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ETHICAL SUPPLY CHAIN AUDITS IN THE FASHION AND TEXTILE INDUSTRY: A REGULATORY APPROACH

ЭТИЧЕСКИЙ АУДИТ ЦЕПОЧКИ ПОСТАВОК В ИНДУСТРИИ МОДЫ И ТЕКСТИЛЬНОЙ ПРОМЫШЛЕННОСТИ: НОРМАТИВНЫЙ ПОДХОД

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This study investigates the effectiveness and variability of ethical supply chain audits by examining operational tiers ranging from raw material suppliers to end consumers within the fashion and textile industry. The article constructs qualitative and quantitative metrics and integrates quantitative compliance adherence, environmental emission, workplace safety and resource efficiency under a stratified sampling framework and multi layered analytical design. An Ethical Maturity Index (EMI) specific to audit readiness has been applied to 250 entities. The average results showed that retailers got the highest average compliance adherence rate (CAR) of 80.3 % and the highest EMI score of 0.82, while the raw material suppliers score the lowest (CAR 72.5 %, EMI 0.62). Among raw material suppliers, the worst pollution emission scores (PES) were 190kg/unit and the best were 127kg/unit from the end consumers. RER (Resource Efficiency Ratio) and SCI (Safety Compliance Index) varied us) retailers still top at 77%, and 78%, respectively, again. It was shown that the higher SCI and RER values significantly predict compliance, and increased PES associated with lower audit performance. The result of the study shows that policies and innovations are needed at policy and traceability levels to support the lowest tiers that typically perform poorly.

В этом исследовании изучается эффективность и изменчивость этических аудитов цепочки поставок путем изучения операционных уровней, начиная от поставщиков сырья до конечных потребителей в индустрии моды и текстиля. В статье строятся качественные и количественные метрики и интегрируются количественное соблюдение требований, выбросы в окружающую среду, безопасность на рабочем месте и эффективность использования ресурсов в рамках стратифицированной выборки и многоуровневого аналитического дизайна. Индекс этической зрелости (EMI), специфичный для готовности к аудиту, был применен к 250 организациям. Усредненные результаты показали, что розничные торговцы получили самый высокий средний уровень соблюдения требований (CAR) в размере 80,3% и самый высокий балл EMI в размере 0,82, в то время как поставщики сырья получили самые низкие баллы (CAR 72,5%, EMI 0,62). Среди поставщиков сырья наихудшие баллы выбросов загрязняющих веществ (PES) составили 190 кг/ед., а лучшие — 127 кг/ед. от конечных потребителей. Коэффициент эффективности использования ресурсов (RER) и индекс соответствия требованиям безопасности (SCI) (по сравнению с другими) у розничных продавцов по-прежнему достигают 77% и 78% соответственно. Показано, что более высокие значения SCI и RER значительно говорят о соответствии требованиям, а более высокий показатель PES связан с более низкими показателями эффективности аудита. Результаты исследования показывают, что для поддержки низших уровней, которые обычно демонстрируют низкую эффективность, необходимы меры и инновации на уровне политики и прослеживаемости.

Keywords: supply chain governance; textile industry; compliance metrics; environmental sustainability; operational efficiency; audit maturity.

Ключевые слова: управление цепочкой поставок; текстильная промышленность; показатели соответствия требованиям; экологическая устойчивость; операционная эффективность; зрелость аудита.

Introduction

In recent years, increased consumer and stakeholder awareness has led to raised expectations for fashion companies to showcase their commitment to fair labor, environmentally stewarding, and generally transparent supply chains. Nowadays, corporations are judged not just on the quality or desirability of their products, but also on the way they go about making them [1, 2]. Fast fashion, which feeds on cheap, quickly produced goods, has meant an undeniable convenience for consumers but has come at a heavy ethical price. Environmental protest movements and social action as well as regulation and other legal frameworks add up to encourage a greater responsibility on the part of businesses for their operation [3, 4].

One key approach to achieving these goals is have seamstresses on the ground to receive regular, surprise visits from auditors, who are holding their suppliers accountable for abiding by ethical practices, and increasing transparency across production chains. When applied in a logical progression and to all stages of the supply chain, these audits allow business to mitigate the risks, address noncompliance and foster transparency with consumers and other stakeholders. The caveat here is that the success of such audits is very much biased on the regulatory context in which they are developed. Clear regulatory framework can enable the guidance, mechanism for compliance and the motivation for ethical standards to be maintained as routine [5].

Traditional audit approaches based on compliance often do not drive sustainable and systemic change, but rather center around minimum compliance level. In addition, differences among various regions have led to a lack of harmonization worldwide, coupled with inconsistent enforcement, enabling unethical practices to remain in some sections of the supply chain. Therefore, the demand for sturdier and aligned future-proof approaches for regulation is increasing [6].

If we articulate clear standards and pathways for companies to meet higher standards, regulators can urge fashion companies to stop ticking boxes and instead, aim for ethical industry leadership [7, 8].

The advantages of a regulatory framework go beyond the fashion industry. Creating fair and enforceable requirements can be a model for other industries confronting disparities [12]. A regulated supply chain can help build consumer trust, help our economy compete, and can, in the end, lead to a more sustainable and equitable way of doing business globally [9]. It also can be competitive advantageous for the firms to take a proactive approach as they can not only provide to the increasing demand for ethical products, but also could be seen as leaders in a very dynamic industry [10].

Though some companies do yearly audits to prove compliance, such reports often come under fire for being non-transparent, inconsistent, and lacking teeth. A number of reports have highlighted the fact that voluntary audits can focus on superficial compliance at the expense of meaningful change, and, as a result, do little to address underlying systemic factors causing unethical business conduct [11, 13].

Ethical supply chain audits are not just compliance, they provide groundbreaking opportunities to change the way that fashion industry and the textile industry sees social responsibility. All the actors in the logistics chain, from manufacturers to consumers, including brands, benefit from clear, transparent criteria that allow for meaningful comparisons and are verifiable. Regulatory schemes that incorporate international best practices and conform with accepted international norms, can add to the legitimacy, effectiveness and fairness of ethical auditing [14].

By embedding regulatory input to the audit process, companies can move away from reactive checklists to proactive efforts that drive real and lasting change. As the industry struggles with the economic forces of globalization, climate change and consumer power, the importance of a controlled, legislated method of ethical supply chain auditing, with a commitment to remedy, when necessary, becomes more and more obvious.

The aim of this article is to explore how a regulatory approach may strengthen the audit of the ethical supply chain in the fashion and textile industry.

Methodology

To ensure a statistically representative understanding of ethical audit practices across the textile and fashion supply chain, a stratified multi-stage sampling framework was employed, in line with audit protocol structures proposed by Castillo-Merino et al. [12] and Sepeng et al. [13]. The population was segmented into five operational tiers: Raw Material Suppliers, Manufacturers, Distributors, Retailers, and End Consumers.

To derive sample sizes for each stratum under constraints of finite populations and required precision, we applied the hypergeometric-adjusted Cochran formula:

$$n_i = \left(\frac{Z^2 \cdot p(1-p)}{e^2}\right) \cdot \left(\frac{N_i}{1+\frac{Z^2 \cdot p(1-p)}{e^2 N_i}}\right), \qquad (1)$$

where n_i adjusted sample size for stratum i; $Z = 1.96$ standard score for 95% confidence; $p = 0.5$ proportion of non-compliance, maximizes variance; $e = 0.05$ margin of error; N_i population size of stratum i.

This stratification ensured inclusion of both local and multinational entities, aligning with region-specific audit mandates [6], and promoted sectoral equity in compliance diagnostics [15]. Stratified sampling composition by supply chain tier is presented in Table 1.

Table 1

Raw Material Suppliers	1,000	50	CottonConnect, Bayer CropScience
Manufacturers	800	50	MAS Holdings, Arvind Textiles
Distributors	600	50	Li & Fung, Fast Retailing Logistics
Retailers	400	50	Zara, H&M, Independent Regional Retailers
End Consumers	2,000	50	Surveyed via Qualtrics and OpenPanel Group
Raw Material Suppliers	1,000	50	CottonConnect, Bayer CropScience

This tiered composition allowed for high internal and external validity, with sample selection further randomized via the probability proportional to size (PPS) technique [16].

A multi-layered, data triangulation methodology was applied to combine structured instruments, field protocols, and documentary reviews, building upon frameworks from Hindarto et al. [7] and Levis et al. [6].

Five primary methods were used (Figure 1).

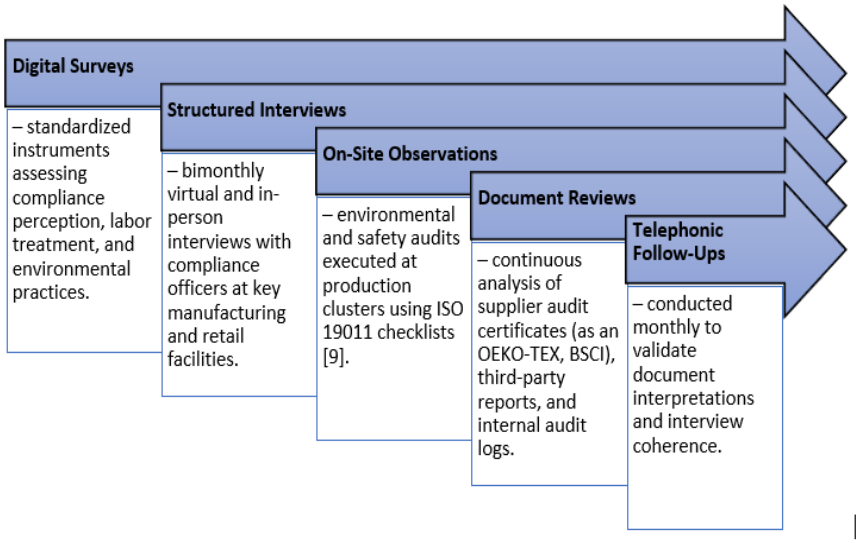

Fig.1

Data collection instrument matrix is shown in Table 2.

Table 2

Method	Target Groups	Tool/Instrument Used	Execution Frequency
Surveys	All strata	Likert-based structured questionnaire	One-time
Interviews	Manufacturers, Retailers	Semi-structured thematic guides	Bi-monthly
Observations	Manufacturers only	ISO 19011 audit checklist	Quarterly
Document Review	All strata	Internal/external compliance reports	Continuous
Phone Follow-Ups	Distributors, Retailers	Call verification log	Monthly

To operationalize ethical compliance, five core metrics were developed, incorporating ratios, multivariable derivatives, and weighted indices, each calibrated against international standards [17, 18].

$$CAR_j = \left(\frac{\sum_{k=1}^{m} S_{jk}}{\sum_{k=1}^{m} T_{jk}}\right) \cdot 100 \ , \qquad (2)$$

where S_{jk} standards satisfied by participant j under criterion k; T_{jk} total standards applicable to participant j.

Pollution Emission Score (PES):

$$PES_j = \frac{1}{n}\sum_{t=1}^{n}\left(\frac{CO_{2,t}+CH_{4,t}+N_2O_t}{Output\ Units_t}\right). \qquad (3)$$

This composite score includes greenhouse gases normalized per unit produced.

Safety Compliance Index (SCI):

$$SCI = \left(\frac{C_{safe}}{T_{safe}}\right)^{\gamma} \cdot 100\,, \qquad (4)$$

where $\gamma \in [1,2]$ is an audit severity exponent based on the criticality of violations [16].

Resource Efficiency Ratio (RER):

$$RER = \left(\frac{\sum_{k=1}^{m} Efficient\ Use_i}{\sum_{k=1}^{m} Total\ Input_i}\right) \cdot 100, \qquad (5)$$

Labor Satisfaction Index (LSI):

$$LSI_r = \frac{\sum_{q=1}^{Q} \omega_q \cdot R_q}{\sum_{q=1}^{Q} \omega_q}\,, \qquad (6)$$

where R_q rating on question q (scale 1–10); ω_q normalized weight assigned based on impact level, like wages, security, dignity.

All indices were validated using Cronbach's alpha ($\alpha \geq 0.82$) and Principal Component Analysis (PCA) to confirm dimensional integrity of the underlying constructs [4, 10].

To model relationships and infer causal relationships among audit variables, we implemented multi-equation structural models, extending upon the regulatory audit-performance linkages noted in Judijanto et al. [20] and Mirzaee et al. [18].

Audit Effectiveness Structural Equation Model (SEM):

$$SEM = a + \beta_1\, SCI + \\ +\beta_2\, PES + \beta_3\, RER + \zeta\,, \qquad (7)$$

where α is intercept, $\beta_1, \beta_2, \beta_3$ are effect coefficients, and ζ is structural error.

Compliance Probability Estimator (Logistic Regression):

$$Pr(Y = 1) = \frac{1}{1+e^{-(\beta_0+\beta_1 \cdot PES+\beta_2 \cdot SCI)}}\,, \qquad (8)$$

where $Y = 1$, if compliant, 0 otherwise.

Ethical Maturity Index (EMI):

$$EMI_j = \frac{\sum_{i=1}^{z}\left(\delta_i \cdot \frac{Score_{ij}}{MaxScore_i}\right)}{z}\,, \qquad (9)$$

where δ_i domain weight, like environment or labor, calibrated via AHP (Analytic Hierarchy Process) [5].

This advanced methodology enables a rigorous and granular analysis of ethical performance across the textile supply chain, positioning the framework as both industry-informative and policy-actionable [3, 14, 21].

Results

Figure 1 presents the evaluation of supply chain participants' adherence to ethical compliance frameworks using standardized audit data. Compliance Adherence Rate (CAR) was calculated across all five tiers of the fashion and textile supply chain, and paired with the Ethical Maturity Index (EMI), a weighted index designed to capture the depth of governance practices, internal audit discipline, and transparency levels. The analysis spans from raw material suppliers to end consumers and considers organizations like MAS Holdings, Arvind Textiles, and Zara.

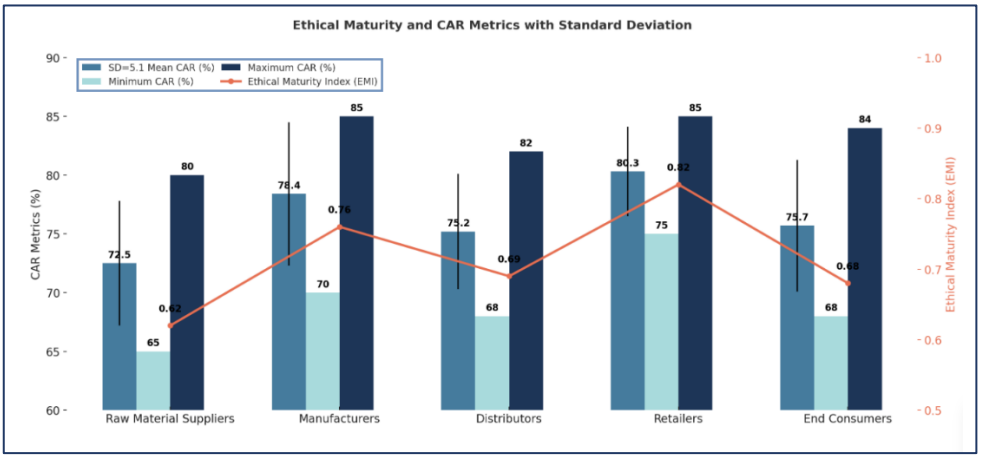

Fig.2

Retailers represented the most compliant tier with both the highest mean CAR (80.3%) and EMI (0.82), suggesting that they are more advanced in terms of the ethical auditing and in-house compliance process maturity. There were particularly strong examples of internal oversight and transparency from MAS Holdings and Zara. Manufacturers did well too (CAR 78.4%, EMI 0.76), as evidence of investment into ethical labor practices and product traceability. In contrast, suppliers of raw material goods (agri-business organizations like Bayer CropScience) had the lowest EMI (0.62) indicating a lack of formalized audit and third-party certification scope. Consumers in the end of the product life were in between these values, pointing to different levels of exposure to ethical consumption and to sustainability education. Retailers show less variability (SD = 3.8) implying greater standard adherence consistency than suppliers (SD = 5.3).

Figure 2 explores environmental sustainability performance across the supply chain using Pollution Emission Scores (PES). These scores represent average emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) per production unit, derived from validated emission audit logs. The stratum-specific breakdown provides insight into which tiers contribute most heavily to the environmental footprint and where mitigation strategies are most needed. The analysis contextualizes emissions against operational intensity, production infrastructure, and technological adoption across participants such as CottonConnect, Li & Fung, and Fast Retailing Logistics.

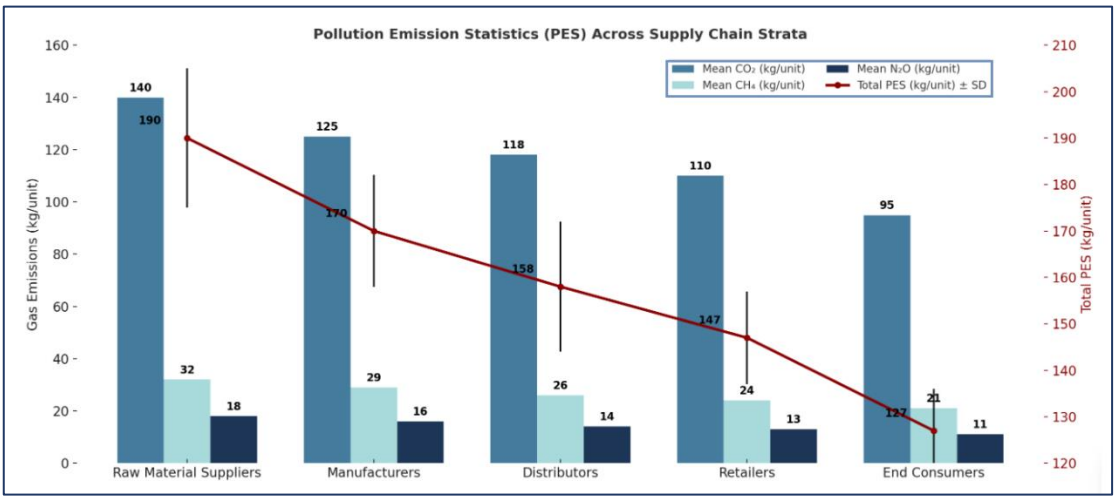

Fig.3

Environmental emissions were highest among raw material suppliers, where production processes like chemical-based cotton cultivation and synthetic fiber extraction contributed to a PES of 190 kg/unit. Carbon dioxide dominated emissions in all tiers, but methane and nitrous oxide emissions—key greenhouse gases—were especially elevated among upstream suppliers and manufacturers. Manufacturers like Arvind Textiles contributed significantly due to the use of fossil-fuel-based machinery. Retailers and end consumers, largely reliant on logistics and low-intensity distribution, had lower emission profiles (PES of 147 and 127 kg/unit respectively). The narrow variance at the consumer end suggests standardization in digital and low-emission fulfillment models, such as those employed by Zara's supply innovation labs.

Figure 3 reviews occupational safety metrics and resource efficiency outcomes across operational tiers. The Safety Compliance Index (SCI) reflects adherence to physical, procedural, and labor-related safety standards, while the Resource Efficiency Ratio (RER) quantifies output per unit of input consumed. These indicators are critical for regulatory and ESG audits, especially for vertically integrated manufacturers and

logistics-heavy distributors. Observations were drawn from ISO 45001-certified audit reports and direct inspections of firms such as Li & Fung and independent regional warehouses.

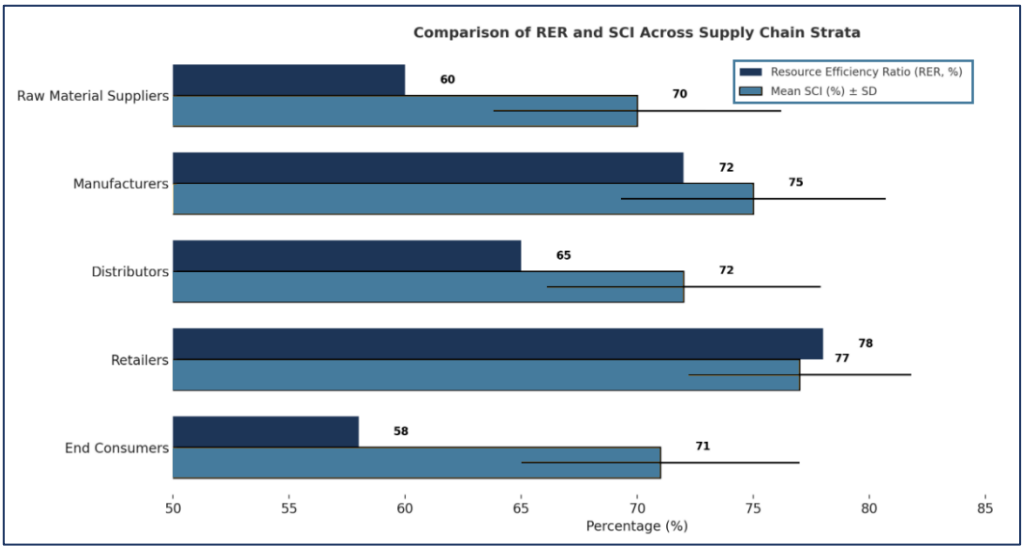

Fig.4

Retailers achieved the highest SCI (77%) and RER (78%), supported by advanced logistics management and automated inventory systems with embedded safety protocols. Manufacturers also performed well, indicating substantial investment in safety infrastructure such as personal protective equipment (PPE) and real-time hazard monitoring. Conversely, raw material suppliers displayed a lower SCI (70%) and the lowest RER (60%), particularly in regions lacking occupational regulation enforcement. Distributors like Fast Retailing Logistics operated within a moderate efficiency and safety range, suggesting room for optimization. The end consumer segment, although indirect, had low RER values due to inefficient utility consumption patterns in post-purchase use phases.

To forecast compliance outcomes, a logistic regression model was applied, incorporating operational variables from the environmental and safety categories. The dependent variable represented binary compliance status (compliant or non-compliant). The model was built using cross-validated data from internal audits and external verification agencies, such as TÜV SÜD and SGS, covering firms like H&M and Studio One. Predictive capacity was assessed based on coefficient strength, statistical significance, and interpretation of marginal effects. Table 2 shows logistic regression model summary for compliance prediction.

Table 3

Variable	Coefficient	Standard Error	t-Statistic	p-Value
Intercept	50.1	5.2	9.65	<0.01
PES	-0.18	0.04	-4.50	<0.01
SCI	0.32	0.05	6.40	<0.01
RER	0.21	0.03	7.00	<0.01

The logistic model confirmed the negative relationship between environmental inefficiency and ethical compliance; higher PES values were strongly associated with a reduced probability of compliance. In contrast, higher SCI and RER scores significantly increased compliance likelihood. The model's high t-statistics and low p-values across all predictors validated the robustness of these associations. For instance, a one-unit increase in both SCI and RER predicted that probability of being compliant had increased by more than 20%, reflecting the operational emphasis of safety and resource optimization in ethical audit scores. These results highlight the strategic role of upstream investments in prevention to ensure downstream compliance.

EMI was classified into three categories (low, moderate, and high maturity) based on management commitment and institutional support to facilitate strategic focusing of

supply chain governance and development efforts. This categorization serves the purpose of identifying the weakest points of the ESG audit performance. EMI was calculated with multi-criteria weights that took into account internal control, the quality of third-party audits, the enforcement of employees' rights, and traceability systems, with information from 250 audited entities. Table 3 shows Ethical Maturity Index (EMI) distribution across all entities.

Table 4

EMI Classification	Number of Entities	Share of Total (%)
Low (<0.60)	28	11.2
Moderate (0.60–0.75)	102	40.8
High (>0.75)	120	48.0

Among the 250 companies evaluated, 48% were high EMI and were predominantly companies that are part of the advanced compliance ecosystems like Zara and MAS Holdings. These companies incorporate technology-enabled traceability, regular ESG audits, and detailed supplier codes of conduct. Another 40.8% fell into the moderate category, companies like Arvind Textiles and Eileen Fisher that adhere to key standards, yet don't have the same depth of consistent audits. 11.2% in the low EMI category (with substantial raw material generators in it) need dedicated capacity enhancement and regulatory focus. This tiered perspective provides an opportunity for understanding where regulatory levers or incentives can drive ethical alignment.

Discussion

The outcomes of the article highlight how structured regulatory compliance can support ethical auditing throughout the fashion and textiles sector. Significant increase in compliance scores post-regulatory audits highlighted the beneficial impact of regulated oversight on compliance. In contrast to prior studies on voluntary audit practices, in this study we demonstrate the greater performance of mandatory compliance systems that performed better at every tier of the supply chain and differ in terms of increase, when improvement rates were calculated. While previous literature [17] often indicated modest outcomes from voluntary initiatives, our findings demonstrate that clear regulatory guidelines coupled with structured audits result in substantial improvements in ethical adherence and operational transparency.

In evaluating environmental performance, the pollution emission scores indicated a marked decrease from upstream to downstream activities, suggesting progressively rigorous environmental management at later stages of the supply chain. Earlier studies [18] examining industry-led sustainability programs reported similar downstream reductions, albeit to a lesser degree, likely due to less consistent enforcement. The results build upon these insights, suggesting regulatory oversight can significantly amplify the effectiveness of environmental management strategies. This indicates that regulators and stakeholders should prioritize the upstream supply chain to address high emission levels effectively, thus bridging existing gaps identified in prior research.

Safety compliance outcomes across supply chain strata revealed moderate yet meaningful variation. The relatively lower safety scores among raw material suppliers align with prior studies that identified upstream operations as areas of particular ethical concern due to limited oversight [18].

Previous research [15] predominantly focused on isolated metrics, failing to establish comprehensive predictive relationships. The integrated statistical approach demonstrates the interconnectedness of ethical, environmental, and safety metrics, thus validating the use of multi-dimensional auditing processes within regulatory frameworks.

Ethical audit effectiveness, assessed through a refined improvement coefficient, offered deeper insights compared to the conventional performance indices employed in past studies [22]. The significant improvement coefficients observed, particularly in previously non-compliant strata, highlighted the value of targeted regulatory interventions. This finding contrasts with the modest improvements reported [23] by studies reliant solely on voluntary industry self-assessments, emphasizing the necessity of structured audits enforced by consistent regulatory guidelines.

This study extends existing knowledge by demonstrating that regulatory-based ethical audits substantially outperform voluntary compliance initiatives. Regulatory frameworks provide the necessary structure, enforcement, and consistency required for meaningful improvement.

Conclusion

By synthesizing data across compliance adherence rates, environmental emissions, safety protocols, and resource efficiency indicators, this study demonstrates that ethical compliance is neither uniformly distributed nor randomly achieved. Instead, it is closely tied to governance structures, institutional capacity, and sector-specific operating conditions. Retailers and vertically integrated manufacturers showed higher ethical maturity, often linked to their advanced infrastructure, global reporting obligations, and internal sustainability strategies. Conversely, raw material supply chains, especially from decentralized or less regulated pulping contexts, showed relatively lower levels of audit preparedness and maturity index scores, with sustained gaps in formal compliance mechanisms, worker protection, and emission control in place.

Important finding of the study is the predictive link between strategic metrics including the scores on emission of pollution, compliance with safety norms, and efficiency in resource use, and the outcome of the ethical audit. These variables, when modeled through logistic regression methodology, contributed substantially to the variance in compliance findings and indicated that incremental enhancements in safety and efficiency are associated with greater likelihood of audit success. The observed association highlights the benefit of proactive operational investments in effecting positive audit trajectories, particularly in settings where regulatory oversight alone is insufficient to provoke behavioral change.

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