Service Quality and Digital Technology Innovation in Chinese SMEs: The Moderating Role of Human-AI Collaboration – a SERVQUAL-Based Study

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Article

Service Quality and Digital Technology Innovation in Chinese SMEs: The Moderating Role of Human-AI Collaboration—A SERVQUAL-Based Study

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Abstract: This study investigates the relationship between service quality and digital technology innovation in Chinese Small and Medium-sized Enterprises (SMEs), with Human-AI collaboration as a moderating variable. Using the SERVQUAL framework, we collected data from 278 technology-oriented SMEs across China's major economic regions. Structural equation modeling reveals that service quality significantly influences digital technology innovation capabilities ($\beta = 0.426$, $p < 0.001$). Furthermore, the degree of Human-AI collaboration positively moderates this relationship ($\beta = 0.217$, $p < 0.01$), amplifying the positive effects of service quality on innovation outcomes. The findings suggest that Chinese SMEs can enhance their innovation performance by simultaneously improving service quality dimensions and strategically implementing Human-AI collaborative systems. This study contributes to the emerging literature on service-innovation linkages in the context of digital transformation and provides actionable insights for SME managers navigating the rapidly evolving technological landscape in China.

Keywords: Service quality; Digital technology innovation; Human-AI collaboration; SERVQUAL; Chinese SMEs; Structural equation modeling

1. Introduction

The digital transformation of Small and Medium-sized Enterprises (SMEs) has become a critical factor in determining competitive advantage in today's global economy (Li et al., 2021). In China, technology-oriented SMEs face intense pressure to innovate while maintaining high service quality standards to meet increasingly sophisticated customer demands (Zhao & Zhou, 2023). Despite the growing importance of both service excellence and digital innovation, research examining their interconnection remains limited, particularly in the Chinese context.

The integration of artificial intelligence (AI) into business processes offers promising opportunities for enhancing both service quality and innovation capabilities (Wang et al., 2022). However, the optimal implementation of AI systems requires effective collaboration between human employees and AI technologies, creating a synergistic relationship that may potentially moderate the service quality-innovation link. This human-AI collaborative approach represents a paradigm shift in how organizations leverage technological capabilities while preserving human expertise and creativity.

This study addresses significant research gaps by: (1) empirically examining the relationship between service quality dimensions and digital technology innovation in Chinese SMEs; (2) investigating the moderating effect of Human-AI collaboration on this relationship; and (3) developing a comprehensive framework that integrates SERVQUAL dimensions with innovation theory in the context of digital transformation. The findings offer both theoretical contributions to the literature and practical implications for SME managers and policymakers in China's rapidly evolving technology sector.

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2. Related Work and Theoretical Support

2.1. Service Quality and the SERVQUAL Framework

The SERVQUAL framework, originally developed by Parasuraman et al. (1988), has been widely adopted to measure service quality across multiple dimensions including reliability, responsiveness, assurance, empathy, and tangibles. In the context of technology-oriented businesses, the SERVQUAL model has been adapted to evaluate digital service quality (Blut, 2016). Wu and Ding (2021) applied modified SERVQUAL dimensions to assess service quality in Chinese technology firms, finding significant associations with customer satisfaction and loyalty.

2.2. Digital Technology Innovation

Digital technology innovation encompasses the development and implementation of novel digital solutions, processes, or business models that create value for organizations and their stakeholders (Nambisan et al., 2019). For SMEs, digital innovation capabilities are increasingly vital for survival and growth in competitive markets (Lee et al., 2022). Recent studies have identified several dimensions of digital technology innovation, including product/service innovation, process innovation, and business model innovation (Yoo et al., 2020).

2.3. Human-AI Collaboration

Human-AI collaboration represents an emerging paradigm in which human capabilities are augmented rather than replaced by AI technologies (Wang, 2021). This collaborative approach combines human creativity, contextual understanding, and ethical judgment with AI's computational power, pattern recognition, and data processing capabilities (Zhang et al., 2022). Recent research suggests that effective Human-AI collaboration can enhance organizational performance across multiple domains (Liu & Chen, 2023).

2.4. Service Quality and Innovation: Theoretical Linkages

The relationship between service quality and innovation can be theoretically grounded in the resource-based view (RBV) of the firm (Barney, 1991) and dynamic capabilities theory (Teece et al., 1997). According to the RBV, superior service quality represents a valuable, rare, and difficult-to-imitate resource that can provide competitive advantage. Dynamic capabilities theory extends this perspective by emphasizing organizations' ability to integrate, build, and reconfigure competencies to address rapidly changing environments—a capacity essential for innovation.

Service quality can drive innovation through several mechanisms: (1) customer feedback obtained through service interactions provides valuable insights for innovation (Gustafsson et al., 2020); (2) service excellence creates organizational learning that spills over into innovation capabilities (Santos-Vijande et al., 2012); and (3) the organizational culture and processes that support high service quality often foster innovation-friendly environments (Tsou & Chen, 2020).

3. Literature Review and Variable Relationships

3.1. SERVQUAL Dimensions and Digital Innovation

Previous studies have explored connections between individual SERVQUAL dimensions and innovation outcomes. Zhang and Wang (2020) found that responsiveness and reliability in service delivery positively influenced Chinese firms' innovation performance. Similarly, Chen et al. (2022) demonstrated that empathy and assurance dimensions of service quality contributed to enhanced innovation capabilities in technology companies.

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3.2. The Moderating Role of Human-AI Collaboration

Research on Human-AI collaboration suggests its potential as a moderating factor in organizational performance relationships. Li and Zhang (2023) found that Human-AI collaborative systems strengthened the relationship between knowledge management and innovation in Chinese enterprises. Wang et al. (2021) demonstrated that Human-AI collaboration enhanced the impact of market orientation on new product development success.

3.3. Hypotheses Development

Based on the theoretical foundations and prior empirical evidence, we propose the following hypotheses:

H1: *Service quality (as measured by SERVQUAL dimensions) positively influences digital technology innovation in Chinese SMEs.*

H2: *Human-AI collaboration positively moderates the relationship between service quality and digital technology innovation in Chinese SMEs.*

4. Methodology

4.1. Sample Selection and Data Sources

Data were collected through a structured questionnaire administered to managers and technical directors of technology-oriented SMEs in China between September 2023 and February 2024. Using stratified random sampling from a comprehensive database of Chinese SMEs, we selected firms from four major economic regions: the Yangtze River Delta, Pearl River Delta, Beijing-Tianjin-Hebei region, and Chengdu-Chongqing economic circle.

From an initial contact list of 650 companies, 278 valid responses were obtained (effective response rate: 42.8%). The sample characteristics are presented in Table 1, showing a balanced representation across regions, firm sizes, and technology sectors.

Table 1. Sample Characteristics.

Characteristic	*Category*	*Frequency*	*Percentage*
Region	Yangtze River Delta	83	29.9%
	Pearl River Delta	76	27.3%
	Beijing-Tianjin-Hebei	65	23.4%
	Chengdu-Chongqing	54	19.4%
Firm Size	10-49 employees	112	40.3%
	50-99 employees	95	34.2%
	100-249 employees	71	25.5%
Technology Sector	Software/IT services	98	35.3%
	Advanced manufacturing	73	26.3%
	E-commerce	58	20.9%
	Fintech	49	17.6%

4.2. Model Design and Definition of Variables

4.2.1. Measurement Instrument Development

The measurement instrument was developed based on established scales from the literature with modifications to suit the Chinese SME context. The questionnaire was initially developed in English, translated into Chinese, and then back-translated to ensure conceptual equivalence. A pilot test with 25 managers was conducted to refine the instrument before full-scale implementation.

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4.2.2. Variable Measurements

Service Quality (SQ): Measured using a modified SERVQUAL scale with five dimensions: reliability (SQ1-SQ3), responsiveness (SQ4-SQ6), assurance (SQ7-SQ9), empathy (SQ10-SQ12), and tangibles (SQ13-SQ15). All items were rated on a 7-point Likert scale.

Digital Technology Innovation (DTI): Assessed through three dimensions: product/service innovation (DTI1-DTI3), process innovation (DTI4-DTI6), and business model innovation (DTI7-DTI9). Items were adapted from Lee et al. (2022) and measured on a 7-point Likert scale.

Human-AI Collaboration (HAC): Measured using a scale developed by Zhang et al. (2022) with modifications, encompassing implementation level (HAC1-HAC3), integration quality (HAC4-HAC6), and collaborative practices (HAC7-HAC9). Items were rated on a 7-point Likert scale.

Control Variables: Firm size (number of employees), firm age (years since establishment), technology sector, and R&D intensity (R&D expenditure as a percentage of total revenue).

Table 2 presents the measurement items for each variable with their corresponding descriptive statistics.

Table 2. Measurement Items and Descriptive Statistics.

Construct	*Items*	*Measurement*	*Mean*	*SD*
Service Quality - Reliability	SQ1	Our company provides services as promised	5.48	1.02
	SQ2	Our services are delivered right the first time	5.36	1.14
	SQ3	Our customer service records are error-free	5.27	1.08
Service Quality - Responsiveness	SQ4	We inform customers exactly when services will be performed	5.64	0.98
	SQ5	Our staff provide prompt service to customers	5.52	1.05
	SQ6	Our staff are always willing to help customers	5.71	0.94
Service Quality - Assurance	SQ7	Our staff behavior instills confidence in customers	5.43	1.12
	SQ8	Customers feel secure in their transactions with us	5.58	1.01
	SQ9	Our staff are consistently courteous	5.62	0.97
Service Quality - Empathy	SQ10	We give customers individual attention	5.37	1.09
	SQ11	We have customers' best interests at heart	5.49	1.03
	SQ12	Our staff understand customers' specific needs	5.31	1.11
Service Quality - Tangibles	SQ13	Our physical/digital facilities are visually appealing	5.28	1.15
	SQ14	Our staff appear professional	5.47	1.04
	SQ15	Our service materials are visually appealing	5.22	1.18
Digital Technology Innovation - Product/Service	DTI1	We frequently introduce new digital products/services	5.12	1.21
	DTI2	Our digital product/service innovations are often radical	4.87	1.32
	DTI3	We pioneer digital solutions in our market	4.93	1.27
Digital Technology Innovation - Process	DTI4	We implement advanced digital technologies in our operations	5.06	1.19

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Digital Technology Innovation - Business Model	DTI5	We continuously improve our digital processes	5.21	1.13
	DTI6	Our process technologies are state-of-the-art	4.95	1.24
	DTI7	We innovate our digital business models	4.82	1.29
	DTI8	We create new digital revenue streams	4.79	1.31
	DTI9	We disrupt traditional value chains through digital innovation	4.76	1.35
Human-AI Collaboration - Implementation	HAC1	We have implemented AI systems that collaborate with human employees	4.58	1.42
	HAC2	Our AI systems are designed for human-AI teamwork	4.45	1.47
	HAC3	We have formalized Human-AI collaborative workflows	4.31	1.53
Human-AI Collaboration - Integration	HAC4	Our human and AI capabilities are well-integrated	4.37	1.49
	HAC5	AI and human decision-making are complementary in our firm	4.52	1.45
	HAC6	We balance AI automation with human expertise	4.63	1.38
Human-AI Collaboration - Practices	HAC7	Our employees are trained to work effectively with AI systems	4.49	1.44
	HAC8	We have protocols for resolving human-AI disagreements	4.33	1.51
	HAC9	We measure the performance of Human-AI collaborative teams	4.28	1.54

5. Results and Findings

5.1. Descriptive Statistics

Table 3 presents the descriptive statistics, including means, standard deviations, and correlations for the main constructs. The correlation matrix shows significant positive correlations between service quality, digital technology innovation, and Human-AI collaboration, providing preliminary support for our hypotheses.

Table 3. Descriptive Statistics and Correlations.

Construct	*Mean*	*SD*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1. SQ-Reliability	5.37	1.08	1.00								
2. SQ-Responsiveness	5.62	0.99	0.52**	1.00							
3. SQ-Assurance	5.54	1.03	0.48**	0.56**	1.00						
4. SQ-Empathy	5.39	1.07	0.45**	0.49**	0.51**	1.00					
5. SQ-Tangibles	5.32	1.12	0.41**	0.38**	0.42**	0.44**	1.00				
6. DTI-Product/Service	4.97	1.27	0.36**	0.39**	0.35**	0.33**	0.29**	1.00			
7. DTI-Process	5.07	1.19	0.38**	0.42**	0.37**	0.34**	0.31**	0.57**	1.00		
8. DTI-Business Model	4.79	1.32	0.32**	0.34**	0.30**	0.29**	0.27**	0.54**	0.52**	1.00	
9. Human-AI Collaboration	4.44	1.45	0.29**	0.31**	0.28**	0.30**	0.26**	0.43**	0.46**	0.48**	1.00

Note: ** $p < 0.01$.

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5.2. Measurement Model Assessment

5.2.1. Reliability and Validity Analysis

Before hypothesis testing, we conducted confirmatory factor analysis (CFA) using AMOS 26.0 to assess the measurement model. Table 4 presents the reliability and validity statistics for the constructs.

Table 4. Reliability and Validity Analysis.

Construct	*Cronbach's α*	*CR*	*AVE*	*MSV*
SQ-Reliability	0.89	0.91	0.77	0.42
SQ-Responsiveness	0.87	0.90	0.75	0.47
SQ-Assurance	0.85	0.88	0.72	0.43
SQ-Empathy	0.88	0.91	0.76	0.39
SQ-Tangibles	0.84	0.87	0.70	0.36
DTI-Product/Service	0.91	0.94	0.83	0.48
DTI-Process	0.90	0.93	0.81	0.45
DTI-Business Model	0.92	0.94	0.84	0.42
Human-AI Collaboration	0.94	0.95	0.72	0.51

Note: CR = Composite Reliability; AVE = Average Variance Extracted; MSV = Maximum Shared Variance.

All constructs demonstrated good reliability with Cronbach's α and composite reliability (CR) values exceeding the recommended threshold of 0.7. Convergent validity was confirmed with average variance extracted (AVE) values above 0.5. Discriminant validity was established as all AVE values exceeded the corresponding maximum shared variance (MSV).

5.2.2. KMO and Bartlett's Test

Principal component analysis was performed to examine the factor structure. Table 5 presents the KMO and Bartlett's test results.

Table 5. KMO and Bartlett's Test Results.

Test	*Value*
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.878
Bartlett's Test of Sphericity - Approx. Chi-Square	7629.43
Bartlett's Test of Sphericity - df	630
Bartlett's Test of Sphericity - Sig.	0.000

The KMO value of 0.878 exceeds the recommended threshold of 0.6, and Bartlett's test is significant ($p < 0.001$), indicating that the data is suitable for factor analysis.

5.3. Structural Model and Hypothesis Testing

5.3.1. Model Fit Indices

We tested the structural model using maximum likelihood estimation in AMOS 26.0. Table 6 presents the model fit indices.

Table 6. Model Fit Indices.

Fit Index	*Value*	*Threshold*	*Interpretation*
Chi-square/df	2.31	< 3.0	Good fit
CFI	0.942	> 0.90	Good fit
TLI	0.935	> 0.90	Good fit

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RMSEA	0.058	< 0.08	Good fit
SRMR	0.046	< 0.08	Good fit
GFI	0.926	> 0.90	Good fit
AGFI	0.913	> 0.90	Good fit

All fit indices meet the recommended thresholds, indicating that the model provides a good fit to the data.

5.3.2. Hypothesis Testing Results

Table 7 presents the results of the hypothesis testing based on the structural equation modeling analysis.

Table 7. Hypothesis Testing Results.

Hypothesis	***Path***	***Standardized Coefficient (β)***	***t-value***	***p-value***	***Result***
H1	Service Quality → Digital Technology Innovation	0.426	6.83	< 0.001	Supported
H2	Service Quality × Human-AI Collaboration → Digital Technology Innovation	0.217	3.45	< 0.01	Supported

Control variables:

Path	***Standardized Coefficient (β)***	***t-value***	***p-value***
Firm Size → Digital Technology Innovation	0.122	2.14	< 0.05
Firm Age → Digital Technology Innovation	-0.084	-1.47	> 0.05
R&D Intensity → Digital Technology Innovation	0.175	2.98	< 0.01

Notes. The results confirm both hypotheses. H1 is supported, as service quality has a significant positive effect on digital technology innovation ($\beta = 0.426$, $p < 0.001$). H2 is also supported, with Human-AI collaboration positively moderating the relationship between service quality and digital technology innovation ($\beta = 0.217$, $p < 0.01$).

To visualize the moderating effect, we plotted the relationship between service quality and digital technology innovation at high (+1 SD) and low (-1 SD) levels of Human-AI collaboration. Figure 1 demonstrates that the positive relationship between service quality and digital technology innovation is stronger when Human-AI collaboration is high, confirming the enhancing effect of this moderator.

6. Discussion and Implications

6.1. Theoretical Implications

This study makes several theoretical contributions. First, it empirically validates the positive relationship between service quality and digital technology innovation in Chinese SMEs, extending the service-innovation literature to the digital transformation context. Second, it identifies Human-AI collaboration as a significant moderator, introducing a novel contingency factor in the service quality-innovation relationship. Third, it demonstrates the applicability of the SERVQUAL framework in measuring service quality in technology-oriented SMEs, offering a validated measurement approach for future research.

The findings align with the resource-based view and dynamic capabilities theory, suggesting that service quality represents a valuable organizational capability that drives innovation performance. Additionally, the moderating effect of Human-AI collaboration supports the emerging theoretical perspective that technological integration enhances organizational capabilities when properly implemented as collaborative systems rather than mere automation tools.

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6.2. Practical Implications

For managers of Chinese SMEs, this study offers several actionable insights. First, investing in service quality improvement yields dividends beyond customer satisfaction, positively influencing innovation capabilities. Second, the moderating effect of Human-AI collaboration highlights the importance of implementing AI systems that complement rather than replace human expertise. SMEs should develop integrated approaches where AI augments human capabilities in both service delivery and innovation processes.

The differential impact of various SERVQUAL dimensions suggests that managers should prioritize responsive and reliable service aspects when seeking to enhance innovation outcomes. Furthermore, the finding that Human-AI collaboration strengthens the service quality-innovation link provides empirical support for technology implementation strategies that emphasize collaborative approaches rather than pure automation.

7. Policy Recommendations

Based on our findings, we propose several policy recommendations to support the digital transformation of Chinese SMEs:

1. Government agencies should develop targeted support programs that help SMEs enhance service quality while simultaneously building digital innovation capabilities, recognizing the synergistic relationship between these domains.
2. Innovation policy should prioritize Human-AI collaborative approaches over pure automation, potentially through incentive programs that reward companies implementing effective Human-AI integration rather than merely adopting AI technologies.
3. Educational and training initiatives should be established to develop the specific skills required for effective Human-AI collaboration in service contexts, addressing the talent gap that may hinder SMEs' digital transformation.
4. Regulatory frameworks should be designed to encourage responsible AI adoption that preserves human oversight and collaborative decision-making, particularly in service-oriented business models.

8. Conclusion

This study investigated the relationship between service quality and digital technology innovation in Chinese SMEs, with Human-AI collaboration as a moderating variable. The results confirm that service quality positively influences digital innovation capabilities, and this relationship is strengthened when firms implement effective Human-AI collaborative systems. These findings contribute to both theoretical understanding and practical management of the service-innovation nexus in the context of digital transformation.

While providing valuable insights, the study has limitations that suggest directions for future research. The cross-sectional design limits causal inference; longitudinal studies could better capture the dynamic nature of the relationships examined. Additionally, future research could explore the potential differential effects of various Human-AI collaboration models and investigate the applicability of our findings to other emerging economies and larger enterprises.

Despite these limitations, this study advances our understanding of how Chinese SMEs can leverage service quality and Human-AI collaboration to enhance their digital innovation performance, offering a foundation for further research and practical implementation in this rapidly evolving domain.

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