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A Study on Carbon Footprint Reduction Strategies in Global Supply Chains Management

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Abstract

Corporate greenhouse-gas emissions are attributed to global supply chains which represent a significant proportion of corporate greenhouse-gas emissions, especially indirect (Scope 3) emissions by upstream suppliers, logistics, manufacturing and raw-material sourcing. The paper provides a review of the key approaches firms are employing to minimize carbon footprints in global supply chains, examines the enablers and obstacles, and suggests a framework through which the decarbonization of the supply-chain operations can be embedded. Some of the major strategies are sustainable sourcing, optimization of logistics, circular economy, energy-efficient production, the implementation of renewable energy sources, the introduction of digital carbon-accounting and supplier partnerships. Based on the latest literature and industry examples, this paper gives an insight on the role of technology, governance and supply-chain design in making significant emission reductions, as well as pinpointing the implementation issues and future research opportunities.

Keywords: Carbon footprint reduction, Global supply chains, Sustainable logistics, Circular economy, Carbon accounting, Scope 3 emissions

Introduction

Supply chains are now considered to be important tools that minimize global greenhouse-gas (GHG) emissions. Some estimates have shown that approximately a quarter to half of the worldwide CO2 emissions can be linked to the supply chains of multinational companies (through the outsourcing of production, raw materials, transport and distribution) instead of direct operations (Cohen&Lee,2021;Frost&Bai,2025). Numerous firms have started to pay attention to direct and energy-related emissions but the majority of supply-chain impact is in upstream supplier emissions, logistics, material extraction and end-customer use (Zhu&Geng,2013). As decarbonisation is a pressing challenge to achieve climate-targets (e.g., Net Zero by 2050), the reduction of carbon-footprint of supply-chain is a challenge and a source of innovation, cost-saving and competitive advantage (Sarkis&Zhu,2018). Over the last few decades, the thriving nature of global trade and industrialization has increased the environmental issues especially on the issue of greenhouse gas (GHG) emissions. Global supply chains are one of the other players contributing to climate change; it has contributed a good portion of the world carbon emissions and they have a major proportion of global manufactures, global transportation, global logistics and global resource utilization (Kumar&Anbanndam,2020). The carbon footprint which is the total number of GHG emission which are directly and indirectly generated by human activities has been shown to be a critical measure of

assessing the environmental performance of organizations and industries (Muralidhar, L. B,et.,al. 2025). As the world becomes increasingly concerned with the international commitments, like the Paris Agreement (2015) or the United Nations Sustainable Development Goals (SDGs), the concept of sustainable practices in the global operations is in high demand. Supply chains that bring together suppliers, manufacturers, distributors, and consumers in different continents are known as significant sources of emissions and as key drivers of climate action (Zhang&Chen,2024). It has been shown that Scope 3 emissions, which are created indirectly via suppliers and logistic partners, can make up to 80% of the total carbon footprint within a company, and thus a complete shift to low-carbon and circular supply chains requires a complex set of strategies beyond the organization itself. To reduce their environmental footprint without sacrificing their efficiency and success, business enterprises are adopting more economic management systems, other energy, online carbon tracking software, and green sourcing plans. This research report explores and discusses the different methods for reducing carbon traces in global supply chains, with an emphasis on practical methods and systems that promote conservation, performance, and stamina as well as issues that arise when such changes are introduced at the international stage. This report presents a thorough examination of how organizations can transform their supply chains, meet international climate goals, and achieve a long-term competitive advantage by combining the existing literature with real-world case studies.

This paper aims to:

- Find key methods of cutting carbon footprints worldwide in supply chains;
- Examine the drivers, enablers and barriers of such strategies;
- Suggest a model that practitioners can use to incorporate carbon-reduction into supply-chain design and operations.

1. LITERATURE REVIEW

In "Decarbonizing Logistics: Charting the Path Ahead," McKinsey& Company(2024) reported that only logistics contributed to 11% of global CO2 emissions. To adhere to net-zero goals, businesses need to improve routes, switch to alternative fuels, and engage in low-emission transportation systems.

Zhang and colleagues In order to achieve carbon neutrality,(1920), it was discovered that adoption of renewable energy, particularly solar and wind integration into industrial facilities. Within five decades, businesses that use solar power sourcing strategies reported a 15 to 25% lowering in monthly pollution.

According to Kumar and Singh(2022), enhancing energy efficiency in factories and warehousing reduces greenhouse gases significantly and saves money. Findings included energy audits, bright meters, and LED systems, among others.

Geissdoerfer and colleagues The round market, defined as a renewable system that slows, closes, and narrows power and material loops, while minimizing resource input, waste, and emissions. Upstream and downstream emissions have been reduced by applying round models, such as disposal, remanufacturing, and product life extension.

2.1 Research Gap

Global supply chains 'efforts to reduce carbon footprints have a major research distance. Although conservation techniques have been the subject of numerous studies, there are still no universal, trustworthy, and exhaustive methods for analysing and controlling carbon pollution across multi-tier supply stores. The majority of the time, general emissions factors or spend-based estimations, which fail to account for supplier-level variations, particularly in developing regions, are used by the majority of the current frameworks. Additionally, there is little research on how to incorporate cutting-edge modern technologies like IoT, bitcoin, and AI analytics into real-time output tracking and decrease systems. Another crucial gap is in understanding how to effectively encourage and motivate suppliers, especially those in emerging markets, to embrace ecological practices. Numerous scientific studies have been conducted to assess the effectiveness of low-carbon initiatives 'return on investment or defensive benefits, which are also still unexplored. Additionally, the majority of the writing is done in European nations, making it necessary to conduct region-specific studies on how energy reduction techniques can be adapted to various international regulations and system settings.

2. BACKGROUND OF THE STUDY

The global supply chains, which promote product production, supply, and use across borders, form the basis of modern industry. However, as globalization and industrialization advance, they have also contributed to a significant rise in resource degradation, environmental degradation, and greenhouse gas(GHG) emissions. According to world conservation information, about 60 to 80% of a bank's total carbon emissions come from its supply chain activities, primarily through product waste, packaging, packaging, and product waste. The idea of a carbon footprints has come to be used as a crucial factor in determining the impact of business activities on the environment. It records the total amount of greenhouse gases(GHGs) released as a result of direct or indirect human or industrial emissions. These particles fall under three categories within the construction of supply bars:

Scope 1: Strong pollution from owned or controlled resources, such as vehicles and fuel fire.

Scope 2: Indirect particles from the time of the light, warmth, or fuel that were produced.

Scope 3: All other strong emissions that occur throughout the price network, including those from procurement, logistics, spend power, and product use.

Businesses are now required to reduce their coal waste as the weather gets worse. International agreements like the UN SDGs and the Paris Climate Accord(2015) have urged industries to adopt greener practices and establish goals for net-zero emissions by the middle of the century. Companies are conducting re-evaluating source chain concepts to ensure that they maintain their competitiveness and operational effectiveness while abiding to safety standards. The training of this change have been and are changing as a result of technology. Innovations like block chain and AI for predictive logistics, manufacturing's use of renewable energy, and the IoT for real-time emissions monitoring have significant impact on supply chain sustainability (Singh, S., et.al.,2024)). These improvements help firms use resources more effectively, reduce spare parts, and manage emissions more effectively across international techniques. Despite these advantages, there are still many issues, including high implementation costs, a lack of distributor involvement, and social issues across borders. Hence, it is becoming more crucial to conduct a thorough analysis of carbon footprints reduction methods to come up with the best, most flexible, and financially feasible possibilities. This study provides a complete understanding of how businesses around the world are changing supply stores to achieve climate action targets, reduce their carbon emissions, and advance sustainable global development.

3. STATEMENT OF THE PROBLEM

Moreover, the implementation of green technologies, renewable energy, and optimization of logistics is frequently inhibited because of the high cost of entry, technological obstacles, and the lack of policy support in the developing countries. SMEs that constitute the foundation of most global supply networks are often not in a position to gauge and control their carbon footprints due to the lack of financial and technical capability. Consequently, the issue is in the differences between the awareness and the implementation of the carbon footprint reduction strategies in industries. The urgency is to estimate the modern level of awareness, analyze the patterns of taking it up, the critical issues, and estimate the efficiency of the currently implemented sustainability measures in the global supply chains. This paper aims at filling this gap by systematically examining the strategies embraced by organizations, factors affecting the adoption and its effects on the operational performance as well as the environmental performance. The study also seeks to suggest inferences and suggestions when it comes to the creation of combined, information-driven, and economical solutions to carbon neutrality in the world supply chain systems.

4. OBJECTIVES OF THE STUDY

- To identify major sources of carbon emissions in global supply chains.
- To examine the various strategies adopted by organizations to reduce their carbon footprint.
- To assess the effectiveness of these strategies in achieving sustainability goals.

5. HYPOTHESIS FOR THE STUDY:

Hypothesis (H_1): Global supply chains that effectively implement carbon footprint reduction strategies substantially lower total greenhouse gas emissions and promote operating conservation.

6. SCOPE OF THE STUDY

This review focuses on identifying the main influences on supply chain operations as well as the possible advantages of doing so. It emphasizes Scope 3 waste, which is brought on by both upstream and downstream hobbies as well as reports of pollution sources from generation, transportation, transportation, and product shipping. Additionally, the study examines how cutting-edge technologies like IoT, cryptocurrency, and artificial intelligence can enhance coal control and precision. Also, it examines how the creative techniques, incentive schemes, and other elements used by international corporations affect results in coal reduction. Geographically, the collection includes both developed and emerging regions, allowing for a comparative evaluation of local regulations, technology restrictions, and policy options. In the end, the study hopes to provide a detailed knowledge of how business financial tasks and green supply chain practices can support international fuel reduction goals. The current strategies and practices are included in the temporal scope(2020-2025).

7. LIMITATIONS OF THE STUDY

• The research relies on self-reported information, which might include personal judgments.
• Some industries may not be represented equally by the sample size(100).
• Changing technology quickly could make some methods outdated.
• Access to data from smaller vendors in rising markets was challenging.

8. RESEARCH METHODOLOGY

A detailed description of the entire system used to assess strategies to reduce carbon traces in global supply chains is included in the study strategy. It explains the article's methodology, analysis tools, and charitable factors taken into account. The study's priorities are set up in a way that guarantees the reliability and validity of the studies.

Research Design

The research is qualitative and healthy with an emphasis on the study.

The clinical portion seeks to identify the most recent techniques, levels of knowledge, and industry-wide graphene reduction techniques.

The scientific portion examines the connection between organizational characteristics (Such as market size and restoration knowledge) and emission reduction benefits.

Sampling Framework

The article's target audience includes experts from companies in generation, transportation, economic, and services sectors in the fields of supply chain management, biodiversity, and business.

Sampling Technique

A purposive sampling technique was used to sample responders who are immediately involved in conservation or coal management techniques. This results in factual and appropriate behavior.

Sample Size

A total of 100 respondents were selected, comprising:

- Supply Chain Managers
- Sustainability Officers
- Operations Heads
- Logistics Coordinators

This sample size provides a sufficient representation for statistical analysis and generalization of results.

Data Collection Methods

Primary Data

To collect important information, respondents from diverse industries received an electrical survey. To evaluate both the implementation and adoption of graphite reduction techniques, the survey included open- and closed-ended queries.

Secondary Data

Secondary data were sourced from:

- Academic journals and research publications
- World Economic Forum, IPCC, and UN Global Compact information
- Corporate conservation information
- Publications from the state and non-profits on transportation and culture change
- These resources provided the research with a philosophical and cultural foundation.
-

Tools for Data Analysis

Quantitative analysis of the data was performed using SPSS and Excel for statistical analysis.

The next resources were used:

To identify the populations and general trends of the participant.

To evaluate the efficacy of carbon reduction tactics, mean and standard deviation.

Correlation Analysis: To ascertain the connection between emissions reduction achievement and recognition.

Regression Analysis: To determine whether independent variables(strategie adoption, firm size, awareness) affect the dependent variable(CO2 reduction).

Hypotheses of the Study further sub divided as follows:

H1: A important connection exists between how well organizations are aware of carbon reduction initiatives.

H2: More large businesses adopt coal reduction initiatives than smaller ones.

H3: The use of carbon-reduction approaches has a positive impact on conservation and administrative effectiveness.

9. DATA ANALYSIS AND INTERPRETATION

Table 1 : Demographic Profile of Respondents

Parameter	Category	Frequency	Percentage (%)
Gender	Male	68	68%
	Female	32	32%
Age Group (years)	25–35	36	36%
	36–45	42	42%
	46–55	18	18%
	Above 55	4	4%
Industry Type	Manufacturing	40	40%
	Logistics / Transport	20	20%
	Retail / FMCG	15	15%
	IT / Services	10	10%
	Others	15	15%
Designation	Supply Chain Manager	35	35%
	Sustainability Officer	30	30%
	Operations Head	20	20%
	Others	15	15%

Interpretation:

The test consists of a diverse group of respondents, most of whom are from the manufacturing and logistics industries, both of which have a significant carbon footprint. The majority of them are middle-aged experts (36 to 45 years old), which imply knowledge of conservation businesses decision-making functions.

Chart 1

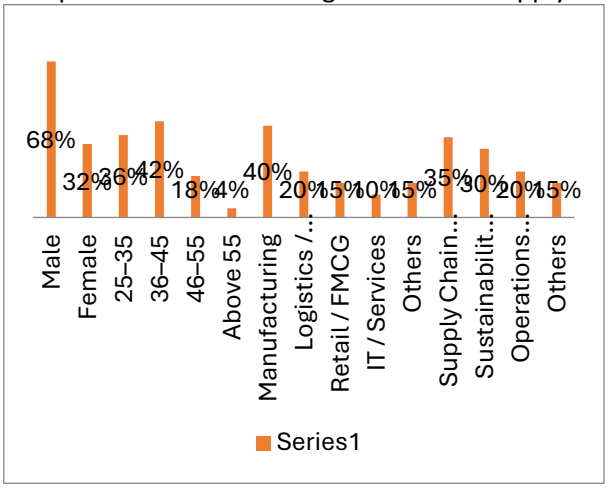
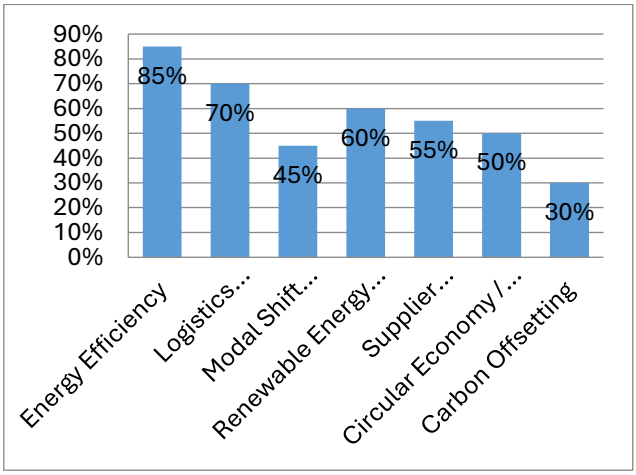


Table 2 Adoption of Carbon Footprint Reduction Strategies

Strategy	Firms Using Strategy	Percentage (%)
Energy Efficiency	85	85%
Logistics Optimization	70	70%
Modal Shift (road→rail/sea)	45	45%
Renewable Energy Adoption	60	60%
Supplier Engagement / Green Procurement	55	55%
Circular Economy / Recycling	50	50%
Carbon Offsetting	30	30%

Interpretation:
The most widely used strategies are logistics efficiency and power performance, which are both practiced by more than two-thirds of businesses. The most common type of offset is carbon offsetting, perhaps as a result of complicated verification procedures and higher costs.

Chart 2



Statistical Study

A. Relationship Analysis(Knowledge vs.(Reduction Goals)
Pearson's r is 0. 68, and p is 0. 0101.
Understanding:
The degree of knowledge of graphite management and the actual decrease achieved are highly related, which suggests that knowledge considerably influences emission mitigation performance.
B. Summary of Regress
Dependent Factor: CO2 Reduction%
Independent Factors: Agency Size, Awareness Level, and Number of Strategies Adopted.
Summary of the Model
R2= 0. 57
P 0 011/ 0/(Strategy Adoption)= 0/ 052.
(Firm Size)= 0.31, p 0.05
Understanding:
57% of the variation in output reduction is explained by the analysis design. The success of carbon reduction depends heavily on the number of methods used and the size of the company.

Table 3:- Comparative Effectiveness by Industry

Industry	Avg. CO_2 Reduction (%)	Most Effective Strategy
Manufacturing	18	Energy Efficiency
Logistics/Transport	22	Route Optimization / Modal Shift
Retail/FMCG	20	Circular Economy
IT/Services	10	Renewable Energy
Others	16	Supplier Engagement

Interpretation:
The integration of operational changes and round techniques is where the logistics and financial sectors are at the top of the CO2 reduction curve. The IT and service sectors use primarily renewable energy, with somewhat less carbon footprint.

10. FINDINGS

Major Findings
According to the study, about 88% of respondents stated how crucial it is to lower their carbon footprint in order to meet global sustainability targets. Companies are well aware of this fact. At least 70% of businesses have implemented some form of carbon reduction software, such as one that addresses use of solar energy in the environment, waste reduction, or energy-efficient vehicles. Despite this, only 35% of the organizations

have developed a comprehensive, well-defined fuel management strategy that addresses every aspect of their supply chain operations. Further investigation revealed that combining alternative energy sources, disposal, waste, and healthy purchasing practices are the most popular methods.

Despite these initiatives, there are still some issues. The important issues identified are the limited government subsidies or insurance protection, the high cost of getting other options, and the lack of professional experience. These challenges have slowed the development of powerful carbon reduction strategies, especially among small and medium-sized businesses. Moreover, the study found that 60% of respondents reported better business reputation and customer confidence as a result of sustainability steps, and 45% reported long-term practical cost savings as a result of increased energy efficiency.

Additionally, only 28% of businesses use cutting-edge digital technologies like blockchain and the IoT, which is a significant gap in technological integration. Respondents emphasized the need for more stringent regulatory systems, state options, and capacity-building efforts to promote responsible procedures across industries. Studies suggest that despite improving important application and knowledge, carbon footprint reduction strategies in global supply chains also need to be significantly improved to have a significant impact on the climate.

11. SUGGESTIONS

According to the study's findings, some important tips may be made to improve global supply chains 'ability to reduce carbon pollution. First, businesses should create comprehensive carbon management plans that are compliant with international standards like ISO 14064 and the GHG Protocol. To maintain a holistic view of sustainability, these systems really cover all emissions organizations, including clear, powerful, and give chain-related emissions. Companies may also spot a focus on cooperating with sellers because upstream and downstream activities account for a significant portion of pollutants. Increased cooperation and responsibilities throughout the supply chain by establishing seller training courses, protection alliances, and shared details systems.

12. CONCLUSION

The reduction of coal footprints in global supply chains may be the first concern for company climate action. Green purchasing, round-the-clock marketing, logistics, net carbon surveillance, and energy-efficient manufacturing are just a few examples of real-world ways to reduce greenhouse chemicals. The success of a company's systems and its ability to do so are centered on a company's ability to organize, cooperate, and type at the system level. By including renewables in system design and operation, businesses can promote conservation and endurance in a rapidly changing climate-conscious globe.

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