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Digital Transformation Capabilities and Operational Cost Efficiency among SMEs in North-Central Nigeria: Evidence from Process Automation, Data Analytics, and Digital Literacy

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Abstract: *This study examines the relationship between digital transformation capabilities and operational cost efficiency among small and medium-sized enterprises (SMEs) in North-Central Nigeria. Specifically, it investigates the cost-efficiency effects of process automation, data analytics capability, and employee digital literacy. Using a quantitative research design, data were obtained from 373 SME owners, managers, and senior employees and analysed using Structural Equation Modelling (SEM). The findings indicate that digital transformation capabilities significantly improve operational cost efficiency. Process automation and employee digital literacy demonstrate the strongest positive effects, suggesting their importance in reducing operational waste, labour intensity, and coordination costs. Data analytics capability also shows a positive but comparatively weaker effect, reflecting its complementary role in strategic monitoring and decision support. The study contributes to digital transformation discourse in emerging economies and offers practical insights for enhancing SME cost competitiveness.*

Keywords**:** cost reduction, data analytics, digital transformation, process automation
JEL Classification: C81, D24, L25, O32

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INTRODUCTION

In developed and developing economies, digital transformation has emerged as a new enabler of cost efficiency, transforming the way organizations manage costs, distribute resources and coordinate operations. By leveraging cloud computing, digital platforms, artificial intelligence, data analytics and process automation, companies minimize transaction costs, enhance productivity, optimize their production processes and cut down on inadequacies (Shatila, 2025; Deku et al., 2024). In competitive markets, costs minimization is the key to sustainability, particularly for small and medium enterprises (SMEs) that typically have narrow profit margins and limited capital buffers (Gontur et al., 2023).

SMEs in Nigeria are responsible for more than 48 per cent of the gross domestic product and approximately 84 percent of employment, hence their role in poverty reduction and support for inclusive growth (SMEDAN & NBS, 2022). Nevertheless, several SMEs are faced with increased operational cost emanating from paper-based records, labour-intensive processes, disintegrated information systems and manual workflows. These results in higher transaction costs, error rates and overheads, which reduces competitiveness and cost monitoring (Gontur et al., 2023; World Bank, 2024). The situation is worse in North Central Nigeria due to infrastructural deficits and uncertainty, which increase the cost of business operations.

Policy responses are progressively focusing on digitalization as a means to SME cost efficiency. Outside funding initiatives like the Anchor Borrowers' Programme and Micro, Small and Medium Enterprises Development Fund, recent efforts focus on digitalization to cut cost and enhance financial transparency (CBN, 2024). E-commerce integration, deployment of ICT and digital skills development are supported by the National Digital Economy Policy and Strategy, whereas the Digital MSME Programme incorporates small businesses to be integrated into digital marketplaces to lower transaction costs and market access (Federal Ministry of Communications & Digital Economy, 2020; SMEDAN, 2023). Likewise, the Development Bank of Nigeria and as well Bank of Industry capacity building programmes support automation, financial management for cost control and digital accounting while the initiative on eNaira aim to transaction hurdles and lower cash-handling cost (CBN, 2024).

In spite of these interventions, cost reduction results are not consistent. Even though digital record keeping and mobile payments systems are growing in use, but less than 30 percent of SMEs are significantly using advanced digital solutions like data analytics, enterprise software or automation systems (SMEDAN & NBS, 2022). High cost of technologies, low digital literacy, inadequate digital infrastructure and unreliable electricity remain a limitation in lowering administrative costs labour costs and inventory losses (World Bank, 2024).

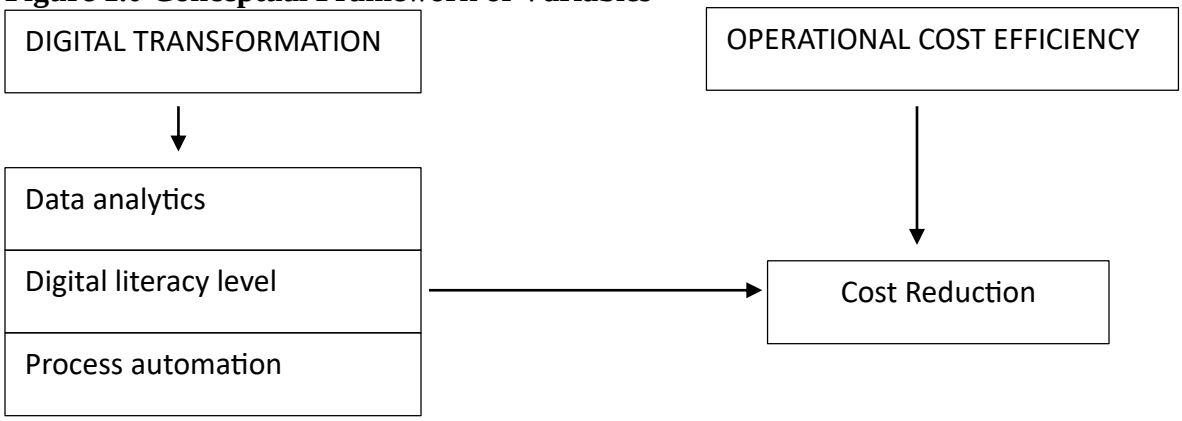
Globally, it has been proven that digitally skilled workers, automation and analytics-oriented monitoring contribute to reduction of operational costs by eliminating waste, optimizing workflows and better financial management (Kahveci, 2025; Shatila et al., 2025). Although, these advantages are dependent on employee capability, process reformation and technology implementation (Benard et al., 2025). In Nigeria, scholarly evidence on cost reduction and digital transformation in small and medium-scale enterprises (SMEs), especially in regions, is still limited. Current research has focused primarily on financial inclusion, resilience and digital marketing, with little work on operational cost structure and operational cost reduction mechanisms as a result of digital implementation (Aliuba, Onwuchekwa, & Edokobi, 2025; Mustapha, Onimole, & Adebusoye, 2025).

Therefore, this study focuses on examining the digital transformation capabilities and the operational cost efficiencies of SMEs in North-Central Nigeria in terms of digital literacy, data analytics, and process automation. It offers region-specific evidence and practical insights for improving the competitiveness, sustainable growth, and cost efficiency of SMEs.

LITERATURE REVIEW

Digital transformation is the adoption of cutting-edge technologies such as intelligent systems, data analytics, and process automation that are applied to various aspects of business operations to boost value creation, decision-making, and efficiency. The key to cost reduction for SMEs is to have streamlined workflows, less manual input, and fewer errors, which save on operational costs and make better use of resources.

Figure 1.0 Conceptual Framework of Variables



Source: Author's concept, 2026

The relationship is explained in this study via an integrated framework which consist of Fourth Industrial Revolution (4IR) theory, the Technology–Organization–Environment (TOE) framework, and Dynamic Capabilities Theory.

The 4IR theory sees digital transformation as a technology-based change that redesigns information processing, production and how organizations are coordinated. In SMEs, automation and analytics can reduce errors, enable real-time decisions and minimize labour-intensive tasks which increases productivity and lowers costs (Schwab, 2016). In contrast, 4IR theory are less focused on contextual barriers for implementation in developing economies (Schwab, 2016; Alabi et al., 2024).

The TOE framework is focused on technological, organizational and environmental settings to fill this gap. Efficiency is increased by digital tools (Wang & Zhang, 2025), whereas digital literacy ensures effectiveness in use of technology (Benard et al., 2025; Nnanna & Ohuonu, 2025). Environmental factors like market pressure, infrastructure and regulation equally affect cost saving and adoption (World Bank, 2024).

Dynamic Capabilities Theory further explains how SMEs seize innovations, sense opportunities, and reconfigure resources (Teece et al., 1997; Teece, 2007), enabling workflows redesign and sustained cost efficiency (Otopah et al., 2025; Rahman et al., 2025).

Empirical Review

Empirical evidence in developed and emerging economies reveals that digital transformation substantially enhances the efficient operations of small and medium-sized enterprises (SMEs) in particular via process optimization and cost reduction. Whereas prior research relates digitalization with enhanced organizational performance, more recent evidence provides insights on how digital tools and capacities particularly lower operating costs, better usage of resources, and improve productivity.

A lot of studies directly link digital transformation to cost reduction in the areas of integrated systems, digital payments and automation. Hamid (2025) and Nguyen (2025) report that digital transformation helps SMEs to optimize workflows, enhance the coordination of supply chains and automate repetitive tasks, thus minimizing risk of human errors and operational expenses. Likewise, Mustapha et al. (2025) found that electronic payment methods boost efficiency by enabling quicker and safer transactions, as well as lowering cost of handling cash and its related risks. Moreover, Benard et al. (2025) demonstrated that digital financial channels like Internet banking POS and ATM enhance productivities of SME by reducing costs of transaction and improving operational efficiency. Similarly, Oketta et al. (2024) noted that mobile money services contribute to enhancing management of cash-flow and reducing financial leakages within micro-enterprises.

Outside saving of cost, digital transformation also brings about indirect efficiencies benefits which reduce operational costs. Azeez et al. (2025) found that digital accounting systems significantly enhance financial reporting accuracy and decrease processing mistakes, which lowers compliance and administrative cost. Also, Aliuba et al. (2025) discovered that blockchain technology contributes to better operation efficiency by cutting down transaction fees and boosting data precision. These studies generally indicate that digital technologies does not only minimize direct costs but equally eradicate inadequacies that contribute to rising operating costs.

More so, digital transformation has been linked to greater overall efficiency and performance enhancement. In this, Goonawardena et al. (2023) and Hang et al. (2023) established that for SMEs, value creation, productivity and coordination are improved through digital transformation. For Opoku et al. (2024) digitalization strengthens innovation capability and operational efficiency via data analytics, social media platforms and ERP systems. The enhancements allow SMEs to streamline processes, minimize waste and cut down on operating expenses.

Supporting proof from Nigeria by Olumide (2025) found that digital connectivity and process automation positively enhance operational efficiency, further underscoring the cost-saving benefits of digital tools in SMEs. Ukoha and Nwachukwu (2025) also found that ERP systems and data analytics contribute to efficiency and increased productivity, resulting in improved resource utilization and reduced operational costs. Moreover, Ojo et al. (2024) highlighted the role fintech innovations play in enhancing cash-flow management and lowering the cost of accessing finance, and Olamide and Adekunle (2024) revealed that digital platforms lower costs of transaction and aid market expansion.

Digital skills and human capital also have been cited in the literature as key factors for cost efficiency. According to Akinola et al. (2024) and Bello and Oladipo (2024), digital literacy boosts SMEs' capacity to embrace and efficiently use digital technologies, thereby enhancing efficiency and minimizing operational wastage. Likewise, Ojo and Adegbie (2024) noted that digital transformation improves organizational relationship, efficiency and flexibility which all drive cost-effective operations.

Strategically, a lot researches emphasize the need to integrate digital transformation with organizational capacities and innovation. According to Otopah et al. (2025) and Tariq et al. (2024), digital transformation positively affects the performance of SMEs provided they have adaptive capabilities and innovate strategically. Similarly, Rahman et al. (2025) and Ghosh and Manokaran (2025) found that innovative firms are more efficient, thus innovation helps to bring about cost savings when incorporated into digital transformation.

In spite of the positive evidence, the study equally outlines limitations related to context, especially in developing nations. In this, Ibrahim et al. (2026) and Okwudiri et al. (2025) posit that high

implementation cost, insufficient infrastructure and low digital literacy are significant issues that lead to limited acceptance and underutilization of digital technologies.

Generally, the scholarly proof is clear that digital transformation has a positive influence on SME performance basically via operational efficiency that, in turn, lowers cost. Direct savings emanates from electronic payment, process integration and automation while indirect savings comes from enhanced productivity, error reduction and improved resource allocation. The magnitude of those benefits however, will vary based on the organizational capabilities, levels of digital adoption as well as the enabling business environment.

METHODOLOGY

Research Design, Population of Study, and Sample Size

The study adopted quantitative, survey-based research design to examine the impact of digital transformation on operational cost efficiency as measured by cost reduction among small and medium scale enterprises (SMEs) in North Central Nigeria. A structured questionnaire was used to collect primary data, which enabled the systematic collection of information regarding the impacts of digital technologies adoption and efficiency outcomes in SMEs. The target population were registered SMEs in North Central Geopolitical Zone of the country, which comprises about 161,515 SMEs**.** FCT has the highest number in SME distribution (61,899) then Nasarawa, Kogi, Kwara, Plateau, and Niger (SMEDAN (2020) cited in Onoja et al., 2024), while Benue was derived from a report by SMEDAN (2017). The population is spread throughout various industries such as agriculture, industry, trade and services. A representative sample of 383 firms was selected by Cochran's (1953) formula and then proportionately assigned to the states. Only those who had enough managerial and operational experience were selected in a multi-stage sampling, which included purposive sampling. The sample size was computed using the formula below:

$$n_0 = \frac{Z^2 * p * (1 - P)}{e^2}$$

Then the finite population adjustment is:

$$n = \frac{Z^2 * p * (1 - P)}{1 + \frac{n_0 - 1}{N}}$$

Where:
Z= 1.96 (for 95% confidence)
p= 0.5 (estimated proportion)
e= 0.05 (margin of error)
N=161,515

$$n_0 = \frac{(1.96)^2 * 0.5 * (1 - 0.5)}{(0.05)^2}$$

$$n_0 = \frac{3.8416 * 0.25}{0.0025}$$

$n_0 = \frac{0.9604}{0.0025} = 384.16$

Now, apply the finite population correction:

$n = \frac{384.16}{1+\frac{384-1}{161,515}} = \frac{384.16}{1+\frac{383.16}{161,515}} = \frac{384.16}{1+0.0024} = \frac{384.16}{1.0024} = 383.24 \approx 383$

Method of Data Analysis

The descriptive statistics and Structural Equation Modeling (SEM) were engaged in carrying out the data analysis in order to analyse the measurement and structural links between cost reduction and digital transformation among SMEs in North Central Nigeria. The reliability and validity of the research instrument were gotten via internal consistency assessment, expert validation and pilot testing using Cronbach's alpha with a coefficient of 0.70–0.96 being the acceptable benchmark which all fulfilled established methodological threshold. The model appropriateness was additionally confirmed via multiple goodness-of-fit metrics which include RMSEA, CFI, GFI, TLI, and chi-square ratios, which aligns with Hair et al. (2010) (see Table 3.1). Generally, these processes offer a strong analytical model for analysing the effects of process automation on turnaround time, cost efficiency, data analytics adoption and employee digital literacy in SMEs within the study area.

Table 3.1 Index Table

S/N	Category	Index Name	Acceptable Threshold
1	Absolute Fit	Chi-square (χ^2)	$p > 0.05$
		Goodness of Fit Index (GFI)	GFI > 0.90
2	Incremental Fit	CFI	CFI > 0.95
		RMSEA	RMSEA ≤ 0.08
		TLI	TLI > 0.90
3	Parsimonious Fit	χ^2/df	χ^2/df < 5.0

Source: Field survey 2026

Model Specification and Measurement Model

The study examines the effect of digital transformation on SME cost efficiency using Data Analytics Tools Adoption, Digital Literacy among Employees, and Process Automation Levels as proxies for digital transformation, while Cost Reduction represents cost efficiency. The measurement and structural models specify relationships between latent constructs and observed indicators through four structural equations consistent with Hair et al. (2010).

Data Analytics Tools Adoption (DATA): $L_1 = \pi_L \xi_1 + \varepsilon_1$ *(1)*

Digital Literacy Levels among Employees (DLLE): $L_2 = \pi_L \xi_2 + \varepsilon_2$ *(2)*

Process Automation Levels (PRAL): $L_3 = \pi_L \xi_3 + \varepsilon_3$ *(3)*

Cost Reduction (CSTR): $L_4 = \pi_L \gamma_4 + \varepsilon_4$ *(4)*

From model 1-4, L_1, L_2, and L_3, and L_4 denote the set of observed indicators that collectively capture the construct related to Data Analytics Tools Adoption, Digital Literacy Levels among Employees, Process Automation Levels, and cost reduction. $\xi_1, \xi_2, \xi_3, and\ \gamma_4$ are the four (4) latent independent and the dependent variables, π_L are parameters to be estimated. Finally, ε_1, ε_2, ε_3, and ε_4, are error terms with zero expectation:

Structural Model

The structural model describes the interconnectedness between the latent dependent variables (TCBP) and the independent variable (Data Analytics Tools Adoption DATA, Digital Literacy Levels among Employees DLLE, and Process Automation Levels PRAL).

$\gamma = \beta\gamma + \Gamma\xi + \zeta$----------(5)

γ represent the dependent variables (Cost Reduction CSTR).

ξ= (Data Analytics Tools Adoption DATA, Digital Literacy Levels among Employees DLLE, and Process Automation Levels PRAL) denotes the independent variables (digital transformation), which affect the cost efficiency of small and medium-scale enterprises (SMEs).

β= represents the coefficients for the relationships among the dependent variables.

Γ= represents the coefficient that captures the direct effect of digital transformation (DATA, DLLE, and PRAL) on the cost of core business operations of small and medium-scale enterprises (SMEs) (TCBP)

ζ= represents the error term, capturing any unobserved factors affecting the dependent variables.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 4.1.1 shows the descriptive statistics for the study variables with 373 valid observations to give initial impressions of the perception of respondents regarding digital transformation and operational efficiency of SMEs in North Central Nigeria. The findings reveal generally high mean scores for all variables, meaning that there was good agreement regarding positive impacts of digital technologies. In particular, the data analytics indicators (data2–data6) have a mean value of 3.83 to 4.00 and a moderate standard deviation of 0.76 to 0.86, meaning that it is widely adopted with moderate variability. The digital literacy variables (dlle1-dlle4) have mean scores ranging from 3.83 to 4.06, with dlle2 having relatively high differences (Std. dev = 1.0182), which shows that there are differences in digital competence among respondents. The mean values for process

automation measures (pral1–pral6) range from 3.82 to 3.93 with a standard deviation of less than 0.92, which indicates that the perception of improved workflow and efficiency is consistent. Likewise, turnaround time indicators (tcbp4–tcbp6) demonstrate high levels of agreement, with a mean score of between 3.85 and 4.15, and while quite a bit of variability was seen within each one, it was relatively low (0.54–0.86), reflecting improved business processes. The variables related to credibility/cost efficiency (cred3, cred4, cred5 and cred6) have the highest mean scores (4.10–4.29) and their standard deviations range between 0.71 and 0.79, indicating a high level of agreement that digital transformation enhances business reliability and trust. The high mean scores (mainly above 3.8) and the moderate spread indicate that respondents generally had positive perceptions, and the range of responses (1 to 5) means that there is variation in experience. The results offer a strong empirical foundation for further structural equation modeling (SEM) analysis, affirming the proposition that digital transformation plays a crucial role in enhancing operational effectiveness and performance among SMEs.

Table 4.1.1: Descriptive Statistics

Variables	Obs	Mean	Std.dev	Min	Max
data2	373	4.002681	0.8597907	1	5
data3	373	3.957105	0.7572475	1	5
data5	373	3.949062	0.7760393	1	5
data6	373	3.825737	0.7719423	1	5
dlle1	373	4.061662	0.8353445	1	5
dlle2	373	3.825737	1.018212	1	5
dlle3	373	3.967828	0.8974485	1	5
dlle4	373	3.951613	0.882793	1	5
pral1	373	3.908847	0.8873375	1	5
pral2	373	3.927614	0.9202699	1	5
pral3	373	3.841823	0.8192371	1	5
pral4	373	3.932976	0.7748125	1	5
pral5	373	3.856757	0.7746109	1	5
pral6	373	3.822581	0.7705676	1	5
cred3	373	4.284182	0.7293329	1	5
cred4	373	4.101877	0.7865275	1	5
cred5	373	4.174263	0.7064848	1	5
cred6	373	4.286863	0.7152442	1	5

Source: Compile by the author 2026
Note: data is data analytics, dlle is digital literacy, pral is process automation, and cred is cost reduction

Multicollinearity Analysis

Table 4.2.1 below shows the multi-collinearity diagnostics for the study variables based on Tolerance and Variance Inflation Factor (VIF) where Tolerance>0.10 and VIF<10 signifies absence of multi-collinearity. Intercorrelations are not problematic in any of the models, with results indicating no evidence of such issues. The tolerance value (0.323 to 0.527) and the value of each VIF (1.898 to 3.099) are in a satisfactory range in Model 1 (Data Analytics: data2, data3, data5, data6), indicating that the indicators are distinct enough and do not cause estimation bias. Model 2 (Digital Literacy: dlle1–dlle4) has tolerance values ranging from 0.380 to 0.458 and VIF values between 2.183 and 2.629, indicating that the variables measure complementary, yet non-redundant aspects of employees' digital competence. Likewise, in Model 3 (Process Automation: pral1 – pral6), the tolerance values of the indicators range from 0.348 to 0.437, and the VIF values range from 2.287 to 2.871, which means that each indicator explains a different part of the variance. In general, the results showed that there was no multicollinearity problem since all variables were within the acceptable limit, which implies that the subsequent regression and structural equation modeling (SEM) results would have reliable and unbiased estimates of parameters.

Table 4.2.1 *Multicollinearity*

Model 1	**Tolerance**	**VIF**
Data Analytics2	0.469	2.133
Data Analytics3	0.323	3.099
Data Analytics5	0.527	1.898
Data Analytics6	0.354	2.826
Model 2	**Tolerance**	**VIF**
Digital Literacy Level Among Employment1	0.423	2.365
Digital Literacy Level Among Employment2	0.458	2.183
Digital Literacy Level Among Employment3	0.383	2.613
Digital Literacy Level Among Employment4	0.380	2.629
Model 3	**Tolerance**	**VIF**
Process Automation Level1	0.389	2.570
Process Automation Level2	0.437	2.287
Process Automation Level3	0.348	2.871
Process Automation Level4	0.383	2.613
Process Automation Level5	0.366	2.730
Process Automation Level6	0.382	2.618

Assessment of fit of the Measurement Model

Table 4.3.1 below is a representation of the Confirmatory Factor Analysis (CFA) report, analysing the sufficiency of the measurement model for key constructs—Data Analytics (DATA), Digital Literacy among Employees (DLLE), Process Automation (PRAL), Turnaround Time of Core

Business Processes (TCDP), and Cost Efficiency (CRED). In general, the outcome reveal satisfactory model fit and strong internal consistency across all constructs, dependent on established thresholds (RMSEA < 0.08; GFI, AGFI, CFI, TLI, NFI ≥ 0.90; $\chi^2/df < 5$; Cronbach's Alpha ≥ 0.70). Particularly, DATA exhibits excellent fit (RMSEA = 0.011; GFI = 0.912; AGFI = 0.998; CFI = 0.910; TLI = 0.956; NFI = 0.930; $\chi^2 = 2.084$) and high reliability ($\alpha = 0.868$), indicating minimal model–data discrepancy and consistent measurement. DLLE equally illustrate good fit (RMSEA = 0.072; GFI = 0.951; AGFI = 0.932; CFI = 0.995; TLI = 0.974; NFI = 0.925; $\chi^2 = 5.902$; p = 0.052) with strong reliability ($\alpha = 0.876$), recommending acceptable specification despite a marginal χ^2 value. PRAL indicate strong performance (RMSEA = 0.079; GFI = 0.919; AGFI = 0.933; CFI = 0.913; TLI = 0.974; NFI = 0.914; $\chi^2 = 1.270$) and the highest internal consistency ($\alpha = 0.903$), depicting excellent construct representation. Similarly, TCDP implies good model fit (RMSEA = 0.079; GFI = 0.930; AGFI = 0.917; CFI = 0.999; TLI = 0.971; NFI = 0.934; $\chi^2 = 1.600$), though its reliability ($\alpha = 0.705$) is comparatively moderate, indicating slight response variability. The CRED construct at same time satisfies all criteria (RMSEA = 0.077; GFI = 0.902; AGFI = 0.976; CFI = 0.936; TLI = 0.981; NFI = 0.922; $\chi^2 = 4.296$; $\alpha = 0.844$), affirming good fit and consistency. Generally, these results justify the measurement model, denoting that all constructs are accurately and reliably operationalized, thereby providing a thorough empirical basis for subsequent structural equation modeling (SEM) analysis.

Table 4.3.1: Individual Confirmatory Factor Analysis CFA (Assessment of fit of the Measurement Model)

Variables	RMSEA	GFI	AGFI	CFI	TLI	NFI	CHISQ/DF	PV	Cronbachα
DATA	0.011	0.912	0.998	0.910	0.956	0.930	2.084	0.000	0.868
DLLE	0.072	0.951	0.932	0.995	0.974	0.925	5.902	0.052	0.876
PRAL	0.079	0.919	0.933	0.913	0.974	0.914	1.270	0.000	0.903
TCDP	0.079	0.930	0.917	0.999	0.971	0.934	1.600	0.004	0.705
CRED	0.077	0.902	0.976	0.936	0.981	0.922	4.296	0.000	0.844

Source: **Source: Field survey 2025**

Factor Loadings of Measurement model

The path diagram shows the connection between observed indicators with their associated latent constructs, and factor loadings represent the strength of the association. In general, the measurement properties of all constructs are satisfactory. In the Data Analytics domain, indicators (data2, data3, data5, data6) have high loadings from 0.70 to 0.88, with data3 (0.88) and data6 (0.84) being the most solid. Likewise, the internal consistency of Digital Literacy among Employees is high with loadings of dlle1–dlle4 ranging from 0.78 to 0.84, with the highest being 0.84 for dlle3. The Process Automation construct is also quite well represented, having six indicators (pral1–pral6) loading from 0.73 to 0.88, pral2 (0.88) being the strongest indicator. The indicators (tcbp4, tcbp5, and tcbp6) for Turnaround Time are 0.96, 0.75, and 0.74 respectively, with tcbp4 (0.96) being an exceptionally strong measure. The loadings of the Cost Reduction

construct (cred3–cred6) range from acceptable to strong, from 0.67 to 0.84, with cred4 (0.84) and cred5 (0.82) performing well, and cred3 (0.67) just adequate. The results of the measurements taken together indicated that the measurement model was reliable and has excellent convergent validity, which is sufficient as a foundation for further analysis using structural equation modeling (SEM).

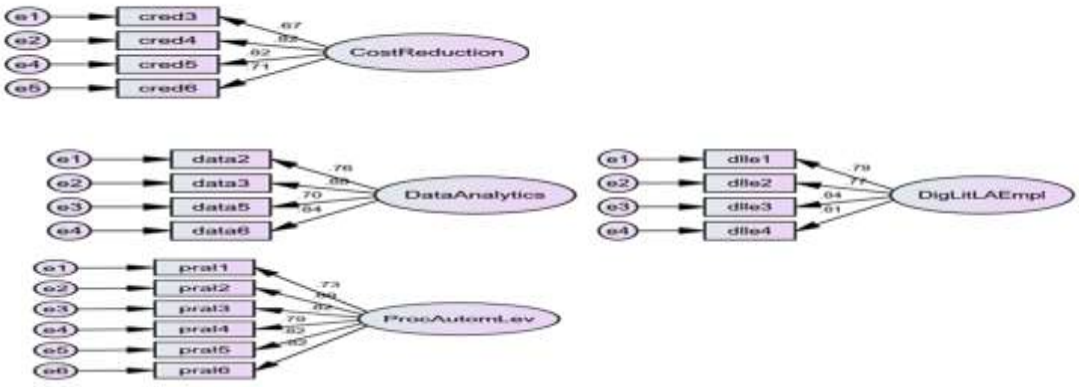


Figure 4.4.1: Measurement model

Eliminated construct with low Factor Loadings

The results of the modification measurement model of confirmatory factor analysis (CFA) for the exclusion of the poorly performing indicators are presented in Table 4.5.1. Factor loadings of less than the acceptable level of 0.50 were dropped to improve construct validity and reliability. Precisely, the data1 (0.03) and data4 (0.43) items were removed from the data analytics construct because they did not represent the construct well, and the dlle5 (0.46) and dlle6 (0.40) were removed from the digital literacy construct because they did not align well with the underlying concept. Furthermore, the loadings on the two constructs of the cost reduction were negative for both constructs, cred1 (-0.11) and cred2 (-0.09), which suggests conceptual inconsistency and possible measurement error. These items are eliminated to enhance the measurement model by only keeping items that are theoretically sound and reliable, which will ultimately make the measurement model more reliable, valid and suitable for further analysis with structural equation modeling (SEM).

Table 4.5.1 construct with low factor loadings

Construct 1	Factor Loadings
data1	0.03
data4	0.43
Construct 2	
dlle5	0.46
dlle6	0.40
construct 3	
cred1	-0.11
cred2	-0.09

Structural model

Based on the results of the structural model from Figure 4.6.1 and Table 4.6.1, there is empirical evidence for the role that different elements of digital transformation like process automation, employee digital literacy, and data analytics play on SME cost reduction in North Central, Nigeria. The results show that these elements are not equally impacted, highlighting that digital transformation has many aspects to improve operational efficiency.

The cost reduction and data analytics show a positive relationship (β = 0.170), and are statistically significant at the 10% level. This means that, although analytics can help to be cost efficient, it has a relatively subtle impact and is likely to take time to manifest. The findings suggest that the effects of data analytics are mostly indirect, functioning via predicting, resource allocation and better decision-making and may be limited in short-term by its initial adoption and capability cost.

Process automation, on the other hand, shows a solid and statistically significant positive impact on cost reduction (β = 0.303). The outcome underline automation as one of the key factors of decreasing manual effort, reducing of errors, cutting of labor costs and financial efficiency, and its ability to streamline processes. The degree and importance of this connection points out that automation generates better instant and tangible cost-saving benefits for SMEs.

Likewise, digital literacy among employees appears to be the most impactful factor of cost reduction (β = 0.323), by having a greater substantial effect. This reflects the importance of human capital's contribution to the realization of digital investments in terms of operational benefits. Digitally skilled workforce improves system usage, minimizes inefficiencies and operational downtime, thus, strengthening cost-saving results. Eminence to digital literacy opines that technology adoption is not enough without the required competence to effectively implement and manage the digital system.

The findings show that digital literacy and process automation represent the most direct and significant mechanisms via which digital transformation minimizes operational cost whereas data

analytics is more balancing and play a gradual role. This approach illustrates correlation between organizational process, human capabilities and technological tools in attaining efficiency gains. In terms of hypothesis testing, the null hypothesis for data analytics is accepted at the normal 5% significance level, while those for process automation and digital literacy are rejected and support their important role in cost reduction. The results generally conclude that the sustainable cost efficiency in an SME can be gained by a combined method of process optimization, employee capacity building and proper utilization of digital technologies.

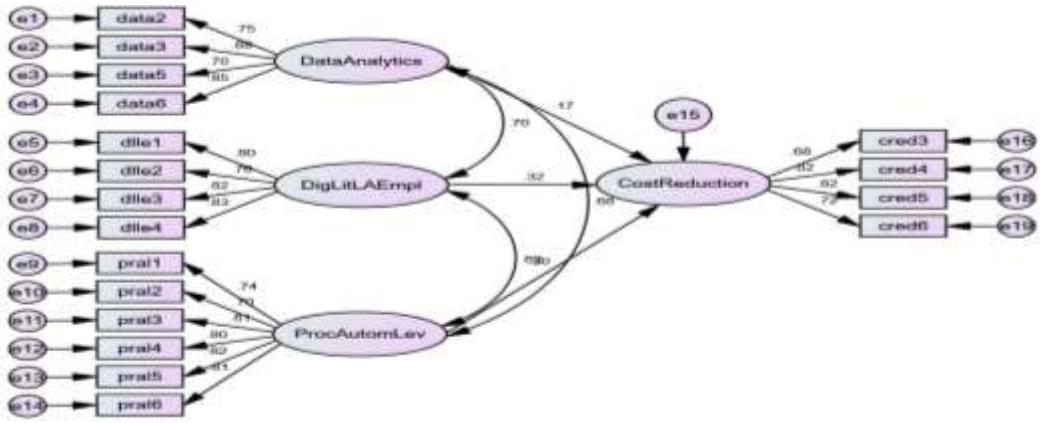


Figure 4.6.1: Structural model

Table 4.6.1: Structural model

Hypothetical Relationship	Path Coefficient	S.E	C.R	p-value
CostReduction <-- DataAnalytics	0.170	0.077	1.680	0.093*
CostReduction <-- ProcAutomLev	0.303	0.072	3.370	0.000***
CostReduction <-- DigLitLAEmpl	0.323	0.064	-3.411	0.000***

Source: Compiled by the author, 2026

Discussion of Major Findings

The results from this study are in full agreement with previous empirical studies regarding the impact of digital transformation on the cost reduction of operational activities of SMEs. The results that the process automation significantly lowers costs is also aligned with Hamid (2025) and Nguyen (2025) which stated that workflows, manual intervention and human error are streamlined and reduced by process automation. Likewise, Azeez (2024), Deku et al. (2025), and Hang et al. (2025) reported that the increased automation reduces labour expenses and removes inefficiencies

in the operations. This current study, therefore, confirm the agreement that automation is one of the most direct ways in which digital transformation can translate to cost savings.

More interestingly, digital literacy has the highest impact on cost reduction, aligning with several literature that highlights the importance of human capital in the outcomes of digital transformation. The result agrees with Akinola et al. (2024) and Bello and Oladipo (2024) who reported that digital competence enhances the effective utilization of digital tools while reducing operational waste. It also backs Ghosh and Manokaran (2025) and Wang and Zhang (2025), who argued organisations attain higher efficiency when its employees are digitally competent. In Nigeria's context, the finding aligns with Ibrahim et al. (2025) and Mustapha et al. (2025) who reported human capability to be a major factor of cost efficiency. The study is therefore an extension of the previous studies which noted that adoption of technology is not enough without proper utilization of the technological tools.

In terms of data analytics, the study noted a positive but relatively small impact on cost reductions with significance level of 10%. This aligns with the findings of Azeez et al. (2025), Oketta et al. (2025), and Deku et al. (2024), who noted that analytics is key to efficiency gains primarily by enhanced decision-making, resource allocation and monitoring. The weaker magnitude is, however, in favor of the debate of Ojo et al. (2024) and Okwudiri et al. (2024) that the cost benefits of analytics may be hindered due to the increased investment costs and the requirement of advanced technical capabilities. This indicates that analytics supplements rather than substitutes automation and digital skills.

Moreover, the results are in line with other researches that link digital transformation to enhanced performance and cost-effectiveness. Goonawardena et al. (2023), Hang et al. (2023) and Opoku et al. (2024) noted that value creation, coordination and productivity are enhanced by digital tools, which leads to reduced costs of operation. Similarly, Olumide (2025) and Ukoha et al. (2025) discovered that the integration of technology and optimization of processes improve the use of resources and reduce waste. The harmonizing tasks between digital literacy, data analytics and automation noticed in this research are found in Tariq et al. (2024) and Nguyen (2025), who stressed that digital transformation outcomes rely on the synchronization of human skills, technology, and processes. Additionally, Rahman et al. (2025) and Ghosh and Manokaran (2025) highlighted that performance benefits can be increased when digital investments are supported organizational innovation and capacity. Lastly, the relatively ineffective impact of data analytics is indicative of challenges common to developing nations like skill shortages, implementation challenges and infrastructure limitations (Ibrahim, et al., 2026; Okwudiri, et al., 2025).

CONCLUSION AND POLICY RECOMMENDATIONS

By employing SEM, the result reveal that automation offers instant cost-savings by workflow streamlining, error and manual labour reduction while digital literacy improves employees

capacity to properly utilize digital tools which further enhances efficiency. Even though data analytics do not substantially minimize costs in the short-term, it supports long-term efficiency via enhanced resource planning and decision-making. Also, the research denotes that digital transformation is multifaceted and mostly applicable when technology implementation is integrated with employee skill development and strategic data usage. Therefore, the study suggests that SMEs adopt a complete and phased mechanism, concentrate on automation for direct benefits investing in digital skills, and leveraging data analytics over time, while policymakers support this transition through improved infrastructure, affordability, and training, ensuring an integrated strategy that drives sustainable performance and competitiveness.

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