مركز الاستشارات والبحوث والتطوير
بأكاديمية السادات للعلوم الإدارية

مجلة البحوث الإدارية
Journal of Management Research

علمية - متخصصة - مُحكمة - دورية ربع سنوية

عدد أكتوبر 2024

للسنة
الثانية والأربعين

Vol. 42, No.4; Oct. 2024

CELEBRATION 42 YEARS ANNIVERSARY

jso.journals.ekb.eg

ISSN : 1110-225X

Journal of Management Research
Vol. 42, No. 4, Oct. 2024

Sadat Academy for Management Sciences
Consultancy, Research and Development Center

Enhancing Waste Management in Construction Industry Using a Reverse Logistics Strategy

A Case Study of Constructions in Egypt

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(PRINT) ISSN :1110-225X https://jso.journals.ekb.eg

ABSTRACT

This thesis is to investigate waste management practices in the construction industry with a focus on the implementation of reverse logistics strategies. A reverse logistics strategy involves planning, implementing, and controlling the efficient flow of recovered materials back from a consumer to a producer for reprocessing or proper disposal. Also, it's a concept aimed at optimizing resource utilization and minimizing waste through the management of surplus materials, holds promise for enhancing sustainability in construction projects.

This study shows construction industry generates a significant amount of waste, and traditional waste management practices often focus on disposal rather than recovery.

and shows implementing a reverse logistics strategy, construction companies can reduce their environmental impact, conserve resources, and potentially generate cost savings.

Hence, the paper suggests that a reverse logistics strategy can be a valuable tool for improving waste management in the construction industry and provides an overview of the study's objectives, methodologies, key dimensions explored, and findings, offering a glimpse into the significance of the research on waste management in construction using reverse logistics strategies.

1. Introduction

The construction industry plays a pivotal role in global development, yet it also generates a substantial amount of waste, posing environmental, economic, and social challenges. Sustainable construction practices have gained traction in recent years as a means to mitigate these challenges, with a focus on waste management to minimize waste generation and promote resource recovery. Despite the potential benefits, the adoption of sustainable practices, particularly reverse logistics, remains limited in the construction sector. Unlike other industries where reverse logistics has been well-established, the construction industry lacks a robust reverse logistics network, hindering efficient waste management and resource utilization. However, integrating reverse logistics into construction waste management holds promise for optimizing resource utilization, reducing waste, and enhancing overall efficiency.

Efforts to promote sustainable waste management in the construction industry must address existing barriers and constraints. Conventional practices often prioritize disposal over recovery or reuse, perpetuating resource depletion and environmental degradation. To achieve sustainable construction goals, there is a need for a paradigm shift towards circular approaches to waste management, emphasizing the conservation and reuse of materials.

This research aims to explore the relationship between reverse logistics and waste management in the construction industry in Egypt, examining the benefits, barriers, and constraints faced by

construction companies. By identifying challenges and opportunities, this study seeks to provide insights into the potential role of reverse logistics in promoting sustainable waste management practices within the construction sector.

2. Key words

1. Waste management
2. Reverse logistics
3. Construction industry
4. Sustainability
5. Resource utilization
6. Waste reduction
7. Demolition waste
8. Cost saving
9. Optimization
10. Implementation

3. Literature review

3.1. Construction and Demolitions Waste Management (C&D wastes)

are materials created during construction, renovation, or demolition and are typically disposed of in landfills. The management of C&D waste presents a significant global challenge due to its detrimental effects on the environment and public health. An effective framework is needed to minimize pollution, climate change, and resource depletion. C&D waste can be classified into physical and non-physical waste, with man-made sources being broken down into design, procurement, material handling, operation, residual, and other sources.

Reverse logistics aims to add value to materials that are conventionally discarded into landfills and make them usable for construction or other developments. It can contribute to resource efficiency by reducing raw mineral material imports for the construction sector in Vienna city. However, there is limited investigation on the practicality of incorporating reverse logistics in large-scale construction projects. This study aims to advance knowledge surrounding construction reverse logistics and provide a theoretical framework to promote the use of recycled materials in construction or other applications.

Purchase, C.K.;Al Zulayq, D.M.; O'Brien, B.T.;Kowalewski, M.J.; Berenjian, A.;Tarighaleslami, A.H.; Seifan, M.Circular Economy of Constructionand Demolition Waste: A LiteratureReview on Lessons, Challenges,and Benefits. Materials 2022, 15, 76.https://doi.org/10.3390/ma15010076Academic Editors: F. Pacheco TorgalReceived: [16 October 2021Accepted: 18 December 2021Published:23 December2021]

3.2. Reverse logistics implementation

Reverse logistics is a strategic approach used by the construction sector to address waste and non-renewable resources, aiming to generate added value and overcome environmental impacts. It involves maintaining, servicing, reusing, and disposing of products, after-sales service, green supply chain management, and product life-cycle management. The implementation of reverse logistics in the manufacturing sector is a strategic decision for companies to improve supply chain performance. Reverse logistics activities include product return activities and product recovery activities, which can include reusing, repairing, refurbishing, remanufacturing, recycling, or down-cycling.

However, reverse logistics is a new concept for the construction industry, especially in developing countries. To successfully implement reverse logistics, the construction sector needs to learn techniques and concepts from the manufacturing industry and adapt to the perspectives of different stakeholders. A study was conducted to gather knowledge about reverse logistics in the construction sector. By understanding the barriers and adapting to the project life cycle, the construction sector can effectively implement reverse logistics and minimize waste problems.

3.3. Benefits of reverse logistics in Constructions

Environmental Benefits:

• Recycling and reusing construction waste reduces landfill waste, prolonging landfill sites' lifespan.
• Chemical additives in building materials intensify contamination, reducing CO2 emissions.
• Recycled materials require less transportation, creating job opportunities.

Economic Benefits:

• Eradication of landfill use can counterbalance job losses by creating new opportunities.
• Recycled materials undergo modification processes, presenting job opportunities.
• This helps the economy and reduces environmental impact.

Societal Benefits:

• Increased recycling in the construction industry can reduce landfill waste and increase high-quality land for housing.
• Waste from construction materials can reduce pollution in natural streams and waterways.
• Waste in concrete can reduce landfill disposal and harmful substances, promoting recycling.

Van Tran, in 2017, [Construction and Demolition Waste: Lessons, Challenges, and Benefits]

3.4. Value Management Framework for Construction Waste Reduction (VMFCWR)

is a business improvement framework that aims to integrate Value Management into the design process for reducing construction waste. The framework consists of five phases: initiating, planning, executing, monitoring, and controlling, and closing. The initiating phase identifies root causes of preventing the integration of Value Management, requiring a strong team with diverse expertise and backgrounds. The planning phase sets procedures and actions to integrate Value Management into the design process, including expected risks and corrective actions. The executing phase integrates resources and ensures successful execution of plans. The monitoring and controlling phase ensure that the integration of Value Management goes according to plans, with feedback from the execution team enabling corrective actions. The closing phase ensures the project is completed as planned and evaluates outcomes to avoid future mistakes. The framework's goal is to enhance the value delivered to clients and achieve sustainability in the built environment.

Yılmaz M, Bakış A (2015) Sustainability in construction sector. Procedia: Soc Behav Sci 195:2253–2262.

4. Research problem

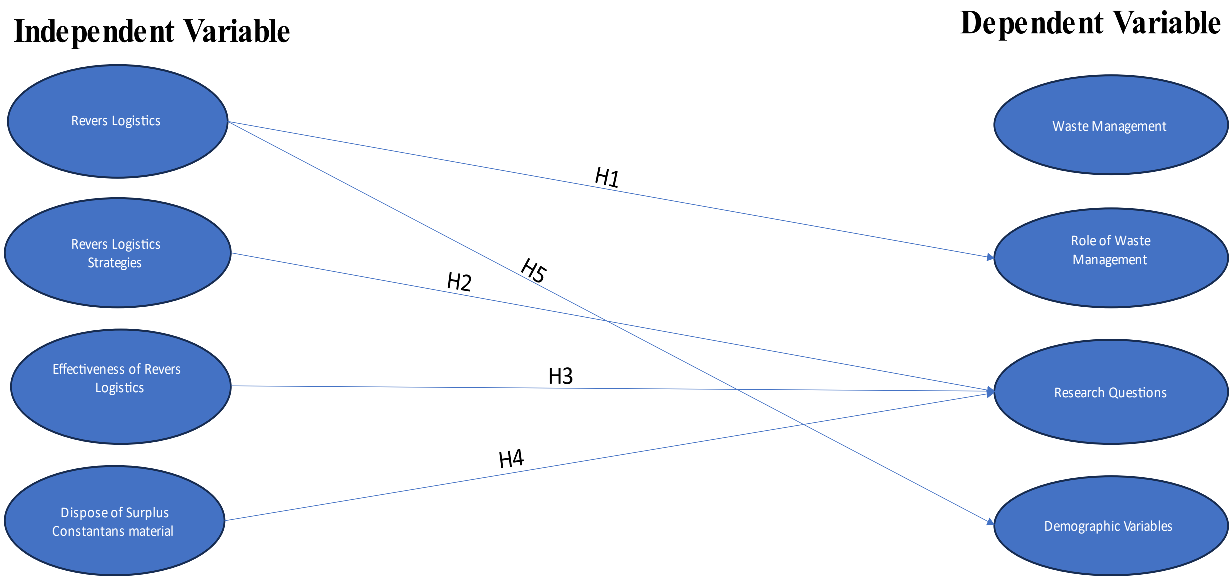
This research aims to investigate effectiveness of using reverse logistics solutions to reduce waste and improve resource utilization in the Egyptian construction industry.

5. Research Objectives:

1. To assess the effectiveness of reverse logistics strategy in minimizing construction waste generation.
2. **To evaluate the potential of a reverse logistics strategy for increasing resource recovery through reuse, remanufacturing, and recycling of construction waste materials.**
3. **To analyze the environmental impact of implementing a reverse logistics strategy in construction projects.**
4. **To investigate the potential economic benefits associated with adopting a reverse logistics strategy for construction waste management.**

5. Research variables:

- **Independent Variable:** Reverse logistics strategy
- **Dependent Variables:** Waste Management
- **Dimensions of the Research:** The dimensions explored in the study encompass various aspects of waste management practices, reverse logistics strategies, and their effectiveness within the construction industry. These dimensions include roles within the construction industry, familiarity with reverse logistics concepts, implementation of reverse logistics strategies, measurement of effectiveness, disposal of surplus construction materials, and demographic factors such as gender, job, and age.



6. Methodology

In this chapter, introduce the research methodology chapter by emphasizing the importance of selecting an appropriate methodology to address the research problem. Highlight how the chosen methodology will help achieve the objectives of studying waste management in the construction industry through reverse logistics strategies.

The study methodology was used to evaluate waste management practices and the possibility of reverse logistics solutions in the construction sector. The quantitative method was used, with data collected and analyzed through surveys and statistical analysis. The study design is explanatory, with the goal of investigating the link between waste management methods and the use of reverse logistics. The data gathering methods include sending standardized questionnaires to construction businesses, managers, and employees at various levels. The poll is designed to analyze existing waste management methods, staff acquaintance with reverse logistics, and views of its potential advantages. The quantitative analysis employs a variety of statistical techniques, including descriptive statistics, inferential statistics, and multivariate analysis, to investigate relationships, identify patterns, and draw conclusions about waste management practices and the potential for reverse logistics in the construction industry. The chapter also discusses the sample selection process, supporting the approach used and emphasizing its usefulness for statistically analyzing the performance of reverse logistics in waste management.

Overall, this chapter gives a thorough description of the study methods used to explore the potential of reverse logistics solutions for improving waste management practices in the construction sector.

7. Research Design:

Describe the research design as explanatory, aiming to explore the relationship between waste management practices and the implementation of reverse logistics strategies in the construction industry. A structured questionnaire was designed to collect quantitative data from employees of Orascom Company regarding their perceptions, experiences, and attitudes towards waste management practices and the potential adoption of reverse logistics strategies in construction projects.

8. Research Approach:

Chosen approach is quantitative research, as it enables the collection and analysis of numerical data to measure and quantify the relationship between variables. Explaining that quantitative methods are suitable for assessing the effectiveness of reverse logistics strategies in waste management quantitatively by enabling the measurement of waste reduction, cost savings, and other relevant metrics.

This research adopts an **explanatory design** to explore the **causal relationship** between waste management practices and the implementation of reverse logistics strategies in construction projects. This design allows for a comprehensive investigation of the research question and the factors influencing the adoption of reverse logistics.

9. Data collection:

Survey

Distributing structured questionnaires to Construction Company, managers, and employees with different managerial levels to collect quantitative data on waste generation, disposal practices, and perceptions towards reverse logistics. Design the survey questionnaire to collect relevant information about waste management practices, reverse logistics strategies, challenges, and perceptions within the construction industry. Consider using validated scales or standardized measures to ensure the reliability and validity of the data.

The survey questionnaire was designed to gather comprehensive insights into:

- **Waste management practices** currently employed in construction projects.
- **Awareness and knowledge** of reverse logistics concepts in construction waste management.
- **Perceptions** towards the potential benefits and challenges of implementing reverse logistics strategies.
- **Survey Instrument:** Developing a structured questionnaire based on the hypotheses and research objectives, containing questions related to the variables outlined in the hypotheses.

- **Survey Administration:** Distributing the survey electronically or in person to the selected sample population, ensuring clarity of instructions and anonymity of responses.
- **Data Validation:** Implementing measures to ensure data accuracy and reliability, such as validation checks and data cleaning process.
-

10.Data analysis

Data Analysis: Conducting statistical analysis to quantify waste reduction, cost savings, and other relevant metrics associated with reverse logistics implementation.

- **Descriptive statistics** were used to summarize the data and understand the sample's characteristics.
- **Frequencies and percentages:** These described the distribution of responses for categorical variables, such as gender, age, and job title.
- **Measures of central tendency (mean and median):** These provided an idea of the "average" value for continuous variables, such as the number of years of experience.
- **Measures of dispersion (standard deviation):** These quantified the spread of data around the central tendency measures, indicating the variability within the sample.
- **Inferential statistics** were then used to test hypotheses about relationships between variables and draw broader conclusions about the construction industry.
- **Correlation analysis:** This assessed the strength and direction of the relationships between variables, for example, the correlation between awareness of reverse logistics and its implementation in projects.
- **Regression analysis:** This investigated how independent variables, such as perceived effectiveness of reverse logistics, might influence dependent variables, such as waste reduction rates. This helped identify factors potentially predicting waste management effectiveness.

11. Hypotheses:

Here are the 5 hypotheses to address the research:

Hypothesis 1 (H1):

- There is a significant relationship between (Q1 role in the construction industry) and (Q2 you familiar with the concept of reverse logistics in construction waste management)

Hypothesis 2 (H2):
- There is a significant relationship between (Q3 you implemented reverse logistics strategies in your construction projects) and some Research Questions 2 and 19.

Hypothesis 3 (H3):
- There is a significant relationship between (Q8 do you measure the effectiveness of reverse logistics in waste management) and some Research Questions.

Hypothesis 4 (H4):
- There is a significant relationship between (Q16 you dispose of surplus construction materials) and some Research Questions

Hypothesis 5 (H5):
- There are statistically significant differences between the demographic variable (gender, job, Age,), according to the total dimension (A Waste Management in Construction Industry Using a Reverse Logistics Strategy)

12.Research importance:
The importance of this research helps construction organizations reduce waste, maximize material use, and save money by adopting reverse logistics by addressing waste.

13.Sampling strategy:
Define the population: Determine the survey's target audience, which include construction businesses, project managers, and employees involved in demolition waste management with different managerial levels involved in demolition wastes procedures within the construction sector.

Probability sampling: Employing random sampling techniques to select representative samples from the target population of construction companies.

Sample size: Determining the sample size based on statistical considerations to ensure adequate power and representativeness of the findings.

Using a systematic sampling technique, researchers may assure the reliability and validity of survey results, obtain useful insights into waste management procedures, and influence evidence-based decision-making in the construction sector.

13.1 Sample Size Formula

The Sample Size Calculator uses the following formulas.

- **n = z^2 * p * (1 - p) / e^2**
- **n (with finite population correction) = [z^2 * p * (1 - p) / e^2] / [1 + (z^2 * p * (1 - p) / (e^2 * N))]**

Where:

***n** is the sample size,*

***z** is the z-score associated with a level of confidence,*

***p** is the sample proportion, expressed as a decimal,*

***e** is the margin of error, expressed as a decimal,*

***N** is the population size.*

The sample size (n) is calculated according to the formula: n = [z^2 * p * (1 - p) / e^2] / [1 + (z^2 * p * (1 - p) / (e^2 * N))]
Where: z = 1.96 for a confidence level (α) of 95%, p = proportion (expressed as a decimal), N = population size, e = margin of error.
z = 1.96, p = 0.5, N = 38, e = 0.05
n = [1.96^2 * 0.5 * (1 - 0.5) / 0.05^2] / [1 + (1.96^2 * 0.5 * (1 - 0.5) / (0.05^2 * 38))]
n = 384.16 / 11.1095 = 34.579
n ≈ 35 responds
The Hotels Project Development division, overseen by the Head of Hotels Project Development, is composed of various departments including Site Management, Hotels Development Senior Director, Logistics Management, and Project Management. Within these departments, there are 38 employees, comprising 10 managers and 28 staff members, with a breakdown of 18 engineers and 8 senior engineers. Among the managers, 7 are males aged between 45 and 55, while 3 are females aged between 40 and 50. The engineering team consists of 14 males and 4 females aged between 25 and 35, while the senior engineering team includes 7 males and 2 females aged between 35 and 45. Overall, there are 28 male employees and 10 female employees across the departments.

14.Limitations:

- **Research Limitations**: Potential limitations of the study may include sample size constraints, respondent bias, and the generalizability of findings to broader construction contexts. Additionally, the study may be limited by the availability and accuracy of survey data.

- **Time Limitations**: Time restrictions may limit the study's depth and breadth of data collecting and analysis. Additionally, changes in industry practices over time may affect the relevance and applicability of the study's findings.
- **Place Limitations:** The research may be limited by geographical constraints, as focusing on a specific region or locality may limit the generalizability of the findings to other contexts.
- **Topic Limitations:** The scope of the study may be limited by the complexity and breadth of the topic. Waste management in the construction industry using reverse logistics strategies encompasses various subtopics and dimensions, and it may not be feasible to address all aspects comprehensively within a single study. Consequently, certain aspects of the topic may be overlooked or underexplored.
- **Industry Limitations:** The research may be constrained by industry-specific factors, such as access to data, cooperation from industry stakeholders, and willingness to adopt innovative practices. Resistance to change, lack of awareness about reverse logistics strategies, and competing priorities within the construction industry may pose challenges to implementing and studying demolition initiatives effectively.

15. Orascom Case Study

A case study used in waste management research in the construction industry that employs reverse logistics strategy entails an in-depth examination of a specific construction project or company, such as Orascom Company, to understand how reverse logistics strategies are implemented and how they affect waste management practices. It entails gathering qualitative and quantitative data via interviews, surveys, and document analysis in order to offer a full account of the problems, accomplishments, and lessons gained while incorporating reverse logistics into waste management procedures. The case study approach enables a comprehensive understanding of the complexities involved in implementing reverse logistics strategies in the construction industry, as well as valuable insights for practitioners, policymakers, and researchers looking to improve sustainability in construction waste management.

In the context of an explanatory case study on waste management in the construction industry utilizing reverse logistics strategy, the research conducted provides valuable insights into the underlying factors influencing the adoption and effectiveness of reverse logistics practices.

15.1 Orascom Developments

Greetings from the Orascom universe. They are a well-known global developer with a focus on creating thriving, integrated communities in North Africa, the Middle East, and Europe. Orascom Development has led the way in developing places where people are motivated to live, work, and play with passion and purpose for over 30 years. Our towns are heartfelt spaces that unite individuals and families, locals and tourists, leisure and commerce, to create uplifting communities. Since 1989, we have made use of our distinctive approach to destination development as we have been listed on the SIX Swiss Exchange.

The idea to build a small paradise close to the Red Sea was the beginning of it all. The biggest company under Orascom Development Holding (ODH), a premier developer of fully integrated towns with vibrant communities, is currently Orascom Egypt. For over 30 years, Orascom Development Egypt has been creating world-class travel experiences. We have honed our skills in creating brand-new communities from the ground up during that time. Beautiful homes, exquisite hotels, and exceptional business and recreational amenities—such as golf courses, marinas, sports facilities, retail stores, and restaurants—are all part of our integrated development strategy. Our communities are built on a wide range of vital infrastructure, and the people who live here and visit here are the focal point of everything we do.

Over fifty million square meters of land in El Gouna, Makadi, O-west, Taba Heights, and Byoum, Egypt, are under our control. With numerous sophisticated plans, we have already developed over 14 million square meters of that land.

15.2 Vision

Our shared vision is to become a global leader in destination development and the partner of choice for transforming land into thriving centers of life.

We aim to elevate the benchmark of living with master planned developments that empower, inspire, integrate, and respect. We are fostering connections to a mindset, a community, and a sense of belonging.

We define our success by the quality of life our destinations deliver and the long-term value we create.

15.3 Mission

Our shared mission is to create integrated destinations and build vibrant communities where people are inspired to live, play, and work, with passion and purpose.

We believe every destination should have a unique character, with its own soul and personality.

We design our master-planned communities with all the facilities and amenities to deliver an improved quality of life and unlock life's potential.

We already have a highly respected track record, but we aim to go further.

16. Hypotheses Statistical Analyzes

16.1 Part 3:

Research Hypotheses
Focuses the researcher to test 5 Hypotheses essential, to address the various dimensions of the research problem and objectives, as follows.

Hypotheses _1: There is a significant relationship between (roles in the construction industry q1) and (you familiar with the concept of reverse logistics in construction waste management q2).

Hypotheses _2: There is a significant relationship between (you implemented reverse logistics strategies in your construction projects q3) and some Research Questions.

Hypotheses _3: There is a significant relationship between (do you measure the effectiveness of reverse logistics in waste management q 8) and some Research Questions.

Hypotheses _4: There is a significant relationship between (you dispose of surplus construction materials q 16) and some Research Questions.

Hypotheses _5: There are statistically significant differences between the demographic variable (gender, job, Age,), according to the total dimension (A Waste Management in Construction Industry Using a Reverse Logistics Strategy).

The following is to test the hypotheses and prove their acceptance or rejection.

H_1: There is a significant relationship between (role in the construction industry q1) and (you familiar with the concept of reverse logistics in construction waste management q2).

Variables Hypothesis

- Role in the construction industry q1
- You familiar with the concept of reverse logistics in construction waste management q2

Statistical method used:

Cross tabulation, Chi-square test **There is a relationship if the significance level of less than (0.05) and if the significance level is greater than (0.05) indicates that the There is no relationship.**

Table

Relationship between " role in the construction industry q1) and (you familiar with the concept of reverse logistics in construction waste management" q2 by use Chi-square test

Q1- role in the construction industry	**Chi-square**	**Contingency Coefficient**	**P-value**	**Result**
Q2- you familiar with the concept of reverse logistics in construction waste management	5.411	0.366	0.05*	Sig.

* Significant level 0.05

From the above table clear that:

There is relationship between, **"q1"** and "q2", which, Chi-square equal (5.411), **Contingency Coefficient** equal (0.366), at a significant less than (0.05).

Prove the hypothesis research:

Acceptance of the Alternative hypothesis there is a significant relationship between (roles in the construction industry q1) and (you familiar with the concept of reverse logistics in construction waste management q2)

H_2: -There is a significant relationship between (you implemented reverse logistics strategies in your construction projects q3) and some Research Questions.

Variables Hypothesis

- you implemented reverse logistics strategies in your construction projects q3
- Research Questions q2. q19

Statistical method used:

Cross tabulation, Chi-square test

Table

Relationship between (you implemented reverse logistics strategies in your construction projects q3) and (Research Questions)

By use Chi-square test

Q3	Chi-square	Contingency Coefficient	P-value	Result
2-	9.527	0.463	0.05*	Sig.
19-	9.069	0.454	0.05*	Sig.

* Significant level 0.05

From the above table clear that:

1. There is relationship between, **"q 3"** and "q2", which, Chi-square equal (9.527), **Contingency Coefficient** equal (0.463), at a significant less than (0.05).

2. There is relationship between, **"q 3"** and "q19", which, Chi-square equal (9.069), **Contingency Coefficient** equal (0.454), at a significant less than (0.05).

It is evident that Q3 has a stronger relationship with Q2, with a Contingency Coefficient measuring the strength of the relationship at 0.463. Then, it is followed by its relationship with Q19, with a Contingency Coefficient of 0.454.

Comment: The table presents the results of the Chi-square test analyzing the relationship between the implementation of reverse logistics strategies in construction projects (Q3) and other research questions. The results indicate significant relationships between Q3 and Q2, as well as between Q3 and Q19, at a significance level of 0.05.

Prove the hypothesis research:

Acceptance of the Alternative hypothesis There is a significant relationship between (you implemented reverse logistics strategies in your construction projects q3) and some Research Questions

H 3: -There is a significant relationship between (do you measure the effectiveness of reverse logistics in waste management q 8) and some Research Questions.

Variables Hypothesis

- q8
- Research Questions q1/2/6//13/14/15/18/20

Statistical method used:

Cross tabulation, Chi-square test

Table

Relationship between (you measure the effectiveness of reverse logistics in waste management q8) and (Research Questions)

by use Chi-square test

Q8- you measure the effectiveness of reverse logistics in waste management	**Chi-square**	**Contingency Coefficient**	**P-value**	**Result**
1	12.257	0.509	0.05*	Sig.
2	10.082	0.473	0.05*	Sig.
6	23.426	0.633	0.05*	Sig.
13	18.437	0.589	0.05*	Sig.
14	20.515	0.608	0.05*	Sig.
15	27.192	0.661	0.05*	Sig.
18	18.979	0.593	0.05*	Sig.
20	18.363	0.587	0.05*	Sig.

* Significant level 0.05

From the above table clear that:

1-There's relationship between, " **q 8**" and " q1" , which, Chi-square equal (12.257), **Contingency Coefficient** equal (0.509), at a significant less than (0.05).

2-There's relationship between, " **q 8**" and " q2" , which, Chi-square equal (10.082), **Contingency Coefficient** equal (0.473), at a significant less than (0.05).

3-There's relationship between, " **q 8**" and " q6" , which, Chi-square equal (23.426), **Contingency Coefficient** equal (0.633), at a significant less than (0.05).

4-There's relationship between, " **q 8**" and " q13" , which, Chi-square equal (18.437), **Contingency Coefficient** equal (0.589), at a significant less than (0.05).

5-There's relationship between, " **q 8**" and " q14" , which, Chi-square equal (20.515), **Contingency Coefficient** equal (0.608), at a significant less than (0.05).

6-There's relationship between, " **q 8**" and " q15" , which, Chi-square equal (27.192), **Contingency Coefficient** equal (0.661), at a significant less than (0.05).

7-There's relationship between, " **q 8**" and " q18" , which, Chi-square equal (18.979), **Contingency Coefficient** equal (0.593), at a significant less than (0.05).

8-There's relationship between, " **q 8**" and " q20" , which, Chi-square equal (18.363), **Contingency Coefficient** equal (0.587), at a significant less than (0.05).

it becomes clear that the strongest relationships with Q8 are with (15), (6), (14), (18), (13), (20), (1), and (2), with Contingency Coefficient values of (.661), (.633), (.608), (.593), (.589), (.587), (.509), and (.473) respectively.

The statistical analysis confirms a significant relationship between measuring the effectiveness of reverse logistics in waste management and various research questions, indicating the importance of this factor in the construction industry.

<u>Prove the hypothesis research:</u>

Acceptance of the Alternative hypothesis There is a significant relationship between (do you measure the effectiveness of reverse logistics in waste management q 8) and some Research Questions.

H_4: -There is a significant relationship between (you dispose of surplus construction materials q 16) and some Research Questions.

Variables Hypothesis

- -- q16

- Research Questions 9/11/13/14/15/18/19/20

Statistical method used:

Cross tabulation, Chi-square test

Table

Relationship between (you dispose of surplus construction materials q16) and (Research Questions) By use Chi-square test.

Q16- you dispose of surplus construction materials	**Chi-square**	**Contingency Coefficient**	**P-value**	**Result**
9	12.683	0.516	0.05*	Sig.
11	22.111	0.622	0.05*	Sig.
13	12.278	0.510	0.05*	Sig.
14	26.616	0.657	0.05*	Sig.
15	19.512	0.598	0.05*	Sig.
18	27.602	0.664	0.05*	Sig.
19	41.561	0.737	0.05*	Sig.
20	19.022	0.593	0.05*	Sig.

* Significant level 0.05

From the above table clear that:

1-There's relationship between, " **q 16**" and " q9" , which, Chi-square equal (12.683), **Contingency Coefficient** equal (0.516), at a significant less than (0.05).

2-There's relationship between, " **q 16**" and " q11" , which, Chi-square equal (22.111), **Contingency Coefficient** equal (0.622), at a significant less than (0.05).

3-There's relationship between, " **q 16**" and " q13" , which, Chi-square equal (12.278), **Contingency Coefficient** equal (0.510), at a significant less than (0.05).

4-There's relationship between, " **q 16**" and " q14" , which, Chi-square equal (26.616), **Contingency Coefficient** equal (0.657), at a significant less than (0.05).

5-There's relationship between, " **q 16**" and " q15" , which, Chi-square equal (19.512), **Contingency Coefficient** equal (0.598), at a significant less than (0.05).

6-There's relationship between, " **q 16**" and " q18" , which, Chi-square equal (27.602), **Contingency Coefficient** equal (0.664), at a significant less than (0.05).

7-There's relationship between, " **q 16**" and " q19" , which, Chi-square equal (41.561), **Contingency Coefficient** equal (0.737), at a significant less than (0.05).

8-There's relationship between, " **q 16**" and " q20" , which, Chi-square equal (19.022), **Contingency Coefficient** equal (0.593), at a significant less than (0.05).

From the above table, it is evident that there is a significant relationship between q16 and q9, q11, q13, q14, q15, q18, q19, and q20, with Contingency Coefficient values ranging from 0.510 to 0.737, indicating the strength of the relationships.

The results demonstrate strong relationships between the disposal of surplus construction materials (q16) and various Research Questions, confirming the hypothesis and highlighting key areas of significance for further investigation.

Prove the hypothesis research:

Acceptance of the Alternative hypothesis There is a significant relationship between (you dispose of surplus construction materials q 16) and some Research Questions

H_5: There are statistically significant differences between the demographic variable (gender, job, Age,), according the total dimension (A Waste Management in Construction Industry Using a Reverse Logistics Strategy).

Statistical method used:

Kruskal Wallis test to find the difference between groups if the level of less than (0.05) indicates that the presence of significant, and if a significance level greater than (0.05) indicates that there was no statistically significant difference

Age

Table

Difference between variable (age) regarding Waste Management in Construction Industry Using a Reverse Logistics Strategy by use Kruskal Wallis test

statement	sample	N	Mean rank	Chi-square	P-value	Sig.
3- you implemented reverse logistics strategies in your construction projects	less 35 years old	4	15.25	0.612	0.73	Non .Sig.
	35 less 45 years old	14	17.75			
	+45	17	18.85			
8- do you measure the effectiveness of reverse logistics in waste management	less 35 years old	4	21.25	3.547	0.17	Non .Sig.
	35 less 45 years old	14	14.32			
	+45	17	20.26			
16- you dispose of surplus construction materials	less 35 years old	4	24.13	3.119	0.21	Non .Sig.
	35 less 45 years old	14	14.96			
	+45	17	19.06			

From the above table it is clear:

1-There is no statistically significant differences category of the variable (age) about the **statement** (you implemented reverse logistics strategies in your construction projects), as the value of (Chi-square) was (0.612), with a significant level more than (0.05)

2- There is no statistically significant differences category of the variable (age) about the **statement** (do you measure the effectiveness of reverse logistics in waste management), as the value of (Chi-square) was (3.547), with a significant level more than (0.05)

3- There is no statistically significant differences category of the variable (age) about the **statement** (you dispose of surplus construction materials), as the value of (Chi-square) was (3.119), with a significant level more than (0.05)

Job

Table

Difference between variable (job) regarding to A Waste Management in Construction Industry Using a Reverse Logistics Strategy

by use Kruskal Wallis test

statement	sample	N	Mean rank	Chi-square	P-value	Sig.
3- you implemented reverse logistics strategies in your construction projects	Managers	7	19.00	0.156	0.92	Non .Sig.
	Senior engineer	19	17.55			
	Engineers	9	18.17			
8- do you measure the effectiveness of reverse logistics in waste management	Managers	7	17.86	0.422	0.81	Non .Sig.
	Senior engineer	19	17.24			
	Engineers	9	19.72			
16- you dispose of surplus construction	Managers	7	18.07	0.023	0.98	Non .Sig.
	Senior engineer	19	17.79			

materials	Engineers	9	18.39			

From the above table it is clear:

1-There is no statistically significant differences category of the variable **job**) about the **statement** (you implemented reverse logistics strategies in your construction projects), as the value of (Chi-square) was (0.156), with a significant level more than (0.05)

2- There is no statistically significant differences category of the variable (**job**) about the **statement** (do you measure the effectiveness of reverse logistics in waste management), as the value of (Chi-square) was (0.422), with a significant level more than (0.05)

3- There is no statistically significant differences category of the variable (**job**) about the **statement** (you dispose of surplus construction materials), as the value of (Chi-square) was (0.023), with a significant level more than (0.05).

Gender

Statistical method used:

Mann whitney test to find the difference between groups if the level of less than (0.05) indicates that the presence of significant, and if a significance level greater than (0.05) indicates that there was not statistically significant difference.

Table

Difference between variable (gender) regarding to A Waste Management in Construction Industry Using a Reverse Logistics Strategy by use Mann whitney test

statement	sample	N	Mean rank	z	P-value	Sig.
3- you implemented reverse logistics strategies in your construction projects	Male	28	19.00	1.404	0.16	Non .Sig.
	Female	7	14.00			
8- do you measure the effectiveness of reverse logistics in waste management	Male	28	19.07	1.337	0.18	
	Female	7	13.71			

16- you dispose of surplus construction materials	Male	28	18.29	0.346	0.73	Non .Sig.
	Female	7	16.86			

From the above table it is clear:

1-There is no statistically significant differences category of the variable (**gender**) about the **statement** (you implemented reverse logistics strategies in your construction projects), as the value of (z) was (3.692), with a significant level more than (0.05)

2- There is no statistically significant differences category of the variable (**gender**) about the **statement** (do you measure the effectiveness of reverse logistics in waste management), as the value of (z) was (3.692), with a significant level more than (0.05)

3- There is no statistically significant differences category of the variable (**gender**) about the **statement** (you dispose of surplus construction materials), as the value of (z) was (3.692), with a significant level more than (0.05)

Prove the hypothesis research:

Acceptance of the null hypothesis that There no is statistically significant differences between the demographic factors (job, Age, gender,), according the total dimension (**A Waste Management in Construction Industry Using a Reverse Logistics Strategy**

17.Study Results

Through this study, the researcher has arrived at several results that can be classified into general findings and statistically significant results within the sector of the study area, as follows:

a. **Through descriptive statistics, which illustrate the main strengths and weaknesses, four sections of the study were identified regarding:**

SECTION 1- To assess the effectiveness of reverse logistics strategy in minimizing construction waste generation consisting of 5 statements:

The researcher found that all roles are important in construction waste management, with 77% of respondents recognizing their diverse significance. 66% agreed on the concept of reverse logistics, while 34% disagreed. Implementation of reverse logistics strategies was strong, with cost savings being the primary reason (66%), followed by stakeholder engagement (11%). Recycling was the most important aspect (66%).

SECTION 2- Evaluating the Potential of Reverse Logistics Strategy for Increasing Resource Recovery in Construction Waste Management: This section comprises 5 statements:

The demolition stage generates the most waste, with lack of awareness being the biggest barrier. Measurement effectiveness is most effective, and challenges in waste segregation are influenced by government incentives.

SECTION 3- aims to analyze the environmental impact of implementing a reverse logistics strategy in construction projects.

The study focuses on handling hazardous waste in construction projects, identifying specific reverse logistics technologies and tools, and their potential contribution to a circular economy. The study also highlights the importance of engaging stakeholders in the implementation of reverse logistics strategies, with financial incentives being the most effective. The study also highlights the need for collaboration with suppliers and contractors.

SECTION 4- aims to explore the potential economic benefits associated with implementing a reverse logistics strategy for construction waste management.

The study reveals that the most effective methods for disposing of surplus construction materials are reselling or donating them, implementing reverse logistics, and evaluating the environmental impact of construction projects. The most effective communication methods are website and social media, while sustainability reports are the least effective. The study also suggests that the adoption of reverse logistics strategies is recommended for other construction companies.

b. **Through inferential statistics:**

To verify the research objectives, the researcher established certain relationships that provide statistically significant direction regarding the importance of activating the use of Waste Management in Construction Industry Using a Reverse Logistics Strategy. This is to support the industry sector in optimizing waste utilization. The researcher imposed 5 hypotheses to verify this as follows:

Hypothesis 1: There is a significant relationship between the respondent's role in the construction industry (question 1) and their familiarity with the concept of reverse logistics in construction waste management (question 2).

Where the Contingency Coefficient, indicating the strength of association, reached 0.366 at a significance level of less than 0.05. The hypothesis is supported overall.

Hypothesis 2: There is a significant relationship between the implementation of reverse logistics strategies in construction projects (Question3) and certain research questions.

Where the Contingency Coefficient, indicating the strength of association, reached 0.463 at a significance level, less than 0.05 with both question 2 and question 9. The hypothesis is supported overall.

Hypothesis 3: There is a significant relationship between the effectiveness of reverse logistics in waste management (question 8) and some Research Questions.

The most influential questions on question 8 are (15), (6), (14), (18), (13), (20), (1), and (2), with contingency coefficient values of (.661), (.633), (.608), (.593), (.589), (.587), and (.509), respectively. The hypothesis is supported overall.

Hypothesis 4: There is a significant relationship between the disposal of surplus construction materials (Question 16) and certain research questions.

The most influential questions on Question 16 are questions (19), (18), (14), (11), (15), (20), (9), and (13), with Contingency Coefficient factors of (.737), (.664), (.657), (.622), (.598), (.593), (.516), and (.510) respectively. The hypothesis is supported overall.

Hypothesis 5: There are statistically significant differences between demographic variables (gender, job, age) according to the overall dimension of Waste Management in Construction Industry Using a Reverse Logistics Strategy.

This indicates that both genders are consistent across all study variables, as well as age groups and job categories. The hypothesis was not fully supported.

18.Findings

The research explores the effectiveness of reverse logistics in reducing construction waste and improving resource utilization in the Egyptian construction industry. It found growing awareness of reverse logistics but limited implementation due to barriers like lack of knowledge, logistical difficulty, and economic feasibility. Key motivators for implementing reverse logistics include cost reductions, environmental sustainability, and regulatory compliance. Waste management practices were found to be strong, with recycling being the most common approach. Decision-making factors, such as government incentives and client needs, were identified as key influences. However, the study identified several problems that need to be addressed before widespread implementation, including lack of awareness, logistical complexity, economic viability, and regulatory constraints.

19.Recommendations:

Considering the previous results, the researcher was able to reach a set of prominent recommendations. The following table outlines the key recommendations of the study, in the form of the following action plan:

No.	Recommendation Content	Assigned Department	Implementation Mechanisms	Required Time
1	Awareness and understanding of the concept of reverse logistics in construction waste management	Project Managers	Conduct training sessions and workshops	3 months
2	Focus on and awareness of implementing reverse logistics strategies in construction projects	Construction Managers	Incorporate reverse logistics principles into project planning and execution	Ongoing
3	Attention to Regulatory Compliance	Regulatory Affairs Department	Regular review of regulations and compliance audits	Quarterly
4	Awareness and action on Stakeholder Engagement	Communication Managers	Develop stakeholder engagement plans and communication strategies	6 months
5	Increasing awareness of Landfilling and Incineration	Environmental Managers	Conduct educational campaigns and workshops on sustainable waste management practices	4 months
6	Avoiding Regulatory Constraints	Legal Department	Regular monitoring of regulatory changes and proactive compliance measures	Ongoing

No.	Recommendation Content	Assigned Department	Implementation Mechanisms	Required Time
7	Developing a clear strategy to activate Market Competition	Marketing Managers	Market research and development of competitive pricing and service strategies	6 months
8	Activation of Mobile Applications requirements	IT Department	Develop and deploy mobile applications for waste tracking and management	9 months
9	Activation of Communication Campaigns role	Public Relations Department	Launch multimedia communication campaigns on waste management initiatives	6 months
10	Attention to Tax Credits	Finance Department	Research and application for tax credits for sustainable construction practices	12 months
11	Activation of Carbon Footprint Analysis	Environmental Engineers	Conduct carbon footprint assessments for construction projects and implement mitigation strategies	6 months
12	Enhancing the level of Sustainability Reports	Sustainability Managers	Improve data collection and reporting processes for sustainability metrics	Ongoing

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