

Impact of Reverse Logistics Practices on the Cost Efficiency of Beverage Manufacturing Firms in Sri Lanka's Colombo District

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ABSTRACT

Reverse logistics practices have been gaining more attention due to their potential contribution to resource utilisation and operational cost management. However, there is less empirical evidence on the link between their and cost efficiency in the Sri Lanka's beverage manufacturing industry. This study was designed to investigate the correlation between the three reverse logistics practices (reuse, recycling and remanufacturing) and cost efficiency of the beverage manufacturing companies in Colombo District of Sri Lanka. The research design used is quantitative, cross section, positivist philosophy and deductive approach. Selected beverage manufacturing companies were sampled by non-probability purposive sampling technique and 226 respondents who were engaged in relevant functional areas of the industries were selected for data collection, using a structured questionnaire. The SPSS software was used for reliability analysis, descriptive statistics, Pearson correlation and multiple linear regression. Overall, the regression model accounted for 75.6% of the variance in cost efficiency ($R^2 = .756$). Reuse was the most statistically significant predictor of cost efficiency ($\beta = .506$, $p < .001$), and recycling was also found as a positive statistic predictor ($\beta = .329$, $p < .001$). The bivariate correlation analysis between remanufacturing and cost efficiency was statistically positive, but was not statistically significant in the multiple regression model ($\beta = .098$, $p = .071$). The results show that the reuse and recycling activities are especially linked to the cost efficiency aspect of the companies analyzed. The study provides empirical evidence on the reverse logistics and cost efficiency of the beverage manufacturing industry in Sri Lanka and recommends deeper research into the factors that can bring about a reverse logistics cost contribution separate from cost efficiency.

Keywords: Reverse Logistics, Cost Efficiency, Reuse, Recycling, Beverage Manufacturing

INTRODUCTION

The beverage industry gains from Sri Lanka's economy in terms of job creation, income and export. The beverage manufacturing sector is growing and the need to control costs and maintain efficient production and supply chain processes is improving. Reverse logistics has consequently become a topic of growing interest as a means of extracting value from returned products, packaging and materials. Reuse, recycling and remanufacturing are typical forms of reverse logistics in the beverage sector, and may be linked to better resource utilisation and cost efficiency.

Beverage manufacturers use reuse practices through their collection and refilling operations of beverage containers including glass bottles to diminish their purchase of new packaging materials. The conversion of discarded materials to new products by recycling allows manufacturers to cut consumption of raw materials which helps reduce their manufacturing expenses. Manufacturers use remanufacturing to restore used equipment along with its components so they can operate for longer periods while avoiding premium expenses for new equipment purchases.

Hence the relationships among the reuse, recycling, remanufacturing and cost efficiency of the beverage manufacturing companies in Colombo District of Sri Lanka is examined in this study.

Background of study

A manufacturer retrieves products or raw materials through the supply chain pathways known as reverse logistics. Industry practices in beverage production often involve bottle retrieval as well as material recycling or re-engineering of packaging products. The core task of reverse logistics reduces business expenses and waste management (Rogers & Tibben-Lembke, 2001). This approach provides cost efficiency for businesses because it enables both material cost reductions and operational efficiency improvements to generate higher profitability. RL demonstrates different principles than forward logistics does by concentrating on both reverse supply chain movements combined with waste reduction and cost optimization goals (Thierry et al., 1995).

Reverse logistics practices play a main role in cost efficiency by reducing production expenses associated with raw material procurement. By reusing materials such as glass bottles and packaging, companies can significantly lower their material costs. Additionally, recycling helps in transforming used materials into new products, cutting down on raw material consumption. Moreover, remanufacturing reduces capital expenditure by refurbishing equipment instead of purchasing new ones. These practices contribute to overall cost savings and improve operational efficiency (Guide & Van Wassenhove, 2000).

Reverse Logistics holds high significance in beverage manufacturing because bottles, plastic containers and packaging materials represent major operational expenses as Jack et al. (2010). Industrial adoption of RL technology in worldwide manufacturing facilities increases because material expenses and market constraints continue to rise. The global operations of Coca-Cola and PepsiCo stand as prime examples of firms that dedicate substantial capital to developing their returnable packaging systems and recycling programs for lowering their production expenses (Stock & Mulki, 2009). The implementation of RL remains restricted in Sri Lanka because the country faces obstacles related to infrastructure deficits as well as high logistics expenditures and minimal public interest in bottle collection systems (Sureka et al., 2017).

The major beverage companies Coca-Cola and Heineken operate reusable bottle systems that decrease packaging material requirements to minimize expenses. The Nigerian brewery sector experienced up to a 30 percent decrease in packaging expenses after instituting a bottle return system as reported by Mobolaji (2017). The global recycling programs of PepsiCo concentrate on PET bottle collection and processing to decrease the costs of buying original raw materials. The integration of recycling into supply chain operations allows businesses to achieve cost savings between 10–15 percent as Jack et al. (2010) document. The European and North American businesses use remanufacturing techniques to fix broken packaging materials and bottling equipment thereby decreasing capital costs. Stock & Mulki (2009) demonstrated that remanufacturing adopted companies realize counteract cost efficiencies up to 25% from longer equipment runs with minimal production budget needs.

When it comes to the implementation or using of reverse logistic practices by the beverage industries of Sri Lanka maintains fewer structures than global companies. Local beverage manufacturers Elephant House and Cargills operate returnable glass bottle programs to make their packaging expenses more efficient. These initiatives exist only at limited operational levels according to Weerathunga and Madurapperuma (2024). PET bottle recycling has experienced growth as Eco Spindles Ltd represents one of the companies operating in plastic waste processing. Numerous organizations do not maintain standardized recycling operations (Thilakarathne, Wijayanayake, & Peter, 2021). The investment in remanufacturing bottling equipment remains low for local firms because of scarce technological advancements combined with expensive machinery startup expenses (Sureka et al., 2017).

Several obstacles exist for reverse logistics operations in Sri Lanka because of inadequate infrastructure coupled with expensive transportation costs together with poor regulatory enforcement. Ineffective recovery and reuse of packaging materials become challenging for beverage firms because there are few collection centers and inadequate sorting systems exist. The high costs of fuel and insufficient road quality combination make it uneconomical for manufacturers to use reverse logistics to transport returned bottles and recyclables. Organizations face significant challenges because strict government policies along with financial incentives which would promote structured reverse logistics systems are entirely absent (Sureka et al., 2017).

Problem Statement

The practice of reverse logistics, including reuse, recycling and remanufacturing, has been gaining more and more attention due to its potential economic and environmental benefits. International research has correlated reverse logistics capabilities with cost savings and better use of resources (Stock & Mulki, 2009; Jack et al., 2010). The results of research done in other countries may not be readily applicable to Sri Lanka, however, due to the differences in infrastructure, regulatory environment, and market characteristics.

The empirical evidence of the correlation between the reverse logistics practices and cost efficiency for the beverage manufacturing industry in the country is insufficient. Though the previous research has focused on sustainability, there has been significant attention focused on the performance and operational difficulties at the chain level, with less attention being given to the individual relationships between reuse, recycling and cost efficiency.

Hence, a quantitative analysis of these individual practices is required to explore the relationship between these practices and cost efficiency as well as to identify which reverse logistics practice is the most powerful predictor among beverage manufacturing companies in Colombo District of Sri Lanka.

Research Questions

Primary Question

What is the impact of RL practices on the cost efficiency of Beverage manufacturing firms in Sri Lanka's Colombo District?

Secondary Questions

1. What is the relationship between Reverse Logistics practices and cost efficiency in these firms?
2. What is the most influencing Reverse Logistics practice that impact on the cost efficiency of beverage manufacturing firms in Sri Lanka's Colombo District?

Research Objectives

Primary Objective

To identify impact of Reverse Logistics practices on the cost efficiency of Beverage manufacturing firms in Sri Lanka's Colombo District.

Secondary Objectives

1. To identify the relationship between Reverse Logistics practices and cost efficiency in these firms.
2. To identify the most influencing Reverse Logistics, practice that impact on the cost efficiency of beverage manufacturing firms in Sri Lanka's Colombo District.

Scope of the study

The research analyzes reverse logistics practices that affect cost efficiency levels within beverage manufacturing companies operating in Colombo District Sri Lanka. The analysis investigates beverage manufacturing firms' implementation or use of essential RLP including reuse and recycling and remanufacturing together with their association with improved cost efficiency.

The research focuses on analyzing beverage manufacturing companies situated in Colombo District as this area contains most beverage manufacturing firms operating in Sri Lanka's economic center.

Significance of Study

The beverage manufacturing sector in Colombo District needs the findings from this study to guide improvements to cost efficiency. The continuously growing beverage industry of Sri Lanka requires manufacturers to demonstrate effective cost management due to market demands. The local beverage sector has not properly investigated how these practices specifically affect cost efficiency levels. This study provides key findings about designing strategic reverse logistics practices which Sri Lankan beverage producers can use to minimize costs.

This study will enhance the existing knowledge about reverse logistics practices in Sri Lanka through its research into this field which existing literature has not fully explored. International studies demonstrate that reverse logistics practices could generate cost savings within beverage industry operations, yet no sufficient research exists on their implementation specifically in Sri Lanka. This study examines how these practices perform in a local setting to deliver guidance for beverage companies in Colombo District about cost efficiency improvement.

LITERATURE REVIEW

Theoretical Framework of Reverse Logistics Practices

The management of returned products as well as packaging components and materials through which value extraction occurs by means of reuse combined with recycling and remanufacturing processes defines reverse logistics practices (RLP) (Kamanga, 2024). Traditional product distribution methods work toward new product movement, but reverse logistics uses fewer resources to minimize waste and maximize resource allocation for reducing spending on procurement (Muttimos, 2014).

Closed-Loop Supply Chain Model

The Closed-Loop Supply Chain (CLSC) Model serves as a complete system to unite forward and reverse logistics operations (Guide & Van Wassenhove, 2000). CLSC differs from standard supply chains since it directs the return flow of used products throughout the supply chain either for reuse operations or remanufacturing or recycling activities (Govindan et al., 2015). Through this model firms can extract value from returned materials which lowers raw material expenditure and decreases material waste (Kamanga, 2024).

Resource-Based View (RBV) Theory

The Resource-Based View (RBV) theory developed by (Barney, 1991) states firms can get competitive advantage through the proper application of internal resources such as reverse logistics capabilities. Firms can enhance their cost efficiency through reverse logistics system development according to Resource-Based View theory (Jack et al., 2010). The beverage manufacturers can reduce their procurement expenses and enhance operational efficiency because of these capabilities (Sureka et al., 2017).

Circular Economy Model

The Circular Economy (CE) Model serves as a sustainability method which maintains resource use through practices of reuse along with recycling and remanufacturing (Ellen MacArthur Foundation, 2013). The CE Model contrasts with linear economy models since it works toward prolonging product existence while it minimizes material disposal (Ghisellini et al., 2016). The CE Model receives support from reverse logistics operations because this framework enables product return processing and material collection and material distribution to secondary market channels (kuno & Arani, 2024).

Challenges of Reverse Logistics Practices in Beverage Manufacturing Firms

Reverse logistics practices implementation by beverage manufacturing firms comes with multiple implementation hurdles although it offers substantial advantages to their businesses. The main obstacle stems

from insufficient facilities dedicated to retrieving handle and manage returned products according to Muttimos (2014). Industrial beverage companies operating in developing economies such as Sri Lanka face complications stemming from their restricted collection sites and ineffective delivery networks because these factors drive up reverse logistics expenses (Sureka et al., 2017). The low level of consumer knowledge combined with minimal incentives restricts people from participating in bottle return systems (Jack et al., 2010). A large financial investment in developing reverse logistics programs including collection centers, processing facilities and tracking systems proves unaffordable for most beverage producers (Weerathunga & Madurapperuma, 2024).

Reuse

Reverse Logistics Practices include reuse when products and packaging materials get multiple uses with minimal reprocessing. Beverage producers usually employ the reuse concept through their refillable glass bottles alongside plastic crates for distributing their products. Using products repeatedly diminishes raw materials required for new production thus lowering both costs and environmental consequences (Muttimos, 2014). Studies demonstrate that multiple uses are possible before discard for refillable bottles which in turn decreases material acquisition expenses together with waste management expenses (Muttimos, 2014).

Recycling

The conversion of waste into new usable resource materials constitutes recycling processes. Beverage companies throughout the industry apply this essential approach mainly to their plastic and aluminum packaging needs. PET bottle recycling and aluminum can recycle, and glass container recycling lowers the demand for original raw materials to achieve decreased manufacturing expenses (Muttimos, 2014).

Remanufacturing

Industrial companies use remanufacturing methods to thoroughly refurbish previously used products along with components for returning them to pristine operational state. Beverage manufacturing organizations use the remanufacturing approach primarily on their bottling and packaging machinery systems. Thorough remanufacturing enables industrial equipment to function longer which cuts down the need to purchase new machinery (Muttimos, 2014). The companies that use remanufacturing reduce their maintenance costs while achieving higher operational performance according to Weerathunga & Madurapperuma (2024).

Cost Efficiency in Beverage Manufacturing Firms

Defining Cost Efficiency

An organization can achieve cost efficiency through producing goods and services at their lowest possible cost levels alongside meeting quality requirements and operational functioning norms. Beverage manufacturing businesses depend on cost-efficient operations because they need to control expenses linked to materials and production together with distribution and logistics (Porter, 1985). Reverse logistics approaches like reuse together with recycling and remanufacturing demonstrate value as powerful cost-reducing solutions for manufacturing businesses (Muttimos, 2014).

Reverse logistics practices in beverage manufacturing help manufacturers reduce costs through waste disposal expense reduction and raw material substitution and improved resource recovery (Jack et al., 2010).

Empirical Studies on the Impact of Reverse Logistics Practices and Cost Efficiency in Beverage Manufacturing Firms

Muttimos (2014) studied reverse logistics practices in Kenyan manufacturing firms and proved that firms which practiced recycling and reuse had lower procurement and waste management costs. Companies that utilize closed-loop supply chains succeed in saving money through reduced dependence on virgin resources which leads to decreased manufacturing costs according to Kamanga (2024).

Data regarding Sri Lankan beverage industries demonstrate that reverse logistics practices show lower adoption rates as well as reduced effectiveness levels in comparison to global market standards. The study conducted by Weerathunga and Madurapperuma (2024) demonstrated major hurdles in Sri Lanka's reverse logistics systems regarding infrastructure, policy backing and consumer participation. The study revealed that some beverage companies in Colombo District started bottle return services, but overall performance remained poor because of high transportation expenses and inadequate standardization in collection methods.

Sureka et al. (2020) discovered that Sri Lanka does not use remanufacturing extensively although this method is common in developed markets. The analysis indicates that insufficient remanufacturing technology investment hinders firms from realizing complete savings possible through bottle machine and equipment refurbishment.

Research Gaps

While there are some cost benefits that have been found in the international literature in reverse logistics, there is limited empirical evidence as to whether such relationships exist in Sri Lanka's beverage manufacturing environment (Jack et al., 2010). Previous studies conducted in Sri Lanka have also focused on sustainability and performance in the supply chain and operational issues associated with implementing reverse logistics (RL) practices rather than on the individual relationships between the reverse logistics practices and cost efficiency. Furthermore, limited evidence is available comparing the individual predictive contributions of reuse, recycling and remanufacturing. This study aims to fill this gap by exploring these three reverse logistics practices quantitatively in terms of cost efficiency in the beverage manufacturing industry in Colombo District of Sri Lanka.

METHODOLOGY

Research Design

A quantitative cross-sectional study was conducted to explore the relationship between re-use, recycling and cost efficiency with remanufacturing within the beverage manufacturing companies in Colombo District in Sri Lanka. The respondents were interviewed with a structured questionnaire to obtain the data. In this sense, the study does not make any claim to establishing causal relationships, but rather statistical associations and predictive relationships.

Research Philosophy

The study was carried out in positivist philosophy and ontological perspective with objectivist.

Research Approach

A deductive method was followed, and hypotheses, the result of the existing theory or literature in the field, were tested with quantitative data obtained from the employees of the selected beverage manufacturing companies in the functional areas.

Conceptual Framework

The conceptual framework suggests that there are relationships between the three independent variables (reuse, recycling, and remanufacturing) and the dependent variable (cost efficiency).

Independent Variable

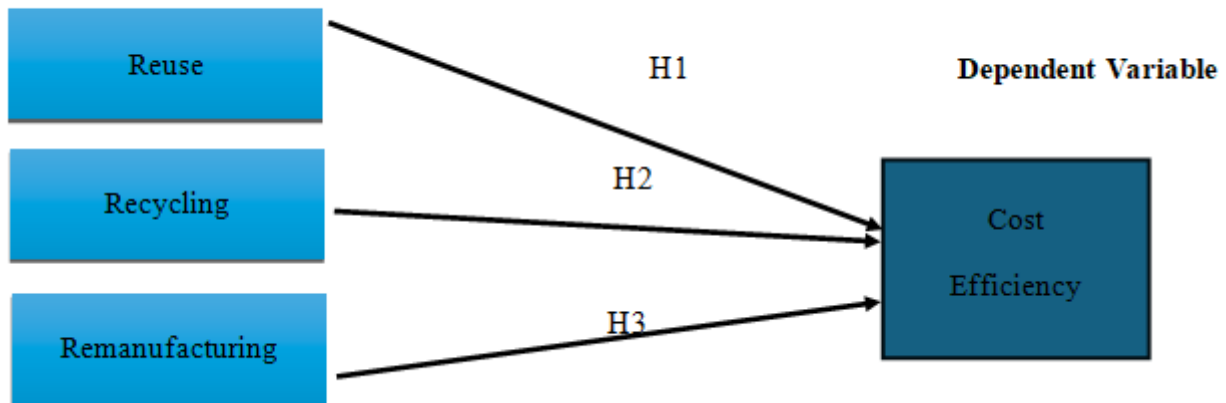


Figure 1: Conceptual Framework of the study

Measurement and Questionnaire Development

A structured, self-developed questionnaire was used for primary data collection. Based on the constructs and operational indicators identified from the literature the questionnaire was developed. It was divided into two parts. Data on the demographic data were gathered in Section 1, and the study constructs were measured by means of five-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree in Section 2. A total of four items were used to measure each of the constructs; reuse, recycling, remanufacturing, cost efficiency, yielding a total of 16 measurement items. Table 1 shows the operationalisation of the constructs and their associated measurement indicators.

Table 1: Operationalisation of Variables

Construct	Variable	Indicators	Measure ment Scale	Question Number
Independent Variables: Reverse Logistics Practices	Reuse	- Frequency of reusable packaging (bottles/crates) collection and usage	5 Point Likert Scale	Section 2.1- 1,2,3,4
		-Reduction in raw material purchasing costs due to reuse		
		- Cost savings from reuse system implementation		
		-Efficiency of customer bottle return system		
	Recycling	- Volume of packing materials (PET, glass, aluminum) recycled	5 Point Likert Scale	Section 2.2- 1,2,3,4
		- Financial savings achieved through recycling activities		
		- Use of recycled material in production		
		- Effectiveness of recycling programs on operational cost		
	Remanufacturing	- Number of components /products remanufactured and reused	5 Point Likert Scale	Section 2.3- 1,2,3,4
		- Cost reduction from remanufacturing processes		
		- Impact of remanufacturing on reducing machinery replacement costs		

		- Productivity improvements due to remanufacturing		
Dependent Variable	Cost Efficiency	- Reduction in total operational costs	5 Point Likert Scale	Section 2.4-1,2,3,4
		- Procurement cost savings from using recovered materials		
		- Lowered expenses on waste management/disposal		
		- Financial performance Improvement due to reverse logistics		

Hypothesis Development

H1: There is a significant impact of reuse on cost efficiency in beverage manufacturing firms.

H2: There is a significant impact of recycling on cost efficiency in beverage manufacturing firms.

H3: There is a significant impact of remanufacturing on cost efficiency in beverage manufacturing firms.

Population, Sample, and Sample Size

Population

The study population included employees working in beverage manufacturing firms in the Colombo District of Sri Lanka. The respondents were selected from areas such as supply chain and logistics, operations and production, finance and cost management, and procurement and purchasing. These areas were considered relevant because the employees are involved in activities related to reverse logistics and cost management. The exact population size was not available, as there was no single source showing the total number of suitable employees working in these areas.

Sample

A non-probability purposive sampling method was used for this study. Respondents were selected based on whether they were working in areas related to reverse logistics and cost management. Therefore, employees from supply chain and logistics, operations and production, finance and cost management, and procurement and purchasing were targeted when collecting the data. This method helped to collect information from respondents who had relevant knowledge and experience related to the research topic.

Sample Size

The study initially aimed to collect responses from 384 participants. However, it was difficult to reach the expected number of respondents due to practical limitations in accessing suitable employees. Therefore, 226 valid responses were collected and used for the final data analysis.

Data Collection

Primary Data Collection Method

The Primary data were collected using a structured questionnaire. The questionnaire included questions related to reuse, recycling, remanufacturing and cost efficiency, and the responses were measured using a five-point Likert scale. The questionnaire was shared with suitable employees through Google Forms, email and LinkedIn. Participation in the study was voluntary, and a total of 226 valid responses were used for the analysis. The questionnaires were used in this study and the measures are thus self-reported assessments of reverse logistics practices and cost efficiency, and are not objective measures of organisational cost data.

Statistical Method of Data Analysis

SPSS was used to analyse the data. Cronbach's alpha was used to assess the internal consistency of the measurement scales. The variables of the study were summarized using descriptive statistics such as mean, standard deviation, skewness and kurtosis. The two variables correlation namely reverse logistics practices and cost efficiency was analyzed through Pearson correlation analysis. Multiple linear regression analysis was conducted to analyse the individual predictive power of reuse, recycling and remanufacturing on cost efficiency. The Durbin–Watson statistic was used to measure the residual independence and visual inspection of the residual scatter plot was used to assess the test of homoscedasticity.

RESULTS

Reliability Analysis

Table 2: Reliability Statistics Table

Variable	Measures (Items)	Cronbach's Alpha Value	Status
Reuse	4	0.885	Good
Recycling	4	0.901	Excellent
Remanufacturing	4	0.926	Excellent
Cost Efficiency	4	0.912	Excellent

The Cronbach's alpha coefficients for the four constructs ranged from 0.885 to 0.926 meeting the 0.70 acceptance criterion for internal consistency.

Distribution of Demographic Factors

This section presents the breakdown of the demographic factors from the 226 respondents who fully completed the survey. It helps understand the profile of the people who took part in the study. The analysis includes gender, age, designation, years of experience, product category, and how often reverse logistics practices are used in their companies. These details are important to understand who is involved in reverse logistics and cost efficiency activities in the beverage manufacturing sector.

Table 3: Respondent Profile Table

Characteristic	Category	Frequency	Percentage
Gender	Male	117	51.8
	Female	109	48.2
Age	18-25 years	92	40.7
	26-35 years	90	39.8
	36-45 years	20	8.8
	Above 45 years	24	10.6
Designation	Manager	54	23.9
	Executive	115	50.9
	Supervisor	57	25.2
Experience	Less than 2 years	60	26.5
	2-5 years	92	40.7
	6-10 years	39	17.3
	More than 10 years	35	15.5
	Carbonated Water	51	22.6

Product Category	Bottled Water	85	37.6
	Dairy-Based Beverages	40	17.7
	Alcoholic Beverages	21	9.3
	Energy Drinks	29	12.8
RLP Frequency	Regularly	102	45.1
	Occasionally	88	38.9
	Rarely	30	13.3
	Never	6	2.7

The respondent profile reveals that 51.8% of the respondents were males and 48.2% were females. The largest group of respondents were between the ages of 18-35 years (80.5%). The most common designation was executives (50.9%) and 40.7% of respondents had 2 to 5 years of work experience. The product category with the greatest representation was bottled water (37.6%). Furthermore, 45.1% of the respondents reported that they practice reverse logistics regularly and 38.9% occasionally.

Descriptive Statistics for Key Variables

Table 4: Descriptive statistics for key Variables

Descriptive Statistics				
	Reuse	Recycle	Remanufacture	Cost
Minimum	1	1	1	1
Maximum	5	5	5	5
Mean	3.5324	3.4878	3.385	3.4801
Std. Deviation	0.9686	0.95836	1.08655	1.01415
Skewness	-0.676	-0.559	-0.671	-0.665
Std. Error of skewness	0.162	0.162	0.162	0.162
Kurtosis	-0.248	-0.36	-0.478	-0.299
Std. Error of Kurtosis	0.322	0.322	0.322	0.322
N	226	226	226	226

The Reuse recorded the highest mean ($M = 3.53$, $SD = 0.97$), followed by recycling ($M = 3.49$, $SD = 0.96$), cost efficiency ($M = 3.48$, $SD = 1.01$) and remanufacturing ($M = 3.39$, $SD = 1.09$). The range of skewness values are from -0.559 to -0.676 which is not extreme departure from symmetry in the observed distributions and range of kurtosis values are from -0.248 to -0.478 which is not extreme departure from symmetry in the observed distributions.

Correlation Analysis

Table 5: Correlation Analysis

Description	Pearson Correlation Coefficient	P-Value	Status	Correlation
Reuse→Cost	0.836	<0.001	Strong Positive Relationship	Significant 1%
Recycle→Cost	0.802	<0.001	Strong Positive Relationship	Significant 1%

Remanufacture→Cost	0.716	<0.001	Strong Positive Relationship	Significant 1%
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Using Pearson's correlation analysis, the study confirmed that cost efficiency is well correlated with reuse ($r = .836$, $p < .001$), recycling ($r = .802$, $p < .001$), and remanufacturing ($r = .716$, $p < .001$). The strongest bivariate relationship with cost efficiency was found for reuse.

Multiple Linear Regression Analysis

Model Summary

Table 6: Model Summary Table

Model Summary ^b					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.870 ^a	0.756	0.753	0.50424	1.709

A multiple regression model resulted in $R = .870$ and $R^2 = .756$ and adjusted $R^2 = .753$, which means that the variance of cost efficiency could be explained by reuse, recycling and remanufacturing altogether. The Durbin–Watson statistic was 1.709, which is not a strong indication of significant residual autocorrelation.

ANOVA Table

Table 7: ANOVA Table

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	174.965	3	58.322	229.379	<.001 ^b
	Residual	56.445	222	0.254		
	Total	231.41	225			
a. Dependent Variable: Cost						
b: Predictors: (Constant), Remanufacture, Reuse, Recycle						

The overall multiple regression model was statistically significant, $F(3,222) = 229.379$, $p < .001$.

Analysis of Co-Efficient

Table 7: Coefficient Analysis

Coefficients ^a						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	0.087	0.134		0.651	0.516
	Reuse	0.529	0.06	0.506	8.866	<.001
	Recycle	0.348	0.064	0.329	5.473	<.001
	Remanufacture	0.091	0.05	0.098	1.812	0.071
a. Dependent Variable: Cost						

The strongest significant predictor was re-use ($\beta = .506$, $p < .001$).

There was also a significant association between recycling ($\beta=.329$, $p<.001$).

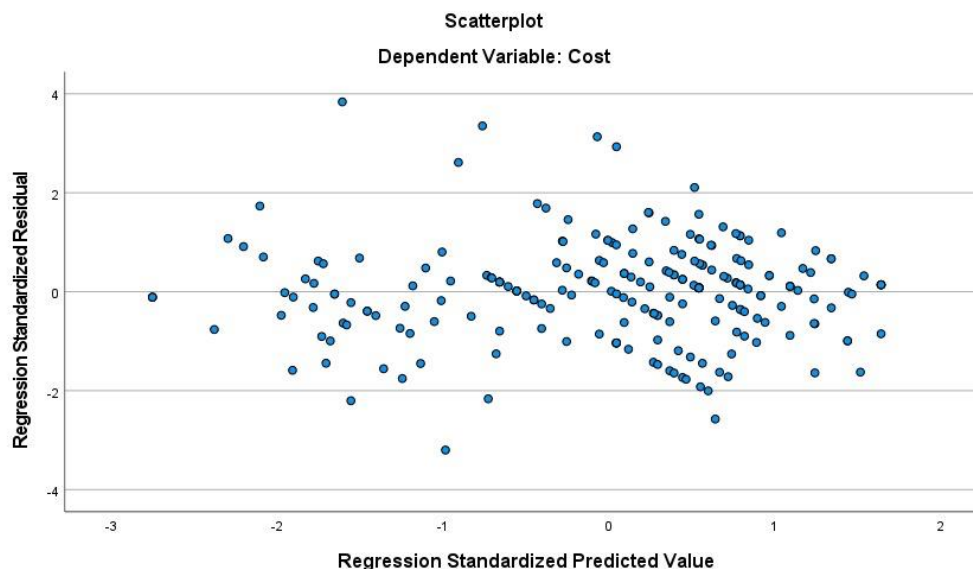
Remanufacturing was not statistically significant ($\beta=.098$, $p=.071$).

Summary of Regression – Hypothesis Testing

Table 8: Hypothesis Testing

Independent Variable	β	P - Value	Conclusion	Hypothesis
Reuse (Ru)	0.506	$.001 < 0.05$	Reuse has significant impact on cost efficiency.	H1- Accepted
Recycle (Rc)	0.329	$.001 < 0.05$	Recycle has significant impact on the cost efficiency.	H2- Accepted
Remanufacture (Rm)	0.098	$.071 > 0.05$	Remanufacture has no significant impact on the cost efficiency.	H3- Rejected

Assessment of Heteroscedasticity



On a residual scatterplot, there was no obvious pattern indicating any significant evidence of heteroscedasticity.

DISCUSSION

Finding of the Research

The results of the present study reveal that the reverse logistics practices are significantly related to cost efficiency of the beverage manufacturing companies in Colombo District of Sri Lanka. The multiple regression model accounted for 75.6% of the variance in cost efficiency ($R^2 = 0.756$), showing that the reverse logistics practices studied in this article collectively have great explanatory power regarding cost efficiency. The overall regression model was also statistically significant, supporting the importance of the selected reverse logistics practices in accounting for the variations in cost efficiency.

Reuse was the most significant ($\beta = 0.506$, $p < 0.001$) among the three reverse logistics practices and most important. This finding indicates that there is a relationship between the increase in reuse practice and cost efficiency of beverage manufacturing companies. Reusable packaging materials such as bottles, containers and others can help to lower the consumption of new materials and use resources more efficiently in the

beverage sector. This is in line with the literature reviewed within this study as it shows that reuse can help to minimise the cost of material acquisition and waste-management.

The recycling was also a strong positive predictor of cost efficiency ($\beta = 0.329$, $p < 0.001$). It meant that recycling practice has an independent role in cost efficiency, but it was found to be less significant than the reuse. Beverage manufacturers could be able to recover value from the used beverage through recycling of PET, glass and aluminum, for example, and decrease reliance on virgin resources. This is in line with the literature search presented in the literature review, which suggests that recycling is linked to material recovery and cost-saving purposes.

Cost efficiency had a strong, statistically significant bivariate correlation with remanufacturing ($r = .716$, $p < .001$). It was not a significant factor in the multiple regression model when used in combination with reuse and recycling, however ($\beta = .098$, $p = .071$). Thus, there was no support for H3 at the 5% level of significance. This indicates that while remanufacturing is, on its own, cost efficient, it could have a unique predictive contribution overlapping with variance common with re-use and recycling.

In general, the findings highlight the relevance of reverse logistics in the cost management in beverage manufacturing companies, especially in respect of reuse and recycling. Reuse was the most influential variable compared to recycling and remanufacturing, which was not statistically significant. The results provide some empirical evidence related to the financial impact of reverse logistics practices in the beverage manufacturing industry in Sri Lanka to fill the gap in the research identified in this study.

LIMITATIONS OF RESEARCH

There are some limitations to this study. First, the method of interviewing using purposive sampling (non-probability sampling) might have caused some bias in the selection process and reduce the representativeness of 226 respondents. Second, the study was based on self-reported responses from the questionnaire, which meant that the measures might be a reflection of the respondents' perception of reverse logistics practices and cost efficiency. Third, the cross-sectional research design only collected responses at one point in time and cannot provide cause and effect relationships. Fourth, the access and organisational confidentiality restrictions were limitations on participation, especially among some managerial respondents. Lastly, the study was geographically delimited to the Colombo District, which makes the results of the study not to be generalised to the rest of the beverage manufacturing sector in Sri Lanka.

RECOMMENDATION OF THE RESEARCH

From the conclusions of the study, it is recommended that beverage manufacturing firms and those in charge make a few adjustments to support better reverse logistics, at a lower cost in the Colombo District.

Encourage More Reuse-Because reusing materials lowers costs the most, companies should focus on projects that let them reuse packaging, containers and bottles instead. Giving customers reasons to return and reuse bottles and cans can be helpful.

Increase the facilities and routines for recycling-Recycling made the company's operations less expensive. Putting in place on-site or outsourced recycling, organizing waste correctly and working with nearby recycling offices help firms recover materials well.

Make more people aware of what to do in case of RL and teach them the basics of the rules-Most of those in leadership positions participate directly in operations, yet they may have limited clarity regarding the long-term cost reductions that can follow RL strategies. Practical training and workshops need to be given to help people learn and gain skills.

CONCLUSION

In this study, reverse logistics practices were investigated in relation to the cost efficiency of beverage manufacturing companies in Colombo District of Sri Lanka focusing on the reuse, recycling and remanufacturing aspects. The survey results are presented based on the data gathered from 226 respondents, giving empirical evidence of how the reverse logistics practices are essential in explaining cost efficiency in this sector.

The R² value of the multiple regression model, which accounted for 75.6% of the variance in cost efficiency, was found to be satisfactory. The three practices studied were all significant predictors of cost efficiency; reuse was the strongest predictor ($\beta = 0.506$, $p < 0.001$) followed by recycling ($\beta = 0.329$, $p < 0.001$). Thus, the hypotheses on reuse and recycling were confirmed. It is however worth noting that the hypothesis of remanufacturing did not get statistical support at the 5% significance level ($\beta = 0.098$, $p = 0.071$), and remanufacturing did not show a statistically significant independent effect on cost efficiency at 5% significance level.

The results suggest that beverage companies in the Colombo District could have better cost-efficient benefits if they increase their re-use and re-use initiatives. In particular, the high impact of reusing indicates the potential significance of the management of reusables such as packaging, containers and other recoverable materials. Recycling is also a significant activity in recovering the value of materials and assisting in cost efficient operations. The results indicated that remanufacturing exhibited a positive relation with cost efficiency, but the relationship was not statistically significant, considering the other reverse logistics practices, simultaneously.

Overall, the study is a contribution to the limited empirical studies on reverse logistics and cost efficiency in Sri Lanka's beverage manufacturing sector as it provides quantitative evidence on the individual contribution of re-use, recycling and remanufacturing. The findings clearly highlight the factors of reuse and recycling as the most closely linked reverse logistics practices to cost efficiency in this context.

FUTURE RESEARCH

In the future, experts should consider beverage manufacturing firms from all parts of Sri Lanka and compare different industries to generalize how reverse logistics or reverse logistics practice is connected to cost efficiency. Using a longitudinal study would make it possible to assess the enduring financial and operational effects that reuse, recycling and remanufacturing practices can have. Talking to supply chain managers through interviews or case studies can give more detailed understanding of both the problems and important decisions involved in relying on RLP. Also, scientists should investigate how emerging technologies including IoT, blockchain and AI can improve how reverse logistics practices operate. Furthermore, understanding how consumers return items and what they know about green practices could add more depth to our examination of reverse logistics systems' success.

REFERENCES

1. Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17(1), 99–120.
2. Coca-Cola Company. (2022). Coca-Cola sustainability report.
3. Gangani, S., & Bandara, M. (2018). Factors affecting the efficiency and effectiveness of reverse logistics process. University of Moratuwa.
4. Geyer, R., & Jackson, T. (2004). Supply loops and their constraints: The industrial ecology of recycling and reuse. *California Management Review*, 46(2), 55–73.
5. Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, 114, 11–32.

6. Govindan, K., Soleimani, H., & Kannan, D. (2015). Reverse logistics and closed-loop supply chain: A comprehensive review. *Transportation Research Part E: Logistics and Transportation Review*, 56, 1–18.
7. Guide, V. D. R., & Wassenhove, L. N. (2000). *Closed-loop supply chains*. Berlin: Springer.
8. Jack, E. P., Powers, T. L., & Skinner, L. (2010). Reverse logistics capabilities: Antecedents and cost savings. *International Journal of Physical Distribution & Logistics Management*, 40(3), 228–246.
9. Kamanga, P. (2024). *Reverse logistics practices in the beverage industry: A study of cost efficiency*. JKUAT University.
10. Kumar, S., & Malegeant, P. (2006). Strategic alliance in a closed-loop supply chain: A case of manufacturer and eco-non-profit organization. *Technovation*, 26(10), 1127–1135.
11. Kuno, N. S., & Arani, W. (2024). Reverse logistics and performance of plastic bottling firms in Mombasa County, Kenya. *International Journal of Supply Chain Management*, 9(4).
12. Mobolaji, D. (2017). *The reverse logistics of beverage containers: A case study of Lagos, Nigeria*. Laurea University of Applied Sciences, Finland.
13. Muttimos, A. (2014). *Reverse logistics practices and organizational performance in manufacturing firms*. Kenyan Journal of Supply Chain Management.
14. PepsiCo Inc. (2021). *PepsiCo annual report*.
15. Porter, M. E. (1985). *Competitive advantage: Creating and sustaining superior performance*. Free Press.
16. Rogers, D. S., & Tibben-Lembke, R. S. (2001). An examination of the role of reverse logistics in the beverage industry. *International Journal of Logistics Management*, 12(2), 5–20.
17. Sarkis, J. (2012). A boundary and flows perspective of green supply chain management. *Supply Chain Management Review*, 16(5), 21–27.
18. Stock, J. R., & Mulki, J. P. (2009). Product returns and logistics costs: A strategic perspective. *Journal of Business Logistics*, 30(1), 35–52.
19. Thilakarathne, H. G. K. L. S., Wijayanayake, A. N., & Peter, S. (2021). *Evaluating the factors that affect the reverse logistics performance in the plastic supply chain*. University of Kelaniya, Sri Lanka.
20. Weerathunga, A., & Madurapperuma, W. (2024). *An investigation into the impact of supply chain management practices on the supply chain responsiveness of the non-alcoholic beverage industry in Western Province, Sri Lanka*. Sri Lanka Technological Campus.
21. Sureka, G., Bandara, Y. M., & Wickramarachchi, D. (2018). Factors affecting the efficiency and effectiveness of reverse logistics process. *Journal of International Logistics and Trade*, 16(2), 74–87.