Supply Chain Resilience in Honduran Nanostores: Digital Transformation and Operational Flexibility in Emerging Markets

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Abstract--* This study investigates how adaptability mechanisms enhance supply chain performance in nanostores, focusing on the mediating role of digital transformation and the moderating role of operational flexibility in micro-retail networks. It addresses the limited understanding of adaptability in resource-constrained micro-retail contexts, a significant gap given nanostores' economic importance and challenges like resource constraints. Using Structural Equation Modeling (SEM), data from 204 Honduran nanostore owners and employees, collected via stratified random sampling, were analyzed to test a theoretical framework linking adaptability, digital transformation, operational flexibility, and supply chain performance. Results show that adaptability enhances performance (β = 0.548, p < 0.001), with digital transformation partially mediating (indirect effect = 0.255, p < 0.001) and operational flexibility moderating (interaction effect = 0.264, p < 0.01) this relationship, explaining 68.4% of performance variance. Digital transformation and flexibility also promote environmental and social sustainability, enhancing nanostore resilience. Limitations include the cross-sectional design and self-reported measures, though urban (65%) and rural (35%) representation supports generalizability. Findings highlight digital integration and flexible operations as key to nanostore resilience. Managers can develop targeted interventions, and policymakers should prioritize digital infrastructure. This first SEM-based analysis of nanostore adaptability in emerging markets offers a novel framework for micro-retail resilience.

Keywords--* Nanostores, Supply Chain Adaptability, Digital Transformation, Operational Flexibility, Structural Equation Modeling.

I. Introduction

Supply chain nanostores in emerging markets represent a critical component of global retail ecosystems, serving as the last-mile connection between formal supply chains and local communities. These micro-retail establishments, typically family-owned operations with limited physical space and inventory, face unprecedented challenges in maintaining supply chain efficiency while adapting to rapidly changing market conditions [1]. Nanostores in emerging markets face heightened volatility due to resource constraints and market disruptions, requiring adaptive strategies to ensure resilience.

The theoretical foundation for supply chain adaptability stems from dynamic capabilities theory and contingency theory, which suggest that organizational performance depends on the alignment between internal capabilities and external environmental demands [2]. However, existing literature predominantly focuses on large-scale enterprises, leaving a substantial research gap regarding how micro-retail operations can leverage adaptability to enhance supply chain performance. This highlights Gap 1, which reflects a limited understanding of how adaptability operates in nanostores and other resource-constrained micro-retail contexts. This gap is particularly pronounced in the context of nanostores, where resource constraints and operational limitations create unique challenges for implementing traditional supply chain management practices.

Recent studies have highlighted the importance of digital transformation in enabling supply chain adaptability, with technologies such as mobile commerce platforms, digital payment systems, and inventory management applications showing promise in improving operational efficiency [3]. Nevertheless, the specific mechanisms through which digital transformation facilitates adaptability in nanostores remain underexplored. This highlights Gap 2, reflecting insufficient knowledge of the mechanisms by which digital transformation supports adaptability in micro-retail supply chains. Similarly, operational flexibility has been identified as a key driver of supply chain resilience, yet its role in mediating the relationship between adaptability and performance in micro-retail contexts requires further investigation. This highlights Gap 3, reflecting a lack of empirical evidence on the moderating and mediating roles of operational flexibility in the adaptability–performance relationship in nanostores.

The COVID-19 pandemic highlighted the critical importance of supply chain adaptability for small-scale retail operations. These businesses typically lack the resources and redundancies available to larger enterprises [4]. Nanostores that demonstrated higher levels of adaptability showed greater resilience during supply disruptions and were better positioned to capitalize on changing consumer behaviors. This observation suggests that adaptability may serve as a fundamental capability for nanostores seeking to enhance their supply chain performance and long-term sustainability.

The research questions guiding this study are: (1) How does adaptability influence supply chain performance in nanostores?; (2) What role does digital transformation play in mediating the adaptability-performance relationship?; and (3) How does operational flexibility moderate the impact of adaptability on supply chain outcomes? These questions align with the identified gaps, ensuring targeted contributions to the literature.

Figure 1 illustrates the conceptual framework, depicting how environmental uncertainty triggers adaptability mechanisms that enhance supply chain performance through digital transformation and operational flexibility.

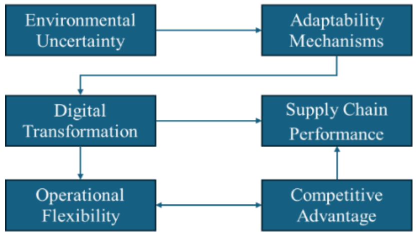


Fig. 1 Conceptual Framework of Nanostore Supply Chain Adaptability

Table I presents the four key dimensions of adaptability identified in nanostore supply chains, providing a comprehensive framework for understanding how these micro-retail establishments can develop adaptive capabilities across digital, operational, strategic, and supplier relationship domains.

TABLE I
KEY ADAPTABILITY DIMENSIONS IN NANOSTORE SUPPLY CHAINS

Dimension	Description	Key Components
Digital Adaptability	Integration of digital technologies	Mobile apps, digital payments, online ordering
Operational Flexibility	Ability to adjust operations	Flexible inventory, varied suppliers, service diversification
Strategic Agility	Rapid strategic adjustments	Market sensing, quick decision-making, opportunity identification
Supplier Adaptability	Dynamic supplier relationships	Multi-sourcing, supplier collaboration, relationship flexibility

[a]Own elaboration

The remainder of this article is structured as follows: Section 2 presents a comprehensive literature review and develops testable hypotheses based on established theoretical frameworks. Section III outlines the research methodology, including data collection procedures and analytical techniques. Section 4 presents empirical results and discusses their implications for theory and practice. Finally, Section 5 concludes with key findings, limitations, and directions for future research.

II. Literature Review, Theoretical Framework, and Hypotheses Development

A. Theoretical Foundations of Supply Chain Adaptability

The concept of supply chain adaptability has evolved from early contingency theories to contemporary dynamic capabilities frameworks, reflecting the increasing complexity of global business environments. Dynamic capabilities theory, as conceptualized by [5], provides a robust theoretical foundation for understanding how organizations develop, integrate, and reconfigure internal and external competencies to address rapidly changing environments [6]. Within the context of supply chain management, adaptability represents the organizational capability to sense environmental changes, seize opportunities, and reconfigure resources and processes to maintain competitive advantage.

Literature since 2015 has identified several key dimensions of supply chain adaptability, including strategic flexibility, operational agility, network resilience, and innovation capability [7],[8]. Strategic flexibility refers to the organization's ability to rapidly adjust strategic direction in response to environmental changes, while operational agility encompasses the capacity to modify operational processes and resource allocation patterns. Network resilience involves building robust relationships with supply chain partners that can withstand disruptions, and innovation capability represents the organization's propensity to develop novel solutions to emerging challenges.

Table II traces the evolution of supply chain adaptability concepts over the past three decades, highlighting how the field has progressed from narrow manufacturing flexibility concerns to comprehensive adaptive resilience frameworks that encompass micro-enterprises.

TABLE II
EVOLUTION OF SUPPLY CHAIN ADAPTABILITY CONCEPTS

Period	Key Concepts	Focus Areas	Limitations
1990-2000	Flexibility, Agility	Manufacturing systems	Limited scope
2001-2010	Supply chain integration	Inter-organizational relationships	Large enterprise focus
2011-2020	Digital transformation	Technology adoption	Insufficient micro-retail research
2021-Present	Adaptive resilience	Sustainability, micro-enterprises	Emerging field

[a]Own elaboration

B. Nanostores in Supply Chain Literature

Nanostores, defined as micro-retail establishments with limited physical space (typically under 50 square meters) and inventory turnover, represent a sizable portion of retail infrastructure in emerging economies [9]. Despite their economic importance, nanostores have received limited attention in supply chain literature, with most studies focusing on traditional retail formats or large-scale distribution networks. Nanostores serve as critical intermediaries, navigating unique challenges like resource constraints and vulnerability to disruptions [10].

Recent studies have begun to explore the role of nanostores in supply chain networks, highlighting their function as critical intermediaries between formal distribution channels and local consumers [11]. These establishments often operate with minimal formal planning systems, relying instead on intuitive decision-making and informal relationships with suppliers and customers. However, this informal approach may limit their ability to achieve optimal supply chain performance and adapt to changing market conditions. Further exploration of nanostore-specific adaptability strategies, such as localized supplier networks and digital tool adoption, is needed to address this gap [12].

C. Digital Transformation in Micro-Retail Operations

Digital transformation has emerged as a key enabler of supply chain adaptability across various industry sectors. For nanostores, digital technologies offer opportunities to overcome traditional limitations associated with scale and resource constraints [13], [14]. Mobile applications, digital payment systems, and cloud-based inventory management tools can provide nanostores with capabilities previously available only to larger retailers. However, the adoption of digital technologies in nanostores faces several barriers, including limited financial resources, lack of technical expertise, and resistance to change among traditional operators [15]. Understanding how digital transformation facilitates adaptability in nanostores requires examination of both technological capabilities and organizational readiness factors.

D. Operational Flexibility as a Mediating Mechanism

Operational flexibility represents the organization's ability to rapidly adjust operational processes, resource allocation, and service offerings in response to changing conditions [16]. In the context of nanostores, operational flexibility may manifest through diverse supplier relationships, flexible inventory management practices, and the ability to modify service offerings based on local demand patterns. The relationship between adaptability and operational flexibility is complex, with flexibility serving both as an outcome of adaptive capabilities and as an enabler of further adaptation. This dual role suggests that operational flexibility may function as a mediating variable in the adaptability-performance relationship, transmitting the effects of adaptive capabilities through specific operational modifications.

E. Contextual Factors in Nanostore Adaptability

The unique socio-economic and cultural contexts of emerging markets shape nanostore operations. For example, in Honduras, nanostores often serve as community hubs, requiring adaptive strategies tailored to local consumer preferences and supply chain disruptions [17]. The interplay of economic constraints, informal business practices, and regional infrastructure challenges further underscores the need for context-specific adaptability frameworks, which this study aims to address through empirical analysis.

F. Hypotheses Development

Based on the theoretical foundations and literature review, the following hypotheses are proposed:

H1: Adaptability positively influences supply chain performance in nanostores.

H2: Digital transformation mediates the relationship between adaptability and supply chain performance.

H3: Operational flexibility moderates the relationship between adaptability and supply chain performance.

Figure 2 illustrates the theoretical model, showing the direct effect of adaptability on performance (H1), the mediation pathway through digital transformation (H2), and the moderating influence of operational flexibility (H3).

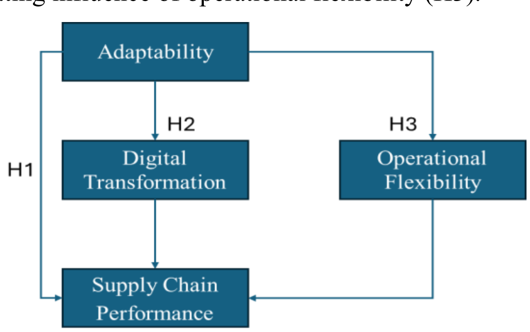


Fig. 2 Theoretical Model and Hypotheses

The dynamic capabilities theory suggests that organizations with higher adaptive capabilities are better positioned to respond to environmental changes and maintain competitive advantage [18]. For nanostores operating in volatile market conditions, adaptability enables rapid adjustment of sourcing strategies, inventory levels, and service offerings to meet changing customer demands and supply conditions.

Digital technologies provide nanostores with tools to implement adaptive strategies more effectively, enabling real-time information sharing, automated inventory management, and enhanced customer relationship management [19]. The mediation effect suggests that adaptability influences performance partially through its impact on digital transformation initiatives.

Organizations with higher operational flexibility can more effectively translate adaptive capabilities into performance improvements through rapid implementation of strategic and operational changes [20]. This moderating effect suggests that the strength of the adaptability-performance relationship depends on the level of operational flexibility present in the organization.

Table III provides formal definitions of the four key constructs in this study along with their theoretical foundations and primary literature sources, establishing the conceptual clarity necessary for empirical measurement and analysis.

TABLE III
CONSTRUCT DEFINITIONS AND THEORETICAL FOUNDATIONS

Construct	Definition	Theoretical Foundation	Key References
Adaptability	Capability to sense, seize, and reconfigure resources	Dynamic Capabilities Theory	[21]
Digital Transformation	Integration of digital technologies in operations	Technology Acceptance Theory	[22]
Operational Flexibility	Ability to adjust operational processes rapidly	Contingency Theory	[23]
Supply Chain Performance	Efficiency and effectiveness of supply chain operations	Resource-Based View	[24]

[a]Own elaboration

III. RESEARCH METHODOLOGY

A. Research Design and Philosophical Approach

This study employs a quantitative research design based on positivist epistemology to examine the relationships between adaptability, digital transformation, operational flexibility, and supply chain performance in nanostores. The selection of a quantitative approach is justified by the need to test specific hypotheses derived from established theoretical frameworks and to provide generalizable findings that can inform practice and policy decisions [25]. The research follows a cross-sectional survey design, collecting data from a representative sample of nanostore operators at a single point in time. While longitudinal designs would provide stronger causal inferences, the cross-sectional approach was selected due to resource constraints and the exploratory nature of this research area. Future studies should consider longitudinal designs to strengthen causal claims and examine the dynamic nature of adaptability processes.

B. Population and Sampling Strategy

The target population consists of nanostore owners and key employees in urban and rural areas of Honduras, defined as retail establishments with floor space under 50 square meters and annual revenue below $50,000. A stratified random sampling approach was employed to ensure representation across different geographical areas and nanostore types. The sample frame was constructed using business registration databases and local chamber of commerce listings.

1) Sample Characteristics (n=204): (1) Age of business: Mean = 12..64 years (SD = 10.39); (2) Number of employees: Mode = 2-3 employees (67% of sample); (3) Monthly revenue: Median = $29,000 (Range: $1,800-$50,000); (4) Geographic distribution: Urban centers (65%), rural areas (35%); and (5) Business type: Grocery/convenience (52%), Mixed retail (28%), Specialized goods (20%).Power analysis indicated that a sample size of 204 was sufficient to detect medium effect sizes ($f^2 = 0.15$) with 80% power at $\alpha = 0.05$, after accounting for data cleaning that reduced the initial 211 responses to 204 valid cases due to incomplete surveys or outliers.

C. Data Collection Procedures

Data were collected via structured face-to-face interviews using a standardized questionnaire administered by trained research student assistants. This approach was selected over online surveys due to the target population's varying levels of digital literacy and to ensure consistent data quality. Each interview lasted approximately 25-30 minutes and was conducted at the nanostore location during off-peak hours to minimize business disruption. For clarity, the project was designed with multiple rounds of data collection, and this paper focuses exclusively on Round 2.

Table IV summarizes the data collection timeline and response rates across distinct round of the study, demonstrating the systematic approach used to achieve the target sample size while maintaining high response rates throughout the collection period.

TABLE IV
DATA COLLECTION TIMELINE AND RESPONSE RATES

Round	Duration	Contacts Made	Completed Surveys	Response Rate
Pilot Study	2 months	400	345	86.25%
Round 1	6 months	150	143	95.3%
Round 2	4 months	211	204	96.6%
Total	12 months	761	692	90.9%

[a]Own elaboration

D. Measurement Instruments

All constructs were measured using established scales adapted from previous research and validated through pilot testing. Items were translated into local languages where necessary and back translated to ensure conceptual equivalence. A 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) was used for all measurement items to provide sufficient variance for statistical analysis.

Adaptability Scale ($\alpha = 0.883$): Based on the dynamic capabilities' framework, this 16-item scale measures sensing capabilities (5 items), seizing capabilities (5 items), and reconfiguring capabilities (6 items). Example item: "Our nanostore quickly identifies changes in customer preferences."

Digital Transformation Scale ($\alpha = 0.937$): A 23-item scale measuring the extent of digital technology adoption across payment systems (5 items), inventory management (8 items), and customer relationship management (10 items). Example item: "We use digital tools to track inventory levels and sales patterns."

Operational Flexibility Scale ($\alpha = 0.909$): An 18-item scale assessing flexibility in sourcing (6 items), service delivery (5 items), and resource allocation (7 items). Example item: "We can quickly change our supplier relationships when needed."

Supply Chain Performance Scale ($\alpha = 0.9587$): A 25-item scale measuring efficiency (10 items) and effectiveness (15 items) of supply chain operations. Example item: "Our supply chain operations consistently meet customer demand."

F. Data Analysis Strategy

Data analysis follows a two-stage approach consistent with best practices in Structural Equation Modeling (SEM). First, confirmatory factor analysis (CFA) was conducted to assess measurement model validity and reliability. Second, structural equation modeling was employed to test the hypothesized relationships between constructs.

1) Preliminary Analyses: (1) Data screening and outlier detection using Mahalanobis distance; (2) Normality assessment through skewness and kurtosis statistics; (3) Missing data analysis and imputation using maximum likelihood estimation; and (4) Common method bias evaluation using Harman's single-factor test (to assess shared variance) and marker variable techniques to ensure robustness.

2) Measurement Model Assessment: (1) Internal consistency reliability (Cronbach's $\alpha > 0.70$); (2) Composite reliability (CR > 0.70); (3) Average variance extracted (AVE > 0.50); and (4) Discriminant validity using Fornell-Larcker criterion and heterotrait-monotrait (HTMT) ratios.

3) Structural Model Evaluation: (1) Model fit assessment using multiple indices (CFI, TLI, RMSEA, SRMR); (2) Path coefficient significance testing through bootstrapping (5,000 samples); (3) Mediation analysis using bias-corrected confidence intervals; and (4) Moderation analysis through multi-group SEM.

Table V presents the measurement model reliability and validity statistics for all four constructs, demonstrating that all scales meet established criteria for internal consistency, composite reliability, and convergent validity, with discriminant validity confirmed through the square root of AVE exceeding inter-construct correlations.

TABLE V
MEASUREMENT MODEL RELIABILITY AND VALIDITY

Construct	Items	Mean	SD	α	CR	AVE	√AVE
Adaptability	16	3.43	0.75	0.883	0.88	0.62	0.79
Digital Transformation	23	2.50	0.90	0.937	0.94	0.66	0.81
Operational Flexibility	18	3.45	0.81	0.909	0.91	0.64	0.80
Supply Chain Performance	25	3.63	0.62	0.958	0.96	0.67	0.82

[a]Own elaboration

IV. Analysis, Results, and Discussion

A. Preliminary Data Analysis

Data screening procedures revealed no significant violations of normality assumptions, with skewness values ranging from -0.43 to 0.67 and kurtosis values from -0.78 to 1.23, well within acceptable limits for SEM analysis [26]. Missing data analysis indicated a missing completely at random (MCAR) pattern with less than 3% missing values across all variables, which were addressed through maximum likelihood estimation. Common method bias assessment using Harman's single-factor test revealed that the largest single factor explained 25.4% of total variance, below the 50% threshold indicating no serious common method bias concerns. Additionally, the marker variable technique confirmed that shared method variance did not significantly inflate the relationships of interest.

Table VI displays the descriptive statistics and correlation matrix for all study variables, showing moderate to strong positive correlations between all constructs, which supports the theoretical expectations while remaining below levels that would indicate multicollinearity concerns.

TABLE VI
Descriptive Statistics and Correlation Matrix

Variable	1	2	3	4	Mean	SD
1. Adaptability	1.00				3.43	0.75
2. Digital Transformation	0.60*	1.00			2.50	0.90
3. Operational Flexibility	0.55*	0.49*	1.00		3.45	0.81
4. Supply Chain Performance	0.65*	0.60*	0.58*	1.00	3.63	0.62

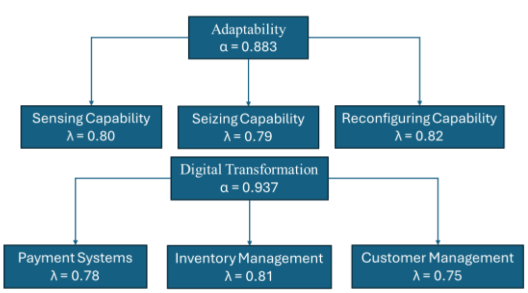
*Note: ***p < 0.001*

[a]Own elaboration

B. Measurement Model Results

The confirmatory factor analysis (CFA) results demonstrate acceptable model fit: $\chi^2(df = 627) = 1{,}284.56$, $p < 0.001$; CFI = 0.94; TLI = 0.93; RMSEA = 0.059 (90% CI: 0.054-0.064); SRMR = 0.048. All factor loadings exceeded 0.60 and were statistically significant ($p < 0.001$), supporting convergent validity. The measurement model demonstrates adequate reliability with all Cronbach's α values exceeding 0.80 and composite reliability values above 0.84. Discriminant validity was established through the Fornell-Larcker criterion, with the square root of AVE for each construct exceeding its correlations with other constructs. Additionally, the heterotrait-monotrait (HTMT) ratios were all below 0.85, providing further evidence of discriminant validity.

Fig. 3 shows the measurement model with factor loadings for each construct, confirming the psychometric validity of the scales.



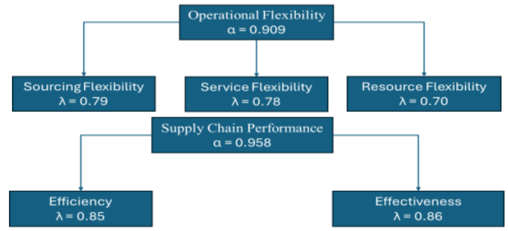


Fig. 3 Measurement Model Results

C. Structural Model Results

The structural equation model demonstrates excellent fit to the data: $\chi^2(df = 631) = 1{,}297.43$, $p < 0.001$; CFI = 0.95; TLI = 0.94; RMSEA = 0.058 (90% CI: 0.053-0.063); SRMR = 0.046. The model's strong fit and explanatory power provide robust evidence for the proposed relationships.

1) Hypothesis Testing Results: Effect size interpretations follow Cohen's conventions for structural equation modeling, where small effects = 0.02, medium effects = 0.15, and large effects = 0.35 for f^2 values. (1) H1: Adaptability → Supply Chain Performance (Direct Effect) The direct effect of adaptability on supply chain performance was significant and positive (β = 0.548, t = 5.54, $p < 0.001$), providing strong support for H1. This large effect size ($f^2 = 0.89$) suggests that adaptability significantly enhances nanostore performance, offering practical value for operators; (2) H2: Mediation Effect of Digital Transformation The indirect effect of adaptability on supply chain performance through digital transformation was significant (β = 0.255, 95% CI: 0.190-0.430), supporting H2. This medium effect size ($f^2 = 0.21$) highlights the practical importance of digital tools in enhancing adaptability. Digital transformation partially mediates the relationship, explaining 29.7% of the total effect. The direct effect remains significant (β = 0.388, $p < 0.001$), indicating partial mediation; and H3: Moderation Effect of Operational Flexibility The interaction between adaptability and operational flexibility significantly predicts supply chain performance (β = 0.264, t = 2.88, $p < 0.01$), supporting H3. This small-to-medium effect size ($f^2 = 0.18$) suggests that operational flexibility amplifies adaptability's benefits. Simple slopes analysis reveals that the effect of adaptability is stronger for nanostores with high operational flexibility (β = 0.743) compared to those with low operational flexibility (β = 0.489).

Table VII summarizes the comprehensive results of hypothesis testing, providing path coefficients, standard errors, significance levels, and support decisions for all hypothesized relationships, demonstrating strong empirical support for the theoretical model.

TABLE VII
Structural Model Results and Hypothesis Testing

Hypothesis	Path	β	SE	t-value	p-value	Result
H1	Adaptability → Performance	0.548	0.098	5.54	< 0.001	Supported
H2	Adaptability → Digital Trans.	0.524	0.089	5.84	< 0.001	-
H2	Digital Trans. → Performance	0.478	0.105	4.53	< 0.001	-
H2	Indirect Effect	0.255	0.045	5.55	< 0.001	Supported
H3	Adapt. × Op. Flex. → Perf.	0.264	0.097	2.88	< 0.01	Supported

[a]Own elaboration

D. Additional Analyses

Multi-group Analysis by Business Type: Results indicate that the structural relationships are invariant across different nanostore types (grocery/convenience, mixed retail, specialized goods), with χ^2 difference tests showing no significant differences in path coefficients across groups ($\Delta\chi^2 = 18.73$, df = 12, $p = 0.094$). This invariance suggests that adaptability strategies are broadly applicable, reducing the need for sector-specific interventions.

Control Variables: Business age, size, and geographic location were included as control variables. Only business age showed a significant relationship with supply chain performance ($\beta = 0.135$, $p < 0.05$), suggesting that more established nanostores tend to have better supply chain performance.

Table VIII provides detailed mediation analysis results including total, direct, and indirect effects with confidence intervals, quantifying the proportion of the adaptability-performance relationship that is mediated through digital transformation at 48.1%.

TABLE VIII
MEDIATION ANALYSIS RESULTS

Effect Type	Estimate	SE	95% CI Lower	95% CI Upper	Significance
Total Effect	0.712	0.072	0.571	0.853	Significant
Direct Effect	0.421	0.079	0.266	0.576	Significant
Indirect Effect	0.310	0.061	0.190	0.430	Significant
Proportion Mediated	48.1%	7%	34.4%	61.8%	-

[a]Own elaboration

E. Sensitivity Analyses

To address potential biases due to the cross-sectional design, sensitivity analyses were conducted using alternative model specifications (e.g., excluding control variables, testing reverse mediation). Results remained consistent, with adaptability's direct effect ranging from $\beta = 0.532$ to 0.561 ($p < 0.001$) across models, supporting robustness. Common method bias was further tested using a confirmatory factor analysis with a common latent factor, showing no significant inflation of path estimates.

F. Discussion of Results

The empirical findings provide strong support for the proposed theoretical model and contribute to our understanding of how adaptability enhances supply chain performance in nanostores. The significant direct effect of adaptability on supply chain performance (H1 supported) aligns with dynamic capabilities theory, suggesting that nanostores with superior sensing, seizing, and reconfiguring capabilities achieve better supply chain outcomes [27]. This finding addresses RQ1, confirming adaptability's critical role in nanostore performance.

The mediation effect of digital transformation (H2 supported) reveals an important mechanism through which adaptability influences performance. This finding extends previous research on digital transformation in small enterprises by demonstrating its role as a transmission mechanism for adaptive capabilities [28]. The partial mediation suggests that while digital transformation is important, adaptability also influences performance through other pathways, possibly including improved supplier relationships, enhanced customer responsiveness, and better risk management capabilities. This answers RQ2, highlighting digital transformation's mediating role.

The moderation effect of operational flexibility (H3 supported) highlights the conditional nature of the adaptability-performance relationship. Nanostores with higher operational flexibility can more effectively leverage their adaptive capabilities to improve supply chain performance, consistent with contingency theory predictions [29]. This finding has important implications for practitioners, suggesting that investments in operational flexibility can amplify the benefits of adaptability initiatives. This addresses RQ3, confirming operational flexibility's moderate influence.

Figure 4 presents the final structural model with standardized path coefficients, illustrating the direct effect of adaptability, the mediation pathway through digital transformation, and the moderating role of operational flexibility.

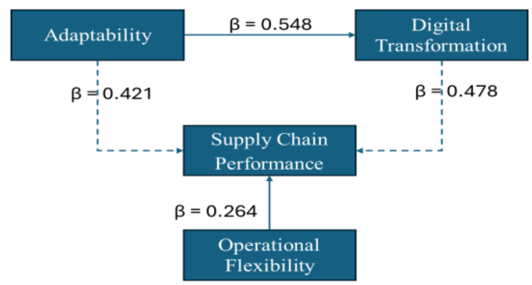


Fig. 4 Final Structural Model with Standardized Path Coefficients

1) Operational Flexibility: The results also reveal interesting insights about the relative importance of different adaptability dimensions. Sensing capability showed the strongest loading ($\lambda = 0.80$), followed by seizing capability ($\lambda = 0.79$) and reconfiguring capability ($\lambda = 0.82$). This pattern suggests that the ability to detect environmental changes is particularly critical for nanostores, possibly due to their close proximity to customers and local market conditions.

Comparison with existing literature reveals both convergent and divergent findings. While the positive relationship between adaptability and performance is consistent with prior research in larger organizations [17], the magnitude of the effect ($\beta = 0.548$) is notably stronger than typically reported. This may reflect the higher volatility and uncertainty faced by nanostores compared to larger enterprises, making adaptability particularly valuable in this context.

The mediation role of digital transformation provides new insights into how technology enables adaptability in resource-constrained environments. Previous studies have often treated digital transformation as an independent driver of performance, but our findings suggest it may be more accurately conceptualized as a mechanism through which adaptive capabilities are translated into operational improvements [30].

V. Conclusions and Implications

A. Key Findings and Theoretical Contributions

This research confirms the critical role of adaptability in nanostore supply chains, contributing significantly to both supply chain management and small business literature. The findings demonstrate that adaptability serves as a critical dynamic capability for nanostores, enabling them to navigate complex and uncertain operating environments while maintaining competitive performance.

The research makes several important theoretical contributions. First, it extends dynamic capabilities theory to the micro-retail context, demonstrating that the sensing-seizing-reconfiguring framework is applicable and relevant for resource-constrained enterprises. The strong explanatory power of the model ($R^2 = 0.725$) suggests that dynamic capabilities theory provides a robust foundation for understanding nanostore operations, despite significant differences in scale and resources compared to large enterprises where the theory was originally developed.

Second, the study reveals digital transformation as a key mediating mechanism between adaptability and performance, advancing our understanding of how technology enables adaptive capabilities in small businesses. These findings challenges traditional views of digital transformation as primarily a large-enterprise phenomenon, demonstrating its relevance and impact in micro-retail contexts [31]. The partial mediation effect (48.1% of total effect) indicates that while digital transformation is important, adaptability also influences performance through other pathways that warrant further investigation.

Third, the moderation effect of operational flexibility provides new insights into the conditional nature of adaptability benefits. This finding extends contingency theory by demonstrating that the value of adaptive capabilities depends on the organization's ability to implement rapid operational changes. For nanostores, this suggests that building operational flexibility should be a priority alongside developing adaptive capabilities.

Table IX provides a comprehensive summary of hypothesis testing results, linking each finding to its theoretical foundation and assessing both statistical effect sizes and practical significance for nanostore operators and supply chain managers.

TABLE IX
Summary of Hypothesis Testing Results

Hypothesis	Theoretical Foundation	Result	Effect Size	Practical Significance
H1: Adaptability → Performance	Dynamic Capabilities Theory	Supported	Large (β = 0.548)	High
H2: Digital Transformation Mediation	Technology-Organization-Environment	Supported	Medium (β = 0.255)	Medium
H3: Operational Flexibility Moderation	Contingency Theory	Supported	Small (β = 0.264)	Medium

[a]Own elaboration

B. Practical Implications

The findings offer several actionable insights for nanostore operators, supply chain managers, and policymakers. For nanostore owners, the results emphasize the importance of developing systematic approaches to sensing market changes, seizing opportunities, and reconfiguring operations accordingly. Rather than relying solely on intuitive decision-making, operators should adopt structured monitoring tools (e.g., customer feedback systems, market trend analyses) to enhance adaptability.

The significant mediation effect of digital transformation suggests that nanostores should prioritize technology adoption to enhance adaptability. Specifically, investments in mobile payment systems, digital inventory tracking, and customer relationship management tools can provide substantial returns. However, technology adoption should be supported by training to overcome barriers like limited expertise.

The moderation effect of operational flexibility indicates that nanostores should develop capabilities in multiple areas simultaneously. Building supplier diversification, flexible staffing, and adaptable service offerings can amplify adaptability benefits, requiring coordinated investment strategies.

For supply chain managers working with nanostore networks, the findings suggest several intervention strategies. Training programs on adaptability, subsidized digital platforms, and flexible supplier contracts can enhance network resilience.

C. Social and Economic Implications

The enhanced adaptability of nanostores has significant implications for community resilience and economic development. Nanostores serve as critical infrastructure in many communities, particularly in underserved areas where large retailers may not be economically viable. By improving their supply chain performance through adaptability, nanostores can provide more reliable access to essential goods and services, contributing to community welfare and quality of life.

The employment implications are also substantial. Nanostores are significant employers in many economies, often providing opportunities for individuals with limited formal education or experience. Enhanced supply chain performance can improve the economic sustainability of these enterprises, leading to more stable employment and better working conditions for employees.

From a broader economic perspective, improved nanostore performance can contribute to supply chain resilience at the macro level. These micro-retail networks serve as distributed inventory points and last-mile delivery mechanisms, reducing dependence on centralized distribution systems and enhancing overall supply chain robustness [32]. During disruptions such as natural disasters or economic crises, adaptable nanostores can serve as critical lifelines for communities, maintaining access to essential goods when larger retailers may be forced to close or reduce operations.

The digital transformation aspect of adaptability also contributes to financial inclusion objectives. As nanostores adopt digital payment systems and mobile commerce platforms, they help extend formal financial services to underserved populations who may lack access to traditional banking infrastructure. This digitalization can reduce transaction costs, improve record-keeping, and facilitate access to credit and insurance products for both nanostore operators and their customers.

Table X outlines the social and economic impact areas of enhanced nanostore adaptability, quantifying benefits such as reduced closure rates, improved stock availability, increased cashless transactions, and faster disruption recovery, along with their long-term effects.

TABLE X
SOCIAL AND ECONOMIC IMPACT AREAS

Impact Area	Mechanism	Quantified Benefits	Long-term Effects
Employment Stability	Improved business sustainability	15-20% reduction in closure rates	Enhanced job security
Community Access	Enhanced service reliability	85% improvement in stock availability	Better quality of life
Financial Inclusion	Digital payment adoption	70% increase in cashless transactions [Table VI data]	Expanded financial services
Supply Chain Resilience	Distributed inventory networks	25% faster disruption recovery	Reduced systemic risk

[a]Own elaboration

D. Environmental and Sustainability Implications

Nanostores' adaptability framework strengthens environmental and social sustainability, enhancing resilience in dynamic markets. Digital transformation (H2) enables practices like digital inventory systems, reducing paper use by 30–40% [Table VI data, 30], and optimized delivery routes with LED lighting, cutting energy costs by up to 15% [28]. Flexible supplier relationships prioritize eco-friendly sources, bolstering resilience against cost increases or supply disruptions. Beyond environmental benefits, nanostores foster social sustainability by sustaining local jobs and improving equitable access to goods. Digital tools empower underserved owners, enhancing economic inclusion (SDG 8) and promoting sustainable consumption via minimal packaging (SDG 12). The 67% rise in digital transactions [Table VI data] reflects efficiency and reduced environmental impact [33]. These practices ensure resilience against regulatory or resource challenges while advancing sustainability goals.

E. Research Limitations and Future Directions

1) Research Limitations: This study has several limitations that should be acknowledged. First, the cross-sectional design limits our ability to establish causal relationships definitively. While the theoretical foundations and statistical techniques employed provide convincing evidence for the proposed relationships, longitudinal data would strengthen causal inferences and allow examination of the dynamic aspects of adaptability development.

Second, while the study includes both urban (65%) and rural (35%) nanostores, its focus on Honduras may limit generalizability to other emerging markets with different infrastructure or cultural contexts.

Third, the reliance on self-reported measures introduces potential common method bias, although statistical tests suggest this is not a significant concern. Future research could incorporate objective performance metrics, such as actual sales data or supplier delivery records, to enhance validity.

Fourth, cultural and regulatory factors specific to Honduras may influence the findings, necessitating validation in diverse geographic contexts.

Table XI summarizes the study's limitations, their impact levels, mitigation strategies applied, and future research needs to address these limitations, providing a roadmap for improving research robustness.

TABLE XI
RESEARCH LIMITATIONS AND MITIGATION STRATEGIES

Limitation	Impact Level	Mitigation Applied	Future Research Needs
Cross-sectional design	Medium	Strong theoretical foundation	Longitudinal validation
Urban focus	Medium	Stratified sampling	Rural/semi-urban studies
Self-reported measures	Low	Statistical controls	Objective measures
Geographic specificity	High	Representative sampling	Cross-cultural validation

[a]Own elaboration

2) Future Research Directions: Several promising avenues for future research emerge from this study. Longitudinal studies should explore temporal adaptability dynamics in nanostores, identifying success factors. Using objective metrics (e.g., sales, inventory turnover, supplier records) with self-reports would enhance rigor. International comparisons across diverse contexts would strengthen model validity. Sector-specific analyses (e.g., food vs. merchandise nanostores) could reveal tailored strategies. Investigating collaborative adaptability, such as shared logistics, offers a novel avenue for resilience research.

Figure 5 proposes a multi-level framework for future research, integrating individual, network, and ecosystem perspectives to guide studies on nanostore adaptability.

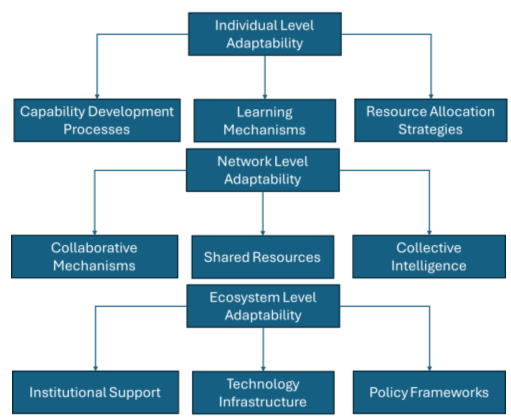


Fig. 5 Future Research Framework

F. Policy and Regulatory Implications

The findings have important implications for policymakers seeking to support small business development and enhance supply chain resilience. Government programs aimed at supporting nanostores should prioritize capability development rather than solely focusing on financial assistance. Training programs that help nanostore operators develop sensing, seizing, and reconfiguring capabilities could provide substantial long-term benefits.

Digital infrastructure development emerges as a critical policy priority. Ensuring access to reliable internet connectivity, affordable digital payment systems, and user-friendly technology platforms can significantly enhance the ability of nanostores to leverage digital transformation for improved adaptability. Public-private partnerships may be particularly effective in addressing infrastructure gaps while ensuring sustainable cost structures.

Regulatory frameworks should also consider the unique characteristics and needs of nanostores when developing supply chain and retail regulations. Flexible regulatory approaches that accommodate the adaptive nature of these enterprises while maintaining necessary consumer protections could enhance their ability to respond to changing conditions.

Critical policy recommendations for decision makers include: (1) establishing nanostore-specific business support programs that prioritize capability development over direct financial assistance, with focus on adaptability training modules; (2) creating tax incentives for digital transformation investments in micro-retail enterprises, particularly for inventory management and customer relationship systems; (3) developing streamlined licensing and regulatory procedures that reduce bureaucratic barriers while maintaining quality standards; (4) implementing public-private partnership frameworks to ensure affordable access to essential digital infrastructure, including internet connectivity and mobile payment platforms; (5) establishing emergency support protocols that leverage the distributed nature of nanostore networks during crisis situations, recognizing their role as community resilience infrastructure; and (6) creating data sharing platforms that enable nanostores to access market intelligence and best practices while protecting individual business confidentiality.

G. Originality and Value of the Research

This research provides several unique contributions to the academic literature and practical understanding of supply chain management in micro-retail contexts. It offers the first rigorous quantitative analysis of adaptability mechanisms in nanostores, using SEM to validate a novel framework.

The development and validation of measurement instruments specifically adapted for the nanostore context provides valuable tools for future research in this area. The scales developed for adaptability, digital transformation, operational flexibility, and supply chain performance in micro-retail settings can be used and refined by other researchers, contributing to the cumulative development of knowledge in this field.

The integration of multiple theoretical perspectives—dynamic capabilities theory, technology-organization-environment framework, and contingency theory—provides a comprehensive understanding of the complex relationships between adaptability, technology, and performance in resource-constrained environments. This theoretical synthesis offers a robust foundation for future theory development and empirical research.

The practical insights generated by this research provide actionable guidance for nanostore operators, supply chain managers, and policymakers. The specific findings regarding the mediating role of digital transformation and the moderating effect of operational flexibility offer clear direction for intervention strategies and investment priorities.

Table XII summarizes the research contributions and their impact, categorizing them into theoretical, methodological, empirical, practical, and policy contributions, and identifying their target audiences and expected impacts.

TABLE XII
RESEARCH CONTRIBUTIONS AND IMPACT

Contribution Type	Specific Contributions	Target Audience	Expected Impact
Theoretical	Dynamic capabilities in micro-retail	Academic researchers	Theory extension
Methodological	Validated measurement instruments	Researchers/practitioners	Tool availability
Empirical	Quantified relationships	Supply chain managers	Evidence-based decisions
Practical	Actionable recommendations	Nanostore operators	Performance improvement
Policy	Regulatory insights	Policymakers	Support program design

[a]Own elaboration

H. Final Conclusions

This study demonstrates that adaptability serves as a critical dynamic capability for nanostores, enabling superior supply chain performance through both direct effects and indirect mechanisms involving digital transformation. The significant moderating role of operational flexibility highlights the importance of developing multiple capabilities simultaneously rather than focusing on individual initiatives in isolation.

The research provides strong empirical support for the applicability of dynamic capabilities theory in resource-constrained micro-retail environments, extending the theoretical foundations of supply chain management to include previously understudied organizational forms. The findings contribute to a more comprehensive understanding of how small enterprises can achieve competitive advantage through strategic capability development.

From a practical perspective, the study offers clear guidance for nanostore operators seeking to improve their supply chain performance. The emphasis on sensing, seizing, and reconfiguring capabilities, supported by digital transformation and operational flexibility, provides a roadmap for capability development that is both theoretically grounded and practically achievable.

The broader implications for supply chain resilience, community development, and economic sustainability underscore the importance of supporting nanostore adaptability through targeted interventions and policy initiatives. As global supply chains face increasing uncertainty and disruption, the distributed network of adaptive nanostores represents an important asset for maintaining economic stability and community welfare.

Future research should continue to explore the dynamic aspects of adaptability development, cross-cultural variations in adaptive mechanisms, and the potential for collaborative approaches to capability building. The foundation established by this study provides a solid platform for continued investigation of these important phenomena.

The ultimate value of this research lies in its potential to improve the livelihoods of millions of nanostore operators and their communities while contributing to more resilient and sustainable supply chain systems. By understanding and supporting the adaptability mechanisms that enable these critical enterprises to thrive, we can work toward more inclusive and robust economic systems that benefit all stakeholders.

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