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A Comparative Study of Cross-Border E-Commerce Green Supply Chains Based on Enhanced G-SCOR: JD.com vs. Amazon

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Abstract. Based on existing literature on green supply chains in cross-border e-commerce and relevant data results, this study constructs an improved G-SCOR model that integrates cross-border indicators (such as carbon tariff sensitivity). To scientifically quantify greenness, the research first combines the Analytic Hierarchy Process (AHP) and entropy weight method to determine the weight of indicators, and then establishes a fuzzy comprehensive evaluation model. It applies and validates the model through practical examples from JD.com and Amazon. The results show that Amazon achieves a 90% carbon reduction primarily through sea transportation (accounting for 65%), with AI optimization reducing mileage by 19%, but the packaging recycling rate is only 52%; JD.com's policy-driven recycling rate reaches 74%, and blockchain reduces dispute-related returns by 30%. The model scoring reveals a dual-path differentiation: policy-driven (JD.com) excels in recycling and planning, while market-driven (Amazon) excels in logistics efficiency. The conclusion calls for the establishment of standardized carbon accounting protocols and international EPR mutual recognition to promote cross-border green collaboration.

Keywords: Cross-border e-commerce, green supply chain, carbon emission reduction, comparative case study, G-SCOR model

1. Introduction

The current theoretical system of Green Supply Chain (GSC) is highly concentrated in the manufacturing field, but there are significant theoretical blind spots in the green management of cross-border e-commerce driven by digitalization [1]. The industry faces unique challenges due to obstacles in multi-country logistics collaboration and fragmented environmental regulations, and mainstream models such as G-SCOR have not yet internalized their cross-border attributes, resulting in a lack of adaptability evaluation tools [2, 3]. This study aims to address this dual dilemma and construct an improved cross-border GSC evaluation framework. By integrating cross-border regulatory response modules (such as carbon tariff sensitivity) and digital empowerment dimensions (blockchain/AI collaborative mechanism), the interpretation boundary of the G-SCOR model is expanded. The practical goal focuses on the comparison of dual-drive carbon reduction paths, selecting policy driven (JD) and market driven (Amazon) as ideal types, and revealing the mutual

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construction law between institutional environment and corporate strategy. This article adopts a comparative study of two cases, systematically deconstructing the ESG reports of enterprises and cross-border logistics policy texts, and conducting triangulation with industry benchmarks. It pioneers a cross-border GSC comparative framework at the theoretical level, promoting research on digital supply chains; at the practical level, it provides a low-carbon transformation path for global e-commerce enterprises and a basis for policy coordination and international standards.

2. Literature review

2.1. The evolution of Green Supply Chain theory

The theoretical foundation of the green supply chain originates from the concept of the circular economy and the extended producer responsibility (EPR) system, which requires producers to be responsible for the environmental impact of their products throughout their entire lifecycle. The concept of Green Supply Chain (GSC) is not achieved overnight, and its development process deeply reflects the evolution of human society's understanding of the relationship between environmental protection and economic development. This process can be roughly divided into three stages: germination, concept formation, and theoretical development. Its germination can be traced back to the 1970s and 1980s. At that time, global environmental awareness began to awaken, and governments around the world introduced a series of strict environmental regulations (such as the U.S. Clean Air Act). The focus of this stage is on internal waste management within the enterprise, and a cross enterprise, systematic supply chain management concept has not yet been formed, which can be seen as a passive, reactive environmental management. From the 1990s to the early 21st century, the concept of green supply chain gradually became clear and formed. Research by Jie Xuemei and Zhu Qiwei points out that at this time, green supply chain management (GSCM) practice has been regarded as a strategic tool aimed at managing the environmental performance of upstream suppliers and downstream customers, seeking cost savings and efficiency improvement while reducing environmental impact. However, the debate over whether GSCM is an "innovation pivot" or a "conservative shackle" for corporate performance has also begun to emerge [1].

In the past decade, research on green supply chains has entered a new stage of theoretical deepening and vigorous practical development. The research focus has expanded from traditional linear management to non-linear, networked full-lifecycle environmental management. Digital technologies such as blockchain and big data provide strong support for supply chain transparency and the precise tracking of carbon footprints [5]. In emerging fields such as cross-border e-commerce, the construction and evaluation of green supply chains have become a research frontier, indicating that their theoretical system is constantly maturing and improving [3].

2.2. The particularity of cross-border e-commerce

Compared to domestic e-commerce, which mainly serves a single domestic market, the operational complexity of cross-border e-commerce has increased exponentially. Its supply chain and logistics system must handle multiple challenges such as cross-border transportation, multi-country customs clearance, international payments, tax compliance, and cultural differences, and build a global and networked collaborative system. However, it is precisely this extremely high complexity that has forged its irreplaceable strategic advantage: it not only opens up the global market ceiling with billions of consumers for enterprises, and provides a new channel to break free from domestic red

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sea competition, and achieve brand internationalization and high product premiums, but also forces enterprises to carry out digital and green transformation of their supply chain.

There are currently two core pain points in this field:

Regulatory fragmentation: Differences between the EU Carbon Border Adjustment Mechanism (CBAM) and China's "dual carbon" policy have increased compliance costs by 15%-30% [2];

Inefficient reverse logistics: a high return rate of about 30% (especially in the electronics/fashion category) leads to repeated packaging transportation and landfilling, with less than 20% of returns achieving local resale [3].

2.3. Current research findings and gaps

Research on the isolated application of digital technology in supply chain greening: A large amount of literature has verified the positive role of specific digital technologies in improving supply chain environmental performance. For example, Abbas et al.'s research confirmed the positive impact of information technology capabilities on green innovation and organizational performance; in addition, many studies focus on the application of the Internet of Things (IoT) in real-time energy consumption monitoring and artificial intelligence (AI) in optimizing logistics routes to reduce carbon emissions [6]. However, these studies often view technology as an isolated tool and explore its "point" application benefits, lacking research on frameworks that integrate multiple technologies into an empowering system to systematically solve green practice problems, resulting in a "disconnection" between technology and practice.

Parallel exploration of cross-border e-commerce supply chain and green management: research presents the characteristics of "two parallel lines". However, unfortunately, there is still insufficient research on deeply and systematically integrating the "cross-border" attribute into the green management framework, and the two have not been organically integrated.

Discussion on the Separation of Policy and Market Dual Driving Mechanisms: Existing literature clearly identifies the two driving forces behind green transformation. One is policy regulation (such as Extended Producer Responsibility (EPR) carbon tax), and the other is market incentives (such as brand reputation, and competitive advantages brought by consumer green preferences). However, most studies only focus on the impact of a single driving force, lacking in-depth exploration into how policy enforcement and market incentives can work together and enhance each other, as well as how enterprises can build dynamic capabilities to respond to both mechanisms simultaneously.

3. Theoretical framework and analysis approach

3.1. Improved G-SCOR framework innovation

The traditional green supply chain model faces the dual limitations of static environmental indicators and superficial technological applications in cross-border scenarios. This study adopts two-dimensional deep reconstruction:

(1) Embedding Cross-border Specific Indicators

Carbon tariff sensitivity: measuring the dynamic response capability of the supply chain to heterogeneous carbon regulatory systems, requiring enterprises to establish a decision chain of policy scanning, risk assessment, and path switching; This indicator reflects the adaptability of enterprises in different global carbon policy environments and is a key feature of cross-border green supply chains.

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The complexity of certification costs in multiple countries: quantifying the compliance burden caused by fragmented environmental standards, driving enterprises to develop certification mutual recognition and collaboration mechanisms [2].

(2) Deep integration of digital empowerment

Blockchain-driven trustworthy traceability: building a cross-border, multi-party environmental data sharing network to solve the problem of green information asymmetry. By using blockchain technology, ensure the transparency and traceability of environmental data at all stages of the supply chain, and enhance the trust of consumers and regulatory agencies.

AI-powered dynamic optimization: predicting regulatory trends and return fluctuations through machine learning to achieve preventive resource allocation. AI technology can analyze market and policy dynamics in real time, help enterprises adjust their operational strategies in advance, optimize resource allocation, and improve the adaptability and resilience of the supply chain.

3.2. Case selection and logic

Based on the dual drive theory proposed by Jie Xuemei et al., an ideal type is constructed using the extreme case sampling method [1]:

JD.com (policy driven): As a core practitioner of China's EPR system, its supply chain design embodies a mandatory compliance orientation — from the legalization of recycling responsibilities to the standardization of reverse logistics, forming a complete chain of policy pressure penetrating into business. Driven by policies, JD.com has achieved significant results in packaging recycling rates and green logistics, and its supply chain management is highly dependent on the guidance and support of policies and regulations.

Amazon (market driven): Building a green voluntary mechanism based on the global consumer market, incentivizing sellers to adopt low-carbon practices through algorithmic traffic allocation, and revealing the driving force of market signals on green transformation. The selection of Jingdong and Amazon as cases can fully demonstrate the different paths of policy-driven and market-driven in the green supply chain of cross-border e-commerce. As a representative enterprise of cross-border e-commerce in China, Jingdong's policy-driven model reflects the implementation effect of China's EPR system; as a global e-commerce giant, Amazon's market-driven model demonstrates the role of the global market mechanism in promoting the green supply chain. These two cases have wide influence and representativeness in the cross-border e-commerce field, and can provide a rich foundation of data and comparative analysis for the study.

4. Findings and theoretical analysis

4.1. Green logistics: institutional environment leads technological evolution

Policy-driven (JD. com) technology investment presents localized and deep cultivation characteristics:

The construction of hydrogen energy distribution vehicles and unmanned aerial vehicle networks serves the hard constraints of China's "dual carbon" policy on urban emission reduction [4]; JD.com is deploying hydrogen energy delivery vehicles and drone networks in key cities to reduce carbon emissions from urban logistics. JD.com prioritizes meeting regulatory compliance requirements in technology selection (such as the proportion of green delivery in key cities), forming a policy-responsive innovation path.

Market-driven (Amazon) highlights the logic of globalization efficiency:

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Replacing air freight with sea freight, using AI to dynamically compress transportation mileage, and pursuing the minimization of cross-border carbon intensity per unit of goods;

The application of technology always anchors on economies of scale and the improvement of consumer experience [6].

4.2. Circular economy: compliance enforcement vs. business models

In the cross practice of circular economy and digitization, enterprises have shown two typical paths: one dominated by policy rigidity, and the other driven by market flexibility innovation. At the level of circular economy, JD.com represents a mandatory compliance implementation model. The high packaging recycling rate is mainly due to the legal recycling quota requirements set by China's Extended Producer Responsibility (EPR) system for e-commerce platforms, and the circular practice shows a clear top-down implementation feature, with enterprises often passively meeting policy-mandated minimum requirements [1]. In contrast, Amazon adopts a market flexible innovation model, which certifies refurbished products and provides warranty commitments through the "Amazon Renewed" platform, successfully building a premium space and consumer trust for second-hand goods [4].

4.3. Digital empowerment: trust building vs. efficiency upgrade

In terms of digital empowerment, the differentiation strategies of the two companies are further highlighted. JD focuses on using blockchain technology to resolve trust deficits in cross-border transactions, significantly reducing controversial returns caused by environmental declaration disputes by putting raw material traceability information on the chain [6]. On the contrary, Amazon focuses more on the application of artificial intelligence in improving global logistics efficiency: relying on machine learning to optimize cross-border multimodal transportation solutions, compress redundant transportation links, and achieve dynamic scheduling and global optimization of supply chain resources [3].

4.4. Theoretical reconstruction of dual drive mode

Table 1. Extracting the dual path of green transformation for cross-border e-commerce based on case comparison

Pattern dimension	Policy driven (JD)	Market driven (Amazon)
Core strengths	Local compliance (recycling/policy response)	Global scalability (logistics efficiency)
key challenges	Cross border rule adaptability	Multi country policy coordination costs
Institutional dependence	Strong policy regulatory environment (such as EPR law)	Market competition and brand pressure dominance
Technical Function Positioning	Compliance and compliance tools	Competitive Advantage Amplifier

As shown in Table 1, this study has extracted two typical paths for green transformation of cross-border e-commerce through a dual case comparison, namely "policy driven" and "market driven", which exhibit systematic differences in multiple dimensions. The policy driven model represented by JD.com has its core advantages reflected in local compliance capabilities (such as recycling systems and policy response speed), and its digital technology mainly serves as a support tool for

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compliance standards, highly relying on a strict policy-driven regulatory environment (such as extended producer responsibility systems). In comparative analysis, the market driven model represented by Amazon emphasizes global logistics efficiency as its core advantage and regards technology as a key tool to enhance competitiveness [7]. Its development is driven more by market competition and brand reputation pressure. The two types of models face different challenges: policy-driven models need to address cross-border rule adaptability issues, while market-driven models need to overcome high institutional costs caused by multi-country policy coordination [8]. This comparison highlights the important role of institutional environment in shaping the green transformation strategy of enterprises [9]. In a market-driven model, companies typically respond to policy pressures and diverse consumer preferences through pricing strategies and emission reduction decisions and optimize supply chain competition and emission reduction strategies under regulatory backgrounds such as carbon trading [10-12]. In addition, green technology licensing mechanisms can further promote low-carbon transformation under the platform sales model [13].

5. Conclusion

Research has found that digital technologies such as blockchain and artificial intelligence serve as key enablers for supply chain visualization, tracing carbon footprints, and optimizing processes, fully empowering every link from procurement, and production to recycling. Institutional environmental factors, especially the intensity of policy regulation and market competition, are the core contextual variables that lead to path differentiation. Although this study has certain limitations, such as selecting top enterprises as the cases and expanding to platforms such as SHEIN that focus on emerging markets to enhance universality, targeted policy recommendations can still be proposed based on the conclusions, including promoting the establishment of an RCEP regional green standard mutual recognition mechanism and actively exploring the development of a blockchain-enabled digital "carbon passport" system empowered by blockchain to systematically promote the collaborative and institutionalized development of cross-border green supply chains.

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