



Research Article

DIGITAL LEARNING VELOCITY AND MANUFACTURING PERFORMANCE: HOW MARKET ORIENTATION DRIVES INNOVATION-EFFICIENCY SEQUENCING UNDER INDUSTRY 4.0

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ABSTRACT

This study examines the coverage, awareness, and satisfaction with statutory social security provisions among women labourers employed in small-scale industries (SSIs) in Indore, Madhya Pradesh, India. Drawing on primary data collected from 444 women workers through a structured interview schedule, non-participant observation, and focused group discussions, the study assesses awareness of core labour welfare legislation — including the Maternity Benefit Act, the Payment of Gratuity Act, and the Employees' State Insurance Act — as well as uptake of national social security schemes such as the Pradhan Mantri Shram Yogi Maan-Dhan Yojana (PM-SYM), the Pradhan Mantri Jeevan Jyoti Bima Yojana (PMJJBY), the Ayushman Bharat-Pradhan Mantri Jan Arogya Yojana (AB-PMJAY), and the Public Distribution System (PDS). Findings indicate high nominal awareness of most statutory schemes (78–98 per cent) but only moderate satisfaction with their practical implementation, with the sharpest gaps observed in financial support during unemployment and disability benefit access. Awareness of contributory pension and insurance schemes substantially exceeds awareness of employer-linked statutory entitlements, suggesting a two-track social security landscape. The study concludes that legal awareness does not automatically translate into adequate coverage or satisfaction, and that implementation gaps — rather than information gaps — constitute the principal barrier to effective social security for women labour in the SSI sector. Policy recommendations focus on strengthening employer compliance monitoring, simplifying claim processes, and integrating scheme awareness with grievance redress mechanisms.

INTRODUCTION

The rapid diffusion of Industry 4.0 technologies such as artificial intelligence, the industrial Internet of Things (IoT), advanced analytics, and cyber–physical systems has fundamentally reshaped manufacturing operations (Danso et al., 2024). Firms increasingly invest in digital infrastructures to enhance visibility, coordination, and responsiveness across production and supply networks. These technologies are widely associated with improvements in efficiency, flexibility, and quality, and are often assumed to generate superior operational and financial performance (Anjum et al., 2012). However, despite similar levels of digital investment, manufacturing firms continue to exhibit markedly uneven performance outcomes, raising critical questions about how and why digitalization delivers value in some contexts but not in others (Vial, 2021).

Empirical evidence suggests that technology adoption alone cannot explain these divergent outcomes (Ahmadimousaabad et al., 2013). Many manufacturers implement similar Industry 4.0 technologies but achieve markedly different levels of efficiency, innovation, and profitability. In some organizations, digitalization creates information-rich environments that overwhelm existing learning and coordination mechanisms, resulting in underutilized systems, delayed decisions, and poorly aligned initiatives (Nasiri et al., 2013). These findings indicate that digital transformation is not simply a technological change but an organizational challenge that depends on how firms integrate, interpret, and act upon digital information (Warner & Wäger, 2019).

Much of the existing literature conceptualizes digitalization primarily as a structural transformation, emphasizing automation intensity, system integration, and connectivity across the value chain (Mobarakabadi & Karami, 2014). While these dimensions are important, growing evidence shows that they are insufficient to account for sustained performance differences. Studies in manufacturing and supply-chain contexts increasingly highlight the mediating role of organizational capabilities (particularly learning-oriented and dynamic capabilities) in translating digital investments into agility, innovation, and process improvement. Without such capabilities, digital technologies may increase complexity rather than enhance performance (Dubey et al., 2022; Vial, 2021).

From a Dynamic Capability Theory, competitive advantage under Industry 4.0 depends less on owning digital technologies and more on the ability to sense opportunities, reconfigure processes, and institutionalize learning (Chikaji et al., 2015). This perspective shifts attention from technology itself to the organizational mechanisms that transform digital resources into value (Permana et al., 2019; Sangari & Razmi, 2015). In rapidly changing manufacturing environments, the speed of learning and adaptation determines whether digital initiatives generate sustained competitive advantage (Teece, 2019).

Despite this shift, two important gaps remain in literature. First, existing studies often treat innovation and efficiency as competing priorities, leaving unclear how firms reconcile experimentation with operational discipline in digital manufacturing contexts. Second, while learning capabilities are frequently acknowledged, little is known about how the speed of learning conditions the performance returns of digitalization. As a result, the mechanisms through which market sensing is converted into innovation, stabilized through efficiency, and amplified by learning velocity remain insufficiently understood (Dubey et al., 2022; Koh et al., 2016).

To address these gaps, this study develops and empirically tests a capability-sequencing framework explaining how manufacturing firms convert market sensing into superior performance under Industry 4.0. Drawing on Dynamic Capability Theory, Market Orientation is conceptualized as a sensing capability that stimulates Supply Chain Innovation, which is subsequently institutionalized through Supply Chain Efficiency to improve Organizational Performance (Yoon et al., 2016). The framework further introduces Digital Learning Velocity, represented by the interaction between Digital Maturity and Digital Absorptive Capability, and examines how Technological Turbulence amplifies this capability sequence (Abourokbah et al., 2023).

This study makes three contributions to the manufacturing and operations management literature. First, it reconceptualizes Market Orientation as a dynamic sensing capability that initiates supply-chain adaptation in digitally intensive manufacturing environments (Karami, 2026). Second, it empirically resolves the

innovation–efficiency paradox by demonstrating that innovation and efficiency operate as sequential, rather than competing, capabilities through which digitalization influences performance. Third, it introduces digital learning velocity as a micro-foundational mechanism explaining why digitally mature firms exhibit divergent performance outcomes under similar technological conditions. Together, these contributions advance Dynamic Capability Theory and offer a coherent explanation of how manufacturing firms convert digital investments into sustained competitive advantage.

THEORY AND HYPOTHESES DEVELOPMENT

Theory Integration Logic: A Dynamic Capability Theory

This study draws on Dynamic Capability Theory to explain how manufacturing firms transform digital investments into performance under Industry 4.0 conditions. Dynamic capabilities emphasize firms' abilities to sense opportunities, seize them through reconfiguration, and transform operational routines to sustain advantage in environments characterized by rapid change (Teece, 2007, 2019). In digitally intensive manufacturing contexts, where information volume and velocity increase dramatically, competitive advantage depends less on technology ownership and more on how firms orchestrate learning and adaptation across organizational processes (Ferreira & Coelho, 2020; Moshood et al., 2025).

Within this framework, Market Orientation represents a sensing capability that structures how firms detect and interpret market and technological signals. Supply Chain Innovation reflects seizing activities through which firms experiment with new configurations and digital solutions, while Supply Chain Efficiency captures transforming processes that institutionalize learning into stable routines (Oshilalu, 2024). Digital learning mechanisms and environmental turbulence further shape the speed and effectiveness of this capability sequence. This perspective enables the development of hypotheses that emphasize process, sequencing, and learning velocity, rather than static associations.

Market Orientation as a Sensing Capability and Supply Chain Innovation

As a sensing capability, Market Orientation (MO) shapes how firms systematically generate, disseminate, and respond to market intelligence relevant to operational and strategic decisions (Mohamad et al., 2015). Rather than serving solely as a marketing philosophy, MO guides organizational attention toward customer needs, competitive moves, and technological trends that signal opportunities for adaptation (Cheng & Yang, 2017; Wang & Zhang, 2025a). In manufacturing environments undergoing Industry 4.0 transformation, such sensing is critical for identifying where digital technologies can be leveraged to redesign supply-chain processes (Jaworski & Kohli, 1993; Kohli & Jaworski, 1990).

Through this sensing function, MO enables firms to initiate Supply Chain Innovation (SCI) by translating external signals into experimentation with new coordination mechanisms, digital tools, and process architecture (Wang & Zhang, 2025b). Market-oriented firms are better positioned to recognize misalignments between existing operations and evolving market requirements, prompting innovation in planning, sourcing, production, and logistics. Prior research shows that firms with stronger market-sensing capabilities are more likely to engage in proactive innovation rather than reactive adjustment (Dubey et al., 2022; Jaworski & Kohli, 1993; Kohli & Jaworski, 1990).

Under Industry 4.0 conditions, the volume and velocity of market and operational data further amplify the importance of sensing capabilities. Firms lacking strong MO may struggle to prioritize relevant signals, leading to fragmented or misdirected innovation efforts (Abu-Rumman et al., 2021; Mariani et al., 2025). In contrast, market-oriented firms can channel digital information toward coherent innovation initiatives, suggesting a positive relationship between MO and SCI.

H1. Market Orientation positively influences Supply Chain Innovation.

Supply Chain Innovation and the Transformation toward Efficiency

While innovation enables experimentation and adaptation, its performance impact depends on whether new practices are stabilized and institutionalized (Durach & Wiengarten, 2017; He et al., 2026). Supply Chain Innovation introduces novel processes, technologies, and coordination mechanisms, but without subsequent consolidation, such experimentation may increase complexity and coordination costs (Yoon et al., 2016). From a Dynamic Capability Theory, innovation represents a seizing activity that must be followed by transforming processes to generate sustained value (Teece, 2007, 2019).

Supply Chain Efficiency (SCE) captures this transformation by embedding successful innovations into standardized routines, performance metrics, and governance structures (Mohammadi et al., 2015). Efficiency does not imply rigidity; rather, it reflects disciplined execution that reduces variability, improves reliability, and enables scalability. In digitally enabled supply chains, efficiency emerges when innovative practices are codified, automated, and aligned across organizational boundaries (Papaioannou et al., 2020).

Industry 4.0 technologies increase the need for such transformation by expanding process interdependencies and information flows. Without efficiency-oriented transformation, innovation initiatives may remain isolated pilots rather than organization-wide improvements. Accordingly, supply chain innovation is expected to positively influence supply chain efficiency (Yoon et al., 2016).

H2. Supply Chain Innovation positively influences Supply Chain Efficiency.

Supply Chain Efficiency and Organizational Performance

Supply Chain Efficiency represents the institutionalization of learning into stable operational routines that support consistent performance outcomes (Ghasemi et al., 2016). Efficient supply chains reduce waste, improve coordination, and enhance responsiveness, enabling firms to translate operational capabilities into financial and competitive benefits (Borazon et al., 2022). Prior research consistently links efficiency-oriented capabilities to improvements in cost, quality, delivery reliability, and overall organizational performance (Hamann-Lohmer et al., 2023).

From a Dynamic Capability Theory, efficiency reflects transforming activities that convert adaptive responses into sustained advantage (Park & Park, 2021). In Industry 4.0 environments, where digital technologies enable real-time monitoring and process optimization, efficiency becomes a critical conduit through which learning and innovation affect performance. Firms that successfully institutionalize innovation into efficient routines are better positioned to scale benefits across the organization (Ghasemi et al., 2019; Mohammadi et al., 2016).

Accordingly, supply chain efficiency is expected to exert a positive effect on organizational performance (Schuh et al., 2018). Beyond mediated pathways, Market Orientation may also exert a residual direct effect on performance. This effect reflects the strategic alignment benefits of market sensing, whereby MO enhances coherence in priorities and resource allocation that operate beyond operational capability enactment (Teece, 2007, 2019).

H3. Supply Chain Efficiency positively influences Organizational Performance.

H4. Market Orientation positively influences Organizational Performance.

Sequential Mediation of Innovation and Efficiency

Taken together, the preceding arguments suggest a sequential capability pathway through which market sensing is converted into performance. Market Orientation initiates adaptation by stimulating innovation, while innovation enables transformation through efficiency (Karami et al., 2014). In addition, previous studies have linked market orientation to strategic performance through operational and digital mediating mechanisms in manufacturing firms (Correia et al., 2021; Motallebi, 2025). This sequencing aligns with

the sensing–seizing–transforming logic of Dynamic Capability Theory and resolves tensions in prior research that treats innovation and efficiency as competing priorities (Bartlett et al., 2007; Moshood et al., 2025). Rather than balancing exploration and exploitation simultaneously, firms benefit from pacing these activities over time (Afriyie et al., 2019; Trieu et al., 2023). Innovation enables experimentation and learning, while efficiency consolidates successful practices into scalable routines. Empirical studies increasingly emphasize such sequencing as a mechanism for managing complexity in digitally intensive supply chains (Dubey et al., 2022; Koh et al., 2016). Accordingly, innovation and efficiency are expected to sequentially mediate the relationship between Market Orientation and Organizational Performance.

H5. Supply Chain Innovation mediates the relationship between Market Orientation and Supply Chain Efficiency.

H6. Supply Chain Innovation and Supply Chain Efficiency sequentially mediate the relationship between Market Orientation and Organizational Performance.

Digital Learning Velocity: The Role of Digital Maturity and Absorptive Capability

While capability sequencing explains *what* firms do, it does not fully explain *how fast* they do it. Digital Maturity (DM) captures the extent to which firms have integrated digital systems across operations, providing the structural capacity for data processing and coordination (Vial, 2021). However, digital infrastructure alone does not guarantee effective learning or adaptation (Juan et al., 2022; Turulja & Bajgoric, 2019).

Digital Absorptive Capability (DAC) reflects firms' abilities to acquire, assimilate, transform, and exploit digital knowledge (Asiaei et al., 2021; Pinto, 2019). Extending absorptive capacity theory into digital contexts, DAC determines how rapidly firms interpret digital information and recombine it into actionable insights (Phadnis et al., 2022; Puschmann & Alt, 2005). Together, DM and DAC shape digital learning velocity, defined as the speed with which firms convert innovation into efficient routines.

When both DM and DAC are high, firms can accelerate the transformation of innovation into efficiency (Biswas & Kapil, 2017; Ting et al., 2021). In contrast, high digital maturity without absorptive capability may lead to data overload and slow decision-making (Venkatraman & Ramanujam, 1986). Thus, digital learning velocity is expected to strengthen the innovation–efficiency relationship.

H7. Digital learning velocity, captured by the interaction of Digital Maturity and Digital Absorptive Capability, positively moderates the relationship between Supply Chain Innovation and Supply Chain Efficiency.

Technological Turbulence as an Environmental Amplifier

Technological Turbulence (TT) reflects the rate and unpredictability of technological change in the external environment (Jaworski & Kohli, 1993; Kohli & Jaworski, 1990). In turbulent contexts, feedback cycles shorten and the costs of delayed adaptation increase (Ali et al., 2020). From a Dynamic Capability Theory, such environments amplify the value of rapid learning and reconfiguration (Teece, 2007, 2019). Under high technological turbulence, firms that effectively sequence sensing, innovation, and efficiency (and do so quickly) are more likely to achieve performance gains (Slater et al., 2006). Conversely, firms with slow learning speed may struggle to keep pace with technological change, eroding the benefits of digital investments (Asbe et al., 2025). Accordingly, technological turbulence is expected to strengthen the indirect performance effects of market orientation through innovation and efficiency.

H8. Technological Turbulence positively moderates the sequential indirect effect of Market Orientation on Organizational Performance through Supply Chain Innovation and Supply Chain Efficiency.

Conceptual Model

Taken together, these hypotheses describe a sequential capability framework in which Market Orientation initiates adaptation, Supply Chain Innovation enables experimentation, Supply Chain Efficiency institutionalizes learning, and performance emerges through learning-accelerated transformation. Digital learning velocity and technological turbulence further shape the speed and payoff of this process. Figure 1 summarizes the proposed research model and associated hypotheses. Figure 1 illustrates the proposed research model grounded in Dynamic Capability Theory, depicting the sensing–seizing–transforming sequence through which Market Orientation influences Organizational Performance via Supply Chain Innovation and Supply Chain Efficiency. The model further highlights the moderating role of Digital Learning Velocity captured by the interaction between Digital Maturity and Digital Absorptive Capability and the amplifying effect of Technological Turbulence.

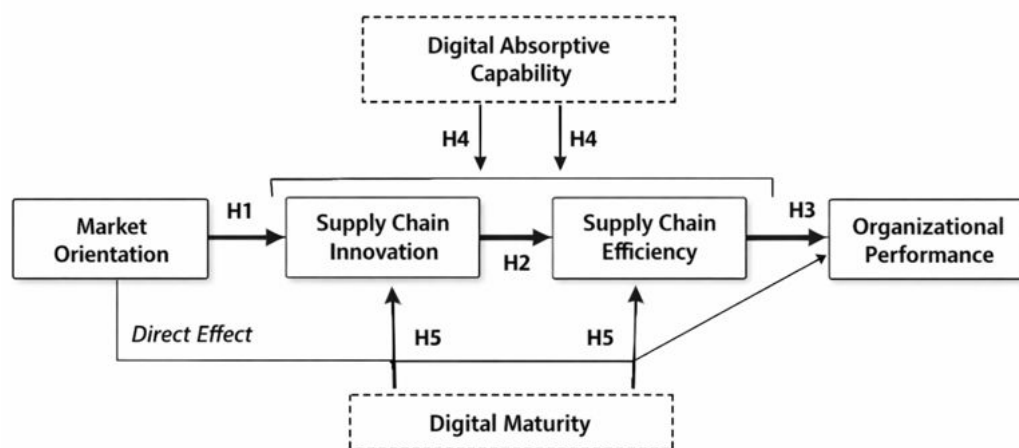


Figure 1. Proposed Research Model

Source: Authors' own elaboration.

RESEARCH METHODOLOGY

Research Design and Analytical Strategy

This study adopts a quantitative, cross-sectional research design to examine how Market Orientation (MO) influences Organizational Performance (OP) through sequential capability mechanisms under Industry 4.0 conditions. The design is explicitly theory-driven, reflecting the sensing–seizing–transforming logic of Dynamic Capability Theory. Rather than modeling static associations, the study focuses on processual relationships among capabilities, capturing how market sensing is converted into innovation, institutionalized through efficiency, and amplified by learning velocity and environmental turbulence. Survey-based designs are well suited for examining such relational capability structures across firms in operations and supply-chain research (Hair & Alamer, 2022; Shmueli et al., 2019).

To ensure both theoretical rigor and predictive robustness, a dual analytical strategy was employed. Covariance-based structural equation modeling (CB-SEM) was used to validate the measurement model and assess construct validity, while partial least squares SEM (PLS-SEM) was applied to test the complex moderated sequential mediation model. This complementary approach is appropriate when models involve interaction effects and predictive objectives, and it aligns with recent methodological standards in manufacturing and supply-chain research (Hair & Alamer, 2022; Henseler et al., 2016).

Sample, Context, and Data Collection

The empirical context comprises medium and large manufacturing firms operating in digitally intensive industries, including electronics, automotive, machinery, and consumer goods. These sectors are central to Industry 4.0 transformation and characterized by complex supply networks and rapid technological change. The unit of analysis is the firm, and respondents were senior managers in operations, supply chain, or general management roles with direct involvement in digital and innovation initiatives, ensuring informed responses (Podsakoff et al., 2003).

Data were collected through an online survey distributed via manufacturing associations and professional networks using a stratified sampling approach to ensure sectoral and regional balance. The final sample comprises 427 usable responses from firms located in Asia–Pacific, Europe, and North America. The sample size exceeds recommended thresholds for complex SEM models and provides adequate statistical power for testing moderated mediation effects (Hair & Alamer, 2022). The study draws on survey data collected from manufacturing firms operating in digitally intensive environments. Respondents were senior managers with direct responsibility for supply chain, operations, or digital transformation initiatives. As shown in Table 1, the sample is concentrated in medium and large manufacturing firms and in sectors characterized by high levels of digital integration, providing an appropriate context for examining capability sequencing under Industry 4.0 conditions.

Table 1. Sample Profile and Descriptive Characteristics

Characteristic	Category	%	Relevance to Industry 4.0
Firm size	100–499 employees	54	Digital coordination across functions
	≥500 employees	46	Complex digital orchestration
Industry	Electronics	26	High digital integration
	Automotive	24	Cyber–physical systems
	Machinery	22	Smart manufacturing
	Other manufacturing	28	Mixed digital intensity
Firm age	≥10 years	68	Established operational routines
Respondent role	Senior / top management	71	Strategic and operational oversight

Note: Percentages may not total exactly 100% because of rounding.

Measurement Development and Instrumentation

All constructs were measured using multi-item scales adapted from established literature and contextualized for digital manufacturing environments. Market Orientation captures intelligence generation, dissemination, and responsiveness. Supply Chain Innovation reflects process redesign and digital coordination initiatives, while Supply Chain Efficiency captures routinization, synchronization, and operational discipline. Digital Maturity measures system integration and digital infrastructure readiness, whereas Digital Absorptive Capability captures learning routines related to digital sensemaking and knowledge recombination. Technological Turbulence assesses the pace and unpredictability of technological change. All items were measured using seven-point Likert scales (Jaworski & Kohli, 1993; Kohli & Jaworski, 1990).

To ensure content validity, the instrument underwent expert review by academics and practitioners, followed by a pilot test to refine wording and scale clarity. Back-translation procedures were applied to ensure semantic equivalence across regions. The final measurement items and their sources are summarized in Table 2, which demonstrates construct grounding in prior research and alignment with the theoretical framework.

Table 2. Measurement Items and Sources

Construct	Sample Items (abbreviated)	Source
Market Orientation	Systematic collection and dissemination of market intelligence	(Kohli & Jaworski, 1990)
Supply Chain Innovation	Adoption of new digital coordination and process designs	(Yoon et al., 2016)
Supply Chain Efficiency	Standardization and synchronization of supply-chain processes	(Papaioannou et al., 2020)
Digital Maturity	Integration of digital systems across operations	(Vial, 2021)
Digital Absorptive Capability	Digital sensemaking and knowledge recombination routines	(Dubey et al., 2022)
Technological Turbulence	Speed and unpredictability of technological change	(Jaworski & Kohli, 1993)
Organizational Performance	Relative operational and financial performance	(Hamann-Lohmer et al., 2023)

Note: The full measurement instrument is available from the corresponding author upon reasonable request.

Reliability and Validity Assessment

Measurement quality was assessed using confirmatory factor analysis within a CB-SEM framework. All standardized factor loadings exceeded recommended thresholds, indicating strong indicator reliability. Internal consistency was confirmed through Cronbach's alpha and composite reliability values above accepted benchmarks. Convergent validity was established via average variance extracted (AVE), while discriminant validity was assessed using the heterotrait–monotrait ratio (HTMT), following contemporary guidelines (Hair & Alamer, 2022; Henseler et al., 2016).

Model fit indices demonstrated satisfactory measurement-model adequacy, supporting the distinctiveness of constructs aligned with the sensing–seizing–transforming hierarchy developed in Section 2. Summary statistics for reliability and validity are reported in Table 3, which confirms that all constructs meet or exceed established quality criteria.

Table 3. Reliability and Validity Assessment

Construct	Cronbach's α	CR	AVE	HTMT (max < 0.85)
Market Orientation (Sensing)	0.88	0.91	0.63	0.82
Supply Chain Innovation (Seizing)	0.86	0.90	0.61	0.79
Supply Chain Efficiency (Transforming)	0.89	0.92	0.65	0.81
Digital Maturity	0.87	0.90	0.62	0.78
Digital Absorptive Capability	0.90	0.93	0.67	0.83
Technological Turbulence	0.85	0.89	0.60	0.76
Organizational Performance	0.88	0.91	0.64	0.80

Note: Cronbach's $\alpha \geq 0.70$, Composite Reliability (CR) ≥ 0.70 , Average Variance Extracted (AVE) ≥ 0.50 , and HTMT < 0.85 indicate acceptable reliability, convergent validity, and discriminant validity.

Common Method Bias and Endogeneity Checks

Several procedural and statistical remedies were implemented to mitigate common method bias. Procedurally, respondent anonymity was ensured, item order was randomized, and scale anchors were varied. Statistically, Harman's single-factor test, and a marker-variable approach indicated no dominant common factor, suggesting that common method bias is unlikely to confound the results (Podsakoff et al., 2003).

To address potential endogeneity, Gaussian copula techniques were applied within the SEM framework. Results indicated no significant endogeneity bias in the estimated relationships. Multicollinearity was assessed using variance inflation factors, with all values below conservative thresholds. These diagnostics enhance confidence that observed effects reflect substantive relationships rather than methodological artifacts.

Structural Model Estimation

The structural model was estimated using PLS-SEM to test the direct, sequential mediation, and moderation hypotheses. Bootstrapping with 5,000 resamples generated bias-corrected confidence intervals for all path coefficients. Sequential mediation effects were assessed using indirect-path estimation, while moderation effects were examined through interaction terms involving Digital Maturity, Digital Absorptive Capability, and Technological Turbulence. Model explanatory power and predictive relevance were evaluated using R^2 and Q^2 metrics, consistent with best practices in SEM-based supply-chain research (Hair & Alamer, 2022).

Ethical Considerations

All research procedures complied with institutional ethical standards and international guidelines for research involving human participants. Participation was voluntary, informed consent was obtained, and respondent anonymity was maintained throughout data collection and analysis.

RESULTS

Model Estimation Overview

The structural model was estimated using partial least squares structural equation modeling (PLS-SEM) to test the hypothesized direct effects, sequential mediation, moderation, and moderated mediation relationships. This approach is appropriate given the model's complexity, interaction terms, and predictive orientation. Prior to hypothesis testing, variance inflation factors (VIFs) were examined to assess multicollinearity. All VIF values were below conservative thresholds, indicating that multicollinearity does not bias the estimated relationships.

The model demonstrates strong explanatory power across endogenous constructs. Market Orientation explains a substantial proportion of variance in Supply Chain Innovation, while Supply Chain Innovation (together with moderation effects) explains meaningful variance in Supply Chain Efficiency. Organizational Performance exhibits the highest explained variance, reflecting the cumulative impact of sensing, seizing, and transforming mechanisms embedded in the proposed framework. Figure 1 illustrates the proposed research model, depicting the sensing–seizing–transforming sequence and the moderating roles of digital learning mechanisms and technological turbulence.

Hypothesis Testing Results

Hypotheses were tested using bootstrapping with 5,000 resamples to generate bias-corrected confidence

intervals. Results show that Market Orientation has a strong positive effect on Supply Chain Innovation, confirming the role of market sensing in initiating innovation activities. Supply Chain Innovation significantly enhances Supply Chain Efficiency, supporting the argument that innovation enables subsequent operational transformation. Supply Chain Efficiency, in turn, positively influences Organizational Performance, indicating that institutionalized efficiency is a key driver of sustained outcomes.

A residual direct effect of Market Orientation on Organizational Performance remains significant, indicating partial mediation. This finding is consistent with Dynamic Capability Theory, which allows sensing capabilities to influence performance both directly and indirectly through downstream capability enactment. Sequential mediation and moderation effects further clarify how and when these relationships materialize. All hypothesis-testing results are summarized in Table 4, which integrates direct, indirect, moderation, and moderated mediation effects. Table 4 reports direct effects (H1–H4), mediation effects (H5–H6), moderation (H7), and moderated mediation results (H8).

Table 4. Integrated Hypothesis Testing Results

Hypothesis	Effect Type	Relationship / Effect	β	t-value	95% CI	p-value	Result
H1	Direct	MO $\rightarrow$ SCI	0.58	11.34	[0.47, 0.68]	<0.001	Supported
H2	Direct	SCI $\rightarrow$ SCE	0.52	9.71	[0.41, 0.62]	<0.001	Supported
H3	Direct	SCE $\rightarrow$ OP	0.47	8.66	[0.36, 0.57]	<0.001	Supported
H4	Direct	MO $\rightarrow$ OP	0.31	4.98	[0.19, 0.43]	<0.001	Supported
H5	Mediation	MO $\rightarrow$ SCI $\rightarrow$ SCE	0.31	5.37	[0.20, 0.43]	<0.01	Supported
H6	Sequential mediation	MO $\rightarrow$ SCI $\rightarrow$ SCE $\rightarrow$ OP	0.24	4.89	[0.14, 0.34]	<0.001	Supported
H7	Moderation	SCI $\times$ (DM $\times$ DAC) $\rightarrow$ SCE	0.18	3.12	[0.06, 0.30]	0.002	Supported
H8	Moderated mediation	MO $\rightarrow$ SCI $\rightarrow$ SCE $\rightarrow$ OP (High TT)	0.17	2.98	[0.06, 0.29]	0.003	Supported

Note: Results are based on bias-corrected bootstrapping with 5,000 resamples. CI = bias-corrected 95% confidence interval. Significant effects are reported at $p < 0.05$.

Sequential Mediation Effects

The mediation results confirm the proposed sensing–seizing–transforming sequence. Supply Chain Innovation significantly mediates the relationship between Market Orientation and Supply Chain Efficiency, indicating that market sensing translates into operational transformation primarily through innovation. More importantly, the full sequential pathway from Market Orientation to Organizational Performance via Supply Chain Innovation and Supply Chain Efficiency is significant.

These findings demonstrate that Market Orientation enhances performance largely by initiating innovation and enabling its institutionalization through efficiency. The magnitude of the sequential indirect effect indicates that a substantial portion of Market Orientation’s influence on performance is transmitted through this capability chain, supporting the theoretical logic developed in Section 2.

Moderation and Moderated Mediation Effects

The interaction between Digital Maturity and Digital Absorptive Capability significantly strengthens the relationship between Supply Chain Innovation and Supply Chain Efficiency. The interaction term between Digital Maturity and Digital Absorptive Capability is positive and statistically significant, indicating that the relationship between Supply Chain Innovation and Supply Chain Efficiency strengthens when both conditions are high. Firms with high levels of both Digital Maturity and Digital Absorptive Capability convert innovative initiatives into efficient routines more effectively than firms lacking either condition. Technological Turbulence further amplifies this process by strengthening the indirect effect of Market Orientation on Organizational Performance. Under high turbulence, rapid learning and reconfiguration become more valuable, increasing the performance payoff from effective capability sequencing. Together, these findings highlight the dual amplification role of internal learning velocity and external environmental dynamism.

Model Explanatory Power and Predictive Relevance

The model exhibits strong explanatory power across all endogenous constructs. Market Orientation explains 34% of the variance in Supply Chain Innovation, while Supply Chain Innovation and its interaction effects explain 49% of the variance in Supply Chain Efficiency. Organizational Performance shows an R² value of 0.61, indicating substantial explanatory strength. Predictive relevance was assessed using Q² statistics, all of which exceeded zero, confirming out-of-sample predictive capability. Effect sizes range from medium to large, suggesting that the observed relationships are not only statistically significant but also substantively meaningful. A summary of model quality indicators is reported in Table 5.

Table 5. Model Explanatory Power and Predictive Validity

Construct	R ²	Q ²	Interpretation
Supply Chain Innovation	0.34	0.21	Moderate
Supply Chain Efficiency	0.49	0.27	Substantial
Organizational Performance	0.61	0.29	Strong

Note: R² represents explained variance, whereas Q² indicates predictive relevance. Values above zero indicate acceptable predictive capability.

DISCUSSION

Market Orientation as a Dynamic Sensing Capability

The findings position Market Orientation (MO) as a core sensing capability that structures how manufacturing firms attend to market and technological signals in Industry 4.0 environments. The strong positive relationship between MO and Supply Chain Innovation confirms that market-oriented firms are more capable of identifying where adaptation is required within supply-chain processes. Rather than acting as a direct performance lever, MO shapes organizational attention and prioritization, guiding firms toward innovation opportunities that align with customer needs and competitive dynamics. This interpretation is consistent with Dynamic Capability Theory, which conceptualizes sensing as a prerequisite for adaptive action (Jaworski & Kohli, 1993). Beyond its indirect effects through capability sequencing, the significant direct relationship between Market Orientation and Organizational Performance suggests that market-oriented firms also benefit from improved strategic alignment and resource allocation. This finding indicates that sensing capabilities contribute not only by stimulating downstream operational capabilities but also by enhancing overall strategic coherence (Dubey et al., 2022).

Innovation and Efficiency as Sequential, Not Competing, Capabilities

A central contribution of this study is the empirical demonstration that Supply Chain Innovation and Supply Chain Efficiency function as sequentially complementary capabilities rather than competing priorities. The significant $MO \rightarrow SCI \rightarrow SCE \rightarrow OP$ pathway indicates that innovation initiates adaptation by enabling experimentation and redesign, while efficiency consolidates these changes into stable, repeatable routines. Innovation without efficiency leads to fragmentation, escalating coordination costs, and operational instability, particularly in digitally complex supply chains. Conversely, efficiency without prior innovation promotes rigidity and path dependence, limiting responsiveness to environmental change. The results demonstrate that firms achieve superior performance by pacing innovation and efficiency over time, thereby aligning seizing and transforming activities within the Dynamic Capability framework (Teece, 2007, 2019). This finding extends operations and supply-chain research by providing empirical support for temporal capability ordering. Rather than treating innovation and efficiency as trade-offs, the study highlights sequencing as a mechanism for managing complexity under Industry 4.0 conditions, consistent with recent evidence from digital supply-chain studies (Dubey et al., 2022).

Digital Absorptive Capability as the Micro-Foundation of Learning Velocity

The interaction between Digital Maturity and Digital Absorptive Capability (DAC) underscores learning velocity as the critical micro-foundation through which digital investments translate into performance. While Digital Maturity provides the structural capacity for data processing and system integration, DAC determines how rapidly firms interpret, recombine, and act on digital information. The significant moderation effect indicates that innovation is transformed into efficiency more effectively when absorptive learning routines are well developed, highlighting speed rather than scale as the decisive factor. This finding advances absorptive capacity theory by extending it into digitally intensive manufacturing contexts and reframing it as a speed-based mechanism. DAC accelerates sensemaking, cross-functional knowledge recombination, and feedback integration, allowing firms to shorten the cycle between experimentation and institutionalization. In doing so, it explains why firms with similar digital infrastructures often exhibit markedly different performance outcomes (Dubey et al., 2022).

Importantly, the results clarify the conceptual boundary between DAC and Supply Chain Innovation. DAC explains how fast firms learn, whereas SCI captures what firms do with that learning. This distinction reinforces the role hierarchy articulated in Section 2 and mitigates concerns of construct redundancy in digital capability research.

Digital Maturity as a Structural Precondition, not a Capability Substitute

An important theoretical implication concerns the role of Digital Maturity (DM). Rather than functioning as a dynamic capability, DM operates as a structural precondition that enables learning mechanisms to function on a scale. The findings indicate that Digital Maturity alone does not generate superior Organizational Performance; instead, it creates the structural conditions that enable Digital Absorptive Capability to transform digital investments into operational improvements. In such cases, digital maturity may even exacerbate rigidity by embedding inflexible architectures and decision rules (Vial, 2021). By positioning DM as an enabling condition rather than a substitute for dynamic capabilities, the study clarifies its role within the broader framework. Digital maturity matters not because it directly improves outcomes, but because it allows absorptive and reconfiguration processes to operate more rapidly and consistently.

Technological Turbulence as an External Performance Amplifier

The moderated mediation results demonstrate that Technological Turbulence (TT) amplifies the performance returns of learning-driven capability sequencing. Under high turbulence, the indirect effect

of Market Orientation on Organizational Performance through innovation and efficiency becomes significantly stronger. These findings challenge traditional contingency perspectives that portray turbulence as uniformly destabilizing and instead supports a Dynamic Capability view in which environmental volatility rewards speed and adaptability. In technologically turbulent environments, feedback cycles are compressed, and experimentation opportunities increase. Firms with high learning velocity can rapidly convert innovation into stable operations, while slower learners experience misalignment between technological change and organizational response. Turbulence therefore magnifies existing differences in capability sequencing rather than creating advantage on its own (Jaworski & Kohli, 1993). Overall, Technological Turbulence strengthens the performance benefits of firms that can rapidly sense, learn, and reconfigure resources. Rather than creating competitive advantage by itself, environmental turbulence increases the value of effective capability sequencing.

Integrating Dynamic Capability and Organizational Learning Perspectives

By integrating Dynamic Capability Theory with organizational learning perspectives, this study offers a more granular explanation of digital competitiveness in manufacturing. Dynamic Capability Theory explains what must be reconfigured (sensing, seizing, and transforming) while organizational learning theory explains how quickly this reconfiguration occurs. Digital Absorptive Capability bridges these perspectives by linking digital infrastructure to learning speed and operational renewal. This integration responds to calls for stronger micro-foundational explanations within Dynamic Capability Theory, particularly in technology-intensive environments where adaptation speed is critical. Learning processes such as experimentation, feedback integration, and knowledge recombination become central drivers of sustained performance rather than peripheral mechanisms (Teece, 2007, 2019). By foregrounding learning velocity, the study moves beyond fragmented accounts of digital transformation and provides a coherent explanation of how manufacturing firms convert digital investments into enduring competitive advantage. To synthesize the empirical findings with the underlying theoretical framework, Table 6 maps the supported hypotheses onto the sensing–seizing–transforming logic of Dynamic Capability Theory.

Table 6. Mapping Hypotheses to Dynamic Capability Roles

Hypothesis	Capability Role	Empirical Support
H1	Sensing → Seizing	Supported
H2	Seizing → Transforming	Supported
H6	Capability sequencing	Supported
H7	Digital learning velocity	Supported
H8	Environmental amplification	Supported

Note: The capability roles are derived from the sensing–seizing–transforming framework of Dynamic Capability Theory.

MANAGERIAL IMPLICATIONS AND LIMITATIONS

Managerial Implications

The findings provide practical guidance for manufacturing managers navigating Industry 4.0 transformation initiatives. First, managers should reconceptualize Market Orientation as a continuous sensing system rather than a marketing function. Effective sensing requires integrating customer intelligence, supplier signals, and technological trend data into real-time decision processes. Firms that

institutionalize sensing routines are better positioned to identify where innovation is necessary within supply-chain operations, thereby avoiding reactive or misaligned digital investments. This implication aligns with research emphasizing the strategic value of intelligence generation and dissemination in dynamic environments (Jaworski & Kohli, 1993; Teece, 2019).

Second, managers should avoid treating innovation and efficiency as competing priorities. The results demonstrate that performance gains arise when innovation is sequenced before efficiency, allowing experimentation to precede standardization. Practically, this implies organizing supply-chain initiatives into phases: exploratory pilots and digital experimentation followed by disciplined process codification. Attempting to optimize efficiency prematurely may suppress learning, while prolonged experimentation without consolidation increases complexity. Managers should therefore design governance mechanisms that explicitly transition innovations into standardized routines once viability is demonstrated (Dubey et al., 2022).

Third, the interaction between Digital Maturity and Digital Absorptive Capability highlights the importance of investing in learning routines, not just technology. Advanced digital infrastructures generate value only when employees possess the skills and processes required to interpret and act on data quickly. Managers should prioritize analytics literacy, cross-functional knowledge sharing, and rapid feedback loops that shorten learning cycles. These practices transform digital maturity from a passive asset into an active accelerator of performance, reinforcing evidence that organizational learning capabilities are central to digital competitiveness (Warner & Wäger, 2019).

Managing Under Technological Turbulence

The results further suggest that technological turbulence should not be managed defensively but leveraged strategically. In volatile environments, firms with high learning velocity benefit disproportionately from rapid experimentation and reconfiguration. Managers should therefore design supply chains with modular architectures, flexible supplier relationships, and adaptive planning systems that allow swift adjustment when technologies change. Rather than seeking stability, firms should develop governance structures that tolerate controlled experimentation and rapid iteration, particularly when digital technologies evolve quickly (Jaworski & Kohli, 1993; Teece, 2019).

Importantly, turbulence amplifies existing capability differences rather than compensating for weak foundations. Managers operating in high-turbulence contexts must ensure that sensing, innovation, and efficiency mechanisms are tightly integrated before volatility increases. Without such integration, turbulence exacerbates misalignment and performance erosion. This insight underscores the need for proactive capability development rather than reactive crisis management, especially in digitally intensive manufacturing sectors.

Limitations and Future Research Directions

Despite these contributions, this study has several limitations that provide opportunities for future research. First, cross-sectional design restricts causal inference regarding the temporal dynamics of capability sequencing. Longitudinal or panel studies could more directly observe how learning velocity and capability transitions evolve over time, particularly during periods of technological disruption. Such designs would strengthen causal claims and capture dynamic feedback effects inherent in Industry 4.0 transformations (Teece, 2019).

Second, the study relies on perceptual performance measures reported by senior managers. While common in operations and supply-chain research, future studies could incorporate objective indicators such as productivity metrics, cost efficiency, or delivery reliability to triangulate findings. Additionally, future research may explore boundary conditions not examined here, such as low-turbulence industries or asset-intensive process manufacturing, where learning velocity may play a different role. Comparative studies across technological regimes would further refine the generalizability of the proposed framework (Vial, 2021).

REFERENCES

1. Abourobkbah, S. H., Mashat, R. M., & Salam, M. A. (2023). Role of absorptive capacity, digital capability, agility, and resilience in supply chain innovation performance. *Sustainability*, 15(4), 3636.
2. Abu-Rumman, A., Al Shraah, A., Al-Madi, F., & Alfalah, T. (2021). Entrepreneurial networks, entrepreneurial orientation, and performance of small and medium enterprises: are dynamic capabilities the missing link? *Journal of Innovation and Entrepreneurship*, 10(1), 29.
3. Afriyie, S., Du, J., & Ibn Musah, A.-A. (2019). Innovation and marketing performance of SME in an emerging economy: the moderating effect of transformational leadership. *Journal of Global Entrepreneurship Research*, 9(1), 40.
4. Ahmadimousaabad, A., Bajuri, N., Jahanzeb, A., Karami, M., & Rehman, S. (2013). Trade-off theory, pecking order theory and market timing theory: a comprehensive review of capital structure theories. *International Journal of Management and Commerce Innovations*, 1(1), 11-18.
5. Ali, S. S., Kaur, R., Ersöz, F., Altaf, B., Basu, A., & Weber, G.-W. (2020). Measuring carbon performance for sustainable green supply chain practices: a developing country scenario. *Central European Journal of Operations Research*, 28(4), 1389-1416.
6. Anjum, M. J., Ali, S. M., Sadiq, M., Karami, M., & Khan, S. (2012). Exploring the nexus: management practices, innovation and firm performance. *World Applied Sciences Journal*, 19(6), 785-794.
7. Asbe, C., Abhyankar, A., Zade, N., & Jadhav, D. (2025). Nexus between Climate Risk, Firm Performance and Firm Value: An Indian Perspective. *International Journal of Global Business and Competitiveness*, 1-11.
8. Asiaei, K., Rezaee, Z., Bontis, N., Barani, O., & Sapiei, N. S. (2021). Knowledge assets, capabilities and performance measurement systems: a resource orchestration theory approach. *Journal of Knowledge Management*, 25(8), 1947-1976.
9. Bartlett, P. A., Julien, D. M., & Baines, T. S. (2007). Improving supply chain performance through improved visibility. *The International Journal of Logistics Management*, 18(2), 294-313.
10. Biswas, S., & Kapil, K. (2017). Linking perceived organizational support and organizational justice to employees' in-role performance and organizational cynicism through organizational trust: A field investigation in India. *Journal of Management Development*, 36(5), 696-711.
11. Borazon, E. Q., Huang, Y.-C., & Liu, J.-M. (2022). Green market orientation and organizational performance in Taiwan's electric and electronic industry: the mediating role of green supply chain management capability. *Journal of Business & Industrial Marketing*, 37(7), 1475-1496.
12. Cheng, C., & Yang, M. (2017). Enhancing performance of cross-border mergers and acquisitions in developed markets: The role of business ties and technological innovation capability. *Journal of business research*, 81, 107-117.
13. Chikaji, A., Karami, M., Mansor, N., Ndaliman, M., Alkali, A., Saleh, A., & Noor, H. (2015). Green product, green consumers and green marketing in Malaysia. *International Journal of Interactive Digital Media*, 2(3), 19-24.
14. Correia, R. J., Dias, J. G., & Teixeira, M. S. (2021). Dynamic capabilities and competitive advantages as mediator variables between market orientation and business performance. *Journal of Strategy and Management*, 14(2), 187-206.
15. Danso, F. K., Adusei, M., Sarpong-Danquah, B., & Prempeh, K. B. (2024). Board expertise diversity and firm performance in sub-Saharan Africa: do firm age and size matter? *Future Business Journal*, 10(1), 98.
16. Dubey, R., Bryde, D. J., Dwivedi, Y. K., Graham, G., & Foropon, C. (2022). Impact of artificial intelligence-driven big data analytics culture on agility and resilience in humanitarian supply chain: a practice-based view. *International journal of production economics*, 250, 108618.

17. Durach, C. F., & Wiengarten, F. (2017). Environmental management: The impact of national and organisational long-term orientation on plants' environmental practices and performance efficacy. *Journal of Cleaner Production*, 167, 749-758.
18. Ferreira, J., & Coelho, A. (2020). Dynamic capabilities, innovation and branding capabilities and their impact on competitive advantage and SME's performance in Portugal: the moderating effects of entrepreneurial orientation. *International journal of innovation science*, 12(3), 255-286.
19. Ghasemi, R., Azmi Mohamad, N., Karami, M., Hafiz Bajuri, N., & Asgharizade, E. (2016). The mediating effect of management accounting system on the relationship between competition and managerial performance. *International Journal of Accounting and Information Management*, 24(3), 272-295.
20. Ghasemi, R., Habibi, H. R., Ghasemlo, M., & Karami, M. (2019). The effectiveness of management accounting systems: evidence from financial organizations in Iran. *Journal of Accounting in Emerging Economies*, 9(2), 182-207.
21. Hair, J., & Alamer, A. (2022). Partial Least Squares Structural Equation Modeling (PLS-SEM) in second language and education research: Guidelines using an applied example. *Research Methods in Applied Linguistics*, 1(3), 100027.
22. Hamann-Lohmer, J., Bendig, M., & Lasch, R. (2023). Investigating the impact of digital transformation on relationship and collaboration dynamics in supply chains and manufacturing networks—A multi-case study. *International journal of production economics*, 262, 108932.
23. He, P., Guo, L., Qu, Y., & Zheng, H. (2026). Environmental, social, and governance performance for enhancing supply chain resilience under the effects of supply chain visibility and resource allocation efficiency. *Supply Chain Management: An International Journal*, 31(1), 1-19.
24. Henseler, J., Hubona, G., & Ray, P. A. (2016). Using PLS path modeling in new technology research: updated guidelines. *Industrial management & data systems*, 116(1), 2-20.
25. Jaworski, B. J., & Kohli, A. K. (1993). Market orientation: antecedents and consequences. *Journal of marketing*, 57(3), 53-70.
26. Juan, S.-J., Li, E. Y., & Hung, W.-H. (2022). An integrated model of supply chain resilience and its impact on supply chain performance under disruption. *The International Journal of Logistics Management*, 33(1), 339-364.
27. Karami, M. (2026). From Market Orientation to Operational Excellence: A Dynamic Capabilities Pathway to Firm Competitiveness in Emerging Manufacturing Economies. *International Journal of Global Business and Competitiveness*. <https://doi.org/10.1007/s42943-026-00155-y>
28. Karami, M., Ghasemi, R., Khan, S., & Hamid, A. (2014). Market orientation and supply chain innovation relationship: Conceptual framework model. *Middle-East Journal of Scientific Research*, 21(9), 1526-1532.
29. Koh, S., Morris, J., Ebrahimi, S. M., & Obayi, R. (2016). Integrated resource efficiency: measurement and management. *International Journal of Operations & Production Management*, 36(11), 1576-1600.
30. Kohli, A. K., & Jaworski, B. J. (1990). Market orientation: the construct, research propositions, and managerial implications. *Journal of marketing*, 54(2), 1-18.
31. Mariani, C., Caccialanza, A., Bugarčić, M., Slavkovic, M., & Mancini, M. (2025). Enhancing project-based organization performance through ESG practices: the role of organizational agility. *Management Decision*.
32. Mobarakabadi, H., & Karami, M. (2014). Investigation of relationship among the organizational culture and creativity. *Research Journal of Applied Sciences, Engineering and Technology*, 7(19), 4069-4071.
33. Mohamad, N. A., Karami, M., Bajuri, N. H., & Asgharizade, E. (2015). The relationship among strategy, competition and management accounting systems on organizational performance. *European Online Journal of Natural and Social Sciences*, 4(3), pp. 565-581.
34. Mohammadi, M. A. D., Khan, M., Karami, M., & Sadatifar, S. R. (2015). Human resource management orientation and market orientation effect on perceived organizational performance mediated by innovation. *Middle-East Journal of Scientific Research*, 23(9), 2155-2165.

35. Mohammadi, M. A. D., Khan, M. N. A. A., Karami, M., & Sadatifar, S. R. (2016). Perceived Organizational Support and Perceived Organizational Performance Mediated by Corporate Entrepreneurship. *Sains Humanika*, 8(1).
36. Moshood, T. D., Rotimi, J. O., & Shahzad, W. (2025). Enhancing construction organizations' performance through strategic decision-making: unveiling the mediating role of quality of information. *International Journal of Organizational Analysis*, 33(9), 2956-2991.
37. Motallebi, S. (2025). Linking Market Orientation to Strategic Performance: Operational and Digital Mediation in Manufacturing Firms. *Business, Technology & Innovation Studies Journal*, 1(1).
38. Nasiri, A. B., Karami, M., & Malekifar, S. (2013). Ethical leadership, job turnover, job satisfaction and organizational citizenship behavior. Conference Paper,
39. Oshilalu, A. Z. (2024). Sustainability meets scalability: transforming energy infrastructure projects into economic catalysts through supply chain innovation. *International Journal of Research Publication and Reviews*, 5(12), 762-779.
40. Papaioannou, G., Mohammed, A.-M., Despoudi, S., Saridakis, G., & Papadopoulos, T. (2020). The role of adverse economic environment and human capital on collaboration within agri-food supply chains. *International Journal of Information Management*, 52, 102077.
41. Park, S., & Park, S. (2021). How can employees adapt to change? Clarifying the adaptive performance concepts. *Human Resource Development Quarterly*, 32(1), E1-E15.
42. Permana, E., Poerwoko, B., Widyastuti, S., & Rachbini, W. (2019). Digital capability and innovation strategy to develop the performance and competitive advantages of fashion Smes in Jakarta, Indonesia. *International Journal of Managerial Studies and Research*, 7(11), 2349-0349.0711002.
43. Phadnis, S., Sheffi, Y., & Caplice, C. (2022). *Strategic Planning for Dynamic Supply Chains*. Springer.
44. Pinto, J. (2019). Key to effective organizational performance management lies at the intersection of paradox theory and stakeholder theory. *International Journal of Management Reviews*, 21(2), 185-208.
45. Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of applied psychology*, 88(5), 879.
46. Puschmann, T., & Alt, R. (2005). Successful use of e-procurement in supply chains. *Supply Chain Management: An International Journal*, 10(2), 122-133.
47. Sangari, M. S., & Razmi, J. (2015). Business intelligence competence, agile capabilities, and agile performance in supply chain: An empirical study. *The International Journal of Logistics Management*, 26(2), 356-380.
48. Schuh, G., Rebentisch, E., Dölle, C., Mattern, C., Volevach, G., & Menges, A. (2018). Defining scaling strategies for the improvement of agility performance in product development projects. *Procedia Cirp*, 70, 29-34.
49. Shmueli, G., Sarstedt, M., Hair, J. F., Cheah, J.-H., Ting, H., Vaithilingam, S., & Ringle, C. M. (2019). Predictive model assessment in PLS-SEM: guidelines for using PLSpredict. *European journal of marketing*, 53(11), 2322-2347.
50. Slater, S. F., Olson, E. M., & Hult, G. T. M. (2006). The moderating influence of strategic orientation on the strategy formation capability–performance relationship. *Strategic management journal*, 27(12), 1221-1231.
51. Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic management journal*, 28(13), 1319-1350.
52. Teece, D. J. (2019). A capability theory of the firm: an economics and (strategic) management perspective. *New zealand economic papers*, 53(1), 1-43.
53. Ting, I. W. K., Sui, H. J., Kweh, Q. L., & Nawanir, G. (2021). Knowledge management and firm innovative performance with the moderating role of transformational leadership. *Journal of Knowledge Management*, 25(8), 2115-2140.

54. Trieu, H. D., Van Nguyen, P., Nguyen, T. T., Vu, H. M., & Tran, K. (2023). Information technology capabilities and organizational ambidexterity facilitating organizational resilience and firm performance of SMEs. *Asia Pacific Management Review*, 28(4), 544-555.
55. Turulja, L., & Bajgoric, N. (2019). Innovation, firms' performance and environmental turbulence: is there a moderator or mediator? *European Journal of Innovation Management*, 22(1), 213-232.
56. Venkatraman, N., & Ramanujam, V. (1986). Measurement of business performance in strategy research: A comparison of approaches. *Academy of management review*, 11(4), 801-814.
57. Vial, G. (2021). Understanding digital transformation: A review and a research agenda. *Managing digital transformation*, 13-66.
58. Wang, S., & Zhang, H. (2025a). Enhancing environmental, social, and governance performance through artificial intelligence supply chains in the energy industry: Roles of innovation, collaboration, and proactive sustainability strategy. *Renewable Energy*, 245, 122855.
59. Wang, S., & Zhang, H. (2025b). Generative artificial intelligence and internationalization green innovation: Roles of supply chain innovations and AI regulation for SMEs. *Technology in Society*, 82, 102898.
60. Warner, K. S., & Wäger, M. (2019). Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal. *Long range planning*, 52(3), 326-349.
61. Yoon, S. N., Lee, D., & Schniederjans, M. (2016). Effects of innovation leadership and supply chain innovation on supply chain efficiency: Focusing on hospital size. *Technological Forecasting and Social Change*, 113, 412-421.