Digital Resilience Framework for MSME Development in Facing Global Market Volatility

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ABSTRACT

This study aims to develop a Digital Resilience Framework for Indonesian MSME by integrating digital innovation, adaptive capabilities, marketing reach, and strategic collaboration in response to global market volatility. **Based on** the Dynamic Capabilities Theory, Innovation Diffusion Theory, Resource-Based View, and Network Theory, this study examines how digital innovation is transformed into enhanced SMEs performance through the development of dual capabilities within a collaborative ecosystem. **A quantitative approach** using SEM-PLS was employed to analyze data from 350 SMEs in Central Java, collected through stratified random sampling. Measurements using a 1-5 Likert scale were used to assess digital innovation, digital adaptive capabilities, digital marketing reach capabilities, SMEs performance, and SMEs collaboration. **The findings** reveal that digital innovation has a significant influence on digital adaptive capabilities and digital marketing reach, both of which positively impact SMEs performance. However, SMEs collaboration does not significantly moderate the relationship between innovation and capability. These findings emphasize the importance of strengthening adaptive and marketing capabilities as drivers of digital transformation. **The study contributes** theoretically through an integrative model that demonstrates a sequential transformation process, expands Dynamic Capabilities Theory in a digital context, and challenges conventional assumptions of Network Theory regarding the role of collaboration. Practical implications suggest that SMEs prioritize capability development as a mediating mechanism for digital transformation, while policymakers should design interventions focused on capability development rather than technology adoption alone. This study encourages further research exploring complex forms of collaboration and longitudinal evaluations of SMEs digital capability development.

1. INTRODUCTION

The digital transformation era has fundamentally changed the global business landscape, forcing every business entity to adapt, including Micro, Small, and Medium Enterprises (MSMEs) in Indonesia. SMEs, which contribute approximately 61% to the Gross Domestic Product (GDP) and employ 97% of the national workforce (Ministry of Cooperatives and SMEs), face significant challenges in adopting digital technology.

Despite demonstrating resilience during the economic crisis, SMEs still struggle to leverage the opportunities of digitalization fully [1]. According to a report by Bank Indonesia in 2023, only 29.6% of SMEs in Indonesia utilize digital platforms in their business operations, lagging far behind neighboring countries such as Malaysia (58.3%) and Thailand (43.7%). The COVID-19 pandemic accelerated the urgency of SME digitalization, transforming it from an option to a necessity [2]. SMEs that have adapted through digital innovation demonstrate greater resilience, while those that have not experienced significant performance declines [3]. This suggests that digital innovation is no longer a differentiating factor but rather a prerequisite for the survival of SMEs in the digital era [1]. In alignment with the global development agenda, this study also contributes to the realization of the Sustainable Development Goals (SDGs), particularly SDG 8 (Decent Work and Economic Growth) and SDG 9 (Industry, Innovation, and Infrastructure). Through the development of the Digital Resilience Framework, Indonesian MSMEs are encouraged to enhance inclusive economic productivity, create sustainable employment opportunities, and foster innovation-driven competitiveness. The integration of digital innovation and adaptive marketing capabilities supports technological advancement and industrial resilience, thereby promoting sustainable growth and digital inclusivity in the global market context. However, the adoption of digital technology alone does not guarantee improved performance without adequate adaptive capability [4].

Digital Adaptive Capability (DAC), defined as an organization's ability to adapt, integrate, and reconfigure digital resources [5], is crucial in transforming digital innovation into value. This capability must align with Marketing Reach Capability (MRC) [6], enabling SMEs to expand markets, enhance brand equity, and sustain customer relationships [7]. The synergy between DAC and MRC generates a multiplier effect on performance [8]. Collaboration among SMEs further accelerates digitalization in the sharing economy through shared knowledge, technology, and market access [9, 10], acting as a moderator that strengthens the link between digital and marketing capabilities and performance. Prior studies [2, 11] addressed partial relationships, yet a gap persists in understanding holistic transformation involving marketing and digital adaptability in collaborative ecosystems [12]. This study develops an integrative model to explain how digital innovation enhances SMEs performance through marketing and adaptive digital capabilities within collaborative settings. Research on SMEs digitalization has progressed from technology adoption [13, 14] to business model transformation [15] and capability development [11]. Four theoretical lenses are integrated through Dynamic Capabilities Theory for conceptualizing DAC via sensing, capturing, and reconfiguring [16], Innovation Diffusion Theory for understanding adoption readiness [17], Resource-Based View for linking capabilities to competitive advantage; and Network Theory for examining collaboration among SMEs [18]. This integration supports a model connecting digital innovation, capability development, and SMEs performance across technological, organizational, and ecosystem dimensions. Based on this background, the research questions are:

- How does Digital Innovation influence Digital Adaptive Capabilities in SMEs in Indonesia?

- How do Digital Adaptive Capabilities influence SMEs marketing reach capabilities in Indonesia?

- How do Digital Adaptive Capabilities and Marketing Reach Capabilities influence SMEs performance in Indonesia?

- How does SMEs collaboration moderate the relationship between Digital Adaptive Capabilities, marketing reach capabilities, and SMEs performance?

- What is the integrative model that explains the transformation of Digital Innovation into improved SMEs performance through the development of dual capabilities in a collaborative ecosystem?

2. LITERATURE REVIEW
2.1. MSME Performance

MSME Performance represents comprehensive final results that reflect an organization's effectiveness in achieving strategic and operational objectives through integrated business activities. MSME Performance refers to the outcomes of a company's business activities that can be measured through dynamic capabilities and financial behavior to accelerate performance recovery [19].

This concept has evolved into a holistic approach that integrates four interrelated dimensions of outcome variables, providing a comprehensive picture of an organization's success [20]. Financial performance

encompasses indicators of profitability (gross profit margin, net profit margin, and return on assets), growth (revenue growth and sales growth), and liquidity (current ratio and cash flow), which form the foundation for measuring an organization's fundamental ability to generate economic value [21].

Marketing performance measures market penetration through market share expansion, customer acquisition and retention, brand awareness, and digital marketing effectiveness [22]. The use of digital economy products, especially fintech, will enhance financial performance by increasing sales volume and business profits, thereby helping to achieve business goals through revenue growth and business expansion [21].

Operational performance encompasses efficiency metrics, productivity indicators, responsiveness capabilities, and quality measures in executing daily business processes. In contrast, innovation performance is measured through the success rate of new product development, the strength of the innovation pipeline, R&D investment returns, and the speed of technology adoption.

2.2. Digital Adaptive Capability

DAC represents an organization's ability to respond flexibly to digital opportunities and threats through rapid learning, experimentation, and adjustment of digital strategies and operations in a dynamic environment. This concept is rooted in the Dynamic Capabilities Theory, which explains how organizations develop sensing, seizing, and reconfiguring capabilities to maintain competitive advantage in the digital age [23].

DAC enables MSME to adopt digital technologies and integrate them strategically to create sustainable value. Operationally, DAC manifests through four interrelated dimensions of digital innovation. Digital process innovation encompasses business process automation, digital workflow optimization, and the implementation of integrated management systems, all of which enhance operational efficiency [24].

Digital Product Innovation encompasses the development of technology-based products, the digitization of traditional services, and the creation of new value propositions through digital platforms. Digital Business Model Innovation encompasses the transformation of revenue models, the development of ecosystem partnerships, and the restructuring of value chains to optimize digital value capture and creation. Digital Customer Experience Innovation includes personalized customer service, the implementation of omnichannel experiences, and the use of analytics to enhance customer engagement [25].

When SMEs develop a strong digital advantage, such firms can quickly identify changes in market preferences, adapt their business processes in an agile manner, and implement digital solutions that respond to customer needs. These capabilities facilitate rapid adjustment to environmental changes, enabling organizations to capitalize more effectively on emerging opportunities and mitigate threats, ultimately leading to superior performance [26, 27]. Organizations with strong adaptive capabilities create sustainable competitive advantages through continuous learning and improvements [22, 28]. Based on theoretical arguments and empirical evidence, this study proposes the following hypothesis:

H1: Digital Adaptive Capability has a positive effect on MSME Performance.

2.3. Marketing Reach Capability (MRC)

MRC represents an organization's strategic ability to expand market access and strengthen customer relationships through integrated digital channels and platforms. This concept is rooted in the Resource-Based View, which emphasizes how organizations develop digital marketing capabilities as a source of sustainable competitive advantage in the digital transformation era. The MRC enables MSME to optimally leverage digital technology, creating value for customers and effectively expanding their market reach [29].

Operationally, the MRC manifests through four interacting dimensions. Market Access Extension includes penetrating new market segments, expanding geographically through digital platforms, and diversifying distribution channels to increase market coverage. Digital Brand Building encompasses the development of online brand awareness, content marketing strategies, and social media engagement to strengthen brand positioning in the digital marketplace [30].

Customer Relationship Management encompasses the implementation of CRM systems, personalization of the customer journey, and development of customer loyalty programs that increase customer lifetime value. Digital Marketing Analytics encompasses data-driven marketing decisions, performance measurement systems, and predictive analytics for optimizing marketing ROI. Strong MRC enables MSME to identify and access previously unreachable customer segments, increase brand recognition through digital touchpoints, and optimize customer engagement through personalized experience [31].

These capabilities directly contribute to performance through an expanded customer base, enhanced customer satisfaction, increased market share, and improved revenue generation [32]. Strong marketing reach

capabilities enable more effective customer targeting, engagement, and retention strategies, resulting in improved brand recognition, customer loyalty, and superior market positioning [33]. Digital marketing capabilities also provide better customer insights, which inform strategic decisions and improve overall business performance [34, 35]. Based on theoretical arguments and empirical evidence, this study proposes the following hypothesis:

H2: Marketing Reach Capability has a positive effect on MSME Performance.

2.4. Digital Innovation

Digital innovation represents an organization's ability to integrate digital technology to create new products, services, processes, or business models that generate significant value for stakeholders. This concept is rooted in Dynamic Capabilities Theory, which emphasizes how organizations develop the ability to sense, capture, and reconfigure resources in response to changes in the digital environment. Digital innovation catalyzes organizational transformation, enabling SMEs to adopt technology and integrate it strategically to create sustainable competitive advantages [36].

Digital innovation manifests through four interrelated dimensions. Digital Sensing encompasses the ability to identify emerging technology opportunities, monitor digital trends, and conduct environmental scanning to detect changes in customer preferences and competitive dynamics. Digital Seizing involves mobilizing resources to implement digital solutions, investing in technology infrastructure, and strategically adopting digital platforms to capture value from identified opportunities. Digital Reconfiguring encompasses the reconfiguration of business processes, restructuring of organizational assets, and transformation of business models to optimize the use of digital technology. Digital learning encompasses the development of digital competencies, knowledge acquisition processes, and organizational learning mechanisms that facilitate continuous improvement in the effective utilization of digital technology [36].

Digital innovation provides a technological foundation and strategic impetus for developing adaptive capabilities through experiential learning and organizational reconfiguration, creating a reinforcing cycle between innovation adoption and capability enhancement [27]. The deployment of digital technologies creates new pathways for customer acquisition and market penetration, directly enhancing marketing reach capabilities [32].

The direct effects of digital innovation on performance operate through efficiency improvements, process enhancements, and new value-creation mechanisms that generate operational efficiencies and competitive advantages [14, 35]. Based on this argument, this study proposes three hypotheses.

H3, H4, H5: Digital Innovation has a positive effect on Digital Adaptive Capability, marketing reach capability, and MSME performance.

2.5. MSME Collaboration

MSME Collaboration represents a strategic engagement with external partners to access resources, share knowledge, and develop capabilities through synergistic partnerships involving fellow MSME, customers, suppliers, technology providers, and government agencies. This concept is rooted in Network Theory, which emphasizes how structural and relational embeddedness in collaborative relationships can strengthen individual firm capabilities through resource complementarity and knowledge spillovers [21].

Collaboration serves as a strategic mechanism that enables MSME to overcome internal resource constraints and accelerate the digital transformation process through collective learning and innovation sharing. Operationally, MSME collaboration manifests through three mutually reinforcing dimensions. Knowledge sharing encompasses the exchange of technical expertise, best practices, and collaborative learning initiatives that facilitate technology transfer and the development of digital competencies among organizations [37].

Resource pooling encompasses shared infrastructure investments, joint technology acquisitions, and collective bargaining power, which enhance access to digital resources that may be beyond the capabilities of individual firms. Collaborative market access encompasses joint marketing initiatives, cross-promotional activities, and shared distribution channels that expand the market reach through network effects and referral systems [38]. Collaboration intensity influences the translation of digital innovation into adaptive capabilities through knowledge spillovers and risk-sharing mechanisms that accelerate the development of capabilities [39]. Partners provide technical expertise, implementation support, and learning opportunities that enhance adaptive capability building through diverse perspectives and access to external knowledge [31]. Similarly, collaborative relationships enhance marketing capability development through shared marketing resources, joint customer

acquisition efforts, and access to new customer segments, thereby amplifying marketing reach through network effects [9, 33]. Based on Network Theory and empirical evidence, this study proposes two moderation hypotheses:

H6 and H7 posit that MSME collaboration moderates the relationships between Digital Innovation and Digital Adaptive Capability, as well as between Digital Innovation and Marketing Reach Capability, with higher collaboration intensity strengthening both positive relationships.

2.6. Integrated Research Model

The integrated research model positions digital innovation as the primary driver of capability development and performance improvement, with digital adaptability and marketing reach capabilities serving as mediating mechanisms that transform innovation input into performance outcomes. SMEs collaboration serves as a contextual moderator, influencing the strength of the relationship between innovation and capability.

This model integrates feedback loops and consistent recursive relationships, aligning with dynamic capability theory, which acknowledges that capability development is a continuous process influenced by performance outcomes and environmental feedback [23, 40]. This dynamic perspective distinguishes the proposed framework from the dominant static linear models in the literature. Thus, the Digital Resilience Framework provides a comprehensive theoretical foundation for understanding how MSME can build resilience through the strategic orchestration of digital innovation, capability development, and collaborative relationships in dynamic and uncertain environments.

Digital innovation is defined as the application of digital technology to create new products, services, processes, or business models that generate significant value for stakeholders [41]. This conceptualization encompasses five dimensions, product innovation (technology-enabled products), process innovation (digital automation and optimization), marketing innovation (digital customer engagement), organizational innovation (digital transformation of structures), and technological innovation (adoption of new technologies) [42]. Digital innovation serves as a catalyst that triggers monitoring activities, provides resources to capitalize on opportunities, and enables adjustments to capabilities [27, 35].
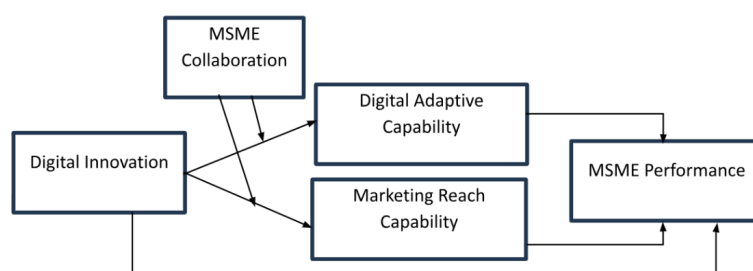

Figure 1. Research Model

Figure 1 illustrates the conceptual framework of this study, where digital innovation influences MSME performance both directly and indirectly through DAC and MRC. MSME collaboration is positioned as a moderating variable that strengthens the relationship between digital innovation and capability development. This model explains how combined digital and collaborative strategies contribute to MSME competitiveness.

3.   METHOD

This study employs a quantitative approach with an explanatory design to investigate the causal relationship between digital innovation, DAC, MRC, and MSME performance, with MSME collaboration serving as a moderating variable [43]. The research design aims to identify patterns and correlations between variables in the context of MSME digital transformation in Central Java.

The research population comprises MSME in Central Java that have been operating for at least two years and have 5–50 employees. The sampling technique employed was stratified random sampling, ensuring proportional representation from 10 selected regions that spanned six districts and four cities, taking into account the geographical distribution and business sector diversity. The total sample consisted of 350 MSMEs, with an allocation of 30-40 MSME per district or city, selected based on predetermined inclusion criteria [44].

Indicator measurement uses a 1-5 Likert scale (1 = strongly disagree to 5 = strongly agree) to measure respondents' perceptions of all research constructs. Digital innovation is measured in four dimensions, namely

digital sensing, digital seizing, digital reconfiguring, and digital learning. DAC includes digital process, product, business model, and customer experience innovation. MRC includes market access extension, digital brand building, customer relationship management, and digital marketing analysis. MSME collaboration is measured through knowledge sharing, resource pooling, and collaborative market access [45]. MSME performance includes financial, marketing, operational, and innovation performance. Data analysis used Structural Equation Modeling (SEM) with SmartPLS software to test structural relationships and analyze moderating effects in an integrated research model [43].

4. RESULT AND DISCUSSION

The evaluation of the measurement model shows that all constructs meet the validity and reliability standards required in SEM-PLS research, with the values of loading factors, Cronbach's alpha, composite reliability, and average variance extracted above the minimum threshold set [44].

Table 1. Results of the Validity and Reliability Test of Constructs

Variable	Indicators		Loading Factors	Cronbach's Alpha	rho_A	Composite Reliability	AVE
	Instrument	Symbol					
Digital Adaptive Capability	Digital Process Innovation	DAC1	0.879				
	Digital Product Innovation	DAC2	0.835	0.877	0.880	0.915	0.730
	Digital Business Model Innovation	DAC3	0.880				
	Digital Customer Experience Innovation	DAC4	0.822				
Digital Innovation	Digital Sensing	DI2	0.905				
	Digital Seizing	DI3	0.906	0.874	0.884	0.915	0.730
	Digital Reconfiguring	DI4	0.871				
	Digital Learning	DI1	0.721				
MSME Collaboration	Knowledge Sharing	MC1	0.858				
	Resource Pooling	MC2	0.885	0.870	0.872	0.911	0.721
	Collaborative Market Access	MC3	0.872				
	Collaborative Innovation	MC4	0.777				
MSME Performance	Financial Performance	MP1	0.838				
	Marketing Performance	MP2	0.883	0.871	0.873	0.912	0.722
	Operational Performance	MP3	0.864				
	Innovation Performance	MP4	0.812				
Marketing Reach Capability	Market Access Extension	MRC1	0.860				
	Digital Brand Building	MRC2	0.858	0.860	0.862	0.906	0.706
	Customer Relationship Management	MRC3	0.863				
	Digital Marketing Analytics	MRC4	0.777				

Source: Processed primary data

The results in Table 1 of the measurement model test show excellent psychometric quality for all research constructs. The loading factor values range from 0.721 to 0.906, all exceeding the threshold of 0.70, indicating strong convergent validity [44]. Cronbach's alpha and composite reliability of all constructs are above 0.80, indicating very good internal consistency reliability [46]. The AVE values range from 0.706 to 0.730, exceeding the minimum of 0.50, indicating that the variance explained by the construct is greater than the measurement error [47].

Digital Innovation shows the highest loading factor on Digital Seizing (0.906), indicating the ability to seize digital opportunities as the strongest dimension. MRC has the lowest loading on Digital Marketing Analytics (0.777), indicating that analytical capabilities are still an area of development for MSME [33]. Overall, the measurement model meets the goodness-of-fit criteria for further structural model analysis.

Evaluation of discriminant validity using the Fornell-Larcker criterion shows that each construct has a distinctive conceptual uniqueness, where the square root of AVE on the main diagonal is greater than the correlation between constructs, proving that the constructs measure statistically different phenomena [48].

Table 2. Results of Discriminant Validity Test (Fornell-Larcker Criterion)

Variable	Digital Adaptive Capability	Digital Innovation	MSME Collaboration	MSME Performance	Marketing Reach Capability
Digital Adaptive Capability	0.854	-	-	-	-
Digital Innovation	0.805	0.854	-	-	-
MSME Collaboration	0.714	0.764	0.849	-	-
MSME Performance	0.710	0.708	0.824	0.850	-
Marketing Reach Capability	0.704	0.750	0.805	0.769	0.840

Source: Processed primary data

The results in Table 2 of the discriminant validity analysis indicate adequate distinctiveness among the research constructs. Diagonal values (0.840–0.854) are consistently higher than off-diagonal correlations, confirming that each construct measures unique latent phenomena [49]. The highest correlation was found between MSME Collaboration and MSME Performance (0.824), indicating collaborative networks as a critical determinant of performance outcomes in the context of Indonesian MSME. Digital Innovation showed a substantial correlation with DAC (0.805), reflecting a synergistic relationship in the digital transformation process [27].

Notably, MRC has the lowest correlation with DAC (0.704), indicating that the two constructs represent distinct aspects of digital capabilities development. This correlation pattern confirms the theoretical positioning that collaborative networks, digital innovation, and capabilities development form an integrated ecosystem that supports performance enhancement in the digital economy era [41].

Furthermore, effect size evaluation using Cohen's f^2 measures the substantive impact of each predictor variable on endogenous constructs in the structural model, providing insights into the practical significance and relative importance of the causal relationships tested in the study.

Table 3. Effect Size Test Results (f^2)

Variable	MSME Performance	Digital Adaptive Capability	Marketing Reach Capability
Marketing Reach Capability	0.277	-	-
Digital Adaptive Capability	0.064	-	-
MSME Collaboration	-	0.072	0.419
Digital Innovation	0.015	0.476	0.135

Source: Processed primary data

The f^2 results in Table 3 indicate substantial variation in the impact between predictor variables. MRC shows a medium effect size on MSME Performance ($f^2=0.277$), indicating that marketing capabilities are a practically significant driver of performance [50].

Digital Innovation has a large effect on DAC ($f^2=0.476$), reflecting innovation as the primary catalyst in the capability development process [23]. MSME Collaboration shows a medium effect on MRC ($f^2=0.419$), confirming collaborative networks as amplifiers of marketing capabilities through resource pooling and knowledge sharing [39].

Conversely, DAC shows a small effect on MSME Performance ($f^2=0.064$), indicating that adaptive capabilities require mediating mechanisms for maximum impact. Digital Innovation and MSME Collaboration have small effects on their respective outcomes, indicating complex interdependencies within the digital transformation ecosystem that require a holistic approach to optimize business performance [26].

The explanatory power evaluation measures the proportion of variance in endogenous constructs explained by predictor variables, providing an indication of the predictive strength of the structural model and the

relative contribution of each antecedent in explaining the phenomena studied in the context of MSME digital transformation.

Table 4. Explanatory Power Test Results (R^2 and Adjusted R^2)

Variable	R Square	R Square Adjusted
Digital Adaptive Capability	0.671	0.668
MSME Performance	0.653	0.650
Marketing Reach Capability	0.692	0.689

Source: Processed primary data

The R² results in Table 4 indicate substantial explanatory power for all endogenous constructs. MRC has the highest R² (0.692), indicating that 69.2% of the variance is explained by Digital Innovation and MSME Collaboration, demonstrating strong predictive power in marketing capability development [44]. DAC shows an R² of 0.671, reflecting that digital innovation and collaboration explain 67.1% of the variance in adaptive capabilities formation. MSME Performance has an R² of 0.653, indicating that 65.3% of performance variance is explained by capabilities and innovation factors.

Consistency between R² and Adjusted R² (difference <0.003) confirms model parsimony without overfitting. Overall, R² values ranging from 0.65 to 0.69 indicate moderate to substantial explanatory power [51], validating the theoretical framework that digital innovation and collaboration are key determinants in the success of MSME digital transformation [44].

4.1. Hypothesis Testing

Hypothesis testing was conducted using SEM with bootstrapping of 5,000 subsamples to evaluate the significance of causal relationships within the Digital Resilience Framework. Acceptance criteria were set at $\alpha = 0.05$ with t-statistics >1.96, encompassing direct effects and moderating effects to validate the seven hypotheses proposed in the SME digital transformation study.

Table 5. Hypothesis Testing

Hypothesis	Standard Deviation	T Statistics	P Values
Digital Innovation to Digital Adaptive Capability	0.060	10.343	0.000
Digital Innovation to Marketing Reach Capability	0.067	4.814	0.000
Digital Innovation to MSME Performance	0.071	1.916	0.056
MSME Collaboration Moderate Digital Innovation to Digital Adaptive Capability	0.029	0.019	0.985
MSME Collaboration Moderate Digital Innovation to Marketing Reach Capability	0.022	0.579	0.563
Digital Adaptive Capability to MSME Performance	0.065	3.992	0.000
Marketing Reach Capability to MSME Performance	0.072	6.697	0.000

Source: Processed primary data

The results of hypothesis testing in Table 5 show mixed findings, with four hypotheses statistically supported and three rejected. Digital Innovation has a significant effect on DAC (t = 10.343; p < 0.001) and MRC (t = 4.814; p < 0.001), confirming the role of innovation as a catalyst in capability development. Both capabilities were also found to contribute significantly to MSME Performance, with MRC showing a larger effect size (t = 6.697; p < 0.001) than DAC (t = 3.992; p < 0.001). Critical findings emerged in the three rejected hypotheses.

Digital Innovation did not directly affect MSME Performance (t = 1.916; p = 0.056), indicating the need for mediation through capability development. Both moderation hypotheses of MSME Collaboration

were insignificant (t = 0.019; 0.579), suggesting that collaboration functions more as an antecedent or mediator than a moderator. Among Indonesian MSME, collaboration tends to be informal, transactional, and resource-limited, weakened further by competitive culture, weak institutional frameworks, and low trust, which reflect institutional voids in developing economies. Consequently, collaboration operates as an indirect enabler rather than a statistical moderator, consistent with emerging studies on dynamic collaboration in resource constrained contexts that evolve through trust and learning. These findings indicate that digital transformation follows a sequential process from innovation to capability development and ultimately performance improvement requiring reconceptualization of collaboration in Indonesian MSME. SEM-PLS, a variance-based method suitable for predictive and exploratory research with complex models, was employed due to its robustness with non-normal data and small-to-medium samples. Hypotheses were tested using bootstrapping with 5,000 sub-samples. Results confirmed that Digital Innovation significantly affects Digital Adaptive Capability (H3) and Marketing Reach Capability (H4), reinforcing its catalytic role, while its direct link to MSME Performance (H5) was insignificant. Both Digital Adaptive Capability (H1) and Marketing Reach Capability (H2) positively influenced MSME Performance, confirming their mediating effects. MSME Collaboration (H6, H7) remained non-significant, indicating contextual factors shaping collaborative dynamics within the studied ecosystem.

The findings of this study make a significant contribution to the understanding of digital transformation in the context of MSME, providing partial validation of the developed Digital Resilience Framework. Empirical results yield mixed findings that necessitate an in-depth interpretation of the mechanisms underlying digital transformation in the Indonesian MSME ecosystem. The confirmation of hypotheses H3 and H4, which show a significant influence of Digital Innovation on DAC (β=0.691; t=10.343) and MRC (β=0.323; t=4.814), validates the proposition of Dynamic Capabilities Theory that innovation functions as a primary catalyst in the capability development process [23]. These findings align with [44], who emphasizes that the adoption of digital technologies triggers organizational learning processes essential for capability enhancement. The enormous effect size (f^2 = 0.476) in the relationship between Digital Innovation and DAC confirms that a technological foundation is a fundamental prerequisite for developing adaptive capabilities, supporting the argument of [26] regarding the reinforcing cycle between innovation adoption and capability development.

The continuation of capability development confirms that capabilities act as mediators in improving performance. The rejection of H5 (Digital Innovation and MSME Performance, t = 1.916, p = 0.056) shows that innovation alone does not enhance performance without intermediary mechanisms. This supports the idea that capability development bridges innovation inputs and performance outcomes [26]. Digital innovation provides the foundation for transformation but must develop into strategic capabilities to create value. In MSME, innovation often focuses on adopting digital tools without full integration into operations or marketing, leaving its benefits unrealized. Mechanisms such as digital adaptive and marketing reach capabilities translate innovation into measurable results. The significant results of H1 and H2 with Digital Adaptive Capability (t = 3.992) and Marketing Reach Capability (t = 6.697) validate the Resource-Based View that distinctive capabilities generate competitive advantage [52].

The superior effect size of MRC (f^2 = 0.277) compared to DAC (f^2 = 0.064) suggests that market-facing capabilities have a more direct impact on business performance, consistent with [53], who posits that market-driven capabilities are key performance drivers. The most surprising and theoretically challenging finding emerged from the rejection of H6 and H7 regarding the moderating effects of MSME Collaboration.

Non-significance with very low t-statistics (0.019 and 0.579) shows that collaborative networks in Indonesian SMEs do not act as moderators but rather as independent antecedents or mediators. This contradicts Network Theory [39], which expects collaboration to strengthen the innovation–capability relationship. The result can be explained by the contextual conditions of Indonesian MSME, where collaboration is often informal, short-term, and transactional, focused on immediate needs instead of strategic goals. Such cooperation limits knowledge sharing, joint innovation, and capability co-development essential for moderation. Many MSME also operate in competitive markets with low trust and unstable networks, while institutional voids such as weak clusters, limited policy support, and poor digital infrastructure further constrain collaboration. Consequently, collaboration tends to serve as an antecedent that contributes to performance rather than a moderator enhancing innovation capability links. This context-specific view reveals the complexity of digital transformation in emerging markets like Indonesia, where collaboration remains informal and transactional [51], constrained by resource limitations and competitive mindsets that weaken knowledge sharing [54], and shaped by institutional voids found in developing economies [9]. Effective collaboration depends on enabling factors such as shared digital infrastructure, institutional trust, and structured governance that support reciprocal knowledge exchange.

Without these foundations, collaboration remains fragmented and limited in moderating digital capability formation, becoming more effective only when reinforced by strategic coordination and digital platforms that facilitate transparent communication and resource sharing.

From a statistical perspective, the moderation analysis results indicate that MSME collaboration did not significantly alter the strength of the relationships between innovation and capability variables. This means that, while collaboration may not show a measurable moderating effect, it still plays an indirect developmental role in enhancing learning, adaptability, and innovation diffusion within the ecosystem. The interpretation has been clarified in simpler terms to ensure accessibility for nontechnical readers, while maintaining analytical rigor in line with the SEM-PLS methodological framework [55].

These findings offer three key contributions to digital transformation research. First, validating the sequential transformation process confirms that digital innovation improves performance through capability mediation, extending Dynamic Capabilities Theory [36]. Second, the greater influence of MRC strengthens the Resource-Based View on capability importance in the digital era. Third, redefining collaboration challenges Network Theory by showing its contextual limits for MSME in developing economies, where weak institutions and informal structures reduce its effectiveness [56]. The proposed framework presents resilience as a capability-driven process integrating innovation, adaptability, and marketing reach. The non-significant moderation of collaboration suggests that network effects act as independent drivers, advancing digital resilience theory in emerging contexts.

Comprehensively, the findings answer the research questions by showing that Digital Innovation significantly influences both adaptive and marketing capabilities, capabilities development serves as a critical mediating mechanism for performance enhancement, collaboration requires theoretical reconceptualization beyond the traditional moderating role, and the integrated model demonstrates a sequential rather than concurrent transformation process in digital resilience building. This pattern confirms that the effectiveness of digital transformation depends on systematic capability development, mediated by innovation adoption, with collaborative networks requiring an alternative conceptualization within the theoretical framework of Indonesian SMEs.

5. MANAGERIAL IMPLICATIONS

From a managerial perspective, MSME leaders should begin by conducting a digital capability audit to assess their current technological readiness and identify gaps in digital literacy, infrastructure, and marketing analytics. Based on this assessment, managers are encouraged to adopt phased digital transformation strategies that combine technology adoption with organizational learning and process reengineering. Strengthening DAC requires continuous employee training, experimentation with emerging technologies (e.g., AI-driven analytics or cloud solutions), and the integration of digital tools across operational and marketing functions. Furthermore, MSME should cultivate strategic partnerships with technology providers, universities, and local business networks to enhance resource sharing and collective innovation.

For policymakers, the findings suggest the importance of designing supportive regulatory and institutional frameworks that facilitate MSME digitalization journey. This can be achieved by providing financial incentives, such as tax breaks or low-interest digital transformation loans, establishing regional digital capability centers to offer training and consultancy services, and promoting collaborative digital ecosystems where MSME, corporates, and government agencies can co-develop technological solutions. Additionally, the government should integrate digital transformation goals with national economic strategies and SDG targets (SDG 8 and SDG 9) to ensure alignment between industrial policy and inclusive economic growth.

6. CONCLUSION

This study developed a Digital Resilience Framework for Indonesian MSME by addressing five research questions using SEM-PLS on 350 MSME in Central Java. Results show that digital innovation significantly affects digital adaptive capabilities and marketing reach, which in turn enhance MSME performance, but it does not directly impact performance, highlighting the need for mediation through capability development. Hypothesis testing supported H1–H4 and rejected H5–H7. MRC (t = 6.697) has a stronger effect on performance than DAC (t = 3.992). Notably, SMEs collaboration was not a significant moderator, contrary to Network Theory but aligned with conditions in emerging markets with institutional voids.

Theoretical contributions include validating the sequential transformation process that extends Dynamic Capabilities Theory in the digital context, emphasizing the importance of MRC in the Resource-Based

View, and redefining collaboration by challenging Network Theory assumptions. The study confirms that effective digital transformation depends on systematic capability development through innovation. The proposed Digital Resilience Framework introduces a new paradigm for viewing digital resilience as a systemic outcome of strategic alignment between innovation, capabilities, and performance in SMEs. It serves as a scalable model applicable to emerging markets with similar structural and institutional characteristics. Through its sequential process from digital innovation to capability development and performance improvement it provides both theoretical and practical insights for SMEs in dynamic and resource-constrained environments. By adapting to local governance, infrastructure readiness, and collaboration dynamics, the framework offers a flexible reference for strengthening digital resilience across contexts, enhancing the study's international relevance and contribution to digital transformation research. Ultimately, it demonstrates that digital resilience extends beyond technology adoption toward building sustainable competitive advantage through sequential capability development.

The finding that MRC has a stronger impact highlights market-facing capabilities as key success factors in the digital economy, offering insights for MSME strategic positioning. Practically, MSME should prioritize capability development as a mediating mechanism, while policymakers should focus on capability building rather than mere technology adoption. Collaborative initiatives must be restructured into strategic partnerships, and government or development agencies should create capability assessment tools and training programs that integrate digital innovation with marketing reach to optimize transformation outcomes. Limitations include the cross-sectional design, single-region focus, and collaboration measurement that may not fully capture complex relationships. Future studies should adopt longitudinal and multi-region approaches, integrate qualitative methods, explore collaboration's mediating role, analyze sector-specific variations in digital resilience, assess institutional moderating effects, and develop dynamic models to better understand capability development in the digital economy.

7. DECLARATIONS

7.1. About Authors

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7.2. Author Contributions

Conceptualization: AA; Methodology: ES; Software: JS; Validation: AA and JS; Formal Analysis: AA and ES; Investigation: AA; Resources: ES; Data Curation: JS; Writing Original Draft Preparation: ES and JS; Writing Review and Editing: AA and ES; Visualization: JS; All authors, AA, ES, and JS, have read and agreed to the published version of the manuscript.

7.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

7.4. Funding

7.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

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