THE ROLE OF DIGITALIZATION AND DIGITAL CAPABILITIES IN FINANCIAL PERFORMANCE: A MULTILAYER PERCEPTRON-BASED HYBRID SEM-ANNS APPROACH

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ABSTRACT

This study aims to examine how different aspects of digitalization and digital capabilities affect financial performance of SMEs. The study employs a deductive approach, collecting data through questionnaires from 396 respondents and utilizing structural equation modeling and artificial neural networks analysis to empirically evaluate the proposed model. The results emphasize the importance of digital transformation, digital innovation, and digital servitization in enhancing the financial performance of SMEs by optimizing processes, reducing operational expenses, and improving customer engagement. Moreover, the research highlights the critical role of digital capabilities (encompassing human, technical, innovation and collaboration capabilities) in facilitating these improvements. Notably, human and innovation capabilities emerge as the most influential factors, demonstrating that a skilled workforce and robust innovative capacity are vital for converting technological investments into tangible financial benefits. This study advances resource-based view theory by examining how digital technologies and capabilities act as vital resources that boost the financial performance of SMEs. By integrating linear with non-linear methods, the research offers a detailed analysis of how digital resources contribute to competitive advantage. The study recommends targeted policies, including financial incentives, digital literacy programs, and innovation hubs, to align technology with SME business needs and foster growth, competitiveness, and sustainability.

Keywords: digital transformation, digital innovation, digital capabilities, digital servitization, financial performance, artificial neural networks

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1.   INTRODUCTION

In the context of Small and Medium-Sized Enterprises (SMEs), financial performance (FP) is integral to their operational effectiveness, revenue generation, business continuity, and growth, all while adapting to changing environmental conditions (Indriastuti and Mutamimah, 2023). Evaluating FP typically involves analyzing metrics such as turnover, operating profit, and capital adequacy. SMEs are essential to Pakistan's economic landscape, representing over 90% of the country's estimated 3.2 million businesses and contributing significantly to both GDP and export revenues (Shah, 2018). Despite their economic significance, SMEs encounter various challenges that impact their financial stability, including rising costs in essential areas such as raw materials, transportation, and labor. This financial strain is often aggravated by their relatively limited resources compared to larger enterprises (Fauzi et al., 2023). The Pakistani government has prioritized improving the business environment for SMEs by implementing policies that stimulate investment and strengthen legal and financial infrastructure, aiming to boost their global competitiveness. Addressing the FP of SMEs is crucial for identifying their specific challenges and formulating strategies that ensure their sustainability and enhance their contributions to the economy.

SMEs are crucial to Pakistan's economy, representing over 90% of the 3.2 million business entities, contributing 40% to GDP, and generating more than 40% of export earnings (Shah, 2018). Their significant role highlights the need for a comprehensive examination of their FP to address unique challenges and develop tailored support strategies. In the face of competition from larger firms, digitalization offers SMEs a vital opportunity to shift from traditional methods to advanced technological frameworks, fostering innovation, operational efficiency, and long-term growth (Queiroz et al., 2022). Embracing digital platforms helps SMEs enhance competitiveness and explore new market opportunities.

Digitalization transforms analogue data, processes, and structures into digital formats, enhancing data management, communication, and efficiency (Indriastuti and Mutamimah, 2023). For SMEs, adopting digital technologies enables process automation, market expansion, and operational improvement, contributing to competitive advantage and innovation (Tahir et al., 2022). Although some scholars argue that its impact on financial performance may not be immediate (Popović-Pantić et al., 2020), digitalization's transformative potential remains significant, enabling SMEs to exploit new opportunities (Heubeck, 2023). Successfully navigating digital transformation requires dynamic capabilities, particularly digital capabilities, defined as the ability to adapt and thrive in a digital environment (El Sawy et al., 2016). These include human resources skills, collaboration, technological proficiency, and innovation, all of which are vital for leveraging digitalization (Nasiri et al., 2020).

Despite the recognized significance of these digital capabilities, current literature lacks a thorough examination of their direct impact on FP. This gap highlights the need for empirical studies to clarify how digitalization and digital capabilities influence FP. Although the importance of this relationship is acknowledged, there is a notable absence of empirical evidence demonstrating a clear and robust connection, especially concerning digital technology. Thus, it is imperative to investigate and understand this relationship within the context of SMEs. To address this research gap, the study is designed with two main objectives: first, to conduct a thorough examination of

how different aspects of digitalization impact FP; and second, to assess how various dimensions of digital capabilities affect the FP of SMEs.

While the transformative potential of digital technologies and capabilities for enhancing FP of SMEs is well acknowledged, the precise mechanisms through which these technologies and capabilities exert their effects remain insufficiently investigated. This research endeavors to address this gap by systematically examining the impact of various dimensions of digitalization and digital capabilities on the FP of SMEs. Previous studies in this domain have predominantly utilized Structural Equation Modeling (SEM) to elucidate linear relationships between digital technology adoption and business outcomes. However, these methodologies often fail to capture the intricate, non-linear interactions that are essential for a comprehensive understanding of the effects of digital technologies. To bridge this gap, this study adopts a hybrid methodological framework, integrating SEM with Artificial Neural Networks (ANNs) to explore both linear and non-linear relationships. By leveraging both SEM and ANNs methodologies, this study offers a wider perspective on the relationship between digital technology adoption and SME performance. The findings guide SME managers on technology investment priorities and inform policymakers on frameworks for sustainable growth through digital technology adoption.

2.   LITERATURE REVIEW

2.1.   *Theoretical Framework*

This study is anchored in the resource-based view (RBV) theory (Wernerfelt, 1984), which emphasizes that a firm's internal resources and capabilities are key to sustaining competitive advantage. The study distinguishes between digitalization and digital capabilities, aligning with RBV by highlighting how SMEs use these tools to boost efficiency, responsiveness, and innovation. Digital capabilities enable firms to maximize the benefits of digitalization (Wernerfelt, 1984; Ullah et al., 2023). RBV underscores that it is the strategic configuration and deployment of digital resources, rather than their mere possession, that enhances performance (Proksch et al., 2024). SMEs that align digital capabilities with digitalization efforts improve financial outcomes through innovation, cost efficiency, and enhanced customer experience (Susanty et al., 2020). This framework positions digitalization as a strategic resource and digital capabilities as core competencies for sustained growth. Figure 1 shows study's conceptual framework.

Figure 1: Conceptual Framework
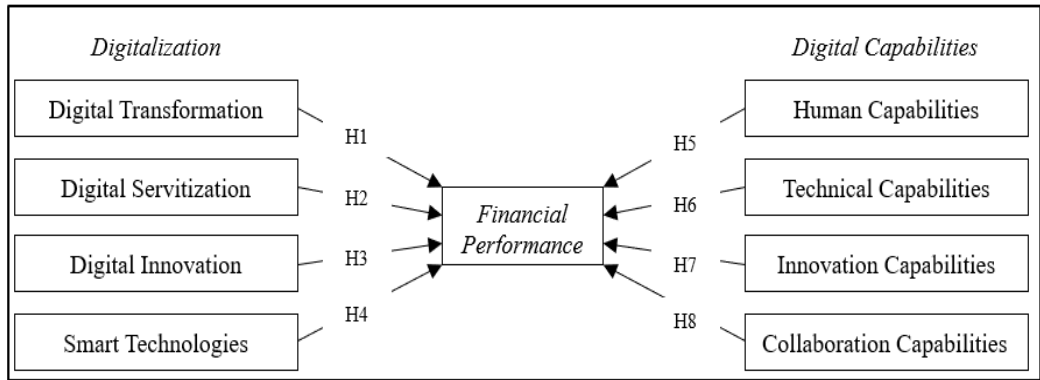
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2.2. Hypotheses Development

2.2.1. Digital Transformation (DT)

Kovalevska et al. (2022) argue that DT has the potential to enhance various business processes, such as sales, procurement, distribution, and marketing, thereby improving the FP of SMEs. However, while these benefits are emphasized, the authors highlight critical concerns regarding the capacity of SMEs to fully implement DT. Key challenges include whether SMEs have the necessary digital skills and expertise, as well as how factors like limited digital literacy and resource constraints might hinder the effective adoption of DT. This perspective aligns with the RBV theory (Wernerfelt, 1984). However, applying this framework to SMEs raises questions about their ability to translate digital investments into tangible performance outcomes, especially given their constrained financial and human resources (Heaton et al., 2023).

While previous studies (Li et al., 2022; Ullah et al., 2023; Susanty et al., 2020) support the positive relationship between DT and improved FP, the broader literature reveals mixed results. For example, Awa et al. (2015) found that DT adoption increases sales productivity, yet findings from Wielgos et al. (2021) present conflicting evidence, showing an insignificant effect of DT on FP. These varying results suggest that the success of DT in enhancing FP may depend on other factors, indicating the need for further research into these contextual influences. Thus, following hypothesis is framed:

H₁: DT has significant impact on FP of SMEs.

2.2.2. Digital Servitization (DS)

Recent studies have focused on DS, a strategy that integrates digital solutions with traditional products to gain competitive advantage (Kovalevska et al., 2022). DS signifies a shift from product-centric to service-oriented models, enabled by digital technologies (Sklyar et al., 2019).

Servitization proponents argue that blending services with products provides more stable and sustainable revenue than product-only models (Sklyar et al., 2019). Suarez et al. (2013) contend that it enhances profitability and differentiates firms. However, such views may overlook operational challenges, including rising costs and inefficiencies in transitioning to service-based models. The financial outcomes of servitization remain debated; while it may drive higher revenues, it also often leads to reduced net profits due to increased labor costs and working capital requirements (Kohtamäki et al., 2020). Ullah et al. (2023) found a positive link between service offerings and FP, but their findings likely reflect specific contextual factors such as industry type, service capabilities, and strategic choices. These mixed outcomes suggest that the effectiveness of servitization is context-dependent and requires further study to determine the conditions for sustained financial success.

Thus, we made that:
H₂: DS has significant effect on FP of SMEs.

2.2.3 Digital Innovation (DI)

DI is the creation of market offerings, business processes, or models utilizing digital technologies (Nambisan et al. 2017). The study in question frames DI as innovative digital solutions that drive significant changes in organizational products, services, and operational structures, emphasizing the enhancement and creation of new digital offerings (Hund et al., 2021). Abbas et al. (2024) argue that DI is pivotal in maintaining the attractiveness of traditional products and generating additional revenue through a modular approach. This implies that DI not only enhances existing products but also creates new income opportunities. Empirical evidence generally supports a positive link between DI and FP. Scott et al. (2017) and Ullah et al. (2023) observed a positive relationship between DI and FP, suggesting that DI improves FP. Hanelt et al. (2021) also found that DI positively impacts FP through panel data regression. However, these positive correlations should be considered cautiously. Existing research often overlooks challenges such as initial investment costs, integration difficulties with existing processes, and the need for continuous adaptation to digital trends. Thus, while DI shows promise for enhancing FP, a more thorough examination of the conditions affecting DI's success is essential for a thorough understanding of its impact.

Thus, following statement is made:
H₃: DI significantly influences FP of SMEs.

2.2.4. Smart Technologies (STs)

The RBV theory suggests the impact of STs on FP by emphasizing the significance of unique organizational resources and capabilities (Estensoro et al., 2022). STs, including AI, data analytics, and the Internet of Things (IoT), are considered crucial assets that enhance a firm's competitive edge and financial outcomes (Zhuo and Chen, 2023). The RBV suggests that effectively leveraging these technologies improve operational efficiency, decision-making, and innovation, potentially leading to increased productivity, cost savings, and revenue growth. However, the RBV's assumption that integrating STs always results in a competitive advantage and superior FP requires scrutiny. While the theory anticipates that firms with advanced technological resources will outperform others (AlZayani et al., 2024), this may overlook challenges such as high adoption

costs, the need for specialized skills, and potential disruptions during integration. Additionally, the theory may not fully account for the fast-paced evolution of technology and its varying impacts across different industries (Lee et al., 2024). Therefore, a more detailed and context-specific analysis is necessary to understand how STs interact with organizational resources and their actual impact on FP.

Hence, we proposed that:
H_4: STs have significant effect on FP of SMEs.

2.2.5 Human Capabilities (HCs)

Bauters et al. (2018) argue that human cognitive abilities offer a unique advantage over automated systems, making HCs essential for learning and adapting to organizational change. This adaptability is crucial for leveraging digitalization to improve traditional practices and operational environments (Atobishi et al., 2024). However, the integration of HCs into digital strategies faces practical challenges. The impact of employees' digital skills on FP depends on factors such as the quality of digital infrastructure, sufficient training, and alignment with organizational culture (Doussard and Yenigun, 2024). Lubis et al. (2024) stress that employee competencies are key to utilizing digitalization and performance management systems effectively, especially when these systems support real-time analysis and continuous process improvement. Yet, their success is heavily reliant on integration within organizational practices. Senoaji et al. (2024) further emphasize the role of employee engagement in digitalization, linking it to improved FP. Thus, while HCs are central to digital success, their effectiveness also hinges on broader organizational enablers and contextual factors. Thus, it is established that:
H_5: HCs have significant effect on FP of SMEs.

2.2.6 Technical Capabilities (TCs)
The widespread adoption of digital technologies has elevated consumer expectations and expanded their awareness of available options (Nudurupati et al., 2016). To leverage these advancements effectively, organizations must develop robust TCs. Integrating physical materiality with software-driven dynamic capabilities exemplifies how TCs enhance product and service offerings (Parida et al., 2015). While TCs are crucial for gaining competitive advantages through digitalization, the assumption that they alone ensure success amidst rapid technological change requires scrutiny. Jum'a et al. (2024) propose strategies for optimizing TCs, including innovative data sourcing from social media and web analytics, robust data infrastructure for analysis, and the development of tailored performance optimization models. However, practical challenges exist, as the effectiveness of these strategies depends on an organization's ability to adapt to rapidly changing conditions and invest in necessary resources and expertise (Atobishi et al., 2024). Therefore, while TCs are essential for driving innovation, a comprehensive approach is needed for achieving sustained FP improvements. Thus, we framed following statement:
H_6: TCs have significant influence on FP of SMEs.

2.2.7 Innovation Capabilities (ICs)

Innovation plays a crucial role in enhancing FP, particularly as digital technologies reshape the business landscape (Schäper et al., 2023). According to Melnyk et al. (2004), innovation positively impacts FP by necessitating firms to develop capabilities such as skilled personnel, organized

processes, effective communication systems, and opportunities for unforeseen innovation. Empirical evidence also supports the significant influence of changes in a firm's capabilities, especially those related to innovation, on FP (Davies et al., 2023). However, the integration of digital technologies fundamentally alters employees' cognitive and behavioral processes (Tsou and Chen, 2023), making effective management of performance assessment processes critical for translating capabilities into desired outcomes (Melnyk et al., 2004). Khalifaturofi'ah (2023) emphasize that innovation management is vital for business success, highlighting that innovations in management practices are essential for improving FP. Despite these insights, the review of ICs within digitalization frameworks reveals complexities. ICs are essential for leveraging digitalization, but their effectiveness depends on their integration into the organizational context and broader factors (Shafqat et al., 2025). Therefore, while ICs are crucial for fostering innovation, their impact on FP requires a deep examination of their practical application and contextual conditions. Thus, it is established that:

H_7: ICs have significant impact on FP of SMEs.

2.2.8 Collaboration Capabilities (CCs)

The shift to digitalization poses significant challenges for managing collaboration aimed at enhancing value through greater efficiency and effectiveness. This shift calls for innovative strategies, such as leveraging product innovations and engaging in collaborative product development (Bals et al., 2018). Research has largely focused on the dynamics between clients and digital service providers, especially in IT outsourcing contexts (Goo et al., 2007). Evidence from Zhou et al. (2024) examined that these relationships facilitate the exchange and synergistic enhancement of IT resources, thereby improving the capabilities of the involved parties. Ardakani et al. (2023) advocate for a broader performance evaluation framework that extends beyond internal metrics to include assessments within collaborative networks and social media. They emphasize the importance of developing CCs to achieve superior performance in digital enterprises (Audretsch et al., 2023). While CCs are essential for leveraging digitalization in collaborative efforts, their impact on FP depends on their effective integration within organizational and collaborative contexts. A deep analysis of CCs is needed to understand their practical application and the broader factors influencing their effectiveness in enhancing FP.

H_8: CCs have significant effect on FP of SMEs.

3. METHODOLOGY

3.1. Research Design

This study employs a quantitative research framework to explore the effects of digital transformation (DI, DT, DS and STs) and digital capabilities (CCs, HCs, ICs, and TCs) on the FP of SMEs in Pakistan. The quantitative methodology allows for a detailed and structured examination, crucial for assessing the key indicators and internal consistency that support SMEs' digital technology adoption. By integrating both Structural Equation Modeling (SEM) and Artificial Neural Networks (ANNs), the research provides a thorough analysis of the linear and non-linear interactions.

3.2. Data Collections: Sample and Procedure

A detailed list of SMEs was obtained from the Small and Medium Enterprises Development Authority (SMEDA, 2023) to facilitate the selection of a representative sample. Data collection was conducted using a structured questionnaire, which was distributed to SME owners, CEOs, and managers. The final sample comprised 396 respondents from various regions across Pakistan, including Punjab, Sindh, Khyber Pakhtunkhwa, Baluchistan, and Gilgit Baltistan, utilizing a stratified proportionate sampling method. To ensure data relevance and consistency, three critical inclusion criteria were established (Ullah et al., 2023). First, SMEs selected for the study were required to have been engaged in digital business activities for at least three-years. The three-year duration was chosen to ensure that SMEs had sufficient time to implement digital initiatives and observe their effects on financial performance. This timeframe allows for a more stable and meaningful assessment of digitalization outcomes, avoiding premature evaluations that may occur with shorter durations and potential external disruptions over longer periods. Second, it was necessary for these SMEs to operate their own dedicated websites. The requirement for SMEs to operate dedicated websites ensures a basic level of digital presence and capability, reflecting their commitment to digital engagement. A website serves as a key indicator of digital readiness, enabling online operations, customer interaction, and data utilization; all essential components for evaluating the impact of digitalization on financial performance. Finally, the presence of an IT department tasked with managing and upgrading the firm's digital infrastructure was a mandatory requirement for inclusion in the study.

3.3. Variables and Measures

The study used digitalization (DT, STs, DI, DS) and digital capabilities (CCs, TCs, ICs, and HCs) as predictors and FP and outcome variable. This study employed established scales from previous literature to evaluate the relevant constructs. Specifically, FP and DT were assessed through items adapted from Al-Mamary et al. (2020), while DS was measured using items drawn from Calabrese et al. (2019). The measurement of DI utilized items from Zhen et al. (2021), whereas STs were evaluated using items adapted from Yoo (2010). HCs and CCs were gauged using scales derived from El Sawy et al. (2016), whereas items of TCs and ICs were drawn from Parida et al. (2015). Each item on the questionnaire was rated on a five-point Likert scale (strongly disagree to strongly agree).

3.4. Econometric Techniques

The research employed SEM to investigate the interrelationships among variables. To assess both the structural and measurement models, the study applied maximum likelihood estimation within the SEM framework. Confirmatory factor analysis was employed to confirm reliability and validity. Subsequently, the structural model was utilized to explore the relationships between predictors and outcomes. The analysis was performed using Smart-PLS4, a variance-based software adept at handling non-normally distributed data and supporting nonparametric multigroup analysis for comparative evaluation across various sample segments. Additionally, ANNs analysis was conducted using SPSS to explore non-linear interactions and ranking the predictors within the data.

3.5. Common Method Bias (CMB)

The use of self-administered questionnaires raises concerns regarding CMB, which could potentially undermine the validity of the research results. To mitigate this risk, Harman's single-factor test was performed using principal component analysis in SPSS. The analysis encompassed all variables, and the total variance extracted was found to be 41.63%, falling below the 50% threshold. This finding suggests that CMB is not a significant issue in this study, thus preserving the reliability and accuracy of the data.

3.6. Demographic Profile

The study's respondents primarily comprised males (91.88%), highlighting gender disparity in SME digitalization in Pakistan. Most participants were aged 40–49 (52.28%), with limited representation from younger and older age groups. Educationally, the majority held Bachelor's (39.34%) or Master's degrees (40.86%), indicating a generally well-educated sample. In terms of experience, 72.84% had over 10 years of work experience, reflecting a seasoned workforce. Sector-wise, respondents were mainly from trading SMEs (53.55%), followed by manufacturing (25.63%) and services (20.81%). Medium-sized enterprises dominated the sample (72.08%), and regionally, SMEs were mostly concentrated in Punjab (47.21%) and Sindh (34.52%). The demographic data emphasizes the need for inclusive, sector-specific, and regionally adaptive digital strategies to enhance SME performance in Pakistan.

4. RESULTS AND DISCUSSION

4.1. Evaluation of Measurement Model

The study's model was analyzed using SEM with the partial least squares (PLS) technique. The outer loadings for all predictors were reviewed, and every observable variable surpassed the recommended threshold of 0.7 (see Figure 2) (Hair et al., 2023), which affirms robust content validity. However, the items (FP3, FP4, FP5, FP6, FP8, DS1, DS5, DI6, ST4 ST5, HC1, TC3, IC3) with factor loadings less than 0.7 were deleted. Convergent validity was determined by examining the average variance extracted (AVE), with each construct achieving a score above 0.5, thus indicating satisfactory convergent validity. The model's reliability and internal consistency were assessed through Cronbach's alpha and composite reliability, both of which exceeded the acceptable standard of 0.7, confirming that the constructs exhibit high reliability and internal consistency (refer to Table 1) (Hair et al., 2023).

Table 1: Reliability, Consistency and Convergent Validity

Construct	Cronbach's Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)
Digital Transformation (DT)	0.870	0.891	0.612
Digital Servitization (DS)	0.881	0.874	0.784
Digital Innovation (DI)	0.896	0.881	0.721
Smart technologies (ST)	0.806	0.884	0.722
Human Capabilities (HC)	0.721	0.777	0.727

Technological Capabilities (TC)	0.841	0.836	0.780
Innovation Capabilities (IC)	0.701	0.860	0.719
Collaboration Capabilities (CC)	0.851	0.867	0.654
Financial Performance (FP)	0.919	0.909	0.795

Figure 2: Measurement Model
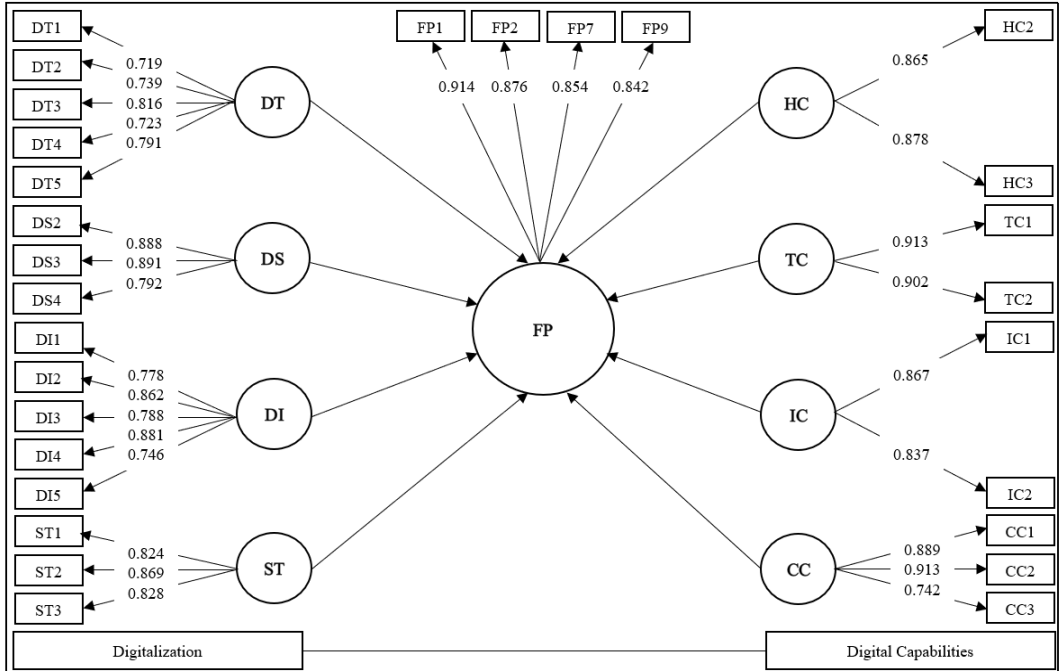
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As per Fornell and Larcker's (1981) discriminant validity criteria, the AVE for each construct should exceed the variance shared with other constructs. Table 2 shows that this requirement was met, as the correlation coefficients between constructs were consistently lower than the square roots of AVE on the bold diagonal, confirming the distinctiveness and proper measurement of each construct.

Table 2: Discriminant Validity: Fornell-Larcker Criterion

| Construct	CC	DI	DS	DT	FP	HC	IC	ST	TC
CC	**0.809**								
DI	0.463	**0.849**							
DS	0.399	0.487	**0.885**						
DT	0.348	0.529	0.403	**0.782**					
FP	0.197	0.513	0.500	0.499	**0.892**				
HC	0.347	0.414	0.602	0.531	0.433	**0.852**			
IC	0.581	0.297	0.421	0.411	0.288	0.510	**0.848**		
ST	0.401	0.559	0.541	0.528	0.317	0.434	0.551	**0.850**	
TC	0.247	0.531	0.374	0.425	0.478	0.532	0.423	0.591	**0.883**

4.2. *Evaluation of Structural Model*

To determine the significance of the path coefficients, the bootstrapping procedure was employed, generating 5000 bootstrap samples (refer to Figure 3) (Hair et al., 2020). Consistent with the guidelines of Hair et al. (2023) for structural model evaluation, key statistical metrics were applied, including path coefficients, t-values, p-values, and the coefficient of determination (R^2). Cohen (2013) noted that an R^2 value of 0.631 indicates a substantial association, as presented in Figure 3. The standardized path coefficients shown in Table 3 indicated that the empirical results established strong positive relationships. Specifically, DT (H_1: 0.493, t: 2.263), DS (H_2: 0.107, t: 8.349) and DI (H_3: 0.500, t: 1.980) showed a significant positive association with FP of SMEs, accepting H_1-H_3. Similarly, HCs (H_5: 0.316, t: 3.044), TCs (H_6: 0.369, t: 2.235), ICs (H_7: 0.130, t: 2.948) and CCs (H_8: 0.866, t: 5.767) indicated significant positive effect on the FP of SMEs, hence, H_5-H_8 are confirmed. However, STs (H_4: -0.301, t: 1.433) had insignificant and negative impact on the FP, thus, H_4 is failed.

Table 3: Hypotheses Testing

Paths	Estimate	Std. Dev.	T-Statistics	P-Values	Remarks
DT → FP	0.493	0.218	2.263	0.024**	H_1: ☑
DS → FP	0.107	0.013	8.349	0.000***	H_2: ☑
DI → FP	0.500	0.253	1.980	0.048**	H_3: ☑
ST → FP	-0.301	0.210	1.433	0.152	H_4: ☒
HC → FP	0.316	0.104	3.044	0.000***	H_5: ☑
TC → FP	0.369	0.165	2.235	0.025***	H_6: ☑
IC → FP	0.130	0.044	2.948	0.003***	H_7: ☑
CC → FP	0.866	0.150	5.767	0.000***	H_8: ☑

Note: "*** $p \leq 0.01$; ** $p \leq 0.05$; * $p \leq 0.10$."

Figure 3: Structural Model
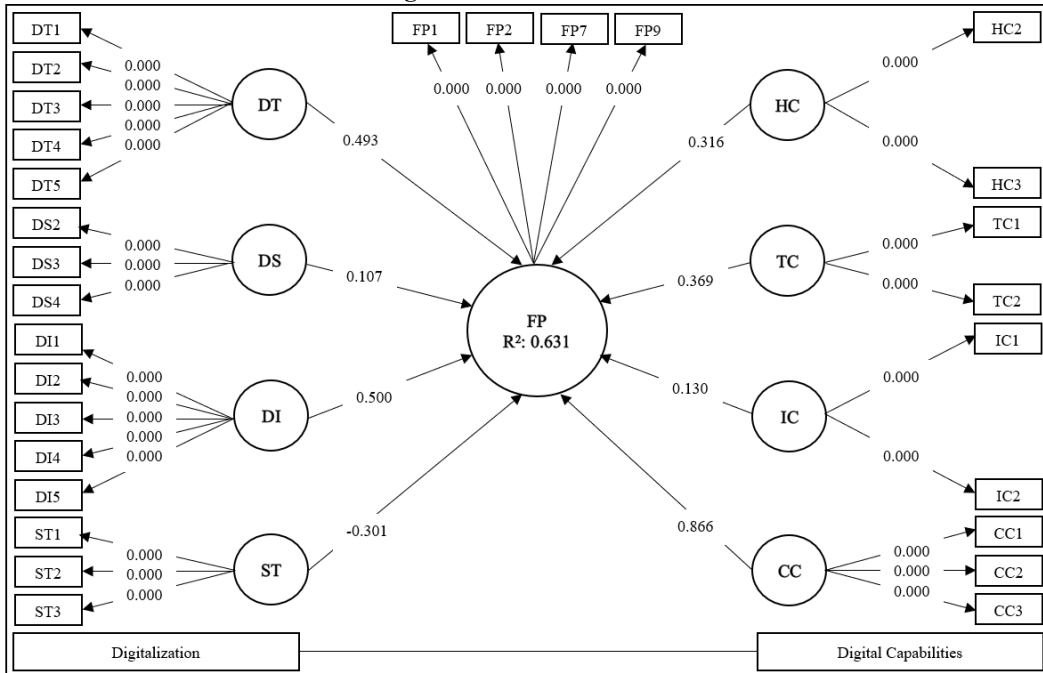
4.3.   *Artificial Neural Networks (ANNs) Analysis*

To determine the ranking of predictors, an analysis using ANNs was performed, facilitating the exploration of relationships between variables in two separate layers: the input layer, comprising digitalization and digital capabilities, and the output layer, representing FP (Bocean and Vărzaru, 2022). The multilayer perceptron was the chosen model for this analysis. For the hidden layer, a hyperbolic tangent activation function was employed, while the output layer utilized a sigmoid function (Bocean and Vărzaru, 2022). Covariates were standardized through normalization (see Table 4). The model achieved an average relative error of 0.019 during the testing phase and 0.016 during the training phase (refer to Table 5).

Figure 4 depicts the multilayer perceptron model, illustrating how digitalization and digital capabilities influence the FP of SMEs. The figure indicates a positive relationship, as reflected by synaptic weights exceeding zero (>0), signifying that enhanced digitalization (DT, DS, DI and STs) and digital capabilities (HCs, TCs, ICs and CCs) lead to improved FP. Additionally, the Figure 4 shows that the larger the block size and the thicker the connecting lines, the greater the impact of the corresponding variable. Table 6 presents a comprehensive summary of the primary predictors identified by the multilayer perceptron model, illustrating the links between the input variables (digitalization and digital capabilities) and the output variable (FP).

Table 4: Artificial Neural Networks (ANNs) Information

Input Layer	Covariates	1	IC
		2	HC
		3	DI
		4	DT
		5	DS
		6	TC
		7	ST
		8	CC
	Number of Units*		8
	Rescaling Method for Covariates		Normalized
Hidden Layer(s)	Number of Hidden Layers		1
	Number of Units in Hidden Layer 1*		1
	Activation Function		Hyperbolic tangent
Output Layer	Dependent Variables 1		FP
	Number of Units		1
	Rescaling Method for Scale Dependents		Normalized
	Activation Function		Sigmoid
	Error Function		Sum of Squares

*Excluding the bias unit

Table 5: Multilayer Perceptron (MLP) and Case Processing Summary

Particular	Multilayer Perceptron (MLP)		Case Processing Summary	
			N	Percent
Training	Sum of Squares Error	0.080	278	70.2%
	Relative Error	0.016		
	Stopping Rule Used	1 consecutive step(s) with no decrease in error*		
	Training Time	0:00:00.02		
Testing	Sum of Squares Error	0.030	118	29.8%
	Relative Error	0.019		

*Error computations are based on the testing sample.
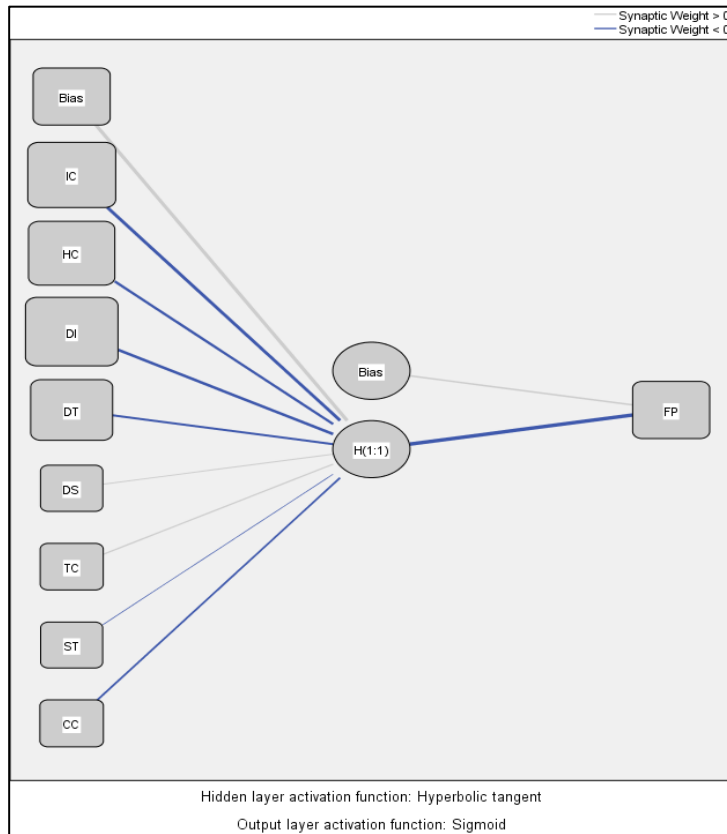
4.3.1 Ranking the Predictors

A sensitivity analysis was conducted to evaluate the predictive power of each input neuron, as detailed in Table 6. The analysis aimed to quantify the normalized importance of these neurons by calculating the ratio of their relative importance to the highest observed importance, with the results expressed as percentages (Karaca et al., 2019). The analysis indicated that ICs (85.1%), HCs (79.6%), DT (65.7%), CCs (5.7%), TC (4.3%), DS (2%), and STs (1%) are found to be the most influential predictors after DI (100%). Figure 5 also shows these rankings. Moreover, all the variables exert positive effects except external biases and STs which negatively influence the FP of SMEs.

Table 6: Estimation of Multilayer Perceptron (MLP) Parameters

Predictors		Predicted		Sensitivity Analysis		Ranking
		Hidden Layer 1 H(1:1)	Output Layer FP	Importance	Normalized Importance	
Input Layers	(Bias)	-1.453				
	IC	0.727		0.248	85.1%	2
	HC	0.564		0.232	79.6%	3
	DI	0.721		0.291	100.0%	1
	DT	0.482		0.191	65.7%	4
	DS	0.019		0.006	2.0%	7
	TC	0.039		0.013	4.3%	6
	ST	-0.009		0.003	1.0%	8
	CC	0.051		0.016	5.7%	5
Hidden Layer 1	(Bias)		0.046			
	H (1:1)		3.264			

Figure 4: Multilayer Perceptron for FP

Source: *author own generated*

Figure 5: Ranking of Predictors
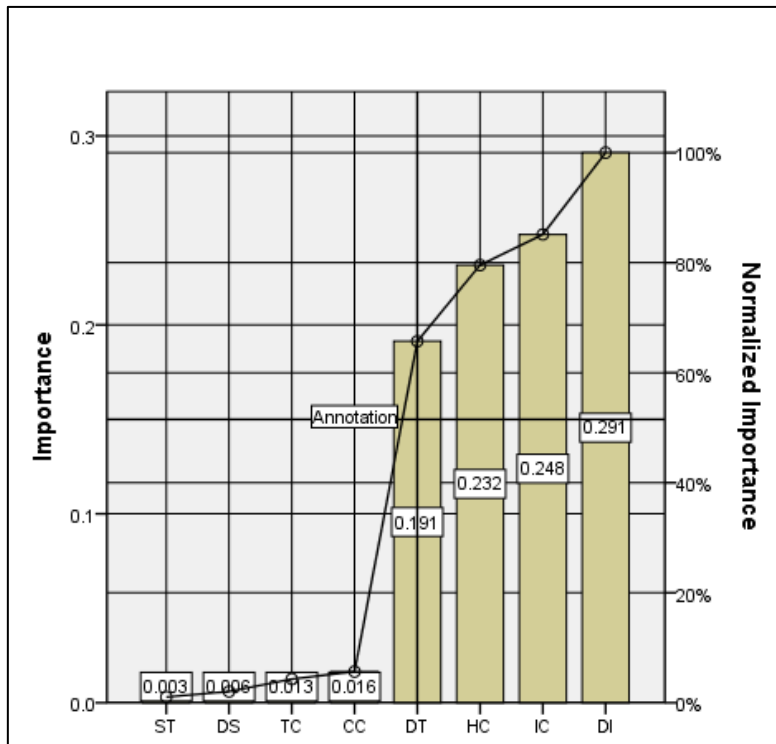
4.4. Discussion

This study significantly contributes to the existing body of knowledge by revealing that DT, DI, and DS exert a positive influence on the FP of SMEs. DT enables SMEs to streamline processes, reduce operational costs, and improve customer engagement through data-driven strategies, ultimately leading to enhanced FP (Heaton et al., 2023). In parallel, DI drives the creation of new products and services, allowing firms to penetrate emerging markets and respond swiftly to shifting consumer preferences, which directly fosters revenue growth and profitability (Ullah et al., 2023). Additionally, DS facilitates the generation of ongoing revenue streams and strengthens customer relationships, contributing to sustained financial viability (Abbas et al., 2024). The insignificant impact of STs indicates that SMEs may not yet fully align advanced technologies like AI and IoT with their needs, requiring significant investment, expertise, and gradual integration for long-term FP improvements (AlZayani et al., 2024).

The findings that digital capabilities positively impact the FP of SMEs, highlight the comprehensive importance of a well-integrated digital strategy. HCs, such as digital proficiency and expertise, play a pivotal role in enabling SMEs to harness digital technologies effectively, transforming technological investments into improved operational performance and increased revenue. A skilled workforce not only enhances process efficiency but also drives innovation by enabling the development of novel products, services, and business models that respond to shifting

market needs (Atobishi et al., 2024). On the other hand, TCs, including robust IT infrastructure and seamless system integration, equip SMEs with the tools necessary to optimize processes, automate tasks, and utilize data-driven insights for strategic decision-making, leading to cost reductions and profitability enhancements (Lubis et al., 2024). ICs ensure that SMEs remain agile and adaptive, fostering continuous improvement and enabling firms to navigate market disruptions, thus maintaining a competitive position (Senoaji et al., 2024). CCs, both within the firm and with external partners, magnify the benefits of digital adoption by facilitating the exchange of knowledge and resources, fostering innovation networks, and enabling SMEs to scale their digital initiatives more effectively (Parida et al., 2015). The interaction among these capabilities is particularly crucial; for instance, without strong human and collaborative efforts, even the most advanced technical systems may fall short of delivering their intended value (Tsou and Chen, 2023). Thus, the alignment of these digital capabilities creates a holistic framework that not only generates immediate financial gains through efficiency and revenue growth but also ensures long-term sustainability and adaptability in an increasingly digitized business environment.

The ANNs analysis presents a detailed ranking of predictors, indicating that ICs and HCs are among the most significant contributors to the FP of SMEs, closely followed by DT and other capabilities. The prominent ranking of ICs (85.1%) emphasizes the pivotal role of a firm's capacity for innovation in responding to evolving market conditions and developing new offerings that maintain competitive advantage and drive revenue growth. Likewise, HCs (79.6%) are crucial, as the expertise, knowledge, and digital skills of employees are essential for translating technological investments into measurable financial gains. DT (65.7%) also emerges as a key factor, facilitating the optimization of operations, enhancing efficiency, and improving customer engagement through technology-enabled processes. While CCs rank lower at 5.7%, they still positively influence FP by promoting knowledge sharing and fostering partnerships that are crucial for scaling operations and integrating innovation across networks. The comparatively lower influence of TCs at 4.3% suggests that while infrastructure and system integration are fundamental, their direct impact on FP may be less pronounced without strong human and innovation capabilities to harness these resources effectively. In addition, DS at 2% and STs at 1% rank lowest, with STs exhibiting a negative effect. This may reflect the current underutilization of advanced technologies such as AI and IoT by SMEs, which could be attributed to the misalignment of these technologies with business models or the substantial costs and complexities associated with their implementation (Lee et al., 2024). The negative influence of STs and external biases likely points to challenges in the technological environment, where premature adoption or inadequate adaptation of these technologies may result in inefficiencies or financial burdens, highlighting the need for more strategic alignment and capability development to realize their full potential.

5. CONCLUSION

5.1. *Theoretical Contribution*

This study advances RBV theory by examining how digital technologies and capabilities act as vital resources that boost the FP of SMEs. By integrating SEM with ANNs, the research offers a detailed analysis of how digital resources contribute to competitive advantage and operational efficiency. It highlights that digital transformation, innovation, and servitization are key strategic resources for SMEs. The study enhances RBV by demonstrating that digital capabilities (human,

technological, innovation, and collaborative) are crucial for translating technological investments into significant financial gains.

5.2. Policy Implications

The results for positive impact of digitalization carry important implications for policy development. Policymakers should focus on formulating specialized programs that incentivize SMEs to adopt and invest in digital technologies. This could involve offering financial subsidies for technology implementation, creating targeted training programs aimed at improving digital literacy among SME employees, and providing tax benefits for firms engaging in R&D related to digital innovation. Furthermore, governments should consider establishing digital innovation hubs to encourage collaboration between SMEs, research institutions, and technology providers, thereby fostering an ecosystem that promotes knowledge exchange and accelerates innovation. Policy frameworks must also support the shift toward DS by encouraging the development of sector-specific platforms that enable SMEs to transition from traditional product-focused models to service-oriented business models, enhancing their long-term financial viability. Moreover, regulatory environments should be optimized to reduce barriers to adopting advanced technologies, ensuring that SMEs can integrate digital solutions without undue financial or regulatory burdens.

The results indicating that digital capabilities positively impact FP of SMEs necessitate targeted policy actions. Policymakers should implement strategic measures to bolster each facet of digital capability within SMEs. To enhance HCs, it is imperative to establish government-funded programs that provide training and development in digital skills and leadership, thus enabling employees to effectively utilize emerging technologies. For TCs, policies should include financial instruments such as grants or low-interest loans aimed at upgrading IT infrastructure and achieving seamless system integration, which are crucial for DT. ICs can be promoted through fiscal incentives, such as tax credits or innovation grants, to stimulate research and development efforts and facilitate the creation of advanced products and services. Furthermore, to strengthen CCs, the formation of industry-specific digital ecosystems or collaborative networks should be encouraged, facilitating partnerships between SMEs, larger enterprises, academic institutions, and technology providers.

The ANNs analysis highlights the necessity for policymakers to prioritize DI, ICs and HCs within SME support frameworks. To leverage these insights, it is essential for policy initiatives to allocate substantial funding and resources to foster innovation, as well as to implement specialized training programs aimed at advancing digital competencies among SME employees. Given the moderate impact of DT, policies should be designed to facilitate the adoption of digital technologies through targeted financial incentives and technical support. Although TCs, DS, and STs exhibit a lower degree of influence, it is crucial to develop targeted interventions that address specific challenges associated with their integration. This approach will ensure these technologies are effectively utilized, thereby maximizing their potential benefits. By tailoring policy efforts to address these critical areas, governments can enhance SME growth and FP in a more strategic and impactful manner.

5.3. Conclusion

SMEs play a pivotal role in maintaining economic stability and fostering growth. However, these enterprises encounter substantial obstacles in effectively harnessing digital technologies to enhance

their FP. This research contributes significantly to the existing body of knowledge by analyzing how various aspects of digitalization and digital capabilities impact FP of SMEs, using both linear and non-linear methods to reveal detailed insights and provide practical guidance for improving SME growth. The results emphasize the importance of DT, DI, and DS in enhancing the FP of SMEs by optimizing processes, reducing operational expenses, and improving customer engagement. Moreover, the research highlights the critical role of digital capabilities (encompassing HC, TCs, ICs, and CCs) in facilitating these improvements. Notably, DI, HCs and ICs emerge as the most influential factors, demonstrating that a skilled workforce and robust innovative capacity are vital for converting technological investments into tangible financial benefits. The study calls for targeted policy measures to support SMEs in their digitalization efforts, recommending financial incentives, enhanced digital literacy programs, and the establishment of innovation hubs and collaborative networks. By addressing the challenges related to aligning technological resources with business requirements and creating a conducive regulatory environment, the study advocates for a strategic approach to digitalization, aimed at bolstering SME growth, competitiveness, and sustainability, thus contributing to a more robust economic framework.

This study's limitations include its focus on SMEs in Pakistan, which may limit the generalizability of the results to other contexts. Future research should consider diverse geographical regions and sectors to broaden applicability. Additionally, investigating moderators like organizational culture or market dynamics and mediators such as managerial expertise or employee digital literacy could offer a deeper understanding of how digitalization influences FP.

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