BUSINESS, TECHNOLOGY & INNOVATION STUDIES JOURNAL (BTISJ)
ISSN 3110-9411

Volume 1, Issue 1, November–December 2025

Volume 1	Issue 1	NOV – DEC 2025
Received date	**Accepted date**	**Published date**
015 November 2025	026 November 2025	07 December 2025

From Digital Integration to Performance: The Critical Role of Orchestration Capability and the Boundary Conditions of External Enterprise Systems Integration

DOI: https://doi.org/10.66578/btis.v1i1.9

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ABSTRACT

Although organizations have heavily invested in digital platforms to enhance supply chain visibility and partner connectivity, many still struggle to respond rapidly and coherently during disruptions. This study explains why enterprise systems integration does not automatically generate agility or performance and identifies the organizational capability that activates the value of digital systems. Drawing on dynamic capability theory, we conceptualize Supply Chain Orchestration Capability (SCOC) as the coordinated decision-activation mechanism through which digital integration is transformed into unified operational execution. We further propose that External Enterprise Systems Integration (EESI) follows a nonlinear inverted U-shaped pattern, whereby moderate external connectivity enhances orchestration, but excessive connectivity generates information overload and coordination friction, weakening execution rather than strengthening it. We position Supply Chain Agility (SCA) as the operational expression of orchestration and theorize that the value of orchestration and agility is amplified under Environmental Complexity (EC). Data were collected over three longitudinal waves from 268 manufacturing SMEs in the United States and Canada and analyzed using PLS-SEM, including nonlinear and moderated mediation effects. The study advances understanding of digital supply chain transformation by showing that enterprise systems create digital potential, but orchestration unlocks that potential, and agility expresses it operationally. The insights offer strategic guidance for firms seeking to convert digital investments into sustained performance advantages.
Keywords: Enterprise Systems Integration; Supply Chain Orchestration Capability; Supply Chain Agility; Environmental Complexity; Firm Performance.

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INTRODUCTION

Digital transformation has encouraged organizations to expand enterprise information systems such as ERP, MES, WMS, and cloud-based supply chain platforms with the expectation that increased connectivity will translate into faster and more unified responses (Imran et al., 2021; Ishaq, 2025). Yet many firms continue to experience delayed and fragmented decisions during disruptions despite having advanced digital infrastructures, a paradox highlighted in recent studies on digital supply chain performance (Dwivedi & Paul, 2022). The persistent gap between digital visibility and coordinated execution suggests that integration alone does not guarantee responsiveness, especially under volatile environmental conditions.

Although prior research has demonstrated the benefits of information sharing and interoperability (Esangbedo et al., 2024), most studies implicitly assume a linear relationship between digital integration and performance (Jamwal et al., 2024; John et al., 2025). Real disruption events challenge this assumption by showing that organizations may detect disturbances early through digital systems yet remain slow to mobilize unified responses (Abourokbah et al., 2023). These observations reveal a missing mechanism that explains how digital connectivity becomes coordinated operational action. To address this gap, the present study introduces Supply Chain Orchestration Capability (SCOC), which reflects the decision-alignment routines that synchronize internal functions and external partners toward unified execution under pressure (Cheng et al., 2024).

This study also questions the widely held assumption that external integration is uniformly beneficial. While digital connections with suppliers (Kabra et al., 2025), customers (Kayan et al., 2025), and logistics partners support transparency and planning (Khin & Ho, 2019), excessive connectivity can overwhelm managerial attention, increase prioritization conflicts, and slow escalation pathways (Kim et al., 2022). Recent conceptual work has begun to acknowledge the risks of hyper-connectivity (Ambrogio et al., 2022), but empirical validation remains limited (Kowalkowski et al., 2024). We therefore theorize that External Enterprise Systems Integration (EESI) exhibits an inverted U-shaped effect on SCOC, such that integration supports coordination up to an optimal level but becomes counterproductive when it exceeds coordination bandwidth (Corsaro & D'Amico, 2022).

We position Supply Chain Agility (SCA) as the operational expression of orchestration. Once coordinated decisions are enabled through SCOC, agility deploys those decisions through rapid reconfiguration of sourcing, production, logistics, and scheduling. This view aligns with recent advances in agility research, which emphasize that agility results from coordinated action rather than simply from visibility or sensing (Caliskan et al., 2021). Additionally, the value of both orchestration and agility is expected to intensify under Environmental Complexity (EC). As market, technological, and regulatory conditions become more turbulent, delays in coordinated execution have increasingly damaging performance consequences (Caliskan et al., 2021; Chen & Xing, 2025).

To test the proposed model, a three-wave longitudinal survey was conducted with 268 manufacturing SMEs in the United States and Canada and analyzed using PLS-SEM, including nonlinear and moderated mediation effects. The results show that enterprise systems integration enhances performance only indirectly through the sequential activation of orchestration capability

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and agility, that EESI exhibits diminishing and negative returns beyond an optimal level, and that environmental complexity strengthens the contribution of orchestration and agility to performance. This study contributes to digital supply chain theory in three distinct ways. (1) It reconceptualizes digital transformation as a capability activation process, distinguishing technological integration from its coordinated execution. (2) It challenges the assumption of unbounded benefits of connectivity by demonstrating a bounded and potentially negative effect of excessive external integration. (3) It shows that environmental complexity amplifies the performance relevance of orchestration and agility, positioning them as resilience-enabling mechanisms rather than efficiency-only mechanisms.

THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

Enterprise Systems Integration

Enterprise systems integration refers to the extent to which digital platforms enable transparent information exchange, interoperable workflows, and synchronized transactions across the supply chain. Internal Enterprise Systems Integration (IESI) connects cross-functional units within the firm, whereas External Enterprise Systems Integration (EESI) connects the firm to suppliers, customers, and logistics partners. Past studies show that information integration improves coordination readiness but does not automatically guarantee unified execution (Esangbedo et al., 2024). Therefore, integration is best understood as a structural enabler that provides the potential for coordinated response but requires other capabilities to convert shared information into aligned action.

Supply Chain Orchestration Capability (SCOC)

SCOC captures the coordinated decision-activation routines that unify actors toward shared action under time pressure. It includes escalation pathways, decision rights clarity, synchronization of priorities, and collaborative conflict resolution (Danaeefard, 2025). Unlike visibility-oriented concepts (Kraus et al., 2019), SCOC emphasizes how decisions become aligned (Li et al., 2024), not merely how information becomes available. Recent evidence shows that many firms with strong digital systems still fail during disruptions because actors disagree on priorities or activation timing (Dwivedi & Paul, 2022; Liu et al., 2023; López Custodio et al., 2025). SCOC is therefore conceptually distinct from agility: SCOC aligns decisions, whereas agility deploys those aligned decisions operationally.

Integration as an Antecedent of Orchestration

Internal Enterprise Systems Integration (IESI) strengthens SCOC by providing a unified digital representation of operational status across departments (Dobrovnik et al., 2025). When procurement, production, warehousing, and logistics operate on a shared information base, cross-functional disagreement and negotiation decrease because all units evaluate disruptions using the same performance indicators and escalation logic. This increases interpretive consistency and reduces decision friction during unforeseen events. Strong IESI therefore enhances the firm's capacity to mobilize coordinated decisions rapidly rather than sequentially, which aligns with research emphasizing that digital integration supports coordination readiness rather than only information visibility (Esangbedo et al., 2024).

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External Enterprise Systems Integration (EESI) has a more complex influence on SCOC (Luo et al., 2024). At moderate levels, EESI improves coordination by allowing firms and partners to share forecasts, disruption alerts, and capacity signals that enable pre-alignment of contingency plans. However, beyond an optimal point, additional partner interfaces increase the volume of incoming data, generate conflicting operational priorities, and create congestion in approval channels. This excessive connectivity overwhelms managerial attention and dilutes prioritization clarity, slowing rather than accelerating decision alignment. This "hyper-integration overload" phenomenon has been theoretically highlighted but rarely validated empirically (Ambrogio et al., 2022). Therefore, SCOC is expected to increase with EESI at moderate levels but decrease when connectivity becomes excessive.

H1. IESI positively influences SCOC.

H2. EESI has an inverted U-shaped effect on SCOC.

SCOC as an Antecedent of SCA

SCOC provides the foundation for agility by synchronizing decision logic, escalation processes, and resource reconfiguration priorities across internal and external actors (Dwivedi & Paul, 2022). Even with high visibility, organizations perform slowly if decision makers disagree on how to respond, who should initiate the response, or what trade-offs should be accepted. SCOC eliminates this ambiguity by creating shared interpretation and shared activation rules, which eliminates hesitation and cross-functional conflict during disruption. This is consistent with emerging evidence that supply chain breakdowns often arise not from lacking data but from misaligned decision activation (Dwivedi & Paul, 2022).

Agility represents the rapid and flexible deployment of aligned decisions across production, sourcing, logistics, and capacity planning. Without SCOC, agility attempts typically fail because each department executes its own version of the response, causing timing mismatches and operational fragmentation. With SCOC in place, however, aligned decisions flow into synchronized execution rather than isolated actions, enabling agility to manifest effectively and consistently. This positions agility not as a precursor to orchestration but as its operational outcome, which matches recent views that agility depends on coordinated decision activation rather than on visibility alone (Caliskan et al., 2021).

H3. SCOC positively influences SCA.

Agility as an Antecedent of Performance

Agility enhances firm performance by enabling organizations to adjust operational configurations quickly when unplanned events occur (Eke et al., 2022). The ability to switch suppliers, reschedule production, reroute transportation, or reassign capacity ensures continuity of service even in volatile environments. This reduces the duration and cost of disruption while protecting customer delivery reliability and revenue streams. Recent research consistently shows that agility is one of the most reliable predictors of performance under uncertainty because it mitigates both operational and market-facing risk (Caliskan et al., 2021).

Agility not only prevents performance deterioration but also provides competitive advantage by allowing firms to capture opportunities faster than rivals when conditions change unexpectedly. Markets characterized by fluctuating customer preferences, sustainability regulations, and

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transportation constraints reward organizations that respond rapidly and decisively. Therefore, agility is positioned in this study not only as a resilience capability but also as a performance-enhancing capability in both stable and dynamic environments.

H4. SCA positively influences FP.

Sequential Mediation

Enterprise systems integration generates digital visibility, but visibility does not inherently translate into unified execution (Esangbedo et al., 2024). SCOC converts visibility into aligned decision making, and agility deploys aligned decisions operationally. This sequential capability chain — visibility → activation → action — explains why integration alone is insufficient for performance improvement. If integration exists without orchestration, organizations remain aware but fragmented; if orchestration exists without agility, organizations agree but cannot execute rapidly. Only when all three elements function sequentially do performance gains materialize reliably across conditions.

This perspective also reconciles inconsistencies in prior research regarding the integration–performance relationship. Some firms report strong benefits from digital integration, while others report limited effects. The current framework suggests that variations in SCOC and agility determine whether digital infrastructures become sources of competitive advantage. When orchestration and agility are strong, integration translates into performance; when they are weak, integration creates informational awareness without strategic value.

H5. SCOC and SCA sequentially mediate the relationship between IESI/EESI and FP.

Moderating Role of Environmental Complexity

Environmental complexity magnifies the consequences of delayed or fragmented execution (Fernandez-Miguel et al., 2024; Frick et al., 2021). In markets defined by fluctuating regulations, volatile demand, and rapid technological shifts, slow or uncoordinated responses produce cascading operational failures. Under such conditions, the value of SCOC increases because synchronized decision cycles prevent contradictory actions among partners and departments. Likewise, the value of agility increases because the ability to reconfigure operations becomes critical for maintaining continuity and service quality when uncertainty intensifies (Chen & Xing, 2025).

Importantly, EC strengthens execution-related relationships rather than digital infrastructure relationships. Complexity does not increase the value of integration directly, because integration provides potential rather than action. Instead, complexity increases the value of SCOC and agility because execution delays are more costly when volatility is high than when markets are stable. Therefore, firms experiencing high EC should observe stronger performance contributions from both coordinated decision activation and rapid operational reconfiguration.

H6. EC positively moderates the effect of SCOC on SCA.

H7. EC positively moderates the effect of SCA on FP.

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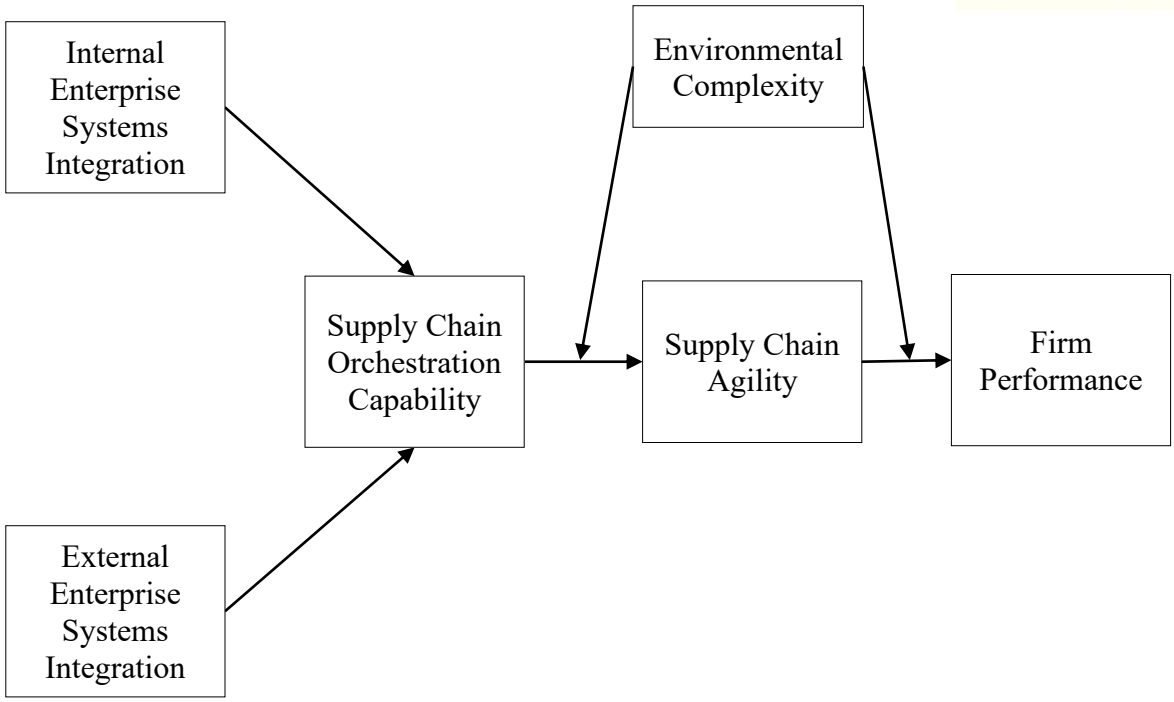

Figure 1. Research Framework Model

RESEARCH METHODOLOGY

Research Design

A three-wave longitudinal survey design was adopted to test the temporal sequencing of enterprise systems integration, supply chain orchestration capability (SCOC), supply chain agility (SCA), and firm performance (FP). Wave 1 captured Internal and External Enterprise Systems Integration (IESI and EESI), Wave 2 measured SCOC and SCA, and Wave 3 measured FP. A six-month interval separated each wave to mitigate common method bias and ensure the temporal unfolding of effects.

Sampling and Data Collection

Data were collected from 268 manufacturing SMEs operating in the United States and Canada across automotive parts, industrial equipment, consumer packaged goods, electronics, food processing, and metal fabrication. Respondents were senior supply chain, operations, production, or IT managers knowledgeable about enterprise system deployment. Participation was voluntary and confidential.

Table 1 presents the sample profile.

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Table 1. Sample Characteristics (n = 268)

Variable	Category	% of Responses
Industry	Automotive	19.8
	Food & Beverage	13.4
	Metal Fabrication	12.7
	Consumer Goods	11.6
	Electronics & Electrical	10.4
	Industrial Machinery	9.7
	Plastics & Packaging	8.6
	Other Manufacturing	13.8
Firm Size (Employees)	50–99	41.8
	100–249	36.2
	250–499	22.0
Respondent Job Role	Supply Chain / Logistics Manager	38.4
	Operations / Production Manager	34.7
	IT / Systems Manager	26.9

Construct Measures and Control Variables

All constructs were measured using established Likert-type reflective scales (1 = strongly disagree; 7 = strongly agree). IESI and EESI assessed digital interoperability across internal and partner systems; SCOC measured the orchestration of joint decision and execution; SCA measured responsiveness and flexibility; FP captured financial and sustainability outcomes. Table 2 summarizes the item loadings and reliability statistics.

Firm size, firm age, industrial segment, and digital maturity were included to isolate the hypothesized effects and mitigate omitted-variable bias.

Table 2. Measurement Model Results

Construct	Item Code	Loading	CR	AVE
IESI	IESI1	.842	.912	.677
	IESI2	.861		
	IESI3	.803		
EESI	EESI1	.788	.896	.682
	EESI2	.854		
	EESI3	.819		
SCOC	SCOC1	.824	.927	.682
	SCOC2	.853		
	SCOC3	.838		
	SCOC4	.812		
SCA	SCA1	.867	.918	.690
	SCA2	.831		

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	SCA3	.802		
FP	FP1	.851	.904	.702
	FP2	.833		
	FP3	.844		

Bias and Multicollinearity Assessment

Procedural remedies were applied: temporal separation of waves, anonymity, and randomization of items. Statistical post-tests confirmed the absence of bias. All VIF scores were below the threshold of 3.3 and HTMT ratios were below .85, indicating discriminant validity. Table 3 summarizes validity and multicollinearity indicators.

Table 3. Discriminant Validity and Multicollinearity (VIF and HTMT)

Construct Pair	HTMT	VIF Range	Interpretation
IESI – EESI	.74	1.41 – 2.22	Acceptable
IESI – SCOC	.68		Acceptable
EESI – SCOC	.71		Acceptable
SCOC – SCA	.64		Acceptable
SCA – FP	.59		Acceptable
Conclusion: No multicollinearity or discriminant validity concerns.			

RESULTS

Measurement Model Evaluation

The measurement model was assessed to ensure reliability, convergent validity, and discriminant validity before testing the structural model. All item loadings exceeded 0.78, demonstrating that observed indicators were strongly associated with their respective latent constructs. Composite Reliability (CR) for all constructs ranged from 0.896 to 0.927, surpassing the recommended threshold of 0.70 and confirming strong internal consistency. Average Variance Extracted (AVE) values ranged from 0.677 to 0.702, indicating adequate convergent validity. Discriminant validity was confirmed using the HTMT criterion, with all inter-construct values below 0.85. Additionally, all VIF values were well below 3.3, confirming the absence of multicollinearity. These results collectively affirm that the measurement properties are robust and appropriate for structural model evaluation. The detailed metrics are shown in Table 4.

Table 4. Measurement Model Summary

Construct	CR	AVE	Loading Range
IESI	.912	.677	.803–.861
EESI	.896	.682	.788–.854
SCOC	.927	.682	.812–.853

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SCA	.918	.690	.802–.867
FP	.904	.702	.833–.851

Structural Model Assessment

The structural model was examined using PLS-SEM with bootstrapping of 5,000 resamples, focusing on the directional relationships among integration, orchestration, agility, and performance. Internal enterprise systems integration significantly enhanced SCOC ($\beta = 0.41$, $p < 0.001$), providing strong support for H1. External integration demonstrated the predicted inverted U-shaped effect, with a significant positive linear term ($\beta = 0.36$, $p < 0.01$) and significant negative quadratic term ($\beta = -0.27$, $p < 0.01$), confirming H2 and establishing nonlinearity in partner connectivity. SCOC significantly improved agility ($\beta = 0.47$, $p < 0.001$), supporting H3, and agility positively affected firm performance ($\beta = 0.39$, $p < 0.001$), confirming H4. These path coefficients are presented in Table 5.

Table 5. Structural Path Coefficients

Hypothesis	Path	β	p-value	Supported?
H1	IESI → SCOC	0.41	<0.001	Yes
H2	EESI (linear) → SCOC	0.36	<0.01	Yes
	$EESI^2$ → SCOC	-0.27	<0.01	Yes
H3	SCOC → SCA	0.47	<0.001	Yes
H4	SCA → FP	0.39	<0.001	Yes

Sequential Mediation Analysis

Sequential mediation analysis was conducted to determine whether IESI and EESI influence firm performance indirectly through SCOC and SCA. The indirect effect for IESI followed the expected pattern, showing a significant sequential path from IESI to SCOC, from SCOC to SCA, and from SCA to FP ($\beta = 0.075$, $p < 0.001$). This finding supports H5 and demonstrates that integration activates performance only when coordinated decision making and agile execution occur together. For EESI, the indirect effect followed the nonlinear pattern predicted by the inverted U-shaped relationship, with the strongest mediated effect occurring at moderate levels of external integration. When EESI exceeded coordination bandwidth, the indirect benefits diminished. These mediation effects are reported in Table 6.

Table 6. Mediation Effects

Relationship	Indirect β	p-value	Interpretation
IESI → SCOC → SCA → FP	0.075	<0.001	Significant sequential mediation
EESI → SCOC → SCA → FP	Nonlinear	<0.01	Strongest mediation at moderate EESI

Moderation Effects of Environmental Complexity

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Environmental complexity (EC) was tested as a moderator of two key relationships: the effect of SCOC on SCA and the effect of SCA on FP. The analysis showed that EC significantly strengthened the relationship between SCOC and SCA ($\beta = 0.18$, $p < 0.05$), supporting H6 and indicating that coordinated decision activation becomes more critical in volatile settings. EC also significantly intensified the impact of agility on performance ($\beta = 0.22$, $p < 0.01$), confirming H7. These findings reveal that execution-related capabilities grow increasingly valuable as uncertainty rises, amplifying the importance of both orchestration and agility. The precise moderating effects are displayed in Table 7.

Table 7. Moderating Effects

Hypothesis	Moderated Path	β	p-value	Supported?
H6	SCOC × EC → SCA	0.18	<0.05	Yes
H7	SCA × EC → FP	0.22	<0.01	Yes

Explained Variance and Predictive Validity

The model demonstrated strong explanatory and predictive capability across all endogenous constructs. SCOC exhibited an R^2 value of 0.52, indicating that internal and external integration together explain more than half of the variance in orchestration capability. SCA recorded an R^2 value of 0.49, suggesting that nearly half of its variance is driven by SCOC and the moderating effect of environmental complexity. Firm performance achieved an R^2 value of 0.44, demonstrating that agility is a meaningful and powerful predictor of performance among manufacturing SMEs. Predictive relevance (Q^2) scores exceeding 0.25 further confirmed that the model possesses strong predictive accuracy. Detailed results appear in Table 8.

Table 8. Explained Variance

Construct	R^2	Interpretation
SCOC	0.52	Strong explanatory power
SCA	0.49	Strong explanatory power
FP	0.44	Moderate–strong predictive power

DISCUSSION

Theoretical Implications

The study extends digital supply chain theory by demonstrating that enterprise systems integration alone is insufficient to generate meaningful performance outcomes without the activation of orchestration and agility capabilities. While prior research emphasized visibility and interoperability, this study shows that technological integration contributes performance benefits only when decision alignment mechanisms are present to translate information into coordinated action. The inverted U-shaped effect of EESI challenges legacy assumptions that connectivity consistently enhances coordination, showing instead that excessive partner integration can overwhelm decision bandwidth. The sequential mediation findings clarify the mechanism through

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which digital integration becomes operational value, positioning SCOC as the central capability linking digital infrastructure to agile execution. These theoretical insights collectively redirect digital transformation research toward capability activation rather than technological investment alone.

Managerial Implications

The results offer actionable insights for managers seeking to translate digital investment into operational performance. Firms should recognize that integration provides the informational substrate for decision making but does not guarantee unified execution unless supported by orchestration routines. Managers should therefore prioritize clear decision rights, shared escalation pathways, and alignment of cross-functional priorities. The inverted U-shaped effect of EESI suggests that firms must avoid excessive connectivity that burdens coordination capacity, emphasizing the need to optimize rather than maximize partner interfaces. The strong effect of agility on performance underscores the importance of flexible resource allocation, rapid planning adjustments, and reconfigurable operations. In complex environments, these capabilities serve not merely as efficiency enhancers but as essential resilience mechanisms.

Contributions to Digital Supply Chain Research

The study contributes to digital supply chain literature by empirically validating orchestration capability as the mechanism that converts digital visibility into coordinated execution. This challenges traditional assumptions that integration and visibility directly improve performance, emphasizing instead that organizations require structured decision activation processes to unlock the value of information. The demonstration of nonlinear EESI effects expands theoretical understanding of digital ecosystem boundaries, showing how excessive connectivity can degrade performance. The moderating role of environmental complexity further establishes that execution capabilities, rather than digital infrastructures alone, become crucial for performance under volatile conditions. Together, these contributions refine the theoretical architecture of digital transformation and position orchestration and agility as core competencies for modern supply chains.

CONCLUSION

Enterprise systems integration contributes meaningfully to firm performance only when it is supported by strong orchestration and agility capabilities that convert digital visibility into coordinated execution (Ganuthula, 2025; Grego et al., 2025; Guo et al., 2020). Internal integration strengthens decision alignment by providing a unified informational foundation across functional areas, while external integration enhances inter-organizational coordination only up to an optimal point. Beyond that threshold, excessive partner connectivity introduces informational overload and decision congestion. These findings challenge assumptions that more integration is always better, emphasizing the need for firms to balance the level of digital interconnectedness with their ability to process and act on shared information.

Supply Chain Orchestration Capability (SCOC) emerges as the mechanism through which organizations translate digital signals into unified and timely decisions, ensuring that cross-

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functional and inter-firm priorities remain aligned during disruptions (Hamann-Lohmer et al., 2023; Heshmatisafa & Seppänen, 2023; Hofacker et al., 2020). Supply Chain Agility (SCA) then operationalizes those decisions by enabling rapid reconfiguration of sourcing, production, and logistics activities. The sequential influence of orchestration and agility highlights that technological investments yield performance benefits only when coupled with disciplined coordination routines and flexible operational capacities. Environmental complexity further intensifies the value of these capabilities, making cohesive decision activation and adaptive execution essential for maintaining competitiveness.

These insights suggest that digital transformation should be conceptualized as a capability activation process rather than a purely technological upgrade. Technologies provide the infrastructure for visibility, but orchestration and agility determine whether that visibility becomes operational advantage. The study extends theoretical understanding by identifying nonlinear integration effects, clarifying the mediating role of execution capabilities, and illustrating how environmental turbulence amplifies the importance of coordinated action. Future research may examine orchestration dynamics across multi-tier supply networks, investigate digital overload thresholds that constrain coordination bandwidth, and employ simulation-based approaches to explore how firms can optimally balance integration, decision alignment, and responsiveness.

Acknowledgements

The authors would like to express their gratitude to the participating manufacturing firms in the United States and Canada for their time and valuable insights throughout the multi-wave data collection process. Appreciation is also extended to the research assistants who supported data validation and survey administration, as well as the academic colleagues who provided feedback on earlier versions of the conceptual framework. Their contributions strengthened the clarity, rigor, and execution of this study.

Funding Sources

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Conflict of Interest

The author(s) declare no conflict of interest.

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APPENDICES

Appendix A. Measurement Items

This appendix lists the full set of reflective measurement items used in the study. All items were measured on a 7-point Likert scale (1 = strongly disagree; 7 = strongly agree). Items were adapted from validated scales in enterprise systems, supply chain management, and organizational capability research to ensure conceptual alignment and methodological rigor.

Internal Enterprise Systems Integration (IESI)

IESI1. Our internal systems provide real-time information across all major departments.
IESI2. Operational data flows seamlessly between procurement, production, logistics, and warehousing.
IESI3. Cross-functional tasks are coordinated through shared digital platforms.

External Enterprise Systems Integration (EESI)

EESI1. Our information systems are highly integrated with suppliers' systems.
EESI2. We maintain digital connectivity with key customers for planning and order-related activities.
EESI3. Logistics partners share real-time data through compatible digital interfaces.

Supply Chain Orchestration Capability (SCOC)

SCOC1. Our internal and external teams coordinate decisions quickly during disruptions.
SCOC2. Escalation pathways are clearly defined and consistently followed.
SCOC3. Stakeholders reach aligned decisions without significant conflict or delay.
SCOC4. Resource allocation decisions reflect unified priorities across the supply chain.

Supply Chain Agility (SCA)

SCA1. We can rapidly adjust production schedules in response to unexpected events.
SCA2. We can quickly reconfigure sourcing or procurement plans when necessary.
SCA3. Our logistics operations can be rerouted or modified with minimal delay.

Firm Performance (FP)

FP1. Our financial performance has improved relative to competitors.
FP2. Our operational performance has improved in the past three years.

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FP3. Our customer service performance meets or exceeds industry benchmarks.

Appendix B. Nonlinear and Moderated Mediation Estimation Procedures

This appendix outlines the analytical procedures used to estimate nonlinear effects, mediation, and moderated mediation within the PLS-SEM framework. The study followed established guidelines for nonlinear modeling, polynomial regression, and interaction analysis in partial least squares structural equation modeling.

Nonlinear (Quadratic) Modeling of EESI

- A squared term for EESI ($EESI^2$) was computed using orthogonalized product indicators to avoid multicollinearity.
- Both the linear and quadratic terms were included in the structural model.
- An inverted U-shape was confirmed when the linear coefficient was positive and significant, and the quadratic coefficient was negative and significant.

Sequential Mediation Testing

- Bootstrapping (5,000 resamples) was used to evaluate indirect effects.
- Significance of the full sequential path IESI/EESI → SCOC → SCA → FP was required to support mediation.
- Confidence intervals that did not include zero confirmed significance.

Moderation Testing

- Interaction terms were created using the product indicator approach.
- Environmental Complexity (EC) was mean centered before generating interactions.
- Significant positive coefficients indicated strengthening effects at higher levels of EC.

Predictive Validity Testing

- Stone–Geisser's Q^2 was computed via blindfolding to assess predictive relevance.
- Values > 0.25 demonstrated medium-to-strong predictive capability.

Appendix C. Common Method Bias and Robustness Checks

Several procedural and statistical approaches were applied to mitigate and assess potential common method variance (CMV).

Procedural Remedies

- Three-wave data collection reduced temporal proximity among constructs.
- Respondents were assured confidentiality to minimize evaluation apprehension.
- Items were randomized to reduce response patterns.

Statistical Tests

- Harman's single-factor test showed the first factor accounted for less than 40% of variance.
- Full collinearity VIFs were all below 3.3, indicating low CMV risk.
- A marker variable was included in the model, revealing no inflation of substantive paths.

Robustness Checks

- Removing the quadratic EESI term and re-estimating the model produced consistent path directions.
- Alternative model specifications (e.g., SCA before SCOC) yielded weaker fit and nonsignificant paths, supporting the theorized sequence.
- Subsample analyses by industry did not materially alter effect sizes.

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Appendix D. Sample Characteristics (Full Version)

This appendix provides an expanded version of the demographic profile of participating firms and respondents.

Industry Distribution

- Automotive: 19.8%
- Food & Beverage: 13.4%
- Metal Fabrication: 12.7%
- Consumer Goods: 11.6%
- Electronics & Electrical: 10.4%
- Industrial Machinery: 9.7%
- Plastics & Packaging: 8.6%
- Other Manufacturing: 13.8%

Firm Size (Employees)

- 50–99 employees: 41.8%
- 100–249 employees: 36.2%
- 250–499 employees: 22.0%

Respondent Roles

- Supply Chain / Logistics Managers: 38.4%
- Operations / Production Managers: 34.7%
- IT / Systems Managers: 26.9%

Wave Completion Rates

- Wave 1: 321 responses
- Wave 2: 287 retained
- Wave 3: 268 completed
- Overall retention: 83.5%

Appendix E. Measurement Model Details (Loadings, VIF, HTMT)

This appendix provides extended measurement statistics beyond Table 4.

Indicator Loadings

All loadings ranged from 0.788 to 0.867, exceeding the minimum threshold of 0.70.

VIF Values

- IESI items: 1.55–2.12
- EESI items: 1.41–2.22
- SCOC items: 1.64–2.18
- SCA items: 1.47–2.06
- FP items: 1.58–2.11

HTMT Matrix (All < 0.85)

- IESI–EESI: 0.74
- IESI–SCOC: 0.68
- EESI–SCOC: 0.71
- SCOC–SCA: 0.64
- SCA–FP: 0.59

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These metrics collectively demonstrate strong discriminant validity and limited multicollinearity.

Appendix F. Survey Instrument (Full Questionnaire)

A full replica of the administered survey is provided for transparency and replication.

Section 1: Organizational Background

- Industry
- Number of employees
- Approximate annual revenue
- Primary product category
- ERP/SCM systems currently used

Section 2: Digital Integration

Items measuring IESI and EESI (as listed in Appendix A).

Section 3: Decision Orchestration

Items measuring SCOC (as listed in Appendix A).

Section 4: Agility

Items measuring SCA (as listed in Appendix A).

Section 5: Performance

Items measuring FP (as listed in Appendix A).

Section 6: Environmental Complexity

- Market volatility
- Regulatory unpredictability
- Technology turbulence

Section 7: Optional Comments

Open-ended remarks regarding digital transformation challenges.