Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 10, No. 3, 277-297
2026
Publisher: Learning Gate
DOI: 10.55214/2576-8484.v10i3.12343

Digital transformation and sustainable firm performance in global manufacturing: A systematic review

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Abstract: Digital transformation is a driving force in sustainable industrial development, yet evidence on the sustainable manufacturing outcomes of digital business initiatives remains incomplete. This systematic literature review (SLR) analyzed 70 empirical studies published between 2010 and January 2026 that examined digital transformation processes resulting in economic, environmental, and innovation performance outcomes. The research combined various digital transformation processes through which organizations achieved business success, using five principal mediator pathways that follow the PRISMA 2020 guidelines. The study results showed that digital transformation does not directly enhance organizational performance; instead, it occurs through the development of organizational capabilities, the transformation of processes, the execution of innovation initiatives, and sustainability-focused activities. The research also shows that capability-based mechanisms are the most common pathways, followed by operational and innovation-mediated pathways. The research field shows a prevailing pattern of using cross-sectional survey methods, which create challenges for establishing causal relationships and evaluating enduring sustainability outcomes. The review shows that digital transformation needs to be better understood, as it plays a vital role in sustainable manufacturing transitions, according to established explanatory frameworks that link digital transformation to sustainable business results. The research study identifies three primary obstacles, which include conceptual fragmentation, measurement inconsistencies, and geographical concentration, while suggesting future research directions.

Keywords: *Digital transformation, Manufacturing, Mediation mechanisms, PRISMA, Sustainable business models, Sustainable firm performance.*

1. Introduction

Digital transformation has emerged as a central pillar in sustainable industrial competitiveness in the era of Industry 4.0 and 5.0 [1] with manufacturing firms investing heavily in digital technologies. These include big data analytics, artificial intelligence (AI), industrial Internet of Things (IIoT), cloud platforms, and cyber–physical systems. These upgrades not only enhance operational efficiency and financial returns [2] but also improve environmental performance, resource efficiency, resilience, and long-term sustainability [3-7]. As regulatory pressures intensify and stakeholders demand stronger environmental, social, and governance (ESG) performance, digital transformation is increasingly seen as a strategic enabler of sustainable firm performance [8, 9].

However, despite rapid growth in empirical research examining the relationship between digital transformation and firm performance, findings remain fragmented and theoretically dispersed [2], [10, 11]. Some studies report positive effects of digitalization on financial and innovation performance [4, 8] while others highlight contextual dependencies and heterogeneous outcomes [12, 13].

History: Received: 2 January 2026; Revised: 9 February 2026; Accepted: 12 February 2026; Published: 6 March 2026
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Moreover, the sustainability implications of digital transformation, particularly its role in enabling environmental performance and sustainable competitive advantage, remain inconsistently theorized and empirically tested [9, 14].

A key reason for this fragmentation lies in the complexity of digital transformation processes. Digital initiatives rarely directly improve performance. Instead, they reshape organizational capabilities, operational routines, innovation activities, and business models, thereby influencing performance outcomes [3, 15]. As a result, an increasing number of empirical studies employ mediation models to explain how digital transformation translates into firm-level outcomes [16, 17]. These mediating mechanisms range from dynamic capabilities and organizational agility [3, 15] to supply chain integration and operational resilience [17, 18], green innovation [8, 19], and servitization strategies [20, 21].

The mechanism-based perspective has advanced theoretical knowledge, yet still requires multiple aspects to be resolved, as the current literature does not provide a comprehensive assessment of the mediating elements in the field. Existing studies typically focus on isolated mechanisms without evaluating their relative prevalence or explanatory patterns across the broader empirical landscape [22].

Sustainability outcomes serve as secondary performance dimensions rather than primary strategic objectives. Many studies emphasize financial or operational metrics while inferring sustainability benefits through indirect means [4, 16]. The research shows that the implementation of sustainability-oriented mediators, including green innovation and sustainable supply chain practices, is lower than reported by researchers studying capability-based explanations [8, 9].

The research shows that academic work primarily relies on cross-sectional survey methods and structural equation modeling techniques, in line with established methodological standards [23, 24]. The research field lacks sufficient resources due to the limited availability of longitudinal studies and multi-level research methods that can track temporal changes in sustainable development processes.

The study conducts a systematic review of the literature on how digital transformation affects the performance of manufacturing companies, aiming to fill existing research gaps. The authors follow the PRISMA 2020 guidelines [25] to combine results from 70 studies published between 2010 and January 2026. We use a mechanism-based synthesis method that divides mediating constructs into main explanatory paths, as our research requires more than just listing results. The pathways show how digital transformation affects performance through economic, environmental, and innovation-related outcomes. The review offers new insights into how digital transformation supports or hinders sustainable manufacturing transitions by combining scattered research evidence with a deeper understanding of its operation.

To address the identified gaps, this study is guided by the following research questions:

RQ1: What mediating mechanisms link digital transformation to sustainable firm performance in manufacturing, and how are these mechanisms distributed across the empirical literature?

RQ2: What methodological patterns exist in current research studies that investigate digital transformation and sustainable performance outcomes in manufacturing firms?

RQ3: What theoretical and empirical gaps exist in research that explain the process by which digital transformation leads to sustainable value creation within manufacturing operations?

2. Methods

2.1. SLR Approach

This study uses a systematic literature review (SLR) to synthesize analytical studies examining how digital transformation affects the performance of manufacturing companies. SLRs provide a rigorous and transparent methodology for identifying, evaluating, and synthesizing existing knowledge using predefined protocols [26, 27]. The SLR method improves research reliability through its use of specific inclusion criteria and repeatable research methods, which control for selection bias that occurs in narrative reviews, as noted by Snyder [28].

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 10, No. 3: 277-297, 2026
DOI: 10.55214/2576-8484.v10i3.12343

The review process follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [25], which establish standardized procedures for literature identification, screening, eligibility assessment, and inclusion. The PRISMA framework improves transparency in reporting and facilitates critical evaluation of review rigor [29].

2.2. Database and Search Strategy

The Web of Science (WoS) Core Collection served as the central database for this research. WoS provides curated indexing of high-quality peer-reviewed journals across management, operations, manufacturing, and sustainability disciplines [30]. The Topic Search function was used to search because it retrieves information from the title, abstract, and author keywords. The search string was designed to combine three conceptual domains: digital transformation, manufacturing context, and performance outcomes. The final search string was:

(("digital transformation" OR digitalization OR "industry 4.0" OR "digital transformation degree") AND (manufacturing OR "manufacturing industry") AND ("firm performance" OR "innovation performance" OR "firm outcome"))

The time frame covered publications from 1 January 2010 to 31 January 2026. The starting year reflects the acceleration of Industry 4.0 scholarship and digital transformation discourse in manufacturing research [1]. Only peer-reviewed journal articles published in English were included to ensure accessibility, comparability, and methodological rigor [28].

2.3. Study Selection Process

The study selection process followed PRISMA 2020 guidelines [25] and consisted of four stages: identification, screening, eligibility assessment, and inclusion (Figure 1).

Edelweiss Applied Science and Technology
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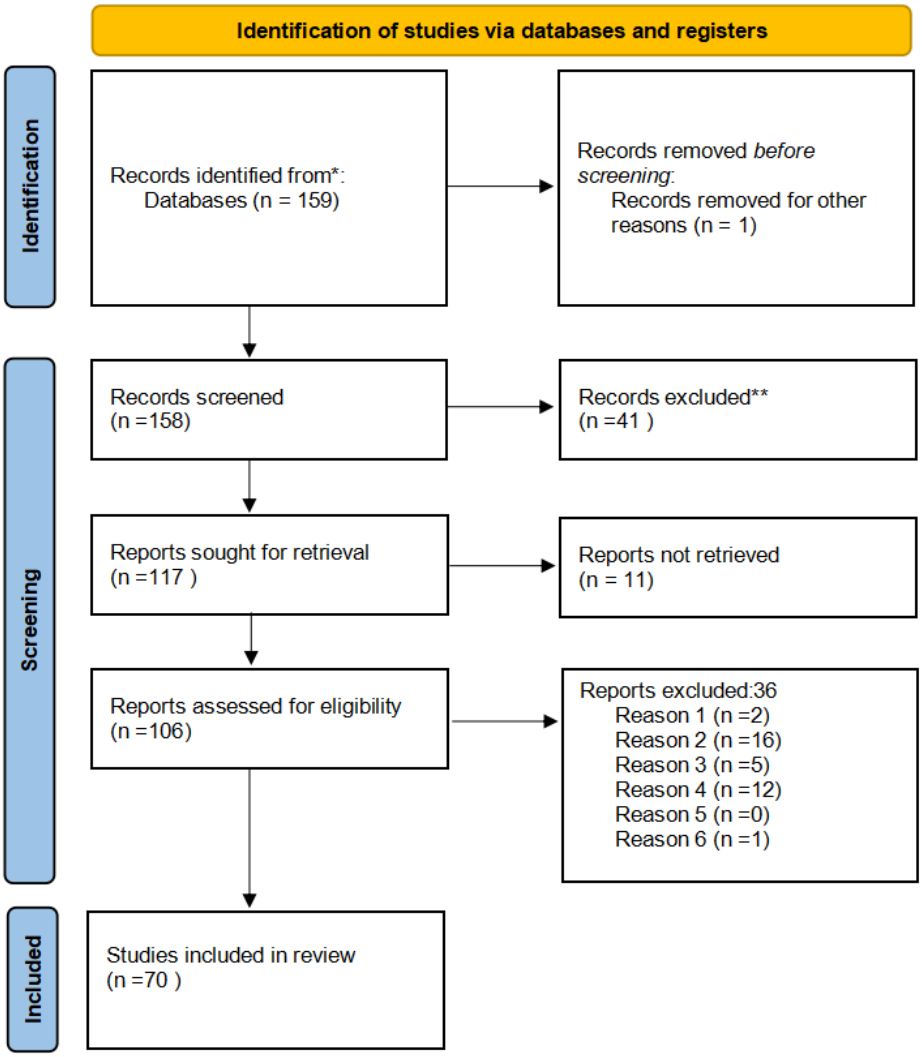

Figure 1.
PRISMA Flow Diagram for the SLR.
Note: PRISMA flow diagram showing: Identification (n=159), Screening (n=158 → 106), Eligibility (n=106 → 70), Included (n=70).

2.3.1. Identification Phase

The initial Web of Science search returned 159 records. One retracted article was removed prior to screening, leaving 158 publications for further evaluation.

2.3.2. Screening Phase

Two researchers independently screened titles and abstracts to ensure alignment with the research scope. Studies were retained if they:

(a) focused on manufacturing firms,
(b) examined digital transformation or closely related constructs, and
(c) assessed firm-level or innovation performance outcomes.

This phase resulted in the exclusion of 41 publications for failing to align with the research objectives. An additional 11 studies were excluded because full texts were inaccessible. A total of 106 publications progressed to the eligibility stage.

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2.3.3. Eligibility Phase

Full-text assessment was conducted using predefined inclusion and exclusion criteria consistent with systematic review best practices [27].

2.3.3.1. Inclusion Criteria

Empirical quantitative studies
Manufacturing firm context
Measurable digital transformation construct
Firm-level or innovation performance outcome
Peer-reviewed journal publication
English language

2.3.3.2. Exclusion Criteria

Conceptual or purely qualitative studies
Macro-level analyses without firm-level data
Absence of a measurable digital transformation variable
Absence of a performance outcome variable
Duplicate or retracted publications
Following full-text assessment, 36 additional articles were excluded.
The remaining 70 empirical studies satisfied all inclusion criteria and were retained for synthesis.

2.4. Data Extraction and Coding

Data extraction followed structured coding procedures consistent with systematic review methodology [26, 28]. Extracted information included:

Bibliographic details (authors, year, journal)
Research design (survey, archival, mixed methods)
Sample characteristics and country context
Measurement approaches for digital transformation
Performance dimensions assessed
Mediating and moderating constructs

The researchers conducted independent coding of a pilot sample comprising 10 studies. The researchers then achieved a 92% inter-coder agreement by coding the studies independently [31]. The team used discussion to resolve discrepancies among members to maintain consistent results. The study division between coders began after calibration, while cross-checks were conducted at regular intervals to verify compliance with systematic review standards [27]. The complete coding framework, together with the study characteristics extracted from the research, is presented in *Appendix Table A1* to provide transparency and allow others to replicate the study.

2.5. Data Synthesis Approach

To address the research questions, a two-stage synthesis strategy was adopted.

2.5.1. Descriptive Analysis

The first stage of the research process began with a descriptive evaluation of three specific aspects: publication year, journal outlet, geographical distribution, research design, and measurement approaches. Management-oriented systematic reviews use descriptive synthesis to create a framework that shows the intellectual structure and methodological patterns of their research [28]. The research question is whether two direct relationships exist, as this stage establishes which research methods scientists use most frequently and which regions they focus their study efforts on.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
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2.5.2. Mechanism-Based Synthesis

The second stage used a mechanism-based synthesis method to identify and categorize mediating constructs linking digital transformation to company performance. Mechanism-based explanations are fundamental components of both organizational theory and management research, which study causal relationships [32, 33].

The research team used an inductive coding method to organize the mediating constructs into higher-level categories through repeated comparisons. The research generated categories that emerged from continuous comparison of empirical models, rather than using existing categories to create the research framework. The method described here should be used when researchers need to resolve theoretical disputes and create unified theoretical frameworks [28].

The mechanism-based synthesis process establishes RQ1 solutions by showing the primary explanation routes. The study used cross-study comparisons to examine three aspects: theoretical framing and analytical methods, and sustainability outcomes. The first aspect identifies conceptual gaps, while the second shows methodological limitations that particularly affect assessments of sustainability over extended periods.

3. Results

3.1. Publication Trends

The analysis of 70 empirical studies shows a clear trend of increasing publication rates throughout the research period (Figure 2). The period from 2010 to 2015 was the first phase, during which publication patterns were irregular. Researchers in this period focused on how organizations adopted technology and achieved better results, while neglecting the actual reasons behind performance success. Liao et al. [1] laid the groundwork in exploring how companies integrated new Industry 4.0 technologies and how these integrations affected their operational efficiency.

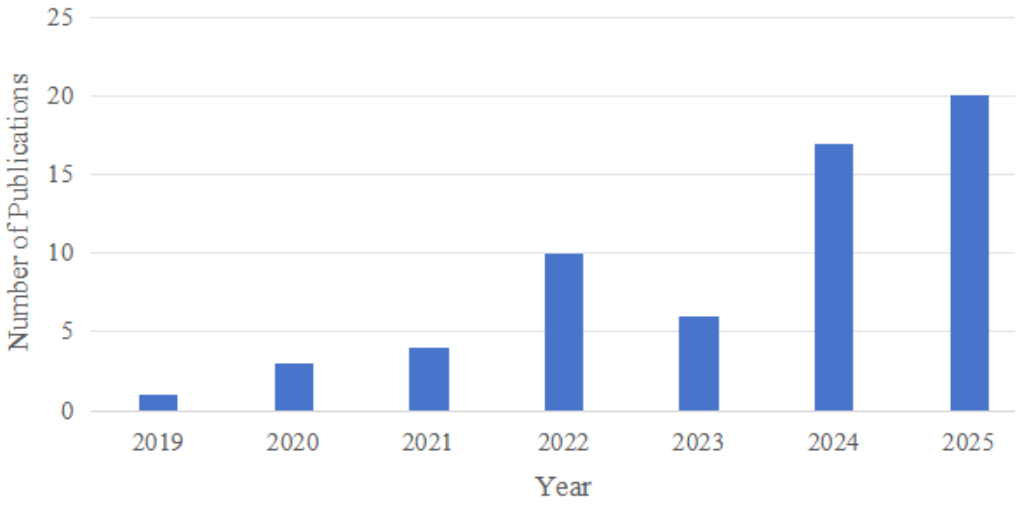

Figure 2.
Annual Distribution of Publications (2010-2026).
Note: Observe the sharp increase post-2018, and steep rise between 2022–2025.

Scholarly output has increased steadily since 2018, when the industrial sector began using digital platforms and intelligent manufacturing systems. The research focus shifted to studying the outcomes of digital transformation, along with the mediating pathways linking digital transformation research to these outcomes, as shown in the studies by Liang and Li [34] and Zhang et al. [35].

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The current period shows the highest growth of all historical periods. Between 2022 and 2025, 53 of 70 studies (75.7%) were published. The current research trend has advanced toward the study of intricate patterns that yield diverse and sophisticated results. Researchers have examined how digital transformation enables organizations to maintain resilience and achieve innovation success while building lasting market power, drawing on the work of Chatterjee et al. [36], Dai and Fang [37], and Zhao et al. [13].

3.2. Journal Distribution

The disciplinary focus of the published research, as detailed in Figure 3, is concentrated in journals with specific thematic orientations. Sustainability-oriented journals, for instance, have been a primary outlet for studies examining the mediating roles of green innovation and environmental management practices [9, 17, 34, 38].

In contrast, engineering and operations management journals frequently feature research adopting capability-based perspectives, where digital technologies are viewed as enablers of specific organizational competencies [10, 11, 39]. Moreover, the production and operations outlets conducted research showing that supply chain integration and digital process implementation serve as essential mediators in achieving better operational results [15, 17, 18].

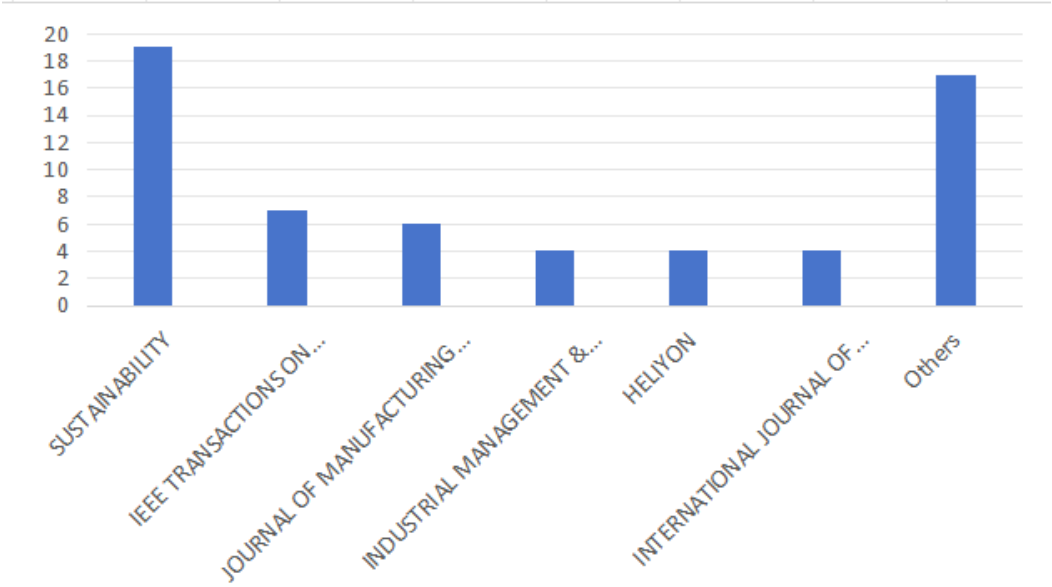

Figure 3.
Publishing sources of Included Articles.
Note: Sustainability (19), IEEE TEM (7), JMTM (6).

3.3. Geographical Distribution

The dataset shows that empirical studies mainly focus on China, which supports previous research that identified China as a key location for digital transformation research [3, 4, 6]. The dataset shows that China and three other countries (Turkey, Spain, and Germany) have made significant research contributions, which now span multiple countries. However, the focus remains on specific areas of study [40, 41].

3.4. Methodological Approaches

While a variety of quantitative methods are employed, the review identified the use of more specialized analytical techniques alongside traditional regression-based approaches. These include

Edelweiss Applied Science and Technology
ISSN: 2576-8484
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necessary condition analysis [23], fuzzy-set qualitative comparative analysis (fsQCA) [24], and event study methodologies [42] reflecting a growing methodological sophistication in the field to capture the complex, non-linear, and configurational nature of the relationships under study.

3.5. Mechanism-Based Classification

The core of this review's contribution is the synthesis of the diverse ways in which digital transformation translates into firm performance. An inductive analysis of the 70 studies yielded five distinct, yet occasionally overlapping, categories of mediating mechanisms, which are summarized in Figure 4 and Table 1. Additionally, this classification suggests a structured framework for understanding the "black box" between digital transformation and its outcomes.

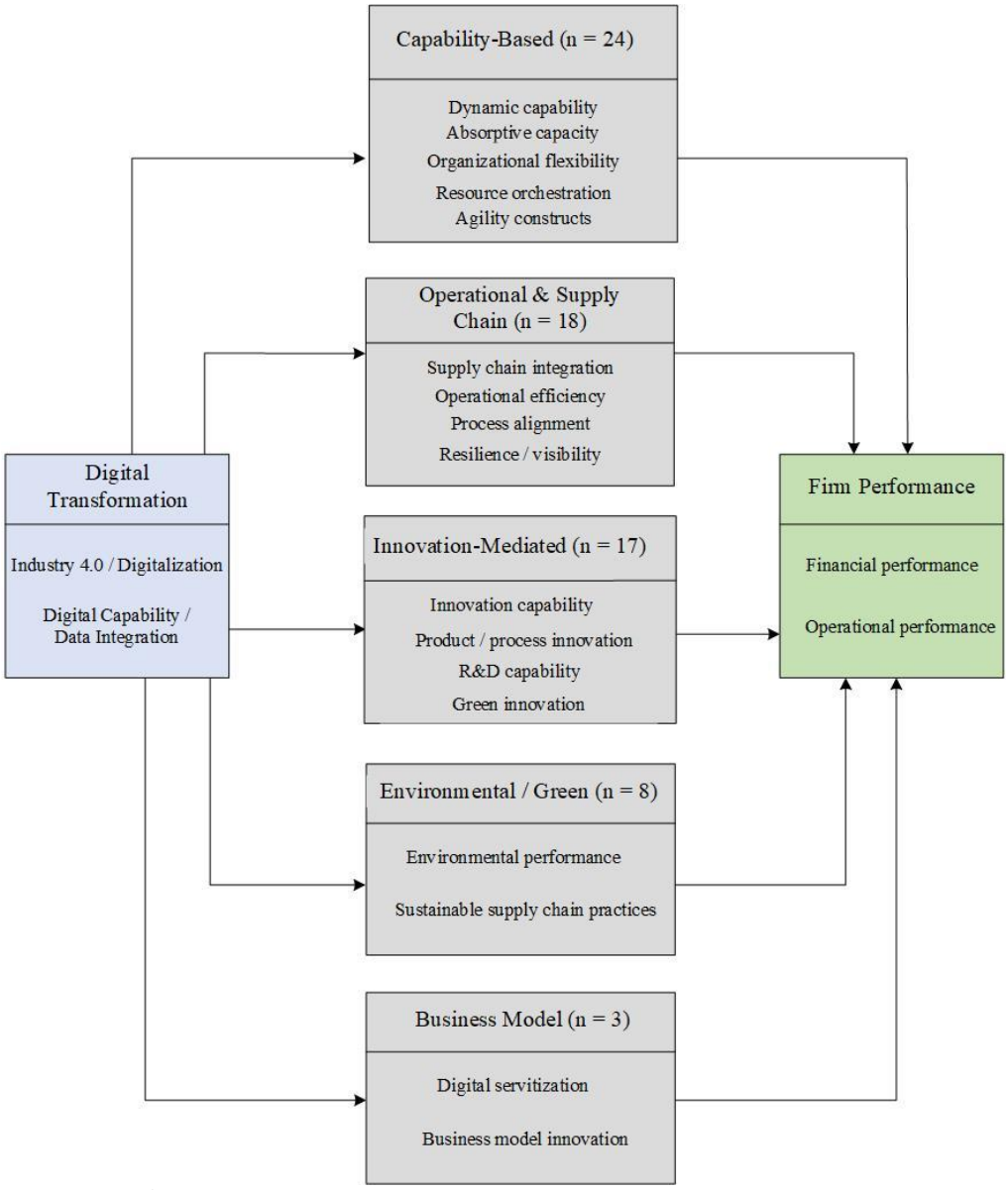

Figure 4.
Five Mechanisms Linking Digital Transformation to Firm Performance.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 10, No. 3: 277-297, 2026
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Table 1.
Distribution of Mediating Mechanisms across Reviewed Studies.

Mechanism Category	n	%	Representative Mediators
Capability-based	24	34.3%	Dynamic capability, absorptive capacity, organizational agility, digital capability
Operational/Supply chain	18	25.7%	Supply chain integration, operational flexibility, lean practices, process efficiency
Innovation-mediated	17	24.3%	Product innovation, process innovation, green innovation, and ambidextrous innovation
Environmental sustainability	8	11.4%	Green supply chain management, circular economy practices, and environmental orientation
Business model–oriented	3	4.3%	Servitization, business model innovation, value configuration
Total	70	100%	

Note: A comprehensive coding table containing detailed descriptions of all 70 included studies is provided in Appendix Table A1.

3.6. Capability-Based Mechanisms

The most frequently observed pathway, appearing in 34.3% of the studies, is through the development and enhancement of organizational capabilities (Table 1). Dynamic capability theory [43] provides the theoretical foundation for this perspective, which holds that organizations must develop their internal and external competencies to achieve competitive advantage in dynamic markets. Research evidence supports this argument: organizations that implement digital transformation projects develop capabilities to achieve organizational agility, absorptive capacity, and operational flexibility, resulting in improved business outcomes. Wang et al. [4] conducted formal testing to determine whether digital capability functioned as a mediator, while Guo and Xu [3] studied the methods through which such capabilities develop. The research has been expanded to examine specific situations, including building dynamic capabilities during disruptive events [16] and using absorptive capacity to support operational recovery [13].

3.7. Innovation-Mediated Mechanisms

Accounting for 24.3% of the studies, innovation-mediated mechanisms represent a second major pathway. Here, digital transformation is shown to enhance firm performance by stimulating and enabling innovation. This innovation can take multiple forms, including product, process, and green innovation. Wang et al. [4] again provide evidence for innovation capability as a key mediator, while Liang and Li [34] isolate R&D intensity as a specific pathway. More recent work has integrated contemporary themes, such as the role of green innovation in mediating the relationship between ESG performance and firm outcomes [8] and the enabling effect of Green IoT on ambidextrous innovation [19].

3.8. Operational and Supply Chain–Oriented Mechanisms

The third category, comprising 25.7% of the studies, focuses on improvements within the firm's internal operations and its external supply chain network as the primary mediating link. This stream of research demonstrates that digital technologies drive performance by enhancing operational efficiency, enabling process digitalization, and fostering greater supply chain integration. The digitalization of the supply chain itself has been identified as a crucial mediator [17], as have specific outcomes like improved supply chain visibility and survivability [44]. Studies also point to the mediating role of implementing specific systems, such as manufacturing execution systems [41] and achieving greater process efficiency [45].

3.9. Environmental Sustainability Mechanisms

A distinct and growing body of literature (11.4% of studies) treats environmental sustainability not merely as an outcome but as a mediating mechanism. In this view, digital transformation helps firms improve their environmental performance, which, in turn, yields broader performance benefits. Pan and

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ISSN: 2576-8484
Vol. 10, No. 3: 277-297, 2026
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Xiao [46], for example, demonstrate the mediating role of environmental orientation. Similarly, studies have shown that digital transformation can enhance green supply chain management practices [39, 47] and strengthen internal control mechanisms to improve overall ESG performance [37], thereby creating a pathway to sustainable innovation and performance.

3.10. Business Model–Oriented Mechanisms

The last emergent category accounted for 4.3% of all research studies demonstrating fundamental business model transformation through their studied mechanisms (Figure 5). Organizations need to develop their value-creation and value-capture functions through this perspective, which goes beyond their current process and capability development work. The primary operational methods businesses use include digital servitization, enabling manufacturers to provide advanced services through their digital tools [20, 48] and the creation of new business models through their digital projects [12]. Resource orchestration capability is a critical factor that enables organizations to achieve their transformation goals while building sustainable competitive advantage, according to research findings [21, 35]. This category, while currently the smallest, signals a promising and advanced direction for future research.

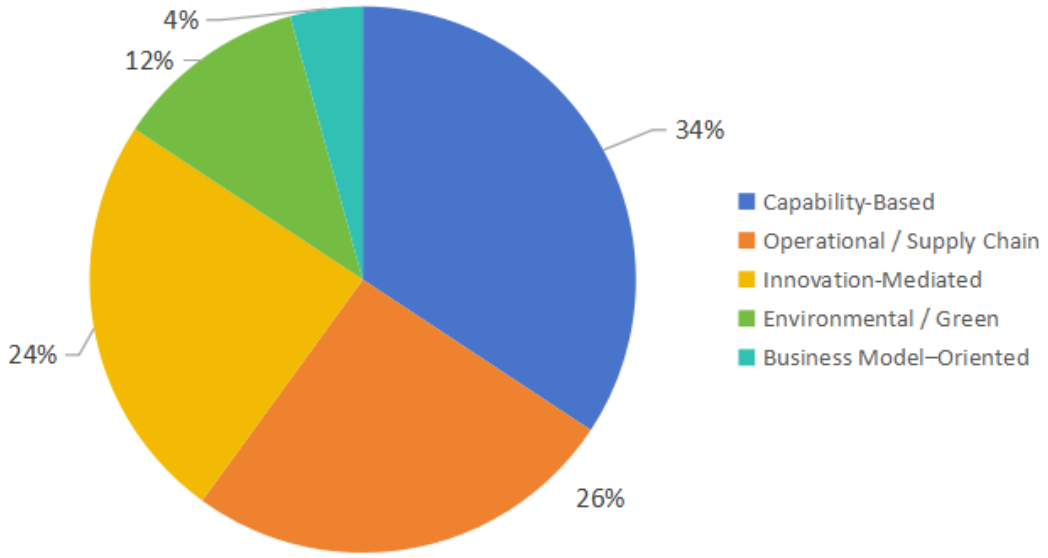

Figure 5.
Relative Distribution of Mechanism Categories.

4. Discussion

4.1. Dominant Mechanism Patterns and Sustainability Implications

The study results show that research on digital transformation in manufacturing now uses advanced performance assessment methods rather than the basic direct measurement methods used in earlier research. The majority of recent studies now treat digitalization as a performance driver that operates through distinct organizational processes rather than as an independent variable that produces immediate performance effects. The field has advanced because researchers now understand that digital investments lead to success only through specific mechanisms.

The empirical landscape currently exists as a research field that relies on capability-oriented explanations. Many studies use dynamic capability theory as their foundation to show that digital technologies function as strategic resources that improve a firm's environmental change detection, opportunity identification, and internal process adaptation capabilities [43]. Digital transformation is important in this context because it enhances an organization's ability to adapt. The situation has

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ISSN: 2576-8484
Vol. 10, No. 3: 277-297, 2026
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significant sustainability consequences. Environmental monitoring, circular resource tracking, and energy optimization capabilities will not develop automatically through technology adoption. Organizations need to develop their capabilities through intentional efforts that need to align with sustainability objectives.

Researchers conduct primary research through innovation-mediated pathways, which serve as a fundamental research pathway. They investigate digital transformation as a technological driver that enables product, process, and environmentally sustainable innovation development. Studies that use green innovation as a mediating factor demonstrate that digital infrastructure systems enable both environmental technological advancements and their market introduction [8, 13, 19]. The field of ecological performance research has made limited progress because researchers have conducted only a few studies on the topic. Most organizations determine sustainability benefits from their innovation outcomes rather than measuring actual environmental performance using environmental assessment metrics.

Operational and supply chain systems are equally important throughout their operations. Digital integration, along with supply chain visibility and process alignment implementations, demonstrates its ability to improve operational efficiency, organizational flexibility, and operational resilience. The results lead to sustainable development by reducing waste and improving resource use. Researchers assess performance using standard economic and operational metrics that fail to capture environmental impacts. The sustainability potential of these mechanisms is a partial theoretical framework that researchers have only tested indirectly.

Environmental sustainability mediators appear less frequently in quantitative models because they are less common than other elements. The digital transformation process leads to environmental results because it establishes fundamental links that show up in their work. The literature shows little interest in studying how digitalization causes environmental harm through its adverse external effects. The energy consumption of data infrastructures and the material costs of hardware turnover complicate the narrative of digital transformation as inherently sustainable [49]. The solution to this conflict requires direct environmental indicator measurement, which must be conducted.

Finally, this research found that researchers have conducted limited studies on business model evaluation methods. The research uses digital technologies for servitization, circular models, and platform-based value creation as its framework, yet only a small number of studies include these elements as mediating factors [50].

5. Conclusion

The systematic review combined 70 empirical studies from 2010 to 2026 that investigate how manufacturing firms perform after undergoing digital transformation. The study identified five main mediation pathways through which research results link to study outcomes and demonstrates how study outcomes are affected by capability-based mechanisms (24 studies), operational and supply chain–oriented mechanisms (18), innovation-mediated mechanisms (17), environmental sustainability mechanisms (8), and business model–oriented mechanisms (3) [9, 12, 51].

The existing literature shows that digital transformation has observable performance impacts. The organization achieves its performance goals through digital transformation by enhancing capabilities, implementing operational changes, developing new products, and applying sustainability practices.

The most common approach to testing dynamic capability theory focuses on capability-based explanations, while environmental and business model views are less frequently used. The research field primarily uses cross-sectional survey designs, which create a bias toward Chinese manufacturing research and restrict both causal inference and general applicability. The findings show that organizations need to implement digital transformation strategies to achieve sustainability advantages.

Organizations should allocate their financial resources toward digital technologies while building their organizational capabilities through green innovation, supply chain development, and the establishment of institutional support systems. The review provides a comprehensive framework that

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ISSN: 2576-8484
Vol. 10, No. 3: 277-297, 2026
DOI: 10.55214/2576-8484.v10i3.12343

researchers can use to investigate sustainable industrial transformation research despite its restriction to Web of Science–indexed English-language journals and interpretive classification procedures.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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Appendix A

In Table A1, the DV (Dependent Variable) is the outcome the researchers are trying to explain or predict. It is the "effect" in a cause-and-effect relationship. In A1, Study 1 aims to explain "Business model innovation," while Study 2 aims to explain "Innovation performance."

Mediator (Mediating Variable) is the "How" or the Mechanism. Its purpose is to explain the process through which the IV (Independent Variable) affects the DV. The IV causes the Mediator, which in turn causes the DV. It sits in the middle of the chain.

Once again, in Table A1, Study 1 suggests that Digital Technologies (IV) do not directly change Business Model Innovation (DV). Instead, they first improve Firm agility and Absorptive capacity (the Mediators), which then lead to business model innovation.

Moderator (Moderating Variable) is the "When" or the "For Whom." It is the variable that affects the strength or direction of the relationship between the IV and DV (or between the Mediator and DV). It changes the context. In A1, Study 1 suggests that the relationship between Digital Technologies/Absorptive Capacity and Business Model Innovation depends on Market turbulence. If markets are highly turbulent, the effect might be stronger; if markets are stable, the effect might be weaker. Study 2 did not test any moderators (the cell is blank).

Independent Variable (IV) is the Predictor or the Cause. This is the variable that is manipulated or measured to see its effect on the DV. Study 1 examines the impact of Digital technologies. Study 2 examines the impact of Digital supply chain dimensions.

When you read a row, you can follow the logic of the research model: Study 1 Logic: Digital Technologies (IV) lead to Firm Agility and Absorptive Capacity (Mediators), which in turn lead to Business Model Innovation (DV). However, this whole process is contingent upon the level of Market Turbulence (Moderator).

Table A1.
Distribution of Mediating Mechanisms across Reviewed Studies.

ID	Method	DV	Mediator	Moderator	IV	Authors
1	SEM (PLS-SEM)	Business model innovation	Firm agility; Absorptive capacity	Market turbulence	Digital technologies	Abuseta, et al. [12]
2	SEM (Smart PLS 4)	Innovation performance	Supply chain agility		Digital supply chain dimensions	Elmouhib and Idrissi [52]

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 10, No. 3: 277-297, 2026
DOI: 10.55214/2576-8484.v10i3.12343

ID	Method	DV	Mediator	Moderator	IV	Authors
3	SEM	Sustainable agricultural supply chain performance	Supply chain integration		Industry 4.0 technology capabilities	Sharma, et al. [39]
4	Hierarchical regression	ESG performance	Green innovation		Digital transformation strategy (business/platform digitalization)	Zhao, et al. [13]
5	SEM (AMOS)	Operational performance; Supply chain competency		Intrinsic barriers; Extrinsic barriers	Industry 4.0 adoption/digitalization practices	Chauhan, et al. [53]
6	Regression (mediation & moderation)	Operational performance	Supply chain flexibility	Environmental uncertainty (customer/supplier)	Smart supply chain / Digital transformation	Enrique, et al. [15]
7	Regression +bootstrapped mediation	Sustainable competitive advantage	Ambidextrous innovation strategy		Big data capability	Zhang, et al. [35]
8	Panel regression + bootstrap mediation	Process innovation; Product innovation	Exploratory and Exploitative R&D capability		Digital transformation (text/keyword frequency in annual reports)	Liang and Li [34]
9	EFA/CFA + SEM	Firm performance	Supplier quality		Supplier selection CSFs (incl. Industry 4.0 approach)	Beltran-Salomon, et al. [54]
10	SEM	Green innovation performance	Green supply chain collaboration	Top management's environmental awareness	Digital capability	Cheng, et al. [8]
11	SEM + multigroup analysis	Firm performance; Resilience	Cost performance; Operational performance	Technology turbulence; Top management commitment	Supply chain digitalization	Chatterjee, et al. [36]
12	Mediation regression	Firm performance	Market capitalizing agility; Operational adjustment agility		Digitalization capability	Li, et al. [16]
13	Panel regression + IV + robustness tests	Firm performance	Low-cost empowerment; Innovation empowerment		Digital transformation (digital investment)	Wang, et al. [4]
14	Panel regression	Non-financial performance (innovation/ESG/resilience/competitiveness)	Internal control quality		Digital transformation	Dai and Fang [37]
15	Panel regression	Circular economy performance		Institutional development; Industry competition	Digital transformation	Yin, et al. [55]
16	SEM	Environmental performance	Innovation capability	Digital organizational	Digital transformation	Sarfraz, et al. [56]

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 10, No. 3: 277-297, 2026
DOI: 10.55214/2576-8484.v10i3.12343

ID	Method	DV	Mediator	Moderator	IV	Authors
				culture	strategy	
17	DID / PSM-DID	Corporate innovation		TMT heterogeneity	Digital transformation (policy quasi-experiment)	Zhang and Yang [57]
18	Panel regression	Environmental performance	Structural effect; Technology effect		Industrial digitalization (ICT penetration)	Wen, et al. [58]
19	SEM (AMOS)	Sustainable competitive performance	Digital capability	Digital culture	Digital strategy	Al-Omush, et al. [59]
20	Time-lagged survey + PROCESS macro	Net-zero green performance	Ambidextrous green innovation	Data-driven lean and green practices	Big data analytics capability; Green IoT	Mehmood, et al. [19]
21	Necessary Condition Analysis (NCA)	Firm performance	Organizational ambidexterity (exploration, exploitation)		Digital servitisation capability	Matusek [23]
22	Panel regression + IV	Financial performance		Productivity; Technological innovation	Digital technology convergence	Gao, et al. [60]
23	SEM + regression	Sustainable corporate performance	Green knowledge acquisition; Innovation performance	Digital transformational leadership	Digital transformation	Asbeetah, et al. [9]
24	Regression (moderated mediation)	Firm performance	Resource flexibility; Coordination flexibility	Market turbulence	Digitalization	Li, et al. [61]
25	SEM	Innovation performance	Big data capability; Organizational agility		Digital transformation	Xu, et al. [62]
26	Regression	Innovation performance	Dual innovation synergy	Strategic flexibility	Digitalization	Wang, et al. [6]
27	SEM/regression	Technology innovation performance		Adaptability to technology embedding	Digital empowerment	Li, et al. [63]
28	SEM	Firm performance		Environmental uncertainty	Digital transformation	Gun, et al. [64]
29	Panel regression	Firm performance	Digitalization	ESG performance	Servitization	Miao, et al. [65]
30	PLS-SEM	Firm performance	Servitization		Industry 4.0 technologies	Imran, et al. [20]
31	Hierarchical regression + bootstrapping	Operational performance	Lean bundles (JIT, TPM, TQM)	Stakeholder engagement	Industry 4.0 technologies	Benitez, et al. [66]
32	Regression analysis	Operational performance	Organizational practices		Digitalization / new technologies	Manresa, et al. [45]
33	Regression	Green process innovation		Horizontal information sharing; Bottom-up learning; Technological modularization	Manufacturing digitalization	Wei and Sun [67]

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 10, No. 3: 277-297, 2026
DOI: 10.55214/2576-8484.v10i3.12343

ID	Method	DV	Mediator	Moderator	IV	Authors
34	Panel regression (non-linear inverted-U)	Innovation performance		CEO digital experience; Family CEO	Digitalization distinctiveness	Zhu, et al. [68]
35	PLS-SEM	Sustainable supply chain performance	Green supply chain management; Circular economy practices		Industry 4.0 technologies	Karmaker, et al. [47]
36	SEM	Supply chain performance	Absorptive capability; Response capability; Recovery capability		Supply chain digitalization	Zhao, et al. [17]
37	Survey regression	Firm performance effects		Organizational structure	Big data analytics; MES implementation	Wiech, et al. [41]
38	SEM	Operational performance	Lean supply chain; Agile supply chain		Industry 4.0 base technologies	de Oliveira-Dias, et al. [18]
39	SEM	Sustainable organizational performance	Lean manufacturing practices		Industry 4.0 technologies	Kamble, et al. [69]
40	Econometric regression	Product innovation; Process innovation		Open innovation search breadth	AI adoption; Big data analytics	Petković and Radicic [70]
41	Moderated mediation	Operational performance	Supply chain agility	Knowledge transfer	Social media utilization	Bai, et al. [71]
42	Regression / SEM	Innovation performance	Digitalization		Servitization	Shen, et al. [72]
43	Survey + archival regression	Green innovation	Opportunity explication: Organizational flexibility	Firm ownership (SOE vs non-SOE)	Business process digitalization	Tao, et al. [38]
44	SEM	Supply chain performance	Supply chain visibility	Supply chain survivability	Supply chain digitalization	Al Tera, et al. [44]
45	PLS-SEM	Sustainable competitive advantage	Innovation capability	Data availability	Big data analytics capability	Ramadan, et al. [73]
46	Longitudinal sequence analysis + mediation	Sustainable innovation performance	Data orchestration capability; Cyber-physical integration		Industry 4.0 technology adoption sequences	Bautista Carrillo and Arias-Aranda [51]
47	Regression/mediation	Firm performance	Resource orchestration capability; Business model design	Industry type	Supply chain digitalization	Li, et al. [74]
48	SEM	Firm performance	Internal process efficiency		Business intelligence capability	Chen, et al. [75]
49	SEM	Environmental performance	Sustainable supply chain management; Innovation		BDA-AI capability	Han, et al. [76]

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 10, No. 3: 277-297, 2026
DOI: 10.55214/2576-8484.v10i3.12343

ID	Method	DV	Mediator	Moderator	IV	Authors
			ambidexterity			
50	CFA + SEM	Operational effectiveness	Process innovation	Strategy alignment	Additive technologies adoption	Tegethoff, et al. [77]
51	SEM (moderated mediation)	Economic performance; Environmental performance	Digital supply chain platform	Environmental dynamism	Digital technologies (Industry 4.0)	Li, et al. [78]
52	Panel regression + mediation tests	Firm performance; Export performance	Cost reduction; R&D intensity; Human capital enhancement	Region; Ownership heterogeneity	Digital transformation	Wang, et al. [5]
53	SEM	Financial performance			Digitalization; Servitization	Abou-Foul, et al. [79]
54	Probit / Tobit / IV regression	Innovation performance		Industry type	Industry 4.0 adoption	Sarbu [40]
55	SEM + fsQCA	Product innovation performance; Process innovation performance	Digital transformation		IT capabilities	Chu, et al. [24]
56	SEM	Sustainable performance	Green entrepreneurial orientation	Environmental dynamism	Digitalization capability	Liang, et al. [80]
57	Hierarchical multiple regression	Operational performance			Factory digitalisation; Lean manufacturing	Buer, et al. [81]
58	Long-horizon event study (panel)	Firm performance		Differentiation strategy; Absorptive capacity; Lean production mechanism	Process digitalization initiative (PDI)	Yang and Yee [42]
59	Panel regression	Operating performance; Financial performance		Policy environment; Innovation environment	Digital transformation intensity	Guo and Xu [3]
60	SEM	Company performance	Digital innovation; Value co-creation		Digital capability	Wang, et al. [5]
61	PLS-SEM	Manufacturing industry performance	Knowledge management activities		Industry 4.0 technologies	Zhang, et al. [82]
62	SEM	Sustained competitive advantage		Data-driven culture	Big data analytics capabilities; IoT capabilities; Innovation capabilities	Vafaei-Zadeh, et al. [83]
63	Panel regression	Innovation performance		Risk-taking level	Digital transformation	Li, et al. [11]
64	SEM	Operational performance; Innovation performance	Dynamic capability	Economic context (developed vs developing)	Industry 4.0 adoption	Sunder and Prashar [84]
65	Endogenous switching regression	Firm performance (e.g.,		Sectoral heterogeneity/performance	Platformization (digital transformation)	Truong and Ngo [85]

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ID	Method	DV	Mediator	Moderator	IV	Authors
		ROS/ROA/cash flow as discussed)		distribution		
66	CB-SEM	Financial performance	Resource orchestration capability; Servitization (serial)	Organizational improvisation (moderates servitization→FP)	Digitalization	Turkcan, et al. [21]
67	Textual analysis + regression	Firm profitability		Digital service offering type (heterogeneity)	Digital servitization	Kwak, et al. [86]
68	SEM	Supply chain performance	Supply chain integration; Supply chain efficiency	Supply chain dynamism	Digitalization	Alzubi and Yinal [87]
69	SEM	Environmental performance	CSR		Digital resources /digitalization	Pan and Xiao [46]
70	Panel regression	Business performance		Digital transformation level; CEO age	IT investment	Guan and Wang [2]

Edelweiss Applied Science and Technology
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