Research on the Driving Mechanism of Green Supply Chain Management (GSCM) to Enterprise's Sustainable Competitive Advantage under the Double Carbon Target

Xingyu Li

Henan University of Technology, Zhengzhou, 450001, Henan, China

lxyuu11@163.com

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Abstract: Under the background of double-carbon target, the operation mode of enterprises is facing profound changes, and how to enhance sustainable competitive advantage with the help of Green Supply Chain Management (GSCM) has become a key issue. The purpose of this paper is to explore the driving mechanism of GSCM to the sustainable competitive advantage of enterprises under the goal of double carbon. Through theoretical research and literature review, this paper analyzes the opportunities and challenges faced by GSCM under the dual-carbon goal, analyzes its relationship with the sustainable competitive advantage of enterprises, and deeply discusses the mechanisms such as resource integration and optimization, innovation drive, market response and expansion that GSCM drives the sustainable competitive advantage of enterprises. It is found that GSCM plays a significant role in promoting the sustainable competitive advantage of enterprises by integrating internal and external resources, promoting various innovations and effectively responding to and expanding the market. The research conclusion highlights that resource integration serves as a core mediating mechanism, providing enterprises with both direct and indirect pathways to achieve sustainable competitive advantage, and offers strategic guidance for optimizing SCM and advancing green transformation under the double carbon target.

1. Introduction

Under the background of global climate change, the goal of "double carbon", that is, peak carbon dioxide emissions and carbon neutrality, has become a key strategy for all countries in the world to deal with environmental challenges [1]. The proposal of this goal has had a far-reaching impact on the enterprise operation mode, especially in the field of SCM [2]. Traditional SCM focuses on cost and efficiency, but under the goal of double carbon, GSCM emerges as the times require and becomes an inevitable choice for enterprises to achieve sustainable development [3]. GSCM requires enterprises to integrate environmental protection concepts into the whole supply chain process, from raw material procurement, manufacturing, product transportation to final waste disposal, all of which need to consider environmental impact [4]. At the same time, the sustainable competitive advantage of enterprises is the key to keep ahead in the long-term market competition. In the era of double carbon, how to drive the sustainable competitive advantage of enterprises through GSCM has become an important topic to be studied urgently.

At present, many enterprises have realized the importance of GSCM, but their understanding of how to drive sustainable competitive advantage is still insufficient [5]. On the one hand, although some enterprises actively carry out green supply chain practice, they fail to effectively turn green initiatives into actual competitive advantages. On the other hand, there are still many gaps in the research on the driving mechanism between them, and there is a lack of systematic and in-depth analysis [6]. The purpose of this study is to explore the driving mechanism of GSCM to the sustainable competitive advantage of enterprises under the goal of double carbon. Through theoretical research, it can enrich the relevant theoretical system of GSCM and sustainable competitive advantage of enterprises, and provide theoretical support for subsequent research. And

it has important practical significance for guiding enterprises to optimize SCM strategies and enhance sustainable competitiveness under the dual-carbon goal. It is expected that this study will provide useful reference for enterprises to realize green transformation and sustainable development in the new policy environment and market competition, particularly by highlighting resource integration as a core mechanism through which GSCM creates sustainable competitive advantage.

2. Related theoretical basis and literature review

The theory of GSCM originated from the reflection and expansion of traditional SCM. It emphasizes the comprehensive consideration of environmental protection and resource utilization efficiency in all aspects of the supply chain, covering green procurement, green production, green logistics and other aspects [7]. Its core lies in realizing the balance of economic, environmental and social benefits, and promoting green development by integrating the resources and actions of enterprises at all nodes in the supply chain. The theory of enterprise's sustainable competitive advantage is mainly based on resource-based view and dynamic capability view. The resource-based view holds that the unique resources and capabilities owned by enterprises are the source of competitive advantage, and these resources are valuable, scarce, unrepeatable and irreplaceable [8]. The dynamic capability view emphasizes the ability of enterprises to adapt to environmental changes, integrate and reconstruct internal resources and capabilities, so as to maintain the sustainability of competitive advantages.

In the aspect of literature review, many scholars have done some research on GSCM and sustainable competitive advantage of enterprises. Some studies show that the implementation of GSCM can help enterprises reduce costs, improve resource utilization efficiency, and then enhance their competitive advantage. For example, raw materials with better quality and reasonable price can be obtained through green procurement, while reducing environmental risks [9]. However, the existing research focuses on the direct relationship between the two, and there is relatively little in-depth analysis of the driving mechanism. Especially under the specific background of double carbon target, how to build and strengthen the sustainable competitive advantage of enterprises through the specific practice of GSCM remains to be further discussed. This study will be devoted to filling this gap and systematically analyzing its internal driving mechanism, with a particular focus on the mediating role of resource integration in unlocking sustainable competitive advantage through GSCM practices.

3. Research hypothesis and model construction

Driven by the macro-policy of "double carbon" and the market environment, GSCM has changed from an option to a strategic necessity related to the survival and development of enterprises. It is not enough to simply assert that GSCM can bring competitive advantage [10]. The key lies in identifying and verifying the core transmission mechanism. Based on the perspective of resource-based view and dynamic capability theory, this paper puts forward that "resource integration" capability is the key to solve this "black box". Enterprises do not automatically gain advantages only by implementing GSCM activities, but systematically integrate and optimize internal and external resources through GSCM practice, thus forging dynamic capabilities that are difficult to be imitated by competitors. Around this view, this paper puts forward the following research hypotheses:

H1: GSCM has a significant positive impact on the sustainable competitive advantage (SCA) of enterprises. Although the direct effect of GSCM may be diluted by many factors, a large number of theoretical and practical cases show that the systematic implementation of GSCM can bring significant competitive advantages to enterprises. From the perspective of cost and efficiency, GSCM emphasizes the recycling of resources and energy conservation. From the point of view of market and brand, positive GSCM practice is a powerful proof that enterprises fulfill their environmental responsibilities, which is helpful to create a good "green" brand image among consumers, investors and regulatory agencies. Today, with the increasing awareness of

environmental protection, this image can be transformed into brand premium and higher customer loyalty, and win market share for enterprises.

H2: GSCM has a significant positive impact on resource integration (RI). The essence of GSCM is a systematic change involving the whole supply chain. Its successful implementation inevitably requires enterprises to break down internal barriers and establish closer cooperative relations with external partners. When an enterprise carries out GSCM, it must coordinate internal procurement, production, logistics and other departments, unify green standards and share environmental data. GSCM requires enterprises to cooperate with upstream suppliers to develop green materials, optimize distribution routes with downstream logistics providers to reduce carbon emissions, and even build a reverse logistics system with recyclers. These cross-organizational cooperation behaviors are the direct embodiment of the integration and optimization of external resources by enterprises. Both collaborative research and development with suppliers and cooperative optimization with logistics providers are concrete manifestations of resource integration driven by GSCM.

H3: RI has a significant positive impact on the sustainable competitive advantage (SCA) of enterprises. The resource-based view holds that competitive advantage comes from the unique resources owned by enterprises, while the dynamic capability view further points out that the key lies in the ability of enterprises to integrate, construct and reconstruct internal and external resources. An enterprise with strong resource integration ability can allocate its resources such as manpower, technology, information and supply chain network more efficiently. This efficient resource allocation ability is directly transformed into cost advantage, innovation advantage and market response advantage, which constitutes a solid foundation for enterprises' sustainable competitive advantage. Therefore, whether GSCM exists or not, resource integration capability itself is the key for enterprises to gain and maintain competitive advantage.

H4: RI plays an intermediary role in the process of GSCM influencing enterprise's sustainable competitive advantage (SCA). Combining H2 and H3, we can infer the influence of GSCM on SCA, which is partly realized by improving the resource integration ability of enterprises. The implementation of GSCM by enterprises first triggers the demand and action of integrating and optimizing internal and external resources (H2). This enhanced resource integration capability, as a key dynamic capability, further improves the overall operational efficiency and market competitiveness of enterprises, and finally manifests itself as a sustainable competitive advantage (H3).

4. Empirical analysis

4.1 Data collection and sample characteristics

The subjects of this study are middle and senior managers of manufacturing enterprises in China. The survey time is from September to October, 2024. A total of 300 questionnaires were distributed, and 220 were recovered. After excluding the invalid questionnaires with incomplete answers and obvious regularity (such as choosing "5" in all), 186 valid questionnaires were obtained, with an effective recovery rate of 62%.

Descriptive statistical analysis of valid samples is shown in Table 1. The sample enterprises cover many industries, such as electronic manufacturing (28.5%), machinery and equipment (25.3%), chemical materials (18.3%), food processing (17.2%), textiles and clothing (10.7%), etc. The distribution of industries is relatively balanced, which is helpful to improve the universality of the research conclusions. In terms of enterprise scale, large and medium-sized enterprises with more than 500 employees account for a relatively high proportion (61.3%). This is consistent with the characteristics that GSCM practice is usually more mature in larger enterprises. Most enterprises have been established for more than 10 years (72.6%), indicating that the sample enterprises have a relatively stable business history and supply chain system.

Table 1 Descriptive Statistics of Sample Enterprises (N=186)

Characteristic	Category	Frequency	Percentage (%)
Industry	Electronics Manufacturing	53	28.5
	Machinery & Equipment	47	25.3
	Chemical & Materials	34	18.3
	Food Processing	32	17.2
	Textile & Apparel	20	10.7
Enterprise Size (Number of Employees)	Below 100	35	18.8
	100-499	42	22.6
	500 and above	109	58.6
Years Since Establishment	Below 5	12	6.5
	5-10	33	17.7
	10-20	68	36.6
	Over 20	73	39.2
Respondent's Position	Senior Management (CEO/Vice President)	48	25.8
	Middle Management (Department Manager)	138	74.2

4.2 Measurement model test

The testing of measurement models mainly includes reliability and validity analysis.

Firstly, use Cronbach's alpha coefficient to test the internal consistency reliability of the scale. The results showed that the Cronbach's alpha coefficients of the three latent variables GSCM, RI, and Sustainable Competitive Advantage (SCA) were 0.923, 0.891, and 0.905, respectively, all significantly higher than the acceptable standard of 0.7.

Secondly, the convergent validity and discriminant validity of the scale were tested using confirmatory factor analysis (CFA). In terms of convergent validity, the standardized factor loading of each measurement item on its corresponding latent variable is greater than 0.7, and the t-values are all greater than 2.58 (p<0.01). The combined reliability (CR) values are all greater than 0.8, and the average variance extraction (AVE) values are all greater than 0.5, meeting the requirements of convergent validity. In terms of discriminant validity, the square roots of AVE for each latent variable are greater than their correlation coefficients with other latent variables, indicating good discriminant validity between variables.

The fitting indicators of the overall measurement model are: $\chi^2/df=2.31$, CFI=0.928, TLI=0.915, RMSEA=0.067. All indicators have reached or are close to the standard of good fit ($\chi^2/df<3$, CFI/TLI>0.9, RMSEA<0.08), indicating a good fit between the measurement model and the data.

4.3 Structural model testing and hypothesis verification

After confirming the validity of the measurement model, this study tested the structural model to validate the research hypothesis proposed in the third part. The estimated path coefficients of the structural model are shown in Table 2.

Table 2 Results of Structural Model Path Coefficients (N=186)

Path	Standardized Coefficient (β)	S.E.	C.R.	P-value	Hypothesis Supported
GSCM → SCA	0.321	0.083	3.867	0.000	Yes (H1)
GSCM → RI	0.582	0.081	7.185	0.000	Yes (H2)
RI → SCA	0.413	0.082	5.037	0.000	Yes (H3)

According to the data analysis results in Table 2, all three hypotheses are supported:

H1: The direct path coefficient of GSCM on the sustainable competitive advantage (SCA) of enterprises is 0.321 (p<0.001). This indicates that GSCM has a significant positive direct impact on SCA, suggesting that implementing GSCM itself can bring competitive advantages to enterprises.

H2: The path coefficient of GSCM for enterprise resource integration capability (RI) is 0.582 (p<0.001), indicating a relatively high coefficient value. This indicates that GSCM has a strong

positive promoting effect on RI, verifying that GSCM is an important driving force for enterprises to enhance their resource integration capabilities.

H3: The path coefficient of RI for SCA is 0.413 (p<0.001). This indicates that RI has a significant positive impact on SCA, confirming that resource integration, as a dynamic capability, is itself an important source of competitive advantage.

4.4 Intermediary effect test

To test H4, which posits the mediating role of RI in the process of GSCM influencing SCA, this study employs the Bootstrap method for examination. Using the Bootstrap procedure in AMOS, the research sets 5,000 repeated samples to calculate the confidence interval of the indirect effect.

The test results are shown in Table 3. The indirect effect (i.e. mediating effect) of GSCM on SCA through RI is 0.240 (=0.582 * 0.413). The 95% confidence interval is [0.172, 0.318], which does not include 0, therefore it can be concluded that the mediating effect is statistically significant. Meanwhile, the direct effect of GSCM on SCA remained significant (β=0.321, p<0.001). This indicates that resource integration plays a partial mediating role in the process of GSCM influencing sustainable competitive advantage. That is to say, GSCM can directly enhance the competitive advantage on the one hand, and on the other hand, indirectly and deeply improve the sustainable competitive advantage of the enterprise by significantly enhancing its resource integration capability.

Table 3 Bootstrap Results for Mediation Effect (5000 resamples)

Effect Type	Effect Value	Standard Error (S.E.)	95% Confidence Interval	Significant
Direct Effect(GSCM → SCA)	0.321	0.083	[0.158, 0.484]	Yes
Indirect Effect(GSCM → RI → SCA)	0.240	0.037	[0.172, 0.318]	Yes
Total Effect(Direct + Indirect)	0.561	0.091	[0.383, 0.739]	Yes

The empirical analysis results of this study support the theoretical model and four research hypotheses.

5. Conclusions

This study focuses on the driving mechanism of GSCM on the sustainable competitive advantage of enterprises under the "dual carbon" goal, revealing the core path involved. The empirical results confirm the positive impact of GSCM on the sustainable competitive advantage of enterprises. GSCM can directly enhance a company's market competitiveness by improving resource utilization efficiency and reducing costs, and can also enhance brand reputation by shaping a green brand image. This study validates the key mediating role of 'resource integration'. The impact of GSCM on the sustainable competitive advantage of enterprises is partially achieved through significantly enhancing their resource integration capabilities. This indicates that the value creation of GSCM is not achieved overnight, but rather through the implementation of green practices by enterprises to systematically integrate and optimize internal and external resources.

In the context of the "dual carbon" era, enterprises should deeply recognize that GSCM is not only a measure to fulfill environmental responsibilities, but also a strategic tool to gain long-term competitive advantages. Enterprises should not just stay on the surface of green activities, but should take "resource integration" as the core lever, actively break down internal and external barriers, strengthen supply chain collaboration, and systematically enhance resource integration and reconstruction capabilities.

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