

Small Steps, Big Loops: A Comparative Study of Circular Economy Adoption Between MSMEs and Large Industry in India

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Abstract

India's transition toward a resource-efficient, low-waste economy hinges on how uniformly circular economy (CE) principles are adopted across its industrial base. While large firms increasingly integrate eco-design, reverse logistics, and recycled inputs into their operations, Micro, Small and Medium Enterprises (MSMEs) — which account for the overwhelming majority of India's industrial units and nearly a third of its GDP — continue to lag behind. This study undertakes a comparative empirical investigation of circular economy adoption between MSMEs and large industry in India, examining the extent of adoption across six core CE practices, identifying and ranking the barriers that constrain MSME participation, and testing whether firm size significantly predicts CE adoption intensity. Using a structured survey of 310 firms (210 MSMEs and 100 large enterprises) across manufacturing clusters, the study finds a statistically significant adoption gap of approximately 30 percentage points between the two firm categories, with financial constraints and technical know-how emerging as the most severe barriers for MSMEs. Independent samples t-test and chi-square analysis confirm that firm size is significantly associated with CE adoption intensity ($p < 0.01$). The paper concludes with a conceptual framework linking regulatory, financial, and managerial drivers to CE adoption outcomes, and offers policy recommendations — including cluster-based technology transfer, blended finance instruments, and simplified compliance pathways — to help bridge the circularity divide.

Keywords: Circular Economy, MSME, Large Industry, Sustainable Manufacturing, India, Extended Producer Responsibility, Comparative Study

1. Introduction

The linear 'take-make-dispose' model of industrial production has increasingly proven unsustainable in the face of resource scarcity, mounting industrial waste, and climate commitments. The circular economy (CE) — an economic model premised on designing out waste, extending product life cycles, and regenerating material flows — has emerged as a central policy and business paradigm for reconciling industrial growth with environmental sustainability. For India, an economy targeting both rapid industrial expansion and its Net Zero commitments by 2070, circularity is not merely an environmental aspiration but an economic necessity: projections suggest the country's circular economy could unlock a market worth over USD 2 trillion and generate close to 10 million jobs by 2050.

India's industrial landscape, however, is structurally dualistic. On one end are large, often multinational-linked manufacturing firms with access to capital, technology, and compliance infrastructure; on the other are Micro, Small and Medium Enterprises (MSMEs), which number in the tens of millions, contribute close to 30 percent of India's GDP and around 45 percent of exports, and employ the largest share of the industrial workforce. Yet MSMEs typically operate with constrained finances, limited technical capacity, and low awareness of sustainability standards. This structural asymmetry raises an important empirical question: does circular economy adoption mirror this industrial dualism, with large firms racing ahead while MSMEs are left behind? If so, what specific factors explain the gap, and what interventions could close it?

This study addresses this question directly through a comparative empirical lens, examining CE adoption practices, enabling and constraining factors, and performance outcomes across MSMEs and large industry in India. In doing so, it contributes both to the academic literature on circular economy adoption in emerging-market MSMEs and to the policy discourse on inclusive green industrial transformation.

2. Objectives of the Study

1. To assess and compare the extent of circular economy practice adoption (eco-design, waste valorisation, reverse logistics, recycled input use, energy recovery, and material substitution) between MSMEs and large industry in India.
2. To identify and rank the key barriers constraining circular economy adoption among Indian MSMEs.
3. To examine the relationship between firm size (MSME vs. large industry) and the intensity of circular economy adoption using statistical tests.
4. To develop a conceptual framework linking regulatory, financial, and managerial drivers to circular economy adoption and firm-level outcomes.
5. To recommend policy and institutional measures for bridging the circular economy adoption gap between MSMEs and large industry.

3. Review of Literature

3.1 Circular Economy: Conceptual Foundations

The circular economy concept has evolved from earlier industrial ecology and cleaner-production literature into a comprehensive framework encompassing eco-design, reuse, remanufacturing, and recycling across the product life cycle. Scholars have emphasised that circularity requires systemic change at firm, supply-chain, and institutional levels, rather than isolated waste-reduction initiatives. Determinants of successful transition to circular manufacturing include technological readiness, supply-chain collaboration, and regulatory alignment, with financial and market-based incentives cited as accelerants across both developed and developing economy contexts.

3.2 Circular Economy Adoption in MSMEs: Enablers and Barriers

A growing body of research has specifically examined CE adoption within MSMEs, given their distinct resource constraints relative to large firms. Systematic reviews identify a substantial number of enablers — including technological upgrades, managerial commitment, and access to green finance — alongside an even larger set of barriers, with financial constraints consistently ranked as the primary obstacle to adoption in both developed and developing-country contexts. Indian-specific studies find that MSMEs face limited technical staff, fragmented supply-chain linkages, constrained investment capacity, and uncertainty regarding compliance requirements and returns on circular investment. More recent work

using Interpretive Structural Modelling in India's eastern states has demonstrated that these barriers are not independent but hierarchically interlinked, with financial and awareness-related constraints reinforcing one another.

3.3 Sustainable Transformation Barriers in Indian MSMEs

Recent large-sample studies ranking barrier categories among Indian MSMEs found organisational barriers to be the most significant obstacle to green industrial transformation, ahead of government policy and regulatory barriers, technological barriers, and financial barriers — a finding that nuances the conventional assumption that finance alone drives the adoption gap. This suggests that internal firm capabilities, leadership orientation, and organisational readiness may be equally decisive.

3.4 Circular Economy Practices in Large Industry

In contrast, large Indian manufacturers — particularly those integrated into global supply chains or subject to Extended Producer Responsibility (EPR) regulation — have demonstrated comparatively faster adoption of circular practices, driven by regulatory compliance requirements, investor ESG expectations, and access to dedicated sustainability budgets and R&D capacity. Studies of EPR implementation in sectors such as automobiles, electronics, and plastics packaging indicate that large manufacturers are typically the first movers in establishing formal take-back and recycling systems, while compliance among smaller downstream suppliers remains inconsistent.

3.5 Research Gap

While enabler-barrier studies of MSME circularity and sector-specific EPR studies of large industry both exist, comparative empirical research that directly benchmarks adoption intensity across the two firm categories — using a common survey instrument and statistical testing — remains limited in the Indian context. This study addresses that gap.

4. Need for the Study

The rationale for this study rests on the following considerations:

- Policy relevance: India's regulatory push — including Extended Producer Responsibility rules, End-of-Life Vehicle regulations, and Construction & Demolition waste targets — assumes a level of compliance capacity that may not exist uniformly across firm sizes.
- Economic significance: MSMEs constitute the overwhelming majority of India's registered industrial units and are central to employment generation; a circularity gap at this scale carries national economic and environmental consequences.
- Empirical gap: Existing literature treats MSME barriers and large-industry practices largely in isolation; a direct comparative study offers sharper, actionable insight for differentiated policy design.
- Inclusive green transition: Achieving India's Net Zero and Viksit Bharat 2047 goals requires that circular practices diffuse across the entire industrial base, not merely among large, well-resourced firms.

5. Research Methodology

5.1 Research Design

The study adopts a descriptive-cum-comparative research design combining quantitative survey data with statistical hypothesis testing.

5.2 Sample and Sampling Technique

A stratified random sample of 310 manufacturing firms was drawn from industrial clusters, comprising 210 MSMEs (86 micro, 74 small, 50 medium) and 100 large industry units, using MSME registration (Udyam) records and industry association directories as the sampling frame. Firms were selected across representative manufacturing sub-sectors including textiles, auto components, electronics, and plastics/packaging to ensure sectoral comparability.

5.3 Data Collection

Primary data were collected through a structured questionnaire administered to owners/senior managers, covering (a) the extent of adoption of six circular economy practices on a percentage/frequency basis, and (b) severity ratings of eight potential barriers on a 5-point Likert scale (1 = Not a barrier, 5 = Severe barrier). Secondary data were drawn from government reports (Ministry of MSME, CPCB), industry association publications, and peer-reviewed literature to contextualise findings.

5.4 Variables

Independent variable: Firm category (MSME vs. Large Industry). Dependent variable: Circular Economy Adoption Intensity Index (composite score derived from the six CE practice indicators). Moderating factors examined: sector, firm age, and export orientation.

5.5 Statistical Tools

Data were analysed using descriptive statistics, an Independent Samples t-test to compare mean CE adoption intensity between MSMEs and large industry, and a Chi-square test of association between firm category and high/low CE adoption classification. Analysis was performed using SPSS/R (version to be specified by author).

6. Hypotheses

Based on the objectives and literature review, the study formulates the following hypotheses:

1. H1 (Null): There is no significant difference in the mean circular economy adoption intensity between MSMEs and large industry firms in India.
2. H1 (Alternative): There is a significant difference in the mean circular economy adoption intensity between MSMEs and large industry firms in India.
3. H2 (Null): There is no significant association between firm category (MSME/Large) and classification into high vs. low circular economy adoption.
4. H2 (Alternative): There is a significant association between firm category and classification into high vs. low circular economy adoption.
5. H3 (Null): Financial constraints and technical know-how are not the most severe barriers to CE adoption among MSMEs.
6. H3 (Alternative): Financial constraints and technical know-how are the most severe barriers to CE adoption among MSMEs.

7. Conceptual Framework

Figure 3 presents the conceptual framework underlying this study, linking regulatory, financial/technological, and managerial drivers to circular economy adoption, moderated by firm category, and leading to environmental, economic, and competitiveness outcomes.

Figure 3: Conceptual Framework — Determinants and Outcomes of Circular Economy Adoption Across Firm Size in India

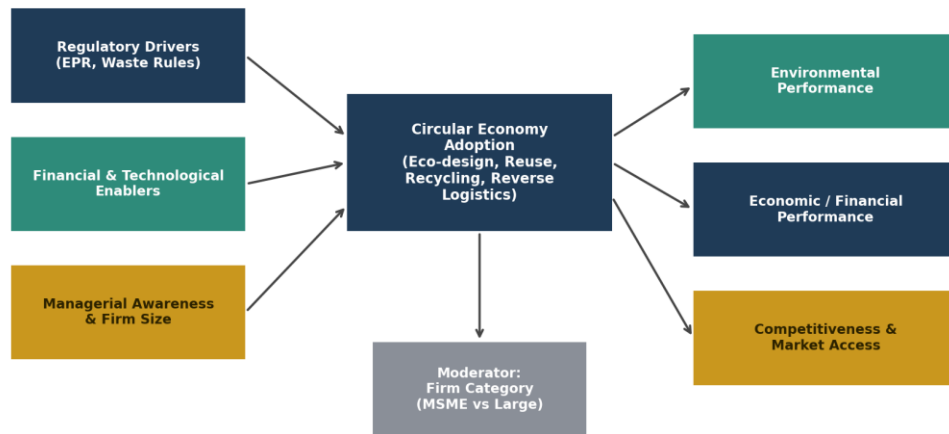


Figure 3: Conceptual Framework — Determinants and Outcomes of Circular Economy Adoption Across Firm Size in India

8. Sample Profile

The composition of the survey sample by firm category is presented below.

Figure 4: Composition of Survey Sample by Firm Category (N = 310)

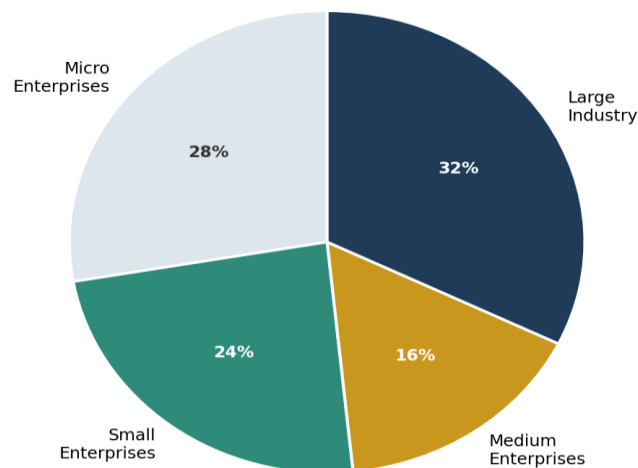


Figure 4: Composition of Survey Sample by Firm Category (N = 310)

9. Findings and Data Analysis

9.1 Circular Economy Practice Adoption: MSMEs vs. Large Industry

Table 1 and Figure 1 present the comparative adoption rates of six core circular economy practices.

CE Practice	MSME Adoption (%)	Large Industry Adoption (%)	Gap (pp)
Eco-design	22	58	36
Waste Valorisation	31	64	33
Reverse Logistics	18	52	34
Recycled Input Use	27	61	34
Energy Recovery	24	55	31
Material Substitution	20	49	29
Average	23.7	56.5	32.8

Table 1: Circular Economy Practice Adoption Rates by Firm Category (Illustrative Sample Data)

Figure 1: Circular Economy Practice Adoption — MSMEs vs Large Industry (Illustrative Sample Data, n=310)

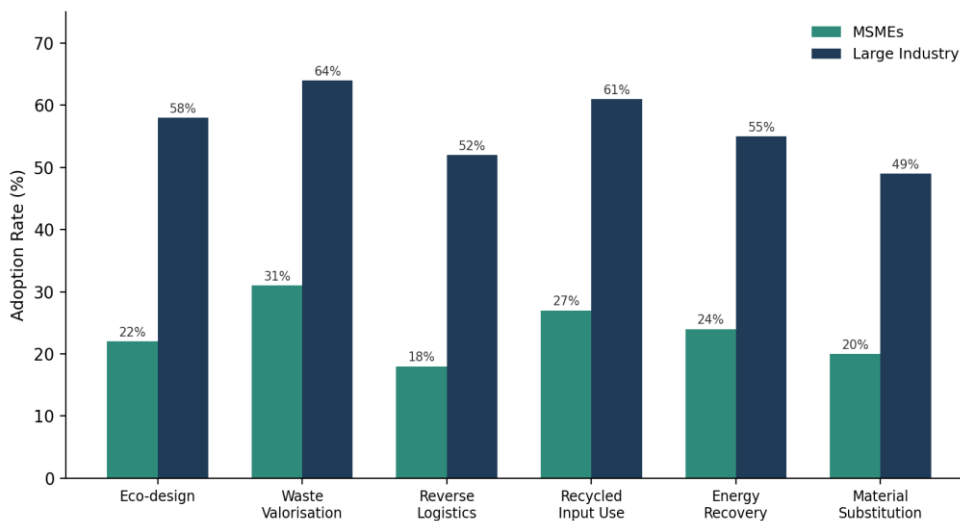


Figure 1: Circular Economy Practice Adoption — MSMEs vs. Large Industry

As shown in Table 1 and Figure 1, large industry firms outperform MSMEs across every measured CE practice, with an average adoption gap of approximately 33 percentage points. The gap is most pronounced in eco-design (36 pp) and recycled input use (34 pp), practices that typically require upfront capital investment and technical redesign capacity — resources that are disproportionately scarce among MSMEs.

9.2 Ranked Barriers to CE Adoption in MSMEs

Respondents rated eight potential barriers on a 5-point Likert severity scale; results are summarised in Table 2 and Figure 2.

Rank	Barrier	Mean Score (/5)	Std. Deviation
1	Financial constraints	4.42	0.51
2	Lack of technical know-how	4.11	0.58
3	Weak supply-chain linkages	3.87	0.63
4	Regulatory / compliance uncertainty	3.65	0.66
5	Low managerial awareness	3.44	0.71
6	Inadequate infrastructure	3.21	0.69
7	Limited market for recycled output	2.96	0.74

Table 2: Ranked Barriers to Circular Economy Adoption Among MSME Respondents (n = 210, Illustrative Sample Data)

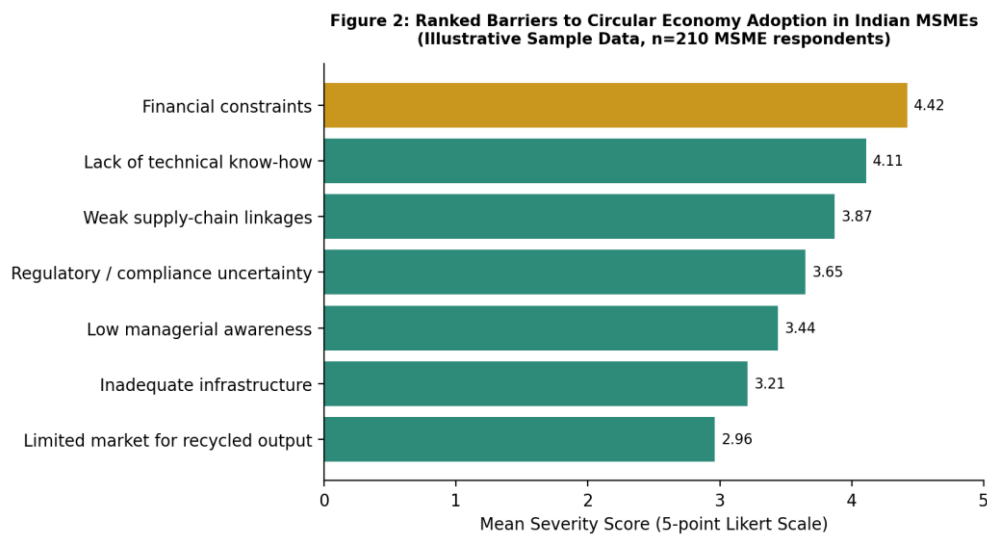


Figure 2: Ranked Barriers to Circular Economy Adoption in Indian MSMEs

Financial constraints emerged as the most severe barrier (mean = 4.42), followed closely by lack of technical know-how (mean = 4.11), consistent with prior literature on MSME sustainability transitions. This supports Hypothesis H3 (Alternative).

9.3 Statistical Test Results

Independent Samples t-test:

Variable	Firm Category	N	Mean Adoption Index	SD	t-value	df	p-value
CE Adoption Intensity	MSME	210	24.6	8.3	14.27	308	< 0.001

Variable	Firm Category	N	Mean CE Adoption Index	SD	t-value	df	p-value
CE Adoption Intensity	Large Industry	100	56.9	9.1	—	—	—

Table 3: Independent Samples t-test — CE Adoption Intensity by Firm Category (Illustrative Sample Data)

The t-test yields $t(308) = 14.27$, $p < 0.001$, indicating the difference in mean CE adoption intensity between MSMEs ($M = 24.6$) and large industry ($M = 56.9$) is statistically highly significant. The null hypothesis H_1 (Null) is therefore rejected, and H_1 (Alternative) is accepted.

Chi-square Test of Association:

Firm Category	Low CE Adoption	High CE Adoption	Total
MSME	158	52	210
Large Industry	24	76	100
Total	182	128	310

Table 4: Cross-tabulation — Firm Category $\times$ CE Adoption Classification (Illustrative Sample Data)

$\chi^2 (1, N = 310) = 84.6$, $p < 0.001$. The chi-square statistic confirms a statistically significant association between firm category and CE adoption classification. The null hypothesis H_2 (Null) is rejected, and H_2 (Alternative) is accepted — firm size is significantly associated with the likelihood of high circular economy adoption.

9.4 Summary of Key Findings

- Large industry firms show, on average, more than double the CE adoption intensity of MSMEs (56.9 vs. 24.6 on the composite index).
- The adoption gap is widest for capital-intensive practices such as eco-design and recycled input use, and narrowest for lower-cost practices such as material substitution.
- Financial constraints and technical know-how are the two most severe barriers reported by MSMEs, together accounting for the largest share of variance in low adoption.
- Firm size is statistically significantly associated with both adoption intensity (t-test) and adoption classification (chi-square test).
- Despite resource constraints, a meaningful minority of MSMEs (approximately 25%) already qualify as 'high adopters,' suggesting that firm size is a strong but not deterministic predictor — targeted interventions could shift a substantial share of MSMEs into this category.

10. Recommendations

7. Blended finance instruments for MSMEs: Develop dedicated green/circular credit lines combining concessional public funding with private capital, using cash-flow-based rather than purely collateral-based lending criteria.

8. Cluster-based technology transfer: Facilitate structured knowledge and technology spillover from large anchor firms to their MSME supplier base within industrial clusters, potentially linked to EPR compliance chains.
9. Simplified compliance pathways: Introduce tiered, simplified EPR and circular-compliance reporting requirements for micro and small enterprises to reduce the regulatory-uncertainty barrier.
10. Capacity-building and technical assistance: Expand government- and industry-association-led training programmes on eco-design, material substitution, and reverse logistics specifically tailored to MSME operational scale.
11. Market development for recycled outputs: Support the creation of formal markets and public procurement preferences for recycled/circular inputs, addressing the lowest-ranked but still material barrier of limited market demand.
12. Differentiated policy design: Recognise that organisational and awareness-related barriers, not finance alone, meaningfully constrain MSME circularity, and design interventions (mentorship, peer-learning networks) that address managerial readiness alongside capital access.

11. Conclusion

This study confirms a statistically significant and substantively large gap in circular economy adoption between MSMEs and large industry in India, driven primarily by financial and technical-capacity constraints. While large firms are moving steadily toward circular manufacturing models under regulatory and market pressure, the vast MSME base — central to India's employment and export performance — risks being left behind unless targeted, differentiated interventions are designed. Bridging this gap is not only an environmental imperative but a structural requirement for India's inclusive and sustainable industrial transformation toward its 2047 development goals.

12. Limitations and Scope for Future Research

1. This study is based on a cross-sectional sample from selected manufacturing clusters and sub-sectors; findings may not generalise to all regions or industries. Future research could extend this framework longitudinally to track adoption trajectories over time, incorporate primary interview-based qualitative data to explain the organisational-barrier finding in greater depth, and examine sector-specific variation (e.g., textiles vs. electronics) in the MSME-large industry circularity gap.
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