



Green Packaging Innovation in Last-Mile Delivery: An Empirical Study on Sustainability, Performance, and Competitive Advantage

Abinaya. N

Research Scholar, AMET Business School, AMET University

Dr. K. Meenatchi Somasundari

AMET Business School, AMET University

DOI : <https://doi.org/10.5281/zenodo.21458771>

ARTICLE DETAILS

Research Paper

Received: 22-05-2026

Accepted: 26-06-2026

Published: 15-07-2026

Keywords:

*Customer satisfaction,
Competitive advantage,
Environmental
performance, Green
packaging, Last-mile
delivery, Operational
efficiency.*

ABSTRACT

The rise of e-commerce has greatly intensified last-mile delivery operations, leading to more packaging waste and environmental degradation. Green packaging innovation has been acknowledged as a strategic approach for managing competing considerations among environmental sustainability, efficiency and competitiveness. The present study attempts to investigate the influences of green packaging innovation on environmental sustainability, efficiency, customer satisfaction and competitiveness via a quantitative research approach. A total of 194 logistics experts and e-commerce customers participated in the survey. Various statistical methods were used such as reliability analysis, correlation analysis, multiple regression analysis and mediation analysis. The results reveal that green packaging innovation has a positive effect on environmental sustainability and efficiency, and thus enhances customer satisfaction and competitiveness.

Introduction:

The advent of e-commerce has revolutionised the practice of supply chain management worldwide, particularly in last-mile delivery. Fast delivery and doorstep delivery are variables that add to consumer

Disclaimer: The opinions, interpretations, conclusions, recommendations, analyses, and statements expressed in this research article are solely those of the author(s) and do not reflect the views, policies, or positions of the Publisher, Chief Editor, Editors, Editorial Board, Reviewers, or their affiliated institutions. The author(s) are solely responsible for ensuring the originality, authenticity, and integrity of the manuscript and for ensuring that it is free from plagiarism, AI-generated content, copyright infringement, data falsification, and any other form of academic misconduct.

satisfaction but also lead to environmental concerns like too much packaging waste and carbon emissions. Traditional packaging materials, especially single-use plastics and oversized corrugated boxes, greatly exacerbate landfill waste and resource depletion. With sustainability becoming an increasingly urgent concern for organisations and governments, green packaging innovation has emerged as a promising focus area. “Green packaging innovation” is the use of eco-friendly packaging materials and designs that have little or no ecological impact, without compromising product efficiency and protection.

Examples of green packaging developments are reusable containers, recyclable packaging, biodegradable packaging and appropriate size. But when it comes to green packaging technologies, companies are generally concerned about the cost. This paper explores the impact of green packaging innovation (independent variable) on the environmental performance, operational effectiveness, customer happiness and competitive advantage (dependent variables). In addition, the study tests the assumptions and explores the mediating role of customer satisfaction...

Literature Review :

The European Commission (2020) states that there has been a broadening of the laws on producer responsibility, which means that businesses have to manage packaging waste. Businesses must develop sustainable packaging technologies to comply with environmental standards. Compliance with environmental standards can improve the legitimacy of a business.

McKinnon (2018) defines sustainable logistics as the reduction of the negative environmental impacts of logistics activities by using efficient transport, optimal packaging and emission reduction strategies. The choice of packaging in last-mile delivery operations has a significant impact on fuel consumption and waste generation. Companies can optimize the vehicle's capacity and reduce carbon emissions by minimizing the weight and size of packing. As per the sustainable logistics theory, the re-engineering of the logistics procedures in the businesses can attain environmental efficacy and efficiency simultaneously. Therefore, sustainable supply chain management has an important role of green packaging innovation.

The circular economy is a regenerative system that aims to eliminate waste by recycling, reuse and resource recovery (Geissdoerfer et al., 2017). Green packaging is another way of applying the principles of the circular economy to the packaging industry by promoting the use of recyclable and biodegradable materials. Last-mile deliveries don't require single-use packaging, thanks to reusable packaging methods. The circular economy approach to sustainability emphasises that sustainability is not about making changes but about changing systems.

According to Joshi and Rahman (2015), green purchasing behavior is influenced by perceived value and environmental knowledge. Consumers flock to brands that are adopting eco-friendly packaging as a way of showing their commitment to the environment. Eco-friendly packaging is a tangible symbol of business ethics and builds brand trust. This means that green packaging may result in greater consumer loyalty and satisfaction.

Urban freight transport is responsible for a disproportionate share of greenhouse gas emissions, according to Browne et al. (2012). Packaging weight and capacity affect fuel use and vehicle travel. Lightweight and compact green packaging reduces the number of deliveries required, and thereby reduces emissions and road congestion.

Finnveden et al. (2009) Life Cycle Assessment (LCA) is a method for assessing the environmental impacts of a product throughout its entire life cycle, from the extraction of raw materials to its disposal. Packaging materials often have a large negative impact on the environment during production and at the end of their life. Organizations can use life cycle assessment (LCA) to identify environmental hotspots and make evidence-based changes to packaging. This strategy enhances transparency and sustainability performance.

According to Seuring and Müller (2008), sustainable supply chain efforts may involve an up-front investment, but they pay off in the long run. Green packaging materials could be more expensive initially but over a period of time cost savings from waste reduction, operational effectiveness and brand value can off set these costs.

Hellström and Saghir (2007) claim that packaging design is important in storage and transit efficiency. Good packing design can reduce the amount of unused space in delivery trucks, making them more efficient to load. Good packaging techniques help the environment and reduce operating expenses. Green packaging may thus improve sustainability outcomes and operational performance simultaneously.

Green supply chain management is defined by Srivastava (2007) as incorporating environmental considerations into supply chain operations, such as product design, procurement of materials, and logistics. Packaging choices are crucial to green supply chain strategies because they have an impact on both upstream suppliers and downstream consumers. Collaboration among supply chain participants reduces environmental risk and enhances sustainable material innovation. Adoption of green packaging hence necessitates concerted efforts across corporate boundaries.

Research Gap:

Firstly, most of the previous studies only studied the environmental benefits of new green packaging such as reducing carbon emissions and waste. However, they did not give a clear explanation on how innovative green packaging could improve both competitive advantage and operational efficiency at the same time. Few studies have combined environmental performance, consumer happiness, and competitive advantage into a single model.

Second, the majority of earlier studies are theoretical or conceptual in character. There aren't many research that support the connections between green packaging innovation and corporate performance results using solid statistical proof and quantitative data.

Third, logistics studies do not thoroughly examine the mediating function of customer satisfaction. Customer happiness has been extensively studied in marketing, but its use in connecting competitive advantage and environmental performance in last-mile delivery remains untapped.

In conclusion, although last-mile delivery is one of the most expensive and environmentally sensitive segments of the supply chain, it has been overlooked by previous research.

Rationale of the Problem

The recent rise of e-commerce use, especially in last-mile delivery, has had a dramatic impact on the global supply chain and logistics network. While e-commerce has greatly improved accessibility, speed and convenience, it has also raised environmental concerns about carbon emissions, excessive packaging and wasteful resource consumption. Traditional last-mile delivery packing techniques heavily rely on single-use plastics, large corrugated boxes, and non-biodegradable materials, all of which significantly increase landfill waste and environmental deterioration. The innovation of green packaging is considered as a feasible solution for these environmental problems, but companies are still reluctant to adopt sustainable packaging solutions due to high costs and unclear return on investment.

In addition, the economic and environmental performance are structurally in conflict because the existing logistics system prioritizes speed and cost effectiveness over sustainability. Previous studies have separately studied sustainable logistics and green supply chain management, but few empirical studies have thoroughly examined the impacts of green packaging innovation on environmental performance, efficiency, customer satisfaction, and competitiveness in last-mile logistics. Moreover, the mediating role of consumer satisfaction on the relationship between environmental initiatives and competitive outcomes has not been

examined. Therefore, it is important to examine whether green packaging innovation can be leveraged to simultaneously improve sustainability performance and competitiveness, and to provide empirical insights that help explain its strategic role in contemporary last-mile logistics.

Research Objectives:

The aims of this study are as follows:

1. To evaluate the application of green packaging in last mile delivery systems.
2. To determine the impact of innovative green packaging on environmental performance.
3. To examine the effect of green packaging on operational efficiency.
4. To explore the relationship between customer satisfaction and environmental performance.
5. To study the mediating effect of customer satisfaction in gaining competitive advantage.

Hypothesis Established:

H1: Green innovative packaging positively influences environmental performance.

H2: Innovation in Green Packaging Enhances Operational Efficiency.

H3: Packaging costs have a strong influence on adoption decisions.

H4: Environmental performance positively influences customer happiness.

H5: Customer happiness mediates competitive advantage.

Conceptual Framework and Diagram Description

Conceptual Framework Brief

The conceptual framework of this study is made up of Sustainable Logistics Theory, Resource-Based View (RBV), Circular Economy Theory and Customer Satisfaction Theory. The framework proposes the direct and indirect pathways of Green Packaging Innovation (independent variable) to company performance results and organizational sustainability. The proposed framework suggests that green packaging initiatives positively impact operational efficiency and environmental performance, which in turn positively impact customer satisfaction and competitive advantage. Furthermore, customer satisfaction is a mediating factor in the relationship between competitive advantage and environmental performance.

Theoretical Grounding of the Framework:

The conceptual model is grounded in several theoretical perspectives:

1. According to sustainable logistics theory, green packaging improves operational and environmental performance.
2. The environmental benefits of packaging technologies that are reused and recyclable are supported by the theory of the circular economy.
3. The Resource-Based View (RBV) explains how sustainability capabilities can turn into competitive advantages.
4. Sustainability and competitiveness are mediated by customer satisfaction theory.

The presence of these ideas in the model offers an all-inclusive account of the connection between green packaging innovation and quantifiable business performance results.

Uses of the Conceptual Model

The guideline recommends that businesses consider green packaging beyond environmental compliance. Instead, it should be seen as a tactical tool that can:

Making operations more efficient

- Increased client loyalty
- Improving one's competitive standing

Encouraging sustained profitability

The model shows how sustainability efforts have a domino effect that starts with innovative packaging and ends with a competitive edge.

Research Methodology

Research Design: To investigate how green packaging innovation affects environmental performance, operational effectiveness, customer happiness, and competitive advantage in last-mile delivery systems, a quantitative research technique was used.

Sample and Data Collection: The study's sample size of 194 respondents is sufficient to guarantee the study's dependability and generalizability within the parameters of the investigation. Convenience sampling and stratified sampling were both used in the study. To guarantee participation from two significant groups of respondents—logistics experts involved in last-mile delivery and e-commerce customers who are directly exposed to packing practices—the stratified sample technique was utilized. To conveniently collect replies from reachable respondents who belonged to these groups, the convenience sampling approach was used. Given the time limits and exploratory character of the empirical investigation, this approach seemed suitable.

The respondent profile comprised online shoppers who are acquainted with e-commerce packing procedures, logistics managers, supply chain managers, and operational staff involved in delivery and distribution networks. The study's validity was improved by the varied respondent profile, which combined user review with industry expertise. A systematic questionnaire created utilizing established constructs from earlier research was used to gather the data. To guarantee greater coverage and effective data collecting, the questionnaire was distributed via internet platforms and direct communication methods.

Measurement of Variables: To guarantee content validity and reliability, all variables were tested in this study using structured questionnaire items that were modified from well-known literature. For every concept, a five-point Likert scale was employed, with 1 denoting "strongly disagree" and 5 denoting "strongly agree." In order to accommodate green packaging innovation in last-mile delivery systems, the measuring items were altered.

Reliability Analysis: All values above 0.85, indicating good internal consistency, according to the reliability analysis's Cronbach's Alpha scores. Strong internal consistency was shown by all constructs, and measurement reliability was confirmed by Cronbach's Alpha values more than 0.85.

Data Analysis Techniques: The statistical tools used for analysis are Correlation Analysis, Multiple Regression Analysis and Mediation Analysis.

Result and Discussions:

Reliability Analysis: Reliability analysis was conducted using Cronbach's Alpha Test to check the internal consistency of the constructs.

Table 1: Reliability Statistics

Variable	No. of Items	Cronbach's Alpha	Result
Green Packaging Innovation (IV)	6	0.90	Excellent reliability
Environmental Performance (DV1)	5	0.93	Excellent reliability
Operational Efficiency (DV2)	5	0.88	Good reliability
Customer Satisfaction (Mediator)	4	0.91	Excellent reliability
Competitive Advantage (DV3)	5	0.89	Good reliability

Source: Primary Data

The alpha values of all constructs are above 0.80, which ensures high internal consistency. This confirms that the instrument is reliable and ready for further statistical analysis.

Descriptive Statistics: Descriptive statistics were calculated to understand respondent perceptions (n = 194).

Table 2: Descriptive Statistics

Variable	Mean	Std. Deviation	Interpretation
Green Packaging Innovation	3.92	0.64	High adoption perception
Environmental Performance	4.05	0.58	Strong environmental improvement
Operational Efficiency	3.88	0.61	Moderate efficiency improvement
Customer Satisfaction	4.02	0.55	High satisfaction level
Competitive Advantage	3.95	0.60	Positive competitive perception

Source: Primary Data

Values above 3.5 indicate positive agreement among respondents. The highest score is for Environmental Performance (4.05), which indicates the perceived environmental advantages of green packaging.

Correlation Analysis: Pearson Correlation was conducted to examine relationships among variables ($p < 0.01$).

Table 3: Correlation Matrix (n = 194)

Variables	GPI	EP	OE	CS	CA
GPI	1	0.76**	0.71**	0.68**	0.65**
EP	0.76**	1	0.73**	0.74**	0.72**
OE	0.71**	0.73**	1	0.69**	0.66**
CS	0.68**	0.74**	0.69**	1	0.75**
CA	0.65**	0.72**	0.66**	0.75**	1

Source: Primary Data

Green Packaging is strongly and positively related to Environmental Performance ($r = 0.76$), Customer Satisfaction is strongly related to Competitive Advantage ($r = 0.75$). All correlations are statistically significant at the 1% significance level. This indicates that the independent and dependent variables are strongly related.

Multiple Regression Analysis:

Model 1: Impact of Green Packaging on Environmental Performance Dependent Variable:

Environmental Performance, Independent Variable: Green Packaging Innovation

Table 4: Regression Results (GPI → EP)

Model Summary	Value
R	0.76
R ²	0.58
Adjusted R ²	0.57
F-value	265.42
Significance	0.000

Source: Primary Data

Coefficient	Beta (β)	t-value	Sig.
-------------	------------------	---------	------

Green Packaging	0.69	16.29	0.000
-----------------	------	-------	-------

Source: Primary Data

$R^2 = 0.58$ indicates that 58% of the variation in Environmental Performance is explained by Green Packaging. $\beta = 0.69$ indicates a strong positive relationship. $p < 0.001$ confirms that it is statistically significant. H1 is supported.

Model 2: Impact of Green Packaging on Operational Efficiency Dependent Variable:

Operational Efficiency

Table 5: Regression Results (GPI → OE)

Model Summary	Value
R	0.71
R^2	0.50
Adjusted R^2	0.49
F-value	193.85
Significance	0.000

Source: Primary Data

Coefficient	Beta (β)	t-value	Sig.
Green Packaging	0.63	13.92	0.000

Source: Primary Data

Green packaging explains 50% of operational efficiency variance. This confirms green packaging improves load optimization and cost efficiency. H2 is supported.

Model 3: Environmental Performance → Customer Satisfaction Dependent Variable:

Customer Satisfaction

Table 6: Regression Results (EP → CS)

Model Summary	Value
---------------	-------

R	0.74
R ²	0.55
Adjusted R ²	0.54
F-value	236.18
Significance	0.000

Source: Primary Data

Coefficient	Beta (β)	t-value	Sig.
Environmental Performance	0.66	15.37	0.000

Source: Primary Data

Environmental performance significantly increases customer satisfaction. H3 is supported.

Model 4: Customer Satisfaction $\rightarrow$ Competitive Advantage
Dependent Variable: Competitive Advantage

Table 7: Regression Results (CS $\rightarrow$ CA)

Model Summary	Value
R	0.75
R ²	0.56
Adjusted R ²	0.55
F-value	245.91
Significance	0.000

Source: Primary Data

Coefficient	Beta (β)	t-value	Sig.
Customer Satisfaction	0.71	15.68	0.000

Source: Primary Data

Customer satisfaction explains 56% of variance in competitive advantage. H3 is supported.

Mediation Analysis:

Table 8: Mediation Results

Path	Beta	Significance	Result
EP → CA (Direct)	0.52	0.000	Significant
EP → CS	0.66	0.000	Significant
CS → CA	0.71	0.000	Significant
EP → CA (with CS)	0.29	0.000	Reduced

Source: Primary Data

The beta value reduced from 0.52 to 0.29 after including Customer Satisfaction. This indicates partial mediation. Thus, Customer Satisfaction partially mediates the relationship between Environmental Performance and Competitive Advantage. H5 is partially supported.

Summary of Hypothesis Testing

Table 9: Hypothesis Results

Hypothesis	Relationship	Result
H1	GPI → EP	Supported
H2	GPI → OE	Supported
H3	EP → CS	Supported
H4	CS → CA	Supported
H5	Mediation Effect	Partially Supported

Source: Data Analysis Report

Green Packaging Innovation is a robust predictor of Environmental Performance and Operational Efficiency. Environmental Performance is a robust enhancer of Customer Satisfaction. Customer Satisfaction results in Competitive Advantage. Mediation effect confirms the indirect competitiveness for sustainability. The model accounts for more than 55% variance in the dependent variables.

Theoretical implications: This research contributes to the existing theories, especially the Resource-Based View (RBV), Circular Economy Theory, and Sustainable Logistics Theory.

Findings: The findings provide empirical support to the Sustainable Logistics Theory that environmental policies (e.g., green packaging innovation) do not adversely affect operational performance. Instead, the results show that green packaging leads to improved operational efficiency and environmental sustainability. This supports the idea that operational efficiency and sustainability are not opposing goals but are rather mutually reinforcing objectives.

Theoretical Implications : This study makes a significant advancement to Resource-Based View (RBV), Circular Economy Theory and Sustainable Logistics Theory.

The findings present empirical evidence that green packaging innovation as an environmental regulation is not a barrier to operational efficiency from the perspective of sustainable logistics theory. Rather, the findings support the notion that green packaging improves environmental performance and operational efficiency. This supports the idea that sustainability and operational efficiency are mutually supportive rather than contradictory objectives.

Managerial Implications: The results of the study provide some practical recommendations for managers and decision makers in logistics and e-commerce organizations.

The empirical results suggest that sustainable packaging improves efficiency and environmental performance. Therefore, green packaging should be integrated into the entire logistics plan, not regarded as an added-cost.

A high statistical association between green packaging and efficiency shows that sustainable packaging can directly save transportation costs by optimizing packaging and can improve environmental consequences by investing in recyclable materials and right-sizing technologies.

Organisations should communicate their environmental efforts through ecolabeling, awareness campaigns and sustainability reporting as consumer satisfaction is partly a mediator of competitive advantage.

Businesses need to incorporate sustainability KPIs into their performance management processes. Executives need to develop partnerships to ensure a steady supply of environmentally friendly materials and to leverage government incentives for sustainable packaging.

Study Limitations

- The study used a total of 194 respondents, which may affect the generalizability of the results.

- However, since the data was collected at a point in time, it may be difficult to investigate the long-term causal association between green packaging innovation and competitive advantage.
- The study was based on perceptions, which may introduce subjectivity or response bias in measuring factors such as customer satisfaction and environmental performance.
- The study focuses on last-mile delivery solutions and does not consider other supply chain stages which may also impact sustainability outcomes.

Scope of Further Research

Further Research Objective

- Future research can examine green packaging innovation in different industries by comparing the adoption rates and performance of various sectors. This will help in finding out the differences in the sustainability practices and performance of the different businesses.
- Cross-sectional nature of the study. Future longitudinal studies can be conducted to study the long-term impacts of green packaging innovation on competitive advantage, consumer loyalty and environmental performance.
- Future research could consider the financial evaluation of green packaging innovation, such as profitability, cost savings and return on investment (ROI), which will reinforce the economic case for adoption.
infrastructure with the use of more advanced technology.
- Comparative studies in different foreign contexts can investigate the impact of cultural differences, legal frameworks, and consumer awareness of environmental issues on the adoption of green packaging and its commercial viability in other countries.

Conclusion

The research confirms that the adoption of new green packaging enhances operational efficiency and environmental performance, which in turn increases customer satisfaction and gives companies a competitive advantage. The statistical evidence from the 194 respondents supports the high positive correlation between the independent and dependent factors. Innovative green packaging is not just an environmental cause, it is an investment in the competitiveness of last-mile delivery systems.

In general, the current study contributes to theory by combining environmental sustainability and competitive strategy into one framework to theorize the linkage between sustainability initiative and competitive outcome through customer satisfaction channels.

References

- Browne, M., Allen, J., Nemoto, T., Patier, D., & Visser, J. (2012). Reducing social and environmental impacts of urban freight transport. *Transport Reviews*, 32(4), 473–490.
- European Commission. (2020). Circular economy action plan.
- Finnveden, G., et al. (2009). Recent developments in life cycle assessment. *Journal of Environmental Management*, 91(1), 1–21.
- Geissdoerfer, M., Savaget, P., Bocken, N., & Hultink, E. (2017). The circular economy. *Journal of Cleaner Production*, 143, 757–768.
- Hellström, D., & Saghir, M. (2007). Packaging and logistics interactions. *Packaging Technology and Science*, 20(3), 197–216.
- Joshi, Y., & Rahman, Z. (2015). Factors affecting green purchase behaviour. *Management Decision*, 53(9), 1991–2007.
- McKinnon, A. (2018). *Decarbonizing logistics*. Kogan Page.
- Porter, M. E., & van der Linde, C. (1995). Green and competitive. *Harvard Business Review*, 73(5), 120–134.
- Seuring, S., & Müller, M. (2008). Sustainable supply chain management. *Journal of Cleaner Production*, 16(15), 1699–1710.
- Srivastava, S. K. (2007). Green supply-chain management. *International Journal of Management Reviews*, 9(1), 53–80.
- Zhu, Q., & Sarkis, J. (2004). Relationships between operational practices and performance. *Journal of Operations Management*, 22(3), 265–289.