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Building digital business ecosystem resilience through orchestration capability: The sequential roles of ecosystem knowledge integration and ecosystem service innovation

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Abstract

This study examines how digital business ecosystem orchestration capability enhances ecosystem resilience through sequential mediation by ecosystem knowledge integration and ecosystem service innovation, while accounting for the moderating effect of ecosystem dynamism. Data were collected via face-to-face surveys from 469 respondents between April and August 2025. Confirmatory factor analysis, bootstrapped mediation and moderated mediation analyses, and instrumental variable estimation were used to test the proposed model. The findings show that orchestration capability improves ecosystem resilience indirectly through knowledge integration and service innovation, with a significant sequential mediation effect. Moreover, ecosystem dynamism strengthens these indirect relationships. The study extends Dynamic Capabilities Theory to the ecosystem level by explaining resilience as the outcome of coordinated capability development and offers practical insights for managers seeking to build resilient digital business ecosystems.

1. Introduction

Digital business ecosystems have become the dominant organizational environment for firms to create value, exchange knowledge, and develop innovative services. Advances in digital platforms, cloud computing, artificial intelligence, and interconnected technologies have expanded collaboration beyond organizational boundaries, enabling firms to co-create value with multiple ecosystem participants rather than relying solely on internal resources (Baumann & Leerhoff, 2022; Demir et al., 2022). At the same time, these ecosystems have become increasingly vulnerable to technological disruptions, shifting customer expectations, cybersecurity risks, and rapidly evolving competitive structures. Recent large-scale digital failures have shown that disruptions affecting a single platform or ecosystem actor can quickly cascade across interconnected networks, threatening the continuity of value creation. Consequently, resilience has emerged as a strategic capability rather than merely an operational outcome. Building resilient digital business ecosystems therefore requires more than technological investment; it demands organizational capabilities to coordinate ecosystem participants, integrate distributed resources, and sustain collaborative adaptation amid changing environmental conditions (Bharadwaj et al., 2013; Dencik et al., 2023; Jacobides et al., 2018).

Growing scholarly attention has significantly advanced understanding of digital business ecosystems, yet several research streams have evolved largely independently. One body of work has focused on ecosystem structures, governance mechanisms, and platform coordination to explain how interdependent actors jointly create value (Chekfoung et al., 2020; Jacobides et al., 2018; Kornyshova et al., 2023). Another has examined orchestration capability as a strategic mechanism through which firms coordinate ecosystem relationships, allocate complementary resources, and align collaborative activities (Hewett et al., 2022; Kamalaldin et al., 2021; Korpela et al., 2013). Parallel research has emphasized ecosystem resilience, highlighting firms' ability to withstand disruptions, recover from shocks, and adapt to environmental turbulence (Bachtiar et al., 2023; Dencik et al., 2023; Gomes et al., 2023).

** The study was approved by the Tianjin University Human Sciences Research and Ethics Committee, dated 12.09.2024, decision number AQTX-42-ZHU. All responsibility belongs to the authors.*

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Meanwhile, studies on knowledge integration and service innovation show that collaborative learning and continuous innovation strengthen organizational performance in networked environments (Agarwal & Selen, 2009; Chandler et al., 2019; Dai et al., 2020). Despite these advances, the literature rarely explains how orchestration capability translates into resilience through interconnected organizational processes. Most studies emphasize individual relationships while overlooking the sequential capability development that characterizes digital business ecosystems.

This omission is important because ecosystem resilience does not emerge automatically from coordination activities. Coordinating ecosystem actors may improve collaboration, yet resilience is more likely to develop when shared knowledge is systematically integrated and transformed into innovative services that enable the ecosystem to respond effectively to changing conditions. Ecosystem knowledge integration (EKI) provides the cognitive foundation for combining dispersed expertise, while ecosystem service innovation (ESI) is the practical manifestation of that collective knowledge in new or improved digital services (Demir et al., 2022; Fernández-Portillo et al., 2024). These capabilities are unlikely to operate independently; instead, they form an interconnected capability-building process through which orchestration capability influences resilience. Furthermore, digital business ecosystems differ substantially in how quickly technologies, customer preferences, platform architectures, and competitive conditions evolve. Under highly dynamic conditions, orchestration capability may become more influential because firms must continuously coordinate ecosystem actors, integrate new knowledge, and redesign services. Examining ecosystem dynamism as a boundary condition therefore offers a more realistic explanation of why orchestration capability produces stronger outcomes in some ecosystems than in others (Alaassar et al., 2022; Kornyshova et al., 2023).

This study adopts Dynamic Capabilities Theory (DCT) as its theoretical foundation because it explains how organizations sustain performance by sensing environmental change, seizing emerging opportunities, and continuously reconfiguring organizational resources and relationships (Eisenhardt & Martin, 2000). Within digital business ecosystems, orchestration capability is a higher-order dynamic capability that enables firms to coordinate ecosystem participants, mobilize complementary resources, and facilitate collaborative adaptation. EKI and ESI are conceptualized as capability development processes through which orchestration capability is transformed into ecosystem resilience. Based on this perspective, this study makes four contributions to the literature. First, it extends DCT beyond the firm level by explaining resilience from an ecosystem perspective. Second, it introduces a sequential mediation framework that clarifies how orchestration capability influences resilience through EKI and ESI, rather than assuming a direct relationship. Third, it identifies digital business ecosystem dynamism (DBED) as an important boundary condition that affects these capability development processes. Finally, the findings provide practical guidance for managers by demonstrating that resilient digital ecosystems require coordinated capability development, systematic knowledge integration, and continuous service innovation, rather than isolated investments in digital technologies alone (Beske, 2012; Eisenhardt & Martin, 2000; Jacobides et al., 2018).

2. Literature review

2.1. Dynamic capabilities theory and digital business ecosystems

Digital business ecosystems are marked by continuous technological evolution, interdependence among multiple actors, and rapidly shifting competitive conditions. Unlike traditional business environments, firms in digital ecosystems cannot rely solely on internally controlled resources to sustain competitive advantage because value creation increasingly depends on the coordinated contributions of platform owners, technology providers, complementors, customers, and other ecosystem participants. As ecosystem boundaries become more fluid, organizational success depends less on resource ownership and more on the ability to mobilize, integrate, and continuously reconfigure distributed resources across organizational boundaries. This perspective aligns closely with DCT, which holds that sustained performance stems from higher-order capabilities that enable firms to sense environmental changes, seize emerging opportunities, and transform organizational resources in response to evolving market conditions (Eisenhardt & Martin, 2000; Teece et al., 1997). Rather than emphasizing static resource possession, DCT focuses on the continuous renewal of organizational capabilities amid uncertainty. This theoretical lens has therefore become increasingly relevant for explaining how firms operate within digital business ecosystems, where technological discontinuities, platform evolution, and shifting stakeholder relationships require ongoing capability adaptation rather than episodic organizational change (Bharadwaj et al., 2013; Jacobides et al., 2018). Recent ecosystem research likewise recognizes that competitive advantage arises from dynamic interactions among heterogeneous actors rather than from firm-specific resources alone, reinforcing DCT's suitability for ecosystem-based research (Baumann & Leerhoff, 2022; Kornyshova et al., 2023).

Applying DCT to digital business ecosystems also offers a coherent explanation of the capability development process examined in this study. Within ecosystems, digital business ecosystem orchestration capability (DBEOC) is a higher-order capability that enables firms to coordinate partners, synchronize digital resources, facilitate collaboration, and align ecosystem-wide activities toward shared objectives. However, orchestration alone does not create resilience. Its value depends on whether ecosystem participants integrate dispersed knowledge and transform it into innovative services that address changing environmental demands. From a dynamic capabilities perspective, EKI is the capability to acquire, combine, and disseminate complementary knowledge from multiple ecosystem actors, thereby strengthening collective learning and decision-making. This integrated knowledge subsequently supports ESI, through which ecosystem participants jointly redesign existing services or develop new digital solutions that enhance customer value and ecosystem adaptability. These interconnected capabilities ultimately contribute to digital business ecosystem resilience (DBER), enabling ecosystems to anticipate disruptions, absorb unexpected shocks, recover efficiently, and continuously adapt while maintaining value creation. Consequently, resilience is conceptualized not as an isolated organizational outcome but as the cumulative result of sequential capability development. This interpretation extends DCT beyond the traditional firm-level perspective by illustrating how higher-order capabilities evolve collectively across interconnected organizations operating within digital business ecosystems (Agarwal & Selen, 2009; Chandler et al., 2019; Eisenhardt & Martin, 2000; Jacobides et al., 2018).

2.2. Digital business ecosystem orchestration capability and ecosystem knowledge integration

Digital business ecosystems depend on the coordinated interaction of diverse actors who collectively generate, exchange, and exploit knowledge. Because ecosystem participants possess heterogeneous resources, expertise, and technological capabilities, the mere existence of collaborative networks does not ensure effective knowledge integration. Instead, firms require orchestration capability to align ecosystem participants, coordinate interdependent activities, facilitate information exchange, and establish governance mechanisms that enable knowledge to flow across organizational boundaries. DBEOC therefore extends beyond coordinating operational activities; it represents the strategic capability to mobilize complementary resources and synchronize ecosystem interactions toward common objectives.

Previous studies have consistently argued that orchestration strengthens collaboration by reducing coordination complexity, enhancing information transparency, and improving collective decision-making across ecosystem partners (Hewett et al., 2022; Kamalaldin et al., 2021; Korpela et al., 2013). Likewise, research on collaborative networks suggests that organizations with stronger coordination mechanisms create more favorable conditions for knowledge sharing, organizational learning, and resource integration because ecosystem participants become more willing to exchange complementary expertise and jointly solve emerging problems (Andrade et al., 2022; Cao & Zhang, 2011; Chen et al., 2023). From a DCT perspective, orchestration capability enables firms to continuously reconfigure ecosystem relationships and transform dispersed knowledge into collective strategic resources. Consequently, firms with stronger orchestration capability are expected to achieve higher levels of EKI by facilitating systematic collaboration among ecosystem actors.

However, the effectiveness of orchestration capability is unlikely to remain constant across digital business ecosystems. These ecosystems differ substantially in the pace of technological innovation, platform evolution, customer expectations, and competitive change. Under relatively stable conditions, organizations may integrate knowledge through established coordination routines. In contrast, highly dynamic ecosystems require organizations to continuously identify new partners, absorb emerging knowledge, and rapidly realign collaborative activities in response to environmental change. DCT suggests that higher-order capabilities become particularly valuable when external environments are uncertain and rapidly changing, because organizations must repeatedly reconfigure relationships and resources to sustain performance (Eisenhardt & Martin, 2000; Teece et al., 1997). Recent ecosystem research similarly argues that environmental dynamism intensifies the need for flexible governance structures, continuous collaboration, and adaptive coordination mechanisms within digital ecosystems (Alaassar et al., 2022; Gomes et al., 2023; Kornyshova et al., 2023). Accordingly, orchestration capability should have a stronger influence on EKI when firms operate in highly dynamic digital business ecosystems, where continuous adaptation depends on effective coordination among ecosystem actors and the rapid integration of newly generated knowledge.

H1. Ecosystem knowledge integration positively mediates the relationship between digital business ecosystem orchestration capability and digital business ecosystem resilience.

H4. Digital business ecosystem dynamism positively moderates the relationship between digital business ecosystem orchestration capability and ecosystem knowledge integration.

2.3. Ecosystem knowledge integration and ecosystem service innovation

The ability to integrate knowledge from multiple ecosystem participants has become a critical determinant of innovation in digital business ecosystems. Unlike traditional organizational settings, knowledge in digital ecosystems is widely dispersed across platform owners, technology providers, complementors, customers, and other ecosystem actors. These diverse knowledge sources differ in technological expertise, market insights, and operational experience, making effective integration a prerequisite for collaborative value creation. EKI therefore extends beyond information sharing, enabling organizations to combine heterogeneous knowledge into a shared understanding that supports collective learning and coordinated decision-making. Previous studies consistently show that organizations that integrate complementary knowledge are better positioned to recognize emerging opportunities, solve complex problems, and develop new solutions that individual firms could not generate independently (Abbate et al., 2022; Andrade et al., 2022; Chen et al., 2023). Within DCT, knowledge integration is an essential capability renewal process that transforms dispersed knowledge into strategic organizational assets. Rather than serving as a passive repository of information, integrated knowledge becomes an active resource that strengthens organizational adaptability and supports continuous capability development in rapidly changing environments (Eisenhardt & Martin, 2000; Teece et al., 1997).

Integrated ecosystem knowledge creates the conditions for developing innovative digital services by enabling ecosystem participants to identify unmet customer needs, combine complementary competencies, and jointly redesign service offerings. Service innovation rarely emerges from isolated organizational efforts within digital ecosystems. Instead, it evolves through continuous interaction among ecosystem participants who collectively generate, evaluate, and refine new service ideas. Earlier research has shown that collaborative learning, cross-organizational knowledge exchange, and capability integration significantly improve firms' ability to develop innovative services that enhance customer value and strengthen ecosystem competitiveness (Agarwal & Selen, 2009; Chandler et al., 2019; Dai et al., 2020). Similarly, studies on digital ecosystems emphasize that collaborative innovation depends on effectively integrating knowledge distributed among ecosystem participants, not on individual organizational expertise alone (Barile et al., 2020; Hein et al., 2019; Kamalaldin et al., 2021). Accordingly, EKI is the underlying capability through which organizations convert dispersed ecosystem intelligence into continuous ESI, thereby establishing a critical capability-building process within digital business ecosystems.

2.4. Ecosystem service innovation and digital business ecosystem resilience

Innovation has long been recognized as a primary mechanism for organizations to adapt to environmental uncertainty and sustain long-term competitiveness. Within digital business ecosystems, however, innovation extends beyond developing new products or technologies. ESI reflects ecosystem participants' collective capability to continuously design, improve, and commercialize digital services by combining complementary resources and capabilities. This innovation enables ecosystem actors to respond rapidly to technological disruptions, shifting customer expectations, and evolving competitive conditions while maintaining continuity in value creation. Previous studies suggest that organizations that continuously renew their service offerings show greater flexibility, faster adaptation, and stronger organizational performance in uncertain environments because innovation strengthens their capacity to reconfigure operational processes and exploit emerging opportunities (Agarwal & Selen, 2009; Chandler et al., 2019; Dai et al., 2020). Likewise, research on business ecosystems argues that collaborative service innovation strengthens ecosystem-wide adaptability by encouraging collective experimentation, shared problem solving, and continuous value co-creation among ecosystem participants (Barile et al., 2020; Hein et al., 2019; Kamalaldin et al., 2021). From a DCT perspective, service innovation is the reconfiguration stage in which previously integrated knowledge is transformed into new ecosystem capabilities that enhance resilience under changing environmental conditions (Eisenhardt & Martin, 2000; Teece et al., 1997). Consequently, ecosystems with stronger service innovation capabilities are expected to develop greater resilience because they can anticipate disruptions, respond more effectively to unexpected events, and sustain value creation despite environmental uncertainty.

Although ESI contributes to resilience, its effectiveness is unlikely to be uniform across ecosystem contexts. Digital business ecosystems vary widely in technological turbulence, platform evolution, customer preferences, and competitive intensity. Under relatively stable conditions, incremental service improvements may suffice to maintain ecosystem performance. However, in highly dynamic ecosystems, organizations must continuously redesign service offerings, introduce new digital solutions, and respond rapidly to emerging technological opportunities. Environmental dynamism therefore increases the strategic value of innovation because existing services become obsolete more quickly and customer expectations evolve faster. DCT holds that the benefits of organizational capabilities become more pronounced when firms operate in turbulent environments that require continuous resource reconfiguration (Eisenhardt & Martin, 2000; Teece et al., 1997). Similarly, recent ecosystem studies emphasize that rapidly changing digital environments heighten the importance of adaptive innovation, collaborative experimentation, and continuous service renewal for sustaining ecosystem performance (Fernández-Portillo et al., 2024; Gomes et al., 2023; Kornyshova et al., 2023). Accordingly, DBED is expected to strengthen the positive influence of DBEOC on ESI because dynamic environments amplify the need for coordinated innovation across ecosystem participants.

H2. Ecosystem service innovation positively mediates the relationship between digital business ecosystem orchestration capability and digital business ecosystem resilience.

H5. Digital business ecosystem dynamism positively moderates the relationship between digital business ecosystem orchestration capability and ecosystem service innovation.

2.5. Sequential capability development toward digital business ecosystem resilience

DCT holds that sustainable competitive advantage rarely stems from a single organizational capability. Instead, superior performance emerges from a sequence of interconnected capabilities that enable organizations to continuously sense environmental changes, integrate relevant resources, and reconfigure existing competencies into new forms of value creation (Eisenhardt & Martin, 2000; Teece et al., 1997). This capability-building perspective is especially relevant to digital business ecosystems, where ecosystem outcomes depend on the coordinated actions of multiple independent actors rather than the capabilities of a single organization. Consequently, ecosystem resilience should not be viewed as the direct consequence of orchestration capability alone but as the cumulative outcome of successive capability development processes operating across the ecosystem.

Within this perspective, DBEOC is the initiating capability that coordinates ecosystem actors, aligns collaborative activities, and facilitates the exchange of complementary resources. However, coordinated interaction alone does not generate resilience unless ecosystem participants integrate the knowledge generated through these interactions. EKI transforms dispersed expertise into shared understanding, creating the cognitive foundation for collaborative learning and strategic decision-making. This collective knowledge subsequently enables ESI by supporting the development, refinement, and commercialization of innovative digital services that respond to emerging ecosystem needs. As new services enhance ecosystem flexibility, strengthen collaborative adaptation, and improve the continuity of value creation, DBER gradually emerges as the final outcome of this capability development process. Rather than operating as independent mechanisms, orchestration capability, knowledge integration, and service innovation constitute complementary and mutually reinforcing capabilities through which digital ecosystems continuously renew themselves under changing environmental conditions (Agarwal & Selen, 2009; Chandler et al., 2019; Jacobides et al., 2018; Kamalaldin et al., 2021).

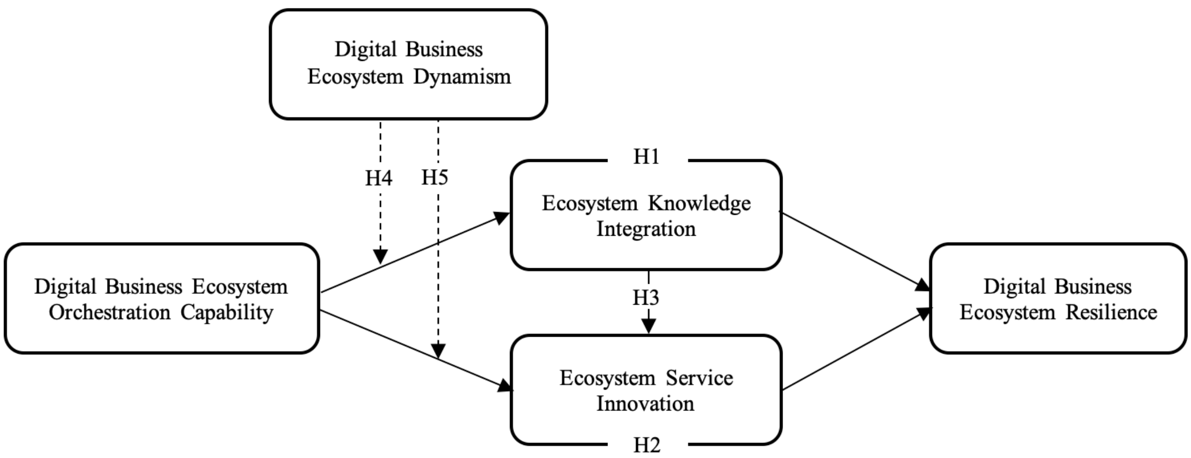

Figure 1. Conceptual model

This sequential perspective offers a more comprehensive explanation than treating knowledge integration and service innovation as parallel mediators. Although both capabilities contribute to ecosystem performance, service innovation is unlikely to occur without first integrating the heterogeneous knowledge distributed across ecosystem participants. Likewise, knowledge integration alone does not strengthen ecosystem resilience unless the integrated knowledge is transformed into innovative services that enhance ecosystem adaptability. Accordingly, the influence of DBEOC on DBER is expected to unfold sequentially, with orchestration capability facilitating EKI, integrated knowledge stimulating ESI, and service innovation ultimately strengthening ecosystem resilience.

H3. Ecosystem knowledge integration and ecosystem service innovation sequentially mediate the relationship between digital business ecosystem orchestration capability and digital business ecosystem resilience.

3. Methodology

The study was approved by the Tianjin University Human Sciences Research and Ethics Committee, dated 12.09.2024, decision number AQTX-42-ZHU.

3.1. Sampling and data collection

This study used a quantitative design to examine relationships among DBEOC, EKI, ESI, DBER, and DBED. Data were collected through a structured questionnaire administered face-to-face from April to August 2025 among chefs and middle- and senior-management staff at 4- and 5-star hotels in the Chinese cities of Chongqing, Shanghai, Beijing, Chengdu, and Guangzhou. Face-to-face administration was preferred because it allowed respondents to seek clarification when needed and improved questionnaire completion.

A total of 469 usable questionnaires were obtained and included in the final analysis. The sample size met the minimum requirements for structural equation modeling and mediation analysis. To assess whether the sample provided sufficient statistical power, a post hoc power analysis was conducted in G*Power. The results indicated that the sample had adequate power to detect the hypothesized effects, supporting the robustness of the empirical analyses (Faul et al., 2009).

Participation in the survey was voluntary, and respondents were informed of the study's academic purpose before completing the questionnaire. The researchers maintained confidentiality and anonymity throughout data collection. All measurement items were rated on a five-point Likert scale, ranging from 1 ("strongly disagree") to 5 ("strongly agree").

3.2. Measures

The measurement instrument was developed by adapting well-established scales from prior studies to the digital business ecosystems context. Minor wording revisions improved clarity while preserving the constructs' original conceptual meanings.

DBEOC was measured using items adapted from Hewett et al. (2022), Kamalaldin et al. (2021), and Demir (2026). EKI was measured using items based on Chen et al. (2023) and Demir and Demir (2025). ESI was assessed using scales developed by Chandler et al. (2019), Dai et al. (2020), and Demir and Demir (2025). DBER was measured using items adapted from Dencik et al. (2023), Dey et al. (2023), and Fornasiero and Tolio (2024). Finally, DBED was measured using items from Korpela et al. (2013), Lettner et al. (2022), and Priyono and Hidayat (2024). Appendix A provides the complete list of measurement items.

3.3. Data analysis

The empirical analysis was conducted in several stages. IBM SPSS Statistics 26 was first used to screen the data, generate descriptive statistics, and assess the measurement scales' dimensional structure. Reliability was evaluated using Cronbach's alpha and composite reliability, and convergent validity was assessed using average variance extracted (AVE). All constructs met the recommended thresholds, indicating satisfactory internal consistency and convergent validity (Fornell & Larcker, 1981; Hair et al., 2010).

The construct validity of the measurement model was subsequently examined using confirmatory factor analysis (CFA) in AMOS 24.0. Model fit was evaluated using multiple goodness-of-fit indices, including χ^2/df, RMSEA, GFI, AGFI, NFI, IFI, TLI, and CFI. The fit indices indicated that the proposed measurement model fit the observed data adequately. Discriminant validity was evaluated using both the Fornell-Larcker criterion and the Heterotrait-Monotrait (HTMT) ratio. The results confirmed that each construct was empirically distinct from the others.

Because all variables were collected from the same respondents, common method bias was also examined. Following the recommendations of Podsakoff et al. (2012), a common latent factor approach was used to compare standardized factor loadings before and after including the method factor. The observed differences were minimal across all measurement items, indicating that common method variance was unlikely to threaten the validity of the findings. The proposed hypotheses were tested using regression-based path analysis with bootstrapping. Direct, indirect, and sequential indirect effects were estimated using bias-corrected bootstrap confidence intervals. Mediation effects were considered significant when the 95% confidence intervals did not include zero (Preacher & Hayes, 2008). Conditional indirect effects were estimated to assess the moderating role of DBED, and moderated mediation was evaluated using the index of moderated mediation with bootstrap confidence intervals.

Finally, endogeneity was assessed using a two-stage least squares (2SLS) instrumental variable approach. Following prior management research, the industry- and region-level mean value of DBEOC, excluding the focal firm, served as the instrument. The Kleibergen-Paap LM and Cragg-Donald Wald F statistics indicated that the instrument was both relevant and sufficiently strong. Consistency between ordinary and instrumental variable estimates further supported the robustness of the proposed relationships.

4. Findings

4.1. Measurement model assessment

The psychometric properties of the measurement model were examined before testing the proposed hypotheses. Internal consistency reliability was assessed using Cronbach's alpha and composite reliability, and convergent validity was evaluated using AVE. As shown in Table 1, Cronbach's alpha coefficients ranged from 0.918 to 0.939, exceeding the recommended threshold of 0.70. Composite reliability ranged from 0.889 to 0.932, indicating strong internal consistency across all constructs. The AVE values ranged from 0.666 to 0.702, remaining well above the recommended minimum of 0.50. These findings confirm that the measurement scales demonstrate satisfactory reliability and convergent validity. Construct validity was subsequently assessed using confirmatory factor analysis. The overall measurement model fit the observed data well ($\chi^2/df = 1.287$, RMSEA = 0.035, GFI = 0.872, AGFI = 0.846, NFI = 0.938, IFI = 0.986, TLI = 0.984, and CFI = 0.986), indicating that the proposed factor structure adequately represented the data.

Table 1. Reliability and convergent validity

Construct	CR	AVE	Cronbach's α
DBEOC	0.921	0.702	0.928
EKI	0.926	0.684	0.936
ESI	0.919	0.671	0.931
DBER	0.932	0.694	0.939
DBED	0.889	0.666	0.918

Notes. $N = 469$. CR: Composite reliability, AVE: Average variance extracted, DBEOC: Digital business ecosystem orchestration capability, EKI: Ecosystem knowledge integration, ESI: Ecosystem service innovation, DBER: Digital business ecosystem resilience, DBED: Digital business ecosystem dynamism.

Table 2. Descriptive statistics, correlations, and discriminant validity

Construct	Mean	SD	1	2	3	4	5
1. DBEOC	3.214	0.982	0.838				
2. EKI	3.476	0.915	0.548**	0.827			
3. ESI	3.542	1.031	0.501**	0.469**	0.818		
4. DBER	3.185	0.948	0.421**	0.446**	0.566**	0.833	
5. DBED	3.688	0.974	0.435**	0.571**	0.489**	0.537**	0.816

Notes. $N = 469$. DBEOC: Digital business ecosystem orchestration capability, EKI: Ecosystem knowledge integration, ESI: Ecosystem service innovation, DBER: Digital business ecosystem resilience, DBED: Digital business ecosystem dynamism, $\chi^2/df = 1.287$ RMSEA = 0.035 GFI = 0.872 AGFI = 0.846 NFI = 0.938 IFI = 0.986 TLI = 0.984 CFI = 0.986 Diagonal values represent the square roots of AVE. ** $p < 0.01$

4.2. Descriptive statistics and discriminant validity

Table 2 presents descriptive statistics and correlation coefficients for the study variables. Mean values ranged from 3.185 to 3.688, and standard deviations ranged from 0.915 to 1.031, indicating adequate variation in respondents' evaluations. All correlations among the constructs were positive and statistically significant ($p < 0.01$). DBEOC was positively associated with EKI ($r = 0.548$), ESI ($r = 0.501$), DBER ($r = 0.421$), and DBED ($r = 0.435$). Similarly, EKI was positively related to ESI ($r = 0.469$), DBER ($r = 0.446$), and DBED ($r = 0.571$). Discriminant validity was first evaluated using the Fornell-Larcker criterion. As shown in Table 2, the square root of each construct's AVE exceeded its correlations with the other constructs, providing initial evidence of discriminant validity. Table 3 further supported this conclusion with the HTMT analysis. All HTMT ratios were below the recommended threshold of 0.85, confirming that the constructs captured conceptually distinct phenomena. Because the data were collected from a single source, common method variance was also assessed. Table 4 compares the standardized factor loadings before and after introducing a common latent factor. The observed differences were consistently small across all measurement items, indicating that common method bias is unlikely to have materially influenced the findings.

Table 3. HTMT analysis

Constructs	DBEOC	EKI	ESI	DBER	DBED
DBEOC	—				
EKI	0.586	—			
ESI	0.542	0.401	—		
DBER	0.447	0.463	0.582	—	
DBED	0.471	0.614	0.593	0.518	—

Notes. N = 469. DBEOC: Digital business ecosystem orchestration capability, EKI: Ecosystem knowledge integration, ESI: Ecosystem service innovation, DBER: Digital business ecosystem resilience, DBED: Digital business ecosystem dynamism.

Table 4. Comparison of standardized factor loadings

Item	Baseline	With method factor	Difference
DBEOC1	0.938	0.917	0.021
DBEOC2	0.872	0.883	−0.011
DBEOC3	0.836	0.814	0.022
DBEOC4	0.821	0.834	−0.013
DBEOC5	0.867	0.853	0.014
EKI1	0.931	0.938	−0.007
EKI2	0.862	0.850	0.012
EKI3	0.837	0.845	−0.008
EKI4	0.812	0.801	0.011
EKI5	0.845	0.833	0.012
EKI6	0.829	0.819	0.010
ESI1	0.944	0.921	0.023
ESI2	0.828	0.846	−0.018
ESI3	0.834	0.808	0.026
ESI4	0.851	0.866	−0.015
ESI5	0.826	0.812	0.014
ESI6	0.869	0.875	−0.006
DBER1	0.947	0.944	0.003
DBER2	0.817	0.828	−0.011
DBER3	0.851	0.839	0.012
DBER4	0.836	0.851	−0.015
DBER5	0.814	0.827	−0.013
DBER6	0.839	0.828	0.011
DBED1	0.929	0.911	0.018
DBED2	0.839	0.853	−0.014
DBED3	0.846	0.818	0.028
DBED4	0.884	0.889	−0.005

Notes. N = 469. DBEOC: Digital business ecosystem orchestration capability, EKI: Ecosystem knowledge integration, ESI: Ecosystem service innovation, DBER: Digital business ecosystem resilience, DBED: Digital business ecosystem dynamism.

4.3. Structural model and hypothesis testing

The proposed hypotheses were tested using bootstrapping with bias-corrected confidence intervals. Table 5 summarizes the direct, indirect, sequential, and conditional indirect effects. The total effect of DBEOC on DBER was positive and statistically significant (β = 0.405, p < 0.001). However, after incorporating the proposed mediators, the direct effect became statistically insignificant (β = 0.096, p = 0.167), indicating that orchestration capability influenced ecosystem resilience through indirect mechanisms rather than a direct relationship. The mediation analyses supported all proposed indirect relationships. EKI significantly mediated the relationship between DBEOC and DBER (indirect effect = 0.243, 95% CI [0.156, 0.338]). Likewise, ESI significantly mediated the relationship (indirect effect = 0.091, 95% CI [0.026, 0.154]). In addition, the sequential mediation effect through EKI followed by ESI was statistically significant (indirect effect = 0.166, 95% CI [0.103, 0.238]). Because none of the confidence intervals included zero, H1, H2, and H3 were supported.

Table 5. The effects of digital business ecosystem orchestration capability on digital business ecosystem resilience

Path	*t*	*SE*	*p*	Effect	LLCI	ULCI
Total effect of DBEOC on DBER						
DBEOC → DBER	6.842	0.059	< 0.001	0.405	0.289	0.521
Direct effect of DBEOC on DBER						
DBEOC → DBER	1.387	0.070	0.167	0.096	−0.040	0.233
Indirect effects of DBEOC on DBER						
Indirect Path		BootSE		Effect	BootLLCI	BootULCI
DBEOC → EKI → DBER		0.046		0.243	0.156	0.338
DBEOC → ESI → DBER		0.032		0.091	0.026	0.154
DBEOC → EKI → ESI → DBER		0.034		0.166	0.103	0.238
Conditional indirect effects at different levels of DBED						
Moderating effect of DBED						
Path	Level of DBED	BootSE		Effect	BootLLCI	BootULCI
DBEOC → EKI → DBER	Low (−1 SD)	0.028		0.071	0.022	0.132
	Mean	0.031		0.098	0.044	0.166
	High (+1 SD)	0.039		0.128	0.061	0.212
DBEOC → ESI → DBER	Low (−1 SD)	0.044		0.117	0.036	0.206
	Mean	0.036		0.136	0.070	0.215
	High (+1 SD)	0.043		0.162	0.084	0.251
Moderated mediation index						
Moderated mediation path	Index	BootSE			BootLLCI	BootULCI
DBEOC → EKI → DBER	0.028	0.011			0.009	0.052
DBEOC → ESI → DBER	0.021	0.010			0.005	0.044

Table 6. Instrumental variable (2SLS) regression results

Variable	First stage: DBEOC	Second stage: EKI	Second stage: ESI	Second stage: DBER
Instrumental variable: Mean DBEOC of other firms in the same industry and region	0.184*** (3.18)			
DBEOC		0.712** (2.34)	1.268** (2.59)	2.241*** (3.92)
DBED	0.226*** (3.89)	0.251** (2.48)	0.176 (1.21)	—
Firm Size	0.173* (1.76)	0.041 (0.29)	−0.119 (−0.67)	−0.284 (−0.93)
Firm Age	0.148* (1.69)	0.087 (0.71)	−0.196 (−1.12)	−0.618* (−1.84)
Constant	0.734*** (3.21)	0.461 (1.18)	−0.082 (−0.14)	−2.196** (−2.16)
Industry Fixed Effects	Yes	Yes	Yes	Yes
Regional Fixed Effects	Yes	Yes	Yes	Yes
Kleibergen–Paap rk LM statistic	19.436***			
Cragg–Donald Wald F statistic	21.782			
Observations	214	214	214	214
Adjusted R^2	0.314	0.298	0.357	0.421

Notes. $N = 469$. Standardized regression coefficients are reported. Values in parentheses are t-statistics.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

The moderating role of DBED was then examined by estimating conditional indirect effects at low, mean, and high levels of the moderator. For the indirect pathway through EKI, the conditional indirect effect rose from 0.071 at low dynamism to 0.128 at high dynamism. A similar pattern emerged for mediation through ESI, with the indirect effect increasing from 0.117 to 0.162 as ecosystem dynamism increased. These findings indicate that the positive influence of orchestration capability strengthens in more dynamic digital business ecosystems. The moderated mediation analysis further confirmed these results.

The index of moderated mediation was positive and statistically significant for both mediation pathways, as the bootstrap confidence intervals did not include zero. Specifically, the index was 0.028 (95% CI [0.009, 0.052]) for the EKI pathway and 0.021 (95% CI [0.005, 0.044]) for the ESI pathway. Accordingly, H4a and H4b were supported. Table 8 summarizes the overall hypothesis-testing results and shows that all proposed hypotheses were empirically supported.

4.4. Robustness check

To address potential endogeneity concerns, a two-stage least squares (2SLS) instrumental variable approach was employed. Following prior research, the industry- and region-level mean of DBEOC was used as the instrument. As reported in Table 6, the instrumental variable significantly predicted DBEOC in the first-stage regression (β = 0.184, $p < 0.001$). The Kleibergen-Paap LM statistic confirmed instrument relevance, and the Cragg-Donald Wald F statistic exceeded the commonly accepted threshold for weak instrument diagnostics. In the second-stage estimates, DBEOC remained positively associated with EKI ($\beta = 0.712$, $p < 0.01$), ESI ($\beta = 1.268$, $p < 0.01$), and DBER ($\beta = 2.241$, $p < 0.001$). These findings suggest the reported relationships are unlikely to be driven by endogeneity and further support the robustness of the empirical results.

Table 7. Standardized measurement model results

Constructs / items	Standardized loading	Squared loading	Error variance
DBEOC1	0.886	0.785	0.215
DBEOC2	0.851	0.724	0.276
DBEOC3	0.817	0.667	0.333
DBEOC4	0.803	0.645	0.355
DBEOC5	0.829	0.687	0.313
EKI1	0.881	0.776	0.224
EKI2	0.848	0.719	0.281
EKI3	0.833	0.694	0.306
EKI4	0.814	0.663	0.337
EKI5	0.798	0.637	0.363
EKI6	0.785	0.616	0.384
ESI1	0.879	0.773	0.227
ESI2	0.842	0.709	0.291
ESI3	0.826	0.682	0.318
ESI4	0.811	0.658	0.342
ESI5	0.798	0.637	0.363
ESI6	0.751	0.564	0.436
DBER1	0.891	0.794	0.206
DBER2	0.856	0.733	0.267
DBER3	0.837	0.701	0.299
DBER4	0.822	0.676	0.324
DBER5	0.801	0.642	0.358
DBER6	0.773	0.598	0.402
DBED1	0.862	0.743	0.257
DBED2	0.831	0.691	0.309
DBED3	0.798	0.637	0.363
DBED4	0.769	0.591	0.409

Table 8. Final hypothesis testing results

Hypothesis	Proposed effect	Effect type	Result
H1	DBEOC → EKI → DBER	Positive indirect effect	Supported
H2	DBEOC → ESI → DBER	Positive indirect effect	Supported
H3	DBEOC → EKI → ESI → DBER	Positive sequential indirect effect	Supported
H4a	DBED positively moderates DBEOC → EKI	Positive first-stage moderation	Supported
H4b	DBED positively moderates DBEOC → ESI	Positive first-stage moderation	Supported

5. Discussion and conclusions

This study examined how DBEOC contributes to DBER by considering the sequential roles of EKI and ESI, while also assessing DBED's moderating influence. Although previous research has recognized the strategic importance of orchestration, innovation, and resilience within digital ecosystems, these constructs have generally been investigated in isolation or through direct relationships. By integrating them into a single capability development framework, this study offers a more comprehensive explanation of how resilience emerges in digitally connected business environments. The findings suggest that ecosystem resilience is not an immediate consequence of orchestration capability. Instead, resilience develops through a sequence of organizational processes that transform coordinated ecosystem interactions into integrated knowledge and, subsequently, into innovative ecosystem services. This interpretation extends existing ecosystem research by emphasizing capability development rather than isolated organizational resources (Agarwal & Selen, 2009; Jacobides et al., 2018; Kamalaldin et al., 2021).

The first important finding concerns the indirect role of EKI. The results indicate that orchestration capability enhances resilience by strengthening the ecosystem's ability to acquire, combine, and disseminate knowledge across multiple participants. This finding aligns with previous studies arguing that effective coordination facilitates knowledge exchange and collaborative learning among ecosystem actors (Andrade et al., 2022; Cao & Zhang, 2011; Chen et al., 2023). However, these findings also extend the literature by showing that knowledge integration should not be viewed merely as an information management activity. Rather, it functions as a dynamic organizational capability that enables ecosystem participants to transform dispersed expertise into collective strategic action. From a DCT perspective, this finding reinforces the argument that competitive advantage depends not only on accessing external knowledge but also on continuously reconfiguring and integrating distributed resources in response to environmental change (Demir, 2026; Eisenhardt & Martin, 2000; Teece et al., 1997). Consequently, orchestration capability creates value by establishing the conditions under which ecosystem knowledge can be effectively integrated rather than simply exchanged.

The second major finding highlights ESI's mediating role. While previous studies have consistently linked collaborative innovation to organizational adaptability and competitive performance, they have rarely explained how service innovation emerges from ecosystem capabilities (Agarwal & Selen, 2009; Chandler et al., 2019; Dai et al., 2020). The present findings suggest that orchestration capability contributes to resilience by enabling continuous service renewal across ecosystem participants. This result supports the growing view that digital ecosystems require ongoing innovation rather than episodic technological improvements (Barile et al., 2020; Hein et al., 2019). At the same time, the findings indicate that service innovation alone cannot explain ecosystem resilience. Instead, innovation appears to be the operational manifestation of broader capability development processes initiated through orchestration and strengthened through knowledge integration. This interpretation broadens the understanding of service innovation by positioning it within a dynamic sequence of interconnected organizational capabilities rather than treating it as an isolated outcome.

Perhaps the most important contribution of the empirical findings concerns the sequential mediation mechanism. Earlier studies have generally treated knowledge integration and innovation as independent explanatory variables. The present results suggest a different interpretation. Knowledge integration appears to provide the cognitive infrastructure through which ecosystem actors develop a shared understanding of emerging opportunities and challenges, whereas service innovation represents the practical implementation of that collective knowledge (Demir & Demir, 2025). The significant sequential mediation therefore indicates that resilience is gradually built through successive stages of capability development rather than generated directly by ecosystem coordination. This finding aligns with the central logic of DCT, which holds that sustainable performance depends on continuous capability renewal rather than isolated organizational actions (Eisenhardt & Martin, 2000; Teece et al., 1997). It also complements ecosystem research, emphasizing that value creation increasingly depends on interactions among multiple organizations rather than firm-specific resources alone (Baumann & Leerhoff, 2022; Jacobides et al., 2018; Zheng, 2026).

Another important finding concerns DBED's moderating role. The results indicate that orchestration capability becomes more influential amid rapid technological change, evolving customer expectations, and increasing ecosystem complexity. This finding supports earlier studies arguing that organizational capabilities become more valuable when firms operate in turbulent environments (Alaassar et al., 2022; Kornyshova et al., 2023; Teece et al., 1997). Nevertheless, the present study offers a more nuanced explanation than previous research. Rather than assuming that environmental dynamism directly improves organizational performance, the findings suggest that dynamism amplifies the effectiveness of orchestration capability by increasing the need for coordinated knowledge integration and collaborative service innovation. In relatively stable ecosystems, existing coordination routines may remain sufficient to maintain performance. By contrast, highly dynamic ecosystems require organizations to repeatedly redesign collaborative relationships, integrate newly generated knowledge, and develop innovative service configurations. Consequently, environmental dynamism should be understood as a contextual condition that strengthens capability deployment rather than as an independent driver of resilience.

Another finding is that the direct relationship between DBEOC and DBER became statistically insignificant after introducing the mediating variables. This pattern suggests that orchestration capability does not generate resilience independently. Instead, it transmits its influence almost entirely through intermediate organizational capabilities. This result differs from several earlier studies that implicitly assumed orchestration directly contributes to ecosystem performance (Demir, 2026; Hewett et al., 2022; Kamalaldin et al., 2021). One possible explanation is that increasing ecosystem complexity reduces the effectiveness of coordination alone. Digital platforms may successfully connect ecosystem participants, but resilience is unlikely to emerge unless the resulting interactions are converted into integrated knowledge and, subsequently, into innovative ecosystem services. Accordingly, orchestration should be interpreted as an enabling capability whose value depends on the quality of subsequent capability development processes.

Taken together, these findings reinforce DCT's suitability for explaining organizational adaptation within digital business ecosystems and extend its application to the ecosystem level. Traditional dynamic capability research has primarily examined how individual firms sense opportunities, seize resources, and reconfigure organizational assets. This study shows that these processes increasingly unfold across interconnected ecosystems, where multiple actors collectively contribute to capability development. Resilience therefore emerges as a shared ecosystem outcome rather than a firm-specific organizational attribute. This perspective reflects the collaborative nature of contemporary digital business ecosystems, where sustained competitiveness depends on the coordinated evolution of ecosystem-wide capabilities rather than the isolated strengths of individual organizations (Bharadwaj et al., 2013; Jacobides et al., 2018; Kornyshova et al., 2023).

Overall, the findings indicate that resilient digital business ecosystems emerge from an interconnected process of orchestration, knowledge integration, and continuous service innovation. Organizations operating in digitally intensive environments should therefore move beyond technology-oriented investments and place greater emphasis on developing collaborative capabilities that strengthen ecosystem learning and innovation. By clarifying the mechanisms linking orchestration capability to ecosystem resilience and identifying the contextual role of ecosystem dynamism, this study offers a more integrated understanding of how digital business ecosystems maintain adaptability and continuity amid increasing uncertainty.

5.1. Theoretical implications

This study contributes to the literature on digital business ecosystems, dynamic capabilities, and ecosystem resilience in several ways. First, it addresses an important gap by explaining how orchestration capability translates into ecosystem resilience through an integrated capability development process. Previous studies have generally examined orchestration capability, knowledge integration, service innovation, and resilience as separate constructs or have focused primarily on their direct relationships (Chekfoung et al., 2020; Hewett et al., 2022; Kamalaldin et al., 2021). The present study demonstrates that these capabilities should not be interpreted in isolation because resilience emerges through their sequential interaction. This finding shifts the emphasis from isolated organizational capabilities to an integrated ecosystem capability perspective.

Second, the study extends DCT beyond its traditional firm-level focus. Earlier applications of the theory have primarily explained how organizations sense opportunities, seize resources, and reconfigure internal capabilities to sustain competitive advantage (Eisenhardt & Martin, 2000; Teece et al., 1997). The findings suggest that these capability-building processes increasingly occur across organizational boundaries rather than within individual firms. Digital business ecosystems require firms to coordinate multiple actors, integrate distributed knowledge, and jointly develop innovative services to achieve resilience. This broader interpretation aligns with recent arguments that competitive advantage in digital environments is increasingly created through ecosystem-wide interactions rather than firm-specific resources alone (Baumann & Leerhoff, 2022; Jacobides et al., 2018; Zheng, 2026).

Third, the study contributes to the knowledge integration literature by positioning EKI as a dynamic capability rather than a simple information-processing mechanism. Existing studies (e.g., Andrade et al., 2022; Chen et al., 2023) have primarily emphasized knowledge sharing, learning, or absorptive capacity as independent determinants of organizational performance. The findings indicate that knowledge integration plays a strategic role by linking orchestration activities to subsequent service innovation. This suggests that the value of knowledge integration depends on acquiring information and on transforming dispersed ecosystem knowledge into coordinated action.

The study also contributes to the service innovation literature by clarifying ESI's role in capability development. Earlier research has consistently linked service innovation to organizational flexibility and customer value creation (Agarwal & Selen, 2009; Chandler et al., 2019; Dai et al., 2020). However, research has paid relatively little attention to the organizational conditions that enable continuous service innovation in digital ecosystems. The findings indicate that service innovation is the operational outcome of prior orchestration and knowledge integration activities. Consequently, innovation should be viewed as a capability developed through ecosystem collaboration rather than as an isolated organizational competence.

Another theoretical contribution concerns the role of DBED. Previous studies have generally treated environmental dynamism as a contextual variable that influences organizational performance (Alaassar et al., 2022; Fernández-Portillo et al., 2024; Kornyshova et al., 2023). The present study refines this perspective by showing that ecosystem dynamism strengthens the effectiveness of orchestration capability rather than directly improving resilience. This finding suggests that rapidly changing environments do not automatically yield superior organizational outcomes. Instead, they heighten the strategic importance of higher-order capabilities that enable ecosystem actors to continuously coordinate relationships, integrate knowledge, and renew service offerings.

Finally, the lack of a significant direct relationship between orchestration capability and resilience, after including the mediators, provides an important theoretical insight. Rather than directly generating resilience, orchestration capability enables it, and its influence depends on subsequent organizational processes. This finding challenges the implicit assumption in parts of the ecosystem literature that coordination alone is sufficient to improve ecosystem outcomes (Hewett et al., 2022; Kamalaldin et al., 2021). Instead, the results suggest that resilience is better understood as the cumulative outcome of successive capability development processes operating across digitally connected ecosystems.

5.2. Practical implications

The findings offer several practical implications for managers responsible for coordinating digital business ecosystems. The results indicate that investments in digital technologies alone are unlikely to produce resilient ecosystems unless paired with mechanisms that strengthen collaboration, knowledge integration, and continuous service innovation. Managers should therefore evaluate orchestration capability not only by platform coordination but also by its ability to facilitate learning and innovation across ecosystem participants.

For ecosystem leaders and platform owners, the findings suggest that governance structures should promote systematic interaction among partners rather than focusing exclusively on operational efficiency. Digital platforms should incorporate collaborative decision-making mechanisms, shared data standards, and transparent communication protocols that enable ecosystem members to exchange knowledge more effectively. These practices can improve the quality of ecosystem learning and accelerate the conversion of new knowledge into innovative service solutions. Managers should also recognize that integrating knowledge requires deliberate organizational support. Simply providing access to digital information does not ensure that ecosystem participants will develop a shared understanding or coordinated responses. Organizations should establish cross-functional teams, joint innovation workshops, digital collaboration platforms, and structured knowledge-sharing routines that encourage the integration of expertise from suppliers, technology providers, customers, and complementary partners. These practices can reduce fragmentation within digital ecosystems and improve collective problem-solving capacity.

The findings further suggest that ecosystem resilience depends on continuous service innovation rather than on occasional technological upgrades. Managers should therefore create organizational environments that support experimentation, rapid prototyping, and collaborative service design. Rather than evaluating innovation solely by the number of new digital services introduced, organizations should assess whether new service configurations improve ecosystem adaptability, strengthen collaboration among partners, and enable faster responses to unexpected disruptions. Continuous service renewal appears particularly important in ecosystems marked by frequent technological change. DBED's moderating role also has managerial implications. Organizations in highly dynamic environments should place greater emphasis on capability development than firms in relatively stable ecosystems. Because technological change and competitive conditions evolve rapidly, managers should regularly review ecosystem governance arrangements, partnership structures, and knowledge integration mechanisms rather than relying on established coordination routines. Periodic ecosystem capability assessments may help identify weaknesses before they erode ecosystem resilience.

The findings also have implications for public policymakers and institutions that support digital transformation. Policies to strengthen digital ecosystems should go beyond investments in digital infrastructure alone. Greater attention should be devoted to initiatives that foster interorganizational collaboration, joint innovation programs, digital skills development, and cross-sector knowledge networks. Such initiatives may enhance the long-term resilience of regional and national digital ecosystems by strengthening the collective capabilities of participating organizations rather than supporting individual firms in isolation. Finally, executives should view ecosystem resilience as a strategic capability that requires ongoing development. Rather than reacting to disruptions after they occur, organizations should invest in collaborative learning processes to improve preparedness before crises emerge. Firms that continuously strengthen orchestration capability, knowledge integration, and service innovation are likely to be better positioned to sustain value creation amid technological uncertainty and environmental turbulence.

5.3. Limitations and future research directions

Several limitations should be considered when interpreting the findings. First, the study used a cross-sectional design. Although the proposed relationships are theoretically grounded and supported by empirical evidence, causal inferences remain limited. Future studies could adopt longitudinal designs to examine how orchestration capability, knowledge integration, and service innovation evolve over time and jointly influence ecosystem resilience. Second, the data were collected from a single country over a specific period. Institutional environments, technological maturity, and ecosystem governance structures may vary across countries, potentially influencing the observed relationships. Comparative studies across multiple countries or regions would improve the findings' generalizability and deepen understanding of contextual differences. Third, the study focused on five ecosystem capabilities derived from DCT. Future research may incorporate additional constructs, such as digital trust, platform governance quality, ecosystem openness, artificial intelligence capability, cybersecurity capability, or inter-organizational absorptive capacity, to provide a more comprehensive explanation of resilience in digital business ecosystems. Finally, future research could explore alternative theoretical perspectives alongside DCT. Integrating this perspective with the Resource-Based View, Knowledge-Based View, Organizational Learning Theory, or Service-Dominant Logic may yield additional insights into how collaborative capabilities develop across digital ecosystems. Multi-level research designs that examine both firm- and ecosystem-level capabilities would also help clarify the mechanisms through which resilience emerges in increasingly interconnected digital environments.

Author contribution

Lee Han-Soo: Conceptualization, Formal analysis, Software, Supervision, Validation, Visualization, Writing-review & editing. **Albia Luna Brestov**: Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing-review & editing.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics committee approval

The study was approved by the Tianjin University Human Sciences Research and Ethics Committee, dated 12.09.2024, decision number AQTX-42-ZHU. It adhered to the Declaration of Helsinki guidelines for research involving human subjects.

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Appendix A. Measurement scale

Construct	Code	Measurement items
Digital business ecosystem orchestration capability (DBEOC)	DBEOC1	Our firm possesses the digital infrastructure and specialized expertise required to coordinate activities across ecosystem partners.
	DBEOC2	Our firm can align the digital resources and capabilities of different ecosystem participants.
	DBEOC3	Our firm can rapidly reconfigure relationships among digital platforms, partners, and technologies.
	DBEOC4	Our firm uses shared digital standards and interfaces to coordinate ecosystem-wide activities.
	DBEOC5	Our firm integrates information from ecosystem actors into joint strategic and operational decisions.
Ecosystem knowledge integration (EKI)	EKI1	We systematically acquire knowledge from customers, suppliers, platform owners, and other ecosystem partners.
	EKI2	Knowledge generated by different ecosystem participants is effectively combined within our firm.
	EKI3	We use digital systems to integrate knowledge from multiple internal and external sources.
	EKI4	Relevant knowledge is shared promptly across organizational and ecosystem boundaries.
	EKI5	Employees modify their decisions and work processes in response to newly integrated ecosystem knowledge.
	EKI6	Insights obtained from ecosystem partners are translated into coordinated organizational action.
Ecosystem service innovation (ESI)	ESI1	We jointly develop new digital services with ecosystem partners.
	ESI2	We frequently redesign existing services by combining complementary partner capabilities.
	ESI3	We use ecosystem data to identify and develop new digital service opportunities.
	ESI4	We rapidly introduce new service configurations in response to ecosystem changes.
	ESI5	We experiment with new digital service delivery processes together with ecosystem participants.
	ESI6	We continuously create innovative value propositions that involve multiple ecosystem actors.
Digital business ecosystem resilience (DBER)	DBER1	Our digital business ecosystem can maintain its essential functions during major disruptions.
	DBER2	Our ecosystem can rapidly restore digital operations following an unexpected disruption.
	DBER3	Ecosystem participants can coordinate effectively when normal digital processes are interrupted.
	DBER4	Our ecosystem can shift resources and responsibilities when critical partners become unavailable.
	DBER5	Our ecosystem can adapt its business model to emerging technological or market disruptions.
	DBER6	Our ecosystem learns from disruptions and becomes better prepared for future disturbances.
Digital business ecosystem dynamism (DBED)	DBED1	Digital technologies relevant to our ecosystem change rapidly.
	DBED2	Customer expectations for digitally enabled products and services change frequently.
	DBED3	Competitors and new digital entrants regularly introduce unexpected business models.
	DBED4	The roles, capabilities, and relationships of ecosystem participants change unpredictably.