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How New Quality Productive Forces Drive SMEs' Collaborative Innovation Performance in China?

Xinxiang Gao [1][0009-0002-9100-3575], Jiawen Yu [2,3][0009-0007-7567-1561], Xiaoyi Liu [1*,4], Lili Xiao [5]

**Corresponding Author*

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[1] School of Financial and Management, Sichuan University of Arts and Science, Dazhou City, Sichuan Province,635000, China
[2] School of Chinese and International Education, Guangzhou International Economics College, Guangzhou, 510540, China
[3] Faculty of Education, Language, Psychology, and Music, SEGi University, Petaling Jaya, Selangor,47810, Malaysia
[4] Faculty of Business Administration, City University of Malaysia, Menara City U, No. 8, Jalan 51A/223, 46100 Petaling Jaya, Selangor Darul Ehsan, Malaysia
[5] Office of Science and Technology, Sichuan University of Arts and Science, Dazhou City, Sichuan Province,635000, China
Email of All Authors: Mark1870064@gmail.com; yujiawencarmen@gmail.com; 14658644@qq.com; 1056873651@qq.com
Tel: +601136876891

Abstract 10AN

This study focuses on the Chengdu-Chongqing Economic Circle, a key area in China's national regional integration strategy, to examine how new quality productive forces (NQPF) and digital transformation (DT) affect the collaborative innovation performance (CIP) of SMEs. Based on dynamic capability and collaborative innovation theory, this study employs a purposive sampling strategy and conducts a cross-sectional questionnaire survey among 314 SMEs. The findings reveal that NQPF significantly enhances CIP and has a positive impact on DT; meanwhile, DT directly promotes CIP, DT mediates the relationship between NQPF and CIP. This study includes recommendations, limitations and future research prospects. (98words)

Keywords: New Quality Productive Forces; Collaborative Innovation Performance; Digital Transformation; SMEs

DOI:

Body of the paper (3336 words)

1.0 Introduction

1.1 Background of the Study

In the context of China's transition toward high-quality development, the Chengdu-Chongqing Economic Circle (CCEC) has been designated as a national pilot zone for regional integration and innovation-driven growth. As one of China's most strategically important urban clusters, the CCEC plays a vital role in promoting synergistic industrial development and stimulating innovation across SMEs (Liu et al., 2023). Amid this regional momentum, the enhancement of collaborative innovation performance (CIP) among SMEs has emerged as a key enabler of sustainable economic competitiveness and ecosystem resilience.

To achieve regional innovation synergies, a new form of productivity, termed New Quality Productive Forces (NQPF), has been proposed by the Chinese leadership as a driver of transformative change. Rooted in technological breakthroughs, innovative factor configurations, and deep industrial upgrading, NQPF emphasizes a fundamental restructuring of production dynamics to achieve substantial improvements in total factor productivity (TFP) (Xi, 2023). It signals a paradigm shift from quantity-focused growth to quality-oriented innovation, particularly relevant for technology-intensive industries and emerging clusters.

At the organizational level, digital transformation (DT) has become a vital vehicle for actualizing the strategic potential of NQPF by enhancing firms' ability to integrate resources, respond to dynamic environments, and co-create value through inter-organizational innovation (Vial, 2019). For SMEs in the CCEC, digital platforms, intelligent manufacturing, and cloud-based collaboration tools have

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not only lowered innovation costs but also facilitated cross-regional and cross-sectoral innovation partnerships. As such, DT is increasingly recognized as a mediating capability that links national innovation strategies with firm-level innovation outcomes.

1.2 Problem Statement and Research Objectives

As China accelerates its modernization and regional integration strategies, the CCEC has emerged as a pivotal region for industrial transformation, cross-border collaboration, and technological advancement. Yet, despite intensive policy attention and investment, the CIP of SMEs in this region remains fragmented, uneven, and often disconnected from national innovation priorities. Many SMEs in the CCEC lack the systemic capacity to convert strategic inputs into synergistic innovation outputs, especially in the face of increasing market volatility, rising technological complexity, and global value chain restructuring.

Theoretically, NQPF—driven by disruptive technologies, novel factor configurations, and deep industrial upgrading—offer a promising foundation for enhancing innovation effectiveness. However, empirical research on how NQPF directly influences enterprise-level collaborative outcomes remains scarce, especially in emerging inland urban clusters like the CCEC. Additionally, the translation of macro-level strategic productivity goals into micro-level performance metrics remains poorly understood (Gao et al.,2023).

Concurrently, DT has been widely acknowledged as a catalyst for innovation network reconfiguration, real-time resource integration, and inter-organizational knowledge sharing (Vial, 2019). Yet, SMEs in the CCEC exhibit varying levels of digital maturity, and few studies have explored whether DT acts as a mediating mechanism between NQPF and CIP, particularly in multi-industry and cross-city collaboration contexts. This gap leaves a critical question unanswered: under what conditions and mechanisms can NQPF be effectively translated into collaborative innovation benefits through DT? In response to the challenges and theoretical gaps, this research objectives: RO1) To examine NQPF on the CIP of SMEs in the Chengdu-Chongqing Economic Circle. RO2) To investigate the influence of NQPF on SMEs' DT. RO3) To assess the impact of DT on CIP among SMEs. RO4) To determine the mediating role of DT in the relationship between NQPF and CIP.

2.0 Literature Review

2.1 Theoretical Foundation

This study grounded in Dynamic Capability Theory (DCT), Collaborative Innovation Theory (CIT), and the emerging theoretical perspective of NQPF, collectively provide a robust framework for explaining the mechanisms through which DT mediates the relationship between NQPF and CIP in SMEs.

Originally proposed by Teece (2007), DCT, referring how enterprises adjust, integrate, and reconfigure internal and external capabilities to address fast switching environments. In this research, DCT helps interpret how SMEs leverage NQPF as a form of strategic capability to sense technological changes, seize opportunities, and transform internal processes. DT, a dynamic capability, illustrates the ability of enterprise to realign its processes, technologies, and organizational routines in response to digital pressures. Therefore, DCT underpins the mechanism by which NQPF enhances SMEs' capabilities to engage in DT and achieve superior innovation outcomes.

CIT emphasizes the value of inter-organizational collaboration, knowledge exchange, and shared innovation processes in enhancing firms' innovation performance (Chesbrough, 2006). Under the regional integration strategy of the Chengdu-Chongqing Economic Circle, collaborative innovation is particularly relevant, as SMEs are encouraged to build partnerships with universities, research institutes, and platform enterprises to improve innovation outcomes (Wang et al., 2024). DT facilitates such collaboration by enabling real-time communication, resource sharing, and coordinated development across organizational boundaries. CIT therefore supports the hypothesized direct effect of DT on CIP, and its mediating role in linking NQPF to innovation outcomes.

NQPF represents a newly proposed conceptual framework in China's high-quality development agenda. It emphasizes breakthroughs in technology, innovative allocation of production factors, and deep industrial transformation, with a particular focus on significantly improving total factor productivity (Gao et al.,2024). Unlike traditional productivity, NQPF integrates digital, intelligent, and green dimensions into enterprise development strategies (Liu et al., 2023). It acts as a strategic driver for dynamic capabilities and collaborative innovation by reshaping how firms combine labor, capital, and data as key inputs. This research positions NQPF as the foundational variable, triggering a chain of strategic responses that culminate in innovation performance, especially within the context of regional innovation ecosystems(Gao, 2024).

DCT provides the logic of enterprise capacity reconfiguration, CIT outlines the structure of innovation collaboration, and the theoretical lens of NQPF aligns with China's modernization strategy by defining the structural forces behind productivity transformation. Together, these theories form the conceptual backbone of this study and guide the formulation of hypotheses and model design.

2.2 Hypothesis Development

NQPF and CIP

NQPF as emphasized by Xi (2023), are characterized by revolutionary technological breakthroughs, innovative reallocation of production factors, and deep industrial transformation. These forces redefine productivity by integrating intelligent labor, digital tools, and high-value data assets. In the context of regional economic zones like the Chengdu-Chongqing Economic Circle, such transformation promotes ecosystem-wide collaboration. According to Teece (2007), dynamic capabilities rooted in such forces enable firms to reconfigure resources and respond to innovation opportunities collaboratively. Prior studies have confirmed that innovation-oriented productivity directly enhances a firm's collaborative performance with partners (Wang et al., 2024).

H1: NQPF positively influence CIP.

NQPF and DT

The integration of digital technologies is a central mechanism by which NQPF are operationalized. Digital platforms, AI, cloud computing, and big data analytics are not only tools but also representations of productivity reconfiguration. From the perspective of dynamic capability theory, the ability to absorb and deploy emerging technologies depends on firms' innovation-driven productive capacity (Teece, 2007). As industries shift toward intelligence-driven and data-enabled models, DT becomes a natural pathway through which enterprises actualize the core functions of NQPF (Liu et al., 2023).

H2: NQPF positively influence DT.

DT and CIP

DT empowers SMEs to transcend organizational boundaries, enabling real-time information sharing, co-creation, and cross-industry innovation. Through digital interfaces and platforms, firms enhance resource orchestration and reduce coordination costs, thereby improving CIP (Chesbrough, 2006). In collaborative networks, the more digitally transformed a firm is, the more it can participate in and contribute to joint innovation activities. Thus, digital maturity becomes a strategic enabler of collaborative output.

H3: DT positively influences CIP.

The Mediating Role of DT

Given the above relationships, DT may serve as a mediating mechanism linking NQPF to collaborative innovation outcomes. While NQPF provide the foundational capabilities and strategic intent, DT operationalizes these capabilities into actionable innovation processes. This sequential linkage aligns with the dynamic capability view, where resources must be transformed and embedded into digital routines to generate performance benefits (Teece, 2007; Liu et al., 2023). In the context of the Chengdu-Chongqing regional innovation ecosystem, this mediation is critical in explaining how structural productivity translates into inter-organizational collaboration.

H4: DT mediates the relationship between NQPF and CIP.

Therefore, the research model of this study is shown in Figure 1.

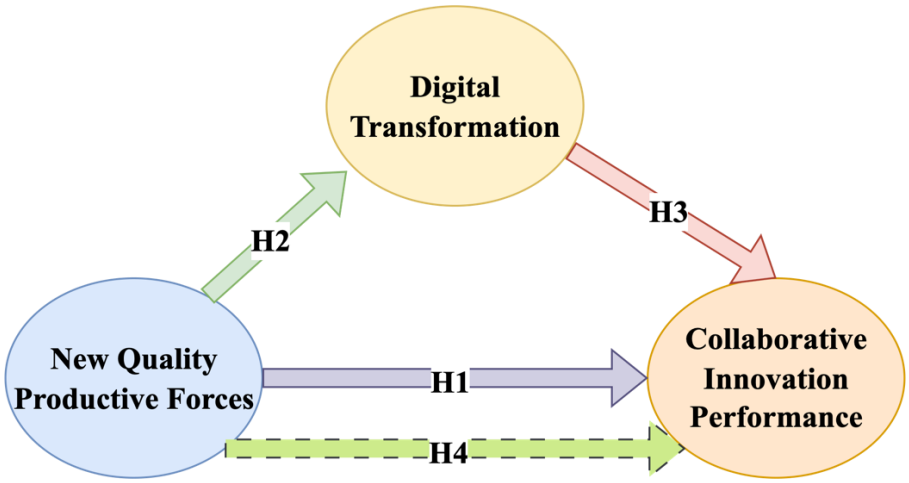

Fig. 1: Research model

3.0 Methodology

3.1 Sampling and Data Collection

*The research targeted a population of over two million SMEs situated in the CCEC, as documented by the National Bureau of Statistics of China (2024). Owing to the vast scale and geographic dispersion of this group, a purposive sampling method was adopted to select SMEs with active participation in digital transformation and collaborative innovation. This non-random sampling technique was appropriate for selecting participants with specialized expertise aligned with the study's objectives (Palinkas et al., 2015). G*Power 3.1.9.7 was utilized, applying power of 0.95, computed minimum sample size was 129. Supported by local industrial zones and government agencies, the research team distributed 600 paper-based questionnaires through face-to-face administration between February and May 2025. This data collection method enhanced item clarity and reduced the likelihood of missing data. Ultimately, 314 valid responses were obtained, resulting in a 52.33% response rate. Among the respondents, 29.62% (n = 93) were executives, 61.14% (n = 192) were mid-level managers, and 9.24% (n = 29) were technical personnel.*

3.2 Measurement Instruments and Data Analysis Techniques

All constructs in this study were evaluated using multiple items based on prior validated scales, measured on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). To ensure accuracy across languages, a double translation procedure following Brislin (1986) was used, translating the English version into Chinese and then back-translated to verify semantic equivalence. The NQPF variable included nine indicators from Cheng et al. (2025), reflecting advanced technological development, restructuring of industrial systems, reallocation of inputs, and improvements in overall productivity. DT was measured using five items derived from Merín-Rodrigáñez et al. (2024), highlighting digital integration, operational redesign, and business model shifts. The measurement of CIP relied on four items adapted from Liu et al. (2021), covering innovation efficiency, inter-firm collaboration, and partnership satisfaction.Before large-scale data collection, a small-scale pilot with 40 SMEs was conducted to refine the instrument. The internal consistency of each

construct was verified with Cronbach's alpha exceeding 0.70 (Hair et al., 2021), indicating strong reliability: NQPF = 0.92, DT = 0.89, CIP = 0.87. To address concerns related to common method bias (CMB). Harman's single-factor test results indicated that the first factor accounted for only 36.4% of the total variance, which is below the critical threshold of 50%, suggesting that CMB was not a significant concern (Podsakoff et al., 2003). This study combination of SPSS and PLS-SEM was utilized to analyze the collected data.

4.0 Findings

4.1 Descriptive Analysis Results

Table 1 presents the outcomes of the descriptive statistics and correlation analysis. The mean for NQPF, DT and CIP were 4.271, 4.527, and 4.437, respectively, suggesting that respondents generally held positive perceptions of these dimensions. By Kline (2011), the skewness and kurtosis values for all variables fell within acceptable thresholds (i.e., skewness < 3.0 and kurtosis < 10.0), indicating no significant deviations from normality. Moreover, the strongest bivariate correlation observed was 0.781, which did not exceed the critical value for multicollinearity concerns, thus confirming the appropriateness of the dataset for further multivariate analysis.

Table 1. Descriptive statistics and correlation analysis

	Mean	SD	Skewness	Kurtosis	1	2	3	4	5	6
1. NQPF	4.271	0.693	0.714	-0.598	1					
2. DT	4.527	0.714	0.529	-0.443	0.651	1				
3. CIP	4.437	0.762	0.972	-1.124	0.693	0.581	1			

4.2 Measurement Model Results

The measurement model was first tested for four aspects: indicator reliability, construct reliability, convergent validity, and discriminant validity. As presented in Table 2 and Figure 2, all factor loadings ranged from 0.743 to 0.878, surpassing the 0.70 threshold (Hair et al., 2022), indicating satisfactory item reliability. In line with Rahman et al. (2020), Cronbach's alpha and CR were used to assess internal consistency, with all values exceeding the 0.70 standard (Nunnally & Bernstein, 1994). These results confirm robust reliability and stable measurement across constructs.

Table 1. Construct validity and reliability.

Structure	Items	Factor Loadings	Alpha	CR	AVE
New Quality Productive Forces	NQPF1	0.847	0.942	0.945	0.683
	NQPF2	0.877			
	NQPF3	0.837			
	NQPF4	0.743			
	NQPF5	0.849			
	NQPF6	0.864			
	NQPF7	0.822			
	NQPF8	0.764			
	NQPF9	0.823			
Digital Transformation	DT1	0.771	0.893	0.896	0.702
	DT2	0.849			
	DT3	0.856			
	DT4	0.832			
	DT5	0.878			
Collaborative Innovation Performance	CIP1	0.787	0.869	0.872	0.719
	CIP2	0.873			
	CIP3	0.854			
	CIP4	0.874			

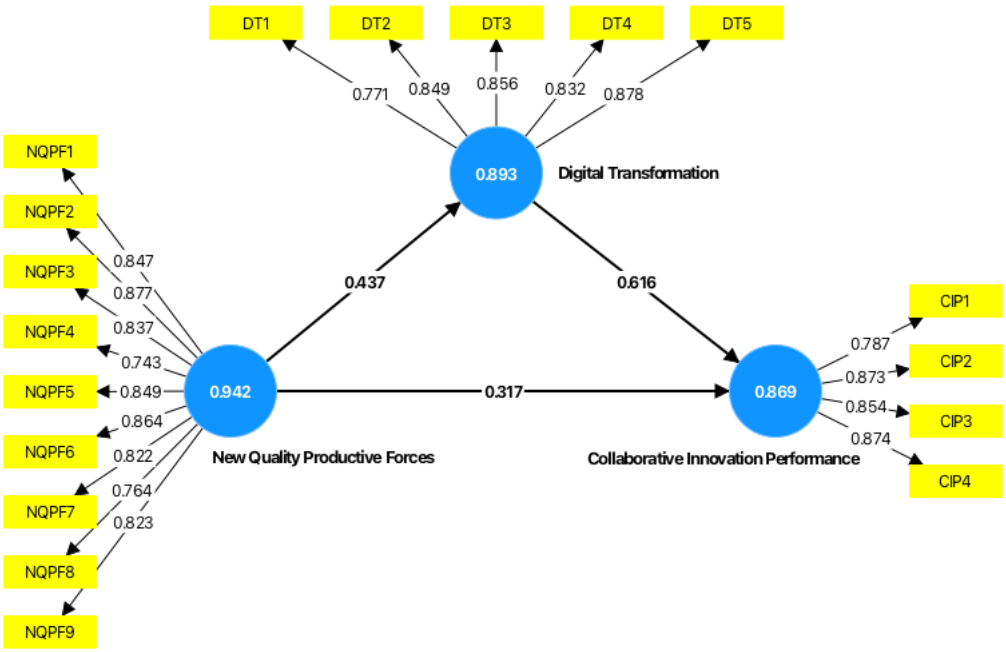

Fig. 2: Factor Loadings and Cronbach's alpha

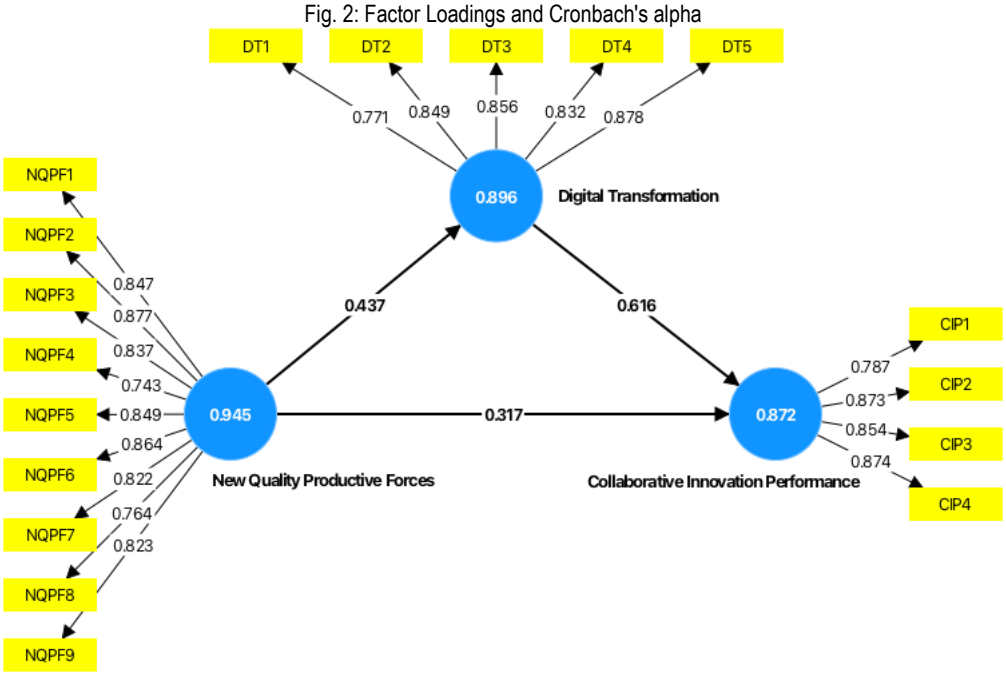

Fig. 3 Factor Loadings and Composite Reliability

Convergent validity was assessed using AVE values, which ranged from 0.683 to 0.702, exceeding the 0.50 cutoff (Hair et al., 2022). For discriminant validity, the HTMT criterion was applied following Henseler et al. (2016), with all values falling below 0.85, indicating sufficient distinction between constructs. Additionally, all VIF scores were under 5 (see Table 4), confirming no multicollinearity and supporting the model's robustness (Hair et al., 2022).

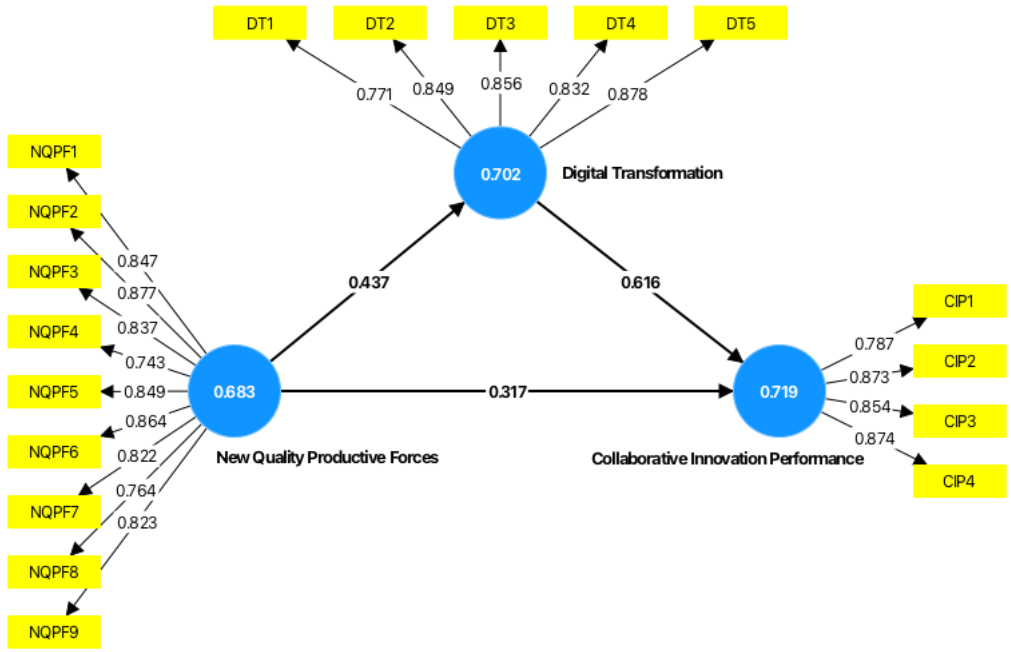

Fig. 4 Factor Loadings and AVE.

Table 3. HTMT criterion and VIF.

	CIP	DT	NQPF	VIF
CIP				1.237
DT	0.559			1.237
NQPF	0.383	0.379		1.000

4.3 Structural Model Results

Once the reliability and validity of the measurement model were confirmed, the structural model was evaluated using SmartPLS through a bootstrapping procedure with 5000 resamples (Hair et al., 2022). This stage focused on testing the hypothesized relationships by examining path coefficients along with their significance values. Hypotheses were considered supported when the p-value was less than 0.05 or the t-statistic exceeded 1.96 (Hair et al., 2022). Detailed outcomes of this analysis are shown in Table 5 and illustrated in Figure 4.

Table 4. Direct and indirect hypotheses testing results.

NO.	Structural Path	Coefficient	T-statistics	Test result
H1	QPFN → CIP	0.317***	12.244	Supported
H2	QPFN → DT	0.437***	12.167	Supported
H3	DT → CIP	0.616***	26.698	supported
H4	QPFN→DT→CIP	0.269***	12.676	Supported

1 Notes: *p <0.05, **p <0.01, ***p <0.001 (two-tailed test).

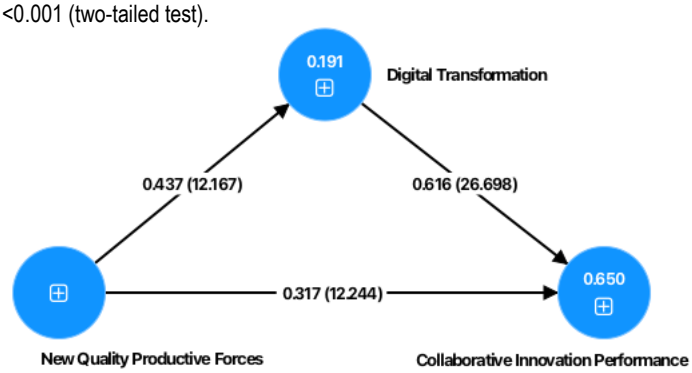

Fig. 4 Structural model(Path coefficients & T values & R^2)

Table 5 reports the predictive capacity of the model using R^2 and Q^2 indicators. Following Cohen's (1992) guideline, an R^2 above 0.26 indicates meaningful explanatory power. The Q^2 values for digital transformation (0.187) and collaborative innovation performance (0.340) were positive, verifying the model's predictive relevance. Furthermore, the SRMR value of 0.057 was well below the 0.10 threshold, indicating satisfactory model fit.

Table 5. Predictive relevance of the model.

	R Square	Q2 (= 1-SSE/SSO)

DT	0.191	0.187
CIP	0.650	0.340

5.0 Discussion

This study investigates the mechanisms through which NQPF influence CIP, with DT playing a mediating role, based on empirical data from 512 SMEs in the Chengdu-Chongqing Economic Circle. The findings provide robust support for all four proposed hypotheses, offering significant theoretical insights and managerial implications.

The study hypothesized (H1) The results indicate that NQPF has a significant and positive impact on CIP ($\beta = 0.317$, $t = 12.244$, $p < 0.001$). This confirms that SMEs that embrace breakthrough technologies, reconfigure production factors innovatively, and pursue deep industrial upgrading tend to achieve superior collaborative innovation outcomes. This finding supports the Dynamic Capability Theory, which posits that firms with reconfigurable capabilities are more likely to adapt and respond effectively to dynamic environments (Teece, 2007). In the context of the Chengdu-Chongqing region, where the national agenda emphasizes innovation-driven regional synergy, this result highlights NQPF as a critical enabler for SMEs' innovation alignment with regional development goals (Cheng et al., 2025).

As posited in H2, the direct relationship between NQPF and DT ($\beta = 0.437$, $t = 12.167$, $p < 0.001$) validates the idea that strategic production transformation naturally stimulates digital adoption. Theoretically, this supports the notion that productive force modernization, particularly through factor recombination and technological upgrading, sets the foundation for digital infrastructure and process reengineering (Merín-Rodrigáñez et al., 2024). For SMEs, especially in second-tier cities within the Chengdu-Chongqing Economic Circle, this finding emphasizes the pathway from capability investment to DT as a necessity rather than an option.

The path coefficient from DT to CIP(H3) is the highest among all direct paths ($\beta = 0.616$, $t = 26.698$, $p < 0.001$), suggesting that DT is a strong predictor of collaborative innovation success. This supports the Collaborative Innovation Theory, which posits that effective information flows, digital connectivity, and technological interoperability are essential for inter-firm innovation networks (Liu et al., 2021). The results imply that SMEs that successfully integrate digital platforms, tools, and communication protocols are more likely to establish agile and innovative partnerships, particularly in a digitally uneven regional context like Chengdu-Chongqing.

The mediating effect of DT between NQPF and CIP(H4) is also statistically significant ($\beta = 0.269$, $t = 12.676$, $p < 0.001$), highlighting the indirect pathway through which NQPF exerts its influence on innovation outcomes. This mediation mechanism demonstrates that while NQPF provides the strategic direction and potential, it is DT that translates these capabilities into operational results. This layered mechanism reflects recent arguments that productivity gains from structural upgrades can only be realized through complementary DT. The predictive relevance ($Q^2 = 0.340$ for CIP; $Q^2 = 0.187$ for DT) and explanatory power ($R^2 = 0.650$ for CIP; $R^2 = 0.191$ for DT) further confirm the strength and reliability of the model. These values are above the suggested thresholds (Hair et al., 2017), reinforcing the model's practical utility and theoretical validity. In summary, the findings collectively establish that NQPF alone are not sufficient for enhancing CIP unless they are accompanied by strong DT capabilities. This integrated pathway is particularly vital for SMEs in the Chengdu-Chongqing Economic Circle seeking to align with China's regional integration and modernization strategies.

6.0 Conclusion& Recommendations

6.1 Theoretical Implications

This study extends the application of DCT and CIT to explore the influence of NQPF and DT on CIP in SMEs within the CCEC. By confirming the direct and mediating effects, the study enriches the understanding of how NQPF—driven by technological breakthroughs, resource reconfiguration, and industrial upgrading—enhances innovation performance.

The findings respond to recent calls for theorizing how emergent productive forces support innovation within digital ecosystems (Merín-Rodrigáñez et al., 2024). Moreover, the integration of NQPF with DT emphasizes the strategic role of digital competence in converting latent capabilities into collaborative innovation outcomes, aligning with current theoretical advancements in capability building and knowledge recombination.

This study further complements emerging literature emphasizing the structural role of digital platforms and ecosystems in innovation-driven growth, particularly in regional policy-driven development zones like Chengdu-Chongqing.

6.2 Policy and Managerial Implications

From a policy perspective, the results underscore the importance of strategically supporting NQPF deployment through investments in digital infrastructure, human capital development, and cross-industry collaborative platforms. Regional governments should strengthen policies that integrate digital capability development with industrial transformation goals, consistent with China's "new quality productivity" framework outlined in recent policy reports (2024–2025).

For managers, especially in SMEs, the findings suggest the need to synchronize investments in NQPF (e.g., AI, green technologies, advanced manufacturing) with internal digital upgrading efforts. Managers should develop digital readiness and innovation management capacity to amplify NQPF's effectiveness, aligning with emerging management models for digital-innovation synergy (Cappa et al., 2021; Al-Omoush et al., 2022).

Furthermore, SMEs should actively participate in digital platform-based collaborative innovation networks to co-create, share, and adapt knowledge rapidly. This is particularly vital in emerging economies where ecosystem coordination enables firms to scale innovation faster and reduce transaction inefficiencies.

6.3 Limitations and Future Research Avenues

This study is subject to several limitations. First, the use of a cross-sectional design limits the ability to infer causality. Longitudinal or panel studies are recommended to capture the dynamic evolution of NQPF and DT over time. Second, the study relied on self-reported data, which may be influenced by perceptual bias despite statistical checks for common method variance.
Future research could explore sectoral differences in the impact of NQPF, particularly between high-tech and traditional manufacturing industries. Additionally, examining the moderating role of organizational culture or absorptive capacity may offer deeper insights into the NQPF–DT–CIP pathway. Lastly, extending the research to other national innovation clusters or comparative studies between regions would enhance generalizability and policy relevance.

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Paper Contribution to Related Field of Study
This study constructs and validates the "NQPF–DT–CIP" model, enriching the theoretical framework of enterprise innovation and extending the application of new quality productive forces in SMEs development.

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