

Strategic Pathways to Circular and Sustainable Supply Chain in the Apparel Industry

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Abstract-- The clothing sector is experiencing a paradigm shift towards a series of circular economy to operate within traditional linear models to mitigate the mounting environmental and operational pressures. This study explores the strategic routes that can be taken to make the shift to circular and sustainable supply chains in the apparel industry. A descriptive research design was used, and a sample of 150 industry professionals was investigated using a structured 5-point Likert scale questionnaire. The objective of the study is to assess how the strategic pathways influence the degree of the circular supply chain integration, operational efficiency, and the environmental performance. The suggested analysis will consist of descriptive statistics, Chi-square, multiple regression, and Pearson correlation using SPSS and MS Excel. This research aims to offer a holistic roadmap to help apparel manufacturers and retailers to streamline long-term cost and attain sustainable change by reviewing the variables of material use, waste minimization, and sustainable sourcing.

Keywords-- Circular Supply Chain, Apparel Industry, Sustainability, Strategic Pathways, Operational Efficiency.

I. INTRODUCTION

The traditional nature of the global apparel industry with its high resource use and a large amount of waste is the reason that the shift to the paradigm of sustainable and cyclic supply chain is a necessity. Circular economy integration is meant to reduce wastage, maximize the use of materials and improve product life cycles. Green supply chain strategies are central to these transformations, as noted by Singh (2025), as a facilitator between environmental objectives and operational feasibility. The social and environmental consequences of these approaches are immense, especially in the multifaceted global value chains where the stakeholders have to harmonize their operational goals with sustainability requirements (Suarez-Visbal et al., 2023).

The shift toward a circular fashion supply chain does not come without any difficulties. The available sources highlight many barriers, such as infrastructural constraints, high initial investment, and the necessity of organized reverse logistics (Pal et al., 2019; Kazancoglu et al., 2020; Raut et al., 2019). Nevertheless, the systematic adoption of the sustainable practices is turning into an uncompromising norm of global retail (Hasan & Shehun, 2022).

Recent research emphasizes the importance of certain enablers and risk reduction measures in supporting this shift, especially in such emerging economies as India, where the textile production is a major industry (Mishra et al., 2025; Dohale et al., 2023). To unlock this circular potential, stakeholders need to be empowered along strategic pathways, digital transparency, and strong management commitment (Chourasiya and Malviya, 2025; Poddar et al., 2024). This paper is based on these theoretical foundations to empirically quantify the direct effects of these strategic courses on the outcome of operations and the environment in the apparel industry.

II. RESEARCH GAP

Although the literature is rich in the barriers, enablers, and theoretical frameworks of circular supply chains (Kazancoglu et al., 2020; Dohale et al., 2023), there is a clear gap in the available empirical evidence on the quantification of the direct relationship between specific strategic paths and the level of operational integration. Moreover, the quantitative data on the interaction of such variables as material utilization, waste reduction, and sustainable sourcing and their impact on lowering the cost of operating in the long term and enhancing environmental performance (e.g., sustainable packaging) simultaneously in the apparel sector is limited.

III. RESEARCH DESIGN

A. Statement of the Problem

The apparel sector is under increasing pressure to adopt a circular supply chain instead of the linear one, owing to environmental degradation and the lack of resources. Although there is extensive awareness and commitment of the top management, the real implementation and adoption of the advanced circular systems, including the reverse logistics and upcycling are moderate. Business organizations face difficulties in balancing these sustainable activities and long-term operational cost savings. This paper is a response to the issue of closing the gap between strategic sustainability objectives and actual operation and environmental realities.

B. Objectives

- To examine the strategic pathways for transitioning apparel supply chains to circular models.
- To analyse the impact of circular practices on operational efficiency and long-run cost reduction.
- To analyse the impact of circular supply chain integration on environmental performance.

C. Research Methodology

In this paper, a Descriptive Research design is used. The methodology is very appropriate since it aims at giving an accurate description of the relations between strategic paths, circular integration and operational efficiency without distorting the variables.

D. Sources of Data

- **Primary Data:** Gathered through a sample size of 150 industry professionals and stakeholders in the supply chain of the apparel industry by using structured questionnaires.
- **Secondary Data:** This was obtained in the form of published academic journals, industry benchmarking reports, and sustainability publications to constitute the theoretical background.

E. Sampling Plan

- **Sampling Unit:** Professionals and executives in the apparel and textile supply chain.
- **Sample Size:** 150 valid responses.
- **Sampling Technique:** Convenience sampling methodology will be applied to access the relevant industry players efficiently.

F. Data Collection Tools

- **Survey:** A questionnaire that is structured using a 5-point Likert scale (Strongly Disagree/Not Implemented through Strongly Agree/Fully Implemented) that will be used to measure attitudes, awareness and the degree of the circular integration.

G. Plan of Analysis

Data obtained will be summarized and tabulated. Descriptive Statistics will be included in the analysis plan in order to summarize means and trends of variables. To test the hypotheses set, inferential tests, such as Chi-square, Multiple Regression, and Pearson Correlation, will be used. Data analysis software tools are MS Excel and SPSS software to provide strong statistical accuracy.

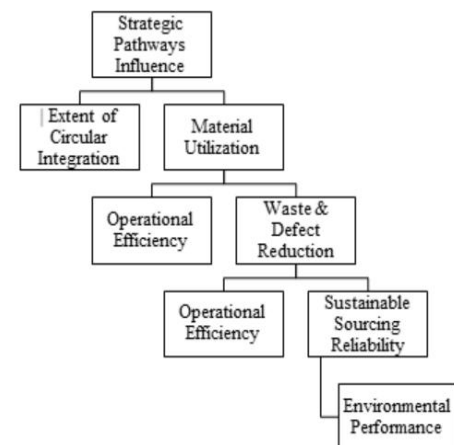
IV. CONCEPTUAL FRAMEWORK

Dependent Variables (DV)

- **Extent of Circular Integration:** The degree to which circular practices are embedded into company operations.
- **Operational Efficiency:** Measured by the reduction of overall operational costs in the long run due to circular practices.
- **Environmental Performance:** The adoption and use of recyclable or biodegradable packaging materials.

Independent Variables (IV)

- **Strategic Pathways Influence:** The impact of strategic direction and management commitment on the circular transition.
- **Material Utilization:** Improvement in the usage and life cycle of raw materials.
- **Waste & Defect Reduction:** Operational initiatives aimed at minimizing production waste.
- **Sustainable Sourcing Reliability:** The improvement in supply chain reliability through sustainable procurement.



V. RESULTS

Tools for Data Analysis

- **Software Used:** IBM SPSS Statistics and Microsoft Excel.
- **Statistical Tests:** Descriptive Statistics, Chi-Square Test of Independence, Multiple Regression Analysis, and Pearson Correlation.

Hypothesis Framework

Hypothesis 1 (Chi-square Test)

- *H0*: There is no significant association between strategic pathways influencing transition and the extent of circular supply chain integration.
- *H1*: There is a significant association between strategic pathways influencing transition and the extent of circular supply chain integration.

Hypothesis 2 (Multiple Regression Test)

- *H0*: Circular practices related to material utilization, waste reduction, and sustainable sourcing do not significantly predict long-run operational cost reduction.
- *H1*: Circular practices related to material utilization, waste reduction, and sustainable sourcing significantly predict long-run operational cost reduction.

Hypothesis 3 (Correlation Test)

- *H0*: There is no significant correlation between the extent of circular supply chain integration and recyclable/biodegradable packaging practices.
- *H1*: There is a significant correlation between the extent of circular supply chain integration and recyclable/biodegradable packaging practices.

Interpretation

The descriptive statistics indicate that the research is conducted on the basis of 150 valid answers, and all variables are noted in full. Circular supply chain awareness has a mean of 0.95, which means that the level of awareness among the respondents is very high. Top management commitment to sustainability (Mean = 4.04) and digital technology enhancing transparency and circularity (Mean = 4.07) are rated high under the strategic and operational variables and have high internal support of circular transformation. Structured reverse logistics systems (Mean = 2.63), and investment in recycling/upcycling processes (Mean = 2.83) are not as high in the mean value, indicating that the deployment of advanced circular systems remains in the middle. On the whole, the descriptive findings suggest the awareness and strategic commitment are good, though practical implementation of the circular supply chain initiatives in the apparel sector is still in its infancy.

Test 1: Chi-square Test

Objective

To examine the strategic pathways for transitioning apparel supply chains to circular models.

Variables selected

- *Question 15*: Strategic pathways have significantly influenced our transition toward circular supply chain models.
- *Question 9*: To what extent are circular supply chain practices integrated into your company's retail operations?

Dataset variables

- StrategicPathwaysInfluenceTransition
- CircularIntegrationExtent

Hypotheses

- *H0*: There is no significant association between strategic pathways influencing transition and the extent of circular supply chain integration.
- *H1*: There is a significant association between strategic pathways influencing transition and the extent of circular supply chain integration.

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	150.898 ^a	16	.000
Likelihood Ratio	122.508	16	.000
No. of Valid Cases	150		
a. 15 cells (60.0%) have expected count less than 5. The minimum expected count is .16.			

Symmetric Measures			
		Value	Approximate Significance
Nominal by Nominal	Phi	1.003	.000
	Cramer's V	.501	.000
N of Valid Cases		150	

Interpretation

The Chi-square is used to demonstrate that the relationship between strategic pathways that affect transition and the level of circular supply chain integration are statistically significant. The p-value is 0.000, which is lower than 0.05: hence, the result is statistically significant. Hence the null hypothesis (H0) is not accepted and the alternative hypothesis (H1) is accepted. This implies that companies that have a greater consensus that strategic paths determine transition are much more likely to record increased degrees of circular supply chain integration.

Test 2: Multiple Regression Test

Objective

To analyse the impact of circular practices on operational efficiency.

Dependent variable

- *Question 24:* Circular supply chain practices have reduced overall operational costs in the long run.

Independent variables

- *Question 20:* Adoption of circular practices has improved material utilization in our supply chain.
- *Question 21:* Circular initiatives have reduced production waste and defects.
- *Question 23:* Adoption of sustainable sourcing practices has improved supply chain reliability.

Dataset variables

- *Dependent Variable:*
CircularPracticesReduceLongRunCosts_Score
- *Independent Variables:*
 - CircularPracticesImproveMaterialUtilization_Score
 - CircularInitiativesReduceWasteDefects_Score
 - SustainableSourcingImprovesReliability_Score

Hypotheses

- *H0:* Circular practices related to material utilization, waste reduction, and sustainable sourcing do not significantly predict long-run operational cost reduction.
- *H1:* Circular practices related to material utilization, waste reduction, and sustainable sourcing significantly predict long-run operational cost reduction.

Regression

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.823 ^a	.678	.671	.600

ANOVA^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	110.543	3	36.848	102.477	.000 ^b
	Residual	52.497	146	.360		
	Total	163.040	149			

Interpretation

The multiple regression model suggests that material use enhancement, reduction of waste and defect and reliability of sustainable sourcing are all significant predictors of the reduction of cost of operation in the long run. The model is statistically significant with the $R = 0.823$, $R^2 = 0.678$, $F = 102.477$, $p = 0.000$ indicating that these predictors capture 67.8 percent of the difference in operational cost reduction. The coefficients of all three predictors are positive and significant indicating that each of them makes a significant contribution towards the enhancement of operational efficiency. Thus, the null hypothesis (H0) is rejected and the alternative hypothesis (H1) is accepted, which proves that the use of circular practices has a strong positive influence on the operational efficiency in the apparel supply chain.

Test 3: Correlation Test

Objective

To analyse the impact of circular practices on environmental performance.

Variables selected

- *Question 9:* Extent of circular supply chain practices integrated into company retail operations
- *Question 25:* Packaging materials are recyclable or biodegradable

Dataset variables

- CircularIntegrationExtent_Code
- PackagingRecyclableOrBiodegradable_Score

Hypotheses

- *H0*: There is no significant correlation between the extent of circular supply chain integration and recyclable/biodegradable packaging practices.
- *H1*: There is a significant correlation between the extent of circular supply chain integration and recyclable/biodegradable packaging practices.

Interpretation

The degree of circular supply chain integration and recyclable/biodegradable packaging practices are strongly positively correlated, according to Pearson correlation research. The p-value is 0.000 less than 0.05, and the correlation coefficient is $r = 0.769$. Consequently, the alternative hypothesis (*H1*) is accepted and the null hypothesis (*H0*) is rejected. It suggests that the utilisation of recyclable or biodegradable packaging materials increases with the degree of circular supply chain integration, which allows determining a strong positive correlation between circular practices and environmental performance.

VI. DISCUSSIONS

- In the descriptive analysis of 150 valid responses, it can be stated that the knowledge of circular supply chains is very high (Mean = 0.95), and the commitment of the top management to sustainability is strong (Mean = 4.04), which makes it a well-organized basis of transforming the industry.
- Although it is highly strategically committed, there are gaps in the actual implementation of circular initiatives. The structured reverse logistics systems (Mean = 2.63) and investments in recycling/upcycling processes (Mean = 2.83) had lower mean scores, which emphasize inadequate infrastructure in the apparel sector.
- Digital technology enhancing transparency and circularity had a high mean score of 4.07, demonstrating that the integration of technology is now winning over physical circular infrastructure in the industry.
- The Chi-square test provided a statistically significant relationship ($p < 0.001$) between strategic pathways that affect the transition and the degree of circular supply chain integration.

This proves the fact that effective strategic direction has a direct positive impact on the implementation of circular models, which is much faster.

- The multiple regression analysis has demonstrated that better material utilization, reduction in waste and sustainable sourcing have a significant predictive value over the long run reduction of operational costs. The R^2 of the model was 0.678, which implies that these circular practices explain 67.8 percent of the difference in the attainment of long-term cost efficiencies.
- All three independent variables in the regression model showed significant positive coefficients, which supports the claim that targeted circular practices increase operational and environmental performance at the same time.
- The Pearson correlation test showed that the relationship between the degree of circular supply chain integration and the adoption of recyclable or biodegradable packaging materials was strong ($r = 0.769$, $p < 0.001$).
- Also, the correlation confirms that, the more apparel companies develop their overall circular supply chain integration, the higher their dedication to particular environmental outputs, which include eco-friendly packaging.

VII. CONCLUSION

The paper has concludes that the transition to circular and sustainable supply chains in the apparel sector is grounded by strategic pathways. The significance of a high R^2 value of 0.678 and very significant p-values is statistical evidence that the incorporation of practices like optimum use of materials, minimizing wastes, and sourcing sustainably will lead to a significant reduction in the costs of operations in the long term. The official rejection of the null hypothesis of the Chi-square, Regression and Correlation tests helps to cement the direct relationship between strategic management commitment, operational integration, and positive environmental performance, including the adoption of biodegradable packaging.

Nevertheless, physical capabilities are experiencing a significant performance discrepancy, although digital awareness and top-level commitment are high. The relatively weak integration of organised systems of reverse logistics and recycling facilities is a bottleneck. Finally, to achieve the full benefits of a circular economy in terms of financial and environmental outcomes, apparel manufacturers and retailers should close the digital and physical infrastructure investments gap.



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