

Research on Green Supply Chain Performance Evaluation in the Sportswear Industry

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Abstract: In the context of increasing global environmental awareness, the apparel industry, as one of the high-pollution and high-energy-consumption industries, faces severe environmental challenges. To address these challenges, this paper constructs a performance evaluation system encompassing four dimensions—financial, customer, internal processes, and learning and growth—using the Balanced Scorecard. Additionally, the Entropy Weight TOPSIS method is employed to comprehensively assess the performance of the green supply chain in the apparel industry. The study aims to provide an in-depth analysis of green supply chain performance evaluation in the apparel industry, offering references and guidance for related enterprises.

Keywords: Green Supply Chain; Balanced Scorecard; Performance Evaluation.

1. Research Background

With the increasing severity of global climate change and resource depletion, environmental protection has become a global consensus. Various industries are actively seeking green transformation and exploring new environmentally friendly development paths. As a significant component of traditional manufacturing, the apparel industry also faces substantial environmental challenges. Therefore, implementing green supply chain management to reduce environmental pollution and resource consumption has become a crucial task for the apparel industry.

According to statistics from the United Nations, the United Nations Environment Programme, and the China National Textile and Apparel Council, the apparel industry has become the second-largest polluting industry globally, second only to oil. With the introduction of green supply chains, the global apparel industry is accelerating the green and low-carbon transformation of its industrial and supply chains. Premier Li Qiang emphasized the need to promote the green and low-carbon transformation of industrial and supply chains. Based on this, China will integrate more deeply into the global industrial and supply chain system and actively participate in international cooperation in green development.

2. Research Significance and Innovation

2.1. Research Significance

Theoretically, most domestic and international studies on the apparel industry focus on theoretical explanations of green supply chains or are limited to simple quantitative or qualitative analyses. In recent years, some scholars have begun to consider both quantitative and qualitative factors, using fuzzy analytic hierarchy processes to evaluate the performance of green supply chains in the apparel industry. However, these methods are not suitable for decision-making problems involving large amounts of quantitative data and requiring objective weight determination. Therefore, this paper constructs a performance evaluation method for the apparel industry's green supply chain by combining the Entropy Weight method and the TOPSIS method, which can promote the innovative development of performance

evaluation in the apparel industry's green supply chain.

Practically, this paper conducts empirical research on the green supply chain in the apparel industry, providing practical references for performance evaluation in the industry. This can enhance the environmental awareness and sustainable development capabilities of the apparel industry, playing an important role in building a harmonious society.

2.2. Research Innovation

Currently, there is a scarcity of literature on the performance evaluation of green supply chains in the apparel industry. Previous studies on the performance evaluation of green supply chains in the apparel industry mostly adopted qualitative analysis methods. To ensure the authority and comprehensiveness of the evaluation index system, this paper constructs an evaluation index system for the apparel industry's green supply chain using the Balanced Scorecard. To avoid the interference of decision-makers' limited rationality, the TOPSIS method is employed to make decisions more effective.

3. Research Approach

This study uses random interviews and the Balanced Scorecard to construct an index system from four dimensions: financial, customer, internal operations, and learning and growth. Based on the Entropy Weight TOPSIS method, the performance evaluation of the green supply chain in the apparel industry is explored.

4. Research Content

4.1. Performance Evaluation Indicators for the Green Supply Chain in the Apparel Industry

Based on the Balanced Scorecard and the concept of green supply chains, this paper constructs an index system from four perspectives: financial, customer, internal operations, and learning and growth. Through designing questionnaires and reviewing company reports, 12 indicators affecting the performance evaluation of the supply chain are preliminarily identified, as shown in Table 1.

Table 1. Green Supply Chain Performance Evaluation Form for the Apparel Industry

Green Supply Chain Performance in Sportswear Industry

(A) | Financial (B1) | Asset-Liability Ratio (C11) |
		Net Profit Margin (C12)
		Gross Profit Margin (C13)
	Customer (B2)	Market Share (C21)
		Customer Satisfaction (C22)
		Customer Green Recognition (C23)
	Internal Processes (B3)	Green Supply Chain Operation Efficiency (C31)
		Green Supply Chain Product Consumption Rate (C32)
		Product Recycling Rate (C33)
	Learning and Growth (B4)	Green Low-Carbon Technology Investment Rate (C41)
		Reverse Logistics Service Level (C42)
		Green Product R&D Capability (C43)

Financial evaluation is a critical focus in enterprise performance evaluation. For the green supply chain in the sportswear industry, it is essential to pay attention to the financial returns, asset-liability status, and development potential of the supply chain. By calculating indicators such as the asset-liability ratio, return on net assets, and net profit growth rate, the financial status of the supply chain can be comprehensively assessed.

Customers are the end-users of the supply chain, and their satisfaction and feedback are crucial for supply chain performance evaluation. For the sportswear industry, indicators such as market share, customer satisfaction, and customer green recognition can be set to reflect customer satisfaction.

The smoothness of internal business processes directly affects the overall performance of the supply chain. For the green supply chain in the sportswear industry, it is necessary to focus on green supply chain operation efficiency, product consumption rate, and quality monitoring. By setting specific indicators to quantify these aspects, issues in internal business processes can be identified and improved promptly.

Learning and growth are essential drivers for the continuous development of enterprises. For the green supply chain in the sportswear industry, attention should be paid to green technology innovation and application, employee training and development, and corporate culture. By setting specific indicators to quantify these aspects, enterprises can be driven to pursue excellence and achieve sustainable development.

4.2. Case Study on Performance Evaluation of the Green Supply Chain in the Apparel Industry

Against the backdrop of global climate change and increasing resource scarcity, green, low-carbon, and sustainable development have become global consensus. The apparel industry, as a traditional high-pollution and high-energy-consumption industry, is facing unprecedented environmental pressures. The Chinese textile and apparel industry, as one of the largest producers and exporters globally, is actively promoting green transformation. In recent years, under the policy guidance of "coal-to-gas" and "coal-to-electricity," the intensity of greenhouse gas emissions in the Chinese textile industry has significantly decreased. Meanwhile, the China National Textile and Apparel Council

(CNTAC) has set a grand vision of achieving zero carbon by 2050 and has formulated a detailed carbon reduction roadmap. Therefore, this paper takes representative domestic sportswear manufacturers such as Xtep, Li-Ning, and Anta as examples to explore and practice actively, contributing to the sustainable development of the entire apparel industry and meeting the market demand for environmentally friendly products.

(1) Data Standardization

Based on the companies' official 2024 interim reports, data from Qianzhan.com, and expert interviews, preliminary data on finance, customers, internal processes, and learning and growth are obtained. The performance evaluation indicators for the green supply chain in the apparel industry are standardized using formulas (4-1) and (4-2), resulting in standardized data for performance evaluation, as shown in Table 2.

Table 2. Standardized Data for Three Companies

0.0000	1.0000	0.5024	
0.0000	0.2183	1.0000	
0.0000	0.2452	1.0000	
0.0000	0.2752	1.0000	
0.0000	0.3333	1.0000	
0.0000	0.7143	1.0000	
0.0000	0.8750	1.0000	
0.0000	0.6000	1.0000	
0.0000	1.0000	1.0000	
0.0000	0.6667	1.0000	
0.0000	0.8000	1.0000	
0.0000	0.7500	1.0000	

(2) Determine Indicator Weights

Based on formulas (4-3), (4-4), and (4-5), the proportion matrix is calculated, and the entropy values of the indicators are determined based on the proportion matrix. The weights of the indicators are then determined, as shown in Table 3.

Table 3. Weights of Evaluation Indicators for Three Companies

Asset-Liability Ratio (C11)	0.0808	
Net Profit Margin (C12)	0.1095	
Gross Profit Margin (C13)	0.1045	
Market Share (C21)	0.1002	
Customer Satisfaction (C22)	0.0941	
Customer Green Recognition (C23)	0.0734	
Green Supply Chain Operation Efficiency (C31)	0.0712	
Green Supply Chain Product Consumption Rate (C32)	0.0764	
Product Recycling Rate (C33)	0.0709	
Green Low-Carbon Technology Investment Rate (C41)	0.0745	
Reverse Logistics Service Level (C42)	0.0719	
Green Product R&D Capability (C43)	0.0726	

(3) Construct a Weighted Normalized Matrix

Based on formula (4-6) and the indicator weight data from Table 3, the TOPSIS method is used to construct a weighted normalized matrix, as shown in Table 4.

Table 4. Weighted Standardized Decision Matrix for Three Companies

0	0.0800	0.0402	
0	0.0240	0.1100	
0	0.0245	0.1000	
0	0.0303	0.1100	
0	0.0300	0.0900	
0	0.0500	0.0700	
0	0.0613	0.0700	
0	0.0480	0.0800	
0	0.0700	0.0700	
0	0.0533	0.0800	
0	0.0560	0.0700	
0	0.0525	0.0700	

(4) Determine the Positive and Negative Ideal Values

Based on formulas (4-7) and (4-8), the positive and negative ideal solutions for the performance evaluation indicators are determined, as shown in Table 5.

Table 5. Positive and Negative Ideal Values for Three Companies

0.0402	0.0800	
0.1100	0.0240	
0.1000	0.0245	
0.1100	0.0303	
0.0900	0.0300	
0.0700	0.0500	
0.0700	0.0613	
0.0480	0.0800	
0.0700	0.0700	
0.0800	0.0533	
0.0700	0.0560	
0.0700	0.0525	

(5) Calculate Relative Closeness and Rank the Evaluation Objects

Based on formulas (4-9) and (4-10), the relative closeness of the three companies for each indicator is calculated. According to the TOPSIS method, the performance status of the three companies is ranked based on the relative closeness values. The larger the value, the higher the ranking, indicating better performance in the green supply chain of the apparel industry. The evaluation results and rankings of the first-level performance evaluation indicators for the three companies are shown in Table 6.

Table 6. Evaluation Results and Rankings for Three Companies

Xtep	0	3	
Li-Ning	7.4780	2	
Anta	11.5024	1	

5. Research Conclusions and Recommendations

5.1. Research Conclusions

1. Overemphasis on Short-Term Financial Indicators**

Current performance evaluations often focus too much on short-term financial indicators, such as cost savings and profit growth, while neglecting the long-term environmental and social benefits brought by green supply chains. This may lead

companies to be overly conservative in assessing the return on green investments, overlooking the potential value of green supply chains.

2. Insufficient Understanding of Customer Needs

Performance evaluations of green supply chains may focus too much on internal processes and production efficiency, neglecting customer demand and expectations for green products. This may result in companies failing to capture market changes in time, losing competitive advantages. Customer awareness and acceptance of green products may influence their purchasing decisions. However, current performance evaluations may lack effective measures of customer satisfaction and loyalty, failing to accurately reflect the value of green supply chains in customers' minds.

3. Insufficient Awareness of Green Supply Chain Management

The apparel industry has relatively weak awareness of green supply chain management and may not fully integrate green concepts into product development, design, procurement, manufacturing, and recycling processes.

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