SUSTAINABLE AND REVERSE LOGISTICS PRACTICES FOR DEVELOPING GREEEN SUPPLYCHAINS: A STUDY OF THE BATTERY MANUFACTURING COMPANY

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Abstract

This study examines the adoption of sustainable and reverse logistics practices within the battery manufacturing industry and their role in developing environmentally responsible supply chains. Increasing environmental concerns and regulatory pressures have encouraged organizations to integrate eco-friendly logistics strategies such as waste minimization, Recycling, and green useful resource utilization. The research is based on primary data collected from 135 respondents working in logistics and supply chain functions. Analytical tools such as percentage analysis and weighted average methods were used to interpret the data.

The findings indicate that while many firms have initiated sustainable logistics practices, the implementation of reverse logistics systems—such as product return, recycling, and buyback programs—remains limited due to cost constraints, lack of awareness, and inadequate infrastructure. The study further highlights that organizations adopting these practices experience improvements in environmental performance, customer satisfaction, and corporate image. The research concludes that strengthening sustainable and reverse logistics systems is essential for achieving long-term supply chain And environmental sustainability withinside the battery production sector.

Keywords: Environmental sustainability, Reverse logistics, Green supply Chain, Battery Manufacturing Industry, Recycling systems, Buyback System, Waste reduction, Carbon footprint, Supply chain Efficiency, Descriptive research, Percentage Analysis, and Weighted average.

1 Introduction

In the modern business environment, sustainability has become a strategic priority, particularly in supply chain and logistics operations. Organizations are increasingly expected to reduce their environmental impact while maintaining operational efficiency and cost-effectiveness.

Sustainable logistics focuses on minimizing the environmental footprint of activities such as transportation, warehousing, packaging, and distribution. This includes reducing emissions, optimizing resource usage, and limiting waste generation. Reverse logistics, on the other hand, involves the movement of products from end users back to manufacturers for reuse, Recycling, refurbishment, or stable disposal. The battery manufacturing industry presents unique challenges due to the hazardous nature of its products. Improper disposal can lead to significant environmental damage, making reverse logistics systems particularly important. Despite growing awareness, the adoption of these practices is often constrained by financial, technological, and infrastructural limitations.

This study aims to evaluate the effectiveness of sustainable and reverse logistics practices in the battery manufacturing sector, identify key challenges, and provide insights to enhance green supply chain development.

2 Literature review

- Luk Van Wassenhove 2002 did a study in about supply chains. He determined out that product take-returned structures are very essential for groups to be sustainable. This study showed that reverse logistics helps companies get value from products by reusing, remanufacturing and recycling them. This is proper for the environment. It helps companies have supply chains.
- Harold Krikke 2001 wrote about closed-loop supply chains in 2001. He said that when companies combine forward and reverse logistics systems they use resources efficiently and hurt the environment less. His research found that reverse logistics is a part of achieving circular economy goals.
- Z. Fan and others 2023 developed a model for logistics in 2023. They focused on waste electric vehicle batteries. The study showed that companies can save money and reduce carbon emissions by making their logistics networks more efficient. This is ideal for each the economic system and the environment.
- G. H. W. Liao and others 2022 looked at logistics systems for electric vehicle batteries in 2022. They found that when companies are not sure how products they will get back or what shape they will be in it can be hard to recycle them efficiently. The study said that companies need to work to make reverse logistics better.
- Mohiuddin 2025 did a review of logistics systems for electric vehicle batteries in 2025. They identified steps like collecting batteries moving them around taking them apart and recycling them. They also found some challenges, like not being sure how many batteries will be returned not having infrastructure And now no longer having regulations in place.
- Rivera and others 2025 said that reverse logistics is very important for creating an economy in the battery industry. They found that some big problems are that there are not rules to support logistics the infrastructure is not good enough and companies are not working together well enough.
- Purwani 2022 He proposed a framework for logistics for battery systems in 2022. He said that companies should reuse, repair, refurbish, remanufacture and recycle batteries. The study concluded that these practices are very good for the environment and help products last in supply chains.
- Aishwarya 2025 looked at how sustainable electric vehicle batteries are throughout their lifecycle in 2025. They found some challenges like rules that're not supportive technology that is not advanced enough and supply chains that are too complicated.

Research Gap

Most studies on reverse logistics focus on concepts and global perspectives but they don't really think about how in reality to put into effect those ideas

There isn't research based on real data especially when it comes to making batteries and handling waste.

Sustainable logistics and reverse logistics are crucial, in the battery manufacturing sector.

They help make the sector more eco-friendly.

Few studies examine both logistics and reverse logistics together using data to understand whats really happening.

This study aims to investigate how sustainable logistics and reverse logistics are performing in the battery manufacturing sector.

It will explore how these practices are used to create supply chains that benefit the environment and make battery production more sustainable.

The goal is to make battery manufacturing more eco-friendly by improving logistics and reverse logistics.

This can be achieved by reducing waste and using resources efficiently.

Research hypothesis

To look at how key things connected in sustainable and reverse logistics we have made some guesses. These guesses are:

* We want to see how certain things affect each other in logistics

* We also want to see how things work in logistics

The key things we are talking about are important to understand how sustainable and reverse logistics work. We are looking at the connection between these things, in sustainable and reverse logistics practices.

H0 (Null Hypothesis): There is no significant relationship between sustainable logistics practices and the effectiveness of reverse logistics system in developing green supply chains.

H1 (Alternative Hypothesis): There is a significant relationship between sustainable logistics practices and the effectiveness of reverse logistics system in developing green supply chains.

3 Research Methodology

Research Design

This study adopts a descriptive research design to evaluate the adoption and effectiveness of sustainable and reverse logistics Practices withinside the battery production industry.

Data Sources

Both number one and secondary facts have been used. Primary data was collected through a structured questionnaire administered to 135 respondents involved in logistics and supply chain operations. Secondary data was obtained from academic journals, industry reports, and online sources.

Tools and Techniques

The collected data was analyzed using percentage analysis and weighted average methods was applied to examine the relationship between sustainable logistics practices and reverse logistics effectiveness.

Sampling Method

Convenience sampling was used to select respondents based on their availability and willingness to participate.

4) Key Insights and Analysis

A) Concepts Explanation

Sustainable logistics is about making logistics practices good for the environment. We focus on things like transportation, warehousing, packaging and distribution. The main goal of logistics is to reduce carbon emissions minimize waste and use resources efficiently in the supply chain. Sustainable logistics is about

reducing the harm we do to the environment. The process of getting products from customers to manufacturers or special facilities is called logistics. In logistics products can be recycled, reused, remade or disposed of safely. This helps us get value from used products and reduces harm to the environment. Sustainable logistics and green supply chain management are connected to reverse logistics.

This enables agencies acquire their sustainability goals. In the battery manufacturing industry sustainable logistics is especially important. Battery elements are hazardous. He circular economy supports logistics practices. It encourages us to use resources through recycling, reuse and extending the life of products. By adopting logistics and reverse logistics practices organizations can reduce their impact, on the environment. Sustainable logistics and green supply chain management help organizations achieve their sustainability goals and reduce harm to the environment.

B) Analysis / Arguments

This study uses a way to figure out what people think about sustainable and reverse logistics practices. It gives points to each answer. If someone says they Strongly Agree (SA), that is = 5. If they Agree (A), that is = 4. If they are Neutral (N), that is = 3. If they Disagree (D), that is = 2. If they Strongly Disagree (SD), that is = 1. The study uses these points to get an weighted average of what people think about logistics practices and reverse logistics practices

Formula:

$$\text{weighted average} = \frac{\sum(f \times w)}{\sum f}$$

This method helps in identifying the overall opinion of respondents. The result shows a general positive perception towards Sustainable logistics and reverse logistics

Q1) Eco-friendly transportation:

Response	Frequency(f)	Weight(x)	f × w
SA	40	5	200
A	50	4	200
V	20	3	60
D	15	2	30
SD	10	1	10
TOTAL	135	-	500

weighted Mean = 500/135 = 3.70

Q2) Return System:

Response	Frequency(f)	Weight(x)	f × w
SA	55	5	275
A	45	4	180
V	15	3	45
D	10	2	20
SD	10	1	10
TOTAL	135	-	530

weighted Mean = 500/135 = 3.70

Q3) Recycling & Reuse:

Response	Frequency(f)	Weight(x)	f × w
SA	50	5	250
A	48	4	192
V	18	3	54
D	12	2	24
SD	7	1	7
TOTAL	135	-	527

weighted Mean = 527/135 = 3.90

Q4) Performance & Brand Impact:

Response	Frequency(f)	Weight(x)	f × w
SA	45	5	225
A	50	4	200
V	20	3	60
D	10	2	20
SD	10	1	10
TOTAL	135	-	515

weighted Mean = 515/135 = 3.81

Q5) Customer Incentives / Buyback:

Response	Frequency(f)	Weight(x)	f × w
SA	30	5	150
A	40	4	160
V	30	3	90
D	20	2	40
SD	15	1	15
TOTAL	135	-	515

weighted Mean = 515/135 = 3.81

Calculating Weighted Averages

Question	Statement	Weighted mean	Interpretation
Q8	Carbon emission monitoring	3.89	Agree
Q9	Product return system exists	4.16	Strongly Agree
Q10	Buyback system	3.45	Neutral
Q11	Proper inspection of returns	4.10	Strongly Agree
Q12	Reuse of components	4.00	Agree
Q13	Refurbishing reduces costs	4.04	Agree
Q14	Buyback improves satisfaction	3.12	Neutral
Q15	Reverse logistics helps environment	4.08	Strongly Agree
Q16	Sustainable logistics reduces cost	3.30	Neutral
Q17	Improve brand image image	3.37	Neutral
Q18	Competitive advantage	3.29	Neutral
Q21	Incentives encourage return	3.92	Agree

Findings And Results

- A significant relationship exists between sustainable logistics and reverse logistics effectiveness.
- Many organizations have initiated eco-friendly logistics practices, though full-scale implementation is still evolving.
- Reverse logistics systems, particularly recycling and reuse, contribute to better resource utilization.
- Companies adopting these practices report improved brand reputation and customer satisfaction.
- Limited awareness and high costs act as major barriers to adoption.

Conclusion

The study confirms that sustainable and reverse logistics practices are critical for developing environmentally responsible supply chains in the battery manufacturing industry. While organizations have made progress in adopting eco-friendly logistics, there is a need for greater focus on reverse logistics systems.

Challenges such as cost, infrastructure limitations, and lack of awareness must be addressed to ensure wider adoption. Strengthening these practices can lead to improved environmental outcomes, operational efficiency, and competitive advantage.

Recommendations & Suggestions

- Investment in Sustainable Logistics Companies should invest in green transportation, energy-efficient warehouses, and sustainable packaging to reduce environmental impact and improve efficiency..
- Develop structured product return and recycling systems.
- Conduct training programs to improve awareness of reverse logistics practices.
- Introduce customer incentives to encourage product returns.
- Strengthen collaboration among manufacturers, suppliers, and recycling partners.
- Companies should adopt advanced technologies such as tracking systems and modern recycling infrastructure to improve efficiency and reduce environmental impact.

References

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