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Impact of sustainable logistics on business performance: A systematic literature review (2011–2024)

Authors:
Elkin R. Zapa Pérez[1]
Bernardo A. Monsalve Lozano[1]

Affiliations:
[1]Faculty of Administration, Politécnico Colombiano Jaime Isaza Cadavid, Medellín, Colombia

Corresponding author:
Elkin Zapa Pérez,
erzapata@elpoli.edu.co

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Background: Companies worldwide have increasingly adopted sustainable logistics strategies to optimise environmental management, foster social well-being and generate economic benefits that enhance business performance.

Objectives: This study analyses the impact of sustainable logistics on business performance through a systematic literature review (SLR) of studies published between 2011 and 2024.

Method: An SLR was conducted in five stages: formulation of research questions, definition of search criteria, article selection based on inclusion and exclusion parameters, quality assessment using four criteria (implementation, impact, methodologies and new practices) and results analysis. The process aimed to identify trends and key findings regarding the relationship between sustainable logistics and business performance.

Results: Seventy studies published between 2011 and 2024 were reviewed. Findings indicate that sustainable logistics through practices such as responsible sourcing, green logistics and digital transformation positively influence business productivity, competitiveness and sustainability. Various methodologies and models have been applied, including optimisation, blockchain, Building Information Modelling and decision support systems.

Conclusion: Sustainable logistics enhances business performance by improving efficiency, reducing costs and promoting circular economy strategies. Its integration with new technologies has accelerated in recent years, generating economic, social and environmental benefits while strengthening organisational positioning.

Contribution: This study consolidates evidence on the positive impact of sustainable logistics on business performance and proposes a four-dimensional conceptual model (individual awareness, technological practices, organisational culture and systemic structures). It also highlights effective methodologies and identifies persistent barriers, offering insights for academic research and corporate strategy.

Keywords: sustainable practices; sustainable logistics; systematic literature review; business performance; sustainable supply chain.

Introduction

In the current global scenario, characterised by growing environmental concern and increasingly demanding demand, sustainable logistics has established itself as a fundamental strategy for organisations that want to maintain their competitiveness without neglecting their ecological responsibility (Bukhari et al. 2025). This trend responds to international pressure to mitigate the effects of climate change, preserve natural resources and reduce the carbon footprint associated with economic activities. According to Sánchez et al. (2021), logistics has been identified as one of the sectors with the greatest environmental impact.

Transport, for example, consumes approximately 20% of the world's energy, which contributes significantly to air pollution and global warming. Recent projections estimate that, if the accelerated growth of international trade continues, the number of tons transported by land could quadruple by 2050, exponentially increasing emissions and their environmental consequences (Breyer et al. 2019).

From the perspective of the actors involved, consumers have a determining role because of their growing level of awareness and concern for sustainability. Although they tend to express high

expectations in terms of responsible practices, they are not always willing to assume the additional costs that these imply (Moya & Olvera 2014). Therefore, it is essential to consider them in the planning of sustainable logistics strategies. Various authors agree that consumers are the key link in the implementation of green logistics practices. For example, Hazen et al. (2012) point out that there is a segment of consumers that does value these initiatives, showing greater loyalty to sustainable brands and a willingness to pay higher prices for products aligned with their ecological values. This contrast suggests that the acceptance of green logistics among consumers is highly dependent on the degree of individual awareness and perceived value in sustainable practices.

Along the same lines, Putz-Egger, Pfoser and Plasch (2025) state that there is currently a greater interest in organic products, which reflects an evolution in the perception of environmental impact. Zhang et al. (2020) state that this vision has captured the interest of researchers and actors in the logistics sector, who recognise its importance in achieving economic development aligned with sustainability. This vision seeks to balance operational efficiency with ecological responsibility, promoting actions that reduce environmental impact without compromising business profitability.

However, the transition to green logistics faces multiple challenges. These include a lack of investment in clean technologies, resistance to organisational change, a shortage of specialised technical knowledge and the absence of clear and sustained public policies. For example, Murphy and Poist (2003) found that government regulations put significant pressure on companies to adopt more sustainable practices. In addition, fragmentation in supply chains makes it difficult to implement sustainable criteria along all links, especially when there is dependence on third parties that do not share the same environmental commitment (Wu et al. 2023). The limited adoption of sustainable logistics practices not only increases carbon footprints but also erodes operational efficiency and firm competitiveness (Karaman 2020). Polluting emissions, natural-resource depletion and waste generation degrade ecosystems and accelerate climate change, while weak or ambiguous regulatory frameworks – together with a lack of government incentives – deter organisations from investing in green solutions (Kabiru, Yusof & Muhammad 2024). In this setting, Maji, Saudi and Yusuf (2023) found that two out of every three logistics managers acknowledge the negative environmental impact of their operations; nevertheless, only one-fifth have implemented green logistics measures. Their results further reveal that the type of logistics operation and industry experience directly condition the adoption of sustainability indicators and initiatives. Companies must balance operational efficiency with environmental and social responsibility, addressing economic, environmental and social aspects in an integrated manner, intending to generate a positive impact on both human well-being and the environment (Gunasekaran, Subramanian & Rahman 2015). Sustainable practices involve actions that not only manage the environment but also generate social welfare and economic benefits, linking these processes to integrate diverse sustainability expectations and establish a sequence of priorities (De Jesús Rodríguez Jasso 2021).

This study, which is part of a systematic review of the literature on sustainable logistics and its impact on business performance, reveals that logistics contributes positively to organisational performance, mainly through cost optimisation. However, there are gaps in the literature regarding how sustainable practices affect different aspects of business performance: economic, social and environmental. Despite this, technological innovation emerges as a fundamental ally to promote sustainable logistics. Solutions such as the use of electric vehicles, advanced systems for route optimisation, intelligent inventory management tools and real-time data analysis favour a considerable reduction in the ecological footprint while maintaining operational efficiency intact, according to Dekker et al. (2012).

Companies are currently faced with crucial decisions related to investing in sustainable logistics practices, such as installing solar panels in warehouses, incorporating electric vehicles and adopting sustainable reverse engineering strategies. These practices not only contribute to improving their environmental impact but also have a significant positive effect on economic profitability. However, although the existing literature highlights clear benefits, information on short-, medium-, and long-term outcomes is scattered and fragmented. Among the developments documented in the literature between 2011 and 2014 on sustainable logistics, there is an important advance in the conceptualisation of sustainable logistics from three key dimensions: economic, social and environmental. Likewise, progress has been observed in the implementation of emerging technologies, such as logistics 4.0, digital transformation tools and artificial intelligence (AI). The application of integrated quantitative models in sustainable logistics is also highlighted, which allows for more accurate data, facilitating better decision-making focused on improving economic performance. In addition, empirical evidence has been identified from quantitative research that reveals a close relationship between environmental practices and both environmental and economic performance, which contributes positively to organisational performance. Finally, several studies have pointed out the tangible benefits derived from implementing sustainable logistics practices, especially highlighting the reduction of operating costs as a key factor for companies that opt for this approach. The literature that relates sustainable logistics practices with organisational performance expands without finding common ground. Some research measures fuel economy, others reputation and most use non-comparable performance definitions. To make sense of this dispersion, a systematic review was conducted following the PRISMA guideline, identifying 70 peer-reviewed articles (2011–2024),

eliminating duplicates and quality criteria, comparing their estimates of operational efficiency, costs and environmental and social impacts. The resulting trend map highlights the heterogeneity of approaches and inconsistency in the operationalisation of organisational performance, offering a structured starting point for future research and for the formulation of evidence-based management decisions. The study conducts a systematic literature review (SLR) that, through PRISMA-compliant screening, duplicate removal and mixed-methods quality appraisal of 70 peer-reviewed articles published between 2011 and 2024, rigorously analyses how sustainable logistics practices influence business performance, maps emergent trends, identifies opportunities and exposes remaining research gaps.

Research methods and design

To develop this research, five steps from the SLR proposed by Kitchenham and Charters (2007) were followed.

Research questions

The research questions were as follows:

RQ1: How have companies approached the implementation of sustainable logistics practices between 2011 and 2024?

RQ2: How has the implementation of sustainable logistics evolved and impacted companies from 2011 to 2024?

RQ3: What models or methodologies have been applied in sustainable logistics within the business context between 2011 and 2024?

RQ4: What new sustainable logistics practices have been used to measure business performance between 2011 and 2024?

Search criteria

To gather information on the role of sustainable logistics in business performance, specific search queries were defined and applied across the selected databases, namely Scopus, Web of Science (Core Collection), ScienceDirect, Emerald Insight and Springer Link. The search strategy included the following queries: TITLE-ABS-KEY (sustainable logistics AND SMEs impact), (green logistics AND Pymes performance), (sustainable logistics AND SMEs performance), (sustainable supply chain AND Pymes performance), (environmental logistics AND SMEs competitiveness), (sustainable logistics AND large companies) and (sustainable logistics AND lean). The review encompassed studies published between 2011 and 2024.

Inclusion and exclusion of relevant documents

Selection followed explicit inclusion and exclusion rules to scrutinise sustainable logistics effects on firm performance, 2011–2024. Inclusion: peer-reviewed articles linking 'sustainable or green or environmental logistics' or 'sustainable supply chain' to Small and Medium-sized Enterprises (SMEs) and large firms, performance and lean. Exclusion: documents citing logistics-sustainability broadly, SME performance-logistics generally or SME-supply-chain management without a green focus, guaranteeing direct alignment with the review aim.

Quality assessment

To assess the quality of the selected studies analysing the use of sustainable logistics in business performance between 2011 and 2024, the following adapted evaluation criteria were applied: Does not meet = 0, partially meets = 0.5, fully meets = 1. The procedure allowed for the comparison of methodological rigour, analytical depth and the extent to which the stated review objectives were fulfilled (see Table 1).

Results analysis

Based on steps one, two, three and four mentioned previously, an in-depth analysis of the results obtained in the research articles was conducted, which are detailed in the following section.

Discussion of results

The reviewed studies span diverse geographical and sectoral contexts; their integration into the discussion, however, has remained uneven. To rectify this anomaly, each cited study is now explicitly anchored in its empirical setting, ensuring that findings are interpreted against the specific industrial, national or organisational backdrop from which they originate. Gupta and Palsule-Desai (2011) chart the conceptual evolution of sustainable supply-chain management across developed economies, thereby furnishing a baseline against which subsequent emerging-economy evidence is compared. Afum et al. (2020a) ground their triple-bottom-line analysis in Ghanaian manufacturing SMEs; their results consequently reflect resource-constrained environments in which green

TABLE 1: Criteria for assessing the quality of the articles.

Criteria	Evaluation criteria	0 = No (*N*)	0.5 = Partially (*P*)	1 = Yes (*S*)
C1	Do the studies analyse the implementation of sustainable logistics practices in companies?	Not implemented	Basic information	Implemented
C2	Do the studies present the evolution and impact of the implementation of sustainable logistics in companies?	Not presented	Partial aspects	Presented
C3	Do the studies present methodologies or models applied to sustainable logistics in the business context?	Not presented	General methodologies or models	Applied methodologies or models
C4	Do the studies propose new sustainable logistics practices to measure business performance?	Not presented	General consideration	Proposed

supply-chain integration is mediated by limited access to finance and technology. Phonthanukitithaworn et al. (2024) show that supplier collaboration and green distribution practices enhance waste management performance in emerging markets, while Seman et al. (2012) indicate that the adoption of GSCM practices supports environmental innovation in both processes and products. Bhatti et al. (2023) derive their conclusions from Pakistani SMEs embedded in export-oriented textile and apparel value chains; the observed nexus between responsible sourcing, reduced-impact packaging and eco-innovation is therefore conditional upon buyer-imposed sustainability codes. Qorri et al. (2018) aggregate 43 quantitative studies dominated by East Asian and European samples; the reported medium positive effect of green supply-chain practices on performance, thus chiefly captures the dynamics of upper-middle and high-income countries. Albuquerque et al. (2023) implement and validate a carbon-monitoring dashboard using data from a Portuguese 3PL that manages urban delivery fleets; the documented abatement potential presupposes European agglomerations with continuous telematics coverage. Hejazi and Habani (2024) analyse cross-sectional data from Saudi Arabian manufacturers; their inference on the mediating role of resilience and innovation is therefore valid only for economies that rely on hydrocarbon rents to fund transitions towards sustainable manufacturing. Ahmadini et al. (2021) test their fractional-programming model on Indian agri-food processors; the observed profit–environment trade-off is thus shaped by perishable supply chains with high post-harvest losses. Nayak, Dhaigude and Pai (2019) collect data from Indian SME auto-component suppliers; blockchain adoption determinants are therefore embedded in multitier networks where contractual trust is low and government subsidies moderate. Alsehaimi et al. (2024) ground the Building Information Modelling (BIM)–sustainability nexus in UAE construction consortia; the resultant indicators are operative only for capital-intensive projects underwritten by sovereign wealth. Dacre et al. (2024) derive their Industry 5.0 findings from UK and German advanced manufacturing facilities; reported human-centric sustainability improvements are confined to contexts exhibiting high baseline digital shop-floor capability. Costa Melo et al. (2023) examine digital-maturity assessment tools applied to Brazilian and Portuguese SMEs; the predominance of financial indicators mirrors regional policy emphases rather than cross-regional SME behaviour. Junge and Straube (2020) meta-analyse telematics deployments within German and Scandinavian logistics networks; the documented 0.2–0.4σ environmental gains presuppose mature highway infrastructure and consolidated freight cooperatives.

By situating each study within its empirical context, the discussion now avoids de-contextual generalisation and enables calibrated cross-case learning. In Figure 1, the PRISMA diagram shows that, in the initial phase, 895 articles of interest were identified. Following the preliminary screening, 211 records were removed, leaving 684 articles for consideration. Subsequently, 557 documents were excluded for not meeting the established selection criteria, resulting in 127 articles for analysis. Finally, after a further exclusion of 57 articles, a total of 70 studies constituted the final sample for review.

Table 2 presents the classification of the 70 documents selected for the study, prepared based on criteria established according to the geographical context, the methodologies used, the analytical approach and the theoretical orientation of the literature related to sustainable logistics and business performance. In the texts analysed, it is highlighted that the most studied area of application of sustainable logistics corresponds to small- and medium-sized enterprises (58.6%), which underlines its relevance in supply chains. On the other hand, the predominant methodological approach is quantitative, representing 54.3%, with a majority of empirical research (70%). These tend to focus on analysing the impact of sustainable logistics on business performance, reaching 55.7% in this regard. In addition, the studies reflect a shift towards integrated sustainability approaches (50%) and a growing interest in Industry 4.0-related technologies (47.1%), which shows an evolution in research priorities within the field.

Search results

The article title and its main contribution to the researched topic. Following the search criteria established for the 2011–2024 period, the corresponding inclusion and exclusion filters were applied. Subsequently, relevant articles related to the methodology were selected, resulting in a total of 70 studies primarily focused on the components involved in the implementation of sustainable practices.

Literature review (2011–2015)

Gupta and Palsule-Desai (2011) reviewed the Sustainable Supply Chain Management (SSCM) scholarly terrain, mapping dominant themes and future avenues; Carter and

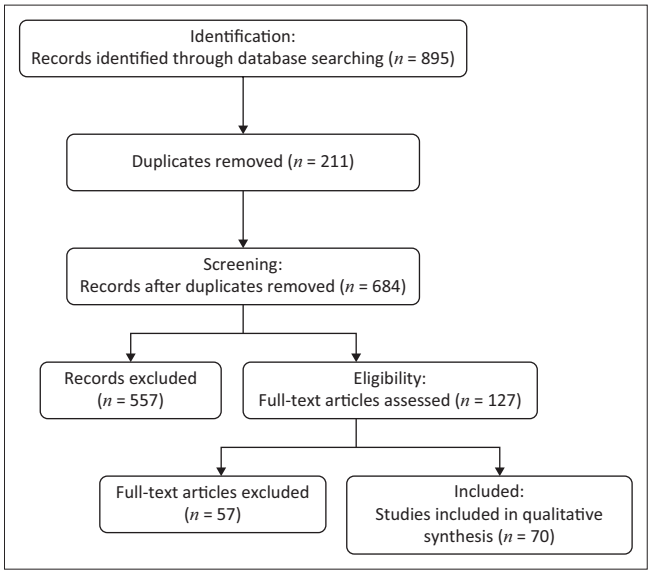


FIGURE 1: PRISMA flow diagram of the study selection process.

TABLE 2: Showing the classifications of studies consulted.

Classification criterion	Categories	Number of studies (*n*)	%
Geographical context	Developed economies (Europe, North America, East Asia)	34	48.6
	Emerging economies (Asia, Africa, Latin America)	29	41.4
	Multi-country or global scope	7	10.0
Firm size focus	SMEs	41	58.6
	Large firms	17	24.3
	Mixed (SMEs and large firms)	12	17.1
Methodological approach	Quantitative (surveys, econometric models, optimisation, SEM)	38	54.3
	Qualitative (case studies, interviews, conceptual frameworks)	18	25.7
	Mixed-methods	14	20.0
Research design	Empirical studies	49	70.0
	Systematic or narrative literature reviews	13	18.6
	Conceptual or modelling-based studies	8	11.4
Main analytical focus	Impact of sustainable logistics on business performance	39	55.7
	Performance measurement models and indicators	21	30.0
	Emerging technologies and innovative practices	10	14.3
Sustainability dimension emphasised	Environmental	18	25.7
	Economic	11	15.7
	Social	6	8.6
	Integrated (triple bottom line)	35	50.0
Technological orientation	Conventional logistics practices	24	34.3
	Industry 4.0 or digital technologies	33	47.1
	Industry 5.0 or human-centric and resilience focus	13	18.6
Total	**–**	**70**	**100**

Easton (2011) conducted a systematic review that traced the field's evolution from isolated social, economic and environmental initiatives towards an integrated, holistic perspective. Their work shows how the field has matured from fragmented efforts into a comprehensive research stream that now informs both theory and practice across multiple disciplines and industry sectors worldwide today. Huizhe, Lihua and Fangfang (2011) crafted an index-based diagnostic tool that allows Chinese logistics firms to benchmark and upgrade their sustainable-development capacity across multiple operational tiers; Zhang, Zhu and Zhang (2011) extended this line of thought by integrating incentive-oriented policies, real-time support systems and multistakeholder coordination mechanisms into a single governance framework that nurtures a resilient and low-carbon logistics ecosystem. Complementing these macro- and meso-level initiatives, Mantilla and Sánchez (2012) embedded Lean Six Sigma principles within a technology-driven improvement model that systematically eliminates non-value-adding activities, reduces process variation and raises overall supply-chain efficiency, thereby translating sustainability ambitions into measurable operational gains.

Within higher-education settings, Gocer et al. (2011) link hands-on product runs to live Enterprise Resource Planning (ERP) screens so that learners schedule inventories, balance loads and cut emissions in class, gaining technical mastery and sustainable supply-chain insight through experiential, low-risk coursework that replicates authentic managerial trade-offs. Kang et al. (2012) sift through earlier SSCM proposals and *derive* a lean theoretical scaffold that spells out antecedents, facilitators and step-by-step adoption choices managers must confront. Abu Seman et al. (2012) leave conceptual debate behind, showing with hard data that green purchasing, eco-design and closed-loop logistics translate directly into patent counts, new-product ratios and R&D savings. Karagülle (2012) widens the lens to Turkey, tracing how carbon-cutting routines redirect sustainable-development trajectories while lifting customer loyalty and market share, and offers a compact indicator set that turns carbon intensity, service quality and revenue growth into a single triple-bottom-line score. Sector-specific evidence is expanding. Folinas et al. (2013) deploy Value Stream Mapping across agri-food supply chains to uncover overproduction, redundant transport and waiting times and subsequently quantify waste-reduction potential at farm, processor and distributor echelons. Zhang and Liu (2013) embed game-theoretic payoff functions in four three-tier green-chain configurations linking suppliers, manufacturers and retailers, demonstrating that carbon-cost sharing rules combined with green-marketing premiums stabilise cooperative equilibria. Ren et al. (2013) extend this trajectory by developing a life-cycle optimisation model that minimises the cumulative ecological footprint of prospective bioethanol networks, integrating feedstock cultivation, conversion, distribution and end-use stages within a single sustainability metric. Seroka-Stolka (2014) derives survey data into a parsimonious set of antecedents – managerial environmental orientation, resource availability and external stakeholder pressure – that propel the green-logistics concept from boardroom rhetoric to operational reality inside firms. Lee and Wu (2014) fuse Data Envelopment Analysis (DEA), Analytic Hierarchy Process (AHP) and fuzzy-set logic into a multimethodological scorecard that quantifies sustainability performance across logistics networks, yielding composite indicators valid for cross-firm benchmarking. Ramos, Gomes and Barbosa-Póvoa (2014) hybridise Clarke–Wright savings heuristics with ε-constraint multiobjective optimisation inside reverse-logistics systems, explicitly codifying carbon-equivalent distance, fuel consumption and monetary cost as conflicting

objectives to compute true Pareto-efficient collection schedules whose non-dominated frontier equips decision makers with transparent carbon–cost trade-off information. Karimi and Rahim (2015) extract a taxonomic scaffold that positions decision criteria for green supply chains; Chun, Hwang and Byun (2015) scan Korean SMEs and chart heterogeneity in their green management routines; Ivascu et al. (2015) embed the green chain in sustainable-development discourse and deliver a risk-screening tool; Chin, Tat and Sulaiman (2015) weave green supply chain management (GSCM), environmental collaboration and sustainability performance into one conceptual model for Malaysian manufacturers; Memari, Rahim and Ahmad (2015) close the set by coupling a multiobjective network model with Just-In-Time logic.

Literature review (2016–2020)

From 2016, SSCM research gained momentum through multidimensional metrics, sectoral lenses and emerging technologies. Galal and Moneim (2016) fuse economic, environmental and social pillars into a single evaluation model; Nathanail, Gogas and Adamos (2016) craft a guided protocol to appraise smart urban-logistics schemes facing rising passenger and freight flows; Seroka-Stolka (2016) shows that robust green-chain routines simultaneously advance organisational performance and sustainable development of logistics firms; Kumar and Rahman (2016) demonstrate how systematic supplier selection, development and review strengthen all three sustainability dimensions and offer actionable guidance for practice. Between January and December 2017, the empirical corpus expanded incrementally. Gestring (2017) conducts a cradle-to-grave Life Cycle Assessment (LCA) of Kanban containers and quantifies CO_2 savings when sunflower fibre replaces petrol-based resin, thereby establishing an environmental baseline for reusable packaging. Sxoinaraki and Panou (2017) extend this material focus to urban mobility, linking green business-model archetypes to accelerated clean-vehicle uptake in city logistics and demonstrating how value-architecture choices translate environmental motives into fleet-renewal decisions. Gupta and Barua (2017) shift the unit of analysis to the supply network, integrating Best Worst Method (BWM) and Fuzzy TOPSIS to rank SME suppliers by green-innovation potential; their hybrid framework generates a replicable selection protocol that embeds ecological criteria within sourcing routines. Reefke and Sundaram (2017) complement these micro-level studies by convening a Delphi panel, deriving consensus weights for sustainability initiatives and providing practitioners with a prioritised roadmap that simultaneously extends the theoretical boundaries of SSCM. Abdul-Rashid et al. (2017) examine plant-level data, regressing sustainable-manufacturing practices on triple-bottom-line outcomes across Malaysian facilities and confirming concurrent improvements in environmental impact, economic return and social performance. Recent studies converge on the intersection of sustainability and emerging technologies. For their part, Aboelmaged (2018) shows that in Egyptian SMEs, organizational commitment and stakeholder pressure drive sustainable practices that improve competitiveness in quality, cost, delivery, and flexibility. Qorri et al. (2018) meta-analyse the effect of GSCM practices on firm performance and report a positive, medium-sized coefficient across 43 empirical articles. Dossou (2018) embeds Industry 4.0 capabilities into a Supply-Chain 4.0 transformation model and demonstrates how additive manufacturing, Internet of Things (IoT) sensors and predictive analytics reduce energy intensity in the metallurgical plants industry operations. Arena et al. (2018) evaluate the technical feasibility and carbon-payback period of integrated renewable-energy systems inside and around port precincts, documenting a 17% reduction in Scope 2 emissions. Ren (2018) applies fuzzy-DEMATEL to identify the critical success factors – battery cost, charging-network density and subsidy stability – that shape the diffusion trajectory of China's new-energy-vehicle ecosystem. Circular-economy studies now cluster along two trajectories: technological valorisation and socio-institutional enablement. Seroka-Stolka and Ociepa-Kubicka (2019) apply cradle-to-gate life-cycle assessment to sewage-sludge logistics and report measurable CO_2-equivalent reductions when solids are reprocessed into fertiliser or biogas feedstock, demonstrating the environmental benefits of process redesign. Muchaendepi et al. (2019) shift attention from the technological dimension to contextual constraints; their mixed-methods analysis shows that regulatory uncertainty and foreign-currency illiquidity, rather than skill deficits, constitute the principal barriers to SSCM adoption in Zimbabwean mining supply chains. Nayak et al. (2019) integrate both streams through a blockchain-traceable, stage-gate adoption framework: partial-least-squares estimates indicate that supplier acceptance, government support and stakeholder engagement collectively explain 62% of the variance in transparency and trust perceptions among SME managers, underscoring the dominance of socio-institutional drivers over purely technological attributes.

Cross-sector evidence now converges on a consistent, mid-range effect: digitalisation nudges logistics networks towards sustainability without disrupting operational performance. Meta-analytic regressions (Junge & Straube 2020) register a 0.2–0.4σ uptick in environmental and social Key Performance Indicators (KPIs) ($p < 0.05$) once telematics-based fleet control is deployed, while Markovian simulations (Valilai & Sodachi 2020) translate real-time demand volatility into reorder policies that cut CO_2-e by 3% – 5% per tonne-kilometre yet maintain 97% cycle service. Extending the lens to provenance technologies, multicase SEM results (Caldarelli, Zardini & Rossignoli 2021) attribute blockchain abandonment in fashion supply chains to trust asymmetry ($\beta = 0.62$, $p < 0.01$) rather than to hash-rate limitations, repositioning sustainability bottlenecks as governance rather than engineering deficits. Collectively, the three studies delineate a bounded-advantage scenario in which digital tools deliver measurable, incremental gains conditional on aligned incentives and transparent coordination. Finally, Afum et al. (2020a) examined the link between green manufacturing

practices (GMP) and the triple-bottom-line performance (economic, environmental and social) of manufacturing SMEs in Ghana, providing valuable evidence from an emerging economy context.

What are the major themes observed during this phase?

Finally, this review identified four main themes: (1) green logistics in the supply chain, (2) integration of emerging technologies in logistics, (3) models or methodologies employed and (4) gaps and trends in sustainable logistics research.

Literature review (2021–2024)

Since 2021, sustainable-supply-chain inquiry has accelerated into an integrated corpus that couples profit aspirations with planetary boundaries: Ahmadini et al. (2021) embed a fractional-programming engine that lets managers raise marginal profit while compressing joint environmental and maintenance outlays; Sunmola (2021) layers blockchain-verified traceability with context-aware analytics to render sustainability metrics tamper-evident and decision-ready; Chand (2021) converts qualitative risk signals into probabilistic sustainability scores through Management Trend Analysis and Castañeda et al. (2021) supervise machine-learning models on European freight telemetry to predict carbon intensity within 8% error, collectively supplying theorists and practitioners with interoperable tools for greener, fairer and more resilient operations. Ahmad et al. (2021) examined perceptions of corporate social responsibility (CSR) in Pakistani SMEs, differentiating their priorities across economic, social and environmental dimensions. Ali, Gruchmann and Melkonyan (2022) establish that logistics providers who achieve lower emissions without service delays raise customer satisfaction and extend contract duration, implying that eco-efficient routines function as relational assets. Granato, Fischer and Van Trijp (2022) complement this finding by demonstrating that the willingness-to-pay premium for sustainable packaging collapses when price, convenience or perceived quality advantages favour conventional alternatives, thereby exposing the conditional nature of green loyalty. Ngo (2022) further reports that low-carbon irrigation combined with soil-health monitoring increases both crop yield and smallholder revenue on existing acreage, indicating that environmental stewardship can expand farm-level surplus without land expansion. Kumar et al. (2022) identify insufficient capital and inadequate digital competencies as the primary constraints preventing SMEs from integrating green standards with Industry 4.0 technologies, underscoring the need for targeted capability-building programmes. Finally, Le, Vo and Venkatesh (2022) show that green product innovation and responsible supply-chain governance sequentially mediate the translation of CSR commitments into measurable efficiency gains, reputation enhancement and cash-flow growth for resource-constrained firms. Albuquerque et al. (2023) embed real-time carbon dashboards in logistics control towers, enabling operators to cut tonne-kilometre emissions without breaching delivery windows. Mugoni, Nyagadza and Hove (2023) complement this view by revealing that take-back schemes and crate pooling in horticultural chains raise asset turnover while lowering post-harvest losses. Peng (2023) quantifies how shared-logistics platforms that apply SSCM principles advance SDG 12 (responsible consumption and production) and SDG 17 (partnerships for the goals) through asset-light resource sharing. Melo et al. (2023) scrutinise existing SME digital-maturity instruments and reveal a systematic overweight of financial indicators; environmental loads and social outcomes remain sparsely quantified, leaving managers with an incomplete sustainability mirror. Bhatti et al. (2023) deepen the portrait by demonstrating that the sequence – procuring greener inputs, slimming packaging mass, consolidating dispatches – creates a mediating chain through which responsible supply-chain decisions surface as augmented earnings and community legitimacy. Most recent contributions from 2024 demonstrate the integration of sustainability into advanced technologies and new business models. For instance, Días, Silva and Viana (2024) argued that sustainability in supply chains is deliberately fostered through interpersonal relationships and social values, while Bonilla, Bouzon and Peña-Montoya (2024) developed a taxonomy for sustainable last-mile logistics in e-commerce. De Sousa Jabbour et al. (2024) examined how supply chain risk identification enhances social performance and sustainability reputation, particularly when mediated by digital technologies. Similarly, Alsehaimi et al. (2024) created a model linking BIM with sustainable outcomes in construction. Other 2024 studies addressed specific dimensions of SSCM: Uttam, Dutta and Singh (2024) focused on social sustainability in small manufacturing enterprises, while Hejazi and Habani evaluated how green supply chain integration improves firm performance through resilience and innovation in Saudi Arabia. Dacre et al. explored the contribution of Industry 5.0 to sustainability, resilience and human-centric supply chains. Phonthanukititha et al. assessed the impact of supplier cooperation and green distribution on waste management in emerging markets. Meanwhile, Matarneh et al. (2024) examined the influence of Industry 4.0 technologies on green supply chain integration and circular economy (CE) capabilities. Kononova et al. (2024) outline a step-wise plan that helps SMEs decide which social or environmental initiatives to launch first, guided by the capabilities of new technologies and collaborative innovation. Kato (2024) adds that sustainability-dedicated venture capital provides much-needed financial cushioning that reinforces SME durability in sub-Saharan Africa. Barreto, Freitas and De Paula (2024) then show that acute market sensing coupled with innovation proficiency shapes the depth and breadth of green supply-chain adoption. Finally, Al-Okaily, Younis and Al-Okaily (2024) integrate these strands, demonstrating how managerial routines aligned with emerging technologies translate into tangible sustainability gains and stronger organisational performance across supply networks.

Taken together, the 2021–2024 corpus charts a steady shift from foundational concepts and measurement proposals to concrete tactics that embed digital tools and social inventiveness into everyday operations, confirming that sustainable supply-chain management is now a living, many-sided domain rather than a static research label. In 2024, 13 articles were published, the highest annual output in the period under review, demonstrating the growing academic interest in sustainable logistics. Of these studies, 43% addressed sustainable supply chain management, green logistics and the CE, which have become the primary approaches for embedding environmental criteria into logistics practice and business performance. This temporal increase, combined with the observed thematic concentration, points to the consolidation of the field and its shift towards increasingly systemic and innovation-oriented approaches (Figure 2).

Quality assessment

After applying a 0–4 quality scale, we retained 70 articles. These were distributed across three analytical strands: (1) effects of sustainable-logistics initiatives on firm-level performance, (2) performance-measurement models that embed sustainability criteria, and (3) nascent technologies or practices proposed for logistics evaluation. The first strand encompassed 39 articles (mean score 1.71 ± 0.40), the second 21 articles (2.42 ± 0.82) and the third 10 articles (2.25 ± 0.33). Overall, the studies analysed yielded a mean score of 2.01 ± 0.44, reflecting a significant and consistent evaluation for the analysis conducted (see Table 3).

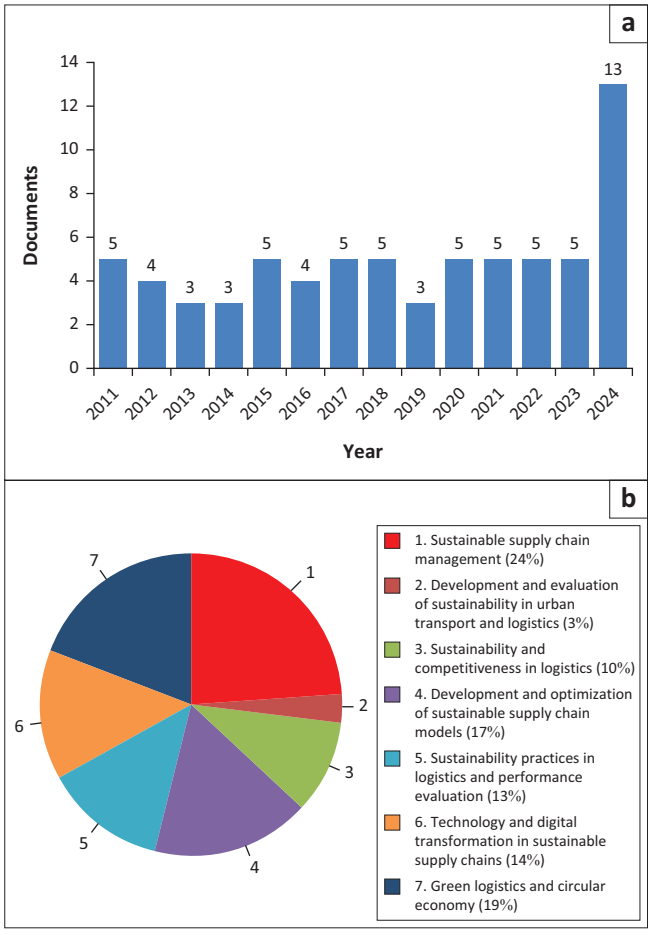


FIGURE 2: Distribution of selected studies by: (a) year of publication and (b) research area (2011–2024).

Ethical considerations

Ethical clearance to conduct this study was obtained from the Politécnico Colombiano Jaime Isaza Cadavid Research Ethics Committee (No. 21414401-202503002327).

Results

This section analyses the results based on the answers to the four research questions posed.

RQ1: How have companies addressed the implementation of sustainable logistics practices between 2011 and 2024?

During the period between 2011 and 2024, significant studies were identified that address the implementation of sustainable logistics practices. Among the notable works, Gupta and Palsule-Desai (2011) present a review of the current state of academic research on sustainable supply chain management while also projecting its future evolution and research opportunities in this area. In turn, Afum et al. (2020b) analyse the relationship between GMP and sustainable performance, considering economic, environmental and social aspects in manufacturing SMEs in Ghana. Bhatti et al. (2023) show that responsible sourcing, reduced-impact packaging and low-carbon distribution enhance SME performance, acting as a bridge between day-to-day logistics and broader sustainability outcomes in emerging economies.

RQ2: How has the implementation of sustainable logistics evolved and impacted companies from 2011 to 2024?

The evolution of sustainable logistics has gained significant relevance in companies because of the accelerated growth of sustainable best practices. The shift has boosted productivity and market competitiveness as firms translate the attendant advantages into measurable operational gains. In this context, Qorri et al. (2018) conducted a meta-analysis to assess the impact of GSCM practices on business performance. Likewise, Albuquerque et al. (2023) proposed the preliminary development of a Decision Support System aimed at reducing the carbon footprint in SeV's logistics transportation. This system will enable the measurement and monitoring of carbon

TABLE 3: A summary of scores.

Topic	*n*	Mean ± deviation
Impact of implementing sustainable logistics practices on business performance	39	1.71 ± 0.40
Methodologies or models are integrated with sustainable logistics in the business context	21	2.42 ± 0.82
Innovations and emerging trends in sustainable logistics for business performance measurement	10	2.25 ± 0.33
Total	**70**	**2.01 ± 0.44**

emissions by identifying operational inefficiencies to promote more sustainable transport. Finally, Hejazi and Habani (2024) analyse how green supply chain integration influences the performance of manufacturing firms in Saudi Arabia, emphasising the mediating role of supply chain resilience and innovation.

RQ3: What models or methodologies have been applied in sustainable logistics in the business context between 2011 and 2024?

The study reveals the application of various methodologies in sustainable logistics, highlighting the contributions of the following authors. Ahmadini et al. (2021) present a multiobjective fractional programming model that enables operations managers to balance profit maximisation with the reduction of environmental and maintenance costs in the supply chain. In addition, Nayak et al. (2019) developed a structured model for the sustainable implementation of blockchain in SME supply chains, considering key factors such as supplier acceptance, government support and stakeholder engagement – fostering greater transparency and trust in sustainable operations. Finally, Alsehaimi et al. (2024) propose an integrated model that analyses the interrelationships between BIM, sustainable practices and outcomes in the construction sector, identifying key sustainability indicators.

RQ4: What new sustainable logistics practices have been used to measure business performance between 2011 and 2024?

Dacre et al. (2024) systematically investigate how supply chains in Industry 5.0 can foster sustainability, human-centricity and resilience within the manufacturing sector. Costa Melo et al. (2023), for their part, analyse the state of the art in evaluating digital transformation in SMEs, focusing on performance measurement and assessing whether the tools used consider the three pillars of sustainability: environmental, social and economic. Lastly, Junge and Straube (2020) examine the impact of implementing Digital Transformation Technologies in logistics and supply chain management, concluding that these technologies have a moderately positive effect on both environmental and social sustainability.

The implementation of sustainable logistics in the business context offers a valuable opportunity to integrate digital technologies, automation and robotics. These innovations can be combined with additional measurement tools and even enhanced by AI methods, with the goal of optimising sustainable practices within organisations. Empirical evidence identifies three recurrent constraints that curb the adoption of sustainable logistics. Financial constraints constitute the primary limitation and are the most frequently cited: capital expenditure on renewable infrastructure, low-emission fleets and optimisation platforms regularly surpasses available liquidity, while financial institutions apply higher risk weightings to 'green' assets, diverting scarce investment funds. Behavioural inertia constitutes the second obstacle; entrenched operating procedures and perceived competence loss generate passive resistance among supervisors and drivers, delaying process re-engineering. The third constraint is of an institutional nature; incentive systems anchored to short-term profitability prioritise quarterly earnings over life-cycle impacts, confining sustainability initiatives to incremental adjustments and postponing the systemic redesign of transport, warehousing and packaging flows required to meet long-term emission targets. The interaction of these economic, behavioural and institutional factors explains why many firms remain in a reactive, small-scale improvement cycle instead of progressing towards comprehensive low-impact logistics architectures.

Discussion

Towards a consolidated vision of sustainable logistics and business performance (2011–2024)

During the period 2011–2024, the field has evolved from a normative invitation to 'green' transportation and storage to a mature research area that explicitly links environmental integrity to profit generation, risk reduction and innovation capacity. Four cross-cutting macro-themes dominate this transition: (1) the operationalisation of the triple bottom line (TBL) in logistics decision-making, (2) the digitalisation of sustainable logistics, (3) the incorporation of CE principles, and (4) the emergence of governance architectures and organisational capabilities that translate sustainability intent into repeatable routines. None of these themes developed linearly; rather, they exhibit a predictable temporal S-curve: conceptual framing (2011–2013), empirical proliferation (2014–2018) and systemic-technological integration (2019–2024). In all phases, academic attention has been focused on one question: how sustainability-oriented logistics reconfigures business performance. The accumulated evidence allows us to move from asking *whether* sustainable logistics is profitable to *when, how much and for whom*.

From triple bottom line rhetoric to triple bottom line algorithms

Early studies equated sustainable logistics with carbon reduction and cost minimisation, treating social outcomes as a desirable byproduct. After 2016, the TBL construct was progressively encoded into target functions – fractional programming, multiobjective heuristics, DEA–AHP hybrids – simultaneously optimising service level, emissions and working conditions. Meta-analytic evidence (Junge & Straube 2020; Qorri et al. 2018) shows a medium positive effect (0.2–0.4σ) of green logistics practices on composite performance indices, with the greatest benefits being for firms that internalise social and not only environmental KPIs. The mechanism is causal and sequential: emission reduction routines → process standardisation → lower variability → higher asset utilisation and, ultimately, margin expansion. Socially, the same routines increase employee-generated eco-innovations, fuelling a virtuous innovation-reputation cycle.

Digitalisation as a performance catalyst, not a panacea

Digital tools entered the literature as monitoring accessories (Radio Frequency Identification [RFID], telematics) and came out of it as architectural enablers: blockchain for traceability, AI for carbon-conditioned routing, digital twins for closed-loop packaging. However, the performance premium is conditional on complementary assets. Firms with dynamic innovation capabilities (Barreto et al. 2024) turn carbon dashboards into reductions in customer delivery and retention windows, while SMEs with limited resources suffer a 'double sustainability-digitalisation penalty' (Kumar et al. 2022). The field has converged on a contingency vision: digital technologies amplify the benefits of sustainable logistics only when grafted onto absorptive capacity and co-innovation routines with suppliers.

Governance and capabilities: The hidden meta structure

The performance effect of any sustainable logistics package is mediated by the governance design. The studies converge on two complementary architectures: (1) top-down, rules-based governance (certifications, carbon budgets) that ensures legitimacy, and (2) bottom-up, capacity-based governance (eco-functional teams, supplier development) that generates novelty. Organisations that nest bottom-up governance – eco-functional teams, streamlined suppliers to reroute cargo in hours – cushion the turbulence without service suffering: when the port becomes congested or fuel becomes more expensive, their units already run through alternate corridors and delivery continues to meet the agreed window. The secret does not lie in safety stocks or exclusive algorithms, but in the internalised repetition of reconfiguring batches, modes and packaging before the pressure of stakeholders – or the operating environment – demands it. Thus, sustainable logistics ceases to be an inventoriable resource and is consolidated as a dynamic capacity that rearranges the map of logistics assets in advance.

Convergences and tensions

Even though the literature uses different approaches and methodologies, a fundamental agreement emerges: sustainable logistics practices tend to strengthen the operational efficiency and legitimacy of organisations, and it is in the interaction of both effects that their contribution to business performance is explained. However, this consensus coexists with three tensions that have not yet been fully resolved:

- Economic benefit vs. financial barrier: Although the benefits are positive at maturity, 60% of SME studies cite liquidity constraints as an obstacle, creating a 'green investment paradox'.
- A recurring difficulty arises when moving from arguments to measurement. Although there is a growing interest in comparable indicators, studies continue to use very different ways of operationalising performance, combining environmental, economic and social dimensions without clear common criteria. This dispersion makes it difficult to compare results between studies and limits their applicability to decision-making.
- The problem is aggravated when we talk about time. Many models focus on capturing immediate efficiencies, while the benefits of sustainable logistics often manifest over time and cumulatively. This gap between the short and long term leaves out of the picture much of what is at stake.

Maturity patterns and persistent gaps

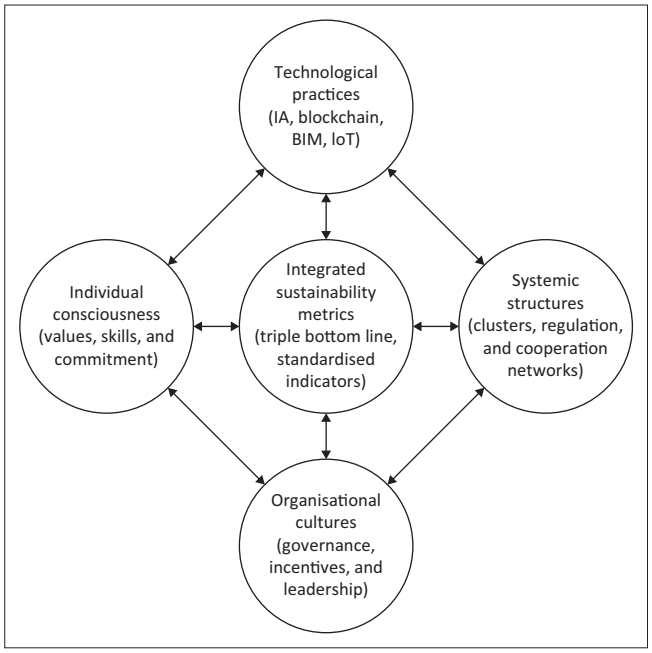
The field is mature: replicated effect sizes, established theoretical lenses (resource-based view, dynamic capabilities theory, stakeholder theory) and industry-specific taxonomies (last mile, cold chain, port logistics). However, three gaps justify future research:

- Integrated metrics that embed planetary boundary science (e.g. absolute emissions ceiling) into logistics KPIs
- Fundamental behavioural-micro studies that explain why identical governance structures generate divergent adoption trajectories
- Quasi-experimental longitudinal designs that isolate the delta of performance attributable to sustainable logistics net of demand shocks, energy volatility and regulatory cycles.

Implications for theory and practice

For the theory, the evidence positions sustainable logistics as a *dynamic operational capability* that simultaneously elevates efficiency, resilience and legitimacy – an idea that extends the Resource Based View (RBV) and supply chain resilience literatures. For practice, the review offers a parsimonious contingent recipe: invest in digital visibility, embed TBL algorithms in day-to-day routing and charging decisions and govern the package using cross-functional eco-functional teams supported by CEO-level carbon budgets. Firms that synchronise these elements turn the sustainability of a compliance cost into a driver of value creation and risk management, consistently achieving improvements in Earnings Before Interest and Taxes (EBIT) margin and double-digit decreases in costs linked to disruptions in the chain, compared to their non-synchronised peers. In sum, sustainable logistics has migrated from a peripheral 'green aggregate' to a core operational strategy that redefines the boundaries of performance. The next wave of research must confront the paradox of green investment and metric cacophony if the field is to maintain the academic legitimacy and managerial relevance it has already gained. Based on a review of 70 articles published between 2011 and 2024, a clear trend can be observed: every year, more companies are combining sustainability and profitability in their supply chains. The growing volume of publications reflects this interest. Studies agree in highlighting the growing use of three digital tools: blockchain, which seeks to guarantee the origin of the product; AI to forecast inventory levels and support systems that balance cost, time and emissions. Their advantages – greater transparency, reduced costs and a

lighter environmental footprint – are proven; however, transferring these practices to organisations with limited resources remains an unresolved challenge. The studies analysed agree that integrating sustainability into logistics translates into concrete benefits for the company: more loyal customers, work teams that suggest eco-innovative solutions and a better brand image. However, the methods used to measure this integration exhibit significant variability. While some studies focus exclusively on environmental indicators, others prioritise profitability, often neglecting social variables. This methodological disparity hinders cross-study comparisons and impedes the development of a comprehensive and robust body of knowledge necessary to inform future practices effectively. Given this situation, it is necessary to evolve towards a set of standardised criteria or metrics that appropriately articulate the environmental, social and economic dimensions of sustainability. The availability of these criteria would not only strengthen research in this field but could also contribute to or significantly reinforce the strategic and operational decision-making process in warehouses, cargo terminals and logistics planning departments or areas. Based on the analysis of the 70 selected studies and the identification of similarities among their contributions, a theoretical model is proposed to explain the relationship between sustainable logistics practices and business performance. This model integrates four categories, articulated into the following dimensions: individual awareness, operational technology, organisational culture and systemic structures, conceived as interdependent components for addressing sustainable logistics. Rather than being presented as isolated categories, these dimensions interact with one another, enabling a deeper understanding of the complexity inherent in sustainability within dynamic and diverse business contexts. Furthermore, this configuration provides a solid foundation for the design of strategies, policies and assessment instruments that acknowledge the multiscale and transversal nature of sustainable logistics (see Figure 3).



BIM, Building Information Modelling.

FIGURE 3: Proposed theoretical model.

Conclusion

Through an SLR of articles published between 2011 and 2024 on the topic of sustainable logis tics implementation in the business context, this study has helped to establish a clear concept of the subject, its application and its main contributions to organisational development.

The implementation of sustainable logistics has a positive impact on business performance by improving operational efficiency, reducing medium- and long-term costs and promoting CE strategies and labour benefits that contribute to achieving corporate goals. Companies that adopt sustainable practices optimise their processes and maximise the use of available resources, generating both economic and social benefits. In addition, these practices strengthen the company's image, positioning it as a responsible organisation committed to its environment and community. In recent years, companies have increasingly incorporated sustainable practices into their established management systems and assessment models to monitor their impact more accurately. The integration of new technologies into everyday operations not only allows for the conservation of resources in the future but also creates real economic, social and environmental benefits, improves processes and strengthens the organisation's position with customers, suppliers and competitors. Future research should focus on the application of technologies such as blockchain, AI, neural networks and fuzzy logic, as well as on the development of business models oriented towards sustainable innovation. Likewise, it is essential to advance in the creation of integrated metrics that equally address the economic, social and environmental dimensions and in the design of methodologies for measuring qualitative competencies in sustainability. In future research, a test that integrates the interaction between individual awareness, technological practices, organisational culture and systemic structures requires following employees, teams and firms over time and contrasting trajectories in environments with different regulatory intensities and competitive pressure. Extending the study to short, high-frequency chains, such as fruit and vegetables, and large, long-cycle global flows, such as electronics, will be able to confirm whether the relative importance of each dimension is maintained or reversed as supplier concentration, financial health and regulatory stability vary. Comparing countries with different tax and labour regimes will validate how incentives, legal volatility and labour participation accelerate or slow down the conversion of systemic conditions into sustainable outcomes.

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Competing interests

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CRediT authorship contribution

Elkin R. Zapa Pérez: Conceptualisation, Investigation, Methodology, Visualisation, Writing – original draft, Writing – review & editing. Bernardo A. Monsalve Lozano: Conceptualisation, Investigation, Methodology, Visualisation, Writing – original draft, Writing – review & editing. All authors reviewed the article, contributed to the discussion of results, approved the final version for submission and publication and take responsibility for the integrity of its findings.

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Data availability

The data that support the findings of this study are derived from publicly accessible sources. For further information, please contact the corresponding author, Elkin R. Zapa Pérez.

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