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Carbon Emission Reduction in Supply Chain Management: A Literature Review

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ABSTRACT

This study aims to examine the literature on carbon reduction in the supply chain over the past few years and to present the drivers, barriers, and performance indicators. The reduction of carbon emissions is a frequently debated topic due to the potential threats posed by irresponsible industrial actions to sustainability. Companies are seeking to minimize environmental impact by integrating ecological concerns into their supply chain operations. To reduce carbon emissions, the industry must overcome various drivers, barriers, and performance indicators, and the practices adopted are highly varied. Many papers were analysed, showing that good coordination with different media in the supply chain system would achieve common goals for reducing gas emissions.

Keywords: carbon emission, supply chain, performance, environmental impact.

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تقليل انبعاثات الكربون في إدارة سلسلة التوريد: مراجعة أدبية

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ملخـــــص البحـــــث

هدف هذه الدراسة هو مراجعة الأدبيات حول تقليل انبعاثات الكربون في سلسلة التوريد خلال السنوات القليلة الماضية وتقديم المحركات والعوائق ومؤشرات الأداء والممارسات. يتم مناقشة قضية تقليل انبعاثات الكربون بشكل متكرر، حيث تشكل الإجراءات غير المخطط لها وغير المسؤولة من قبل الصناعات تهديدات محتملة للاستدامة. تسعى الشركات الآن إلى تقليل التأثير البيئي من خلال دمج الاهتمامات البيئية في عمليات سلسلة التوريد الخاصة بها. من أجل تقليل انبعاثات الكربون، تواجه الصناعة محركات وعوائق ومؤشرات أداء مختلفة. نظرًا لتنوع المشاكل المواجهة، فإن الممارسات المعتمدة لتقليل انبعاثات الكربون متنوعة للغاية. تم جمع ثلاثين ورقة بحثية من الدراسات السابقة وترتبط بنقاط المناقشة. أظهرت النتيجة أن التنسيق الجيد مع وسائل مختلفة في نظام سلسلة التوريد سيحقق أهدافًا مشتركة لتقليل انبعاثات الغازات.

الكلمات المفتاحية: انبعاثات الكربون، سلسلة التوريد، الأداء، التأثير البيئي.

1. Introduction

Supply chain management is strategically important for sustainability, performance, and organizational success [1, 2]. It plays a vital role in operations management and significantly impacts the environment, particularly regarding emissions, pollution, and public health risks. Inefficient management of upstream and downstream supply chain activities can inadvertently result in high greenhouse gas emissions. The increase in global warming and biodiversity loss has put global sustainability at immediate risk. Experts from various fields, including researchers, academics, practitioners, and scientists, have collaborated to propose solutions for maintaining environmental sustainability.

According to [3], unplanned and irresponsible industrial actions threaten sustainability. Companies are now aiming to reduce environmental impacts by integrating environmental considerations into their supply chain operations, referred to as the "Green Supply Chain" [4] The importance of addressing environmental issues is clear in today's globalized supply chains. Over the past decade, carbon emissions and pollution linked to economic development have caused significant problems like the greenhouse effect, abnormal climate patterns, and environmental degradation [5]. Therefore, companies must improve and carefully plan their gas emission management. Numerous previous studies have explored strategies and scenarios to reduce gas emissions.

This article examines the problem of carbon emission reduction, evaluating the study in terms of drivers, obstacles, and performance indicators. The article is organized as follows: Section 2 reviews the literature, Section 3 discusses drivers and obstacles, Section 4 covers performance indicators, and Section 5 concludes the article.

2. Literature Review

First, [6] posit a strong correlation between annual emissions costs and economic growth, emphasizing the need for decision-makers to consider this when implementing cap-and-trade allowances or designing carbon taxes, especially in industries where production may already be limited below socially optimal levels [7]. Regulatory measures such as carbon cap and trade and investment in green technologies are highlighted as effective methods for carbon emission reduction by [8]. Also, [9] propose network designs to minimize carbon emissions, while [10] recommend four policies—carbon offsets, carbon caps, carbon taxes, and cap and trade systems—to reduce emissions without significant cost escalation, with cap and trade being the most favoured due to its flexibility. [11] employs decomposition structural analysis and path structural analysis methods to identify air pollution emissions and suggests adjusting energy consumption structures and providing consumption guidelines as gradual emission reduction strategies. [12] advocate for promoting carbon reduction technologies to decrease emissions, with a specific policy recommendation being the promotion of renewable energy usage in relevant industries. Thus, [13] develop a recovery supply chain model integrating security stocks and carbon emissions costs to overcome supply disruptions, emphasizing the consideration of environmental impact in supply chain strategies.

Moreover, [2] devised a strategic model for decision-making, taking into consideration the social and operational expenses linked to carbon dioxide emissions within the supply chain. Their analysis encompassed a range of scenarios and case studies involving industrial products. [14] illustrated the potential for collaboration between retailers and manufacturers in carbon emission reduction efforts, determining the most advantageous cost-sharing rates and wholesale price premiums through numerical simulations and analyses. [15] explored government incentive mechanisms aimed at fostering

cooperation among supply chain members to curb carbon emissions, underlining the pivotal role of such collaboration in bolstering environmental performance. In their study, [16] compared the efficacy of two emission reduction strategies—the production strategy versus the joint emission reduction strategy—concluding that the latter proves to be more economically viable for both manufacturers and retailers.

In recent years, there has been a notable surge of interest within commercial and scientific circles regarding the pressing issue of gas emissions. [17] argue that the core objective of emission reduction efforts remains elusive if companies pursue such initiatives independently, without aligning with their trading partners, potentially resulting in inadvertent emission increases within the supply chain. [18 - 20] discovered that integration into the supply chain system can yield substantial reductions in overall costs and carbon emissions. Contractual arrangements should be carefully crafted to ensure seamless coordination among all stakeholders within the supply chain [21]. Effective collaboration among supply chain actors has demonstrated tangible benefits, including lowered transportation costs and carbon emissions. Hence, the effective coordination of the supply chain emerges as pivotal for enhancing performance and reaping the advantages of a globally interconnected supply chain network.

According to [22] emphasize the necessity of effective environmental policies to diminish overall costs within the supply chain, advocating for mechanisms that reduce quantities to align actors across the chain. [23] introduce models for three-tier supply chains, aiming to optimize delivery numbers and sizes, starting from suppliers to third-party logistics (3PL), then from 3PL to buyers, thereby curtailing carbon emissions. [24] scrutinize strategies for curbing shared emissions and designing contracts in multi-channel supply chains within a low-carbon context, endorsing cooperative advertising and emission reduction cost-sharing agreements for supply chain enhancement.

Thus, [25] investigate the efficacy of bulk delivery contracts in coordinating supply chain actors, concluding that both bulk and revenue-sharing contracts effectively synchronize low-carbon supply chains across various scenarios. Dash [26] explore win-win scenarios, underscoring the manufacturer's role in investing in emission reduction and proposing contract frameworks to harmonize supply chains based on optimal order quantity, manufacturer's wholesale price, and carbon emission levels. Then, [11] delve into the coordination effects of emission reduction, illustrating successful coordination of the supply chain system through Revenue-Sharing and Investment Contracts (RIS), facilitating increased profits for suppliers and manufacturers without repercussions from carbon caps. [27] also achieve a low-carbon supply chain through revenue-sharing agreements.

On the other hand, [28] posit that cost-sharing and wholesale contracts can efficiently coordinate supply chain systems under cap-and-trade regulations, ensuring reductions in carbon emissions without compromising individual profitability. [29] craft an optimal pricing strategy model for environmentally friendly supply chain systems, stressing robust coordination between government and manufacturing entities to enhance system performance.

According to [30] explore pricing and stakeholder coordination in green supply chain systems, highlighting the superiority of cooperative games over non-cooperative ones. They propose employing Revenue Sharing (RS) and Revenue Recovery Sharing (RRS) contracts to coordinate the system, with RRS contracts demonstrating superior coordination and profitability.

Thus, [31] analyze competing supply chains under cap-and-trade regimes, suggesting profit-sharing contracts offered by retailers as an effective means of achieving win-win solutions between manufacturers and retailers while enhancing environmental benefits through emission reductions. [32]

suggest that cap-and-trade acceptance among supply chain members depends on strong consumer preferences for low-carbon products.

Finally, [33] suggest that cooperative advertising and emission reduction cost-sharing agreements can facilitate channel coordination and achieve win-win outcomes under specific conditions. [34] demonstrates that addressing late payments can improve both economic and environmental performance within the supply chain system.

3. Drivers and Barriers

Different factors drive or hinder the implementation of strategies aimed at reducing carbon emissions within a supply chain system. The drivers in this context refer to elements that motivate companies to adopt measures to reduce carbon emissions, such as enhancing corporate reputation or responding to competitive pressures. Conversely, barriers represent obstacles that impede certain processes from effectively reducing carbon emissions.

According to research conducted by [35], carbon emission reduction drivers can be categorized into internal and external sources.

- **Internal sources of carbon reduction engines:**
  - The green image of the company
  - The requirement of ISO 14000
  - Internal environmental awareness
  - Resource efficiency through waste reduction
- **External sources of carbon reduction engines:**
  - Government regulation
  - Regulation of an environmental group
  - Outreach to trading partners
  - Competitive pressure due to competitors
  - Business Partner Requirements

Similarly, barriers to reducing carbon emissions are also classified into internal and external sources:

- **Internal sources of barriers to reducing carbon emissions**:
  - Resistance to organizational change
  - Lack of financial resources to invest in cleaner technologies
  - Lack of internal awareness of environmental issues
  - Operational or technical constraints
- **External sources of barriers to reducing carbon emissions:**
  - Restrictive or ambiguous government regulations
  - High costs of green technologies or emission reduction measures
  - Competitive pressures related to market practices
  - Lack of collaboration or coordination with trading partners

4. Performance Indicator

In the context of assessing the effectiveness of carbon reduction policies, performance indicators play a crucial role. A performance indicator serves as a metric to gauge the success of implementing these policies. Economic factors are commonly used as performance indicators due to their direct correlation

with business outcomes. According to research by [36], performance indicators are typically categorized into three main groups: First, Economic performance indicators focus on evaluating the financial impacts of carbon reduction efforts. These indicators encompass various aspects such as cost minimization, identification of new market opportunities, profit margins, sales growth, market share, net income, cost of goods sold (C.O.G.S), overall company performance, and the financial burden imposed on customers. Second, Environmental performance indicators, on the other hand, highlight the ecological ramifications of carbon reduction initiatives. These metrics include waste minimization strategies, environmental impact assessments, and measures to mitigate pollution levels. Finally, Operational performance indicators assess the efficiency and effectiveness of operational processes in achieving carbon reduction objectives. These indicators encompass improvements in efficiency, quality, productivity, accuracy and speed of delivery, level of flexibility, overall operational performance, and efforts to minimize production lead times. By analysing these performance indicators across the three dimensions, organizations can comprehensively evaluate the impact of their carbon reduction strategies on both economic and environmental fronts.

5. Conclusion

In conclusion, this study sheds light on the importance of addressing carbon reduction within the supply chain. The literature review highlights the ongoing debate surrounding carbon emissions and emphasizes the need for proactive measures to mitigate environmental impact. Companies are increasingly recognizing the significance of integrating environmental considerations into their supply chain operations. However, effectively reducing carbon emissions requires overcoming a multitude of drivers, barriers, and performance indicators, reflecting the complexity of the challenge. The analysis of most papers underscores the critical role of coordination across various channels within the supply chain system in achieving collective goals for reducing gas emissions. Moving forward, fostering collaboration and implementing innovative strategies will be essential in advancing sustainability efforts and mitigating the adverse effects of carbon emissions on our environment.

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