

A Study on the Role of Carbon Offsetting in Sustainable Supply Chains Encouraging Low-Carbon Footprint Practices

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Abstract

In this paper, carbon offsetting in contributing to making the supply chains sustainable in manufacturing businesses is under analysis. Given rising environmental challenges, carbon offsetting has appeared to be central among strategies geared toward decreasing global supply chain carbon footprint. Carbon footprint investment, awareness of a company's footprint, low- carbon supplier preference, government compliance policies, and new technology influence contribution to a supply chain as a sustainable undertaking have been subjected to inquiry under research. The research uses a descriptive research design, gathering information from 112 manufacturers and suppliers using questionnaires and interviews and secondary data based on industry and academic sources. Quantitative and qualitative analysis are used to test the impact of different factors in the adoption of carbon offsetting practices. The research points out the benefits of carbon offset programs in lowering carbon emissions, improving brand image, cost savings, and compliance with regulations. Challenges including low awareness of low-carbon suppliers and the necessity of thirdparty verification for offset programs are also pointed out. The study concludes by offering practical suggestions for companies to adopt efficient carbon offsetting strategies, such as greater investment, improved visibility of suppliers, and building transparency through third-party certification. In the end, this research emphasizes the importance of carbon offsetting in building sustainable and competitive supply chains, which will lead to long-term environmental and economic advantages.

Keywords

Carbon Offsetting, Sustainable Supply Chains, Manufacturing, Carbon Footprint, Low-Carbon Suppliers, Compliance, Cost Savings, Transparency.

Introduction

To With the growing international concern regarding climate change, companies have started embrace sustainable methods, with carbon offsetting taking center stage in minimizing environmental footprint. In line with sustainability ethics, companies can offset their carbon footprint by investing in carbon offset projects, increasing awareness along their value chains, and selecting low-carbon-footprint suppliers. Carbon offsetting involves compensating for unavoidable emissions through supporting initiatives that offset or capture carbon dioxide emissions, including renewable energy, forestation, and energy efficiency initiatives. In today's business environment, businesses are not only responsible for their direct emissions but also for the carbon content in their supply chains. Consequently, organizations are increasingly incorporating environmental factors into procurement choices, favoring suppliers that share low-carbon goals. This change is not only good for the planet but also boosts brand reputation, regulatory compliance, and long-term business resilience.

The aim of this research is to investigate the importance of carbon offsetting within sustainable supply chains and how it contributes to minimizing the overall carbon footprint. It delves into the ways companies can effectively integrate carbon offset practices, impact the selection of suppliers on the basis of sustainability parameters, and generate

awareness of carbon emissions throughout the supply chain. By learning about these factors, companies can make contributions to worldwide climate objectives while being competitive in a green-sensitive market.

| Area of my industry | |
|---------------------|---------------------------------|
| Sample size | : 112 supplier and manufacturer |
| Targeted people | : supplier and manufacturer |
| Type of Industry | : Manufacturing Industry |

Variables of the study : The research examines the contribution of carbon offsetting to sustainable supply chains, with particular attention to independent variables such as investment, awareness, preference for low-carbon suppliers, government regulations, technological innovations, and moderating variables such as industry type and economic conditions.

Review of literature

Tang, S., Wang, W., & Cho, S. (2014). This study investigates logistics outsourcing as a means of minimizing carbon footprints through collaboration with third-party logistics service providers. LTL shipping has the potential to decrease transportation costs without decreasing inventory replenishment frequency. It can, however, lead to increased lead-time due to network structure. Analytical models are formulated to investigate the effect of logistics outsourcing on emissions reduction and related costs.

Eloranta, A. (2021) This thesis examines the marketing potential of voluntary carbon offsetting for firms as a quick fix to climate change. The research centers on the impact of types of

compensation projects on purchase intentions and case company Wiima Logistics Oy. In April 2021, an online survey was administered among 60 Finnish clients. The results indicated that firms with defined carbon neutrality targets paid for emissions more than those without. Carbon neutral transport services were of most interest to companies with definitive goals, with renewable energy and forestry-related projects being the most desirable offset project types. The research offers useful data regarding clients' need for carbon compensated transport services that could be applied to future strategy formation. The research also underscores the necessity of driving sustainable practice and the conceivable advantages of carbon offset projects.

Ngilangwa, B. N. (2015) Countries are being forced to impose environmental restrictions due to the growing effects of climate change. Organizations can comply by reducing these impacts through carbon offset schemes. Organizations invest in carbon offset projects as a result of compliance, which also improves supply sustainability and energy efficiency. Corporate social responsibility, customer pressure, growing raw material costs, shareholder values, and product rivalry are further factors.

Suchona, M. A., Sabah, S., & Mamun Habib, M. (2024). This study highlights the need for visible action against climate change by examining the challenges to scope 3 emission reduction programs in the logistics sector, including as regulatory restrictions, financial barriers, and the lack of technology and monitoring assistance. Using a qualitative methodology, information was acquired by meeting and interviewing at least 500 Bangladeshi green factories. Political obstacles and a lack of time prevented the research from continuing and gathering more data. identifies several obstacles to climate action in the logistics sector, such as a lack of technology, high costs, restricted access, a shortage of qualified personnel, difficulties with monitoring and reporting, and a lack of cooperation. It highlights the need of coordinated action in changing the logistics environment towards sustainability and implies that awareness and cooperation can aid in lowering Scope 3 emissions.

Dhanda, K. K., & Hartman, L. P. (2011) The market for carbon offsets is examined in this article as a reaction to the growing contribution of carbon emissions to global warming. Numerous suppliers have appeared under both regulated

and voluntary regimes, despite the fact that it is relatively new. However, providers lack a consistent quality or certification framework because of a lack of technical knowledge. A thorough grasp of the offset market, its potential for carbon neutrality, and the moral dilemmas it raises are the main goals of this study. The standards environment for offset providers is also described, emphasizing the necessity of a unified set of standards for consumer stakeholders. The results can assist consumers and providers in making well-informed decisions about the reduction of carbon emissions.

Su, L., Cao, Y., & Zhang, W. (2023). This study examines how supplier decision-making and coordination methods in low-carbon supply chains are impacted by consumer preferences using game theory models. The findings indicate that when consumers' sensitivity to retail prices, promotional rates, and carbon emission reduction increases, producers and retailers are more inclined to create and market low-carbon items. This emphasizes how crucial customer preferences are in guiding suppliers' tactics.

Objectives of study

- 1. To analyze the impact of carbon offsetting initiatives on supply chain sustainability.
- 2. To bring awareness of carbon footprint in the value chain and give preference for low carbon footprint suppliers
- 3. To provide recommendations for businesses to integrate effective carbon offset practices in their supply chains.

Methodology of study

This research employs a descriptive research design to explore the function of carbon offsetting in sustainable supply chains with emphasis on manufacturing industries. The data is gathered through questionnaires and interviews with 112 manufacturers and suppliers and secondary data from review of literature , websites, and research thesis. A purposive sampling approach is employed to identify suppliers and manufacturers involved in sustainable supply chain activities. Data analysis comprises quantitative statistics to determine supplier preferences and levels of awareness, and qualitative analysis to determine industry views on carbon offsetting challenges and advantages. Independent variables are investment in carbon offset programs, carbon footprint awareness, low-carbon supplier preference, government regulations, and technological advancements. Dependent variables are industry type and economic conditions influencing sustainability adoption. This systematic assessment provides actionable guidance for firms to incorporate successful low-carbon strategies.

Data Analysis

| DOGRAPHIC FACTORS | PARTICULARS | FREQUENCY | PERCENTAGE |
|----------------------|----------------|-----------|------------|
| GENDER | MALE | 78 | 69.6% |
| | FEMALE | 34 | 30.4% |
| AGE | 18-24 Years | 38 | 33.9% |
| | 25-34 Years | 40 | 35.7% |
| | 35-44 Years | 13 | 11.6% |
| | 44-54 years | 11 | 9.8% |
| | Above 55 Years | 10 | 8.9% |

Table i. Table indicating demographic details of the respondents



| EDUCATIONAL OUALIFICATION | High School Diploma | 11 | 9.8% |
|------------------------------|----------------------------------|-----|-------|
| | Associate Diploma | 9 | 8% |
| | Bachelor's Degree | 42 | 37.5% |
| | Master's Degree | 48 | 42.9% |
| | Doctorate / PhD | 2 | 1.8% |
| Size of the oraganization | nSmall (1 – 50 employees) | 28 | 25% |
| | Medium (51–250 employees) | 48 | 42.9% |
| | Large (251–1,000) | 22 | 19.6% |
| | Enterprise (1,000+ employees) | 9 | 8% |
| | Self-employed/ Freelancer | 5 | 4.5% |
| Employed Status | Employee Full time | 85 | 75.9% |
| | Employee part time | 3 | 2.7% |
| | Self Employed | 6 | 5.4 |
| | Student | 18 | 16.1% |
| | TOTAL | 112 | 100 |



Figure i. Chart representing demographic details of the respondent

Inference: The survey indicates 69.6% of men, showing there is a gender imbalance or increased male participation within the area of study. A majority of 18-34-year-olds responds, showing the younger age range is more involved in

the area of study. A majority of 80.4% possesses a Bachelor's or Master's degree, reflecting a highly qualified group. Most (67.9%) respond from small and medium-sized firms, showing further involvement in the area of study. Most (75.9%) are full-time workers, and students (16.1%) report future employment. The lesser coverage of part-timers and self-employed implies minimal contribution from flexible or independent employees.

Table ii. Table indicating statements of the impact of carbon offsetting initiatives

| | Imp | mpact of carbon Strongly A | | | | | | ٩gre | e | | 35 | | 31.39 | | | | | % | | | | | | | | |
|-----|--|----------------------------|----------------------------|--------------------------|------------------|--------------|-------------------|------------------|-------------------|------------|----------|---------------------|------------------------|----------------------|-------------------|--------------------|-------------------------|--------------------------|-----------------------|------------------|-----------------|------------------------------------|-------------------------------------|-------------------------------|--------------------------------------|------------------|
| | and | l dir | ect | pip | elir | ne | | A | gre | е | | | | 30 | | | | | 26 | 6.8 | % | | | | | |
| | routes on supply chain sustainability | | | | | | N | leut | ral | | | | 24 2 | | | | | | 21.4% | | | | | | | |
| | | | | | | | D | isa | sagree | | | | 12 1 | | | | | |).7º | % | | | | | | |
| | | | | | | S | Strongly Disagree | | | | | | | | | | | 9. | 8% |) | | | | | | |
| | | | | | | Т | TOTAL | | | | | | 112 1 | | | | | 1(| 100 | | | | | | | |
| 120 | 222 | 2223 | 2222 | 2222 | | 222 | | | 2222 | 3333 | 2222 | 222 | | 12222 | | 2222 | 2222 | 2223 | | 2222 | 2222 | 2222 | 2223 | 222 | | 112 |
| 100 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 80 | %0 | 5% | %0 | .5% | 5% | Yes | ays | nes | -ely | 9 | ied | ied | tral | ied | | | | | ree | | | | न | ree | | |
| 60 | 50 | % - 2 | % - 5 | - 1% | then 7 | | Alw | ometin | Rar | | ' Satisf | Satisf | Neu | ssatisf | | | | | Disag | | | | Neuti | Disag | | |
| 40 | | \$ ⁴ | 26 | 51 | More . | 39 | | 32 | | | Anav 4 | 26 | 36 | ā | | 27 | 35 | 24 | | | 35 | 30 | 24 | | | |
| 20 | | | 17 | 10 | | 88 | 15 | 33 | 14 | 12 | | | | 15 | 11 | | | | 15 | 11 | | | | 12 | 11 | |
| 0 | 38 | 88 | 22 | 23 | 3 <u>4</u> 33 | 22 | 3 3 | 3 3 | 2 2 | 88 | 22 | 2 | 88 | 12 2 | 5 5 | 2 <mark>0</mark> 2 | e B | | 2 | e B | e e | e B | 88 | 88 | e | |
| | | | | | | | | | | | | | | | Very Dissatisfied | Strongly Agree | Agree | Neutra | | Strongly Disagre | Strongly Agre | Agre | | | Strongly Disagre | ТОТА |
| | Anr bud ca | ual s get a arbor | iustai alloca n offs | inabi ation settin | lity for g | Inve off: | estmo settii | ent ir ng ini | n cark itiativ | oon /es | Savail | atisfa able o | ictio carb ptior | n wit on of ns | h ffset | Tr verif | ust ir fied c pro | n thire arbo ograr | d-par n offs ns | ty set | Imp i pip | act o nitiat oeline chair | f carl tives e rout n sust | oon o and es or aina | offset direct n supp bility | ting : oly |

Figure ii. Chart representing statements of the impact of carbon offsetting initiatives

Inference: The majority of sustainability budgets allocate only 0%-10% to carbon offsetting, with 48.2% actively investing. However, a significant portion (23.2%) rarely or never invest, indicating room for increased commitment. The majority (32.1%) has a neutral stance on carbon offset options, trusting companies with third-party verified programs. Direct pipeline routes are strongly supported for reducing congestion and emissions.

Table iii. Table indicating statements of Awareness of carbon footprint in the value chain and preference for low-carbon suppliers



| wareness of carbon | PARTICULARS | FREQUENCY | PERCENTAGE |
|--|-------------------|-----------|------------|
| otprint in the value ain and | | | |
| the impact of carbon offsetting initiatives | PARTICULARS | FREQUENCY | PERCENTAGE |
| Annual sustainabilit budget allocation for | ty $0\% - 10\%$ | 50 | 44.6% |
| carbon offsetting | 26% - 50% | 17 | 15.2% |
| | 51% - 75% | 10 | 2.9% |
| | More then 75% | 1 | 0.9% |
| Investment in carbon | Yes | 39 | 34.8% |
| orrsetting initiatives | Always | 15 | 13.4% |
| | Sometimes | 32 | 28.6% |
| | Rarely | 14 | 12.5% |
| | NO | 12 | 10.7% |
| Satisfaction with | Very Satisfied | 24 | 21.4% |
| offset options | Satisfied | 26 | 23.2% |
| | Neutral | 36 | 32.1% |
| | Dissatisfied | 15 | 13.4% |
| | Very Dissatisfied | 11 | 9.8% |
| Trust in third-party | Strongly Agree | 27 | 24.1% |
| programs | Agree | 35 | 31.3% |
| | Neutral | 24 | 21.4% |
| | Disagree | 15 | 13.4% |
| | Strongly Disagree | 11 | 9.8% |



| Prioritizing low- carbon | Yes | 23 | 20.5% | | | |
|--|-------------------------------------|----|-------|--|--|--|
| footprint suppliers in sourcing | Always | 18 | 16.1% | | | |
| 6 | Sometimes | 37 | 33% | | | |
| | Rarely | 20 | 17.9% | | | |
| | No | 14 | 12.5% | | | |
| Key factor in supplier selection | Cost- effectiveness | 20 | 17.9% | | | |
| | Product/service quality | 22 | 19.6% | | | |
| | Low carbon footprint | 25 | 22.3% | | | |
| | Supplier reputation and compliance | 12 | 10.7% | | | |
| | Reliability and delivery efficiency | 33 | 29.5% | | | |
| Stricter regulations and | Strongly Agree | 35 | 31.3% | | | |
| carbon suppliers | Agree | 30 | 26.8% | | | |
| | Neutral | 24 | 21.4% | | | |
| | Disagree | 13 | 11.6% | | | |
| | Strongly Disagree | 10 | 8.9% | | | |
| Importance of Supplier | Very Important | 36 | 32.1% | | | |
| Engagement for Sustainability | Important | 28 | 25% | | | |
| | Neutral | 22 | 19.6% | | | |
| | Not Important | 15 | 13.4% | | | |
| | Very Not Important | 11 | 9.8% | | | |
| Satisfaction with | Very Satisfied | 23 | 20.5% | | | |
| availability of low- carbon suppliers | Satisfied | 27 | 24.1% | | | |
| | Neutral | 35 | 31.2% | | | |
| | Dissatisfied | 15 | 13.4% | | | |
| | Very Dissatisfied | 12 | 10.7% | | | |



| TOTAL | 112 | 100 | |
|-------|-----|-----|--|
|-------|-----|-----|--|

| 20 00 80 | Yes | Always | metimes | Rarely | No | | | | | | | | | | | | | | | | Satisfied | | | | | 112 |
|----------------|--------------|-----------------------|---------------------------|----------------------|---------------|--------------------|-----------------|----------------------|-------------------------|--------------------------|-----------------|------------------------|------------------------|---------------------------|---------------------|----------------|------------------------|-----------------------|-------------------------|--------------------|-----------|----------------|-------------------------|--------------------------|-------------------|-------|
| 50 40 20 | 23 | 18 | S 37 | 20 | 14 | 20 | 22 | 25 | 12 | 33 | 35 | 30 | 24 | 13 | 10 | 36 | 28 | 22 | 15 | 11 | 22 Very | 27 | 35 | 15 | 12 | |
| 0 | | | | | | Cost-effectiveness | Product/service | Low carbon footprint | Supplier reputation and | Reliability and delivery | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree | Very Important | Important | Neutral | Not Important | Very Not Important | | Satisfied | Neutral | Dissatisfied | Very Dissatisfied | TOTAL |
| | Prior foo | itizir tprin sc | ng lov t sup ourcir | w-ca opliei ng | rbon rs in | Кеу | facto se | or in s lectio | supp on | lier | Str and c | icter incer arbo | regu ntive n sup | ulatic s for oplier | ins I Iow- Is | mpo E | ortan Ingag Sust | ce of eme ainat | Supp nt fo pility | olier r | ava | Sati ailabi | sfact lity o supp | ion v f low oliers | vith -carl | oon |

Figure iii. Chart representing statements of Awareness of carbon footprint in the value chain and preference for low-carbon suppliers

Inference:Most respondents (33%) give priority to low-carbon footprint suppliers, reflecting inconsistent use of sustainable sourcing practices. They also give priority to reliability and delivery efficiency in supplier choice. Increased regulation and incentives are agreed on by 31.3% strongly. Supplier engagement is greatly valued for sustainability, but 31.2% are neutral regarding the existence of low-carbon suppliers.

Table iv.. Table Indicating One Way AnovaTest

Hypothesis 1: ANOVA

Ho: There is no significant difference in supply chain sustainability across different levels of carbon offsetting initiatives.

H₁: There is a significant difference in supply chain sustainability across different levels of carbon offsetting initiatives.

| GENDER | | | | | |
|----------------|-------------------|-----|-------------|------|------|
| | Sum of Squares | df | Mean Square | F | Sig. |
| Between Groups | 1.845 | 13 | .142 | .637 | .817 |
| Within Groups | 21.833 | 98 | .223 | | |
| Total | 23.679 | 111 | | | |

ANOVA

Accpecting H0 as the p-value is above 0.05 So we rejected H1



Inference: The ANOVA test shows no significant variation among gender groups when it comes to the variable being measured since the p-value is above 0.05, showing that gender has no effect on the dependent variable. The low F-value tells us that the variance across groups is somewhat modest.

Table v.. Table Indicating Chi-Square Test

Hypothesis 2: chi - square

H₀: There is no significant relationship between awareness of carbon footprint in the value chain and the preference for low-carbon footprint suppliers

H₁: There is a significant relationship between awareness of carbon footprint in the value chain and the preference for low-carbon footprint suppliers

| Chi | -Square Te | ests | |
|---------------------------------|------------|------|---|
| | Value | df | Asymptotic Significance (2-sided) |
| Pearson Chi-Square | 25.222ª | 15 | .047 |
| Likelihood Ratio | 29.148 | 15 | .015 |
| Linear-by-Linear Association | 1.642 | 1 | .200 |
| N of Valid Cases | 112 | | |

 a. 24 cells (75.0%) have expected count less than 5. The minimum expected count is .30.

Rejecting H0 as the p-value just below the 0.05 significance level, So we accepting H1

Inference:With a p-value just below the 0.05 significance level, the Chi-Square test findings show a statistically significant relationship between the categorical variables. However, because 75% of projected counts are less than 5, the test's validity is called into question, potentially rendering the results untrustworthy. The findings are supported by the likelihood ratio test, which likewise demonstrates statistical significance. A p-value of 0.200 indicates that there is no discernible linear trend in the findings of the linear-by-linear association test.

Recommendations

• Highlight the Urgency of Increased Investment in Carbon Offsetting: Companies need increased investment in carbon offsetting to maximize long-term environmental and economic benefits and integrate them into sustainability strategies, as they only allocate a small percentage of their sustainability budget.

• Build Trust Through Third-Party Verified Programs: You can stress the significance of transparency and certification because a large number of respondents have faith in businesses that have third-party verified carbon offset schemes. Talk about how third- party verification helps maintain trust and stop greenwashing.



• Increase Knowledge of Low-Carbon Suppliers: The neutrality (31.2%) on the availability of low-carbon suppliers suggests that industry platforms and partnerships are needed to increase the visibility and accessibility of these suppliers.

Conclusion

This research identifies the significant role of carbon offsetting in ensuring sustainability in supply chains. Through the analysis of the effect of carbon offset projects, it is clear that companies can reduce their carbon emissions by a great deal and help in protecting the environment. The research also calls for the need for awareness in the value chain to push organizations to place emphasis on low-carbon suppliers. Statistical tests produced mixed results. The ANOVA test upheld that gender does not affect attitudes towards carbon offsetting, whereas the Chi-Square test indicated a statistical relationship between categorical variables, although with reservations about its validity. The likelihood ratio test confirmed these results, but the linear-by-linear association test did not provide a clear trend. Despite such restraints, the research highlights the importance of embedding successful carbon offsetting initiatives within supply chains for businesses. A multi-faceted strategy comprising supplier sourcing according to carbon footprint, investing in sustainable strategies, and strict carbon neutrality objectives needs to be pursued by companies. This can increase sustainability, allow companies to follow environmental standards, and develop a competitive advantage within a rapidly environment-conscious marketplace.

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