

Review

Rethinking Supply Chain Performance in the Industry 5.0 Era: An Integrative Review and the SC360PM Framework

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Abstract

Supply chain performance (SCP) has traditionally emphasized efficiency, but recent disruptions and the transition to Industry 5.0 (I5.0), organized around the principles of human-centricity, sustainability, and resilience, have exposed the limits of this orientation. These principles redefine what supply chains must deliver, yet most frameworks treat them in isolation or subordinate them to efficiency. This study reconceptualizes SCP management for the I5.0 era through an integrative review following Whitemore and Knafl's protocol and PRISMA 2020 reporting. A Web of Science search of peer-reviewed articles (2020–2026), two-phase screening, and supplementary citation searches yielded 55 studies. The synthesis reveals three limitations: an efficiency bias privileging financial and operational metrics; an integration gap treating the I5.0 principles separately; and a human-centric measurement gap disconnecting social and workforce outcomes from strategic performance. The Supply Chain 360° Performance Management (SC360PM) framework is introduced as a conceptual architecture ready for validation that organizes SCP into five coequal dimensions: resilience and agility; cost efficiency and financial health; sustainability and environmental responsibility; innovation and digitalization; and human-centricity and social responsibility, decomposed into eighteen attributes. SC360PM conceptualizes performance as a multidimensional model for joint management, offering researchers a structured basis for empirical validation and managers a pathway toward viability-oriented performance governance.

Keywords: Industry 5.0; supply chain performance; SCP; performance management; SC360PM; resilience; sustainability; human-centricity; integrative review



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1. Introduction

During the past decade, supply chain management (SCM) has undergone substantial change, driven by rapid digitalization, rising customer expectations, and intensifying sustainability requirements [1–3]. Global crises such as climate-related catastrophes, geopolitical tensions, the COVID-19 pandemic, and technological discontinuities have further reshaped this landscape [4,5]. These pressures emphasize the necessity of robust and adaptive performance management frameworks that can handle complexity and risk rather than merely optimize efficiency [6]. Consequently, supply chain performance (SCP) has become a strategic capability with an increasingly broad scope, extending well beyond cost and service levels [2,6,7].

As this landscape evolved, the competitive logic of the supply chains shifted accordingly. Competitive advantage is now determined across integrated networks instead of

individual firms [8,9]. Organizations are therefore required to invest in digital capabilities to meet the growing demand for speed, affordability, and quality [10]. Central to this evolution is the development of precise, multidimensional performance attributes and frameworks that help firms assess, manage, and improve SCP [11,12]. These frameworks extend beyond reporting; they diagnose vulnerabilities, guide investment decisions, and maintain network competitiveness [12].

Industry 4.0 (I4.0) transformed manufacturing and logistics through automation, AI, IoT, and advanced analytics [13,14]. Practitioner analyses suggest that digital supply chains (DSCs) can substantially reduce operational expenses, lost sales, and inventory requirements [15]. Nevertheless, the dominant focus of I4.0 on operational efficiency has frequently sidelined broader objectives such as resilience, sustainability, and human-centricity, which are now central to competitive positioning [13,16,17]. This limitation became especially clear during disruptions, when performance measurement systems anchored exclusively in cost minimization, speed, and throughput proved insufficient under systemic shocks [6,18–20].

The shift from I4.0 to Industry 5.0 (I5.0), centered on human-centricity, sustainability, and resilience, significantly broadens the performance paradigm [16,21,22]. Instead of replacing the technological base, it strategically redirects it: AI and other digital tools that were mainly used for automation and efficiency are now oriented toward human-centric, sustainable, and resilient goals [16,17,22]. As supply chains adopt these principles, organizations must reassess their performance management strategies to stay competitive, sustainable, and resilient amid evolving global challenges [17,23].

Each I5.0 principle reshapes how SCP must be managed. Human-centricity prioritizes workforce capabilities, well-being, and human–machine complementarity as primary performance outcomes rather than secondary enabling factors [13,24–26]. Sustainability emphasizes decarbonization, circularity, and resource efficiency as core operational metrics, evaluated alongside cost and service [21,27]. Resilience elevates recovery capability, adaptive capacity, and long-term survivability to equivalent strategic objectives, not just safeguards against disruptions [4,18,24]. Collectively, these principles are redefining performance, but current measurement architectures have not yet fully absorbed these changes [6,13,17]. This shift reflects the convergence of stakeholder expectations, regulatory requirements, and competitive dynamics, which are realigning around a broader conception of value [7].

Despite increasing recognition of supply chain complexity, the existing SCP frameworks remain fragmented, conceptually rigid, and predominantly oriented toward efficiency [1,17,19,20]. Although numerous frameworks are available for evaluating SCP [28], the Supply Chain Operations Reference (SCOR) model remains dominant [20,29]. Its latest iteration, the SCOR Digital Standard (SCOR DS), released by the Association for Supply Chain Management (ASCM) in 2019 and updated in 2022 (version 14), offers a process-oriented approach in seven management processes and more than 250 metrics [1,30]. However, its focus remains on physical material flows [31], and it does not treat human-centricity and the capability of digital innovation as first-order dimensions [1]. SCOR DS also lacks indicators for priorities such as digitalization maturity and predictive analytics, both critical for Supply Chain 4.0 and 5.0 [20]. Consequently, key I5.0 priorities are not adequately captured, affecting the implementation of I5.0 priorities [1,12,32]. These limitations are structural gaps: human-centric outcomes remain confined to the people skills taxonomy and limited social metrics [1], there is no guidance on metric prioritization [33], and high metric density further complicates practical adoption [1,32]. More broadly, the literature predominantly emphasizes individual performance attributes or isolated dimensions rather than adopting holistic frameworks that integrate traditional operational goals

with contemporary strategic imperatives [1,8,34–36]. This leaves a clear gap: organizations that operationalize only narrow, cost-centric subsets of available metrics risk neglecting resilience, digital maturity, and sustainability, the omission of which has been shown to increase vulnerability to disruptions and erode long-term competitive standing [7,19].

Fragmentation in the literature appears in at least three forms. First, taxonomy fragmentation occurs when conceptually similar constructs are labeled inconsistently, while unrelated constructs are sometimes grouped under the same label, complicating theory building [37,38]. Second, level fragmentation arises as some studies focus on firm-level financial measures [39], others on network-level resilience [40], and still others on process-level digital maturity, often without explicit cross-level integration [41]. Third, temporal fragmentation appears when performance systems optimized for steady-state efficiency fail in turbulent conditions, where recovery and survivability become primary concerns [42,43]. The viable supply chain (VSC) concept addresses this issue by linking resilience, agility, and sustainability to long-term survivability [4,18]. From this perspective, performance should include adaptive structural capacity alongside profitability [24,44] and broader supply chain well-being [45].

Addressing these limitations requires more than simply adding additional indicators to legacy models; it necessitates a performance architecture designed from the outset around the coequality of economic, adaptive, environmental, digital, and human-centric outcomes. Consequently, this study conducts an integrative review of contemporary SCP literature and proposes the Supply Chain 360° Performance Management (SC360PM) framework based on its findings. This framework is a multidimensional architecture that consolidates the performance dimensions identified in the review into a single, validation-ready structure. Jouicha et al. [6] assert that no existing performance system integrates all three I5.0 pillars. This gap is both conceptual and operational: because the pillars are interdependent, evaluating them individually obscures their interactions, while the structural rigidity of traditional measurement systems means that merely appending new indicators does not realign their underlying objectives [6]. Recent studies similarly indicate that the application of I5.0 principles to SCP management remains fragmented [13,17,23,25]. Although some studies present partial solutions, a comprehensive architecture is still underdeveloped. This study builds upon that diagnosis by synthesizing the broader literature on SCP and translating the identified gaps into a holistic and structured framework. Accordingly, the study is guided by two research questions:

RQ1. *What structural limitations characterize existing SCP frameworks, and what design requirements must an SCP management framework satisfy to align with I5.0 principles?*

RQ2. *Which performance dimensions and attributes should constitute an SCP management framework aligned with the principles of I5.0?*

This paper makes three principal contributions to SCM literature. First, it provides an integrative synthesis of recent SCP research, identifying major conceptual developments reshaping the field and the taxonomic, level-related, and temporal fragmentation that constrains cumulative theory building. Second, it critically evaluates the structural limitations of existing performance frameworks, identifying the gaps that impede the development of comprehensive, future-ready performance management systems. Third, it proposes the SC360PM framework as a structured response to these gaps, organizing SCP into five dimensions: resilience and agility; cost efficiency and financial health; sustainability and environmental responsibility; innovation and digitalization; and human-centricity and social responsibility. These dimensions are further decomposed into eighteen literature-grounded attributes, forming a structured, empirically testable architecture for SCP management in the I5.0 era. SC360PM is presented as a conceptual, validation-ready framework rather

than an empirically validated measurement model, with its validation pathway proposed as future research.

The remainder of the paper is organized as follows. Section 2 establishes the conceptual foundation of the framework and positions the study relative to previous literature reviews. Section 3 details the review methodology. Section 4 synthesizes the findings, identifies structural gaps, and derives the design requirements for SC360PM. Section 5 presents the SC360PM framework. Section 6 discusses the theoretical and managerial implications, limitations, and future research directions. Section 7 concludes the paper.

2. Background

2.1. Definitions

2.1.1. Supply Chain and Supply Chain Management

A supply chain is a coordinated network of interdependent entities (suppliers, manufacturers, logistics providers, distributors, retailers, and end customers) through which materials, information, and financial resources flow from raw material sourcing to final consumption [14,46]. It covers upstream procurement, midstream production and assembly, and downstream distribution and retail [14,47]. Functionally, it operates as a value-creating system in which each stage adds incremental value to the product or service as it approaches the end user [48]. Recent scholarship increasingly conceptualizes the supply chain as an open, transformative social-ecological system embedded in its social and environmental contexts and capable of fundamental change in response to external shocks [49–51]. Accordingly, SCP must be evaluated not only by how efficiently flows are managed but also by how well the network adapts, transforms, and contributes to broader social and ecological outcomes [6,13,45].

SCM is the strategic, end-to-end orchestration and coordination of business functions, processes, and inter-organizational relationships across the supply chain network, aimed at optimizing the flow of materials, information, and financial resources among all participating entities [20,22,52]. It is a dynamic management discipline characterized by integration across functions and firms [53,54], coordination and mapping across supply chain participants and activities [2,55], and strategic alignment of operational decisions with long-term competitive priorities [56]. A central tenet of modern SCM is that competitive advantage now accrues at the network level rather than the firm level, implying that performance frameworks must evaluate outcomes that span firm boundaries [57,58].

2.1.2. Performance, Performance Measurement, and Performance Management

In a business context, performance refers to how effectively and efficiently an entity achieves its objectives. Effectiveness denotes the extent to which goals or customer requirements are met, while efficiency relates to the optimal use of resources [46]. Neely et al. [59] operationalized this view by defining performance measurement as “the process of quantifying the efficiency and effectiveness of action,” with performance metrics as the indicators used to quantify it. Lebas [60] offers a complementary, forward-looking view, defining performance as the capacity to implement future actions successfully to achieve defined organizational targets. This dual emphasis on realized outcomes and the capabilities that signal future potential underpins the analytical distinction between performance measurement and performance management.

Performance measurement involves establishing objectives, identifying relevant indicators, and collecting, evaluating, and interpreting performance data [46,61]. Performance management is the broader, more dynamic process that uses performance information to align behaviors with strategic objectives, guide decisions, and promote continuous improvement [62]. The two domains are complementary: measurement quantifies what

has happened, while management determines what should happen next, which is essential for SCP.

2.1.3. Supply Chain Performance

SCP refers to the degree to which a supply chain achieves its objectives efficiently, effectively, and sustainably across multiple dimensions, including cost, quality, responsiveness, flexibility, reliability, and asset management [22,63]. It encompasses both firm-level outcomes and outcomes realized across the wider value chain [10]. However, SCP differs from firm-level performance in two important respects. First, it is inherently multi-actor: outcomes emerge from the coordinated behavior of multiple interdependent organizations, not the actions of a single firm [33,64]. Most existing measurement systems remain fragmented across SC interfaces, evaluating individual nodes in isolation rather than the chain as an integrated system [34]. Second, it is multidimensional: while early SCP frameworks emphasized financial and operational efficiency, recent scholarship demonstrates that performance must also capture customer satisfaction, sustainability, resilience, digital capability, and human-centric outcomes [6,19,20,26]. A complete SCP system, therefore, requires both measurement and management. Measurement provides the data infrastructure and KPIs needed to evaluate performance, while management translates these insights into governance, corrective action, and continuous improvement [11,64,65].

2.2. Conceptual and Theoretical Foundation

SC360PM is built on four complementary foundations. First, SCOR DS provides the underlying process and attribute architecture. Second, I5.0 supplies value orientation. Third, VSC theory introduces the logic of long-horizon survivability. Finally, the combined perspective of resource-based view (RBV), dynamic capabilities, and systems theory explains how SCP capabilities are generated, reconfigured, and sustained.

2.2.1. Supply Chain Operations Reference Digital Standard

SCOR DS, along with its predecessor SCOR, is the most widely adopted process-oriented framework for SCP evaluation [1,28,33,66]. It organizes supply chain activities around seven primary management processes: plan, source, transform (formerly known as make), order, fulfill (split from deliver), return, and the newly introduced orchestrate. Performance evaluation is based on three groups of attributes: customer-focused attributes (reliability, responsiveness, and agility) that enhance resilience; internally focused attributes (cost, profit, and assets) that drive economic performance; and outward-focused attributes (environmental and social) that promote sustainability. Metrics are structured hierarchically, with level-1 strategic metrics further decomposed into level-2 and level-3 diagnostics [30,32].

SCOR DS's tri-dimensional logic partially aligns with the broader I5.0 priority set, and its hierarchical metric structure provides a proven framework for translating high-level dimensions into operational measurements [1,32]. This ongoing relevance has led scholars to propose extended versions, including SCOR 4.0 [67] and Extended SCOR 4.0 [20], which aim to better align with digital transformation and evolving industry requirements. Nonetheless, remnants of its process-standardization origins remain evident. Human-centric outcomes are still largely restricted to the people skills taxonomy and a limited set of social metrics. Additionally, the high density of metrics poses substantial implementation challenges [1]. Becker [32] critiques SCOR DS further for its limited cross-functional integration and inadequate representation of logistics, scheduling, and inventory-planning activities. Another limitation across all SCOR versions is the lack of guidance on metric prioritization. Importance weighting is left to organizational decisions, leading to inconsistencies in operationalization among different firms and sectors [33].

Several attributes of SC360PM are directly derived from SCOR DS. Its internally focused attributes define cost efficiency and financial health, while its customer-focused attributes correspond to resilience and agility. The outward-focused environmental attribute supports sustainability and environmental responsibility, and its social attribute only partially addresses human-centricity and social responsibility. Both the human-centricity and the innovation and digitalization dimensions lack a first-order counterpart in SCOR DS and are therefore derived from other foundations. SC360PM enhances SCOR DS by promoting digitalization and human-centricity from peripheral attributes to core performance dimensions, making them equal in importance to economic, resilience, and sustainability considerations.

2.2.2. Industry 5.0 Principles

The term “Industry 5.0” began circulating in academic and industrial discussions in the late 2010s and early 2020s. I5.0 is intended to complement, not replace, I4.0 [24]. While I4.0 focused on placing technologies at the heart of industrial transformation, I5.0 emphasizes the intelligent and ethical use of these technologies to promote human-centric and sustainable innovation [68,69]. This shift redefines the unit of value from shareholder to stakeholder [24], expands the legitimate purposes of industrial activities, and operationalizes through three principles—human-centricity, sustainability, and resilience [68].

Human-centricity alters the role of workers, transforming them from interchangeable components in automated systems to essential contributors in value creation within the supply chain [25]. This principle involves the intentional design of technologies, such as collaborative robots and AI-driven decision support tools, that augment rather than replace human capabilities. It also necessitates investment in upskilling, digital literacy, and improvement in work–life quality [16,70]. Consequently, for performance measurement, worker safety, well-being, equity, and skill development are elevated from peripheral concerns to fundamental outcomes [27,68]. Sustainability seeks to align industrial activities with environmental stewardship and social responsibility through initiatives such as decarbonization, circular economy practices, and supply chains that operate within planetary boundaries [25]. The European Commission regards environmental and societal well-being as fundamental imperatives [21]. This approach necessitates the direct measurement of environmental impact, resource efficiency, and circularity, instead of treating them as compliance-related tasks [27]. Resilience pertains to the ability of supply networks to anticipate, absorb, adapt to, and recover from disruption [70]. The COVID-19 pandemic and subsequent geopolitical shocks have led to a shift in the understanding of resilience, now viewed as equally important as financial efficiency [71].

In the context of SC360PM, the principles of I5.0 inform three of the five performance dimensions of the framework: sustainability and environmental responsibility, human-centricity and social responsibility, and resilience and agility.

2.2.3. Viable Supply Chain Theory

VSC theory enhances conventional resilience thinking by introducing survivability as a long-horizon objective [4,18]. Ivanov [4] defines viability as “the ability of a supply chain to maintain itself and survive in a changing environment through a redesign of structures and replanning of performance with long-term impacts.” This concept was first introduced for intertwined supply networks by Ivanov and Dolgui [18].

Viability broadens the scope of resilience without duplicating it. While resilience focuses on the economic performance of individual supply chains during disruptions, viability encompasses a wider perspective. It integrates resilience and sustainability through

both economic and societal components, applies to intertwined supply networks and ecosystems instead of solely individual chains, and includes survivability under long-term and unpredictably scaling disruptions [4,18]. This distinction is relevant for SCP. Where resilience asks how a supply chain recovers, viability investigates how it continues to deliver value amid cascading and systemically transformative crises [72,73].

The VSC theory presents two key contributions that are directly applicable to SC360PM. First, it formalizes the integration of agility and resilience within a unified survivability logic, emphasizing their role as complementary rather than competing priorities. Second, it operates across multiple levels (plant, network, and ecosystem), thereby aligning operational performance with broader societal value creation [4]. For SC360PM, VSC theory provides both temporal and structural justification for the framework's emphasis on long-horizon adaptive capability. It supports the inclusion of resilience and agility as a coequal performance dimension rather than as subordinate concerns. Given that viability integrates economic alongside societal components, it also justifies the inclusion of cost efficiency and financial health as a coequal dimension instead of viewing them as the primary objective. As viability emerges from continuous redesign of structures and replanning of performance [4,18], it relies on the informational and analytical capabilities represented by the innovation and digitalization dimension. Furthermore, it reinforces the idea that resilience, sustainability, and human-centricity are mutually strengthening facets of long-term viability.

2.2.4. Resource-Based View, Dynamic Capabilities, and Systems Theory

RBV, dynamic capabilities theory, and systems theory collectively form the fourth theoretical lens for understanding and explaining how SCP is generated and sustained.

The RBV, formalized by Barney [74], posits that sustainable competitive advantage arises from the resources that are strategically valuable, rare, inimitable, and non-substitutable (VRIN) [27,74]. These resources are typically classified into human capital, physical capital, and organizational capital [75]. When applied to supply chains, RBV focuses on the configurations of resources that facilitate network-level performance, encompassing elements such as digital infrastructure and technologies [63], supplier relationships [76], workforce capabilities [2], and organizational knowledge [45]. Dynamic capabilities theory, which extends and complements RBV [7], was developed by Teece, Pisano, and Shuen [77] and addresses how firms can reconfigure their resources in response to changing environments. This theory concerns the capacity to sense and shape opportunities and threats, seize opportunities through resource commitment, and maintain competitiveness by enhancing, combining, protecting, and reconfiguring both tangible and intangible assets [78]. Recent scholarship in SCM has applied this logic to the concept of digital and technological reconfiguration [35,79]. Systems theory enriches the preceding perspectives by treating the supply chain as a system whose performance emerges from interactions among components rather than from any single node [80,81]. It also highlights how localized inefficiencies propagate through the network [82]. This perspective is especially relevant for performance measurement at the network level, where outcomes depend on coordination across firm boundaries and where ripple effects can cascade through the entire system [81,83].

These three perspectives work together synergistically. For the SC360PM framework, this combined perspective provides the mechanistic foundation underpinning the framework's operational logic. RBV grounds the recognition of digital and human resources as performance drivers, informing the innovation and digitalization and human-centricity and social responsibility dimensions. Physical capital, one of the three resource classes noted above [75], and the financial capacity required to commit resources and reconfigure

the asset base [78] inform the cost efficiency and financial health dimension. Dynamic capabilities ground the emphasis on adaptive, forward-looking performance, informing the resilience and agility dimension. Systems theory grounds the network-level orientation and supports the framework's claim that performance must be measured at the network level. Table 1 summarizes which lens contributes to the grounding of the SC360PM dimensions.

Table 1. Theoretical grounding of the five SC360PM dimensions in the framework's four lenses.

SC360PM Dimensions	SCOR DS	I5.0 Principles	VSC Theory	RBV + DC + ST
Resilience and Agility	✓	✓	✓	✓
Cost Efficiency and Financial Health	✓		✓	✓
Sustainability and Environmental Responsibility	✓	✓	✓	
Innovation and Digitalization			✓	✓
Human-Centricity and Social Responsibility	✓	✓	✓	✓

2.3. Prior Reviews Related to SCP

2.3.1. Historical Evolution of SCP

SCP measurement has evolved substantially over the past three decades, moving from a narrow focus on cost and operational efficiency toward multidimensional frameworks that incorporate strategic, environmental, social, and digital considerations [12,20].

Early efforts (pre-1990s) were dominated by cost accounting and purely financial methods. As the limitations of these methods became apparent, performance evaluation shifted toward quality, competitiveness, customer satisfaction, and innovation [52,61]. The 1990s then introduced two foundational frameworks that fundamentally reshaped the field. First, the Balanced Scorecard (BSC), introduced by Kaplan and Norton [84], and second, the SCOR model, which provided a standardized process language and linked these processes to performance [1]. Together, these two frameworks established the dominant logic of SCP measurement for the next two decades, and they continue to shape both academic and industry contexts [12,38,55].

The 2000s and 2010s introduced two extensions to this foundation. First, sustainability-oriented frameworks emerged, drawing on the TBL [85]. These frameworks responded to growing environmental concerns and to the recognition that SCP affects stakeholders beyond shareholders [41,86]. Early empirical applications, such as the Triple E model, began to integrate environmental indicators such as CO₂ emissions alongside efficiency and service metrics [34]. In contrast to other strands of sustainable supply chain research, empirical work connecting social sustainability practices to SCP outcomes remains thin [36,87]. Second, the era of I4.0 introduced the concept of Supply Chain 4.0, or the DSC, which leveraged IoT, big data analytics, AI, and blockchain to achieve agility, transparency, and real-time responsiveness [14,51]. Early attempts to integrate these digital capabilities into SCOR-based measurement, such as the SCOR 4.0 extension proposed by Ayyildiz and Taskin Gumus [67], anticipated the more comprehensive digital reorientation later formalized in SCOR DS.

Building on these foundations, post-2020 work sought to embed circular economy logic directly within the SCOR architecture, integrating reuse, recycling, and recovery considerations into the traditional process taxonomy [51,88]. These extensions, however, retain SCOR's process-efficiency orientation and stop short of the broader paradigmatic shift currently underway. The most recent shift, beginning around 2020, reflects the transition from I4.0 to I5.0 [17]. Whereas I4.0 emphasized digitalization, I5.0 reframes industrial activity around human well-being, ecological boundaries, and resilience to systemic disruption [16,21,22]. This is not an incremental extension of digital measurement, but a reorientation of what performance is taken to mean, and it is this reframing—rather

than the addition of new technologies—that the measurement literature has yet to absorb. Supply Chain 5.0 thinking accordingly prioritizes mass customization, worker well-being, and the network’s capacity to withstand and recover from systemic shocks [6]. This transition exposes the structural limits of frameworks designed under earlier paradigms and motivates the development of integrated, multidimensional measurement architectures, clarifying the need for SCP management to move beyond process efficiency alone [89].

2.3.2. Critical Review of Prior Literature Reviews

This subsection examines prior review-level contributions to position the present study; the findings of this study’s own integrative review of the selected original articles are reported in Section 4. Several influential reviews predate 2020, notably Maestrini et al. [90], Balfaqih et al. [91], and Gunasekaran et al. [92], and they remain frequently cited points of reference. The post-2020 literature on SCP measurement is dense, but a critical reading reveals three structural patterns that, taken together, explain why the development of an I5.0-aligned framework remains overdue.

The Paradigmatic Break: Most Post-2020 Reviews Remain Epistemically Anchored in I4.0

The first and most consequential observation is that a clear majority of the recent reviews ask an I4.0 rather than an I5.0 question. The term epistemically anchored in I4.0 is used here in a precise sense: it refers to reviews whose foundational performance ontology assumes that performance is generated by technology adoption and is adequately measured by efficiency-oriented metrics. Based on this criterion, Govindan et al. [14], Rad et al. [93], Kamble et al. [94], Govardhan et al. [10], and Xie et al. [48] all thoroughly engage with the I4.0 question. They explore how technologies such as IoT, big data analytics, blockchain, and additive manufacturing improve specific operational outcomes, such as cost, responsiveness, or transparency. Empirical studies reveal a similar pattern [39,55,95,96]. However, their perspective assumes that performance is solely derived from technology adoption and captured through efficiency-oriented metrics. This is the ontology that I5.0 seeks to replace. Under I5.0, performance is not generated by technology alone; rather, it is generated by the purposeful deployment of technology toward human-centric, sustainable, and resilient ends [6,13,23]. Reviews that do not reframe the fundamental question therefore fail to tackle the I5.0 measurement challenge, even with updated bibliographies. In contrast, Jouicha et al. [6], Hajjem et al. [13], and Dos-sou et al. [23] explicitly adopt an I5.0 stance. All three are recent contributions and each identifies substantial structural gaps in the existing literature.

A second symptom of the paradigmatic lag is the ongoing reliance on financial and efficiency metrics in managerial practice. Galankashi and Rafiei [46] confirm that cost, ROA, ROI, and asset turnover dominate real-world SCP assessment, despite two decades of scholarly advocacy for broader indicators. Rasool et al. [97] further refine this finding by showing, through a BSC mapping of 299 metrics, that internal efficiency and reliability perspectives still command 61% of scholarly attention, while the growth and learning perspective receives only 6%. The gap is critical: the disparity between scholarly recommendation and managerial practice remains unchanged, and academic literature perpetuates the biases it seeks to challenge. Consequently, a framework aiming to influence practice under I5.0 must not only propose broader measurement criteria but also propose an architecture that is feasible enough to disrupt the prevailing financial-bias equilibrium.

The Integration Gap: Pillars Are Addressed in Parallel

The second analytical pattern concerns how performance domains are organized within the reviewed frameworks. Even the most sophisticated multi-attribute models tend to treat performance dimensions as a parallel inventory rather than as an interdependent

system. Xie et al.'s [48] seven-indicator framework, Saleheen and Habib's [12] ten-attribute ISCPM, and Kamble et al.'s [94] 102-measure SMPMS all expand the attribute set considerably, but each places its dimensions side by side without theorizing how they constitute one another. Consistent with this pattern, Oubrahim et al. [28] explicitly identify a field-level limitation, finding that the dominant frameworks (SCOR and BSC) do not address integrated visibility, leagility, sustainability, or digitalization as mutually reinforcing rather than additive concerns.

This integration gap becomes acute under I5.0 because the three I5.0 pillars are not independent. Human-centric workplaces foster the creativity that underpins resilience; sustainability initiatives drive technological upgrades that improve both worker conditions and system robustness [13,27]. Treating the pillars as fully separable is therefore a simplification with substantive consequences. Resolving it completely requires empirical mapping of inter-dimensional influences, a task no existing framework has undertaken [98]. Accordingly, a conceptual architecture can and should meet three preconditions for that empirical work: the simultaneous inclusion of all pillars within a single framework, grounding in a theory that treats them as jointly necessary, and the explicit articulation of the interdependencies that subsequent empirical analysis must quantify.

Several reviews acknowledge the imperative of integration without operationalizing it. Tripathi and Roy [64] propose a dynamic integrated performance system grounded in the RBV and dynamic capabilities theory, but the integration is asserted conceptually and not translated into measurable attributes. Zekhnini et al. [47] propose a holonic architecture in which performance, technology, and management cohere across strategic, tactical, and operational layers, but the framework itself remains paradigmatically I4.0 and is silent on human-centric outcomes. In another study, Zekhnini et al. [51] integrate lean and green practices into a viable, sustainable, and digital supply chain (VSDSC) model, but the integration is operational rather than constitutive. Taken together, these reviews show the limits of partial integration; Jouicha et al. [6], in their systematic review of SCP measurement systems for Supply Chain 5.0, conclude unambiguously that no existing system simultaneously integrates resilience, human-centricity, and sustainability.

Within this integration gap, the under-measurement of human-centric performance is the most striking sub-pattern. Although worker well-being is a foundational I5.0 priority, specific metrics for human-machine collaboration, worker mental well-being, equity, and skill development remain scarce across the reviewed literature [6,13,23,97]. Existing frameworks tend to place the social dimension within compliance categories such as codes of conduct and audit indicators, rather than treat it as a constitutive performance outcome.

The Validation Gap: Conceptual Sophistication Without Empirical Reach

The third pattern concerns the gap between the conceptual proposition and empirical demonstration. A large share of the I5.0-aligned proposals are conceptual frameworks unaccompanied by case study, survey, or longitudinal validation. Dossou et al. [23] propose a Supply Chain Manager 5.0 dashboard without empirical demonstration. Hajjem et al. [13] propose an operations-technology alignment grid for I5.0 but provide no implementation roadmap. Where empirical work exists, it is dominated by cross-sectional surveys. The single substantial exception is Saleheen and Habib [12], whose ISCPM model is validated through structural equation modeling across twenty-four manufacturing sectors in Bangladesh, but the validation is geographically bounded and remains cross-sectional.

The validation gap is not incidental. Resilience and viability are temporal constructs that cannot be evaluated through point-in-time cross-sectional designs. A framework that claims to measure resilience or long-horizon viability must be tested under conditions of actual disruption or, at a minimum, against multi-period data. SC360PM is subject to the same constraint: it is advanced as a conceptual architecture rather than a validated

scorecard or measurement instrument, but Section 6 specifies the staged pathway through which it should be tested.

2.3.3. Synthesis, Theoretical Positioning, and Research Gaps

The three patterns above explain why an I5.0-aligned SCP measurement framework grounded in a coherent theoretical foundation is overdue. Post-2020 literature has produced sophisticated single-paradigm and single-pillar contributions, but has not produced an architecture that simultaneously demonstrates the following:

- Adopts an I5.0 position rather than an I4.0 one;
- Grounds the three pillars in a shared theoretical logic of viability and articulates their interdependencies, instead of listing them as unrelated parallel domains;
- Is specified to a level of granularity that supports empirical validation across sectors and time.

SC360PM is designed to satisfy the first two requirements at the conceptual level and to operationalize the third through the staged validation pathway specified in Section 6. Table 2 isolates the subset of reviews that engage directly with four theoretical foundations on which SC360PM is built and characterizes each by its conceptual contribution, its structural limit, and its implication for SC360PM. The table is deliberately restricted to these theoretically aligned studies; reviews focused on I4.0 technologies or single-dimension financial measurement are discussed in the narrative above but are not theoretically positioned to inform the SC360PM architecture. These conceptual gaps motivate the integrative review methodology described next, through which the performance dimensions and operational attributes of SC360PM are identified, synthesized, and organized.

Table 2. Theoretically aligned post-2020 SCP reviews: conceptual contributions, structural limits, and implications for SC360PM.

Study	Conceptual Contribution to Lens	Structural Limit	Implication for SC360PM
Teymourifar [1]	Frames SCOR DS as embedding ESG, orchestration, and digitalization as first-class concerns, moving beyond process-efficiency origins.	Critique stays internal to SCOR DS; treats the social sphere through conventional KPIs without foregrounding human-centricity; offers no architectural alternative.	Supports adopting SCOR DS as the process-architectural backbone while elevating human-centricity and sustainability as coequal dimensions.
Dossou et al. [23]	Articulates a dashboard for the “Supply Chain Manager 5.0” structured around four adjustment criteria (SCM fundamentals, ethics, sustainable management, and digital management).	Remains a conceptual proposition without empirical validation; the four criteria are placed in parallel rather than shown to be theoretically interdependent.	Supports the claim that sustainability and ethics must be elevated to first-order dimensions but motivates a tighter theoretical integration than parallel axes can deliver.
Hajjem et al. [13]	Maps I5.0’s three pillars onto operations-management practices, producing an operations–technology alignment grid.	Operationalizes the pillars at the level of OM practices rather than of performance measurement; offers no KPI architecture, and its implementation roadmap stops short of specifying measurement constructs.	Confirms the substantive content of the three I5.0 pillars but exposes the need for a measurement-specific architecture that translates the pillars into operational attributes.
Jouicha et al. [6]	Conducts one of the earliest SLRs of SCPMS under the I5.0 paradigm and concludes that no existing SCPMS is designed to measure SC5.0 performance, with current systems failing to address its three pillars at the same time.	Identifies the gap without proposing a framework to close it; recommends future development without specifying its architectural form.	Provides the strongest single warrant for SC360PM: the integration void is systematically evidenced through an SLR, and SC360PM is the architectural response they call for.

Table 2. Cont.

Study	Conceptual Contribution to Lens	Structural Limit	Implication for SC360PM
Zekhnini et al. [51]	Operationalizes Ivanov's viability construct by integrating lean and green practices into a viable, sustainable, and digital supply chain (VSDSC) model.	Treats viability primarily through the lean-green operational lens; leaves unaddressed the human-centric dimension that I5.0 foregrounds; and treats risk governance as a technological capability rather than an integrated measurement concern.	Supports SC360PM's adoption of VSC theory as a long-horizon survivability logic, while motivating the inclusion of human-centric and risk governance attributes.
Zekhnini et al. [47]	Proposes a multi-level holarchy in which SCM, technology implementation, and performance capabilities operate as coupled holons across strategic, tactical, and operational layers.	Mechanistically rich at the architectural level but leaves human-centricity peripheral and treats risk only marginally; the holonic framework is paradigmatically I4.0 and does not engage with the I5.0 value orientation.	Endorses SC360PM's systems-theoretic grounding and its network-level orientation, while justifying the extension of holonic logic and the dynamic capabilities mechanism.
Tripathi & Roy [64]	Proposes a dynamic-integrated-performance-system (DIPS) in RBV and dynamic capabilities, arguing that SCP and organizational strategic performance must be measured as one integrated system.	Theoretical integration is asserted at the conceptual level but not operationalized into measurable attributes or KPIs; the study is a literature review without empirical validation.	Affirms RBV/DC as SC360PM's mechanistic foundation; motivates operationalizing integration into five dimensions and eighteen measurable attributes.
Saleheen & Habib [12]	Develops and empirically validates the ISCPM model with ten performance attributes (including resilience and workplace health) across 24 manufacturing sectors using AHP and SEM.	Does not engage the I5.0 reorientation; the ten attributes are placed in parallel rather than theorized as expressions of an integrated value orientation; geographically bounded.	Demonstrates that multi-attribute, empirically validated SCP architectures are feasible at scale, and motivates SC360PM's use of multi-sector empirical validation.

3. Review Methodology

The methodology selected for this study is an integrative literature review that synthesizes empirical and theoretical contributions to develop a thorough understanding of the phenomenon. As one of the broadest categories of literature review, the integrative approach accommodates diverse research designs and methods and is well-suited to both mature and emerging topics [99]. It also supports knowledge synthesis across disciplines, enabling the formulation of novel theoretical frameworks and the identification of gaps in the existing body of research [100,101].

The approach has been applied in SCM research [102,103] and was selected here for its ability to critique a wide range of literature, draw insights from diverse theoretical and empirical perspectives, and support the development of a novel management framework. The integrative review differs in purpose from a systematic review or meta-analysis. While systematic reviews and meta-analyses prioritize exhaustive coverage and, in the latter case, statistical aggregation of effect sizes, the integrative review pursues theory-building synthesis that clarifies dimensions, resolves inconsistencies in constructs, and enables cumulative measurement development [99,104]. The primary output of this synthesis is the SC360PM framework.

Following the framework established by Whittemore and Knafl [99], the review process encompasses five essential stages:

1. Problem identification;
2. Literature search;
3. Data evaluation;

4. Data analysis;
5. Presentation of findings.

The methodology also incorporates guidance from Snyder [100], which emphasizes careful review design, critical analysis, and rigorous synthesis. A structured, transparent selection process is recommended practice for integrative reviews [100,101]. PRISMA 2020 [105] is applied here strictly to structure the reporting of the literature identification and selection process, and no claim of systematic-review compliance with PRISMA guidelines is intended. Accordingly, the elements applied include the review rationale and objectives, eligibility criteria, information sources and search strategy, the study selection process, and the study selection flow diagram (Figure 1).

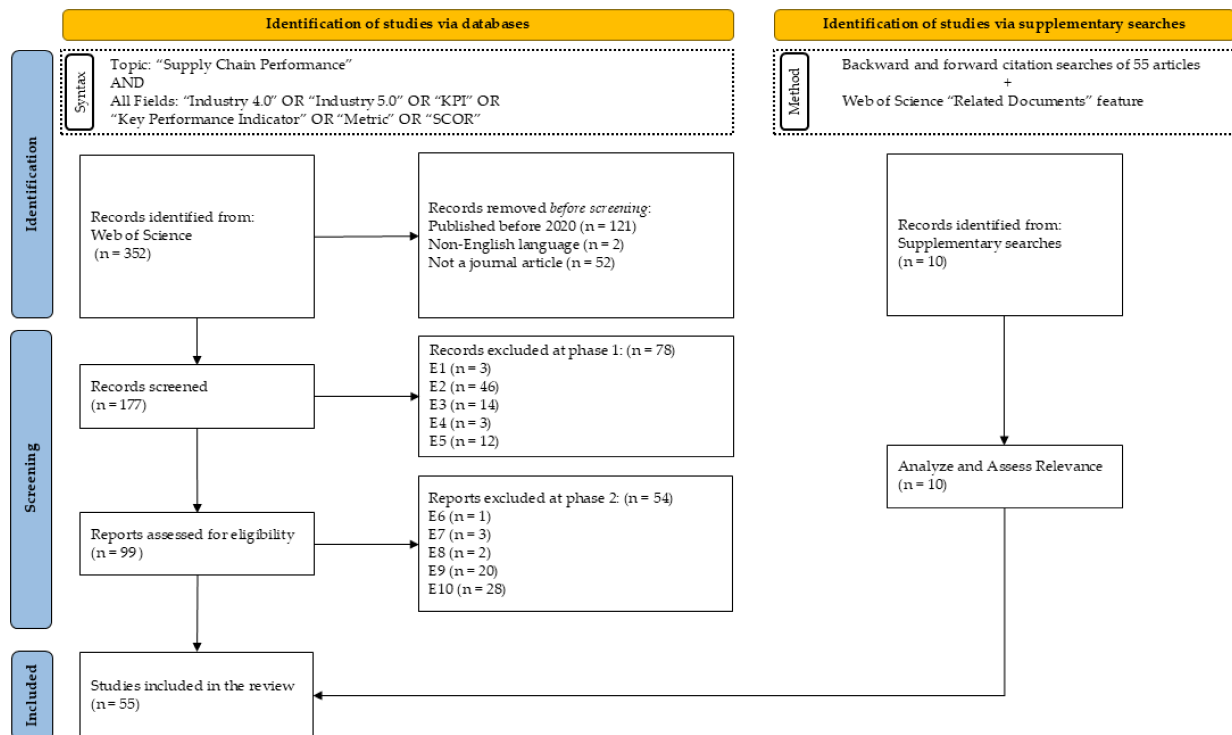


Figure 1. PRISMA 2020 Flow Diagram for the Integrative Review.

3.1. Search Strategy

The Web of Science database was systematically searched using a single Boolean query that combined the core construct with related performance and paradigm terms. As documented in Figure 1, the query is: TS = ("Supply Chain Performance") AND ALL = ("Industry 4.0" OR "Industry 5.0" OR "KPI" OR "Key Performance Indicator" OR "Metric" OR "SCOR"). The Topic tag (TS) searches title, abstract, and keywords, while the All Fields tag (ALL) additionally captures the secondary terms wherever they appear in the record, ensuring comprehensive coverage and avoiding narrow keyword dependence, a recognized limitation in field-specific reviews.

Web of Science was selected as the primary database because of its established quality filter for peer-reviewed scholarship in management and operations research and its strong indexing of leading SCM journals. This choice is consistent with bibliometric evidence identifying Web of Science as the most selective of the major citation indices, indexing a high-quality core of which 99.11% of titles are also covered by Scopus [106]. Web of Science was therefore adopted as a rigorous quality filter appropriate to a review prioritizing peer-reviewed scholarship, with the residual coverage gap relative to broader indices addressed through the supplementary citation searches and acknowledged as a limitation. The search

was initially executed in June 2025 and subsequently updated in March 2026. Eligibility was restricted to peer-reviewed journal articles published in English between 2020 and 2026; these restrictions were applied as automated database-level filters. This window captures the post-pandemic acceleration of resilience and viability research and the emergence of I5.0 as a policy construct and an evolving academic paradigm.

3.2. Screening and Selection

The initial database query returned 352 records from Web of Science. An automated filter applied at the database level removed 175 records (121 published before 2020, 2 not in English, and 52 that were not journal articles). The remaining 177 records advanced to manual screening.

Phase 1 screening was conducted based on the title, abstract, and keywords. Records were assessed against the five exclusion criteria detailed in Table 3, which together establish broad relevance and basic eligibility. When in doubt at this stage, records were retained for full-text assessment in keeping with conservative screening practice. Phase 1 excluded 78 records, leaving 99 for full-text review. Criterion E3 requires explicit justification because journal rank is a source-level proxy rather than an article-level quality. This criterion was adopted for two main reasons. First, integrative reviews aim to synthesize concepts and findings rather than aggregate effect sizes, making formal risk-of-bias instruments used in systematic reviews inapplicable; therefore, a transparent source-level credibility screen has become the standard pragmatic alternative [99,100]. Second, the criterion was consistently applied in Phase 1, resulting in the removal of 14 records, and its application is explicitly documented. The trade-off is acknowledged as a limitation in the next section, and none of the structural findings of the review rely on prevalence estimates that could be distorted by this exclusion.

Table 3. Exclusion criteria applied during phase 1 screening of titles, abstracts and keywords.

Code	Criterion
E1	No relevance to SCM or SCP
E2	Supply chain focus present but no or limited focus on performance measurement, metrics, KPIs, or evaluation frameworks
E3	Published in a Q3, Q4, or unranked journal (per Scimago SJR)
E4	Article retracted
E5	Not a journal article (book chapter, conference paper, editorial or letter) *

* Applied to records misclassified by the database's document-type metadata.

Phase 2 screening was conducted through full-text assessment of the remaining 99 records, evaluating depth of contribution and alignment with the review's analytical scope. Records were assessed against the five exclusion criteria detailed in Table 4. At this stage, retain or exclude decisions were documented with explicit justification. Phase 2 excluded 54 records, leaving 45 studies from the database search.

To ensure comprehensive coverage and minimize the risk of missing seminal or highly relevant works, supplementary searching was conducted following full-text screening. This included forward and backward citation searches of the confirmed included articles using Google Scholar, as well as the Related Documents feature in Web of Science. All additional records were subjected to the same inclusion and exclusion criteria used during the primary screening phases. These supplementary searches identified 10 additional studies that met all criteria, bringing the final sample to 55 (45 from the database search and 10 from citation searches), see Supplementary Material File S1. Figure 1 documents the study selection process in accordance with PRISMA 2020 guidance.

Table 4. Exclusion criteria applied during phase 2 full-text assessment of remaining records.

Code	Criterion
E6	Full text unavailable or inaccessible despite reasonable retrieval attempts
E7	Performance measurement is addressed in a domain entirely unrelated to supply chains
E8	Purely speculative content with no conceptual, methodological, or empirical contribution to SCP measurement
E9	Application of SCOR without adaptation, novelty, or critical engagement
E10	Focus restricted to a single, narrowly isolated operational metric without broader relevance to SCP frameworks

All 55 studies contributed to the development of SC360PM, which informs both the structural gap analysis and design requirements in Section 4, as well as the five dimensions and eighteen attributes derived in Section 5. The complete attribute–study mapping is reported in Appendix A (Table A1), which details how all 55 studies correspond to the eighteen attributes. Each included study was read in full, and every performance metric or attribute it proposed, evaluated, or operationalized was meticulously recorded. Synonymous and overlapping constructs were grouped through iterative comparison. For example, delivery reliability, order fulfillment rate, and perfect order fulfillment were merged into the Fulfillment Excellence Rate (RA1); supplier on-time delivery, quality conformance, and supplier flexibility measures were combined into the Supplier Reliability Index (RA2); and carbon intensity, Scope 1–3 emission reduction, and emissions-monitoring indicators were merged into the Decarbonization Momentum Score (SE1). These consolidated attributes were then clustered and iteratively refined until each attribute could be assigned to one dimension. This process resulted in the creation of the five dimensions and eighteen attributes of the SC360PM framework. All screening decisions were made by the first author based on the criteria outlined in Tables 3 and 4. The extraction and consolidation of attributes were also conducted by the first author, with consolidated attributes named to reflect the shared measurement intent of the constructs they encompass. The co-authors subsequently reviewed the attribute names, definitions, and dimension assignments, resolving any disagreements through discussion. A formal multi-coder design with intercoder-agreement assessment was not utilized.

3.3. Methodological Limitations

The review acknowledges three methodological limitations. First, the focus on peer-reviewed journal articles may overlook practitioner-oriented frameworks and industry standards that contribute substantively to performance management in practice; this concern is partially mitigated by the explicit treatment of the SCOR DS framework, which incorporates a major industry-developed standard. Relatedly, the journal-rank criterion (E3) may have excluded relevant contributions in emerging or unranked outlets, a trade-off accepted in exchange for a uniform, transparent credibility filter. Second, the use of a single primary database may have excluded studies indexed in alternative databases. This limitation is partially mitigated by the supplementary backward and forward citation searches. Third, because screening, extraction, and construct consolidation were performed by a single researcher, the synthesis is subject to interpretive subjectivity. This concern is partially mitigated by the explicit two-phase exclusion criteria in Tables 3 and 4, the co-authors' review of attribute definitions and dimension assignments, and the transparent reporting of all selection decisions. Expert content validation specified as the first stage of the validation pathway in Section 6.3 provides a further external check on the attribute taxonomy.

4. Findings of the Integrative Review: Structural Gaps and Design Requirements

This section presents the findings of the integrative review. Unlike Section 2.3, which summarizes the conclusions of earlier literature reviews, this section reports the results of the selected articles. The three analytical patterns identified through the critical assessment of prior literature reviews are further developed here into the specific design gaps that frame the rationale of the SC360PM framework. These gaps recur across most of the 55 reviewed studies with enough consistency to suggest structural limitations.

4.1. The Efficiency Bias and the Need for Multidimensional Performance

Financial and efficiency-related performance attributes are indispensable, and nothing in the analysis that follows questions their inclusion: SC360PM retains them as a full, coequal dimension. The problem here is not their presence, but their structural dominance—the dominant tradition in SCP remains anchored in an efficiency paradigm inherited from operations management and financial accounting [19,41,46,58]. Despite sustained scholarly advocacy for broader indicators, this tradition sustains an implementation gap between scholarship and practice [20,46]. Some studies observe that performance measurement in the supply chain literature has typically been organized around two metric families: cost metrics, dominated by inventory and operating costs, and non-cost metrics, focused on customer responsiveness, flexibility, delivery time, and quality [55,107]. In practice, however, the cost family enjoys primacy [46].

This bias actively influences firm strategy, internal capability development, managerial cognition, and strategic decision-making [11,17,46]. When firms instrument their supply chains around lead time, inventory turns, and cost, they implicitly assume a steady-state operating environment in which disturbances are treated as exogenous shocks to be absorbed. As a result, reliance on static efficiency is insufficient to cope with dynamic and complex environments [34,65,108], and supply chains optimized purely around cost and throughput accumulate hidden structural costs (in inventory, emissions, and service trade-offs) that remain invisible to single-dimension measurement systems [34]. Accordingly, performance measures and metrics should be standardized and diverse, encompassing both financial and non-financial aspects to capture the heterogeneity of business requirements and risks under disruption [17,109]. The bias surfaces even within frameworks explicitly designed to extend traditional measurement. For example, when Ozbiltekin-Pala et al. [88] asked manufacturing experts to prioritize seventeen Circular-SCOR criteria, demand fulfillment, operational flexibility, and cost dominated the ranking, while circular criteria ranked lowest. The pattern persists even in sustainability-oriented sectors: in e-waste supply chains, whose operational mission is inherently environmental, cost attributes account for nearly 25% of the total performance weight, while social criteria receive less than 4% [33].

The pandemic, cascading geopolitical disruptions, and climate-related supply interruptions have revealed the untenability of this assumption [5,88]. Consequently, an efficiency-optimal supply chain often proves to be fragile [4,18], and frameworks that fail to account for fragility cannot effectively guide its mitigation [6,19]. Research highlights a critical trade-off in which the pursuit of efficiency alone amplifies supply chain risk, making globally dispersed networks vulnerable to cascading effects [12,19,40,109]. Furthermore, issues such as weak construct discipline and fragmented taxonomy exacerbate the situation. In practice, studies categorized as financial-performance research frequently replace financial constructs with operational proxies. For example, Gangaraju et al. [39] assess financial performance through metrics related to delivery and supplier-relationship items instead of focusing on cost, profit, or asset measures.

Thus, a new generation of SCP frameworks must regard performance as a vector rather than a scalar, with each dimension possessing independent normative significance [6,19,20,34]. Accordingly, performance frameworks for the I5.0 era cannot simply append new indicators to existing systems; they must recalibrate the interplay among economic, environmental, social, and digital dimensions to ensure that no single category holds structural primacy by default [6,17]. The first design imperative is therefore an explicitly multidimensional performance architecture in which efficiency and financial health remain valid performance concerns among several, instead of being the dominant variables to which all others are subordinated.

4.2. The Industry 5.0 Integration Gap and the Need for an Integrated Architecture

No measurement system integrates the I5.0 pillars into a cohesive architecture [6]. While literature extends beyond efficiency, these extensions are often bilateral [6,13]. Three pairings dominate the empirical landscape. The first links resilience with sustainability, examining how green practices enhance recovery capacity and vice versa [8,88]. The second connects digital transformation with sustainability, positing that digital technologies serve as enablers of decarbonization, circularity, and overall green and sustainable SCM [20,95,110–113]. The third associates digital transformation with resilience, exploring how technologies improve efficiency, quality, and overall SCP [55,63,96,107,114]. A fourth strand attempts a three-pillar integration of digital, resilience, and sustainability constructs [2,35,108,115,116]. However, even these triadic efforts replace human-centricity with digital capability. The I5.0 triad itself, comprising human-centricity, sustainability, and resilience, remains unexamined as an integrated measurement object. Moreover, these efforts typically retain a hierarchical structure: one construct is the antecedent, and the others are mediators or outcomes. For instance, in Dixit et al. [108], I4.0 drives visibility, resilience, and sustainability sequentially towards performance, or in Belhadi et al. [116], I4.0 capabilities improve sustainable performance only when mediated through digital business transformation and organizational ambidexterity.

The empirical consequences of bilateral integration are visible even in frameworks that explicitly aim for breadth. Yang et al. [19] propose the Resilient-Sustainable Supply Chain Performance Measurement (RSSCPM) framework. It organizes SCP around four domains: resilience, economic performance, environmental performance, and social performance. However, their findings also show that these dimensions may create competing priorities. Actions intended to strengthen resilience, such as maintaining higher safety stock or using multiple suppliers, can increase storage-related energy use and transportation emissions. At the same time, a strong emphasis on sustainability, such as relying heavily on a single environmentally preferred supplier, may reduce flexibility during disruptions. Srivastava et al. [36] illustrate the same pattern from the social side. They link human-centric practices to delivery performance in isolation from other dimensions.

I5.0 should function as a redefinition of the relationships among performance attributes [17,22]. Its foundational triad assumes that these dimensions are coequal and mutually influential. Ivanov [24] supports this perspective, framing I5.0 as an integration based on viability. Jamil et al. [98] demonstrate that I5.0 technologies improve SCP and mitigate risk only when channeled through sustainable supply chain practices. The decisive implication is that genuine I5.0 performance depends on human-machine complementarity rather than substitution. A supply chain that gains resilience by exploiting or displacing workers, or that digitizes sustainability reporting while removing the human judgment that would catch reporting errors, is not delivering the required performance, even if each isolated indicator improves [117].

What is required is an integrated architecture in which I5.0 constructs, together with efficiency and financial dimensions, are arranged as coequal performance axes. The second design imperative is therefore architectural integration. The framework should arrange the resilience, sustainability, and human-centric dimensions alongside, not subordinate to, the operational and digital dimensions. This architecture makes the central claim explicit: I5.0 performance depends on integrated, coequal dimensions rather than isolated improvements.

4.3. *The Human-Centric Measurement Gap and the Need for Constitutive Social Metrics*

Treatment of the social dimension has attracted markedly less empirical attention than its environmental and economic counterparts [36,41]. Metrics for human–machine collaboration, worker mental well-being, equity, and skill development remain scarce across the reviewed literature [6,13,23]. Where environmental sustainability has acquired a mature measurement vocabulary anchored in carbon, water, waste, and circularity indicators, social performance is typically operationalized as a compliance checklist. Human-centricity differs from conventional social sustainability by extending beyond compliance with labor standards to encompass human agency, capability development, well-being, learning, equity, and human–machine collaboration. Srivastava et al. [36] frame it in terms of monetary benefits, training, health and safety, and policy awareness; Aprilia et al. [118] reduce it largely to health and safety within a broader job-opportunity and community-relations frame. This pattern is reinforced by evidence from the fashion industry: even in sector-specific frameworks designed to operationalize all three TBL dimensions, social indicators reduce to wage compliance, child labor prohibition, and basic safety standards, with no leading indicators of capability development or human–machine complementarity [119]. The asymmetry is sharpest in recent MCDM-based prioritization. Štreimikienė et al. [120] populate the social dimension with three indicators, ethical sourcing, human–robot collaboration, and customer engagement, and find that ethical sourcing alone absorbs 70.6% of the dimensional weight, with worker well-being, capability development, and equity absent from the indicator set altogether.

A human-centric approach is crucial because process enhancements must align with worker outcomes [26]. I5.0's human-centric pillar complements this logic. It treats workers as the primary locus of judgment, creativity, and adaptive intelligence in increasingly automated supply chains, and positions human–machine complementarity, rather than automation intensity, as the defining characteristic of the next operating model [98,117]. Empirical evidence supports this re-centering. De Araújo et al. [26] show that worker outcomes—productivity, collaboration, flexibility, and quality of work—are conceptually and statistically distinct from operational performance, and that gains in one do not automatically translate into gains in the other. Yang et al. [19] classify employee well-being as the effect-group metric with the strongest dependence on other determinants in their RSSCPM analysis, and Vergara et al. [57] find that working conditions and social responsibility exert the greatest influence on performance. In another study, Vergara et al. [37] report that all four social criteria in their resilient–sustainable framework ranked among the top ten according to expert consensus, suggesting that the under-measurement reflects the framework's design rather than practitioner indifference. The omission nonetheless persists, even in technology-forward contributions that explicitly adopt I5.0 framing: Tsang et al. [115] extend SCOR with circularity and digital dimensions, and invoke I5.0's value reorientation throughout, yet operationalize only sustainability and resilience, leaving the human-centric pillar entirely outside the measurement architecture. Nazarian and Khan's [22] study positions itself within the I5.0 paradigm but operationalizes performance through an essentially I4.0 architecture, omitting human-centric outcomes entirely.

Sharma et al. [117] display the same gap from the adoption side: although their I5.0 analysis foregrounds human–machine collaboration, machine ethics, and worker trust as central concerns, these remain qualitative solution initiatives rather than measurable performance outcomes.

Where social indicators appear at all, they tend to be lagging, compliance-oriented, and disconnected from operational and digital metrics, making it impossible to demonstrate that human-centric investments produce measurable performance gains [95]. Even recent agri-food SCP designs operationalize the social dimension through inter-organizational constructs such as cooperative relationships and socio-economic policies [121], leaving worker-centric performance outside the measurement architecture. As a result, this perpetuates a self-fulfilling cycle in which the social dimension is treated as a cost center of secondary importance because it cannot be shown to create value [122,123]. In the e-waste supply chain, social criteria rank lowest not because practitioners discount them, but because the available metrics cannot demonstrate strategic value [33]. The third design imperative is therefore to elevate human-centric measurement from a compliance appendix to a constitutive performance dimension, with leading indicators of workforce capability, engagement, learning, well-being, and human–machine complementarity that can be benchmarked alongside cost, service, emissions, and digital maturity metrics.

4.4. Synthesis: Design Requirements for an Industry 5.0 SCP Framework

Taken together, the examined limitations motivate stringent design requirements. An I5.0 SCP framework must satisfy the following criteria.

1. **Multidimensionality:** The framework must treat performance as a vector across distinct dimensions, where efficiency and responsiveness coexist with resilience, sustainability, digital, and human-centric axes, with no single dimension serving as the master objective to which the others are reduced;
2. **Integrated I5.0 architecture:** The framework's internal structure must encode the coequal, mutually conditioning relationship among human-centricity, resilience, and sustainability, rejecting strictly causal arrangements in favor of coequal, simultaneously measurable performance axes;
3. **Constitutive human-centric measurement:** The social dimension must be elevated from compliance auditing to a fully developed performance axis, populated with leading indicators of workforce capability, engagement, learning, well-being, and human–machine complementarity that can be benchmarked alongside operational, environmental, and digital metrics;
4. **Constitutive digital and innovation dimension:** The framework must include a digital and innovation axis that captures the technological and analytical capabilities through which contemporary supply chains operationalize the other dimensions, instead of treating technology as an exogenous driver of efficiency. Although digitalization is not one of the three core I5.0 pillars, it is an enabling capability through which firms operationalize resilience, sustainability, and human-centric performance;
5. **Operationalizability, multi-level structure, and validation readiness:** The framework must decompose each dimension into measurable attributes and be structured for empirical validation across sectors and time, rather than remain a purely conceptual proposition, responding to level fragmentation;
6. **Diagnostic balance:** Emerging from the conjunction of the previous five requirements, this criterion demands that the framework expose performance across all dimensions simultaneously, allowing decision-makers to recognize trade-offs and complementarities *ex ante* instead of discovering them only after dimension-specific optimization has produced unintended consequences elsewhere in the system.

These six requirements jointly define the design space for the SC360PM framework.

5. Development of the SC360PM Framework

SC360PM reconceptualizes SCP as a multidimensional vector, organized around five coequal, interdependent dimensions and eighteen operational attributes, designed to expose the complementarities and trade-offs that efficiency-focused architectures systematically obscure. It integrates the process discipline of SCOR DS with the value orientation of I5.0, the long-horizon survivability logic of VSC theory, and the explanatory lenses provided by the RBV, dynamic capabilities, and systems theory. Figure 2 summarizes the architecture.

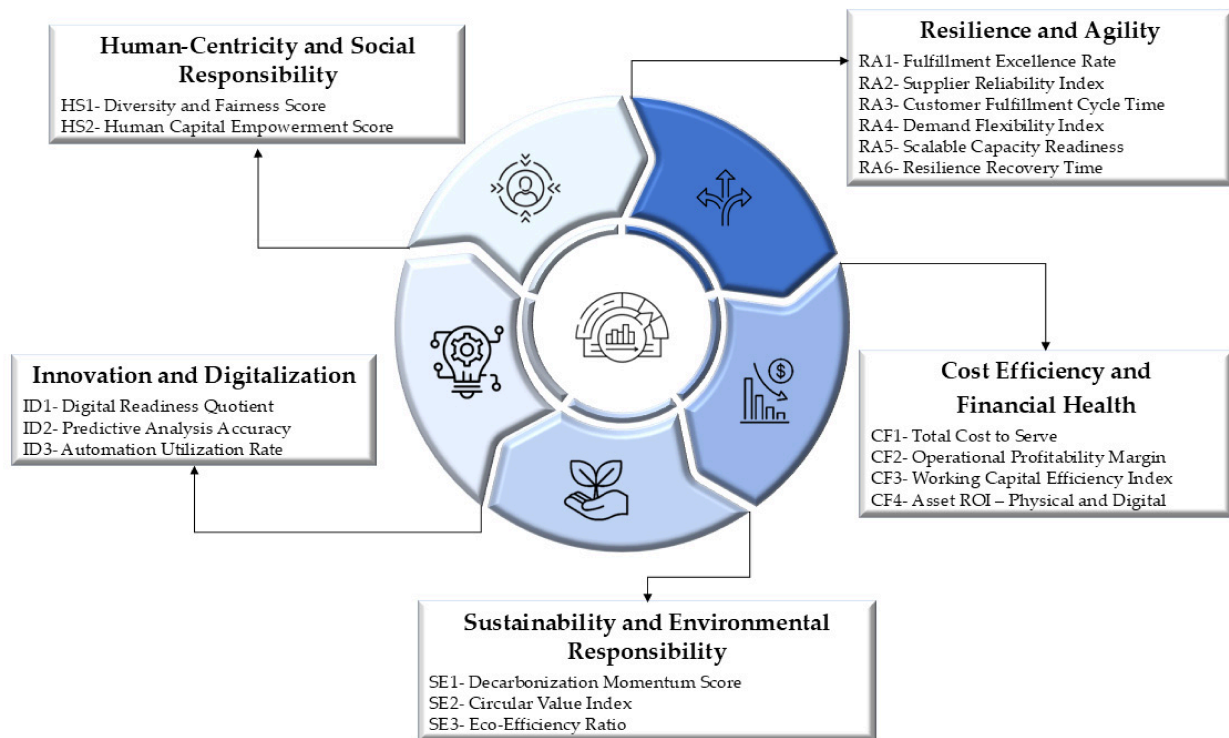


Figure 2. Supply Chain 360° Performance Management (SC360PM) framework: five dimensions and eighteen performance attributes.

SC360PM is primarily a performance management framework: its purpose is to structure how performance information is interpreted and acted upon, not merely to quantify outcomes. The other characterizations are nested within this function rather than competing with it. Measurement is its content—the five dimensions and eighteen attributes specify what must be observed; diagnosis is its mode of use—the dimensions are read jointly to expose trade-offs and complementarities rather than aggregated into a single compensatory score; and governance is its institutional expression—dimension ownership, guardrails, review cadence, and documented weighting determine whether the diagnostic signal changes managerial action. SC360PM is therefore a performance management framework that contains a measurement architecture, not a measurement instrument, a maturity model, or a reporting standard.

The framework proceeds from a simple premise: SCP in the I5.0 era should be evaluated as the joint ability of the supply chain to deliver reliable service, preserve financial viability, reduce environmental burden, exploit digital capability, and protect and develop its workforce, so that managers can assess performance across outcomes that matter in practice. By construction, SC360PM is designed to satisfy the six design requirements derived in Section 4.4, as summarized in Table 5.

Table 5. How SC360PM is designed to satisfy the design requirements.

Requirement		SC360PM Feature
1.	Multidimensionality	Five structurally distinct performance dimensions
2.	Integrated I5.0 architecture	Coequal dimensions with literature-grounded interdependencies; empirical mapping specified in Section 6
3.	Constitutive human-centric measurement	Human-centricity and social responsibility dimension (Section 5.5), operationalized through composite attributes
4.	Constitutive digital and innovation dimension	Innovation and digitalization dimension (Section 5.4)
5.	Operationalizability, multi-level structure, validation readiness	Eighteen measurable attributes spanning firm- and network-level metrics; attribute–study mapping (Table A1); validation pathway (Section 6)
6.	Diagnostic balance	Joint interpretation exposing cross-dimensional trade-offs

SC360PM is intentionally designed to be parsimonious. In contrast, SCOR DS specifies over 250 metrics across its attribute hierarchy [30]. This high density contributes to its implementation challenges [1,32]. Conversely, SC360PM outlines 18 attributes within 5 dimensions, functioning as a strategic measurement layer rather than an exhaustive catalog of metrics. More specifically, the framework aims to extend SCOR DS. When SC360PM attributes align with established SCOR DS attributes, organizations can implement them using existing SCOR DS level-1 and level-2 metrics. In areas where SCOR DS lacks detail, SC360PM establishes the measurement space that future metric development must address. This approach to parsimony can be considered as a response to the financial-bias equilibrium: a framework can replace entrenched, efficiency-dominated practices only if it is sufficiently compact to be integrated with existing reporting structures.

SC360PM is organized around five performance dimensions, each decomposed into several performance attributes: resilience and agility (six attributes); cost efficiency and financial health (four attributes); sustainability and environmental responsibility (three attributes); innovation and digitalization (three attributes); and human-centricity and social responsibility (two attributes). Attribute labels follow the consolidation procedure reported in Section 3.2. Where a consolidated attribute corresponds to a single established construct, the established term is retained; where it merges several synonymous or overlapping constructs, a unifying label is assigned, and the constituent constructs and their sources are identified in the attribute definition.

The number of attributes per dimension reflects the granularity at which each construct is currently measured in the reviewed literature, not its relative importance. The resilience and agility dimension decomposes into six attributes because it is the most extensively instrumented domain in the post-2020 corpus (Table A1), and the literature reliably distinguishes its facets at that resolution; human-centricity, by contrast, is the least instrumented domain, and imposing a finer decomposition than the evidence supports would manufacture false precision. The two human-centric attributes are deliberately composite; each bundles several named leading indicators so that organizations can translate undermeasured concerns into actionable evaluation criteria. This composite design keeps every sub-indicator visible and separately reportable while acknowledging the current immaturity of human-centric measurement; the progressive decomposition of these composites into free-standing attributes, as measurement practice matures, is an explicit priority of the validation agenda.

The five dimensions are analytically separable but operationally interdependent, and the reviewed literature supports this proposition. Financial health provides the investment capacity needed to fund resilience buffers, digital infrastructure, and sustainability upgrades [19]. Digital capability generates the visibility and predictive analytics that both disruption response and environmental monitoring depend on [40,63,113,114]. Human-centric work systems provide the adaptive judgment that automated processes cannot replace, particularly under conditions of disruption or novel failure [2,26,45,98]. Sustainability initiatives reduce material waste and energy intensity, thereby lowering operating costs and reducing exposure to supply risk [36,108,123]. These relationships are treated here as literature-grounded propositions; none is tested by the present review.

5.1. Resilience and Agility

Resilience refers to the supply chain's capability to anticipate, absorb, adapt to, and recover from disruptions while maintaining operational continuity [19,124,125]. Agility emphasizes the ability to respond rapidly and effectively to short-term changes in demand, supply, or market conditions [7,121], leveraging real-time analytics and data streams to support timely decision-making and adaptation to disruptions [17]. Although analytically distinct, resilience operates across disruption timescales [19], while agility addresses sudden, short-horizon demand variability [39,57]. Both share an adaptive foundation and interact empirically [7], so their co-location in a single dimension therefore reflects functional interdependence rather than conceptual conflation. From the VSC perspective, these capabilities are fundamental to long-term survivability, rather than supplementary to efficiency [4]. This prioritization is empirically supported by recent expert-based evaluations, which indicate that supply chain resilience is the dominant strategic performance dimension during digital transformation [120,126]. Recent studies further identify resilience and agility as critical drivers of adaptive capability in SCP [17,108]. SC360PM operationalizes this dimension through six specific attributes.

Fulfillment Excellence Rate (RA1) measures whether customer and return orders are delivered correctly and completely (on-time-in-full) [20,36,52,127]. This is increasingly relevant in circular and omnichannel supply chains, where high return volumes and complex service expectations require measuring both outbound delivery reliability and inbound recovery performance [88]. It also serves as an execution-related reliability indicator and provides early warning of network instability, as sharp declines in this attribute often precede deeper operational disturbances [67,128]. Empirical prioritization studies consistently identify RA1 as a central criterion, with experts repeatedly ranking it as the highest priority [8,11,88].

Supplier Reliability Index (RA2) captures upstream dependability through a composite assessment of on-time delivery, order accuracy, quality conformance, lead time adherence, flexibility, and cost stability [118,129,130]. While supplier evaluation frameworks are increasingly incorporating social and environmental dimensions alongside economic criteria, economic factors continue to hold the highest overall importance in practice [130]. As supply chains become more geographically dispersed and multi-tiered, supplier unreliability has surfaced as a significant cause of production stoppages and widespread disruptions [83,129]. The index functions as both a diagnostic tool, distinguishing between low-cost and genuinely dependable suppliers, and a predictive tool, facilitating early intervention through development programs, audits, or multi-sourcing strategies [12,76,131]. Because supplier performance depends on inter-firm coordination, the index also serves as a central point for assessing coordination and cooperation among supply chain partners [55,76,80].

Customer Fulfillment Cycle Time (RA3) quantifies the end-to-end duration required to complete customer orders, encompassing source, make, and delivery components [8,20,52]. Shorter lead times are often treated as the origin of agility [121]. Consequently, shorter and more stable cycles reflect faster adaptation to demand fluctuations and stronger operational control. In contrast, irregular or prolonged cycles often signal bottlenecks and the propagation of disturbances across the network [12,40,58]. Expert-based prioritization confirms this centrality: lead time carries the highest global weight among all resilience KPIs evaluated [40]. This attribute functions as a responsiveness indicator [8,132], and its breakdown into component cycle times enables targeted intervention at specific points of delay.

Demand Flexibility Index (RA4) assesses the supply chain's ability to absorb short- to medium-term demand variability without compromising service levels, lead times, or inventory efficiency [8,121]. It serves as a key indicator of responsiveness and flexibility [133,134], and evaluates structural preparedness. Specifically, it captures the operational flexibility that allows the supply chain to sustain performance when demand deviates from expectations [33,94,109]. Empirical studies confirm that agility operates as the dominant pathway through which digital capability translates into resilience [5]. Further, evidence from the manufacturing sector underscores its centrality during periods of disruption [35,88]. The COVID-19 pandemic produced a bullwhip effect of exceptional scale [135], exposing the limits of forecast-driven control and reinforcing the case for demand absorption as a measurable performance attribute [109,136].

Scalable Capacity Readiness (RA5) evaluates the structural capability of the supply chain and organization to expand, repurpose, or reconfigure production and service capacity in response to sustained change rather than short-run reaction [45,51,137]. Unlike RA4, which captures operational absorption of short- to medium-term demand variability within existing capacity, RA5 evaluates the organization's structural ability to reconfigure its capacity base in response to sustained or transformational change. This attribute reflects strategic elasticity, encompassing the ability to scale operations, reconfigure manufacturing lines, redeploy human capital, or shift to alternative service channels [138]. It relies on modular infrastructure, cross-trained teams, and reconfigurable automation [139]. Illustrative operationalizations include volume flexibility indicators, which measure the maximum sustainable output increase achievable within a defined planning horizon and the time required to achieve it. Other indicators include line changeover or repurposing time, the share of a cross-trained workforce, and the proportion of modular or reconfigurable assets [138,139]. It is particularly relevant to the smart factories and personalized production models associated with I5.0 [22,117,138]. Gangaraju et al. [39] find modularity to be the strongest predictor of agile supply chain capability.

Resilience Recovery Time (RA6) measures the time elapsed between the onset of disruption and the restoration of standard performance, decomposed into time to detect, time to act, and time to recover [6,40,140]. This decomposition reflects the established detect–respond–recover sequence [140] and aligns with emergency-management capability frameworks [19]. RA6 consistently ranks among the highest-priority resilience KPIs in expert-based evaluations [40]. It captures sustained stabilization rather than short-term responsiveness [35] and directly operationalizes viability. Prolonged disruptions increase the risk of customer loss, reputational damage, and operational inefficiency [109,128]. Traditional frameworks frequently assess performance indicators in isolation, obscuring recovery dynamics and systemic vulnerabilities. Resilience Recovery Time directly addresses this measurement gap [6,19,120].

5.2. Cost Efficiency and Financial Health

The cost efficiency and financial health dimension maintains SCP's economic foundation. Metrics such as cost, profitability, liquidity, asset turnover, return on investment, and cash-to-cash cycles continue to inform strategic decisions across supply chains and are deeply embedded in financial systems and performance contracts [12,46,58,141]. However, the literature demonstrates that financial measures should not be the sole focus of performance assessment, as sustainable and resilient supply chains require a balanced approach that incorporates economic, social, and environmental objectives [19,46]. Profitability, in particular, has been identified as the most influential determinant in integrated resilient-sustainable performance frameworks, providing the financial resources necessary for subsequent capability investments [19]. SC360PM, therefore, includes these metrics as a core dimension but intentionally limits their traditional dominance by granting equal importance to the other four dimensions. This dimension is operationalized through four attributes.

Total Cost to Serve (CF1) measures the end-to-end cost required to fulfill customer demand, including planning, procurement, production, warehousing, transportation, returns, IT, supply chain governance costs, and COGS, often expressed as a percentage of revenue [20,52,58,142]. Recently, reverse logistics and innovation costs have been proposed as new KPIs for DSCs [11]. Unlike traditional siloed cost metrics, this attribute reveals the true cost of serving specific products, channels, or customer segments, which is critical for making informed decisions regarding pricing, product design, and channel strategies [33,142,143]. A nominally low-cost supplier may incur high downstream logistics costs that negate initial savings, an insight visible only through end-to-end cost-to-serve analysis [141]. Additionally, measuring end-to-end cost should also consider the time value of money and revenue justification throughout the entire order cycle, because upstream planning investments can reduce downstream costs [33].

Operational Profitability Margin (CF2) measures earnings before interest and taxes (EBIT) as a percentage of revenue, isolating the financial outcome attributable to core operations from the effects of financing and taxation [1,12,58]. This attribute specifically assesses the profitability of supply chain operations [8,19]. It enables consistent benchmarking across firms with varying capital structures and tax policies. It also indicates how operational design choices, digitalization investments, and process improvements contribute to profit creation [46]. Recent work links digital transformation to profitability, testing whether digital initiatives generate financial outcomes rather than remaining operational improvements disconnected from profitability [5,95,144].

Working Capital Efficiency Index (CF3) evaluates liquidity and capital productivity by analyzing cash-to-cash cycle time and return on working capital, using revenue, costs, inventory, accounts receivable, and accounts payable [58,141]. Shorter cycle times typically signal improved liquidity [33,145], but the framework emphasizes strategic balance: working capital must be fast-moving yet sufficient to support supplier relationships, inventory buffers, and shifting market demands [46,146]. This attribute facilitates stress testing and capital optimization by linking short-term liquidity management to long-term financial health.

Asset ROI for Fixed and Digital Assets (CF4) quantifies the returns generated by capital investments in both physical infrastructure (plants, fleets, equipment) [58,67] and digital infrastructure (ERP systems, AI platforms, robotics, IoT) [144,147]. As digital technologies become central to supply chain operations, SCOR-extension and digitally oriented SCP studies increasingly support the evaluation of digital technology as a distinct performance domain alongside traditional asset-management measures, reflecting the need to assess digital investments on their own measurable terms [20,67]. Explicit tracking of digital

asset ROI serves as both a performance diagnostic and a strategic signal. Persistently low returns indicate the need to review deployment strategies, whereas strong returns demonstrate that digital asset productivity enhances financial performance, adaptability, and innovation concurrently [11,26]. CF4 captures the financial-return view of digital and physical assets and is therefore situated in the financial dimension, complementing the capability-oriented view of digital investment measured in the innovation and digitalization dimension.

5.3. Sustainability and Environmental Responsibility

In SC360PM, the dimension of sustainability and environmental responsibility specifically addresses environmental sustainability, while social sustainability is encompassed within the dimension of human-centricity and social responsibility. The sustainability dimension translates environmental concerns into measurable operational performance [120], with a focus on emissions reduction [7,34], circularity [88,113], and resource efficiency [8]. I5.0 positions environmental stewardship as a foundational performance objective and transforms corporate social responsibility (CSR) from a compliance obligation to a strategic approach [148]. Accordingly, measurement systems are required to capture decarbonization progress and circularity at the operational level effectively [6,20,112]. Sharma et al. [123] indicate that environmental factors are the highest-priority driver of I4.0 adoption, with reduced emissions and production waste identified as causal variables influencing the broader sustainability system. Consequently, SC360PM operationalizes this dimension through three attributes that elevate sustainability from compliance reporting to managerial performance.

Decarbonization Momentum Score (SE1) measures year-over-year reductions in Scope 1 (direct), Scope 2 (purchased energy), and Scope 3 (value chain) emissions, capturing the extent to which the supply chain is actively decarbonizing instead of merely reporting [112,120,149]. Because Scope 3 emissions often account for most of total emissions, value-chain coverage is essential for any credible measurement of decarbonization [149–151]. Measurement is expressed as the percentage change in emissions relative to the prior-year baseline, computed separately for each scope so that progress remains visible where it occurs rather than obscured by aggregation. Štreimikienė et al. [120] found that emissions monitoring and reduction is the highest-ranked environmental indicator and has a positive effect on financial performance [152]. In turn, the attribute supports identification of emission hotspots and targeted intervention through renewable procurement, logistics decarbonization, and network redesign while linking climate stewardship to long-term cost competitiveness and access to ESG-aligned capital [23,153].

Circular Value Index (SE2) measures the extent to which materials are reused, recycled, remanufactured, or diverted from disposal, assessed system-wide against total material consumption and waste generation [20,88,113]. Rather than prescribing a fixed indicator set, the attribute defines the measurement space that organizations populate with the circularity metrics relevant to their material profile, sector, and regulatory obligations. This attribute operationalizes the closed-loop logic that I5.0 explicitly endorses through circular-economy and 6R or 9R practices [117]. It is consistent with its regenerative industrial vision [154] and supports compliance with Extended Producer Responsibility [155] and the zero-waste policy [45]. High circularity performance reduces dependency on virgin inputs [88], which is an increasingly critical resilience capability under geopolitical supply risk and climate regulation [113,156]. Empirical prioritization in e-waste supply chains finds that active material recovery indicators, including recycling utilization and remanufacturing rates, receive greater performance weight than waste-diversion indicators, such as landfill reduction [33].

Eco-Efficiency Ratio (SE3) measures how effectively the supply chain converts energy, water, and raw materials into economic or physical output [8,41,122]. By linking environmental stewardship to productivity, the attribute makes sustainability measurable in operational terms rather than as an abstract commitment, and supports lean, low-impact operations, particularly in carbon- and water-intensive sectors such as textiles, chemicals, and food manufacturing [157]. The attribute also aligns directly with the I5.0 principle of respecting planetary boundaries while delivering operational output [21,25]. Recent empirical evidence further identifies energy consumption as among the most influential determinants of integrated resilient–sustainable SCP [19,120].

5.4. Innovation and Digitalization

Digitalization aims to improve operational efficiency and quality performance by systematically leveraging data to support production and operational processes, facilitate supply chain transformation, and enhance overall SCP [158]. As the technological complexity of DSCs increases, established KPI systems should be selectively expanded with a limited set of new digitally enabled indicators [11,97]. The innovation and digitalization dimension captures the technological and analytical capabilities that allow contemporary supply chains to operationalize the other four dimensions. I5.0 does not dismiss digitalization but reframes it: technology is viewed as an enabler of resilience, sustainability, and human augmentation rather than as an end in itself [22,70,98,111]. This perspective is supported by empirical evidence: technology adoption alone does not improve SCP and yields gains only when channeled through integration and visibility capabilities, with integration serving as a relational capability that builds visibility, a higher-order informational capability [2,7,26,63,80,133]. The dimension distinguishes strategic digital capability from tactical tool adoption and is operationalized through three attributes.

Digital Readiness Quotient (ID1) captures the strategic depth and organizational coherence of digital adoption across systems, people, governance, and decision processes [22,67,113,159]. It is further operationalized through indicators such as digital culture and talent, a clear long-term digital vision, and the systematic extraction of insights for data-driven decision-making [5]. The attribute is typically derived from structured frameworks that score the organization on a standardized scale across technology, people, governance, and processes. Crucially, the score reflects not just technical capability, but the cultural and organizational coherence needed to sustain innovation, distinguishing organizations that merely hold tools from those that deploy them coherently to support visibility, resilience, integration, and collaboration [35,63,96,147,160].

Predictive Analytics Accuracy (ID2) evaluates how well AI, machine learning, big data analytics capabilities, and statistical forecasting tools predict demand, risk, disruption, product failures, and lead times, comparing predicted to actual outcomes across multiple models and forecast horizons [17,147,161,162]. In this sense, the attribute captures whether digitalization is generating genuine foresight [35,45,112]. Predictive performance is the mechanism by which a supply chain transitions from reactive control to anticipatory management [45,65,163].

Automation Utilization Rate (ID3) measures the share of supply chain tasks performed through robotic, software, or intelligent automation—both physical (robotics, autonomous vehicles) [26,95] and digital (ERP integration, blockchain, voice-activated assistants) [26,80,95,115]. Consistent with digitization level KPI [11], the attribute is task-focused rather than capability-focused, complementing the ID1 by measuring actual operational deployment. Higher automation rates correlate with reduced cycle times, improved accuracy, and reduced reliance on manual labor for repetitive tasks [35,79,95,108], yet I5.0 frames automation specifically as a human-augmenting strategy: the relevant question is

not whether automation exists but whether it improves throughput, resilience, safety, and work quality in measurable ways [22,26,117]. Accordingly, the attribute is read through the character of deployment: I5.0-aligned automation relieves workers of repetitive and hazardous tasks and redeploys human capacity toward judgment-intensive roles, so a rising rate obtained by displacing workers or degrading work quality does not register as improved performance [26,70,117].

5.5. Human-Centricity and Social Responsibility

The human-centricity and social responsibility dimension is the most distinctive performance shift introduced by I5.0 and the least measured in classical frameworks. The literature consistently argues that future supply chains must treat worker well-being and welfare, fair labor practices, capability development, equity, and human-machine complementarity as constitutive performance outcomes rather than compliance addenda [17,164–166]. Yet inclusion alone is insufficient: frameworks that incorporate social measures without elevating them structurally continue to assign them marginal performance weight, perpetuating their treatment as peripheral rather than constitutive [33]. Empirical evidence indicates that social sustainability initiatives produce measurable effects on supply chain cost structures and operational performance indicators [36,119]. Recent empirical work further demonstrates that worker outcomes constitute a distinct performance construct that responds to digital and process investments via SCM mediation [26]. Vergara et al. [57] likewise identify the social dimension as the most influential within an integrated RSSC framework, with working conditions and social responsibility carrying the greatest weight on SCP. SC360PM elevates this dimension through two composite attributes that translate normative commitments into measurable performance, making the construct linkage explicit and moving social performance from a cost-center logic to a strategic-asset logic.

Diversity and Fairness Score (HS1) is a composite index that measures how effectively the organization integrates equity, inclusivity, and fair treatment into its workforce and supplier relationships [166]. The score integrates three components: a Diversity Representation Index capturing the proportion of underrepresented groups across operational, managerial, and executive levels [41,122]; a Pay Equity Ratio comparing compensation across demographic groups in comparable roles, ensuring wages are compliant with applicable standards and regulations [119]; and a Promotion Fairness Index measuring advancement opportunities adjusted for representation in the eligible workforce [118]. In addition to the focal workforce, the attribute extends through governance rather than direct observation: requirements are cascaded via supplier codes of conduct, verified by audit and certification, with the share of sourcing spend covered by such reporting indicating multi-tier reach [103,129,130]. Beyond its ethical content, organizational research indicates that inclusive workplaces improve engagement, retention, and decision quality [150], capabilities that are particularly consequential in supply chains facing disruption and rapid technological change. However, direct supply chain evidence on the performance effects of workforce diversity remains limited, creating a gap that SC360PM is designed to help close by including this attribute as a measurable performance domain [167]. Monetary instruments such as wage stability, health insurance, and employee financial assistance constitute the strongest single predictor of social sustainability outcomes in emerging economy contexts [33,36].

Human Capital Empowerment Score (HS2) measures employee well-being and capability development as components of a single composite index [116]. The well-being component integrates workplace safety incident rates, employee satisfaction and engagement scores, living standards, and the availability and utilization of physical and mental health support [33,41,98,119]; the development component captures average training

hours per employee, training coverage across the workforce, and certification or upskilling rates [33,119]. Both components remain separately reportable alongside the composite score. This composite logic aligns with recent empirical operationalizations that treat worker outcomes as multi-component constructs distinct from operational performance [26]. Applied SCOR-based frameworks confirm this multi-component structure, yet consistently assign social measures the lowest performance weight relative to cost and quality attributes [33], precisely the measurement gap SC360PM is designed to address. Empirical evidence from sustainability-oriented supply chain studies confirms that working conditions and labor practices exert a measurable influence on both cost structures and operational performance outcomes [37,122], underscoring the strategic rather than merely ethical relevance of this attribute.

6. Discussion and Implications

The structural limitations identified in Section 4—the efficiency bias, the I5.0 integration gap, and the human-centric measurement gap—reflect a common underlying issue: performance frameworks inherited from I4.0 and earlier eras were designed to address a far more limited question than that posed by I5.0. The SC360PM framework reframes this question by shifting the SCP dependent variable from efficiency to viability. Instead of focusing on how efficiently the supply chain operates, SC360PM now asks whether the supply chain is viable, defined as its capability to deliver economic, adaptive, environmental, digital, and human value simultaneously and sustainably. The following discussion explores the theoretical, managerial, and research implications. The value of SC360PM lies not in adding another list of supply chain indicators, but in clarifying what constitutes performance in the I5.0 era. Evidence synthesized in this review suggests that contemporary SCP cannot be inferred solely from cost, service, or utilization [17,19,120]; rather, performance arises from the integrated management of economic viability, adaptive capacity, environmental stewardship, digital capability, and human development across interconnected actors [19,67,95,113,118]. Within this context, SC360PM marks the critical transition from efficiency-led extensions of legacy systems to a framework around viability.

SC360PM differs from previous frameworks in three key ways. Unlike traditional SCOR-based extensions, which focus primarily on process efficiency, this framework incorporates digitalization, sustainability, and human-centricity as dimensions equal in importance to operational and economic concerns. In contrast to BSC adaptations that emphasize strategic balance, SC360PM translates each dimension into a concrete attribute architecture that is operationally applicable and analytically comparable. Furthermore, instead of simply adding new indicators as seen in fragmented sustainability or resilience models, SC360PM integrates economic, environmental, digital, social, and resilience dimensions within a single framework. In this sense, viability serves as the integrative lens that connects resilience, sustainability, and human-centricity. Table 6 summarizes this positioning. Whether this architecture provides a more workable foundation for empirical validation and context-sensitive weighting than the frameworks it builds on remains to be established through the research agenda outlined below.

Table 6. Comparative overview of representative SCP frameworks and SC360PM.

Framework	Year	Architecture	Core Strength	Principal Limitations
TBL BSC-SCOR set [41]	2021	33 KPIs across six BSC perspectives (classic four + environment and social), mapped to SCOR processes across the whole chain	Balanced TBL coverage, including pillar intersections (14 KPIs span all three pillars)	Sustainability-centered; digitalization, resilience, and human-centricity beyond social PIs absent; pre-dates I5.0
SCOR 4.0 [67]	2021	Three-level metric hierarchy; seven Level-1 metrics, five SCOR attributes + digital technology and information systems	First to formalize digital maturity as a SCOR performance attribute	Environmental and social dimensions absent; resilience confined to the agility attribute
Circular-SCOR [88]	2022	Six SCOR processes extended with 9R circular-economy principles; 17 performance criteria	Embeds circularity in an established process hierarchy	Circularity-focused; digitalization, resilience, and human factors not addressed
Extended SCOR 4.0/MLP model [20]	2026	SCOR 4.0 attributes extended with digitalization and sustainability metrics; neural-network (MLP) prediction layer	Anticipatory; bridges digitalization and sustainability in one hierarchy	Human-centricity absent; environmental criteria appended rather than integrated
RSSCPM [19]	2026	Four dimensions (resilience, economic, environmental, social) with 17 metrics and modeled interdependencies	Joint resilience–sustainability measurement; maps inter-criteria dependencies	Digitalization and human factors embedded as sub-metrics, not first-order dimensions
ISCPM [12]	2023	Ten parallel attributes (incl. resilience, sustainability, work place health, visibility) in an input–process–output logic across SRM–ISCM–CRM macro-processes	Broadest empirically validated attribute set; resilience, sustainability, and work place health explicit	Flat structure without integration or weighting logic; human-centricity limited to worker health; digitalization only via visibility proxies
DSC KPI set [11]	2024	37 literature-derived KPIs in BSC perspectives, tiered by expert endorsement; five new digital-era KPIs added	Expert-validated inventory of digital-era KPI needs; shows existing KPIs remain useful	Flat inventory without integration logic; sustainability and human factors peripheral; no resilience construct
SC Manager 5.0 [23]	2024	Three-axis conceptual frame (sustainability, digital, optimization) with a manager dashboard of four parallel adjustment criteria	Explicitly I5.0-native, human-centered design; sustainability at the core of digital transformation	No operational metrics or measurement protocol; financial dimension partial; resilience absent
SC360PM (this study)	2026	Five coequal, interdependent dimensions; eighteen attributes	Full I5.0 coverage with an explicit integration logic; guardrails precede weighting	Conceptual; empirical attribute weighting pending (Section 6.3)

6.1. Theoretical Implications

SC360PM advances SCP theory in four significant ways. First and most consequentially, it reframes the object of measurement. The framework eliminates the implicit hierarchy that positions non-financial concerns as subordinate perspectives supporting a financial apex, replacing it with a coequal multidimensional structure in which human-centricity

and sustainability are established as primary performance domains. This reframing represents an ontological respecification of the SCP construct, rather than a methodological extension of existing frameworks. The dominant tradition, as seen in SCOR DS, BSC adaptations, and financial performance models, positions economic outcomes as the apex construct, with resilience, sustainability, and human-centricity relegated to the role of antecedents or constraints [1,47]. SC360PM removes this hierarchy by establishing human-centricity and sustainability as first-order performance domains. This shift is most evident in how the framework treats the dependent variable, moving from efficiency-conditioned value, in which environmental and social outcomes are treated as costs or constraints, to viability-conditioned value, in which these outcomes are integral to the definition of performance [4,24].

Second, the framework shifts the SCP construct from a scalar outcome to a multidimensional performance vector. The reviewed literature does not support the common assumption that resilience, sustainability, or social variables are secondary to financial or service outcomes. Several studies indicate that improving one dimension may compromise another. For example, inventory buffers can improve recovery but may intensify working capital pressure and emissions [19,34]. Automation may reduce cycle time but can undermine knowledge retention or task quality if human roles are poorly redesigned [26,95]. Similarly, sustainability investments may strengthen long-term robustness while appearing cost-ineffective in the short term [113]. These trade-offs are not anomalies that can be disregarded. Evidence from sustainability performance measurement shows that the importance of competing dimensions shifts systematically across supply chain positions and institutional contexts. Consequently, a performance profile balanced at one stage or under one regulatory regime may be significantly imbalanced in another [122]. Therefore, SCP should be conceptualized as a profile of jointly relevant outcomes, incorporating explicit non-linearities and threshold effects, rather than as a single latent construct inferred from a limited number of operational proxies. A single composite score is justifiable only when the underlying weighting and compensability assumptions are clearly articulated and subjected to sensitivity analysis. Otherwise, aggregation risks obscuring strategically significant deterioration in one or more dimensions.

Third, the framework sharpens the causal logic linking digitalization to performance. The reviewed studies repeatedly indicate that digital technologies do not improve SCP through adoption alone. Instead, their effects are largely mediated by information integration, visibility, predictive capability, sustainable operating practices, and the firm's ability to reconfigure routines in response to change [35,63,96,147,160]. This matters theoretically because it positions digitalization not as a direct driver of performance, but as an enabling capability whose value is contingent upon organizational and inter-organizational complements. The five dimensions represent distinct capability domains whose interactions generate observed outcomes. This perspective also repositions human-centricity from a normative consideration to a productive capability. This repositioning is consistent with sociotechnical accounts of technology-enabled organizations, in which performance emerges from the joint configuration of human and technical systems, and in which the quality of that configuration—not automation intensity—is the operative driver [26]. Worker learning, ergonomic design, trustworthy decision support, fair progression systems, and well-being protections affect exception handling, judgment quality, adaptability, and recovery speed, particularly in settings where advanced analytics and automation still rely on human interpretation, escalation, and override [26,45]. Worker outcomes are conceptually and statistically distinct from operational performance, such that improvements in one do not automatically translate to gains in the other [26]. Furthermore, the knowledge and well-being of the workforce have been theorized as a distinct facet of SCP, whose realization

depends on the absorptive and analytical capacity that digital decision-support systems provide [45].

The third contribution also reveals a less apparent but significant implication: a measurement dependency among the five dimensions. The innovation and digitalization dimension not only improves performance alongside the other four, but also provides the data infrastructure necessary for making sustainability and human-centric performance observable at an operational cadence [40,45]. In the absence of real-time supplier emissions data, Scope 3 measurement is limited to annual disclosure [20]. Similarly, without IoT-enabled worker monitoring and digital skill-tracking systems, human-centricity indicators are restricted to lagging compliance counts [26]. Consequently, investment in the digital dimension generates a dual benefit: it improves operational capability [5,31,95] and establishes the measurement infrastructure required for dimensions that would otherwise remain unobservable at a granular, actionable level [112,113].

Fourth, SC360PM clarifies the level and temporality fragmentation in SCP theory. Viability, resilience, and decarbonization are not single-firm, point-in-time phenomena. Some attributes belong to the focal firm, some to dyadic relationships, and still others to multi-tier networks or broader ecosystems. Some indicators serve as leading measures, while others are lagging effects observable only after disruptions, redesigns, or reporting cycles. The framework, therefore, suggests that future SCP theory should differentiate between event-bounded resilience measures and long-term viability measures, between firm-level performance and network-level conditions, and between indicators that assess readiness and those that capture realized outcomes [4,45]. This distinction has begun to receive empirical support: dependency-mapping analyses that separate performance metrics into driving and outcome groups indicate, for example, that workforce well-being behaves as a strongly dependent outcome rather than an independent driver, with direct consequences for how leading and lagging human-centric indicators should be specified and interpreted [19]. This multilevel and longitudinal reading is essential if scholarly claims about adaptation, survivability, and human-machine complementarity are to be more than conceptual aspiration.

6.2. Managerial Implications

For supply chain leaders, the primary implication is that SC360PM should function as a decision-making system rather than solely as a reporting mechanism. The practical objective extends beyond displaying additional indicators; it is to fundamentally alter the governance trade-offs. The resilience–efficiency tension exemplifies this point: by measuring resilience and agility as equally important alongside cost efficiency and financial health, SC360PM enables redundancy, multi-sourcing, and buffer capacity to be evaluated as risk-adjusted investments and considered deliberately at the board level, instead of being dismissed as inefficiencies under a cost-centric approach. A minimum viable implementation requires assigning executive ownership to each dimension, establishing a concise set of auditable leading and lagging indicators, defining a review cadence, and specifying clear guardrails. Metrics such as cost-to-serve, on-time-in-full (OTIF) delivery, and working capital should remain in the system, but they must be balanced with explicit thresholds for emissions, supplier reliability, recovery time, workforce capability, and digital reliability. Managers should avoid aggregating the five dimensions into a single composite score unless compensability assumptions, which define the extent to which dimensions may offset one another, are explicitly articulated and sensitivity-tested. In most operational contexts, dimension-specific guardrails provide greater analytical safety than premature aggregation, because severe declines in the environmental or human dimension should not be offset by

short-run improvements in cost or throughput. Determining the appropriate threshold for compensatory aggregation is a matter of governance, not a default measurement practice.

A rigorous implementation pathway consists of five elements. The first element is instrumentation, which involves establishing a baseline portfolio for each dimension and clearly distinguishing among operational, managerial, and network-level measures. Most firms already capture cost and financial attributes, as well as some resilience attributes, through ERP systems and SCOR-aligned reporting. The immediate priority is to conduct a gap audit across all eighteen attributes to identify what is measured, what is merely proxied, and what remains unmeasured, typically including several sustainability and most human-centric attributes. The second element is establishing guardrails before assigning weights. Before comparing dimensions, managers should set dimension-specific minimum thresholds to prevent masking effects. Guardrails can be implemented immediately, whereas defensible weights require careful calibration. The third element is weighting and governance, which entails calibrating the relative importance of each dimension through structured elicitation and documenting the rationale for the resulting priorities. Appropriate weights depend on strategy and stakeholder requirements. For example, a life-critical pharmaceutical supply chain may reasonably assign greater weight to resilience than a price-sensitive consumer goods supply chain. The SC360PM framework is designed to accommodate such differentiation rather than enforce a uniform template. The fourth element is stress testing, which involves evaluating proposed changes under counterfactual scenarios prior to full implementation. In organizations with adequate data maturity, this process can be supported by supply chain simulation or digital twin environments that show how a single intervention affects the entire performance vector. The last element is cascading and incentive redesign. This step embeds selected indicators into supplier scorecards, joint review routines, and cross-tier data-sharing arrangements, ensuring that resilience, sustainability, and human-centricity are measurable beyond the focal firm.

Three further recommendations sharpen this pathway, each qualified by the conditions it presupposes. First, begin with a minimum viable indicator set—one auditable leading and one lagging indicator per dimension, drawn wherever possible from data already held in ERP, quality, and sustainability-reporting systems. Second, sequence by measurement dependency: because the innovation and digitalization dimension supplies the data infrastructure through which sustainability and human-centric performance become observable at an operational cadence, digital instrumentation should be scheduled ahead of, or jointly with, expanded coverage of the sustainability and human-centric attributes. Third, anchor each dimension in an existing governance routine—sales and operations planning, capital review, ESG reporting, technology governance, and workforce review, respectively—rather than erecting a parallel reporting apparatus.

These recommendations do not remove the implementation burden. Data requirements are asymmetric: resilience and financial attributes are largely computable from existing transactional systems, whereas Scope 3 decarbonization (SE1) and the human-centric attributes (HS1, HS2) depend on supplier data sharing and workforce data practices that many organizations do not yet possess. SC360PM should therefore be expected to expose measurement gaps before it improves decisions. Resource requirements also scale with network complexity, and the five-element pathway will exceed the capacity of many small and medium-sized enterprises (SMEs) if attempted in full; for SMEs, the appropriate entry point is the minimum viable indicator set above, with sector-association benchmarks and customer-provided ESG platforms substituting for proprietary instrumentation and coverage expanded as data maturity grows. Full eighteen-attribute instrumentation is a multi-year trajectory, not an entry condition.

Three measurement priorities deserve particular attention. First, human-centricity should be assessed through leading indicators instead of relying solely on retrospective compliance checks. For instance, relevant metrics such as training intensity can be associated with role redesign, skill-certification coverage, promotion fairness, retention of critical knowledge, AI-override quality, safety-related leading indicators, employee engagement, and the availability and use of mental-health and ergonomic support. Second, sustainability should be tracked at an operational cadence rather than being confined to annual disclosure. For many firms, the decisive issue is no longer whether Scope 3 matters, but whether supplier-level data are timely, complete, auditable, and sufficiently actionable to influence sourcing, design, logistics, and recovery decisions. Where disclosure obligations already compel the collection of such data, the marginal cost of redirecting it to managerial use is correspondingly lower; where they do not, the same instrumentation must be justified on managerial grounds alone. Third, digitalization should be evaluated by the quality of its contribution rather than only by the volume of adoption. Metrics such as forecast accuracy, alert precision, data latency, exception-resolution time, and realized improvements following disruptions provide a more meaningful assessment of digitalization than simply counting deployed tools.

6.3. Limitations and a Future Research Agenda

The framework is currently at a conceptual stage. It has not been empirically validated, and it should not be treated as a finished scorecard or a definitive measurement model until the validation program set out below has been completed. As an integrative review, it is constrained by the scope of its evidence base: the final corpus of identified 55 articles is inherently selective. The database, language, and journal-rank criteria, along with the single-author synthesis acknowledged before, may have excluded relevant practitioner-oriented and non-English sources, as well as sound work published in emerging or unranked outlets, particularly regarding the social dimension. While the five dimensions and eighteen attributes are theoretically grounded, the literature base is uneven across sectors, geographies, and methodologies. Human-centric indicators are still less mature than financial or operational ones. Lower-tier environmental and social data are challenging to obtain at sufficient quality and frequency, and sectoral heterogeneity is likely to influence both the relative importance and operational interpretation of several attributes. The salience of competing performance dimensions has been shown to shift systematically with supply chain position and institutional context [122]; on that basis, life-critical and highly regulated sectors such as pharmaceuticals and healthcare would be expected to weight resilience and compliance-linked attributes more heavily, and resource-intensive sectors such as agriculture and process manufacturing to weight eco-efficiency and circularity. The dimensional architecture is nonetheless proposed as invariant across these settings, and that invariance is itself untested: SC360PM has not been instantiated in any sector, and cross-sector applicability should be treated as a hypothesis for the validation program. These limitations suggest that SC360PM should currently be viewed as a structured design proposition, pending validation, rather than as a universally validated scorecard. Sectoral context, regulatory intensity, supply-network structure, and data maturity should be considered as boundary conditions rather than as background variables.

Future research can be carried out in six directions, establishing a validation pathway that addresses the validation-readiness requirement outlined in Section 4.4. First, content and construct validation: the completeness, relevance, and definitional clarity of the five dimensions and eighteen attributes should be assessed through structured expert judgment, such as a Delphi study with supply chain executives and scholars from

various sectors, before large-scale testing. SC360PM should subsequently be validated as a multilevel measurement model using case studies, survey instruments, and longitudinal designs. Second, metric specification and operationalization: subsequent research should develop and validate concrete Level-1, Level-2, and Level-3 metrics for each attribute, extending the SCOR DS metric hierarchy on which SC360PM is based. Particular emphasis should be placed on the under-instrumented human-centric and sustainability attributes, using emerging ESG and worker well-being measurement systems. The third direction is interdependence mapping, weighting, and prioritization. Researchers can empirically map the literature-grounded interdependencies, establishing their direction and strength, using DEMATEL or fuzzy DEMATEL. Moreover, context-sensitive weighting and prioritization schemes should be derived using methods such as AHP or BWM, while preserving dimensional transparency in reporting to avoid masking imbalance. A companion study under development applies Best-Worst Scaling to determine the relative importance of the eighteen attributes from a managerial and academic perspective. Fourth, closing the human-centricity measurement gap: given that the social dimension is the least developed, dedicated research should construct and test human-centricity indicators across multiple supply chain tiers, integrating physical, cognitive, and social ergonomics as well as labor-equity measures. As this indicator base matures, HS1 and HS2 should be progressively decomposed into free-standing attributes, rebalancing the framework's attribute distribution to reflect measurement maturity. Fifth, digital enablement of measurement: future studies should investigate how I5.0 enabling technologies, including digital twins, IIoT, human–digital twins, AI analytics, and increasingly generative AI for scenario generation and decision support, explainable AI as a precondition for trustworthy human–machine complementarity in performance governance, and autonomous or agentic decision-making systems whose delegation boundaries themselves become measurable human-centricity concerns, can provide the real-time data infrastructure necessary to operationalize SC360PM. Additionally, research should examine how the innovation and digitalization dimension can be sequenced to generate measurement capacity for the sustainability and human-centric dimensions. Sixth, longitudinal and sectoral generalization, including disruption-window studies: research should evaluate whether the framework's dimensional balance and attribute relevance vary across sectors and over time. Since resilience and viability are inherently temporal, a promising research design involves using actual disruptions, such as supplier collapses, port closures, or regulatory shocks, as natural experiments. This approach enables observation of changes in the full performance vector and assessment of whether SC360PM's multidimensional profile predicts recovery and survivability more effectively than single-dimension measures.

Collectively, these six directions constitute a validation program that moves SC360PM from a conceptual architecture toward an empirically grounded measurement system. These directions evaluate not only the validity and reliability of SC360PM's dimensions, but also whether a viability-oriented performance architecture provides more actionable insights than the efficiency-focused systems it is designed to supersede.

7. Conclusions

SCP management is at an inflection point and is undergoing a significant transformation. The frameworks that have traditionally governed the field, including process-efficiency models, financial scorecards, and isolated resilience or sustainability extensions, were designed for an industrial paradigm that the transition to I5.0 has rendered structurally inadequate. This study's integrative review of 55 studies published between 2020 and 2026 clarifies this inadequacy: a persistent efficiency bias, insufficient integration of I5.0 pillars as coequal performance domains, and ongoing under-measurement of human-centric out-

comes collectively explain why a genuinely I5.0-aligned performance architecture has not yet emerged despite substantial scholarly attention.

The SC360PM framework responds to this diagnosis by respecifying what counts as SCP and how it functions in practice. SC360PM treats economic viability, adaptive capacity, environmental stewardship, digital capability, and human development not as additive concerns to be appended to a financial core, but as constitutive dimensions of viability, to be managed jointly and measured simultaneously. Drawing on SCOR DS for process discipline, I5.0 for value orientation, VSC theory for long-horizon survivability, and RBV, dynamic capabilities, and systems theory for their mechanistic foundations, SC360PM operationalizes these principles within a structured, empirically testable architecture comprising five dimensions and eighteen operational attributes.

SC360PM responds to the identified gap but does not yet close it. The framework represents an initial step rather than a definitive solution. Its value will be determined by subsequent empirical research, including construct validation, metric specification, interdependence mapping, and longitudinal testing under actual disruption conditions. At present, it provides a sufficiently precise respecification to allow for empirical testing, which is a prerequisite for any performance architecture to govern practice and guide decision-making.

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Abbreviations

The following abbreviations are used in this manuscript:

AHP	Analytic Hierarchy Process
BSC	Balanced Scorecard
BWS	Best-Worst Scaling
DSC	Digital Supply Chain
ESG	Environmental, Social, and Governance
I4.0	Industry 4.0
I5.0	Industry 5.0
KPI	Key Performance Indicator
MCDM	Multi Criteria Decision Making
OTIF	On Time, In Full
RBV	Resource-Based View
SC360PM	Supply Chain 360° Performance Management
SCM	Supply Chain Management

SCOR DS Supply Chain Operations Reference Digital Standard
 SCP Supply Chain Performance
 SEM Structural Equation Modeling
 TBL Triple Bottom Line
 VSC Viable Supply Chain

Appendix A

Table A1. Mapping of the 55 reviewed studies against the eighteen SC360PM performance attributes.

Study	RA1	RA2	RA3	RA4	RA5	RA6	CF1	CF2	CF3	CF4	SE1	SE2	SE3	ID1	ID2	ID3	HS1	HS2
Abdallah et al. [96]	•	●	•	●	○	○	•	○	○	○	○	○	○	•	•	•	○	○
Abdulameer & Ibrahim [112]	○	○	○	●	●	○	●	•	○	○	•	•	●	•	•	•	•	•
Al Tera et al. [158]	○	●	●	○	○	•	●	○	○	●	○	○	○	●	○	●	○	○
Aprilia et al. [118]	●	●	●	•	○	○	●	○	●	●	○	●	●	○	○	○	●	●
Ayyildiz & Taskin Gumus [67]	•	●	•	•	○	○	•	○	•	•	○	○	○	●	●	●	○	○
Bamakan et al. [65]	•	•	•	●	○	○	●	○	●	●	○	•	●	○	●	○	○	○
Belhadi et al. [116]	○	○	●	•	●	●	●	•	○	○	•	•	•	•	•	•	○	•
Chand et al. [8]	•	•	•	•	●	○	●	•	●	•	•	●	•	○	○	○	●	○
de Araújo et al. [26]	●	●	●	•	○	○	○	○	○	●	○	○	○	●	●	•	●	•
Dixit et al. [108]	○	○	○	○	○	●	○	○	○	○	○	○	○	●	●	•	○	○
Elnadi et al. [7]	•	●	●	•	○	•	•	○	○	○	○	○	○	•	○	○	○	○
Fares & Lloret [109]	•	○	●	●	●	●	○	○	●	●	○	○	○	○	○	○	○	○
Gangaraju et al. [39]	●	•	●	●	•	○	●	○	○	○	○	○	○	●	○	○	○	○
Ghag et al. [17]	○	○	●	•	•	●	•	○	○	○	○	●	○	●	•	○	●	●
Haldar et al. [35]	○	○	○	•	•	•	○	○	○	○	○	○	○	●	●	●	○	○
Hallikas et al. [147]	○	○	●	●	○	○	●	•	○	•	○	○	○	•	●	○	○	○
Jain et al. [33]	•	●	•	•	•	○	•	○	•	●	•	•	•	○	○	○	•	•
Jamil et al. [98]	○	●	○	●	○	○	●	●	○	○	•	•	•	●	●	•	●	•
Kharat et al. [76]	○	•	○	○	○	○	○	•	○	●	○	○	○	●	○	○	○	●
Kirsten et al. [95]	●	●	●	○	○	○	●	•	○	●	•	●	○	•	○	•	○	○
Kumar et al. [111]	○	○	○	○	○	○	●	○	○	○	●	●	●	●	○	●	●	●
Kundu & Rani [130]	○	•	○	○	○	○	●	○	○	○	○	○	●	○	○	○	●	●
Leon-Bravo & Caniato [122]	○	○	○	○	○	○	●	•	○	•	●	•	•	○	○	○	●	○
Lima-Junior & Carpinetti [52]	•	○	•	●	●	○	•	○	•	●	○	○	○	○	○	○	○	○
Meena et al. [129]	●	•	●	●	●	○	●	●	○	○	○	○	○	○	○	○	●	○
Mohaghar et al. [55]	●	•	●	●	●	○	●	○	○	●	○	○	○	•	•	•	○	●
Mrad & Belgaroui [113]	○	○	○	○	○	○	○	○	○	○	●	•	•	●	●	●	○	●
Mrad et al. [20]	•	○	•	○	○	○	•	•	•	•	●	•	●	○	○	●	○	○
Nazarian & Khan [22]	○	○	○	•	•	○	○	○	○	○	○	○	○	•	●	•	○	○
Neri et al. [41]	•	○	•	•	•	•	•	•	•	•	•	•	•	○	○	○	●	●
Nisrina et al. [119]	○	○	•	○	○	○	●	○	○	○	○	•	•	○	○	○	•	•
Ozbiltekin-Pala et al. [88]	•	●	●	•	●	●	•	○	○	○	○	•	●	●	●	○	○	○
Patidar et al. [40]	○	●	•	●	●	•	○	○	○	○	○	○	○	○	○	○	○	○
Piprani et al. [2]	○	●	○	●	●	•	○	○	○	●	●	●	●	•	•	•	○	●
Ramos et al. [121]	●	●	●	•	•	○	•	○	○	○	○	●	●	•	○	○	○	●
Rana et al. [5]	●	•	●	•	•	•	●	○	○	○	○	○	○	•	•	•	○	○
Rasool et al. [11]	•	●	•	●	●	○	•	•	●	•	○	●	●	•	○	•	●	●
Reaidy et al. [63]	●	•	●	•	•	○	●	○	○	•	○	○	○	•	•	•	○	○
Riaz et al. [114]	●	●	○	•	○	•	○	○	○	○	○	○	○	●	○	○	○	○

Table A1. Cont.

Study	RA1	RA2	RA3	RA4	RA5	RA6	CF1	CF2	CF3	CF4	SE1	SE2	SE3	ID1	ID2	ID3	HS1	HS2
Saranghi & Ghosh [107]	•	●	•	●	●	○	●	●	○	○	○	○	○	•	•	•	○	○
Sharma et al. [79]	○	•	○	○	•	○	●	●	○	○	•	●	•	•	•	•	●	•
Sharma et al. [123]	○	○	•	●	●	○	●	•	○	○	•	●	●	●	●	●	•	•
Sharma et al. [117]	○	●	○	○	●	○	○	○	○	●	●	•	•	•	•	•	●	●
Simão et al. [34]	○	○	•	○	○	○	●	○	○	○	•	○	○	○	○	○	○	○
Srivastava et al. [36]	•	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	•	•
Štreimikienė et al. [120]	○	●	○	○	○	•	○	○	○	○	•	•	•	•	•	•	○	●
Tripathi & Talukder [141]	○	○	•	○	○	○	•	•	•	•	○	○	○	○	○	○	○	○
Tripathi et al. [58]	○	○	•	○	○	○	•	•	•	•	○	○	○	○	○	○	○	○
Tsang et al. [115]	•	○	•	○	○	•	•	○	•	○	•	○	•	○	○	•	○	○
Vergara et al. [37]	○	•	○	•	●	•	●	○	○	○	●	•	•	●	○	○	●	•
Vergara et al. [57]	○	●	○	•	●	○	●	○	○	○	○	●	○	●	○	○	●	•
Yang et al. [19]	○	•	○	•	○	•	○	•	○	○	○	●	•	•	○	○	●	•
Yarson et al. [45]	○	○	●	•	•	•	●	●	○	○	•	•	•	●	●	●	•	○
Zaid et al. [133]	○	●	●	●	○	○	●	●	○	○	○	○	○	●	○	●	○	○
Zelbst et al. [80]	•	●	○	○	○	○	○	○	○	○	○	○	●	●	○	●	○	○

• addressed: the study explicitly proposes, operationalizes, uses, or empirically measures the attribute.
 ● partially/indirectly addressed: the study treats the attribute as a sub-component of a broader construct, mentions it only in passing, discusses it qualitatively without metric-level treatment, or evidences it only as an antecedent or outcome of another measured construct. ○ not addressed: the attribute does not appear in the study in any of the above forms.

References

1. Teymourifar, A. A critical review of the SCOR Digital Standard (SCOR-DS): Conceptual implications for supply chain performance measurement. *Front. Sustain.* **2026**, *7*, 1769304. [\[CrossRef\]](#)
2. Piprani, A.Z.; Jaafar, N.I.; Ellahi, R.M.; Watabe, M.; Islam, M.A.; Najmi, A. Supply Chain Mapping for High Risk Environment: Industry 4.0 and the Quest for Resilient and Sustainable Supply Chains. *Sustain. Dev.* **2025**, *33*, 7441–7458. [\[CrossRef\]](#)
3. Cantoni, F.; Ricciardi, A.; Bisogni, P.G.; Zsifkovits, H. The unravelled role of soft skills in the logistics and supply chain management field. *J. Innov. Knowl.* **2024**, *9*, 100615. [\[CrossRef\]](#)
4. Ivanov, D. Viable supply chain model: Integrating agility, resilience and sustainability perspectives—Lessons from and thinking beyond the COVID-19 pandemic. *Ann. Oper. Res.* **2022**, *319*, 1411–1431. [\[CrossRef\]](#)
5. Rana, J.; Daultani, Y.; Goswami, M.; Kumar, S. Exploring the Impact of Supply Chain Digital Transformation on Supply Chain Performance: An Empirical Investigation. *Bus. Strategy Environ.* **2025**, *34*, 3497–3521. [\[CrossRef\]](#)
6. Jouicha, Y.; Cherrafi, A.; Hamani, N.; Elfezazi, S. Performance Measurement Systems for Supply Chain 5.0: Gaps, Challenges, and Future Research Avenues. *IFAC-PapersOnLine* **2025**, *59*, 2933–2938. [\[CrossRef\]](#)
7. Elnadi, M.; Gheith, M.H.; Troise, C.; Abdallah, Y.O.; Abdelaziz, M.A.A. Digital Transformation and Sustainable Supply Chain Performance for Sustainable Development: The Mediating Role of Supply Chain Capabilities. *Sustain. Dev.* **2026**, *34*, 611–637. [\[CrossRef\]](#)
8. Chand, P.; Thakkar, J.J.; Ghosh, K.K. Analysis of supply chain performance metrics for Indian mining & earthmoving equipment manufacturing companies using hybrid MCDM model. *Resour. Policy* **2020**, *68*, 101742. [\[CrossRef\]](#)
9. Filippidis, M.; Kizys, R.; Tzouvanas, P. Supply Chain Network, ESG Scores and Financial Performance. *Bus. Strategy Environ.* **2026**, *early access*. [\[CrossRef\]](#)
10. Govardhan, S.; Narkhede, B.E.; Raut, R.D.; Zhang, L.L.; Ghoshal, S. Significance of Industry 4.0 in Achieving Sustainable Performance Across Supply Chains—A Research Perspective. *Bus. Strategy Dev.* **2025**, *8*, e70064. [\[CrossRef\]](#)
11. Rasool, F.; Greco, M.; Strazzullo, S. Understanding the future KPI needs for digital supply chain. *Supply Chain Forum Int. J.* **2024**, *25*, 550–561. [\[CrossRef\]](#)
12. Saleheen, F.; Habib, M.M. Embedding attributes towards the supply chain performance measurement. *Clean. Logist. Supply Chain* **2023**, *6*, 100090. [\[CrossRef\]](#)
13. Hajjem, O.; Zekhnini, K.; Hamani, N. Synergies of Industry 5.0 paradigms: Unraveling the dynamics of operational management for supply chains excellence. *Sustain. Futur.* **2025**, *10*, 101498. [\[CrossRef\]](#)
14. Govindan, K.; Kannan, D.; Jørgensen, T.B.; Nielsen, T.S. Supply Chain 4.0 performance measurement: A systematic literature review, framework development, and empirical evidence. *Transp. Res. Part E Logist. Transp. Rev.* **2022**, *164*, 102725. [\[CrossRef\]](#)

15. GEP. *Impact of Industry 4.0 on Supply Chains and Its Benefits—All You Need to Know*; GEP: Clark, NJ, USA, 2019.
16. Xu, X.; Lu, Y.; Vogel-Heuser, B.; Wang, L. Industry 4.0 and Industry 5.0—Inception, conception and perception. *J. Manuf. Syst.* **2021**, *61*, 530–535. [\[CrossRef\]](#)
17. Ghag, N.; Sonar, H.; Sawant, R.; Bankapalli, K. Examining industry 5.0 and supply chain performance: An empirical study for managing supply chain complexity. *Prod. Manuf. Res.* **2025**, *13*, 2501181. [\[CrossRef\]](#)
18. Ivanov, D.; Dolgui, A. Viability of intertwined supply networks: Extending the supply chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak. *Int. J. Prod. Res.* **2020**, *58*, 2904–2915. [\[CrossRef\]](#)
19. Yang, Q.; Wei, S.-J.; Wang, Z.-S.; Deveci, M.; Demir, G. A novel decision support framework for unveiling critical determinants in resilient–sustainable supply chain performance measurement. *Adv. Eng. Inform.* **2026**, *73*, 104540. [\[CrossRef\]](#)
20. Mrad, M.; Belgaroui, R.; Boujelbene, Y.; Abelkawy, N.A. Bridging Digitalization and Sustainability in Supply Chain Performance Measurement: An MLP-Based Predictive Model. *Logistics* **2026**, *10*, 42. [\[CrossRef\]](#)
21. Breque, M.; De Nul, L.; Petridis, A.; Directorate-General for Research and Innovation. *Industry 5.0—Towards a Sustainable, Human-Centric and Resilient European Industry*; Publications Office of the European Union: Luxembourg, 2021.
22. Nazarian, H.; Khan, S.A. The impact of industry 5.0 on supply chain performance. *Int. J. Eng. Bus. Manag.* **2024**, *16*, 18479790241297022. [\[CrossRef\]](#)
23. Dossou, P.-E.; Alvarez-de-los-Mozos, E.; Pawlewski, P. A Conceptual Framework for Optimizing Performance in Sustainable Supply Chain Management and Digital Transformation towards Industry 5.0. *Mathematics* **2024**, *12*, 2737. [\[CrossRef\]](#)
24. Ivanov, D. The Industry 5.0 framework: Viability-based integration of the resilience, sustainability, and human-centricity perspectives. *Int. J. Prod. Res.* **2023**, *61*, 1683–1695. [\[CrossRef\]](#)
25. Dacre, N.; Yan, J.; Frei, R.; Al-Mhdawi, M.K.S.; Dong, H. Advancing sustainable manufacturing: A systematic exploration of Industry 5.0 supply chains for sustainability, human-centricity, and resilience. *Prod. Plan. Control* **2025**, *36*, 1499–1528. [\[CrossRef\]](#)
26. Araújo, J.D.D.; Franco, C.W.; Sousa, P.R.D.; Frank, A.G. Redefining work in the supply chain: Combining digital technologies and knowledge sharing for a smart working environment. *Int. J. Prod. Econ.* **2026**, *291*, 109860. [\[CrossRef\]](#)
27. Fares, N.; Anass, C.; Shardeo, V.; Garza-Reyes, J.A. Supply chain management in the Industry 5.0 era: Strategic implications. *Benchmarking Int. J.* **2026**, *33*, 2949–2977. [\[CrossRef\]](#)
28. Oubrahim, I.; Sefiani, N.; Happonen, A. Supply chain performance evaluation models: A literature review. *Acta Logist.* **2022**, *9*, 207–221. [\[CrossRef\]](#)
29. Rodríguez Mañay, L.O.; Guaita-Pradas, I.; Marques-Perez, I. Measuring the Supply Chain Performance of the Floricultural Sector Using the SCOR Model and a Multicriteria Decision-Making Method. *Horticulturae* **2022**, *8*, 168. [\[CrossRef\]](#)
30. ASCM. *ASCM Supply Chain Operations Reference Model SCOR Digital Standard*; ASCM: Chicago, IL, USA, 2025.
31. El Kihel, Y.; Zouggar Amrani, A.; Ducq, Y.; Amegouz, D.; Lfakir, A. Methodology combining industry 4.0 technologies and KPI's reliability for supply chain performance. *Int. J. Comput. Integr. Manuf.* **2023**, *36*, 1128–1152. [\[CrossRef\]](#)
32. Becker, T. Improving the SCOR model: Is the new SCOR Digital Standard a better process reference model? *J. Supply Chain Manag. Logist. Procure.* **2023**, *6*, 155–167. [\[CrossRef\]](#)
33. Jain, V.; Kumar, S.; Mostofi, A.; Arab Momeni, M. Sustainability performance evaluation of the E-waste closed-loop supply chain with the SCOR model. *Waste Manag.* **2022**, *147*, 36–47. [\[CrossRef\]](#)
34. Simão, L.E.; Somensi, K.; Dávalos, R.V.; Rodriguez, C.M.T. Measuring supply chain performance: The triple E model. *Int. J. Product. Perform. Manag.* **2021**, *71*, 2951–2969. [\[CrossRef\]](#)
35. Haldar, D.K.; Saha, P.; Belal, H.M.; Kayas, O.G. An analytical study on integrating Artificial Intelligence and Industry 4.0 technologies for supply chain resilience and sustainability. *Supply Chain Anal.* **2026**, *14*, 100209. [\[CrossRef\]](#)
36. Srivastava, A.; Gurtu, A.; Vyas, V. Analysis of supply chain performance under the influence of social sustainability initiative of organizations. *Oper. Supply Chain Manag.* **2025**, *18*, 65–78. [\[CrossRef\]](#)
37. Torres Vergara, J.I.; Saucedo Martínez, J.A.; Olivo Lucio, D. Resilient and sustainable supply chain criteria for performance evaluation: Selection and ranking through fuzzy Delphi. *Benchmarking Int. J.* **2023**, *31*, 799–823. [\[CrossRef\]](#)
38. Lehyani, F.; Zouari, A.; Ghorbel, A.; Tollenaere, M. Defining and Measuring Supply Chain Performance: A Systematic Literature Review. *Eng. Manag. J.* **2021**, *33*, 283–313. [\[CrossRef\]](#)
39. Gangaraju, P.K.; Raj, R.; Kumar, V.; Akhil, N.S.B.; De, T.; Kaswan, M.S. Financial performance in Industry 4.0 agile supply chains: Evidence from manufacturing companies. *TQM J.* **2023**, *37*, 222–248. [\[CrossRef\]](#)
40. Patidar, A.; Sharma, M.; Agrawal, R.; Sangwan, K.S. Supply chain resilience and its key performance indicators: An evaluation under Industry 4.0 and sustainability perspective. *Manag. Environ. Qual. Int. J.* **2022**, *34*, 962–980. [\[CrossRef\]](#)
41. Neri, A.; Cagno, E.; Lepri, M.; Trianni, A. A triple bottom line balanced set of key performance indicators to measure the sustainability performance of industrial supply chains. *Sustain. Prod. Consum.* **2021**, *26*, 648–691. [\[CrossRef\]](#)
42. Darmian, S.M.; Sgarbossa, F.; Fattahi, M.; Castelblanco, J.P.M. Supply Chain Viability by Integrating R-imperatives, Product Development, and Design Decisions: A Stochastic Programming Framework. *Omega* **2025**, *136*, 103317. [\[CrossRef\]](#)

43. Ivanov, D. Lean resilience: AURA (Active Usage of Resilience Assets) framework for post-COVID-19 supply chain management. *Int. J. Logist. Manag.* **2021**, *33*, 1196–1217. [\[CrossRef\]](#)
44. Ivanov, D. Supply Chain Viability. In *Introduction to Supply Chain Resilience and Viability: Management, Modelling, Technology*; Ivanov, D., Ed.; Springer Nature: Cham, Switzerland, 2025; pp. 131–155.
45. Yaroson, E.V.; Chowdhury, S.; Mangla, S.K.; Dey, P.K. Unearthing the interplay between organisational resources, knowledge and industry 4.0 analytical decision support tools to achieve sustainability and supply chain wellbeing. *Ann. Oper. Res.* **2024**, *342*, 1321–1368. [\[CrossRef\]](#)
46. Rahiminezhad Galankashi, M.; Mokhtab Rafiei, F. Financial performance measurement of supply chains: A review. *Int. J. Product. Perform. Manag.* **2022**, *71*, 1674–1707. [\[CrossRef\]](#)
47. Zekhnini, K.; Cherrafi, A.; Bouhaddou, I.; Benabdellah, A.C.; Raut, R. A holonic architecture for the supply chain performance in industry 4.0 context. *Int. J. Logist. Res. Appl.* **2024**, *27*, 852–879. [\[CrossRef\]](#)
48. Xie, Y.; Yin, Y.; Xue, W.; Shi, H.; Chong, D. Intelligent supply chain performance measurement in Industry 4.0. *Syst. Res. Behav. Sci.* **2020**, *37*, 711–718. [\[CrossRef\]](#)
49. Ivanov, D.; Dolgui, A. Stress testing supply chains and creating viable ecosystems. *Oper. Manag. Res.* **2022**, *15*, 475–486. [\[CrossRef\]](#)
50. Wieland, A. Dancing the Supply Chain: Toward Transformative Supply Chain Management. *J. Supply Chain Manag.* **2021**, *57*, 58–73. [\[CrossRef\]](#)
51. Zekhnini, K.; Cherrafi, A.; Bouhaddou, I.; Chaouni Benabdellah, A.; Bag, S. A model integrating lean and green practices for viable, sustainable, and digital supply chain performance. *Int. J. Prod. Res.* **2022**, *60*, 6529–6555. [\[CrossRef\]](#)
52. Lima-Junior, F.R.; Carpinetti, L.C.R. An adaptive network-based fuzzy inference system to supply chain performance evaluation based on SCOR® metrics. *Comput. Ind. Eng.* **2020**, *139*, 106191. [\[CrossRef\]](#)
53. Madanchi, F.; Maghroor, H.R.; O'Neal, T. A Systematic Review of the Internet of Things Contribution to Obtain Supply Chain Integration. In Proceedings of the 9th North American International Conference on Industrial Engineering and Operations Management, Washington, DC, USA, 4–6 June 2024. [\[CrossRef\]](#)
54. Wetsandornphong, S.T.; Farr, R.; Coleman, J.; Salimi, Z.; Sweeney, E. Performance, integration and dynamic capabilities in supply chains: An interpretive investigation of their relationships. *Supply Chain Manag. Int. J.* **2025**, *30*, 452–475. [\[CrossRef\]](#)
55. Mohaghar, A.; Ghasemi, R.; Taghipour, M. An empirical study on technology adoption and supply chain optimization using structural modeling. *Supply Chain Anal.* **2026**, *13*, 100181. [\[CrossRef\]](#)
56. Madanchi, F.; Maghroor, H.R.; O'Neal, T. Integrating Objectives and Key Results (OKRs) and Key Performance Indicators (KPIs) in Supply Chain Performance Management. In Proceedings of the 10th North American International Conference on Industrial Engineering and Operations Management, Orlando, FL, USA, 17–19 June 2025. [\[CrossRef\]](#)
57. Vergara, J.I.T.; Martínez, J.A.S.; Salais-Fierro, T.E. Performance measurement of a Resilient-Sustainable Supply Chain through fuzzy multi-criteria techniques. *Comput. Ind. Eng.* **2023**, *177*, 109059. [\[CrossRef\]](#)
58. Tripathi, S.; Talukder, B.; Rangarajan, K. Do Supply Chain Performance Influence Firm Profitability? A Predictive Approach in the Context of the Indian Pharmaceutical Industry. *IIM Kozhikode Soc. Manag. Rev.* **2024**, *13*, 166–183. [\[CrossRef\]](#)
59. Neely, A.; Gregory, M.; Platts, K. Performance measurement system design: A literature review and research agenda. *Int. J. Oper. Prod. Manag.* **1995**, *15*, 80–116. [\[CrossRef\]](#)
60. Lebas, M.J. Performance measurement and performance management. *Int. J. Prod. Econ.* **1995**, *41*, 23–35. [\[CrossRef\]](#)
61. Gonzalez-Pascual, E.; Nosedal-Sanchez, J.; Garcia-Gutierrez, J. Performance evaluation of a road freight transportation company through SCOR metrics. *Case Stud. Transp. Policy* **2021**, *9*, 1431–1439. [\[CrossRef\]](#)
62. Al-Jaradi, M.H.; de Waal, A.; Al-Hadramy, A.M. Increasing competitive performance through effective use of performance management systems. *Int. J. Product. Perform. Manag.* **2022**, *72*, 1924–1941. [\[CrossRef\]](#)
63. Reaidy, P.; Alaeddini, M.; Gunasekaran, A.; Lavastre, O.; Shahzad, M. Unveiling the impact of industry 4.0 on supply chain performance: The mediating role of integration and visibility. *Prod. Plan. Control* **2026**, *37*, 45–66. [\[CrossRef\]](#)
64. Tripathi, S.; Roy, S.S. Linking supply chain performance with organizational strategic performance—A review and research agenda. *Int. J. Product. Perform. Manag.* **2023**, *73*, 2037–2067. [\[CrossRef\]](#)
65. Bamakan, S.M.H.; Faregh, N.; ZareRavasan, A. Di-ANFIS: An integrated blockchain-IoT-big data-enabled framework for evaluating service supply chain performance. *J. Comput. Des. Eng.* **2021**, *8*, 676–690. [\[CrossRef\]](#)
66. Piotrowicz, W.D.; Ryciuk, U.; Szymczak, M. Lean and agile metrics. Literature review and framework for measuring leagile supply chain. *Int. J. Product. Perform. Manag.* **2021**, *72*, 1560–1583. [\[CrossRef\]](#)
67. Ayyildiz, E.; Taskin Gumus, A. Interval-valued Pythagorean fuzzy AHP method-based supply chain performance evaluation by a new extension of SCOR model: SCOR 4.0. *Complex Intell. Syst.* **2021**, *7*, 559–576. [\[CrossRef\]](#)
68. Ghobakhloo, M.; Iranmanesh, M.; Tseng, M.-L.; Grybauskas, A.; Stefanini, A.; Amran, A. Behind the definition of Industry 5.0: A systematic review of technologies, principles, components, and values. *J. Ind. Prod. Eng.* **2023**, *40*, 432–447. [\[CrossRef\]](#)
69. Ghobakhloo, M.; Mahdiraji, H.A.; Iranmanesh, M.; Jafari-Sadeghi, V. From Industry 4.0 Digital Manufacturing to Industry 5.0 Digital Society: A Roadmap Toward Human-Centric, Sustainable, and Resilient Production. *Inf. Syst. Front.* **2024**. [\[CrossRef\]](#)

70. Ghobakhloo, M.; Fathi, M.; Okwir, S.; Al-Emran, M.; Ivanov, D. Adaptive social manufacturing: A human-centric, resilient, and sustainable framework for advancing Industry 5.0. *Int. J. Prod. Res.* **2026**, *64*, 1127–1160. [\[CrossRef\]](#)
71. Ivanov, D. No risk, no fun? A bioinspired adaptation-based framework for supply chain resilience in Industry 5.0. *Int. J. Prod. Res.* **2025**, *63*, 7153–7173. [\[CrossRef\]](#)
72. Ivanov, D.; Dolgui, A.; Blackhurst, J.V.; Choi, T.-M. Toward supply chain viability theory: From lessons learned through COVID-19 pandemic to viable ecosystems. *Int. J. Prod. Res.* **2023**, *61*, 2402–2415. [\[CrossRef\]](#)
73. Ivanov, D. Transformation of supply chain resilience research through the COVID-19 pandemic. *Int. J. Prod. Res.* **2024**, *62*, 8217–8238. [\[CrossRef\]](#)
74. Barney, J. Firm Resources and Sustained Competitive Advantage. *J. Manag.* **1991**, *17*, 99–120. [\[CrossRef\]](#)
75. Barney, J.B.; Ketchen Jr, D.J.; Wright, M. Resource-Based Theory and the Value Creation Framework. *J. Manag.* **2021**, *47*, 1936–1955. [\[CrossRef\]](#)
76. Kharat, M.G.; Kharat, M.G.; Parhi, S.; Kapoor, S.; Joshi, S.P.; Agrawal, R. Strategic management of the dyadic buyer–supplier relationship and supplier development practices with respect to industry 4.0: An empirical study. *Oper. Manag. Res.* **2025**, *18*, 821–847. [\[CrossRef\]](#)
77. Teece, D.J.; Pisano, G.; Shuen, A. Chapter 8: Dynamic Capabilities and Strategic Management. In *Strategy, Technology and Public Policy*; Edward Elgar Publishing: Cheltenham, UK, 1998; pp. 197–222.
78. Teece, D.J. Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strateg. Manag. J.* **2007**, *28*, 1319–1350. [\[CrossRef\]](#)
79. Sharma, R.; Kamble, S.; Mani, V.; Belhadi, A. An Empirical Investigation of the Influence of Industry 4.0 Technology Capabilities on Agriculture Supply Chain Integration and Sustainable Performance. *IEEE Trans. Eng. Manag.* **2024**, *71*, 12364–12384. [\[CrossRef\]](#)
80. Zelbst, P.J.; Yang, L.; Green, K.W.; Sower, V.E. Linkages between technologies and supply chain performance: Benefits, power and risk reduction. *Supply Chain Manag. Int. J.* **2023**, *29*, 207–218. [\[CrossRef\]](#)
81. Rana, R.; Sauser, B.; Gligor, D.; Prybutok, V.; Hiatt, B. A Systematic Review of Systems Thinking in Supply Chain Research to Manage Complexity, Resilience and Sustainability. *Syst. Res. Behav. Sci.* **2025**, *43*, 789–809. [\[CrossRef\]](#)
82. Fatorachian, H.; Kazemi, H. Impact of Industry 4.0 on supply chain performance. *Prod. Plan. Control* **2021**, *32*, 63–81. [\[CrossRef\]](#)
83. Carnovale, S.; DuHadway, S.; Patrucco, A.S.; Yeniyurt, S. Balancing risk and resilience: How network structures and firm strategies mitigate supply chain disruptions. *Int. J. Phys. Distrib. Logist. Manag.* **2025**, *55*, 761–790. [\[CrossRef\]](#)
84. Kaplan, R.S.; Norton, D.P. *The Balanced Scorecard-Measures that Drive Performance*; Harvard Business Publishing: Boston, MA, USA, 1992.
85. Purvis, B.; Mao, Y.; Robinson, D. Three pillars of sustainability: In search of conceptual origins. *Sustain. Sci.* **2019**, *14*, 681–695. [\[CrossRef\]](#)
86. Seuring, S.; Müller, M. From a literature review to a conceptual framework for sustainable supply chain management. *J. Clean. Prod.* **2008**, *16*, 1699–1710. [\[CrossRef\]](#)
87. Fernando, Y.; Halili, M.; Tseng, M.-L.; Tseng, J.W.; Lim, M.K. Sustainable social supply chain practices and firm social performance: Framework and empirical evidence. *Sustain. Prod. Consum.* **2022**, *32*, 160–172. [\[CrossRef\]](#)
88. Ozbiltekin-Pala, M.; Koçak, A.; Kazancoglu, Y. A proposed circular-SCOR model for supply chain performance measurement in manufacturing industry during COVID-19. *Int. J. Qual. Reliab. Manag.* **2022**, *40*, 1203–1232. [\[CrossRef\]](#)
89. Kumar, A.; Shrivastav, S.K.; Shrivastava, A.K.; Panigrahi, R.R.; Mardani, A.; Cavallaro, F. Sustainable Supply Chain Management, Performance Measurement, and Management: A Review. *Sustainability* **2023**, *15*, 5290. [\[CrossRef\]](#)
90. Maestrini, V.; Luzzini, D.; Maccarrone, P.; Caniato, F. Supply chain performance measurement systems: A systematic review and research agenda. *Int. J. Prod. Econ.* **2017**, *183*, 299–315. [\[CrossRef\]](#)
91. Balfaqih, H.; Nopiah, Z.M.; Saibani, N.; Al-Nory, M.T. Review of supply chain performance measurement systems: 1998–2015. *Comput. Ind.* **2016**, *82*, 135–150. [\[CrossRef\]](#)
92. Gunasekaran, A.; Irani, Z.; Choy, K.-L.; Filippi, L.; Papadopoulos, T. Performance measures and metrics in outsourcing decisions: A review for research and applications. *Int. J. Prod. Econ.* **2015**, *161*, 153–166. [\[CrossRef\]](#)
93. Rad, F.F.; Oghazi, P.; Palmié, M.; Chirumalla, K.; Pashkevich, N.; Patel, P.C.; Sattari, S. Industry 4.0 and supply chain performance: A systematic literature review of the benefits, challenges, and critical success factors of 11 core technologies. *Ind. Mark. Manag.* **2022**, *105*, 268–293. [\[CrossRef\]](#)
94. Kamble, S.S.; Gunasekaran, A.; Ghadge, A.; Raut, R. A performance measurement system for industry 4.0 enabled smart manufacturing system in SMMEs– A review and empirical investigation. *Int. J. Prod. Econ.* **2020**, *229*, 107853. [\[CrossRef\]](#)
95. Kirsten, M.; Mthethwa, S.; Sitsha, T.; Niemann, W. Advancing sustainable supply chain management through digitalisation: Insights from the South African automotive industry. *J. Transp. Supply Chain Manag.* **2025**, *19*, 1221. [\[CrossRef\]](#)
96. Abdallah, A.B.; Almomani, H.A.; Al-Zu'bi, Z.B.M.F. Industry 4.0-Enabled Supply Chain Performance: Do Supply Chain Capabilities and Innovation Matter? *Logistics* **2025**, *9*, 36. [\[CrossRef\]](#)

97. Rasool, F.; Greco, M.; Grimaldi, M. Digital supply chain performance metrics: A literature review. *Meas. Bus. Excell.* **2022**, *26*, 23–38. [\[CrossRef\]](#)
98. Jamil, M.A.; Mustofa, R.; Hossain, N.U.I.; Rahman, S.M.A.; Chowdhury, S. A structural equation modeling framework for exploring the industry 5.0 and sustainable supply chain determinants. *Supply Chain Anal.* **2024**, *6*, 100060. [\[CrossRef\]](#)
99. Whittemore, R.; Knafl, K. The integrative review: Updated methodology. *J. Adv. Nurs.* **2005**, *52*, 546–553. [\[CrossRef\]](#)
100. Snyder, H. Literature review as a research methodology: An overview and guidelines. *J. Bus. Res.* **2019**, *104*, 333–339. [\[CrossRef\]](#)
101. Torraco, R.J. Writing Integrative Literature Reviews: Guidelines and Examples. *Hum. Resour. Dev. Rev.* **2005**, *4*, 356–367. [\[CrossRef\]](#)
102. Beal Partyka, R. Supply chain management: An integrative review from the agency theory perspective. *Rev. De Gestão* **2021**, *29*, 175–198. [\[CrossRef\]](#)
103. Soundararajan, V.; Wilhelm, M.; Crane, A.; Agarwal, P.; Shetty, H. Towards a Systemic Approach for Improving Working Conditions in Global Supply Chains: An Integrative Review and Research Agenda. *Acad. Manag. Ann.* **2024**, *19*, 230–264. [\[CrossRef\]](#)
104. Fain, J.A. Distinguishing Between Integrative and Systematic Literature Reviews. *Sci. Diabetes Self-Manag. Care* **2024**, *50*, 105–106. [\[CrossRef\]](#)
105. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ* **2021**, *372*, n71. [\[CrossRef\]](#)
106. Singh, V.K.; Singh, P.; Karmakar, M.; Leta, J.; Mayr, P. The journal coverage of Web of Science, Scopus and Dimensions: A comparative analysis. *Scientometrics* **2021**, *126*, 5113–5142. [\[CrossRef\]](#)
107. Sarangi, S.; Ghosh, D. The impact of industry 4.0 technologies enable supply chain performance and quality management practice in the healthcare sector. *TQM J.* **2024**, *38*, 297–323. [\[CrossRef\]](#)
108. Dixit, C.; Kumar, R.; Kumar, A. Developing sustainable and resilient supply chain: Industry 4.0 drivers, dynamic capabilities, and performance evaluation. *Prod. Plan. Control* **2026**, 1–15. [\[CrossRef\]](#)
109. Fares, N.; Lloret, J. Barriers to supply chain performance measurement during disruptions such as the COVID-19 pandemic. *Int. J. Qual. Reliab. Manag.* **2023**, *40*, 1316–1342. [\[CrossRef\]](#)
110. Godinho Filho, M.; Monteiro, L.; de Oliveira Mota, R.; dos Santos Leite Gonella, J.; de Souza Campos, L.M. The Relationship between Circular Economy, Industry 4.0 and Supply Chain Performance: A Combined ISM/Fuzzy MICMAC Approach. *Sustainability* **2022**, *14*, 2772. [\[CrossRef\]](#)
111. Kumar, M.; Raut, R.D.; Mangla, S.K.; Chowdhury, S.; Choubey, V.K. Moderating ESG compliance between industry 4.0 and green practices with green servitization: Examining its impact on green supply chain performance. *Technovation* **2024**, *129*, 102898. [\[CrossRef\]](#)
112. Abdulameer, S.S.; Ibrahim, Y.M. Leveraging Industry 4.0 technologies, AI-based supply chain analytics and circular economy practices for net-zero and sustainable supply chain performance: A moderated mediation model. *Supply Chain Manag. Int. J.* **2025**, *30*, 701–718. [\[CrossRef\]](#)
113. Mrad, M.; Belgaroui, R. Digital–Circular Synergies in Sustainable Supply Chain Management: An Integrative Framework for SME Performance Enhancement. *Sustainability* **2025**, *17*, 10616. [\[CrossRef\]](#)
114. Riaz, A.; Rehman, H.M.; Sohail, A.; Rehman, M. Industry 4.0 supply chain nexus: Sequential mediating effects of traceability, visibility and resilience on performance. *Asia Pac. J. Mark. Logist.* **2024**, *37*, 842–860. [\[CrossRef\]](#)
115. Tsang, Y.P.; Fan, Y.; Lee, C.K.M.; Lau, H.C.W. Blockchain sharding for e-commerce supply chain performance analytics towards Industry 5.0. *Enterp. Inf. Syst.* **2024**, *18*, 2311807. [\[CrossRef\]](#)
116. Belhadi, A.; Kamble, S.; Gunasekaran, A.; Mani, V. Analyzing the mediating role of organizational ambidexterity and digital business transformation on industry 4.0 capabilities and sustainable supply chain performance. *Supply Chain Manag. Int. J.* **2021**, *27*, 696–711. [\[CrossRef\]](#)
117. Sharma, M.; Sehrawat, R.; Luthra, S.; Daim, T.; Bakry, D. Moving Towards Industry 5.0 in the Pharmaceutical Manufacturing Sector: Challenges and Solutions for Germany. *IEEE Trans. Eng. Manag.* **2024**, *71*, 13757–13774. [\[CrossRef\]](#)
118. Aprilia, A.; Syafrial; Koestiono, D.; Riana, D.F.; Maulidah, S. Sustainability performance evaluation of tropical fruit supply chain in Indonesia using the best-worst method. *Agric. Econ.* **2026**, *72*, 120–134. [\[CrossRef\]](#)
119. Nisrina, N.; Ardi, R.; Tjahjono, B. Designing sustainable supply chain metrics for the Indonesian fashion industry: A DEMATEL-Based ANP approach. *Clean. Eng. Technol.* **2025**, *25*, 100921. [\[CrossRef\]](#)
120. Štreimikienė, D.; Bathaei, A.; Streimikis, J. Enhancing Sustainable Global Supply Chain Performance: A Multi-Criteria Decision-Making-Based Approach to Industry 4.0 and AI Integration. *Sustainability* **2025**, *17*, 4453. [\[CrossRef\]](#)
121. Ramos, E.; Chavez Grados, M.A.; Govindan, K.; Gamarra Gomez, K.E.; Gavirneni, N. Designing a sustainable performance measurement system for an agri-food supply chain through supply chain agility based on digital technologies. *Benchmarking Int. J.* **2025**, *33*, 1291–1322. [\[CrossRef\]](#)

122. León-Bravo, V.; Caniato, F. Sustainability performance measurement in the food supply chain: Trade-offs, institutional pressures, and contextual factors. *Eur. Manag. J.* **2024**, *42*, 633–646. [\[CrossRef\]](#)
123. Sharma, M.; Kamble, S.; Mani, V.; Sehrawat, R.; Belhadi, A.; Sharma, V. Industry 4.0 adoption for sustainability in multi-tier manufacturing supply chain in emerging economies. *J. Clean. Prod.* **2021**, *281*, 125013. [\[CrossRef\]](#)
124. Ponomarov, S.Y.; Holcomb, M.C. Understanding the concept of supply chain resilience. *Int. J. Logist. Manag.* **2009**, *20*, 124–143. [\[CrossRef\]](#)
125. Mamun, M. Supply chain resilience: A systematic literature review of definitions, drivers, and practices. *Transp. Res. Interdiscip. Perspect.* **2026**, *38*, 102055. [\[CrossRef\]](#)
126. Li, P.; Chen, Y.; Guo, X. Digital transformation and supply chain resilience. *Int. Rev. Econ. Financ.* **2025**, *99*, 104033. [\[CrossRef\]](#)
127. Tian, Z.; Pajić, V.; Kilibarda, M.; Andrejić, M. Enhancing Distribution Efficiency Through OTIF Performance Evaluation. *Mathematics* **2024**, *12*, 3372. [\[CrossRef\]](#)
128. Ivanov, D. When is the supply chain resilient? Customer and operational perspectives. *Int. J. Prod. Res.* **2025**, *63*, 5512–5527. [\[CrossRef\]](#)
129. Meena, P.L.; Katiyar, R.; Kumar, G. Supplier performance and selection from sustainable supply chain performance perspective. *Int. J. Product. Perform. Manag.* **2022**, *72*, 2420–2445. [\[CrossRef\]](#)
130. Kundu, S.; Rani, M.V. A Fermatean fuzzy-based framework for sustainable supplier selection to enhance humanitarian supply chain performance. *Int. J. Product. Perform. Manag.* **2026**, 1–21. [\[CrossRef\]](#)
131. Jin, Y.; Hu, Q.; Kim, S.W.; Zhou, S.X. Supplier Development and Integration in Competitive Supply Chains. *Prod. Oper. Manag.* **2019**, *28*, 1256–1271. [\[CrossRef\]](#)
132. Kazancoglu, I.; Ozbiltekin-Pala, M.; Kumar Mangla, S.; Kazancoglu, Y.; Jabeen, F. Role of flexibility, agility and responsiveness for sustainable supply chain resilience during COVID-19. *J. Clean. Prod.* **2022**, *362*, 132431. [\[CrossRef\]](#)
133. Zaid, M.; Farooqi, R.; Azmi, S.N. Driving sustainable supply chain performance through digital transformation: The role of information exchange and responsiveness. *Cogent Bus. Manag.* **2025**, *12*, 2443047. [\[CrossRef\]](#)
134. Agrawal, N.; Sharma, M.; Raut, R.D.; Mangla, S.K.; Arisian, S. Supply Chain Flexibility and Post-pandemic Resilience. *Glob. J. Flex. Syst. Manag.* **2023**, *24*, 119–138. [\[CrossRef\]](#)
135. Scarpin, M.R.S.; Scarpin, J.E.; Krespi Musial, N.T.; Nakamura, W.T. The implications of COVID-19: Bullwhip and ripple effects in global supply chains. *Int. J. Prod. Econ.* **2022**, *251*, 108523. [\[CrossRef\]](#)
136. Nguyen, A.; Lamouri, S.; Pellerin, R. Managing demand volatility during unplanned events with sentiment analysis: A case study of the COVID-19 pandemic. *IFAC-PapersOnLine* **2021**, *54*, 1017–1022. [\[CrossRef\]](#)
137. Thanou, E.; Matopoulos, A. Pathways to upscaling: Aligning capabilities with supply chain design in automotive manufacturing. *Supply Chain Manag. Int. J.* **2026**, *31*, 536–559. [\[CrossRef\]](#)
138. Li, X.; Gu, X.; Huang, S.; Wang, B.; Leng, J.; Wang, L. Smart reconfigurable manufacturing towards Industry 5.0. *J. Manuf. Syst.* **2026**, *86*, 178–202. [\[CrossRef\]](#)
139. Phadnis, S. A review of research on supply chain adaptability: Opening the black box. *J. Bus. Logist.* **2024**, *45*, e12370. [\[CrossRef\]](#)
140. Han, Y.; Chong, W.K.; Li, D. A systematic literature review of the capabilities and performance metrics of supply chain resilience. *Int. J. Prod. Res.* **2020**, *58*, 4541–4566. [\[CrossRef\]](#)
141. Tripathi, S.; Talukder, B. Supply Chain Performance and Profitability in Indian Automobile Industry: Evidence of Segmental Difference. *Glob. Bus. Rev.* **2023**, *24*, 371–392. [\[CrossRef\]](#)
142. Guerreiro, R.; Rodrigues Bio, S.; Vazquez Villamor Merschmann, E. Cost-to-serve measurement and customer profitability analysis. *Int. J. Logist. Manag.* **2008**, *19*, 389–407. [\[CrossRef\]](#)
143. Whitmore, C.; Bartos, B.; Arrambide, O.; Karlov, D. Cost to Serve: Does Your Profitability Reporting Tell the Full Story? 2025. Available online: <https://www.deloitte.com/content/dam/assets-zone3/us/en/docs/services/risk-advisory/2024/us-advisory-cost-to-serve.pdf> (accessed on 31 July 2026).
144. Huang, C.-K.; Cheng, Y.-H. Assessing firm performance in digital transformation: A preliminary analysis using financial indicators. *Manag. Financ.* **2024**, *50*, 1641–1661. [\[CrossRef\]](#)
145. Guragai, B.; Hutchison, P.D.; Farris, M.T., II. Cash-to-Cash (C2C) Length: Insights on Present and Future Profitability and Liquidity. In *Advances in Management Accounting*; Burney, L.L., Malina, M.A., Eds.; Emerald Publishing Limited: Leeds, UK, 2019; Volume 31.
146. Wu, L.-C.; Eng, T.-Y.; Wang, C.-W. Working capital management under supply chain disruption: The role of government response during economic uncertainty. *J. General. Manag.* **2024**, *50*, 65–77. [\[CrossRef\]](#)
147. Hallikas, J.; Immonen, M.; Brax, S. Digitalizing procurement: The impact of data analytics on supply chain performance. *Supply Chain Manag. Int. J.* **2021**, *26*, 629–646. [\[CrossRef\]](#)
148. Seelent, J.F.C.; Mendonça, J.A.; Lermen, F.H.; Benitez, G.B. Navigating Industry 5.0 through corporate social responsibility and digital transformation: A stakeholder and institutional perspective. *Prod. Plan. Control* **2026**, *37*, 413–439. [\[CrossRef\]](#)
149. Stenzel, A.; Waichman, I. Supply-chain data sharing for scope 3 emissions. *npj Clim. Action* **2023**, *2*, 7. [\[CrossRef\]](#)

150. Canal Vieira, L.; Longo, M.; Mura, M. Making Scope 3 emissions management count: Enhancing shared responsibility in the supply chain. *Int. J. Oper. Prod. Manag.* **2025**, *46*, 1–25. [[CrossRef](#)]
151. Hettler, M.; Graf-Vlachy, L. Corporate scope 3 carbon emission reporting as an enabler of supply chain decarbonization: A systematic review and comprehensive research agenda. *Bus. Strategy Environ.* **2024**, *33*, 263–282. [[CrossRef](#)]
152. Wang, M.; Liu, Y.; Geng, D.; Dora, M.; Hill, A. Decarbonisation and firm financial performance: The roles of supply chain transparency and resilience. *Int. J. Prod. Econ.* **2026**, *296*, 109988. [[CrossRef](#)]
153. Zhang, A.; Tay, H.L.; Alvi, M.F.; Wang, J.X.; Gong, Y. Carbon neutrality drivers and implications for firm performance and supply chain management. *Bus. Strategy Environ.* **2023**, *32*, 1966–1980. [[CrossRef](#)]
154. Atif, S. Analysing the alignment between circular economy and industry 4.0 nexus with industry 5.0 era: An integrative systematic literature review. *Sustain. Dev.* **2023**, *31*, 2155–2175. [[CrossRef](#)]
155. Marizcurrena, M.; Morás, V.; Ulery, G.; Rossit, D.; Piñeyro, P. Chapter 9—Closed-loop supply chain and extended producer responsibility (EPR): A literature review. In *Evolution and Trends of Sustainable Approaches*; Rossit, D.A., Hussain, C.M., Eds.; Elsevier: Amsterdam, The Netherlands, 2024; pp. 129–151.
156. Baldassarre, B. Circular economy for resource security in the European Union (EU): Case study, research framework, and future directions. *Ecol. Econ.* **2025**, *227*, 108345. [[CrossRef](#)]
157. Zhou, H.; Liu, J. Digitalization of the economy and resource efficiency for meeting the ESG goals. *Resour. Policy* **2023**, *86*, 104199. [[CrossRef](#)]
158. Al Tera, A.; Alzubi, A.; Iyiola, K. Supply chain digitalization and performance: A moderated mediation of supply chain visibility and supply chain survivability. *Heliyon* **2024**, *10*, e25584. [[CrossRef](#)]
159. Hellweg, F.; Lechtenberg, S.; Hellingrath, B.; Thomé, A.M.T. Literature Review on Maturity Models for Digital Supply Chains. *Braz. J. Oper. Prod. Manag.* **2021**, *18*, 1–12. [[CrossRef](#)]
160. Hein-Pensel, F.; Winkler, H.; Brückner, A.; Wölke, M.; Jabs, I.; Mayan, I.J.; Kirschenbaum, A.; Friedrich, J.; Zinke-Wehlmann, C. Maturity assessment for Industry 5.0: A review of existing maturity models. *J. Manuf. Syst.* **2023**, *66*, 200–210. [[CrossRef](#)]
161. Kagalwala, H.; Radhakrishnan, G.V.; Mohammed, I.A.; Kothinti, R.R.; Kulkarni, N. Predictive Analytics in Supply Chain Management: The Role of AI and Machine Learning in Demand Forecasting. *Adv. Consum. Res.* **2025**, *2*, 142–149.
162. Aljohani, A. Predictive Analytics and Machine Learning for Real-Time Supply Chain Risk Mitigation and Agility. *Sustainability* **2023**, *15*, 15088. [[CrossRef](#)]
163. Kamble, S.S.; Gunasekaran, A. Big data-driven supply chain performance measurement system: A review and framework for implementation. *Int. J. Prod. Res.* **2020**, *58*, 65–86. [[CrossRef](#)]
164. Li, L.; Duan, L. Human centric innovation at the heart of industry 5.0—Exploring research challenges and opportunities. *Int. J. Prod. Res.* **2026**, *64*, 4901–4933. [[CrossRef](#)]
165. Nayeri, S.; Sazvar, Z.; Heydari, J. Towards a responsive supply chain based on the industry 5.0 dimensions: A novel decision-making method. *Expert Syst. Appl.* **2023**, *213*, 119267. [[CrossRef](#)]
166. D'souza, C.P.; Tapas, P. Diversity 5.0 framework: Managing innovation in Industry 5.0 through diversity and inclusion. *Eur. J. Innov. Manag.* **2024**, *28*, 1834–1857. [[CrossRef](#)]
167. Jerónimo, H.M.; Henriques, P.L.; Carvalho, S.I. Being inclusive boosts impact of diversity practices on employee engagement. *Manag. Res. J. Iberoam. Acad. Manag.* **2021**, *20*, 129–147. [[CrossRef](#)]

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