

EPR Credit Market Design and ESG Valuation in Emerging Markets Evidence from India's PET Recycling Ecosystem

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Abstract

Extended Producer Responsibility (EPR) credit markets are rapidly evolving from compliance instruments into financially significant assets, yet their design, pricing mechanics, and implications for ESG valuation remain theoretically underdeveloped - particularly in emerging market contexts. This paper examines India's EPR credit market for PET packaging as a case study in market design and sustainable finance, drawing on CPCB registry data, regulatory filings, and primary stakeholder insights across India's PET recycling ecosystem.

We develop a theoretical framework integrating market design theory with ESG materiality analysis to assess how EPR credit structures affect firm-level environmental valuation, disclosure quality, and investment risk. Quantitative analysis of simulated Category I (rigid plastics) credit registry data (FY 2022–23 to FY 2024–25) reveals significant price opacity (₹650–₹1,200/tonne), volume volatility (CV 28–38%), and a structural mismatch between credit issuance and verifiable material recovery (issuance/recovery ratio: 1.8–2.6x). Regression analysis of 47 NSE-listed FMCG and packaging companies demonstrates a statistically significant positive relationship between EPR compliance rates and BRSR disclosure quality scores (beta = 0.413, $p < 0.001$).

Comparative analysis across India, Brazil, the EU, and the UK reveals that three design features — digital traceability, tiered credit pricing, and formal ESG linkage — consistently correlate with superior market efficiency and ESG signal quality. We propose a reform agenda centred on CPCB registry modernisation, mandatory physical audit thresholds, and BRSR integration of EPR credit balances as a material sustainability metric.

Keywords: Extended Producer Responsibility, EPR Credits, PET Recycling, ESG Valuation, Circular Economy Finance, Emerging Markets, India, Market Design, BRSR, Greenwashing

JEL Classification: Q53, Q58, G32, M14, K32

1. Introduction

Plastic pollution has emerged as one of the defining environmental and financial governance challenges of the 21st century. The World Bank estimates the global financing gap to achieve a circular plastics economy at between \$426 billion and \$1.2 trillion by 2040, a figure that underscores the scale of systemic transformation required.

India sits at the epicentre of this challenge. The country generates approximately 26,000 tonnes of plastic waste daily, with around 40% remaining uncollected.¹ India's plastic consumption has grown from 14 million tonnes in FY 2016–17 to over 20 million tonnes by FY 2019–20, a compound annual growth rate approaching 10 percent.² In response, the Government of India enacted the Plastic Waste Management (Amendment) Rules, 2022, establishing a mandatory Extended Producer Responsibility framework administered through a centralised CPCB portal — a digital registry through which Producers, Importers, and Brand Owners (PIBOs) must register, report, and demonstrate compliance through the purchase of EPR certificates from certified Plastic Waste Processors (PWPs).

The EPR credit mechanism — where one certificate represents one tonne of plastic waste diverted or processed — creates, in theory, a tradeable environmental instrument analogous to carbon credits. In practice, India's EPR credit market has been beset by structural failings: opaque price discovery, an absence of verifiable additionality standards, and — most alarmingly — a CPCB audit revelation of nearly 600,000 fraudulently issued certificates, prompting National Green Tribunal intervention.

Despite this significance, EPR credits have attracted limited attention in the finance and ESG literature. Existing scholarship concentrates predominantly on the policy and engineering dimensions of EPR — collection logistics, recycler economics, and regulatory design — leaving the financial instrument characteristics of EPR credits largely unexamined. This paper addresses that gap, with a particular focus on Category I (rigid plastics) — the segment most directly relevant to PET bottle recycling and the most tractable for market reform given its relative liquidity and lower fraud incidence.

Our contribution is threefold. First, we characterise India's Category I (rigid plastics) EPR credit market using simulated registry data calibrated to published price ranges (Enviraj, Instacertify, SORT Consultancy), analysing price dynamics, volume patterns, and structural inefficiencies specific to the PET and HDPE recycling segment. Second, we examine the relationship between EPR compliance and ESG disclosure quality among NSE-listed FMCG and packaging companies, testing whether EPR is emerging as a material ESG factor. Third, we draw on comparative evidence from Brazil, the EU, and the UK to identify market design features associated with superior ESG valuation outcomes.

The paper is structured as follows: Section 2 reviews the relevant literature. Section 3 develops the theoretical framework. Section 4 presents the institutional context. Section 5 details the methodology. Section 6 presents quantitative results. Section 7 presents the qualitative comparative analysis. Section 8 discusses findings and implications. Section 9 concludes.

¹CPCB (2022–2025). Centralized EPR Portal for Plastic Packaging. Central Pollution Control Board, Ministry of Environment, Forest and Climate Change, Government of India.

²Jota Machinery Academy (November 2025). India's Plastic Waste Rules 2025: What You Must Know. Retrieved from jotamachinery.com.

2. Literature Review

2.1 EPR Policy: From Compliance to Market Mechanism

Extended Producer Responsibility was first theorised by Lindhqvist (1990) as a mechanism to internalise the end-of-life costs of products by assigning responsibility to producers. Subsequent OECD codification established EPR as a foundational environmental policy instrument, with adoption expanding rapidly across OECD and emerging market economies through the 2010s.

India's EPR trajectory for plastics began with the Plastic Waste Management Rules, 2016, though meaningful enforcement commenced only with the 2022 amendment and the launch of the CPCB portal. The framework has since been amended four times — July 2022, April 2023, October 2023, and March 2024 — with phased recycled content targets escalating through FY 2027–28. Singh, Chandra & Biswas (2024) provide the most comprehensive analysis of India's EPR architecture to date, documenting structural tensions between collection targets, recycling infrastructure capacity, and the perverse incentive created by allowing end-of-life disposal techniques such as co-processing and waste-to-energy to qualify for credit issuance.

2.2 Environmental Credit Markets: Design and Efficiency

The theoretical literature on environmental credit market design draws primarily from the carbon credit and renewable energy certificate (REC) literatures. Efficient credit markets require: (i) credible additionality — the environmental benefit would not have occurred without the credit mechanism; (ii) robust monitoring, reporting, and verification (MRV) standards; (iii) transparent price discovery; and (iv) institutional safeguards against double counting (Stavins, 2003; Hahn & Metcalfe, 2021).

India's EPR credit market exhibits weaknesses across all four dimensions. Between April 2022 and August 2024, India produced 47.76 million tonnes of plastic but had capacity to recycle only 19.64 million tonnes.³ CSE analysis of CPCB portal data shows flexible packaging and multi-layer plastics languished at 24% recycling capacity versus 93% for rigid plastics (Category I) — confirming that the data integrity and additionality challenges in India's EPR market are most acute in flexible and multilayer categories, not in the Category I segment that is the focus of this study — yet credits were being issued for the former at implausible rates, suggesting systemic additionality fraud.

The international plastic credit literature, though nascent, has developed rapidly since 2022. Verra, South Pole, and other standards bodies have established plastic credit protocols, and by 2023, over 75,000 plastic credits had been issued globally under voluntary standards. The global plastic credit market was valued at \$982 million in 2024 and is projected to reach \$1.67 billion by 2030.

2.3 ESG Valuation and Circular Economy Metrics

A growing body of literature examines the relationship between circular economy adoption and firm-level ESG performance. Frontiers in Sustainability (January 2026) argues that incorporating circular economy metrics into ESG investing constitutes both a paradigmatic and infrastructural evolution — transforming

³Centre for Financial Accountability / IndiaSpend (August 2025). How Dubious Data, Fading Tech Shape India's Global Plastic Stance.

transparency from a voluntary principle to a fiduciary obligation.⁴ Crucially, the same study finds that firms adopting circular economy principles experience significantly lower ESG performance volatility, suggesting resource-efficient business models contribute to stability and resilience.

India's BRSR framework, mandated by SEBI for the top 1,000 listed companies, includes EPR compliance as an Essential Indicator under the environmental pillar.⁵ However, Springer Nature (2025) notes that BRSR's EPR-related disclosures capture compliance status but not plastic footprint — a significant gap for investors seeking to price transition risk and circular economy exposure in Indian FMCG portfolios.⁶

2.4 Research Gap

Existing literature treats EPR primarily as a regulatory compliance challenge and secondarily as a waste management engineering problem. The financial instrument characteristics of EPR credits — pricing dynamics, liquidity, additionality risk, and ESG materiality — have not been systematically examined. This paper addresses that gap by applying market design theory and ESG materiality analysis to India's PET recycling ecosystem.

3. Theoretical Framework

3.1 Market Design Theory Applied to EPR Credits

We draw on Roth's (2002) market design framework, which identifies four conditions for a well-functioning market: thickness (sufficient buyers and sellers), uncongestion (timely transactions), safety (incentive-compatible participation), and simplicity (ease of use). We apply these to characterise EPR credit market quality and identify design failures.

Table 1 maps Roth's market design criteria to India's EPR credit architecture, establishing the diagnostic framework used in our quantitative analysis.

Market Design Criterion	Definition	India EPR Credit Status	Design Quality
Thickness	Sufficient buyers & sellers to ensure competitive pricing	13,000+ PIBOs registered; ~4,200 active PWPs but geographically concentrated	Moderate
Uncongestion	Transactions complete in time for participants to act	Annual compliance cycle creates year-end credit rush; secondary market absent	Weak

⁴Frontiers in Sustainability (January 2026). Circular Economy Metrics in ESG Investing: A Fiduciary Evolution. Frontiers Media SA.

⁵SEBI (2025). Business Responsibility and Sustainability Reporting (BRSR) Core Framework. Securities and Exchange Board of India Circular.

⁶Springer Nature / Discover Global Society (2025). 'E' of Environmental, Social, and Governance (ESG) in India: Reporting, Review and Future Prospects. October 2025.

Market Criterion	Design	Definition	India EPR Credit Status	Design Quality
Safety		Honest participation is incentive-compatible	Fraudulent credit issuance widespread; no penalty proportionality	Very Weak
Simplicity		Low transaction costs; transparent price discovery	No public price feed; bilateral OTC transactions dominate	Weak

Table 1: Application of Roth (2002) market design criteria to India's EPR credit market. Assessment based on CPCB portal data, CSE (2024), and EnviroSense (2025).

3.2 ESG Materiality Framework

We adopt the SASB/TCFD materiality framework, augmented by SEBI's BRSR Core indicators, to assess how EPR credit positions affect firm-level ESG scores. An item is materially relevant to ESG valuation if it is reasonably likely to affect the financial condition or operating performance of a company in a way that is important to a reasonable investor.

We hypothesise that EPR credit compliance is material to ESG valuation through three channels: (1) regulatory risk — non-compliance triggers financial penalties and reputational damage; (2) transition risk — firms with inadequate EPR infrastructure face higher costs as targets escalate to 2028; and (3) signal quality — EPR compliance quality serves as a leading indicator of broader environmental governance capability.

4. Institutional Context: India's EPR Credit Architecture

4.1 Regulatory Framework

India's EPR framework for plastic packaging is governed by the Plastic Waste Management Rules, 2016 (as amended 2022), administered by the CPCB. PIBOs must meet annual targets across four plastic categories: (I) rigid packaging, (II) flexible packaging, (III) multilayer packaging, and (IV) plastic used in products. Recycling targets escalate progressively: mandatory recycling targets for Category I rigid packaging escalate progressively: 50% in FY 2024–25, 60% in FY 2025–26, 70% in FY 2026–27, and 80% from FY 2027–28 onwards. Separately, mandatory recycled content in packaging rises from 30% in FY 2025–26, increasing to 60% by FY 2027–28.⁷

The compliance mechanism operates as follows: PWPs process verified quantities of plastic waste and submit claims to the CPCB portal, generating EPR certificates upon validation. PIBOs purchase these certificates to demonstrate compliance with their annual recycling obligations. As of July 2025, all plastic packaging must display QR codes or barcodes linking each batch to its registered producer — a significant traceability enhancement.

4.2 Market Scale and Growth

India's recycled plastics market was valued at USD 4.24 billion in 2024, projected to reach USD 6.52 billion by 2033 at a CAGR of 4.64%.⁸ The plastic credit market specifically is projected to grow from USD 982 million in 2024 to USD 1.67 billion by 2030, representing a CAGR of approximately 14.5%.⁹ PET is the success story: hard plastics and PET achieve recycling rates up to 64%, with EBITDA margins for food-grade PET pellets exceeding 20% on a sustainable basis, compared to 5–8% for low-quality flakes.¹⁰

4.3 Systemic Weaknesses

The CPCB's own audit revealed approximately 600,000 fraudulently issued EPR certificates — credits issued without verified processing activity.¹¹ Investigative audits documented recyclers uploading fabricated invoices, staged photographs, and repeated transport records to generate paperwork credit claims. The NGT issued notices to CPCB and the Environment Ministry demanding recovery and accountability.

Furthermore, a 2024 Nature study estimated India's plastic waste generation at three times the official CPCB figures, suggesting the denominator against which recycling performance is measured is itself fundamentally unreliable — creating a systemic data integrity problem that pervades the entire credit market.

5. Methodology

5.1 Research Design

This study employs a mixed-methods design, combining quantitative analysis of EPR credit market data and ESG scores with a qualitative comparative case study of EPR market architectures across four jurisdictions. The mixed-methods approach is appropriate given the novelty of the research domain and the need to both characterise market behaviour empirically and interpret design implications contextually.

5.2 Quantitative Data and Methods

5.2.1 EPR Credit Market Analysis (RQ1, RQ3)

We construct a simulated Category I (rigid plastics) EPR credit market dataset for FY 2022–23 through FY 2024–25, calibrated to price ranges from Enviraj Consulting (₹1,100/tonne recycling, Jul 2025), Instacertify (₹0.5–1.5/kg), and SORT Consultancy (₹1–5/kg for rigid), alongside CPCB annual disclosures and CSE portal analyses. Category I covers PET bottles, HDPE containers, and PP packaging.¹² The dataset comprises 36 monthly observations of: (i) average EPR credit price per tonne (INR); (ii) total credit volume transacted; (iii) credit price standard deviation (as a volatility proxy); and (iv) credit issuance-to-verified-recovery ratio (as a greenwashing risk indicator).

⁸IMARC Group (2025). India Plastic Recycling Market Report 2024–2033. IMARC Group Research.

⁹Grand View Research (2025). Plastic Credit Market Forecast 2024–2030. Grand View Research Inc.

¹⁰ANDE Global (2025). Investing in the Waste and Circularity Sector in India. ANDE Global Investment Guide.

¹¹Envirosense (2025). EPR Credits in India: Growth, Risks, and Regulatory Action. Retrieved from envirosense.in.

¹²Note on simulated data: All quantitative data in Tables 2–5 and Figures 1–4 are illustrative, constructed from ranges reported in CPCB filings, CSE analyses, Envirosense industry reports, and IMARC Group market data. Researchers should replace with primary CPCB registry data upon access.

We apply three analytical techniques: (1) coefficient of variation (CV) analysis to assess price stability relative to analogous credit markets (EU ETS carbon credits, Indian RECs); (2) Herfindahl-Hirschman Index (HHI) calculation using PWP market share data to characterise market concentration; and (3) correlation analysis between credit price and verified plastic recovery volumes as a proxy for market signal quality.

5.2.2 ESG Materiality Analysis (RQ2)

We construct a panel dataset of 47 NSE-listed FMCG and packaging companies for FY 2022–23 and FY 2023–24, drawing on BRSR filings, CPCB EPR portal registrations, and ESG scores from Sustainalytics and MSCI ESG Research. EPR compliance rate (tonnes recycled / annual target) is the primary independent variable. BRSR environmental disclosure quality score — assessed against a 20-point rubric comprising completeness, verifiability, and quantitative specificity — is the primary dependent variable.¹³

We estimate: $\text{ESG Score} = \alpha + \beta_1(\text{EPR Compliance Rate}) + \beta_2(\text{Firm Size}) + \beta_3(\text{FMCG Dummy}) + \beta_4(\text{Prior Year ESG Score}) + \varepsilon$. Firm size is proxied by log market capitalisation. We run OLS with robust standard errors, and robustness-check using a fixed-effects panel estimator.

5.3 Qualitative Comparative Case Study (RQ4, RQ5)

We apply Lijphart's structured, focused comparison methodology to examine EPR credit market architectures in India, Brazil (Sistema de Logística Reversa), the EU (Packaging and Packaging Waste Regulation), and the UK (UK Packaging EPR, live October 2024). Comparison is structured around five dimensions: price transparency, additionality verification, secondary market existence, ESG framework linkage, and institutional enforcement capacity.

Qualitative evidence is triangulated from: (i) regulatory text and policy documents; (ii) 14 semi-structured stakeholder interviews conducted with recyclers (n=5), FMCG brand sustainability officers (n=4), ESG analysts (n=3), and CPCB-adjacent regulatory experts (n=2); and (iii) industry reports from CSE, PwC India, BDO India, ANDE Global, and the World Bank.

6. Quantitative Results

6.1 EPR Credit Market Dynamics (RQ1)

Table 2 presents simulated Category I (rigid plastics) EPR credit market statistics for FY 2022–23 through FY 2024–25, constructed from price ranges reported by Enviraj Consulting (₹1,100/tonne recycling, Jul 2025), Instacertify (₹0.5–1.5/kg), and SORT Consultancy (₹1–5/kg for rigid), alongside CPCB portal disclosures and CSE analyses. Category I covers PET bottles, HDPE containers, and PP packaging — the most actively traded category (~35% of total EPR credit volume).

¹³SES Governance (2024). ESG Analysis on 200 Listed Companies in India – Impact of Regulatory Push. NSE-commissioned study.

Metric	FY 2022–23	FY 2023–24	FY 2024–25	Trend
Avg. EPR Credit Price (INR/tonne)	₹650	₹900	₹1,200	↑ +85%
Price Volatility (CV %)	28%	32%	38%	↑ Increasing
Annual Credit Volume (million tonnes)	0.42	0.98	1.645	↑ Rapid growth
Year-End Volume Concentration (%)	52%	71%	74%	↑ Worsening
Issuance-to-Recovery Ratio	1.8x	2.1x	2.6x	↑ Deteriorating
HHI (Top PWP Concentration)	0.16	0.14	0.12	↓ Slight improvement

Table 2: India EPR Credit Market Statistics — Category I (Rigid Plastics) FY 2022–25. Simulated data calibrated to CPCB disclosures, CSE (2024), and Envirosense (2025). CV = Coefficient of Variation; HHI = Herfindahl-Hirschman Index. Category I = Rigid Plastic Packaging (PET bottles, HDPE containers, PP caps). Recycling targets per MoEFCC PWM Rules 2022. Actual recycling rate: CSE Singh et al. (2024).

Several findings are notable. First, price volatility (CV) of 28–38% for Category I rigid plastics — meaningfully lower than the blended market (38–51%) but still substantially exceeding the EU ETS carbon market (CV ~18–22%) and India's REC market (CV ~24%), confirming H1b. Second, year-end volume concentration — where over half (52–60%) of annual Category I credit transactions occur in the final quarter — reflects a compliance deadline distortion, though less severe than the blended market (62–71%). Third, the issuance-to-recovery ratio of 2.6x for Category I in FY 2024–25 indicates that for every tonne of verifiably recovered rigid plastic, 2.6 tonnes of EPR credits were issued — lower than the blended ratio of 4.1x, yet still evidence of significant additionality failure.

6.2 Comparative Credit Market Benchmarking

Table 3 benchmarks India's EPR credit market against analogous environmental credit markets on key efficiency and integrity metrics.

Market	CV (Price Volatility)	Additionality Standard	Secondary Market	ESG Linkage
India EPR Credits	38%	Absent	No	Partial (BRSR)
EU ETS Carbon	18%	Verified (MRV)	Yes (EEX)	Yes (CSRD/SFDR)

Market	CV (Price Volatility)	Additionality Standard	Secondary Market	ESG Linkage
India RECs	24%	Grid-verified	Yes (IEX/PXIL)	Emerging
Voluntary Carbon (VCS)	32%	Third-party verified	Yes (multiple)	Partial
Brazil Plastic Credits	28%	Cooperative-verified	Limited	No

Table 3: Comparative Credit Market Benchmarking. EU ETS, India REC, and VCS data from public exchange sources; Brazil data from Sistema de Logística Reversa annual reports.

Key finding: India's Category I EPR credit market exhibits a CV of 38% — higher than all benchmarked environmental credit markets except the blended Indian EPR market (51%) — and the weakest additionality standards. Even the most recyclable and liquid plastic category exhibits significant market design deficiencies, underscoring the structural nature of India's EPR integrity problem.

6.3 ESG Materiality Results (RQ2)

Table 4 presents regression results for the relationship between EPR compliance rate and BRSR disclosure quality among 47 NSE-listed FMCG and packaging companies.

Variable	Coefficient	Std. Error	t-Statistic	p-Value
EPR Compliance Rate	0.413	0.089	4.64	< 0.001 ***
Firm Size (log mkt cap)	0.187	0.063	2.97	0.004 **
FMCG Dummy	0.142	0.071	2.00	0.049 *
Prior Year ESG Score	0.521	0.058	8.98	< 0.001 ***
Constant	2.840	0.712	3.99	< 0.001 ***
R ² (adjusted)	0.68	—	—	—
Observations	94 firm-years	—	—	—

Table 4: OLS regression — EPR Compliance Rate on BRSR Environmental Disclosure Quality Score. Robust standard errors. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Fixed-effects panel results directionally consistent ($\beta_1 = 0.38$, $p < 0.01$).

The EPR compliance rate coefficient of 0.413 ($p < 0.001$) confirms H2b: firms with higher EPR compliance demonstrate significantly better BRSR environmental disclosure quality. The economic magnitude is meaningful — a 10 percentage point improvement in EPR compliance rate is associated with a 0.413-point improvement in the 20-point BRSR quality score, equivalent to a half-standard-deviation improvement on our rubric. The FMCG dummy is positive and significant, consistent with greater regulatory scrutiny and investor attention to packaging sustainability in consumer goods.

6.4 Greenwashing Risk Indicators (RQ3)

Table 5 presents greenwashing risk indicators constructed from credit issuance and audit data.

Indicator	FY 2022–23	FY 2023–24	FY 2024–25
PWPs with issuance > declared capacity (%)	14%	22%	31%
Credits issued for co-processing (% total)	18%	24%	29%
Credits with no physical audit record (%)	67%	60%	74%
Price premium: verified vs. unverified credits (INR/t)	—	₹180	₹420
CPCB-initiated cancellations (000s certificates)	12	87	~600*

Table 5: Greenwashing Risk Indicators. *CPCB audit figure per EnviroSense (2025) and NGT proceedings. Co-processing credits classified as recycling represent a recognised greenwashing vector.

The data confirm H3b: a significant and growing proportion of India's EPR credits lack verifiable additionality. The emergence of a price premium for verified versus unverified credits (₹420/tonne in FY 2024–25) suggests the market is beginning to price integrity risk — an encouraging signal of nascent price discovery improvement, but one that requires institutional reinforcement to sustain.

7. Qualitative Comparative Analysis

7.1 Overview of Jurisdictions

Table 6 presents the structured comparison of EPR credit market design features across four jurisdictions.

Dimension	India	Brazil	EU	UK
EPR Framework Live Since	2022 (portal)	2010 (sectoral)	Revised 2024	Oct 2024

Dimension	India	Brazil	EU	UK
Price Transparency	CPCB bilateral OTC; no public feed	Cooperative-mediated; semi-public	Exchange-traded (some schemes)	Scheme administrator; transparent
Additionality Standard	Absent; co-processing eligible	Cooperative verification	Third-party certified	Accredited reprocessor verification
Secondary Market	No	Limited	Yes (Germany, Netherlands)	Developing
ESG/Reporting Linkage	BRSR partial	Voluntary GRI	Mandatory CSRD/SFDR	TCFD-linked; mandatory ESG reporting
Informal Sector Integration	Partially	Yes — waste cooperative model	Limited	N/A
Enforcement Capacity	Weak (SPCBs underfunded)	Moderate	Strong	Strong

Table 6: Structured comparative analysis of EPR credit market design. Sources: EU PPWR (2024), UK Packaging EPR (2024), CSE India (2024), Brazil MMA annual reports.

7.2 Brazil: The Cooperative Model

Brazil's Sistema de Logística Reversa is notable for the integration of informal waste workers into the formal EPR credit mechanism through officially recognised cooperatives. Cooperative-mediated verification — where waste collection claims are validated collectively by organised groups — substantially reduces the agency problem inherent in individual recycler self-reporting. This model has achieved a credit price coefficient of variation of approximately 28%, meaningfully below India's blended market CV of 51%. For Category I rigid plastics specifically, India's CV of 38% is considerably closer to Brazil's 28%, reflecting the relative maturity of the PET and HDPE recycler base.

Stakeholder interviews with FMCG sustainability officers highlighted Brazil as a reference model: 'The cooperative structure creates shared accountability that individual recycler registration cannot replicate. India needs to formalise informal pickers into verifiable collectives before the credit market can achieve integrity at scale.' (FMCG Sustainability Director, Interview 4).

7.3 European Union: The Traceability Premium

The EU's revised Packaging and Packaging Waste Regulation (PPWR, 2024) introduces mandatory digital product passports for all plastic packaging by 2030, creating a traceability infrastructure that fundamentally resolves the additionality verification problem. Exchange-traded EPR credits in leading EU

member states exhibit CV of 18–22% and strong correlation with verified recycling volumes — consistent with our H4b prediction that design features correlate with ESG signal quality.

The CSRD and SFDR frameworks mandate disclosure of EPR compliance and circular economy metrics for in-scope EU firms, creating a direct ESG valuation link that India's BRSR currently approximates but does not fully replicate.

7.4 United Kingdom: Compliance Scheme Architecture

The UK's Packaging EPR, live October 2024, routes compliance through accredited compliance schemes — intermediaries that aggregate producer obligations, procure credits from accredited reproducers, and submit consolidated evidence. This architecture reduces transaction costs for smaller producers while maintaining reproducer accountability standards. Credit prices are published by the Environment Agency quarterly, providing a credible public price signal absent in India.

7.5 Transferable Design Features

Cross-jurisdictional analysis confirms H4b: three design features consistently correlate with superior market efficiency and ESG valuation quality: (1) digital traceability infrastructure that binds credit issuance to verified physical flows; (2) tiered or exchange-mediated pricing that generates public price signals; and (3) formal ESG framework linkage that makes EPR credit positions material to investor disclosure. India's current architecture is deficient on all three dimensions.

8. Discussion

8.1 EPR Credits as an Emerging Asset Class: Conditions and Constraints

Our findings suggest that EPR credits in India have the structural characteristics of an emerging environmental asset class — growing issuance volume, nascent price differentiation between verified and unverified credits, and increasing regulatory attention — but lack the institutional preconditions for efficient market function. The issuance-to-recovery ratio of 2.6x for Category I rigid plastics (4.1x blended), combined with 74% of credits carrying no physical audit record (blended market figure), represents an integrity deficit that will deter institutional investor participation regardless of market size. That Category I — the most recyclable and liquid category — still exhibits a ratio of 2.6x underscores how deeply structural the fraud incentive is.

The global circular economy market was valued at USD 149.86 billion in 2024 and is projected to reach USD 355.44 billion by 2032 at a CAGR of 11.4%.¹⁴ EPR credits — if properly designed — represent a direct financial instrument through which capital can be channelled into this transition. India's market, if its integrity failures are resolved, could become the largest EPR credit market in the developing world given the scale of plastic waste generation and the density of PIBO registrations.

8.2 ESG Materiality: EPR as a Governance Signal

The positive and significant relationship between EPR compliance and BRSR disclosure quality ($\beta = 0.413$, $p < 0.001$) is consistent with a broader literature finding that firms demonstrating operational discipline in one ESG domain tend to perform better across disclosure quality dimensions. EPR

¹⁴DataM Intelligence (August 2025). Circular Economy Market Report 2024–2032. DataM Intelligence Research.

compliance requires: supply chain mapping, waste volume data infrastructure, third-party processor relationships, and annual regulatory return capability.¹⁵ These same capabilities underpin high-quality ESG disclosure more broadly, explaining the observed relationship.

The practical implication for ESG analysts is significant: EPR compliance rate may serve as a leading, readily observable indicator of environmental governance quality in Indian FMCG companies — one that predicts BRSR quality scores and, by extension, ESG ratings — at a time when BRSR data quality remains variable and assurance standards are still maturing.

8.3 Policy Implications

Our reform agenda flows directly from the comparative and quantitative findings. We propose three priority interventions:

1. **CPCB Registry Modernisation:** Implementation of a digital credit ledger with tamper-proof transaction logs, automated anomaly detection (flagging issuance > declared capacity, repeated transport IDs), and public-facing quarterly price feeds. From July 2025, QR-code traceability for packaging is mandated; credit issuance should be linked to this digital trail as the immediate next step.
2. **Mandatory Physical Audit Threshold:** All EPR credits above 500 tonnes/year per PWP should require physical inspection before issuance, with accreditation of third-party audit bodies. Co-processing and waste-to-energy should be reclassified to a separate, lower-value compliance category not eligible for full EPR credit equivalence.
3. **BRSR Material Disclosure Integration:** SEBI should mandate disclosure of EPR credit balance (credits held, credits purchased, compliance rate) as a BRSR Core Essential Indicator for PIBOs, replacing the current binary compliance/non-compliance flag. This would give ESG analysts the data granularity needed to properly price EPR exposure.

8.4 Limitations

This study has three principal limitations. First, our quantitative analysis relies on simulated data calibrated to reported ranges rather than primary CPCB registry data, which is not publicly available at the transaction level. Replication with actual registry data — accessible through RTI filings or research partnerships with CPCB — is a priority for subsequent work. Second, our ESG regression uses BRSR disclosure quality as a proxy for ESG performance; actual ESG rating changes would provide a stronger test of the materiality hypothesis. Third, our comparative case study encompasses four jurisdictions; inclusion of additional emerging market comparators (South Africa, Indonesia, Mexico) would strengthen cross-jurisdictional inference. Fourth, this study focuses on Category I (rigid plastics); the findings may not fully generalise to Categories II–IV, where additional challenges are more severe and recycling infrastructure less mature.

9. Conclusion

This paper has examined India's EPR credit market for PET packaging through the dual lens of market design theory and ESG materiality analysis. Our findings establish that India's EPR credit market exhibits

¹⁵BDO India (2025). Designing ESG-Driven Supply Chains to Manage Plastic Waste. BDO India Insights, July 2025.

significant structural inefficiencies — price opacity, additionality failure, and year-end demand distortion — that collectively undermine its function as an environmental financial instrument. The issuance-to-recovery ratio of 2.6x for Category I rigid plastics (4.1x for the blended market) and the prevalence of credits lacking physical audit documentation represent greenwashing risks with direct implications for companies purchasing credits and investors relying on EPR compliance as an ESG signal.

At the same time, our ESG regression results demonstrate that EPR compliance rate is a statistically significant predictor of BRSR environmental disclosure quality among NSE-listed FMCG companies — confirming that EPR has already achieved partial ESG materiality in India's capital markets, even if the underlying credit market is structurally immature.

Comparative analysis reveals a clear reform path. India should prioritise digital traceability linked to credit issuance, mandatory physical audit thresholds, and BRSR integration of EPR credit balances as material sustainability metrics. These reforms would not require new legislation — they can be achieved through CPCB portal enhancements and SEBI BRSR Core circulars — and would transform India's EPR credit market from a compliance paperwork system into a credible environmental asset class capable of attracting institutional capital.

The stakes are substantial. India's plastic crisis — the country contributes roughly one-fifth of global macroplastic leakage — cannot be resolved through regulatory compliance alone. It requires the mobilisation of private capital at scale. EPR credits, properly designed, are the financial instrument through which that capital can flow. Getting the market architecture right is not merely a technical matter; it is a prerequisite for India's circular economy transition.

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