

THE IMPACT OF REVERSE LOGISTICS ON ENVIRONMENTAL PROTECTION (AN APPLIED STUDY AT THE GENERAL COMPANY FOR BATTERY MANUFACTURING IN BAGHDAD)

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ABSTRACT

This study aimed to analyze the impact of reverse logistics on environmental protection at the General Company for Battery Manufacturing in Baghdad. The study adopted the descriptive analytical method. Primary data were collected using a questionnaire distributed to a random sample of the company's employees, with a sample size of (125) respondents. The questionnaire included two main axes: reverse logistics with its dimensions (collection and sorting, transportation, storage, recycling), and environmental protection. The results showed a statistically significant impact of reverse logistics on environmental protection in the surveyed company, as the weighted arithmetic mean for the reverse logistics variable was (6.59) and for the environmental protection variable was (7.02). The study also revealed a gap in coordination with external logistics service providers and weakness in the use of environmentally friendly raw materials. The study concluded with a set of recommendations, most notably: developing reverse storage infrastructure, building external strategic logistics partnerships, and shifting towards Design for Environment (DfE).

Keywords: Reverse Logistics, Environmental Protection, Recycling, Sustainability, General Company for Battery Manufacturing.

1. INTRODUCTION

1.1 Research Methodology and General Framework of the Study

The topic of reverse logistics is relatively modern in the field of management. Its importance has emerged in light of global trends towards environmental sustainability and reducing the negative impacts of industrial activities. Organizations no longer limit themselves to managing the flow of products from producer to consumer but have also become concerned with managing the flow of returned or consumed products for the purpose of reuse, recycling, or disposal in environmentally friendly ways. In this context, the importance of linking reverse logistics and environmental protection emerges, especially in industries dealing with hazardous or polluting materials, such as battery manufacturing, which represents one of the main sources of environmental pollution if its waste is not managed properly.

1.2 Research Problem

Industrial organizations, particularly those operating in chemical industries such as battery manufacturing, face significant challenges related to waste management and damaged or returned products, due to their negative impacts on the environment and human health. The research

problem stems from attempting to answer the following main question: **What is the impact of applying reverse logistics on environmental protection at the General Company for Battery Manufacturing in Baghdad?** The following sub-questions branch out from this:

- What is the level of reverse logistics application in the company?
- To what extent is the company interested in environmental protection?
- Is there a statistically significant relationship between reverse logistics and environmental protection?

1.3 Research Importance

The importance of this research is evident in both theoretical and applied aspects:

- **Theoretical Importance:** Enriching Arabic literature in the field of reverse logistics, and highlighting the relationship between it and environmental protection.
- **Applied Importance:** Assisting the General Company for Battery Manufacturing in improving its environmental practices, providing practical recommendations to reduce negative impacts, and supporting decision-makers in adopting sustainable strategies.

1.4 Research Objectives

1. Identify the concept of reverse logistics and its main applications.
2. Clarify the role of reverse logistics in environmental protection.
3. Measure the level of reverse logistics application in the surveyed company.
4. Analyze the relationship between reverse logistics and environmental protection.
5. Provide proposals that contribute to enhancing the company's environmental performance.

1.5 Research Hypotheses

- **Main Hypothesis:** There is a statistically significant relationship between reverse logistics and environmental protection.
- **Sub-Hypotheses:**
 1. There is a statistically significant correlation between reverse logistics and environmental protection.
 2. There is a significant impact of reverse logistics on environmental protection.
 3. The application of reverse logistics contributes to reducing environmental pollution in the company.

1.6 Research Methodology

The research adopted the descriptive analytical method, as it is one of the most suitable methods for studying administrative phenomena and analyzing relationships between their variables. The reality of reverse logistics was described and its impact on environmental protection at the surveyed company was analyzed.

1.7 Research Population and Sample

- **Research Population:** Consists of all employees of the General Company for Battery Manufacturing in Baghdad.
- **Research Sample:** A random sample of (125) employees working in departments related to the study topic (Production, Storage, Quality Control, Environmental Safety) was selected.

1.8 Data Collection Tools

- **Primary Data:** Collected through a questionnaire specifically designed for this purpose and distributed to the sample members. An eleven-point scale (0% to 100%) was adopted.
- **Secondary Data:** Obtained from books, scientific journals, university theses, and electronic sources relevant to the research topic.

1.9 Research Limitations

- **Spatial Limitations:** The General Company for Battery Manufacturing in Baghdad.
- **Temporal Limitations:** (2025–2026 AD).
- **Subject Limitations:** Studying the impact of reverse logistics on environmental protection.

1.10 Previous Studies

- **Arabic Studies:**
 - **Al-Ubaidi (2021):** The role of reverse logistics in improving environmental performance in Iraqi industrial organizations. Concluded that there is a positive relationship between reverse logistics and reducing industrial waste.
 - **Al-Shammari (2020):** The impact of reverse logistics practices on achieving environmental sustainability in the manufacturing sector.
 - **Hussein (2019):** The role of reverse logistics in industrial waste management in chemical companies, indicating that weak infrastructure and lack of awareness are among the most prominent obstacles.
- **Foreign Studies:**
 - **Rogers & Tibben-Lembke (1999):** A pioneering study that defined reverse logistics and confirmed its importance in reducing environmental impact.
 - **Srivastava (2008):** The role of reverse logistics in green supply chains and waste reduction.
 - **Guide & Van Wassenhove (2009):** The dual (economic and environmental) benefits of applying reverse logistics.
- **Research Gap:** Despite the multitude of studies, there is a clear lack of applied studies linking reverse logistics and environmental protection in the Iraqi environment, especially in the chemical industries sector such as battery manufacturing, which the current research seeks to fill.

2. INTELLECTUAL FOUNDATIONS OF REVERSE LOGISTICS AND ENVIRONMENTAL PROTECTION

2.1 Introduction

The theoretical framework constitutes the scientific basis upon which the research relies in analyzing the relationship between its variables. The concepts of reverse logistics and environmental protection have received increasing attention in modern management literature due to environmental challenges and shifts towards the green economy and sustainable development.

2.2 Reverse Logistics (Independent Variable)

2.2.1 Concept of Reverse Logistics

Reverse logistics is defined as "the process of planning, implementing, and controlling the flow of materials from the point of consumption to the point of origin for the purpose of recovering value or proper disposal" (Rogers & Tibben-Lembke, 1999: 2). It can be operationally defined as the set of activities carried out by the organization to manage returned or damaged products in a way that achieves environmental protection and reduces waste.

2.2.2 Importance of Reverse Logistics

1. **Reducing Waste and Environmental Pollution:** Directly contributes to reducing waste volume through reuse or recycling (Srivastava, 2008: 60).
2. **Recovering Economic Value:** A portion of the economic value of consumed products can be recovered, reducing costs and increasing profitability (Guide & Van Wassenhove, 2009: 18).

3. **Improving the Organization's Image:** Enhances the organization's reputation as an environmentally responsible entity (Al-Shammari, 2020: 40).

4. **Compliance with Environmental Legislation:** An effective means of complying with strict waste management laws (Dowlathshahi, 2000: 150).

2.2.3 Objectives of Reverse Logistics

1. Environmental protection.
2. Cost reduction.
3. Improving operational efficiency.
4. Supporting sustainability.

2.2.4 Activities and Processes of Reverse Logistics

1. Collection of returned products.
2. Inspection and evaluation.
3. Reuse.
4. Recycling.
5. Safe disposal.

2.2.5 Challenges Facing Reverse Logistics

1. High costs.
2. Weak administrative awareness.
3. Lack of infrastructure.
4. Difficulty in predicting returns.

2.3 Environmental Protection (Dependent Variable)

2.3.1 Concept of Environmental Protection

Environmental protection is defined as "the set of procedures and policies aimed at preserving environmental components from pollution and degradation" (UNEP, 2020: 14). It can be operationally defined as the set of policies and practices aimed at reducing environmental pollution resulting from industrial activities and achieving sustainability.

2.3.2 Importance of Environmental Protection

1. Preserving human health.
2. Achieving sustainable development.
3. Reducing environmental pollution.
4. Improving organizational reputation.

2.3.3 Environmental Pollutants and Their Types

1. Air pollution.
2. Water pollution.
3. Soil pollution.
4. Industrial pollution.

2.3.4 Role of Industrial Organizations in Environmental Protection

1. Adopting clean technologies.
2. Managing industrial waste.
3. Complying with environmental legislation.
4. Spreading environmental awareness.

2.3.5 Relationship between Reverse Logistics and Environmental Protection

1. Reducing industrial waste.
2. Enhancing recycling.

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3. Supporting environmental sustainability.
 4. Reducing harmful emissions.

3. APPLIED ASPECT: DATA ANALYSIS AND HYPOTHESIS TESTING

3.1 Introduction

This Section presents and analyzes the data revealed by the questionnaire. The weighted arithmetic mean, standard deviation, coefficient of variation, and response intensity percentage were relied upon. The hypothetical arithmetic mean was (6) as an average for the measurement tool (on an 11-rank scale), and response intensity is calculated as follows: $(\text{Weighted Arithmetic Mean} \div 11) \times 100\%$.

3.2 Description and Diagnosis of the Study Sample's Opinions on Reverse Logistics (Independent Variable X)

3.2.1 Analysis of Collection and Sorting Axis

Table (1) Frequencies, Arithmetic Mean, Standard Deviation, Coefficient of Variation, and Response Intensity Percentage for Collection and Sorting Items

Item	Arithmetic Mean	Standard Deviation	Response Intensity %	Coefficient of Variation %
Waste is collected in special storage areas	8.35	1.461	75.9%	17.5%
Suitable containers are available at the waste generation site	6.64	1.948	60.4%	29.3%
Waste is collected immediately after falling on the same day	5.95	1.415	54.1%	23.8%
There are clean and prepared collection centers for collection and sorting in the factory	6.44	1.881	58.5%	29.2%
There is insufficient readiness from workers in collection and sorting operations	4.75	2.381	43.2%	50.1%
Different containers are used according to the type of fallen waste	6.24	1.920	56.7%	30.8%

Item	Arithmetic Mean	Standard Deviation	Response Intensity %	Coefficient of Variation %
Special carts are used for waste collection	6.14	1.593	55.8%	25.9%
Overall Axis Average	6.35	1.799	57.8%	29.5%

It is clear from Table (1) that the weighted arithmetic mean for the collection and sorting axis was (6.35), which is slightly higher than the hypothetical mean (6), indicating an acceptable reality at its minimum limits, with a clear need for development.

3.2.2 Analysis of Transportation Axis

Table (2) Frequencies, Arithmetic Mean, Standard Deviation, Coefficient of Variation, and Response Intensity Percentage for Transportation Items

Item	Arithmetic Mean	Standard Deviation	Response Intensity %	Coefficient of Variation %
Waste is transported immediately after falling to special places	6.84	1.561	62.2%	22.8%
Waste is not damaged during loading, transport, and unloading	4.74	1.798	43.1%	37.9%
Waste is transported by a free-moving conveyor belt	6.57	1.582	59.7%	24.1%
Open containers are used during transport	8.25	1.230	75.0%	14.9%
Closed containers are used during transport	2.25	2.192	20.5%	97.4%
Special carts are used for waste transport	6.18	1.549	56.2%	25.0%
Waste containers do not match supply containers	4.25	1.862	38.6%	43.8%

Item	Arithmetic Mean	Standard Deviation	Response Intensity %	Coefficient of Variation %
Overall Axis Average	6.01	1.682	50.72%	37.9%

Table (2) shows that the arithmetic mean for the transportation axis was (6.01), approximately equal to the acceptable level, but it reveals fundamental problems, most notably waste damage during transport (4.74) and the almost complete absence of closed containers (2.25).

3.2.3 Analysis of Storage Axis

Table (3) Frequencies, Arithmetic Mean, Standard Deviation, Coefficient of Variation, and Response Intensity Percentage for Storage Items

Item	Arithmetic Mean	Standard Deviation	Response Intensity %	Coefficient of Variation %
Waste is stored in prepared and special places	6.90	1.921	62.7%	27.8%
Waste is stored randomly	5.66	1.522	51.5%	26.9%
Storage and treatment are done inside the company	9.65	1.320	87.7%	13.7%
The company stores waste mixed with sound materials	5.06	1.611	45.0%	31.8%
Waste is stored in open warehouses (in the open)	6.01	1.710	54.6%	28.5%
Temporary storage of waste is used	7.74	1.729	70.4%	22.3%
There is no difficulty using storage means such as containers and storage places	6.52	1.491	59.3%	22.9%
Overall Axis Average	6.79	1.614	61.8%	24.8%

Table (3) shows that storage achieves an arithmetic mean of (6.79) and is characterized by storage and treatment operations being largely carried out inside the company (9.65). However, there remains a problem with open storage (6.01), posing an environmental risk.

3.2.4 Analysis of Recycling Axis

Table (4) Frequencies, Arithmetic Mean, Standard Deviation, Coefficient of Variation, and Response Intensity Percentage for Recycling Items

Item	Arithmetic Mean	Standard Deviation	Response Intensity %	Coefficient of Variation %
The customer and worker know about waste for recycling purposes	7.58	1.522	68.9%	20.1%
Recycling costs are very high and disproportionate to economic feasibility	5.97	1.434	54.3%	24.0%
The target limit of pollution is achieved through waste recycling	7.51	1.710	68.3%	22.8%
There is coordination between service providers and the external environment with the company	4.24	1.892	38.5%	44.6%
The company improves its image using organic fertilizer	6.24	1.622	56.7%	25.9%
A special treatment unit for production waste is available	9.67	1.301	87.9%	13.5%
Waste recycling contributes to producing good products and reducing costs	9.94	1.311	90.4%	13.2%
Overall Axis Average	7.31	1.541	61.3%	23.4%

Table (4) shows that the recycling axis achieves the highest arithmetic mean (7.31), indicating a great awareness of its importance. Particularly prominent is the recognition of recycling's role in reducing costs (9.94) and the availability of a treatment unit (9.67). Conversely, item (4.24) showed a severe weakness in coordination with the external environment.

3.3 Description and Diagnosis of the Study Sample's Opinions on Environmental Protection (Dependent Variable Y)

Table (5) Frequencies, Arithmetic Mean, Standard Deviation, Coefficient of Variation, and Response Intensity Percentage for Environmental Protection Items

(The long table is condensed focusing on key metrics)

Item	Arithmetic Mean	Standard Deviation	Response Intensity %	Coefficient of Variation %
The company complies with environmental protection requirements	4.73	1.822	43.0%	38.5%
The company complies with media to improve protection requirements	6.62	1.334	60.2%	20.1%
The company seeks to improve its image through protection	4.74	1.713	43.1%	36.1%
The company works to comply with environmentally friendly laws and legislation	7.19	1.292	65.4%	17.9%
The company seeks to improve production methods environmentally, which reflects on society	6.66	1.322	60.5%	19.8%
The company uses modern technological methods in environmental protection processes	7.34	1.311	66.7%	17.8%

Item	Arithmetic Mean	Standard Deviation	Response Intensity %	Coefficient of Variation %
The company seeks to join new markets through environmental advocacy	6.33	1.313	57.5%	20.7%
Use of materials used in the production process that are environmentally friendly	4.27	1.828	38.8%	42.8%
The company conducts research and development for improvement and products to make them less harmful to the environment	6.85	1.421	62.3%	20.7%
... (remaining items follow) ...	...	...	...	...
There is a specialized cadre concerned with environmental affairs	6.65	1.562	60.5%	23.4%
There is a department with a number of workers to monitor the environment	8.73	1.210	79.4%	13.8%
There are specialized researchers to solve environmental problems in the company	8.12	1.261	73.8%	15.5%
The company complies with legislation and laws issued by the state regarding environmental protection	8.29	1.207	75.4%	14.5%
The company has an environmental management	8.19	1.320	74.5%	16.1%

Item	Arithmetic Mean	Standard Deviation	Response Intensity %	Coefficient of Variation %
system that complies with ISO 14001				
Overall Axis Average	7.02	1.414	69.8%	21.5%

Table (5) shows that the arithmetic mean for the environmental protection variable (7.02) is higher than the hypothetical mean, reflecting acceptable interest. However, serious weaknesses emerge, including the company's weak compliance with environmental protection requirements (4.73), failure to improve image through protection (4.74), and the use of raw materials harmful to the environment (4.27). In contrast, there is clear strength in compliance with government legislation and environmental management systems (ISO 14001).

4. RESULTS AND RECOMMENDATIONS

4.1 Results of the Study

1. **Level of Reverse Logistics Application:** The results showed that the level of reverse logistics application in the company was acceptable at its minimum limits, with the overall variable average reaching (6.59), varying across its axes. The "Recycling" axis was the best (7.31), followed by "Storage" (6.79), then "Collection and Sorting" (6.35), and finally "Transportation" (6.01), which suffers from damage problems and mismatched containers.
2. **Attention to Environmental Protection:** The company's attention to environmental protection was moderate (7.02), with a clear duality: strong commitment to government legislation and international standards (ISO 14001), yet weakness in fundamental aspects such as the safety of raw materials and failure to invest the environmental dimension to improve the company's image.
3. **Impact of Reverse Logistics on Environmental Protection:** A statistically significant correlation and impact were proven between the application of reverse logistics practices (especially recycling and safe storage) and the enhancement of environmental protection, thus confirming the validity of the formulated hypotheses.
4. **Most Important Gaps Discovered:**
 - A gap in logistics coordination with external parties (mean 4.24).
 - A gap in the use of environmentally friendly raw materials (mean 4.27).
 - A gap in negative disposal through open storage and unsafe transportation means.

4.2 Recommendations of the Study

First: Operational Recommendations

1. **Development of Reverse Storage Infrastructure:** Immediate investment in specialized, closed storage containers classified by waste type (chemical, plastic, metallic) instead of general and open storage, to address the weakness in items (x5, x7).
2. **Activation of External Logistics Coordination (3PL):** Building strategic partnerships with logistics companies specialized in "reverse transport" to ensure safe collection and transport of

waste from the source to the company, addressing the severe weakness in item (x4) of the recycling axis.

Second: Technical and Environmental Recommendations

1. **Shift Towards Design for Environment (DfE):** Reviewing procurement policies and obligating suppliers to provide raw materials that are less harmful to the environment, in response to the low indicator of item (y8).
2. **Automation of Environmental Monitoring:** Using remote sensing technologies and smart software to monitor emission and waste levels in open warehouses and transport lines, to reduce environmental risks.

Third: Administrative and Marketing Recommendations

1. **Investing "Green Logistics" in Promotion:** Transforming the ISO 14001 certification and environmental commitment into marketing campaigns that highlight the company's social responsibility, thereby improving the mental image (addressing item y3) and opening new markets interested in sustainability.
2. **Specialized Training Programs:** Conducting mandatory training courses for employees in production, storage, and logistics departments on how to handle hazardous and returned materials, to increase awareness and improve the efficiency of collection and sorting operations (addressing item x5).

Fourth: Strategic Recommendations

1. **Adoption of the "Circular Economy" Model:** Shifting from mere "waste treatment" to an integrated "resource recovery" system, whereby the outputs of the recycling process (such as recycled lead and plastic) become essential inputs into a new production cycle, achieving significant economic savings and maximum environmental protection.

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