management of its supply chain, signed a "Green Supply Chain Management Contract" with suppliers, requiring them to comply with national environmental regulations, reduce emissions, improve processes and production methods, and provide necessary environmental certificates. BYD has established a supply chain supervision mechanism to conduct regular audits and on-site inspections of its cooperative suppliers, ensuring the fulfillment of its environmental commitments.

3 INDICATOR SYSTEM AND EVALUATION METHODS

3.1 Evaluation Index System for Green Supply Chain Management Enterprises in the Automotive Industry

This article uses the "Evaluation Index System for Green Supply Chain Enterprises in the Automotive Industry" released by the Ministry of Industry and Information Technology to score BYD's green supply chain management from 2019 to 2023, in order to measure the impact of green supply chain management on the performance of automotive enterprises. The evaluation index system for green supply chain management enterprises in the automotive industry is shown in Table 2:

Table 2 Evaluation Index System for Green Supply Chain Management Enterprises in the Automotive Industry

Primary indicator	Secondary indicator	Index Properties
Management Strategy X1(20 points)	X11 The concept of green development should be proposed in the enterprise management policy (4 points)	Qualitative
	X12 Develop green supply chain management goals and implementation plans annually (4 points)	Qualitative
	X13 Establish a green supply chain management system and standard system (4 points)	Qualitative
	X14 Has personnel or institutions dedicated to managing the supply chain (4 points)	Qualitative
	X15 Establish education and training mechanisms (4 points)	Qualitative
Green Procurement and Supplier Management X2(25 points)	X21 The existing supplier admission standards and management should clearly specify the requirements for providing material data, and issue and effectively implement green procurement guidelines (6 points)	Qualitative
	X22 Proportion of suppliers certified with ISO14001 or GB/T24001 (3 points)	Quantitative
	X23 Proportion of suppliers using energy-saving and environmentally friendly processes/equipment (4 points)	Quantitative
	X24 Has an upstream supplier performance evaluation mechanism, awarding green suppliers to suppliers whose evaluation results meet certain standards, and carrying out environmental performance improvement for those with poor results (6 points)	Quantitative
	X25 Supplier Regular Audit (2 points)	Qualitative
	X26 Conducts green supply chain training for supplier organizations (4 points)	Qualitative
Green Production X3(15 points)	X31 Automotive Green Design Requirements (4 points)	Qualitative
	X32 Uses advanced technology and intelligent equipment (2 points)	Qualitative
	X33 Requirements for the use of toxic and harmful substances (3 points)	Quantitative
	X34 Passed the clean production audit (2 points)	Qualitative
	X35 Recycled material usage ratio (2 points)	Quantitative
Green consumption and recycling X4(20 points)	X36 Promotes green logistics (2 points)	Qualitative
	X41 Green Marketing (1 point)	Qualitative
	X42 Packaging material recycling rate (1 point)	Quantitative
	X43 Recycling System Construction (8 points)	Quantitative/Qualitative

Green Information Platform Construction and Information Disclosure X5(20 points)	X44 Standardized recycling rate of scrapped cars/products (4 points)	Quantitative
	X45 Guides downstream enterprises in recycling and dismantling (2 points)	Qualitative
	X46 Carries out automobile remanufacturing (2 points)	Qualitative
	X47 Actual recycling rate of automobiles or parts (2 points)	Quantitative
	X51 Has a green supply chain management information platform that enables the collection of automotive material data, energy consumption, and other information throughout the entire industry chain (10 points)	Qualitative
	X52 Disclosing Enterprise Energy Conservation and Emission Reduction Information to the Public (2 Points)	Qualitative
	X53 Disclosing information on recycling outlets to the public (2 points)	Qualitative
	X54 Discloses the proportion of green suppliers to the public (2 points)	Qualitative
	X55 Discloses to the public the measures and implementation results of jointly carrying out environmental performance improvement with suppliers (2 points)	Qualitative
	X56 Releases corporate social responsibility report to the public (2 points)	Qualitative

The evaluation index system for green supply chain enterprises in the automotive industry includes five primary indicators and thirty secondary indicators. This includes twenty-one qualitative indicators, eight quantitative indicators, and one indicator that is both qualitative and quantitative. All indicators comply with industry regulations and relevant policies. The specific calculation formula for the overall score of green supply chain management in the automotive industry is as follows:

$$AGSCI = X11 + X12 + X13 + X14 + X15 + X21 + X22 + X23 + X24 + X25 + X26 + X31 + X32 + X33 + X34 + X35 + X36 + X41 + X42 + X43 + X44 + X45 + X46 + X47 + X51 + X52 + X53 + X54 + X55 + X56(1)$$

In the formula, AGSCI stands for the evaluation index of green supply chain management enterprises in the automotive industry.

3.2 Grey Correlation Analysis Method

Grey correlation analysis is suitable for research contexts with small sample sizes and unclear data patterns, and its analysis results are generally consistent with qualitative analysis. The core of this method is to evaluate the geometric relationship between two sequence curves in order to determine the degree of correlation between them, that is, the grey correlation degree. In short, the smaller the difference between two sequences, the stronger their correlation; The greater the difference, the weaker the correlation.

Grey correlation analysis has two main functions: system analysis and comprehensive evaluation. Many studies focus on the evaluation of indicators for a certain system, but the focus of this article is to use the grey relational analysis method to analyze the degree of correlation between BYD's enterprise value and green supply chain, and conduct analysis.

In the initial stage of conducting grey relational analysis, it is necessary to dimensionless the parent sequence and sub sequences, where the parent sequence is the dependent variable and the sub sequence is the independent variable [10]. This article adopts a standardized approach to the evaluation indicators of green supply chain management and the dimensionless processing of ROE.

The second step is to calculate the grey correlation coefficient between the parameters of the parent sequence and the sub sequence, using the following formula to calculate the grey correlation coefficient:

$$\gamma = \frac{\Delta_{\min} + \rho \Delta_{\max}}{\Delta t(i,0) + \rho \Delta_{\max}} \quad (2)$$

Among them, Δ_{\min} is the minimum absolute value of the difference between two sequence values, Δ_{\max} is the maximum value, and $\Delta t(i,0)$ is the difference at the t -th data point ($i=1,2,3,4,5,6$). ρ is the resolution coefficient between $[0,1]$, and usually takes 0.5 to obtain the most accurate correlation. Therefore, 0.5 is used for calculation in this section.

4 EMPIRICAL ANALYSIS

4.1 Quality Analysis of BYD Green Supply Chain Index

According to the "Evaluation Index System for Green Supply Chain Management Enterprises in the Automotive Industry" mentioned above, score BYD's annual reports and corporate social responsibility reports from 2018 to 2023,

and calculate its green supply chain management index. Due to space limitations, a detailed index calculation table will not be presented. Table 3 shows the scoring details of green supply chain management based on primary indicators:

Table 3 BYD Green Supply Chain Management Index Detail Table

Indicator/Year	2019	2020	2021	2022	2023
Management strategy	18	20	20	20	20
Green procurement and supplier management	19.5	20	21.5	22	22.5
Green production.	14	15	15	15	15
Green consumption and recycling	16	17.5	18	18.5	18.5
Construction of Green Information Platform and Information Disclosure	15.5	16	17	17.5	18
Green supply chain management	83	88.5	91.5	93	94

The green supply chain index scoring data will be normalized using normalization method, and the processed results are shown in Table 4:

Table 4 BYD Green Supply Chain Index Data Processing

Indicator/Year	2019	2020	2021	2022	2023
Management strategy	0.95	1.05	1.05	1.05	1.05
Green procurement and supplier management	0.95	0.98	0.96	0.99	1.05
Green production.	0.95	1.05	1.05	1.05	1.05
Green consumption and recycling	0.95	1.02	1.04	1.05	1.05
Construction of Green Information Platform and Information Disclosure	0.95	0.97	1.03	1.04	1.05
Green supply chain management	0.95	1.00	1.04	1.05	1.05

In the past five years, BYD's rating results have shown an overall upward trend, indicating that the level of green supply chain management has maintained a good trend.

4.2 BYD Enterprise Value Analysis

Based on previous research, this article adopts the return on equity (ROE) to reflect enterprise value. The return on equity is the core indicator of the DuPont analysis system, which can effectively reflect the value of the enterprise. The return on equity data of BYD from 2019 to 2023 can be obtained from Dongfang Wealth Network, and the results are shown in Table 5:

Table 5 BYD ROE Calculation Table for 2019-2023

Indicator/Year	2019	2020	2021	2022	2023
ROE(%)	0.95	1.00	1.04	1.05	1.05

From Table 5, it can be seen that except for a significant decrease in ROE values in 2021, all other years have shown an upward trend, especially in 2022, where the growth rate is the most significant. According to relevant information, the continuous rise in global raw material prices in 2021 has led to high manufacturing costs for automobiles, which in turn has affected economic value added. However, in 2022, the new energy vehicle industry reached its peak of development, and BYD successfully withstood the test of the market. Its car sales reached a historical high, becoming the world's best-selling new energy vehicle manufacturer, and its operating profit achieved significant growth, effectively alleviating the cost pressure caused by rising raw material prices [7].

4.3 Grey Relational Analysis

Using the ROE value as the parent sequence and the first level evaluation index and the total score of green supply chain management as sub sequences, calculate the grey correlation coefficient. The results are shown in Table 6:

Table 6 Grey Relational Coefficient

Indicator/Year	2019	2020	2021	2022	2023
Management strategy	0.69	0.94	0.68	0.82	0.48
Green procurement and supplier management	0.67	0.97	0.70	0.81	0.49
Green production.	0.69	0.94	0.68	0.82	0.48
Green consumption and recycling	0.68	0.96	0.68	0.82	0.48
Construction of Green Information Platform and Information Disclosure	0.68	1.00	0.68	0.83	0.49
Green supply chain management	0.68	0.98	0.68	0.83	0.48

Finally, the average correlation coefficient of each point on the sequence is taken to calculate the correlation between the sequences, and the ranking is based on the magnitude of the correlation, as shown in Table 7:

Table 7 Grey Correlation Degree and Ranking Situation

Evaluative items	Correlation	Rank
Construction of Green Information Platform and Information Disclosure	0.733	1
Green supply chain management	0.729	2
Green procurement and supplier management	0.727	3
Green consumption and recycling	0.726	4
Management strategy	0.721	5
Green production	0.721	6

According to Table 7, the grey correlation degrees of five indicators, including management strategy, green procurement and supplier management, green production, green consumption and recycling, green information platform construction and information disclosure, for enterprise value are all between 0.65 and 0.85, indicating a high correlation. This proves that green supply chain management has a significant impact on the enterprise value of new energy vehicles. The construction of green information platforms and information disclosure scores the highest, with the greatest correlation with enterprise value. As mentioned earlier, BYD has strengthened the transparency and compliance management of its supply chain. Since 2010, BYD has continuously released social responsibility reports to the society and is one of the early automotive companies to carry out ESG information disclosure. Its leadership and commitment in green information platform construction and information disclosure have contributed significantly to global sustainable development.

The correlation between green production is relatively low, but it also has a positive impact on the value of enterprises. In the early stage of green production, it may lead to an increase in research and development expenses for enterprises, which may increase production costs and reduce operating profits in the short term, making the immediate improvement effect on enterprise value less significant. However, in the long run, green production can enhance the innovation capability of enterprises, improve resource utilization efficiency, and reduce environmental pollution, which helps to reduce enterprise costs and enhance profitability, ultimately increasing enterprise value [8].

5 CONCLUSION

This article adopts the grey relational analysis method to evaluate BYD's green supply chain management evaluation index, and represents its enterprise value in the past five years by calculating the return on equity (ROE). The research results indicate that BYD's green supply chain management has a certain positive impact on its corporate value. Based on the above research, the new energy vehicle industry can consider the following steps in the future to enhance its level of management:

1. Strengthen the systematic construction of green supply chain management: Enterprises should further improve the system and standard system of green supply chain management to ensure the effective implementation of green transformation in all links. At the same time, strengthen cooperation with suppliers, promote their environmental awareness and capabilities, and jointly achieve the sustainable development of green supply chains.
2. Enhance the construction and disclosure level of green information platforms: Enterprises should continue to strengthen the construction and management of green information platforms, improve the transparency and quality of information disclosure, and enhance public trust and support for enterprises. Simultaneously improving the

collaborative efficiency of the supply chain, achieving real-time sharing and dynamic management of information at all stages of the supply chain.

3. Focus on the long-term benefits of green production: Although green production may increase a company's research and development expenses and production costs in the early stages, in the long run, green production can enhance a company's innovation capabilities, improve resource utilization efficiency, and reduce environmental pollution. Enterprises should increase their investment in research and development of green production technologies, optimize production processes, reduce production costs, and enhance the market competitiveness of their products.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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