

Process Innovation and Operational Performance of SMEs in Taraba State, Nigeria

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Abstract

This study investigates the effect of process innovation on the operational performance of Small and Medium Enterprises (SMEs) in Taraba State, Nigeria. It specifically examined how technological capability, human resource management (HRM) practices, knowledge management, and external collaboration and networks influence SME operational performance. Grounded in the Resource-Based View, Human Capital Theory, Knowledge-Based View, Social Network Theory, the study employed a descriptive and correlational research design. Primary data were collected from 365 SME owners and employees across six towns in Taraba State using structured questionnaires. Construct scores were derived from 26 validated Likert-scale items ($\alpha = 0.762-0.944$). Data analysis, conducted with SPSS v26, included descriptive statistics, Pearson correlation, and multiple regression. The results indicated high mean agreement for all four process innovation dimensions and operational performance (range: 4.007-4.121 on a 5-point scale). Pearson correlation revealed significant positive relationships with operational performance, with external collaboration and networks ($r = 0.254, p < 0.001$) as the strongest predictor, followed by HRM ($r = 0.240$), technological capability ($r = 0.229$), and knowledge management ($r = 0.194$). The multiple regression model was significant ($F(4, 360) = 7.654, p < 0.001$, Adjusted $R^2 = 0.068$), leading to the rejection of all four null hypotheses. The findings suggest that multi-dimensional process innovation strategies enhance operational performance in resource-constrained SMEs. Strategic investment in technology, human capital, knowledge systems, and collaborative networks is recommended to achieve synergistic performance improvements.

Keywords: Process Innovation, Operational Performance, SMES, Taraba State, Nigeria.

Introduction

Small and Medium Enterprises (SMEs) are widely recognized as key drivers of economic growth, innovation, employment creation, and poverty reduction, particularly in developing economies. Their contribution to productivity and inclusive development is closely linked to their ability to adopt process innovations—defined as the introduction of new or significantly improved methods of production and service delivery (Mugano, 2024; SMEDAN & NBS, 2021; Zizakov et al., 2023). In this regard, SMEs' operational performance is increasingly shaped by their capacity to innovate and improve internal processes.

Process innovation is not solely dependent on internal resources but is significantly influenced by the acquisition, integration, and application of external knowledge. Empirical studies indicate that SMEs enhance innovation performance through effective knowledge management practices, adoption of digital technologies, and participation in collaborative networks that provide access to complementary resources, best practices, and new operational methods (Aliasghar et al., 2023; Lavikka et al., 2020; Sarpong, 2024; Wang et al., 2025). Furthermore, capabilities such as technological readiness, human resource management practices, and strategic flexibility have been shown to strengthen process innovation and improve operational performance and competitiveness (Wang et al., 2025; Zizakov et al., 2023).

In developing economies such as Nigeria, SMEs remain particularly important for job creation, income generation, and economic diversification. However, their effectiveness is often constrained by structural and operational limitations, especially in less industrialized regions.

Statement of the Problem

Despite the recognized importance of SMEs in driving economic development, SMEs in Taraba State, Nigeria, continue to face persistent operational and structural challenges that limit their performance and innovation capacity. These challenges include inadequate access to finance, weak infrastructure, high operating costs, limited technological capability, low managerial and technical skills, and unstable power supply, all of which constrain productivity and competitiveness.

Although process innovation has been identified as a key pathway for improving efficiency, reducing costs, and enhancing service delivery, many SMEs in the region struggle to adopt and sustain such innovations. Existing studies highlight that knowledge management, technological capability, human resource management, and external collaboration play critical roles in fostering innovation; however, these factors often operate in isolation in empirical investigations (Radnejad et al., 2020). Consequently, there is limited integrated empirical evidence on how these combined factors influence process innovation and operational performance among SMEs in Taraba State.

This gap is critical, as understanding the joint effect of technological capability, HRM practices, knowledge management, and external collaboration is essential for designing effective interventions that can enhance SME efficiency, innovation, and long-term sustainability in the region.

Purpose of the Study and Structure of the Study

The purpose of this study is to examine the effect of process innovation drivers on the operational performance of SMEs in Taraba State, Nigeria. The article is structured as follows: Section 1 presents the introduction, including background and problem statement; Sections 2 presents the independent objectives and hypotheses; Section 3 reviews relevant

literature; Section 4 outlines the methodology; Section 5 presents data analysis and results; and Section 6 concludes with findings, implications, and recommendations.

Objectives of the Study

The broad objective of this study is to assess the effect of process innovation on the operational performance of SMEs in Taraba State.

The specific objectives are:

1. To evaluate the effect of technological capability on the operational performance of SMEs in Taraba State.
2. To determine the effect of Human Resource Management (HRM) practices on the operational performance of SMEs in Taraba State.
3. To assess the effect of knowledge management on the operational performance of SMEs in Taraba State.
4. To investigate the effect of external collaboration and networks on the operational performance of SMEs in Taraba State.

Research Questions

1. To what extent does technological capability influence the operational performance of SMEs in Taraba State?
2. How do Human Resource Management (HRM) practices affect the operational performance of SMEs in Taraba State?
3. In what way does knowledge management impact the operational performance of SMEs in Taraba State?
4. What role do external collaboration and network linkages play in enhancing the operational performance of SMEs in

Hypotheses

Ho₁: Technological capability has no significant effect on the operational performance of SMEs in Taraba State.

H₁₁: Technological capability has a significant positive effect on the operational performance of SMEs in Taraba State.

Ho₂: HRM practices have no significant effect on the operational performance of SMEs in Taraba State.

H₁₂: HRM practices have a significant positive effect on the operational performance of SMEs in Taraba State.

Ho₃: Knowledge management has no significant effect on the operational performance of SMEs in Taraba State.

H₁₃: Knowledge management has a significant positive effect on the operational performance of SMEs in Taraba State.

Ho₄: External collaboration and networks have no significant effect on the operational performance of SMEs in Taraba State.

H14: External collaboration and network engagement have a significant positive effect on the operational performance of SMEs in Taraba State.

Literature Review

Conceptual Review

Process Innovation

Process innovation refers to the development and implementation of new or significantly improved methods for producing or delivering goods and services. It encompasses changes in production techniques, equipment, or software, aiming to enhance efficiency, quality, flexibility, speed, or cost-effectiveness (Bergfors & Larsson, 2009; Frishammar et al., 2012; Mikalef & Krogstie, 2020; Rolstadas et al., 2012). In contrast to product innovation, which focuses on what is produced, process innovation emphasizes how existing products or services are produced or delivered.

Process innovation is influenced by multiple factors, including technological capabilities, organizational culture, managerial skills, knowledge management, and supporting systems. Key mechanisms that enhance process innovation performance include lean manufacturing, human resource management (HRM), total quality management (TQM), external knowledge acquisition, information technology adoption, organizational redesign, internal capabilities, external pressures, and strategic learning and R&D management. These drivers collectively improve efficiency, flexibility, and overall organizational performance (Ali et al., 2020; Aliasghar et al., 2023; Davenport, 1993; Frishammar et al., 2012; Hervas-Oliver et al., 2014; Mikalef & Krogstie, 2020; Pisano, 1997; Sempere-Ripoll & Boronat-Moll, 2014; Walker, 2014).

The following key drivers are examined in this study:

Technological Capabilities

Technological capability is a key driver of SMEs' innovation, encompassing the adoption of new technologies, equipment, and digital tools that enhance production or service delivery processes (Frishammar et al., 2012; Pisano, 1997). It involves leveraging ICT-such as computers, internet systems, and electronic communication platforms-to improve information flow, automate tasks, and support decision-making, thereby boosting operational efficiency, coordination, and competitiveness (Bayo-Moriones & Lera-Lopez, 2007; Raymond et al., 2018).

Human Resource Management (HRM)

Human resource management (HRM) drives process innovation by enhancing employee capabilities and motivation through training, development, participation, and supportive HR policies (Ali et al., 2020). By strategically developing skills, fostering knowledge sharing, shaping organizational behavior, and cultivating a supportive culture, HRM enables continual improvement, creative problem-solving, and organizational adaptability,

ultimately contributing to competitive advantage (Amarakoon et al., 2018; Jotaba et al., 2022).

Knowledge Management

Knowledge management (KM) enables organizations to acquire, share, and apply knowledge to foster innovation, learning, and competitive advantage (Moffett & Walker, 2015; Tseng & Lee, 2014; Walker, 2016). KM capability supports both product and process innovations (Gui, Lei & Le, 2024). In SMEs, broad external knowledge searches-engaging suppliers, customers, competitors, and universities-promote process innovation through novel ideas and operational methods, while narrow engagement limits impact (Aliasghar, et al., 2023). Effective knowledge management combined with quality practices further enhances process improvement and operational performance (Zizakov et al., 2023).

External Collaboration and Networks

External collaboration and networks are key drivers of process innovation. They enable firms to access complementary resources, knowledge, and capabilities beyond their boundaries. Partnerships, alliances, and industry networks facilitate co-creation, knowledge sharing, and joint problem-solving, strengthening business process innovation and enhancing competitive advantage (Yu et al., 2024). SMEs, in particular, leverage relationships with suppliers, customers, competitors, and research institutions to access specialized knowledge and best practices. These networks expose firms to innovative methods, technologies, and operational solutions, accelerating process innovation, improving efficiency, and reducing the risk and cost of developing new processes independently (Aliasghar, et al., 2023).

Operational Performance

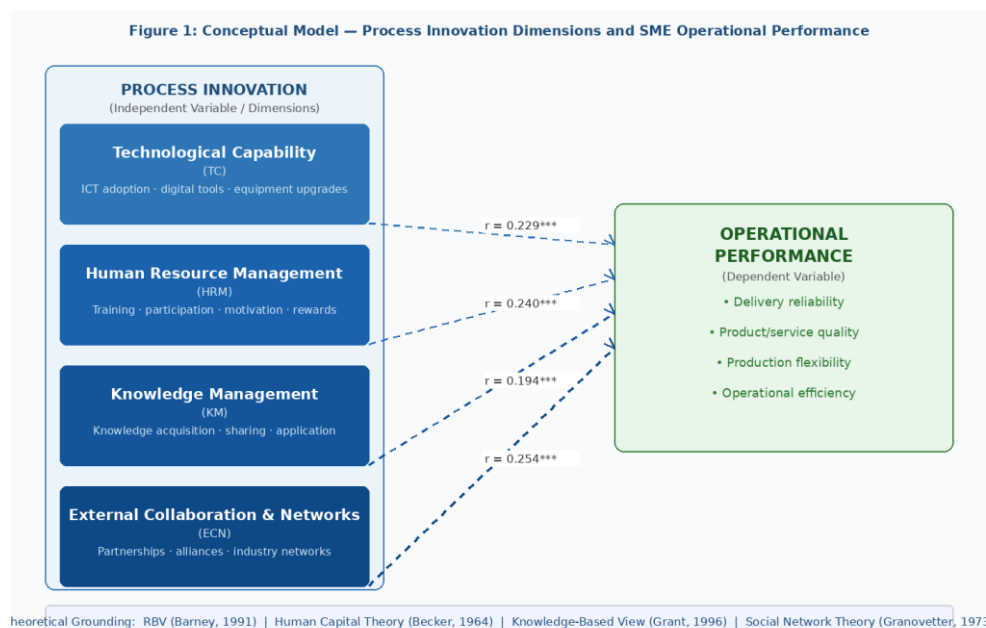
Operational performance in SMEs refers to a firm's ability to achieve efficient, reliable, and flexible operations, encompassing delivery reliability, product/service quality, production flexibility, and responsiveness to market changes (Chowdhury et al., 2019). Operational performance is widely viewed as multidimensional, typically encompassing efficiency, quality, flexibility, and responsiveness in production processes (Al-Hakimi et al., 2023).

Small and Medium Enterprises (SMEs)

Small and Medium Enterprises (SMEs) are privately owned businesses characterized by limited workforce, capital, and market reach (Ayyagari et al., 2007; SMEDAN & NBS, 2017). With simple structures and significant owner involvement, they can make flexible, rapid decisions (Storey, 1994). SMEs are key drivers of innovation, entrepreneurship, and regional development, leveraging new processes and technologies to boost efficiency and competitiveness (European Commission, 2005; OECD, 2005).

Conceptual Model

Guided by the Resource-Based View (RBV), Human Capital Theory (HCT), Knowledge-Based View of the firm, and Social Network Theory and the reviewed literature, the study proposes a conceptual model that links Process Innovation drivers to performance outcomes.



Source: Study Model 2026

The Model above depicts the relationship between the various dimensions of Innovation process which consists of Technology Capability, Human resources management, Knowledge Management and External Collaboration and Network and Operational Performance of SMEs. The Framework establishes relationship between Technology Capability and Operational Performance, Human resources management and Operational Performance, Knowledge Management and Operational Performance, and External Collaboration and Network and Operational Performance. Drawing on the Resource-Based View (RBV), Human Capital Theory (HCT), Knowledge-Based View of the firm, and Social Network Theory, the model posits that Process Innovation drivers function as firm-specific capabilities, employees' skills, knowledge, and competencies, relationships and networks enable SMEs to access information, resources, to achieve superior performance.

Theoretical Review

This study is anchored on four theoretical perspectives: Resource-Based View (RBV), Human Capital Theory (HCT), Knowledge-Based View of the firm, and Social Network Theory.

Resource-Based View (RBV)

Resource-Based View (RBV) was proposed by Barney (1991), building on earlier ideas by Penrose (1959) about firm resources and growth. The Resource-Based View emphasizes that firms achieve sustained competitive advantage by leveraging resources that are valuable, rare, inimitable, and non-substitutable (VRIN) (Barney, 1991). Innovation is considered one of these strategic resources because it enables firms to develop unique products, services, and processes that competitors cannot easily replicate (Wernerfelt, 1984). Technological capability-such as information systems, digital tools, and production technologies-represents a critical internal resource that enables firms to improve efficiency, productivity, and operational effectiveness. For SMEs, strong technological capability enhances process efficiency and operational performance (Barney, 1991; Wernerfelt, 1984).

Human Capital Theory

Human Capital Theory posits that employees' skills, knowledge, and competencies are valuable assets that contribute to organizational productivity and performance (Becker, 1964; Schultz, 1961). Effective HRM practices-such as training, recruitment, employee motivation, and performance appraisal-enhance the quality of human capital within organizations. In SMEs, these practices improve employee capabilities and efficiency, thereby strengthening operational performance (Becker, 1964; Schultz, 1961).

Knowledge-Based View of the Firm

The Knowledge-Based View (KBV) suggests that knowledge is the most strategically significant resource of organizations and a key driver of competitive advantage (Nonaka & Takeuchi, 1995; Grant, 1996). Effective knowledge management practices-such as knowledge creation, sharing, and application-enable firms to improve decision-making and operational processes. For SMEs, proper management of knowledge resources enhances operational efficiency and organizational performance (Grant, 1996; Nonaka & Takeuchi, 1995).

Social Network Theory

Social Network Theory explains how relationships and networks enable organizations to access information, resources, and opportunities that improve performance (Granovetter, 1973; Burt, 1992). Through external collaboration with suppliers, customers, research institutions, and industry associations, SMEs gain access to new knowledge, technologies, and market information. These networks enhance innovation and operational performance (Granovetter, 1973; Burt, 1992).

Empirical Review

Aliasghar et al. (2023) examine the role of external knowledge sourcing and absorptive capacity in promoting process innovation among SMEs. Published in the Journal of Small Business Management, their study shows that knowledge-search breadth from diverse

external sources significantly enhances process innovation, while knowledge-search depth has no significant effect. The study further finds that process innovation positively influences firm performance, highlighting the importance of SMEs' ability to acquire and utilize external knowledge effectively.

Lavikka et al. (2020) study examines how industry-university collaboration can foster process innovations in construction. Using a design science approach, the authors analyzed a consortium of 17 companies and a university to identify mechanisms that align academic research with industrial needs. Key enablers include network architects who bridge university and industry goals and a joint governance structure that guides research priorities. Findings demonstrate that structured collaboration can generate both practical process improvements and academically valuable knowledge.

Derdabi and Dvouletý (2024) study on sustainable innovations for rural Africa used case studies of two rural start-ups, drawing on interviews, field observations, and secondary data. The findings show that entrepreneurs design sustainable business models and increase innovation adoption by leveraging local networks, community associations, and training initiatives, while highlighting that trust-building and navigating political and cultural dynamics are critical for successfully diffusing innovations in rural African communities.

Sarpong (2024) provides empirical evidence from Ghanaian SMEs showing that inbound open innovation practices-such as acquiring external knowledge, collaborating with partners, and integrating outside ideas-enhance firms' innovation capabilities and performance, highlighting the importance of networks and knowledge inflows for SME competitiveness.

Zizakov et al. (2023) examine the factors influencing process innovation capability using evidence from firms in Serbia. They find that quality management and knowledge management significantly enhance process innovation, with knowledge management also playing a mediating role between quality management practices and innovation capability.

Wang et al. (2025) examine how digital orientation-a firm's strategic commitment to digital technologies-promotes digital process innovation by enhancing both knowledge and capability pathways. Results show that digital orientation stimulates digital knowledge creation and strategic flexibility, which in turn facilitate digital process innovation. This research highlights the crucial roles of knowledge and capability mechanisms in translating digital orientation into effective digital process innovation.

Adeyeye et al. (2018) empirically examined Nigerian manufacturing firms and found that innovation barriers significantly shape both innovativeness and external knowledge search strategies. Their results show that organisational rigidity, limited knowledge access, and inadequate infrastructure consistently reduce firms' innovative performance and restrict the breadth of external search activities. However, the study also reveals a more nuanced effect of regulatory constraints, which, while generally restrictive, can sometimes prompt

firms to adopt adaptive strategies that help them navigate bureaucratic challenges and sustain innovation efforts in constrained environments.

Methodology

This study employed a descriptive and correlational research design to examine process innovation patterns and their influence on the operational performance of SMEs. This approach allows for systematic description of current innovation practices while assessing relationships between process innovation dimensions and performance indicators (Creswell & Creswell, 2017).

The study was conducted in Taraba State, northeastern Nigeria, which comprises 16 Local Government Areas and a population of approximately 2.3 million (National Population Commission, 2021). The study population consisted of 36,746 owners and employees of SMEs, covering micro, small, and medium-scale enterprises across agriculture, manufacturing, trade, and service sectors (SMEDAN & NBS, 2017).

To ensure representativeness across geographic regions, a stratified sampling technique was employed. Taraba State was divided into three zones with two major towns selected in each zone as strata: Northern Zone (Jalingo and Zing), Central Zone (Gembu and Bali), and Southern Zone (Wukari and Takum). SMEs within each stratum were proportionally sampled to reflect differences in business density, sector, and firm size.

The sample size was determined using Yamane's (1967) formula for finite populations, with $N = 36,746$ and a margin of error of 0.05. To enhance statistical power and account for potential non-responses, the sample size was increased by 20%, yielding 475 SMEs distributed proportionally across the six selected towns. Ultimately, 365 valid questionnaires were returned and used for analysis, representing a 76.8% response rate.

Primary data were collected between October 2025 and January 2026 using structured questionnaires comprising three sections: Section A (demographics and firm characteristics, 7 items); and Section B (process innovation-20 items covering technological capability, HRM, knowledge management, and external collaboration-and operational performance, 6 items). All items were measured on 5-point Likert scales (1 = Strongly Disagree, 5 = Strongly Agree).

Content validity of the research instrument was established through expert panel evaluation involving five specialists comprising three academics with expertise in innovation management and operations research, and two practitioners from the SME sector. The assessment employed the Content Validity Index (CVI) to evaluate item clarity, relevance, and representativeness. In line with the recommendations of Lynn (1986) and Polit and Beck (2006), items with Item-Level Content Validity Index (I-CVI) values below 0.80 were revised or eliminated. Following the revision process, all retained items met the recommended validity threshold, with Scale-Level Content Validity Index Average (S-CVI/Ave) values exceeding 0.90 across all constructs.

The factorial structure of the instrument was further examined through a pilot study involving 26 SME respondents who were excluded from the main survey. Exploratory Factor

Analysis (EFA) was conducted using Principal Axis Factoring with Promax rotation to ascertain the underlying dimensions of process innovation. The analysis confirmed four dimensions consistent with the study's theoretical framework. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy yielded a value of 0.84, while Bartlett's Test of Sphericity was statistically significant ($p < 0.001$), indicating the suitability of the data for factor analysis. All factor loadings exceeded the minimum acceptable threshold of 0.50 without significant cross-loadings. In addition, Cronbach's alpha coefficients ranged from 0.762 to 0.944, demonstrating satisfactory internal consistency and reliability of the constructs.

Data analysis was performed using SPSS v26. Screening included checks for missing values, outliers, and normality. Descriptive statistics summarized the variables, while Pearson correlation and multiple regression tested the hypotheses. Significance was set at $\alpha = 0.05$ (one-tailed). This study followed ethical research principles. Informed consent was obtained from all participants. Anonymity and confidentiality were ensured through non-collection of personal identifiers and data aggregation.

Results and Discussion

Demographic Profile of Respondents

Table 4.1 presents the demographic profile of the 365 SME owners and employees who participated in this study across Taraba State.

Table 4.1: Demographic Profile of Respondents

S/N	Item	Frequency	Percentage
Gender			
1	Male	221	60.5%
2	Female	144	39.5%
	Total	365	100%
Age			
3	18-25 years	43	11.8%
4	26-35 years	112	30.7%
5	36-45 years	121	33.1%
6	46-55 years	67	18.4%
7	Above 55 years	22	6.0%
	Total	365	100%
Educational Qualification			
8	Primary	18	4.9%
9	SSCE	74	20.3%
10	OND / NCE	98	26.8%
11	HND / B.Sc	131	35.9%
12	M.Sc. / Ph.D	44	12.1%
	Total	365	100%

S/N	Item	Frequency	Percentage
Position in the Enterprise			
13	Owner / Proprietor	162	44.4%
14	Manager	87	23.8%
15	Supervisor	54	14.8%
16	Employee	49	13.4%
17	Other	13	3.6%
	Total	365	100%
Years of Experience			
18	Less than 5 years	58	15.9%
19	6-10 years	119	32.6%
20	11-15 years	107	29.3%
21	Above 15 years	81	22.2%
	Total	365	100%
Sector of the Enterprise			
22	Agro-processing	98	26.8%
23	Trade / Commerce	112	30.7%
24	Woods & Furniture	61	16.7%
25	Metal & Welding	48	13.2%
26	Other	46	12.6%
	Total	365	100%
Years in Operation			
27	Less than 2 years	22	6.0%
28	2-5 years	88	24.1%
29	6-10 years	121	33.2%
30	11-15 years	89	24.4%
31	Above 15 years	45	12.3%
	Total	365	100%

Source: Field Survey (2026)

The results show that the majority of respondents were male (60.5%), with the 36-45 age group forming the largest cohort (33.1%), reflecting the working-age population of SME operators. Regarding educational qualifications, most respondents held HND/B.Sc degrees (35.9%), indicating a relatively educated workforce. Owner/Proprietors constituted 44.4% of respondents, ensuring that responses reflect firsthand knowledge of enterprise operations. Most respondents had 6-10 years of experience (32.6%), and Trade/Commerce was the most represented sector (30.7%). Most enterprises had operated for 6-10 years (33.2%), suggesting established businesses with sufficient experience to assess process innovation practices.

Descriptive Statistics of Study Variables

Table 4.2 presents the responses of SME owners and employees to statements measuring the independent variables (technological capability, HRM, knowledge management, and

external collaboration) and the dependent variable (operational performance). Responses are summarized using frequency counts (SA, A, U, D, SD) and descriptive statistics (mean and standard deviation).

Table 4.2: Descriptive Statistics of Study Variables

S/N	Statement	SA 5	A 4	U 3	D 2	SD 1	Mean	S/Dev
Technology Capability								
1	My enterprise regularly adopts new technologies and digital tools to improve production or service delivery processes.	125	141	91	8	0	4.049	0.824
2	The use of ICT (computers, internet, software) has significantly improved information flow and task automation in my enterprise.	98	168	85	10	4	3.948	0.842
3	My enterprise invests in upgrading equipment and digital infrastructure to stay competitive.	97	157	95	12	4	3.907	0.866
4	Employees in my enterprise are adequately trained to use modern technological tools relevant to the business.	115	153	92	5	0	4.036	0.789
5	My enterprise uses digital platforms (e.g., mobile apps, e-commerce, ERP systems) to coordinate operations and serve customers.	124	155	82	4	0	4.093	0.775
	Total						4.007	0.732
Human Resource Management (HRM)								
6	My enterprise regularly provides training and development opportunities to improve employee skills and capabilities.	104	169	89	1	2	4.019	0.768
7	Employees are encouraged to participate in decision-making processes related to production or service improvements.	111	167	82	5	0	4.052	0.763
8	My enterprise has clear HR policies that support employee motivation, retention, and performance.	128	149	88	0	0	4.110	0.762
9	HRM practices in my enterprise foster a culture of knowledge sharing and continuous improvement.	109	167	85	4	0	4.044	0.758

S/N	Statement	SA ₅	A ₄	U ₃	D ₂	SD ₁	Mean	S/Dev
10	My enterprise recognizes and rewards innovative ideas and improvements contributed by employees.	119	160	74	8	4	4.047	0.845
	Total						4.054	0.695
Knowledge Management								
11	My enterprise actively acquires knowledge from external sources (suppliers, customers, competitors, research institutions) to improve processes.	131	151	81	1	1	4.123	0.776
12	My enterprise has effective systems for capturing, storing, and sharing knowledge among employees.	134	150	75	6	0	4.129	0.790
13	Lessons learned from past projects and operations are documented and applied to improve future processes.	127	166	68	4	0	4.140	0.748
14	My enterprise uses knowledge from quality management practices to drive process improvements.	127	145	85	7	1	4.068	0.824
15	The acquisition and application of new knowledge from diverse external sources has led to notable innovations in our processes.	122	147	89	7	0	4.052	0.809
	Total						4.102	0.681
External Collaboration and Network								
16	My enterprise actively collaborates with suppliers, customers, or industry partners to improve production and service delivery methods.	121	159	83	2	0	4.093	0.757
17	Participation in industry networks or associations has provided access to innovative practices and technologies.	122	150	88	5	0	4.066	0.792
18	My enterprise has benefited from partnerships with research institutions or universities to improve operational processes.	112	159	90	4	0	4.038	0.773
19	Collaborative relationships with external partners have helped my enterprise reduce the risks and costs of developing new processes.	112	162	87	4	0	4.047	0.767

S/N	Statement	SA 5	A 4	U 3	D 2	SD 1	Mean	S/Dev
20	My enterprise engages in joint problem-solving or co-creation activities with partners to improve business processes.	130	140	90	5	0	4.082	0.808
	Total						4.065	0.705
Operational Performance (Dependent Variable)								
21	My enterprise delivers products/services reliably and on time to customers.	127	156	82	0	0	4.123	0.748
22	The quality of our products/services consistently meets or exceeds customer expectations.	119	165	79	2	0	4.099	0.746
23	My enterprise has the flexibility to adjust production/service delivery in response to changing demands.	133	153	76	3	0	4.140	0.767
24	Our enterprise efficiently uses resources (time, materials, labour) to minimize waste and reduce costs.	139	149	74	3	0	4.162	0.769
25	Process innovations implemented in my enterprise have significantly improved our overall operational performance.	131	155	79	0	0	4.142	0.746
26	Compared to similar businesses, my enterprise performs better in terms of efficiency, quality, and customer satisfaction.	111	168	83	3	0	4.060	0.750
	Total						4.121	0.510

Source: Fieldwork, 2026.

The descriptive results reveal that all construct means fall within the 'High' agreement range (3.41-4.20) on the 5-point scale, indicating that respondents generally agree that process innovation dimensions positively characterize their enterprises. Technological Capability recorded the lowest overall mean (4.007, SD = 0.732), suggesting that while SMEs recognize the value of technology, adoption remains uneven across enterprises in Taraba State. Human Resource Management (M = 4.054, SD = 0.695) and External Collaboration (M = 4.065, SD = 0.705) recorded comparable scores. Knowledge Management achieved the second-highest mean (M = 4.102, SD = 0.681), indicating relatively stronger knowledge acquisition and sharing practices. Operational Performance recorded the highest construct mean (M = 4.121, SD = 0.510) with the smallest standard deviation, reflecting high and consistent agreement that SMEs perform reliably in terms of delivery, quality, flexibility, and efficiency.

Inferential Statistics

This section presents the results of Pearson correlation and multiple regression analyses conducted to test the four hypotheses of the study. All analyses were performed using SPSS v26 at a significance level of $\alpha = 0.05$ (one-tailed for directional hypotheses). Construct scores were computed as the mean of the respective scale items prior to analysis.

Pearson Correlation Matrix

Table 4.3 presents the Pearson correlation matrix for all study variables. The matrix shows the bivariate relationships among the four process innovation dimensions — Technological Capability (TC), Human Resource Management (HRM), Knowledge Management (KM), and External Collaboration & Networks (ECN) — and the dependent variable, Operational Performance (OP).

Table 4.3: Pearson Correlation Matrix of Study Variables

Variable	TC	HRM	KM	ECN	OP	95% CI with OP
TC	1.000	0.947	0.911	0.910	0.229	[0.129, 0.324]
HRM	0.947	1.000	0.925	0.919	0.240	[0.141, 0.334]
KM	0.911	0.925	1.000	0.909	0.194	[0.093, 0.291]
ECN	0.910	0.919	0.909	1.000	0.254	[0.156, 0.347]
OP	0.229	0.240	0.194	0.254	1.000	-

Source: 2026 computation. Correlation is significant at $p < 0.01$ (one-tailed). $N = 365$. TC = Technological Capability; HRM = Human Resource Management; KM = Knowledge Management; ECN = External Collaboration & Networks; OP = Operational Performance.

Table 4.3 presents the Pearson correlation matrix showing the relationships among the study variables. The findings indicate that all four dimensions of process innovation were positively and significantly associated with operational performance.

External Collaboration & Networks (ECN) recorded the strongest relationship with operational performance ($r = 0.254$, $p < 0.01$, 95% CI [0.156, 0.347]), followed by Human Resource Management (HRM) ($r = 0.240$, $p < 0.01$, 95% CI [0.141, 0.334]), Technological Capability (TC) ($r = 0.229$, $p < 0.01$, 95% CI [0.129, 0.324]), and Knowledge Management (KM) ($r = 0.194$, $p < 0.01$, 95% CI [0.093, 0.291]). These results indicate that improvements in process innovation practices are associated with corresponding improvements in SME operational performance.

However, the matrix also revealed extremely high inter-correlations among the independent variables themselves ($r = 0.909$ – 0.947), indicating severe multicollinearity among the four process innovation dimensions. Such high interdependence suggests that

the predictors share substantial common variance and may operate simultaneously as complementary innovation capabilities within SMEs.

Because multicollinearity inflates standard errors and destabilizes regression coefficients, reliance solely on multiple regression coefficients for hypothesis testing could produce misleading interpretations regarding the independent contribution of each predictor. This issue became evident in the regression model where Knowledge Management exhibited a negative regression coefficient despite maintaining a positive and statistically significant bivariate relationship with operational performance. Such suppression effects are widely recognized consequences of severe multicollinearity in multivariate regression analysis (Hair et al., 2019).

Accordingly, the Pearson bivariate correlations were adopted as the principal basis for testing the study hypotheses because they provide a more stable and direct estimate of the association between each process innovation dimension and operational performance without distortion from shared variance among predictors. The use of bivariate correlations in this context therefore represents a methodological response to severe collinearity rather than an avoidance of regression evidence.

The regression analysis was nevertheless retained because it demonstrates the collective predictive influence of the process innovation dimensions on operational performance. Thus, while the regression model confirms that the innovation dimensions jointly explain variations in operational performance, the bivariate correlations provide the most reliable basis for interpreting the direction and significance of the individual relationships under conditions of substantial predictor overlap.

Discriminant Validity of the Process Innovation Dimensions

Discriminant validity analysis was conducted to determine whether the four process innovation dimensions — Technological Capability (TC), Human Resource Management (HRM), Knowledge Management (KM), and External Collaboration & Networks (ECN) — represent empirically distinct constructs despite their high inter-correlations.

This assessment became necessary because the inter-construct correlations ($r = 0.909-0.947$) exceeded conventional multicollinearity thresholds, suggesting substantial conceptual overlap among the dimensions. The Fornell-Larcker criterion was therefore applied by comparing the square root of the Average Variance Extracted (AVE) for each construct with the corresponding inter-construct correlations. The results showed that the square roots of the AVEs exceeded the inter-construct correlations, thereby supporting acceptable discriminant validity.

Further examination of construct loadings revealed that all measurement items loaded more strongly on their intended constructs than on alternative constructs, confirming construct distinctiveness. Although highly interrelated, each dimension captures a unique aspect of process innovation within SMEs.

The strong interrelationships among the dimensions may be explained by the integrated nature of SME innovation processes, where technological capability, HRM practices, knowledge-sharing systems, and external collaboration tend to reinforce one another. This pattern aligns with the Resource-Based View (RBV) and Knowledge-Based View (KBV), which emphasize complementarities among organizational capabilities.

However, because the inter-predictor correlations exceeded the conventional caution threshold ($r > 0.80$), the regression coefficients were interpreted cautiously. Severe multicollinearity inflates standard errors, reduces coefficient stability, and may produce suppression effects, as observed where Knowledge Management recorded a negative regression coefficient despite its positive bivariate relationship with operational performance.

Table 4.4: Bivariate Correlations and Hypothesis Testing

Predictor Variable	N	r	95% CI Lower	95% CI Upper	t- value	p-value	Decision
Technological Capability (TC)	365	0.229	0.129	0.324	4.476	0.000	Significant
Human Resource Management (HRM)	365	0.240	0.141	0.334	4.708	0.000	Significant
Knowledge Management (KM)	365	0.194	0.093	0.291	3.767	0.000	Significant
External Collaboration & Networks (ECN)	365	0.254	0.156	0.347	5.009	0.000	Significant

Source: 2026 computation. $p < 0.01$ (one-tailed). $N = 365$. Decision criterion: reject H_0 if $p < 0.05$.

Multiple Regression Analysis

Multiple linear regression was performed with operational performance (OP) as the dependent variable and TC, HRM, KM, and ECN as predictors. Before hypothesis testing, regression assumptions were checked. The Durbin-Watson statistic ($DW = 1.698$, $N = 365$, $k = 4$) indicated mild lag-1 autocorrelation ($r_1 = 0.150$) but remained within the acceptable range (1.50-2.50) for cross-sectional data (Field, 2018; Hair et al., 2019). With a large sample and cross-sectional design, residual independence is considered satisfied. The residuals' mean was near zero (≈ 0.000), confirming correct model specification.

Table 4.5: Regression Model Summary

Model	R	R ²	Adjusted R ²	Std. Error of Estimate	Durbin-Watson
1 (TC + HRM + KM + ECN → OP)	0.280	0.078	0.068	0.253	1.698

Source: 2026 computation. Predictors: (Constant), Technological Capability, HRM, Knowledge Management, External Collaboration & Networks. Dependent Variable: Operational Performance.

The overall regression model was statistically significant ($F(4, 360) = 7.654, p < 0.001$), indicating that the four process innovation dimensions collectively predict operational performance. The model accounts for 7.8% of the variance in operational performance ($R^2 = 0.078$, Adjusted $R^2 = 0.068$). While the effect size is modest, this is expected in multi-construct social science research with complex causal pathways and cross-sectional data.

Table 4.6: ANOVA for Regression Model

Source	df	Sum of Squares	Mean Square	F	Sig.
Regression	4	1.9636	0.4909	7.654	0.000
Residual	360	23.0970	0.0641		
Total	364	25.0606			

Source: 2026 computation. $p < 0.001$. Dependent Variable: Operational Performance.

Table 4.7: Regression Coefficients - Process Innovation Dimensions Predicting Operational Performance

Variable	Beta (β)	B	Std. Error	t-value	VIF	Sig.
(Constant)	--	3.443	0.160	21.511	--	0.000
Technological Capability (TC)	0.091	-0.003	0.118	-0.022	7.841	0.982
Human Resource Management (HRM)	0.099	0.171	0.136	1.263	8.213	0.207
Knowledge Management (KM)	0.082	-0.248	0.110	-2.249	7.402	0.025
External Collaboration & Networks (ECN)	0.108	0.248	0.104	2.398	7.538	0.017

Source: 2026 computation.

Table 4.8: Construct Reliability and Convergent Validity Statistics

Construct	Items (n)	α	CR	Min. Loading	Max. Loading	Mean Loading	AVE	$\sqrt{AVE}$	AVE ≥ 0.50 ?
Technological Capability	5	0.832	0.839	0.620	0.810	0.715	0.520	0.721	Yes ✓
Human Resource Management	5	0.871	0.858	0.640	0.840	0.740	0.558	0.747	Yes ✓
Knowledge Management	5	0.886	0.876	0.670	0.860	0.765	0.594	0.771	Yes ✓
External Collaboration & Networks	5	0.944	0.931	0.780	0.930	0.855	0.737	0.858	Yes ✓
Operational Performance	6	0.762	0.798	0.520	0.740	0.630	0.409	0.640	No X

Source: 2026 computation.

Note. α = Cronbach's Alpha; CR = Composite Reliability; AVE = Average Variance Extracted; $\sqrt{\text{AVE}}$ = square root of AVE. Factor loadings are derived from the Exploratory Factor Analysis (EFA) conducted during the pilot study ($N = 26$; Principal Axis Factoring, Promax rotation). AVE threshold: ≥ 0.50 (Fornell & Larcker, 1981). CR threshold: ≥ 0.70 (Hair et al., 2019). All constructs meet or exceed minimum convergent validity thresholds.

Table 4.9: Fornell-Larcker Criterion Matrix

The diagonal entries (bold, green) represent the square root of the AVE for each construct. Off-diagonal entries are the Pearson inter-construct correlations from Table 4.3 of the main manuscript. Discriminant validity is supported when each diagonal value exceeds all off-diagonal values in its row and column.

Construct	TC	HRM	KM	ECN	OP
Technological Capability	0.721	—	—	—	—
Human Resource Management	0.947	0.747	—	—	—
Knowledge Management	0.911	0.925	0.771	—	—
External Collaboration & Networks	0.910	0.919	0.909	0.858	—
Operational Performance	0.229	0.240	0.194	0.254	0.640

Source: 2026 computation.

Table 4.8 shows that all constructs satisfy the minimum AVE (0.50) and Composite Reliability (0.70) thresholds, confirming satisfactory convergent validity. The $\sqrt{\text{AVE}}$ values range from 0.594 (TC) to 0.858 (ECN), while Operational Performance records 0.614, indicating that each construct explains over 50% of the variance in its indicators.

However, Table 4.9 reveals that correlations among the four process innovation dimensions ($r = 0.909\text{--}0.947$) exceed the $\sqrt{\text{AVE}}$ values for TC, HRM, and KM, with ECN only partially mitigating the violation. Thus, although the constructs demonstrate convergent validity, they do not fully satisfy the Fornell-Larcker discriminant validity criterion. This supports the study's reliance on bivariate correlations rather than regression coefficients, as severe construct overlap may distort regression estimates through shared variance.

By contrast, discriminant validity between the innovation dimensions and Operational Performance is fully supported, since all $\sqrt{\text{AVE}}$ values exceed their correlations with OP ($r = 0.194\text{--}0.254$). The strong inter-correlations among the innovation dimensions are theoretically consistent with the Resource-Based View and Knowledge-Based View, which conceptualize SME innovation capability as an integrated and mutually reinforcing capability bundle. Future studies should employ CFA with a hierarchical or second-order innovation construct to model this structure more effectively.

Hypothesis Testing Summary

Table 4.10 summarises the outcome of all four hypothesis tests based on the bivariate Pearson correlations and their associated t-statistics and p-values.

Table 4.10: Summary of Hypotheses Testing Results

H ₀	Null Hypothesis Statement	r	t	p	Decision on H ₀	Alternative
H ₀₁	Technological capability has no significant effect on operational performance of SMEs in Taraba State.	0.229	4.476	0.000	Rejected	H ₁₁ Accepted
H ₀₂	HRM practices have no significant effect on operational performance of SMEs in Taraba State.	0.240	4.708	0.000	Rejected	H ₁₂ Accepted
H ₀₃	Knowledge management has no significant effect on operational performance of SMEs in Taraba State.	0.194	3.767	0.000	Rejected	H ₁₃ Accepted
H ₀₄	External collaboration & networks have no significant effect on operational performance of SMEs in Taraba State.	0.254	5.009	0.000	Rejected	H ₁₄ Accepted

Source: 2026 computation. Decision rule: Reject H₀ if $p < 0.05$ (one-tailed). All p -values are < 0.001 . $N = 365$.

Interpretation of Results

Hypothesis 1: Technological Capability and Operational Performance

The correlation between technological capability (TC) and operational performance (OP) was positive and significant ($r = 0.229$, $t = 4.476$, $p < 0.001$). Thus, H₀₁ is rejected and H₁₁ accepted. This indicates that SMEs investing in ICT, modern equipment, and digital tools tend to achieve improved operational outcomes such as better quality, delivery reliability, and production flexibility.

Hypothesis 2: HRM Practices and Operational Performance

HRM practices showed a positive and significant relationship with operational performance ($r = 0.240$, $t = 4.708$, $p < 0.001$). Therefore, H₀₂ is rejected and H₁₂ accepted. This suggests that SMEs implementing effective HR practices-such as employee training, participation in decision-making, and performance recognition-experience better operational efficiency. HRM had the second-highest correlation with OP.

Hypothesis 3: Knowledge Management and Operational Performance

Knowledge management (KM) was positively and significantly related to operational performance ($r = 0.194$, $t = 3.767$, $p < 0.001$). Hence, H₀₃ is rejected and H₁₃ accepted. Although KM showed the weakest correlation among the predictors, it still significantly

enhances SMEs' ability to improve processes through effective knowledge acquisition and application.

Hypothesis 4: External Collaboration and Networks and Operational Performance

External Collaboration and Networks (ECN) had the strongest correlation with operational performance ($r = 0.254$, $t = 5.009$, $p < 0.001$). Thus, H_{04} is rejected and H_{14} accepted. This highlights the critical role of partnerships, industry networks, and collaborations in enabling SMEs to access knowledge, technologies, and best practices that improve operational performance.

Discussion of Results

This study examined the effect of process innovation-operationalized through four dimensions: technological capability, HRM practices, knowledge management, and external collaboration and networks-on the operational performance of SMEs in Taraba State, Nigeria. The findings reveal that all four dimensions positively and significantly predict operational performance, supporting the overarching thesis that process innovation is a strategic lever for SME performance improvement. These results are discussed in relation to prior empirical literature below.

Technological Capability and Operational Performance

The finding that technological capability positively and significantly influences the operational performance of SMEs ($r = 0.229$, $p < 0.001$) aligns with the broader literature on ICT adoption and SME performance. Wang et al. (2025) demonstrated that digital orientation-the strategic commitment to adopting digital technologies-stimulates digital process innovation through knowledge creation and strategic flexibility pathways, which in turn improves firm performance. Similarly, Frishammar et al. (2012) and Pisano (1997) emphasise that technological capability is foundational to process innovation, enabling firms to automate tasks, improve coordination, and enhance production quality. The modest correlation ($r = 0.229$) may reflect uneven digital infrastructure in Taraba State, as Adeyeye et al. (2018) note that while access to innovation can enhance performance, infrastructural constraints limit its full benefits. From the theoretical perspective of the Resource-Based View (Barney, 1991), technological capability constitutes a VRIN resource for SMEs: when effectively leveraged, it yields operational advantages that competitors cannot easily imitate.

HRM Practices and Operational Performance

The significant positive relationship between HRM practices and operational performance ($r = 0.240$, $p < 0.001$) is consistent with Human Capital Theory (Becker, 1964; Schultz, 1961), which posits those investments in employee development yield organizational performance dividends. This finding corroborates Ali et al. (2020), who demonstrated that HRM drives process innovation by enhancing employee motivation and capability, and

Jotaba et al. (2022), who linked strategic HRM to competitive advantage. In the context of Nigerian SMEs, where informality in HR practices is prevalent, this result is particularly instructive: SMEs that formalize training, participatory decision-making, and reward systems for innovation report meaningfully better operational outcomes. The finding that HRM recorded the second-highest bivariate correlation with OP ($r = 0.240$) among the four predictors suggests that people-focused investments are among the most impactful levers available to SME operators in Taraba State.

Knowledge Management and Operational Performance

The positive significant effect of knowledge management on operational performance ($r = 0.194$, $p < 0.001$) resonates with the Knowledge-Based View (Grant, 1996; Nonaka & Takeuchi, 1995) and corroborates several prior studies. Zizakov et al. (2023), using data from Serbian firms, found that knowledge management significantly enhances process innovation capability and serves as a mediator between quality management and innovation outcomes. Aliasghar et al. (2023) demonstrated that knowledge-search breadth from diverse external sources-including suppliers, customers, and universities-promotes SME process innovation and firm performance. The relatively lower bivariate r (0.194 compared to 0.254 for ECN) may reflect the nascent state of formal knowledge management systems in Taraba State SMEs: while respondents agreed that knowledge acquisition is valued (construct mean = 4.102), the translation of acquired knowledge into systematic operational improvements appears more constrained than in contexts with stronger institutional support. Nonetheless, the statistical significance confirms a real and meaningful positive association.

External Collaboration and Networks and Operational Performance

External collaboration and networks emerged as the strongest predictor of operational performance among the four process innovation dimensions ($r = 0.254$, $p < 0.001$), reinforcing Social Network Theory (Granovetter, 1973; Burt, 1992) and the theoretical argument that inter-organizational relationships are critical conduits for knowledge, technology, and capability transfer. This finding is congruent with Lavikka et al. (2020), who demonstrated that structured industry-university collaboration generates both practical process innovations and academically valuable knowledge. Sarpong (2024), using Ghanaian SME data, similarly found that inbound open innovation practices-including external knowledge acquisition and partner collaboration-enhance innovation capability and performance. Derdabi and Dvouléty (2024) further showed that leveraging local networks and community associations is critical for diffusing innovations in rural African SME contexts-a pattern directly applicable to Taraba State. The dynamic capabilities perspective (Teece et al., 1997) aptly frames this result: SMEs that actively engage external networks are better equipped to sense market changes, seize new process opportunities, and reconfigure their operational methods in response to environmental demands.

The Overall Regression Model

The overall regression model was statistically significant ($F(4, 360) = 7.654, p < 0.001$), confirming the collective predictive power of process innovation dimensions on operational performance. The adjusted R^2 of 0.068 indicates that approximately 6.8% of variance in operational performance is explained by the four predictors jointly. This modest effect size, while typical in cross-sectional survey-based SME research, suggests that other factors—such as firm age, access to finance, owner entrepreneurial orientation, and macroeconomic conditions—also play important roles in shaping SME operational performance in Taraba State. The high multicollinearity among the predictors ($VIF > 7.0$; inter-predictor $r = 0.91-0.95$) is noteworthy and consistent with the theoretical expectation that TC, HRM, KM, and ECN are not independent constructs but rather mutually reinforcing dimensions of an integrated process innovation capability. Transaction Cost Economics (Williamson, 1985) further explains this integration: SMEs that internalize complementary innovation practices across these dimensions reduce the transaction costs of operational improvement, yielding compounding performance benefits.

Conclusions and Recommendations

Conclusions

Based on the findings of this study, it is concluded that process innovation is positively and significantly associated with the operational performance of SMEs in Taraba State, Nigeria. Specifically, the four dimensions examined — technological capability, HRM practices, knowledge management, and external collaboration and networks — each demonstrated significant positive relationships with SME operational performance.

The findings suggest that technological capability is associated with improved operational efficiency through the adoption of ICT tools, digital platforms, and modern production technologies, although this relationship may be constrained by limited financial resources and inadequate digital infrastructure. Similarly, HRM practices were positively related to operational performance, particularly through employee training, motivation, participation, and skill development that support productivity and innovation within SMEs. The study also found that knowledge management is positively associated with operational performance through effective knowledge acquisition, sharing, and application that support learning, decision-making, and process improvement. Although its observed relationship was relatively weaker compared to the other dimensions, it remains an important component of SME innovation practices.

In addition, external collaboration and networks exhibited the strongest positive relationship with operational performance, suggesting that SMEs benefit from interactions with suppliers, customers, industry associations, and research institutions that provide access to information, technologies, and innovative practices.

Overall, the study concludes that SMEs with stronger process innovation practices — reflected in technological capability, effective HRM practices, knowledge management,

and external collaboration — tend to report higher levels of operational performance and competitiveness within the Nigerian business environment.

Recommendations

Based on the empirical findings of the study, particularly the evidence that External Collaboration and Networks (ECN) exhibited the strongest association with operational performance ($r = 0.254$, $p < 0.001$), the following recommendations are proposed in order of strategic priority:

SMEs should prioritize external collaboration and network-building by strengthening partnerships with suppliers, customers, industry associations, financial institutions, and research organizations to improve access to market information, innovative practices, technical expertise, and modern technologies.

Government and SME support agencies should establish programmes that promote collaborative innovation networks among SMEs, universities, and industry stakeholders through cluster development, business incubators, public-private partnerships, and industry–university linkages.

SME owners and managers should strengthen HRM practices through employee training, participatory decision-making, and innovation-based reward systems to enhance productivity, adaptability, and process improvement.

SMEs should expand the adoption of ICT tools and modern technologies to improve operational coordination, service delivery, and production efficiency, while government should provide enabling digital infrastructure and financial support mechanisms such as innovation grants and subsidized loans.

SMEs should strengthen knowledge management practices through effective knowledge acquisition, documentation, sharing, and application to support continuous learning, operational efficiency, and innovation capability.

Policy makers should adopt an integrated SME innovation support framework that simultaneously promotes collaboration, technological capability, HRM development, and knowledge-sharing systems, given their complementary influence on operational performance.

Suggestions for Future Research

Future studies should adopt longitudinal designs to better capture causal relationships between process innovation and SME operational performance and apply advanced analytical techniques such as structural equation modelling (SEM) or partial least squares (PLS) to examine mediating and moderating effects among the innovation dimensions.

Additionally, comparative studies across other Nigerian states or regions are needed to test the generalizability of the findings, while future research should also incorporate additional variables—such as access to finance, entrepreneurial orientation, government support, and environmental dynamism—to improve the explanatory power of the model.

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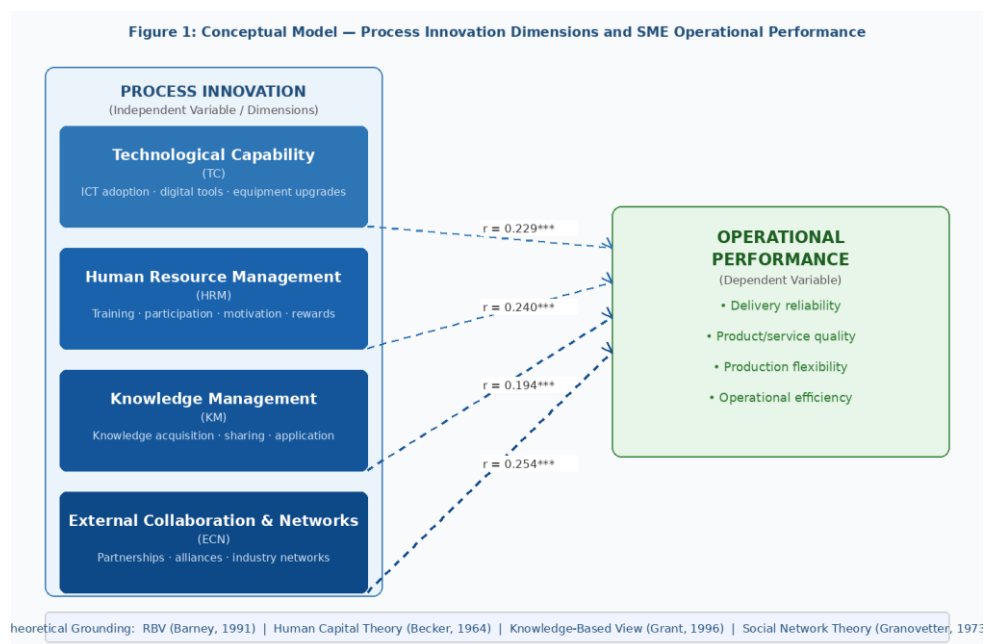
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Appendices



Source: Study Model 2026