

# Adaptability and Quality Practices for Customer-Centered Retail: Strengthening Nanostores in Vulnerable Communities

Cesar H. Ortega-Jimenez, Ph.D.<sup>1</sup>; Dany N. Sabillón Palomeque, Eng<sup>2</sup>; Narciso A. Melgar-Martínez, Eng<sup>3</sup>; Jose R. Tome, Eng<sup>4</sup>

<sup>1</sup> Faculty of Engineering-CU, CURLP, UNAH, Honduras, [cortega@unah.edu.hn](mailto:cortega@unah.edu.hn)

<sup>2,3,4</sup> Faculty of Engineering, UNAH-CORTES, Honduras, [narciso.melgar@unah.edu.hn](mailto:narciso.melgar@unah.edu.hn), [dany.sabillon@unah.hn](mailto:dany.sabillon@unah.hn), [jose.tome@unah.hn](mailto:jose.tome@unah.hn).

**Abstract**— This study explores how adaptability, framed by Total Quality Management (TQM) principles, influences customer experience in nanostores. Using data from 143 nanostore owners, managers, and employees in Honduras, the study finds that adaptability significantly drives TQM practices (path coefficient = 0.68,  $p < 0.001$ ), which, in turn, improve customer experience (path coefficient = 0.72,  $p < 0.001$ ). Adaptability also directly influences customer satisfaction (path coefficient = 0.45,  $p < 0.001$ ), highlighting the importance of market agility. Aligned with the principles of humanitarian engineering for sustainable development in Latin America, this research underscores the need for context-sensitive strategies that integrate adaptability and total quality management to foster innovation, build resilience, and enhance long-term competitiveness in small-scale retail environments. The study suggests that prioritizing adaptability and embedding TQM principles enhances service quality and customer loyalty. Future research should investigate the long-term impact of digitalization on nanostores' adaptability and customer experience, particularly in response to evolving consumption patterns and technologies. Ongoing data collection in Honduras, Colombia, and Peru will explore scalable paths to innovation and sustainable development for micro-retail ecosystems in Latin America.

**Keywords**—Adaptability, Total Quality Management (TQM), Customer Experience, Digitalization, Vulnerable Communities.

## I. INTRODUCTION: RESILIENCE IN INFORMAL RETAIL

### A. Background and Context

Nanostores, or micro-retail outlets, are critical to retail ecosystems in emerging economies. These stores, with limited space and minimal use of advanced technologies, primarily serve localized customer bases in underserved areas. Despite their size constraints, nanostores play an essential role in meeting daily consumer needs and contribute to the local economy through adaptability in product stocking, pricing, and inventory management [1]. Understanding the factors influencing their competitiveness and customer satisfaction is vital for their long-term sustainability.

Total Quality Management (TQM) is a proven framework for enhancing operational efficiency and customer satisfaction in large-scale retail. However, its potential in nanostores, characterized by limited resources and informal management structures, remains underexplored. This research aims to examine how TQM can be adapted to improve operational effectiveness and customer service in these unique settings [2]. Nanostores, especially in Latin America, are increasingly

viewed as key to fostering inclusive economic development. They present opportunities to apply adaptable, quality-focused management systems that can drive resilience and improve service quality.

Table I below contrasts nanostores and large retailers, highlighting key differences relevant to the Humanitarian Engineering in Latin America (HELA) framework, which focuses on vulnerable communities and sustainable systems.

TABLE I  
NANOSTORES VS. LARGE RETAILERS: RESILIENCE & TECH INCLUSION

Feature	Nanostores	Large Retailers
Average Store Size	<50 sqm	>500 sqm
Technology Adoption	Low	High
Customer Base	Localized	Diverse, large-scale
Operational Flexibility	High	Moderate

<sup>a</sup>Own elaboration

### B. Justification of the Study

Adapting TQM frameworks to nanostores could offer innovative solutions to longstanding issues, such as inconsistent service quality and inefficient inventory management. Despite their significance in emerging economies, nanostores remain unexplored in academic discussions on quality management. As small-scale retailers play an increasingly crucial role in local economies, their challenges and needs warrant more focused academic inquiry. Their ability to adapt to customer needs and market conditions plays a crucial role in shaping customer experience, yet this adaptability has not been systematically analyzed within a TQM framework [3].

The humanitarian dimension of this research lies in the empowerment of vulnerable retail ecosystems. Through interdisciplinary inquiry and practice-oriented methodologies like path analysis, this study seeks to elevate the operational capacities of nanostores—not only as economic actors but also as community-level platforms for resilience, gender inclusion, and sustainable livelihoods.

Thus, our study applies path analysis to investigate the relationship between adaptability and customer perceptions, with TQM serving as a mediating factor. This analytical approach offers a deeper understanding of how specific TQM practices can be tailored to enhance adaptability and customer satisfaction in nanostores. By understanding these relationships, the study provides actionable insights for policymakers, retail owners, and industry stakeholders to develop customized TQM practices that improve service

quality, customer satisfaction, and long-term business sustainability. Furthermore, this study sets the stage for future research that can further explore and validate adaptable TQM strategies within micro-businesses across diverse economic contexts.

Fig. 1 illustrates the conceptual relationship between adaptability, TQM practices, and customer experience in nanostores. It adds a humanitarian angle by highlighting “human-centered innovation” and how the framework serves community impact through micro-retailers.

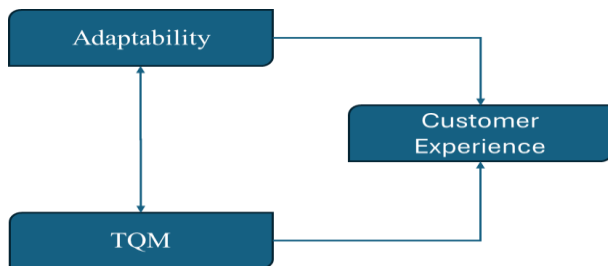


Fig. 1 Pathways to Human-Centered Retail Innovation: A Conceptual Model Linking Adaptability, TQM, and Customer Experience in Nanostores

### C. Research Gap, Questions and Objectives

While existing studies on retail quality management focus primarily on large retailers and e-commerce platforms, nanostores remain understudied, particularly in terms of adaptability and service quality. Addressing this research void is essential, as nanostores operate in highly dynamic environments where flexibility and customer responsiveness are critical to survival. However, the relationship between adaptability and customer experience, especially within the TQM framework—has not been systematically explored. This study seeks to fill this void by investigating the influence of adaptability on customer satisfaction through the mediating role of TQM [3].

To define the study’s contribution, this section identifies three major research gaps:

1) *Limited research on adaptability in nanostores* – Studies on small retailers rarely examine how adaptability—the ability to modify operations in response to customer needs and external pressures—affects customer experience.

2) *Lack of integration between adaptability and TQM* – Existing TQM literature focuses primarily on structured environments like large retail chains, overlooking how TQM principles can be adapted to more flexible, resource-constrained settings like nanostores.

3) *Absence of empirical studies using path analysis* – Prior research has not systematically quantified the direct and mediated effects of adaptability on customer experience through TQM.

In line with the HELA framework, these gaps not only represent academic opportunities but also underscore the urgency of engineering scalable, data-driven solutions for real-world social impact in retail communities across Latin America. To address these gaps, this study formulates the following research questions to guide its investigation:

### D. Research Questions:

1) *How does adaptability influence customer satisfaction with nanostores?*

2) *In what ways does TQM mediate the relationship between adaptability and customer experience?*

By answering these questions, the study aims to clarify the role of adaptability in shaping customer perceptions and determine whether TQM acts as a key mechanism for enhancing service quality in nanostores. Building on the identified gaps and research questions, this study pursues the following objectives:

### E. Research Objectives:

1) *To assess the extent to which adaptability influences customer experience in nanostores.*

2) *To evaluate the mediating role of TQM in enhancing customer perceptions and satisfaction.*

3) *To develop practical recommendations for integrating adaptability and TQM principles in nanostore operations.*

Achieving these objectives will provide actionable insights for nanostore owners, policymakers, and industry stakeholders, equipping them with strategies to enhance customer satisfaction and business sustainability through adaptability-driven TQM implementation.

Moreover, the outcomes are expected to inform humanitarian engineering efforts that prioritize technology transfer, inclusive management practices, and bottom-up innovation in vulnerable micro-retail settings.

The remainder of this paper is organized to provide a coherent progression of ideas, evidence, and implications grounded in humanitarian engineering for sustainable development in Latin America:

1) *Section II* reviews the relevant literature on adaptability, total quality management, and customer experience in micro-retail, establishing the theoretical foundations and formulating key hypotheses.

2) *Section III* outlines the methodological approach, including the ethical framework, data collection process, and analytical techniques used to examine the proposed relationships.

4) *Section IV* presents the empirical results and offers an integrated discussion, highlighting how adaptability and quality management practices influence customer outcomes within nanostores, with particular attention to the socio-economic context.

5) *Section V* concludes the paper by synthesizing major findings, acknowledging limitations, and offering directions for future research that support inclusive innovation and sustainable retail practices.

This structure enables a systematic investigation of how adaptability and total quality management jointly shape customer experience in small-scale retail environments, advancing the goals of humanitarian engineering in Latin American communities.

## II. LITERATURE AND CONCEPTUAL FOUNDATIONS FOR HUMAN-CENTERED QUALITY AND ADAPTABILITY IN NANOSTORES

This section bridges literature and theory, framing adaptability and TQM as interdependent drivers of customer experience in nanostores. By embedding HELA principles—such as community co-design, frugal engineering, and systems resilience—the framework advances both scholarly discourse and practical tools for inclusive retail development.

### A. Evolution of Total Quality Management and Its Relevance for Community-Based Retail Models

Total Quality Management (TQM) has traditionally been linked to industrial settings, but its potential to improve retail operations in community-based models like nanostores is increasingly recognized in inclusive development contexts. While early TQM research emphasized quality control and continuous improvement in high-resource environments [4], nanostores operate with distinct constraints—limited technology, smaller budgets, and localized customer bases [5]. Despite these challenges, nanostores exhibit high adaptability, enabling rapid responses to market demands and customer loyalty.

This tension—between constrained resources and responsive capacity—creates a unique context to rethink TQM as a humanitarian enabler, aligning with principles of equity-driven design and grassroots innovation.

Existing studies on TQM in retail focus on isolated factors (e.g., customer satisfaction, inventory management) but rarely combine these in nanostore contexts. The gap is particularly pronounced in resource-constrained settings, where TQM’s traditional tools (e.g., digital surveys, automated workflows) require low-cost, community-centric adaptations [2].

Moreover, while Total Quality Management (TQM) has been widely implemented in large retail chains, its role within nanostores remains insufficiently examined. In particular, the dynamic interaction between TQM, adaptability, and operational reconfigurability in nanostore environments suggests the need for context-specific quality management approaches. This study advances discussion by exploring how TQM mediates the relationship between adaptability and customer experience in vulnerable retail ecosystems.

Table II reframes the evolution of TQM as a pathway to empowerment in community retail ecosystems.

TABLE II  
EVOLUTION OF TQM PRINCIPLES AND OPPORTUNITIES FOR EMPOWERMENT IN COMMUNITY RETAIL

Era	Key Developments in TQM	Potential Application in Nanostores
1950s-1970s	Emphasis on quality control	Basic inventory and service quality tracking
1980s-1990s	Customer-focused strategies	Localized customer feedback integration
2000s-Present	Technology-driven TQM tools	Low-cost digital tools for quality management
Emerging	Focus on digital innovation in vulnerable communities	Digital tools supporting community-based retail strategies

<sup>a</sup>Own elaboration

### B. Adaptive Strategies in Resource-Constrained Retail: A Path to Inclusive Customer Engagement

Adaptability—defined as the ability to adjust to dynamic market conditions—is a strategic asset for nanostores serving vulnerable populations. Practices like localized product assortments, flexible pricing, and community-driven responsiveness underscore the humanitarian relevance of agility in micro-retail [6].

Recent advancements in low-cost digital tools (e.g., mobile inventory systems) enhance adaptive capacity, bridging informal local knowledge with structured quality practices [7].

Fig. 2 synthesizes adaptability’s core dimensions for nanostores, showing how digital enablement and community engagement foster operational resilience: (1) Localized Product Assortment; (2) Flexible Pricing Mechanisms; (3) Community-Driven Responsiveness; (4) Digital Enablement for Market Adaptation

This positions adaptability as both a business competency and a social innovation lever—aligning with HELA’s emphasis on participatory, engineering-led strategies.

This positions adaptability as both a business competency and a social innovation lever—aligning with HELA’s emphasis on participatory, engineering-led strategies.

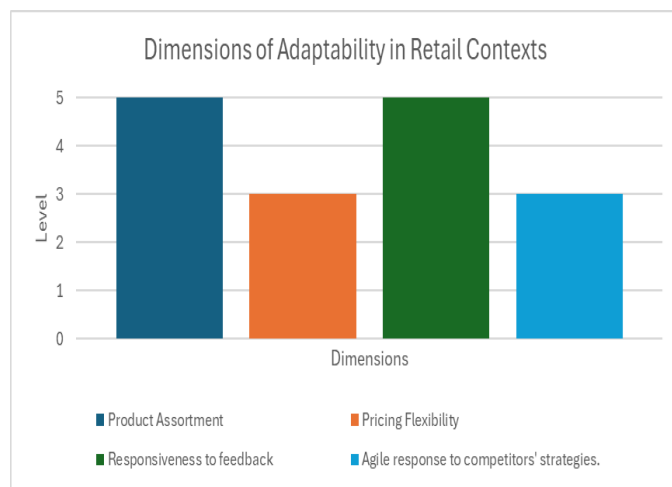


Fig. 2 Dimensions of Adaptability for Inclusive and Resilient Retail Systems

### C. Integrating TQM into Vulnerable Retail Ecosystems: Engineering Better Customer Experiences

TQM’s role in nanostores extends beyond efficiency—it becomes a vehicle for dignity, access, and relational service quality. While traditional retail relies on digital surveys and automated workflows, nanostores adapt TQM through face-to-face feedback, community trust, and on-the-job training (Table III). This shift reflects a humanitarian engineering ethos: doing more with less, for those with less. [8] [2].

TABLE III  
TQM IN TRADITIONAL RETAIL VS. NANOSTORES

TQM Practice	Traditional Retail Approach	Nanostore-Specific Adaptation
Customer Feedback Systems	Digital surveys	Face-to-face interactions
Process Standardization	Automated workflows	Manual, simplified processes
Employee Training	Extensive formal training	On-the-job training with minimal costs

<sup>a</sup>Own elaboration

**D. Gaps in Literature and Pathways for Sustainable Innovation**  
Three critical gaps emerge:

- 1) Limited empirical links between adaptability and customer experience in nanostores.
- 2) Sparse exploration of TQM adaptations for resource-constrained retail.
- 3) No unified framework integrating adaptability and TQM for customer satisfaction.

These gaps underscore the need for interdisciplinary, tech-enabled solutions—a core tenet of HELA—where engineering principles (e.g., iterative design, systems thinking) converge with social science to co-create equitable retail systems.

Furthermore, while previous studies have addressed aspects of nanostore operations, such as supply chain agility and adaptability, they often lack a comprehensive framework that integrates these elements with TQM to enhance customer experience. Our study seeks to fill this void by proposing a model that synergizes adaptability and TQM within the context of humanitarian engineering[9].

**E. Conceptual Framework: Synergizing Adaptability and TQM for Humanitarian Retail**

Building on the literature, this study proposes a conceptual model (Fig. 3) where:

- 1) *Adaptability* (flexibility, responsiveness) drives TQM practices (continuous improvement, customer focus).
- 2) *TQM* practices enhance customer experience (satisfaction, loyalty).
- 3) *Adaptability* also directly improves customer experience, independent of TQM.

Fig. 3 conceptualizes nanostores as dynamic systems where quality and responsiveness are co-engineered for community impact. This framework advances methodological rigor by applying path analysis to examine both direct and indirect effects, offering causal clarity for humanitarian engineering interventions in retail systems.

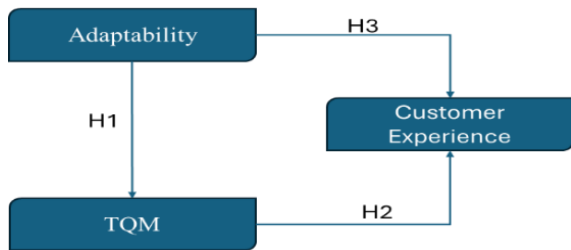


Fig. 3 Conceptual Model and Hypothesis: Engineering Pathways to Customer-Centric Resilience in Nanostores

**F. Rationale for the Hypotheses: Foundations for Engineering for Social Good**

1) *H1: Adaptability positively influences TQM practices in nanostores.* Adaptable nanostores leverage real-time feedback and agile decision-making to implement TQM, even under constraints [17]. In HELA contexts, this mirrors grassroots innovation—where community needs to drive frugal quality solutions.

2) *H2: TQM practices positively influence customer experience in nanostores.* TQM’s customer-centric processes

improve experience, even when deployed via informal or analog systems (e.g., verbal feedback, informal audits) [18].

3) *H3: Adaptability directly influences customer experience in nanostores.* Adaptability enables hyper-localized service delivery—critical in vulnerable markets where trust, familiarity, and context-sensitivity matter more than standardization [2].

Table IV shows a summary of the path relationships of the stated hypotheses.

TABLE IV  
PATHWAYS OF IMPACT IN HELA-ALIGNED NANOSTORE RESEARCH

Hypothesis	Relationship	Expected Path Coefficient	Justification
H1	Adaptability → TQM Practices	Positive	Adaptable nanostores are more likely to implement TQM practices to enhance operational efficiency.
H2	TQM Practices → Customer Experience	Positive	Effective TQM practices lead to improved customer experience through process improvement and customer satisfaction.
H3	Adaptability → Customer Experience	Positive	Adaptability enhances customer experience by enabling nanostores to quickly respond to customer needs and market changes.

<sup>a</sup>Own elaboration

The hypotheses presented in this section form the foundation for the empirical investigation of how adaptability and TQM practices interact to influence customer experience in nanostores. By merging resilience thinking with inclusive quality strategies, this study contributes both theoretical advancement and practice-oriented insights for small-scale, community-aligned retail.

Furthermore, it supports the HELA mission of leveraging engineering as a catalyst for social innovation—using retail ecosystems as vehicles for equity, empowerment, and systems change.

The next section outlines the methodology used to test these hypotheses.

III. METHODOLOGY

A. Research Design and Community-Driven Approach

This study adopts a quantitative approach utilizing path analysis to explore how adaptability influences customer experience in nanostores, framed by Total Quality Management (TQM) principles. This approach is particularly relevant given the need to understand both direct and indirect effects between these variables, contributing to a more comprehensive view of retail adaptation strategies. Path analysis is an advanced statistical method that allows for the examination of complex relationships between variables, making it suitable for investigating the interconnections between adaptability, TQM, and customer experience [19].

The research design incorporates a community-centered perspective, focusing on nanostores as vital components of local economies. By examining how these businesses adapt through TQM, the study aligns with sustainable development

goals and the HELA track's emphasis on socially responsive innovation. Engineering solutions are co-developed with local actors, positioning the research within humanitarian frameworks that prioritize dignity, inclusion, and system resilience. This design also incorporates interdisciplinary collaboration and participatory data gathering, ensuring inclusion of community voices in shaping resilient retail systems.

**B. Data Collection Process for Community Contextualization**

**1) Literature Review and Theoretical Framework Development:** A thorough review of peer-reviewed literature was conducted across Scopus, Web of Science, and Springer databases, covering TQM in small-scale retail, adaptability, and customer experience. This study goes beyond fragmented analyses by integrating these concepts into a unified framework tailored for nanostores. Studies on digital transformation in small retailers were also considered, highlighting external pressures shaping adaptability and TQM practices today[1].

**2) Development of Survey Instrument:** Guided by literature and expert feedback, the survey was divided into three sections: (1) Adaptability: Responsiveness to customer needs, operational changes, and technology; (2) TQM Practices: Focus on process standardization, continuous improvement, and customer orientation; (3) Customer Experience: Perceptions of service quality and satisfaction. All items used a 5-point Likert scale. Questions were adapted from validated instruments and pilot-tested for clarity. Minor revisions improved internal coherence. The survey instrument was designed to be linguistically accessible and context-appropriate for low-literacy populations, following HELA's equity-centered design ethos.

**C. Inclusive Data Collection for Cross-Regional Analysis**

A total of 143 responses were collected over a two-month period from various regions in Honduras, involving nanostore owners, managers, and employees. The data collection process was supported by university outreach initiatives, with students facilitating responses through both assisted online surveys (via Google Forms) and in-person interviews. All activities adhered strictly to ethical protocols, including informed consent and the assurance of respondent anonymity.

To broaden the HELA-aligned scope, a second phase of data collection is underway in Colombia and Peru. This regional expansion will enhance cross-cultural insights and support comparative modeling of adaptability and TQM dynamics across Latin America..

**D. Statistical Analysis for Sustainable Retail Practices**

**1) Data Preparation Descriptive Analysis:** Survey responses were cleaned, coded, and analyzed to ensure accuracy. Exploratory Data Analysis (EDA) techniques were employed to identify patterns, outliers, and data distribution trends, confirming the data's suitability for advanced statistical modeling. Table V provides a summary of key descriptive statistics for each construction.

TABLE V  
DESCRIPTIVE STATISTICS OF SURVEY VARIABLES

Variable	Mean	Standard Deviation	Range
Adaptability	3.74	0.509	2 - 5
TQM Practices	3.80	0.570	1.7 - 5
Customer Experience	3.25	0.600	1.5 - 5

<sup>a</sup>Own elaboration

**2) Reliability Testing:** To ensure internal consistency, Cronbach's alpha was calculated for each construct. All values exceeded the recommended threshold of 0.70, confirming the reliability of the instrument. Table VI presents the reliability coefficients.

TABLE VI  
CRONBACH'S ALPHA COEFFICIENTS FOR CONSTRUCTS

Construct	Cronbach's Alpha
Adaptability	0.848
TQM Practices	0.884
Customer Experience	0.878

<sup>a</sup>Own elaboration

**3) Measurement Model Assessment:** Convergent validity was evaluated using Confirmatory Factor Analysis (CFA). All standardized factor loadings exceeded 0.60, indicating strong associations between observed items and latent constructions. Table VII summarizes these results.

TABLE VII  
STANDARDIZED FACTOR LOADINGS FOR MEASUREMENT ITEMS

Constructo	item Code	Standardized Loading
Adaptability	A1–A14	0.799
TQM Practices	Q1–Q12	0.727
Customer Experience	C1–C18	0.870

<sup>a</sup>Own elaboration

Average Variance Extracted (AVE) values were above 0.50 for all constructs.

TABLE VIII  
AVERAGE VARIANCE EXTRACTED (AVE) VALUES

Constructo	AVE
Adaptability	0.721
TQM Practices	0.631
Customer Experience	0.651

<sup>a</sup>Own elaboration

**E. Validation and Reliability for Cross-Regional Applicability**

To ensure the robustness and transferability of results across regions, multiple diagnostic tests were performed:

**1) Construct Validity:** Both Exploratory Factor Analysis (EFA) and CFA validated the theoretical model. (1) EFA revealed three distinct constructs with eigenvalues above 1.0, jointly explaining 79.88% of the variance; (2) CFA confirmed high standardized loadings (0.727–0.870,  $p < 0.001$ ).

**2) Multicollinearity Testing:** Variance Inflation Factor (VIF) scores for all predictors were below 5.0.

TABLE IX  
VARIANCE INFLATION FACTOR VALUE

Predictor Variable	VIF Value
Adaptability	1.565
TQM Practices	2.355
Customer Experience	1.853

<sup>a</sup>Own elaboration

3) *Heteroscedasticity Check and Model Robustness*: The Breusch-Pagan test ( $p = 0.273$ ) confirmed homoscedasticity. Sensitivity analyses using Maximum Likelihood Estimation and Bayesian Estimation yielded consistent results. This methodological triangulation enhances the validity of findings, particularly in the HELA context where evidence-based insights guide impactful, frugal innovation.

F. *Ethical Considerations for Community-Centered Research*  
Ethical standards were strictly upheld throughout the study. Participants were fully informed of the research and voluntarily consented to participate. Confidentiality and anonymity were preserved, and all data was securely stored.

The research was conducted under the HELA framework, emphasizing co-responsibility with local actors, transparency in the research process, and ethical engagement with vulnerable communities. By prioritizing social justice and equitable outcomes, this study contributes not only to the scholarly discourse but also to the lived realities of those at the heart of humanitarian engineering.

#### IV. ANALYSIS, RESULTS, AND DISCUSSION: ENHANCING COMMUNITY-CENTRIC RETAIL PRACTICES

##### A. Path Analysis Results: Adaptability’s Impact on Customer Experience in Vulnerable Communities

This section presents the findings from the path analysis conducted on data collected from 143 individuals, including nanostore owners, managers, and employees. The primary aim was to examine the interconnected pathways between nanostore adaptability, Total Quality Management (TQM) practices, and customer experience in vulnerable retail ecosystems.

The hypothesized model—shown in Fig. 4—posits that adaptability positively impacts customer experience, with TQM serving as a mediating factor. Structural equation modeling (SEM) was employed for the analysis, using SPSS Amos 26, which is well-suited for small-sample, multi-path models. Fit indices were evaluated to ensure model adequacy. Table VII summarizes the path coefficients, their statistical significance, and goodness-of-fit indices. Robustness was verified through bootstrapping (5,000 resamples), reinforcing the validity of the findings.

Unlike traditional regression, SEM allows for the concurrent estimation of interdependent relationships, offering a systemic view of the innovation dynamics within nanostores. This approach supports the HELA framework’s emphasis on interdisciplinary modeling and resilience-building through systems thinking.

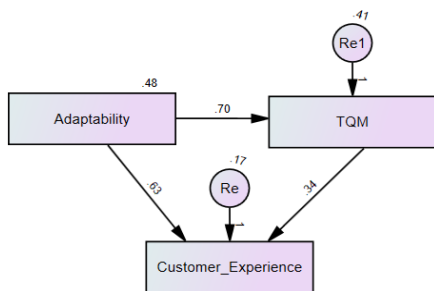


Fig. 4 Pathways to Nanostore Performance

TABLE X  
PATH ANALYSIS RESULTS – COMMUNITY-DRIVEN RETAIL ADAPTABILITY

Path	Path Coefficient	Standard Error	t-Value	p-Value
Adaptability → TQM Practices	0.695	0.078	8.91	<0.001
TQM Practices → Customer Experience	0.335	0.054	6.20	<0.001
Adaptability → Customer Experience	0.632	0.063	10.03	<0.001
Total Effect	0.865	–	–	–
Goodness-of-Fit Indices				
Index	Value	Acceptable Threshold		
Chi-Square / df	2.81	<3.0		
CFI	0.91	>0.90		
RMSEA	0.06	<0.08		

<sup>a</sup>Own elaboration

The results offer compelling evidence that both adaptability and quality management are critical enablers of enhanced customer experience. The strong coefficient from adaptability to TQM (0.695) suggests that agile nanostores tend to institutionalize quality-oriented processes. TQM, in turn, positively affects customer experience (0.335), highlighting its role as a key operational lever. Notably, adaptability also has a significant direct effect on customer experience (0.632), underscoring its independent value in driving customer satisfaction. The total effect (0.865) demonstrates the dominant influence of adaptability in driving outcomes.

##### B. Hypothesis Testing: Validating the Role of Adaptability and Quality Management in Vulnerable Community Retail

1) *H1: Adaptability positively influences TQM practices in nanostores*: Supported ( $\beta = 0.695, p < 0.001$ ). Agile nanostores are more likely to embed robust TQM principles, contributing to improved service delivery in fragile retail environments.

2) *H2: TQM practices positively influence customer experience in nanostores*: Accepted ( $\beta = 0.335, p < 0.001$ ). Emphasis on process quality, responsiveness, and continuous improvement significantly enhances the customer journey in community-oriented stores.

3) *H3: Adaptability directly influences customer experience in nanostores*: Confirmed ( $\beta = 0.632, p < 0.001$ ). Even without strong TQM practices, adaptability alone contributes meaningfully to customer satisfaction, which is crucial for dynamic, low-resource retail systems.

##### C. Discussion of Results: Leveraging Adaptability and TQM Practices to Support Vulnerable Communities

1) *Impact of Adaptability*: The results affirm adaptability as a cornerstone of customer satisfaction. For nanostores, this entails being responsive to local market shifts, cultural preferences, and supply disruptions. Adaptability fuels grassroots innovation, supporting new service models, digital inclusion, and personalized interactions—principles central to the HELA agenda. By leveraging adaptive capacity, nanostores serve not only as economic agents but also as social infrastructure for community well-being. [3].

2) *Role of TQM Practices*: TQM acts as a process-driven enabler of better service delivery. The strong mediating effect

underscores the relevance of structured quality mechanisms—even in informal or resource-scarce settings. For humanitarian engineering, this suggests a pathway to embed low-cost, high-impact process standards in community enterprises, enhancing both efficiency and trust. [20].

3) *The Combined Effect of Adaptability and TQM Practices*: Together, adaptability and TQM form a synergistic strategy for community-based retail transformation. Nanostores that embrace both strategies holistically demonstrate stronger customer loyalty and operational resilience. This synergy aligns with HELA’s goal of sustainable, inclusive innovation driven by locally appropriate practices and active beneficiary engagement

#### D. *Implications for Practice and Theory : Supporting Resilient Retail in Vulnerable Communities*

1) *Practical Implications*: Nanostore operators should prioritize adaptability strategies—such as flexible sourcing, localized customer feedback, and rapid service adjustments—to remain aligned with community needs. Simultaneously, scalable TQM methods (e.g., checklists, simple metrics, staff training) can elevate performance without overburdening small teams. Digital tools and participatory design methods can further reinforce both adaptability and quality.

2) *Theoretical Implications*: This study enriches theory by modeling how operational and behavioral capabilities intersect in informal retail. It confirms that adaptability and TQM jointly shape customer experience and offers a transferable framework for humanitarian interventions. Future research should explore how these mechanisms interact with cultural context, gender dynamics, or informal economies, and how engineering-driven solutions can amplify resilience at scale.

## VI. CONCLUSIONS FOR SUSTAINABLE RETAIL PRACTICES IN NANOSTORES

### A. *Main Findings*

The purpose of this study was to explore the pathways through which adaptability influences customer experience in nanostores, framed by Total Quality Management (TQM) principles. By applying path analysis, we examined the relationships between adaptability, TQM practices, and customer experience, revealing several key findings:

1) *Adaptability positively influences TQM practices*: Nanostores that are more adaptable to customer needs and market changes tend to implement stronger TQM practices. This was confirmed by a significant path coefficient (0.695), indicating that adaptability is not just a reactive measure but an initiative-taking driver of operational excellence through TQM.

2) *TQM practices enhance customer experience*: The analysis demonstrated that TQM practices—such as continuous improvement, customer engagement, and quality control—have a significant positive impact on customer experience (path coefficient of 0.335). This highlights the crucial role of operational practices in delivering customer satisfaction and fostering loyalty. These results confirm that quality assurance frameworks are both scalable and impactful, even in low-resource retail settings.

3) *Adaptability directly influences customer experience*: Even without the mediation of TQM practices, adaptability had a direct, positive effect on customer experience (path coefficient of 0.632). This suggests that customer perceptions are shaped not only by operational quality but also by the store’s responsiveness to evolving demands and local market conditions.

Collectively, these findings reinforce that adaptability and TQM are mutually reinforcing drivers of positive customer outcomes, with a combined total effect of 0.865. Flexibility, when integrated with structured management, yields a competitive advantage for small-scale retailers and supports sustainable service delivery in community-based markets.

### B. *Limitations and Implications for Future Research*

While the findings of this study provide valuable insights, several limitations must be acknowledged:

1) *Sample Size and Generalizability*: The study focused on 143 individuals, including nanostore owners, managers, and employees. While this is adequate for path analysis, it may not fully capture the diversity of nanostores across different geographic and economic settings. Larger, multi-country studies are needed to assess broader regional dynamics, particularly across vulnerable populations.

2) *Cross-sectional Data*: The data reflects a single point in time, limiting our ability to assess long-term effects. Longitudinal studies are needed to better understand how adaptability and TQM influence outcomes over time, including their role in building resilience and business continuity.

3) *Potential Confounding Variables*: Although multiple factors were controlled, variables such as location, employee skill levels, or access to capital could also impact outcomes. Further research should explore how these intersecting variables shape innovation trajectories in nanostores.

Despite these limitations, this research lays a foundation for future studies in key areas:

1) *Investigating the Role of Digitalization*: Future work should assess how tools like e-commerce, mobile payments, and CRM systems influence adaptability and customer experience. These insights would support scalable tech integration aligned with HELA’s goal of bridging the digital divide.

2) *Examining Leadership and Decision-Making*: Studies could examine how leadership styles affect innovation and quality adoption in small retail. Understanding the decision-making logic of local leaders can enhance participatory and context-driven interventions.

3) *Exploring Cultural and Regional Differences in the HELA Context*: Assessing how cultural and social dynamics mediate the effectiveness of adaptability and TQM will allow for more tailored, community-responsive strategies.

### C. *Managerial and Research Implications*

#### 1) *Managerial Implications*:

Nanostore owners and managers can adopt several strategies based on this study: (1) *Invest in Adaptability*: Agile inventory management, real-time feedback mechanisms, and flexible business models can help stores respond to rapid

market shifts. This adaptability not only enhances competitiveness but also empowers local communities to weather socioeconomic disruptions; (2) Strengthen TQM Practices: Training employees on customer satisfaction, process efficiency, and continuous improvement is essential. Embedding a culture of quality can help nanostores scale sustainably, even under resource constraints; (3) Adopt an Integrated Approach: Recognizing adaptability and TQM as interconnected, rather than isolated, strengthens the value chain and customer journey. This integration supports inclusive growth, especially in underserved urban and rural retail corridors.

2) *Research Implications:* This study contributes a new theoretical model linking adaptability and TQM to customer experience in nanostores. It advances the literature by showing that small-scale retailers, when strategically adaptive, can achieve outcomes typically associated with larger enterprises. Future studies can build on this by incorporating humanitarian engineering principles to design equitable and resilient retail ecosystems [2].

#### D. Economic and Social Implications

From an economic perspective, improved adaptability and TQM can help nanostores remain competitive amid digital disruption and changing customer expectations. Operational excellence aligned with responsiveness can unlock new revenue streams, promote entrepreneurship, and reduce economic vulnerability.

From a social standpoint, these findings reaffirm the importance of customer-centricity in fostering strong local ties. Nanostores that build trust and deliver personalized services serve not only as economic nodes but also as social anchors in their communities. This is especially relevant in Latin America, where small businesses often double as informal safety nets.

#### E. Unique Contributions and Research Significance

1) *Novelty of the Research:* This study brings fresh insight into how nanostores can operate quality and adaptability strategies despite constraints. It fills a critical gap by applying structured management theory to informal and semi-formal retail operations, with direct relevance to HELA’s mission of applying engineering for development in vulnerable regions.[2].

2) *Practical Insights:* Clear, actionable strategies are presented for nanostore improvement. These include prioritizing agility, engaging customers, and embedding quality practices. Such strategies are directly aligned with HELA’s commitment to empowering local actors through contextual, replicable interventions. [19].

3) *Theoretical Contributions:* By quantifying both direct and mediated effects of adaptability on customer experience, this study enriches existing models of strategic agility and micro-retail management. It also opens new avenues for interdisciplinary research, where engineering, business, and social sciences intersect to drive inclusive innovation. [3].

#### F. Strategic Implications

Table XI below summarizes the key contributions of this study and their implications for enhancing customer experience

and fostering sustainable retail practices in nanostores. The table illustrates the interplay between adaptability, TQM, and customer outcomes, underscoring the importance of strategic integration.

TABLE XI  
SUMMARY OF KEY FINDINGS AND IMPLICATIONS

Contribution	Implication	Impact (Aligned with HELA)
Adaptability influences TQM practices in nanostores	Encourages training and process improvements focused on flexibility	Promotes operational resilience and supports digital transformation
TQM practices positively impact customer experience	Drives the adoption of TQM in small-scale retail	Strengthens customer loyalty and supports business sustainability
Adaptability directly influences customer satisfaction	Highlights the need for agile practices and real-time feedback	Helps nanostores thrive in dynamic and competitive markets

\*Own elaboration

In conclusion, this study underscores the essential role of adaptability and TQM in enhancing customer experience in nanostores. By combining empirical evidence with strategic insights, it presents a roadmap for building more resilient, responsive, and sustainable micro-retail systems.

The broader aim is to advance inclusiveness, sustainability, and resilience in vulnerable communities across Latin America. Although this research is grounded in data from Honduras, future HELA-aligned studies will expand the scope through new rounds of data collection in Colombia and Peru, offering a more comprehensive regional perspective.

These future efforts will deepen our understanding of how nanostores navigate digital, economic, and post-pandemic challenges—and how humanitarian engineering can support their transformation into engines of community well-being.

#### ACKNOWLEDGMENT

Supply Chain and Operations Research Group (GICSO) GI-2021-04, Faculty of Engineering, Universidad Nacional Autónoma de Honduras.

#### REFERENCES

- [1] R. Escamilla, J. C. Fransoo, and C. S. Tang, “Improving Agility, Adaptability, Alignment, Accessibility, and Affordability in Nanostore Supply Chains,” *https://doi.org/10.1111/poms.13309*, vol. 30, no. 3, pp. 676–688, Mar. 2021, doi: 10.1111/POMS.13309.
- [2] C. H. Ortega Jimenez, A. Amador Matute, J. D. Cruz-Amaya, and N. A. Melgar-Martinez, “Optimizing Nanostore Performance in Honduras: Interplay of Total Quality Management, Adaptability, and Reconfigurability,” *Proceedings of the LACCEI international Multi-conference for Engineering, Education and Technology*, 2024, doi: 10.18687/LACCEI2024.1.1.1164.
- [3] C. H. Ortega-Jiménez, A. M. Amador-Matute, J. S. Parada-López, N. A. Melgar-Martínez, and J. D. Cruz-Amaya, “Entorno competitivo de nanostores durante covid-19: adaptabilidad para mayor rendimiento en Honduras,” *Revista Universidad y Sociedad*, vol. 14, no. 6, pp. 473–483, 2022, Accessed: Jan. 25, 2025. [Online]. Available: [http://scielo.sld.cu/scielo.php?script=sci\\_arttext&pid=S2218-36202022000600473&lng=pt&nrm=iso&tlng=es](http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S2218-36202022000600473&lng=pt&nrm=iso&tlng=es)
- [4] K. Lepistö, M. Saunila, and J. Ukko, “Enhancing customer satisfaction, personnel satisfaction and company reputation with total quality management: combining traditional and new views,” *Benchmarking*, vol. 31, no. 1, pp. 75–97, Jan. 2024, doi: 10.1108/BIJ-12-2021-0749/FULL/PDF.

- [5] C. Raluca Gh Popescu, S. Oduro, D. Ernesto Salinas-Navarro, E. Vilalta-Perdomo, and R. Michel-Villarreal, "Empowering Nanostores for Competitiveness and Sustainable Communities in Emerging Countries: A Generative Artificial Intelligence Strategy Ideation Process," *Sustainability* 2024, Vol. 16, Page 11244, vol. 16, no. 24, p. 11244, Dec. 2024, doi: 10.3390/SU162411244.
- [6] I. Farida and D. Setiawan, "Business Strategies and Competitive Advantage: The Role of Performance and Innovation," *Journal of Open Innovation: Technology, Market, and Complexity* 2022, Vol. 8, Page 163, vol. 8, no. 3, p. 163, Sep. 2022, doi: 10.3390/JOITMC8030163.
- [7] C. H. Ortega-Jimenez, D. N. D1, M.-M. Sabillón Palomeque, and A. Narciso, "Implications of Smart Logistics in Nanostores: A Meta-analysis of Challenges and Opportunities for Industry 5.0 and Society 5.0," Aug. 11, 2023, doi: 10.18687/LEIRD2024.1.1.761.
- [8] E. P. Arhin and C. Cobblah, "Total quality management implementation practices and customer satisfaction: the role of innovative employee behavior and employee empowerment," *Management Research Quarterly*, vol. 1, no. 1, pp. 26–41, Apr. 2024, doi: 10.63029/CXN5XA68.
- [9] B. K. AlNuaimi, S. Kumar Singh, S. Ren, P. Budhwar, and D. Vorobyev, "Mastering digital transformation: The nexus between leadership, agility, and digital strategy," *J Bus Res*, vol. 145, pp. 636–648, Jun. 2022, doi: 10.1016/j.jbusres.2022.03.038.
- [10] A. B. E. Aichouni, C. Silva, and L. M. D. F. Ferreira, "A Systematic Literature Review of the Integration of Total Quality Management and Industry 4.0: Enhancing Sustainability Performance Through Dynamic Capabilities," *Sustainability* 2024, Vol. 16, Page 9108, vol. 16, no. 20, p. 9108, Oct. 2024, doi: 10.3390/SU16209108.
- [11] I. Shaheen, A. Azadegan, and D. F. Davis, "Resource Scarcity and Humanitarian Social Innovation: Observations from Hunger Relief in the Context of the COVID-19 Pandemic," *Journal of Business Ethics*, vol. 182, no. 3, p. 597, Jan. 2022, doi: 10.1007/S10551-021-05014-9.
- [12] S. Mehra and S. Ranganathan, "Implementing total quality management with a focus on enhancing customer satisfaction," *International Journal of Quality and Reliability Management*, vol. 25, no. 9, pp. 913–927, 2008, doi: 10.1108/02656710810908070.
- [13] S. Gupta and D. Ramachandran, "Emerging Market Retail: Transitioning from a Product-Centric to a Customer-Centric Approach," *Journal of Retailing*, vol. 97, no. 4, pp. 597–620, Dec. 2021, doi: 10.1016/J.JRETAI.2021.01.008.
- [14] V. G. Kuppelwieser, P. Klaus, A. Manthiou, and L. D. Hollebeek, "The role of customer experience in the perceived value–word-of-mouth relationship," *Journal of Services Marketing*, vol. 36, no. 3, pp. 364–378, May 2022, doi: 10.1108/JSM-11-2020-0447.
- [15] S. S. Peñaherrera Chipre and N. R. Yoza Rodríguez, "Gestión de inventarios y el control de la calidad ambiental para la rentabilidad," *Cienc Desarro*, vol. 27, no. 3, p. 525, Sep. 2024, doi: 10.21503/CYD.V27I3.2712.
- [16] A. P. Anil and K. P. Satish, "Enhancing customer satisfaction through total quality management practices—an empirical examination," *Total Quality Management and Business Excellence*, vol. 30, no. 13–14, pp. 1528–1548, Oct. 2019, doi: 10.1080/14783363.2017.1378572.
- [17] A. N. Wassan, M. S. Memon, S. I. Mari, and M. A. Kalwar, "Impact of Total Quality Management (TQM) practices on Sustainability and Organisational Performance," *Journal of Applied Research in Technology & Engineering*, vol. 3, no. 2, pp. 93–102, Jul. 2022, doi: 10.4995/JARTE.2022.17408.
- [18] F. Schiavone, M. C. Pietronudo, A. Sabetta, and M. Ferretti, "Total quality service in digital era," *TQM Journal*, vol. 35, no. 5, pp. 1170–1193, Jun. 2023, doi: 10.1108/TQM-12-2021-0377/FULL/PDF.
- [19] S. Valenzuela and I. Bachmann, "Path Analysis," *The International Encyclopedia of Communication Research Methods*, pp. 1–9, Nov. 2017, doi: 10.1002/9781118901731.IECRM0181.
- [20] M. Parhan and A. Bakhtiar, "The Relationship Between Total Quality Management and Customer Satisfaction Through the Mediation of Employee Performance," *Jurnal Teknik Industri*, vol. 25, no. 2, pp. 161–172, Aug. 2024, doi: 10.22219/JTIUMM.VOL25.NO2.161-172.