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Digital Inclusive Finance as a Catalyst for Technological Innovation in Small and Medium Enterprises in Pakistan

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ABSTRACT

This paper looks into how digital inclusive finance influences technological innovation among small and medium sized enterprises in Pakistan (SMEs). Using a quantitative method, the study employs property data of 32 SMEs, listed at the Pakistan Stock Exchange in 2020-2024. The proposed longitudinal study will provide a chance to compare the changes in the digital financial engagement, and the result of innovation with the course of time. In addition to investigating the mediating role played by the monetary constraints, the key goal is ensuring there is a complex interaction between the technical innovativeness by the SMEs and digital financial services. It has been established that digital inclusive financing can significantly and positively affect technological innovation. Financial inclusion in digital form is also discovered to be fit under lesser financing constraints within firms. The restriction in the provision of funds, in its turn, has adverse and significant influence on innovation. The study revealed that technological innovation increases marginally by about 0.452 percent per 1 percent of increase in digital financial inclusion. Having matched the effects of digital financial inclusion to a funding constraint, it continued to have a significant impact on innovation (with possible linear and non-linear effects (via alleviation of constraints)). These results are similar to other research studies regarding the importance of having gone past the financing bottlenecks in an attempt to reach more innovation and shows that SMEs can employ digital inclusive finance to find a way to curb their financing bottleneck and make their technology more popular. The results are expected to contribute to further knowledge on the Pakistani SME sector and give practical knowledge to policy makers and monetary institutions.

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1. Introduction

SMEs are seen as pertinent agents in economic development, innovations, and also generation of employment opportunities across the world. Pakistan SMEs are of great importance. The SMEs are regarded as the life blood of the country and they are assumed to be giving a lot of diversification and weight to the economy. Digital inclusive finance are financial services such as digital payments, online lending provisions, and mobile banking. The SMEs in Pakistan can be a goldmine with use of digital inclusive finance (DIF). DIF has the capability to minimize transaction costs, increase effectiveness, and extend into rural, sparsely populated areas. With the current digital era, remaining technologically nimble is necessary owing to unprecedented technological advancement speed. Small and Medium-sized Enterprises (SMEs) frequently face

significant difficulties and challenges when trying to obtain the funding or capital they need to operate or grow. It is a noteworthy field of research, technological innovation and digital inclusive finance with respect to SMEs.

1.1. Problem Statement

The financial constraint of SMEs and the prospect of inclusive finance in the form of digital systems is discussed in international literature. This argument is becoming stronger but its most recognized research gap is the understanding of the contribution of digital inclusive finance towards technological innovation in SMEs. The disparity increases in respect to growing economies and becomes an open hole in case of Pakistan. SMEs usually undergo difficulties in accessing funds thus rendering their potential in technological innovation disabled. The fact that SMEs possess low credit history, unstable cash flows and low-quality collaterals is normally perceived by traditional financial institutions as a high risk investment thereby making it difficult to raise funds to carry out research and development.

1.2. Significance of the Study

This research is important since it tends to enhance understanding of Pakistani SME sector through the impacts of digital inclusive finance in technological innovation of considering the mediation role of financial constraints. The results are predicted to be of value to policymakers and financial institutions in Pakistan who seek to carry out SMEs growth/increase and innovation. In the process of finding the right data, meetings were held with high-ranking officers and employees of such institutions like The State Bank of Pakistan, SMEDA, Pakistan Foreign Exchange, and Chamber of Commerce Lahore. All those institutions working towards the betterment of SMEs appreciated and highlighted the importance of this research. This paper discusses how digital financial instruments may influence innovation and overcome funding shortages. It facilitates an establishment of targeted initiatives and policies which all the institutes listed above are working on.

1.3. Research Questions

This research aims at addressing the following research question,

How dependent is technological innovation among the SMEs listed on the Pakistan stock exchange on digital inclusive finance? What are the effects of financial constraints which mediates relationship between these variables after adjusting on firm size, asset liability ratio, return on equity, fixed asset ratio and management fee rate?

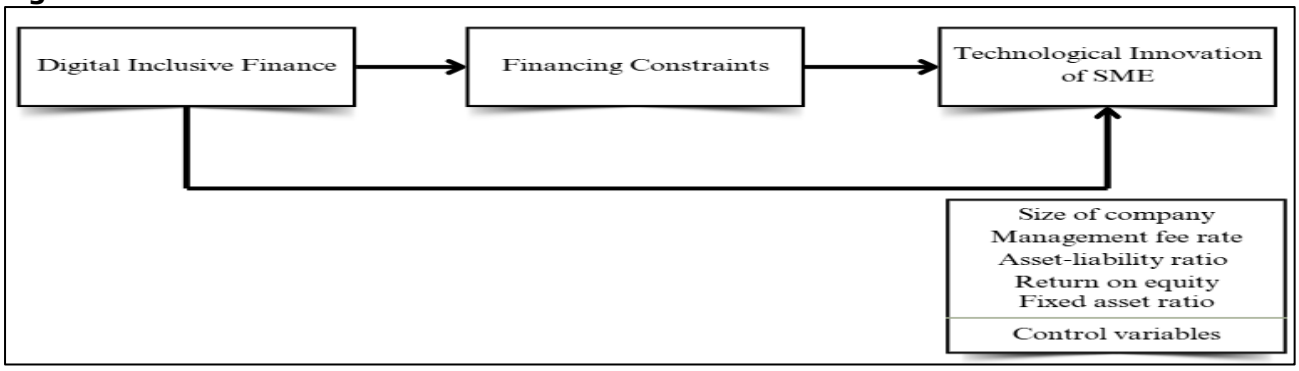
1.4. Objectives of the Study

The primary purpose of the study involves analyzing the connection between technological innovation and digital inclusive finance among the Pakistani SMEs. The exact aims of the study are as follows: to measure how much t digital financial tools enhance the innovation outcomes and overcome the financing constraints; to explore the connection between digital finance and innovation and the mediating role of financing.

1.5. Organization of the Study

The structure of the rest of the paper is presented as follows: Section 2 presents the literature, Section 3 presents the research design, its data sources and methods, Section 4 presents the empirical results, Section 5 highlights the policy implications and contributions to the literature, and the final section includes recommendations of further research.

Figure 1: Theoretical Framework



2. Literature Review

Due to their substantial contributions to GDP, employment, and total national growth, SMEs are essential to economic development. Representing more than 90% of all businesses worldwide and generating roughly half of the global GDP, SMEs are integral to economic systems. However, these enterprises face significant challenges in securing financing, hindering their ability to innovate technologically. SMEs are frequently categorized as high-risk by traditional financial institutions because of their lack of credit history, and unpredictable cash flows and insufficient collateral (Ayyagari, Demirgüç-Kunt, & Maksimovic, 2011). Consequently, it becomes difficult to secure funds for research and development, which is essential for the advancement of technology (Taghizadeh-Hesary et al., 2021). The use of digital tools to offer financial services to underprivileged persons and enterprises is known as "digital inclusive finance. "It encompasses platforms like mobile banking, peer-to-peer lending, digital payments, and credit-scoring algorithms (Abbasi et al., 2021). Digital inclusive finance seeks to break down traditional financial barriers by offering scalable, low-cost, and flexible services, making financial solutions more accessible to underrepresented regions and populations. This is particularly essential for SMEs which frequently lack necessary collateral or credit history required for funding from conventional financial institutions (Gomber et al., 2018). By leveraging technologies like big data, artificial intelligence, and blockchain, digital inclusive finance enhances the efficiency, transparency, and reliability of financial transaction fostering economic growth (Lu et al., 2022).

H1: There is a significant relationship between digital inclusive finance and financial constraints

Technological innovation within SMEs enterprises involves the development and application of new technologies, products, or processes aimed at enhancing productivity, efficiency, and competitiveness. This type of technological innovation can be measured by key indicators such as investments in research and development (R&D), patent applications, or the adoption of new business models (Hall & Lerner, 2010). Technological innovation plays a vital role in enabling SMEs to remain competitive in evolving markets, yet it often requires substantial initial investments and carries significant financial risks (Ayyagari, Demirgüç-Kunt, & Maksimovic, 2011). Several studies establish a positive relationship between the availability of digital financial services and increased technological innovation, particularly in developing economies with limited traditional banking infrastructure (Philippon, 2019). Digital inclusive finance also enhances SME technological innovation by facilitating digital payments and financial management. Digital transaction platforms not only improve financial inclusion but also generate verifiable financial records that strengthen SMEs' creditworthiness. With structured financial data, digital lenders can evaluate an SME's repayment ability with greater precision, leading to higher loan approvals and lower default risks (Klapper & Lusardi, 2020). Empirical studies indicate that SMEs utilizing mobile payment systems and e-wallets, such as M-Pesa and Alipay, report greater financial stability and higher investment in technological innovation compared to businesses that rely on cash-based transactions (Chava et al., 2023). Additionally, formalizing financial transactions via digital channels allows SMEs to participate in global trade networks. Hence enhancing technological innovation in their business models (Beck, Senbet, & Simbanegavi, 2015).

H2: There is a significant relationship between financial constraints and technological innovation

Digital inclusive finance fosters technological innovation in SMEs through several key mechanisms. First, digital inclusive finance reduces information asymmetry between lenders and SMEs (Yao & Yang, 2022). Traditional financial institutions like banks have a hard time to evaluate the creditworthiness of SMEs. This is because they do not have reliable financial records or other traditional data points (Mushtaq, Gull, & Usman, 2022). Consequently, SMEs then face higher rejection rates or are proposed unfavorable terms. Digital inclusive finance platforms use alternative data sources such as online transactions, digital payment histories, and supplier networks to assess credit risk, enabling more accurate and inclusive credit evaluations (Zhang et al., 2023). This access to credit affects the SMEs' capacity to invest in technological innovation. Apart from traditional lending, DIF finances innovation through the innovation of new finance models like crowd funding and peer-to-peer (P2P) lending. Unlike traditional bank loans that involve lengthy paperwork and high collateral requirements, such platforms facilitate SMEs to directly interface with consumers and investors to raise funds to develop new products and improve technologies (Nylund & Brem, 2021). Evidence indicates that SMEs utilizing crowd funding sites such as Kickstarter and Indiegogo have improved technological innovation outcomes. Such mechanisms are a double-edged sword since they not only raise capital but also

authenticate market demand for new concepts (Cumming, Johan, & Reardon, 2021). In the same vein, P2P lending increases access to credit with a decreased necessity for intermediaries, decreasing the cost of borrowing, and increasing investment in technological developments (Walthoff-Borm, Vanacker, & Collewaert, 2018).

H3: There is a strong correlation between technology inclusive finance and technological innovation.

In Southeast Asia, to give one instance, research has found that SMEs that utilized P2P lending platforms achieved a 15% decrease in funding cost, whereupon they could direct these savings to tech innovation ventures such as new product development and process improvement (Walthoff-Borm, Vanacker, & Collewaert, 2018). The value of inclusive digital finance is especially pronounced for high-tech SMEs, which are generally more dependent on external funding to cover long-term R&D endeavors. Such SMEs usually have a harder time than others in obtaining traditional funding because of the great amount of risk and uncertainty involved with their tech innovation cycles. digital inclusive finance provides alternative financing structures that suit high-tech SMEs more appropriately, including milestone financing, equity crowd funding, and technology innovation-specific credit lines (Yao & Yang, 2022). In the case of developing nations such as Pakistan, inclusive digital finance has a revolutionary impact on the financial performance of SMEs. Payment systems based on mobile such as Easypaisa and Jazz Cash bring rural and semi-urban businesses into the formal financial system. These platforms not only enable real-time transactions but also help SMEs build a financial history, which is crucial for creditworthiness. Furthermore, crowdfunding and digital lending platforms empower SMEs to pool resources for projects previously unattainable due to limited capital. Access to diversified funding sources helps stabilize revenue streams and expand market reach, ultimately boosting financial performance (Khan, Shah, & Rizwan, 2021).

H4: The relationship between technical innovation and digital inclusive finance is mediated by financial limitations; as digital inclusive finance grows, financial constraints may decrease, which in turn may enhance technological innovation.

3. Research Design

3.1. Sample Selection and Data Source

The source of the data for this study was Pakistan stock exchange limited. 32 SMEs were selected from the listed companies on Pakistan stock exchange for data collection and analysis. The reason why such selection was made is the availability of detailed financial information and data. The rest of the companies were not included in this research because they lacked available and complete financial data for inclusion in their reports. The period covered in the data used in this analysis is from 2020 to 2024 to identify trends and differences over a five-year cycle. The sample size is 160 observations.

3.2. Estimation methods

Both Random Effects (RE) and Fixed Effects (FE) models were estimated in this study. The FE model picks up time-constant characteristics by permitting each entity to have its own intercept, while the RE model assumes entity-specific effects are random and independent of the explanatory variables (Borenstein et al., 2010). Based on the Hausman test, the appropriate model was selected. Less than 0.05 p-value was achieved through the test, indicating that the results generated using the Fixed Effects model are more precise and reliable. As the Fixed Effects Model captures unobserved heterogeneity better and also the interaction between entity-specific effects and independent variables, it has been employed for the ultimate analysis.

3.3. Description of the variables

Digital Inclusive Finance (independent variable) is a term for the application of digital resources to offer financial services to underprivileged people and entities. It includes entities such as mobile banking, peer-to-peer lending, digital payments, and algorithms for credit scoring (Abbasi et al., 2021). Digital inclusive finance seeks to break down traditional financial barriers by offering scalable, low-cost, and flexible services, making financial solutions more accessible to underrepresented regions and populations.

Technological innovation (dependent variable) within SMEs enterprises involves the development and application of new technologies, products, or processes aimed at enhancing productivity, efficiency, and competitiveness. This type of technological innovation can be measured by key indicators such as investments in research and development (R&D), patent applications, or the adoption of new business models (Hall & Lerner, 2010). Technological innovation plays a vital role in enabling SMEs to remain competitive in evolving markets, yet it often requires substantial initial investments and carries significant financial risks (Ayyagari, Demirgüç-Kunt, & Maksimovic, 2011).

As financial constraints (mediating variables) cannot be observed, it is hard to be clear about the definition of financial constraints and which firms are constrained. Studies provide a simple definition of financial constraints as frictions to when firms cannot fund all of the investments that they want. Some examples of frictions are asymmetric information, agency costs and incomplete contractibility (Mjøs & Pedersen, 2019).

3.4. Measurement of Variables

The technological innovation that is the explained or dependent variable and it is calculated by Total R&D expenditure/ total operating income (Leiming, Dizhen, & Yahui, 2012). For digital inclusive finance, a proxy for the Peking University Digital Finance Index is used (Sheng, Zhang, & Wang, 2021). The proxy is the rate of the digital financial inclusion of SMEs in Pakistan. The rate will describe the degree of financial inclusion of SMEs in Pakistan. Financing constraints is measured through SA index, formula is -0.737Size + 0.043Size^2 - 0. 04Age. This index is used as it is easy to use and reliable (Xiong et al., 2023). Moreover, control variable will be measured as follows:

1. Size and of the firms control the business scope of the SMEs through Ln (total assets) (Almustafa et al., 2023).
2. Fixed asset ratio controls the effect of asset structure on experience risk. Thus, the fixed ratio is calculated as total fixed assets/ total assets (Sun & Zou, 2021).
3. Return on equity is also controlled as it has a positive impact on firms. It is calculated as Net profit/ net assets (Wei et al., 2021).
4. Gearing/ asset-liability ratio also needs to be controlled as it has a negative impact on SMEs. It is calculated as Total liabilities/ assets (Tang, Wu, & Zhu, 2020).
5. Lastly, the management expense ratio is calculated as administrative expenses/ operating income (Zhang et al., 2023).

Table 1: Measurement of Variables

Type	Name	Symbol	Measure
Dependent Variable	Technological technological innovation	RD	Total R&D expenditure/total operating income
Independent Variable	Digital inclusive finance	Index	Digital inclusive financial index/1000
Mediating Variable	Financial Constraints (SA Index)	SA	SA = −0.737Size + 0.043Size2 − 0.04Age
Control Variables	Size of firms	Size	Ln (total assets)
	Asset-liability ratio	Lev	Total liabilities/assets
	Management Fee Rate	Mfee	Administrative expenses/operating income
	Return on equity	Roe	Net profit/net assets
	Fixed asset ratio	Fix	Total fixed assets/total assets

4. Results

In this chapter, the researchers talk about the results of the influence of the Digital Inclusive Finance on the Technological Innovation of SMEs in Pakistan. This chapter uses panel data analysis to research the association that exists between: independent variable of interest, dependent variables and control variables. Regarding the variables of the technological innovation, of the financial inclusion of the model of the digital era, and the corresponding control variables, the research sheds light on the vectors that are causing the technological innovation of SME sector used in the changing economy of Pakistan.

4.1. Descriptive Statistics

The basic features of the dataset are listed and explained using descriptive statistics. It offers a straight summary of the data.

Table 2: Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max	Observations
Technology innovation	0.641	0.189	-0.105	1	160
Digital finance	0.35	0.085	0.2	0.64	160
Financial constraint	1.57	0.45	3.77	6.08	160
Size of company	1.03	0.75	7.45	10.68	160
Asset liability ratio	-0.85	0.42	-1.8	0.05	160
Management fee rate	0.025	0.015	0	0.3	160
Return on equity	0.12	0.085	-0.05	0.4	160
Fixed assets ratio	-0.45	0.32	-1.2	0.05	160

Source: Author's own calculation

Table 2 shows descriptive statistics of study's primary variables. Technological innovation, shows substantial variation within enterprises. For digital financial inclusion, the sample's firms appear to have comparable levels of access to and use of digital financial services. Financing constraints indicate a considerable degree of diversity among businesses.

4.2. Panel Data Estimation Model

A panel analysis is used in the analysis. In a panel data model, a regression method is employed to pooled statistics that contain cross-sectional and time-series statistics. The two major types of models that can be applied to this type of model are fixed effect and random effect.

4.3. Fixed Effects Regression

This model only considers within-firm variation over time (e.g., how changes in either DIF or FC affect a firm's innovation performance over time), and it controls for all time-invariant firm characteristics.

Table 3: Regression results for fixed effect model

Technological Innovation	Coefficient	Std error	t value	P-value	[95% Interval]	Confidence
Digital inclusion	0.453	0.109	4.15	0.000	0.237	0.667
Financing constraint	-0.785	0.187	-4.20	0.001	-1.155	-0.415
Size of company	0.312	0.092	3.39	0.001	0.130	0.0494
Asset liability ratio	-0.204	0.051	-4.00	0.000	-0.305	-0.103
Management fee rate	-0.001	0.000	-2.50	0.014	-0.002	-0.000
Return on equity	0.158	0.035	4.51	0.000	0.089	0.0227
Fixed asset ratio	0.075	0.033	2.27	0.025	0.010	0.140
Constant	1.892	0.453	4.18	0.000	0.0996	2.788

Source: Author's own calculation

Technological Innovation is positively and statistically significantly impacted by Digital Inclusive Finance (DIF). This implies that businesses will probably invest in and use new technology more when access to new financial services, including digital financing and mobile payments, soars. Innovation is negatively and statistically significantly impacted by financial constraints (FC). Businesses are discouraged from inventing when they face more serious finance issues.

4.4. Mediation Analysis

4.4.1. Effect of Digital Financial Inclusion on Financing Constraints

$$Financing\ Constraints = \beta_0 + \beta_1 \cdot Digital\ Financial\ Inclusion + Controls + \varepsilon$$

Table 4: Mediation Analysis of the effect of digital financial inclusion on financing constraint

Financing constraint	Coefficient	Std. Error	t--value	P-value	[Confidence Interval]	
Digital inclusion	-0.125	0.028	-4.46	0.000	-0.181	-0.069

Size of company	0.042	0.012	3.50	0.001	0.018	0.066
Asset liability ratio	0.085	0.020	4.25	0.000	0.046	0.124
Management fee rate	0.0005	0.0002	2.50	0.014	0.000	0.001
Return on equity	-0.032	0.015	-2.13	0.035	-0.062	-0.002
Fixed asset ratio	-0.018	0.008	-2.25	0.026	-0.034	-0.002
Constant	4.112	0.305	13.48	0.000	3.508	4.716

Source: Author's own calculation

This inverse and statistically significant relation suggest that improvements in digital financial inclusion (DFI) correlate with firms experiencing less of a financing constraint. Digital financial inclusion will most likely give firms more pluralistic access to financial services through digital-based, which may lessen reliance on traditional banks and diminish barriers to obtaining financing such as high collateral demands or limited access. Because of this, firms—especially SMEs—should find it easier obtaining the funds necessary for their innovations or operations.

4.4.2. Direct Effect of Digital Financial Inclusion on Technological Innovation

$$Technological\ Innovation\ =\ \alpha_0\ +\ \alpha_1 \cdot Digital\ Financial\ Inclusion\ +\ Controls\ +\ \varepsilon$$

Table 5: Regress dependent variable (technological innovation) on independent variable (digital financial inclusion)

Technological Innovation	Coefficient	Std. Error	t-value	P-value	Confidence Interval	
Digital inclusion	0.452	0.109	4.15	0.000	0.237	0.667
Size of company	0.312	0.092	3.39	0.001	0.130	0.494
Asset liability ratio	0.204	0.051	-4.00	0.000	-0.305	-0.103
Management fee rate	0.001	0.000	-2.50	0.014	-0.002	-0.000
Return on equity	0.158	0.035	4.51	0.000	0.089	0.227
Fixed asset ratio	0.075	0.033	2.27	0.025	0.010	0.140
Constant	1.892	0.453	4.18	0.000	0.996	2.788

Source: Author's own calculation

All other things being equal, there is a about 0.452% rise in technical innovation for every 1% increase in digital financial inclusion. Businesses are more likely to innovate technologically in areas or settings with greater levels of digital financial inclusion.

4.4.3. Mediated Effect via Financing Constraints

$$Technological\ Innovation$$
$$= \gamma_0\ +\ \gamma_1 \cdot Digital\ Financial\ Inclusion\ +\ \gamma_2 \cdot Financing\ Constraints\ +\ Controls\ +\ \varepsilon$$

Table 6: Regress dependent variable (technological innovation) on main independent variable (digital financial inclusion) with mediator variable (financing constraint)

Technological Innovation	Coefficient	Std error	t value	P-value	[95% Interval]	Confidence
Digital inclusion	0.453	0.109	4.15	0.000	0.237	0.667
Financing constraint	-0.785	0.187	-4.20	0.001	-1.155	-0.415
Size of company	0.312	0.092	3.39	0.001	0.130	0.0494
Asset liability ratio	-0.204	0.051	-4.00	0.000	-0.305	-0.103
Management fee rate	-0.001	0.000	-2.50	0.014	-0.002	-0.000
Return on equity	0.158	0.035	4.51	0.000	0.089	0.0227
Fixed asset ratio	0.075	0.033	2.27	0.025	0.010	0.140
Constant	1.892	0.453	4.18	0.000	0.0996	2.788

Source: Author's own calculation

The negative coefficient of financing constraints shows that greater financing constraints inhibit innovation rates. The direct impact of digital financial inclusion on innovation remained statistically significant controlled for financing constraints - thus signifying that one portion of DFI's impact on innovation is indirect - removing financing constraints - and another portion of DFI's impact on innovation is through direct effects.

5. Discussion

This section provides a thorough analysis of the study's findings and contrasts them with previous research on the functions of technical innovation (TI), financial constraints (FC), and

digital inclusive financing (DIF) in the context of SMEs in Pakistan. Financial restrictions and digital inclusive finance are significantly correlated, according to Hypothesis 1. The results indicate a significant negative association, meaning that increased access to DIF helps reduce financial constraints for SMEs. This finding aligns with the financial constraint theory, which asserts that reducing capital barriers improves firm performance and growth (Fazzari, Hubbard, & Petersen, 1988). Digital financial services like mobile banking, peer-to-peer lending, and online credit scoring make it easier to access credit, particularly in areas that are not well covered by conventional banking (Ozili, 2018). These findings are in line with the conclusion of (Zhang et al., 2023) that DIF alleviates financing constraints among SMEs firms in China. Likewise, (Zhao, He, & Zhang, 2021) emphasized the use of digital finance for broadening financial access and improving the funding environment of SMEs. In the Pakistani context, increasing penetration of mobile wallets and fintech platforms contributes significantly to alleviating the credit access challenges faced by SMEs, particularly in rural or semi-urban areas (Shahid & Manarvi, 2013). Hence, the results support H1, confirming that DIF has a favorable and statistically significant impact on easing financial barriers.

Hypothesis 2 states that there is a strong correlation between technological innovation and financial limitations. The findings indicate a strong inverse link, confirming the idea that more creative endeavors result from less financial restraint. The reasoning behind this is simple: innovation is risky, requires an initial investment, and frequently yields a delayed return.

This makes sense as Schumpeter's theory of innovation states that businesses won't be inspired to create if they don't have access to resources (Schumpeter, 1959). Consequently, this bolsters the findings of (Chen & Yoon, 2022), who discovered that organizations with greater financial constraints tend to invest less in research and development as well as less in digital transformation. Furthermore, beyond the two hypotheses positively tested above, (Savignac, 2008) assessed that one of the most significant hindrances to innovation is financial constraints; this is largely true for SMEs as well. In Pakistan, for example, many SMEs function with little cash revenue flowing in and limited collateral. Thus, to them, innovation is more of an expensed line item than a value-added capital investment (Ali, Ullah, & Jan, 2023). Thus, this hypothesis is supported as the less financial constraints there are, the more technology innovation will occur. In Hypothesis 3, it is mentioned that digital inclusive finance and technical innovation are also significantly correlated. The results exhibit a high degree of positive relationship. Digital inclusive finance is certainly a wager in relation to innovation. It provides the SMEs with the source of funding which helps them to invest in the sophisticated technology. The study of, (Gu et al., 2024) backs the results in their study and provides evidence of the effectiveness and the role of DIF in innovation in the technological field as well as other numerous studies that have presented evidence (Wang & Yu, 2024) states that the role of digital finance is to contribute to more capital being allocated and it helps the SME take more risks with innovation. Another study of (Han & Gu, 2021) insists that digital financial literacy matters—it is important that SMEs know how to deploy DIF tools for innovation. Ma notes that SMEs that access digital financial services are more likely to upgrade their technology systems, similarly another study notes that DIF can help SMEs solve the problem of "no collateral, no loan" and indirectly support their innovation activities (Guo, Feng, & Lin, 2023). Hence, the results support H3, confirming that DIF has a favorable and statistically significant impact on technological innovation of SMEs.

Hypothesis 4 states that technology innovation, digital inclusive finance, and financial restrictions are significantly correlated. The findings suggest that the relationship between technical innovation and digital inclusive finance is mediated by financial constraints. Specifically, an increase in digital inclusive finance may result in fewer financial limitations, which in turn may enhance technological innovation. The results are supported by the study of (Zhu, Asimakopoulos, & Kim, 2020) which notes that Digital platforms (such as peer-to-peer lending and mobile banking) can help widen the reach of financial services in the areas where SMEs are most under-served. DIF has provided automated processes to help reduce the costs of obtaining financing, thereby making financing more accessible to smaller enterprises noted by (Qing, 2024). Similarly, (Shofawati, 2019) suggests that SME innovation is particularly well-supported by DIF in the high-tech sectors that require substantial R&D investment and (Li & Li, 2022) states that due to this ease digital financial services allow SMEs to spend more on research and development. Hence, the results support H4, confirming that DIF has a favorable and statistically significant impact on technological innovation of SMEs by reducing the financing constraints.

6. Conclusion

In this research, the linkage between technology-driven inclusive finance and technological innovation was analyzed amongst the SMEs of Pakistan. It was an analysis of the effects of the digital financial services provided to the SMEs in terms of improved technological advancement, mediated by the constraints of finance. The controls such as firm size, leverage, return on equity, etc. are also taken care of in the results of the analysis. It is understood that they are not parameters that one should ignore but the study is about DIF and FC. These findings are also in line with the existing evidence that stresses how it is essential to eliminate the financing bottlenecks to promote innovation. They provide an indication that SMEs can use digital inclusive finance in order to empower their ability to go through the bottlenecks and develop their own technology. This research was restricted to 32 Pakistan Stock Exchange-listed SMEs, and such a sample may not be representative of the wider SME universe, particularly micro and informal enterprises. The 2020-2024 sampling period, with disruption from the pandemic, may not capture longer-term trends or delayed consequences. Future studies may include larger samples representing a broader spectrum of SMEs and longer time intervals to gain a better understanding of these phenomena.

6.1. Policy Recommendation

- To expand SMEs' access to digital financial services, the government and telecom authorities must upgrade the Internet and mobile infrastructure in rural areas.
- Financial institutions, government and private organizations should host workshops and training to raise awareness of digital tools, financial literacy, and cybersecurity for SME owners.
- FinTech companies in collaboration with policymakers should develop financial products for SMEs, such as collateral-free microloans combined with flexible digital repayment.
- The government should implement innovation grants or tax deductions for SMEs investing in digital platforms for innovation, to encourage traditional businesses to adapt to digital finance.

Theoretical Implications: This research enriches the literature by exploring financing constraints as a mediating factor that underpins the role of digital inclusive in the context of technological innovation in emerging economies.

Practical Implications: The insights of this research provide a basis for formulating policy responses and delivering financial services in a way that targets those things that improve access for SMEs to digital finance and ultimately leads to emerging economies that innovate to grow sustainably.

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