Harnessing FinTech for Financial Inclusion: Analysis of the influence of system scalability, online authentication, and products substitutability

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Abstract
This study looks at the evolution of FinTech from a disruptive force to a complementary element within the financial landscape. Drawing on disruptive innovation theory and financial intermediation theory, this study takes a holistic approach to uncover the mechanisms driving this change. Data was collected using a structured questionnaire distributed to 162 IT employees of financial institutions in Tanzania. The data was analyzed using structural equation modeling with Smart PLS. The results show the positive influence of the scalability of FinTech systems and online authentication on financial inclusion and emphasize their central role in expanding access to financial services. The effectiveness of online authentication in promoting financial inclusion is particularly noteworthy. However, the results show that product substitutability has a negligible influence on financial inclusion, pointing to the need for a strategic reorientation of resource allocation. These findings provide industry practitioners with valuable strategies to navigate the complex intersection of FinTech and traditional banking. This study contributes to the theoretical discourse by presenting a unique model that integrates disruptive innovation theory and financial intermediation theory. It argues for concerted efforts to use FinTech as a catalyst for promoting financial inclusion and draws attention to its potential as a powerful enabler for inclusive financial systems.

Keywords: Financial inclusion; financial technology; FinTech; Disruptive Innovation; Financial Intermediation.

Introduction
Access to financial services is fundamental to facilitating economic growth, alleviating poverty and promoting social development. Yet, a significant portion of the world's population is under-served by traditional banking systems, limiting their opportunities for financial inclusion (Quresh, Ismail, Khan, & Gill, 2023). FinTech has emerged as a transformative force in recent years, reforming the financial services sector and creating new opportunities to expand the reach of financial products and services. Financial inclusion, which encompasses the availability, accessibility and affordability of financial services for individuals and businesses, will benefit significantly from the innovative integration of technology and data through FinTech (Afjal, 2023). FinTech has the potential to revolutionize the financial services landscape by introducing new distribution channels, improving efficiency and reducing costs. Through the use of digital platforms, mobile devices and advanced analytics, FinTech solutions can overcome the

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limitations of traditional banking systems and extend financial services to individuals and businesses that were previously excluded (Quresh *et al.*, 2023).

Throughout history, financial systems have thrived and functioned efficiently due to financial innovation. The recent wave of financial innovation, especially related to digitization, has the potential to significantly change the landscape of financial service providers (Arnaut & Bećirović, 2023). FinTech innovations have disrupted traditional banking and financial practices, offering new and more accessible channels for financial transactions, savings, loans and investments (Arnaut & Bećirović, 2023). The disruptive influence of FinTech has triggered a wave of both positive and negative changes in extending the reach of financial services to previously unserved or underserved populations (Harris & Wonglimpiyarat, 2023). Financial inclusion has been enabled by the digital transformation of financial services (Tsindeliani *et al.*, 2022).

Financial inclusivity, accessibility and affordability of financial services for individuals and businesses are fundamental aspects of sustainable economic development (Chitimira & Warikandwa, 2023). However, for many years, a significant portion of the world's population, particularly in rural and underserved areas, was excluded from access to traditional financial services (Ji, Wang, Xu, & Li, 2021). This exclusion has had a significant economic and social impact, hindering economic growth and poverty reduction. There are two complementary contributions to the process of inclusive financial sector development (Anagnostopoulos, 2018; Cecchetti & Schoenholtz, 2021). Mainly drawing on the Disruptive Innovation Theory introduced by Christensen in 1997 and the Financial Intermediation Theory proposed by economists Gurley, Shaw and Enthoven in 1960, researchers have analyzed the impact of FinTech on the financial services sector (Goswami, Sharma, & Chouhan, 2022; Gupta & Kanungo, 2022). The interplay between disruptive and complementary forces is a crucial aspect of the change that FinTech is bringing to the industry.

Some scholars view FinTech as disruptive to financial services, whereas others regard it as complementary (Murinde, Rizopoulos, & Zachariadis, 2022). With the development of FinTech, a decisive change is taking place in the relationship with traditional financial institutions. While FinTech was initially seen as a disruptive force challenging the status quo, it is increasingly seen as a complementary element of the broader financial ecosystem (Murinde *et al.*, 2022). FinTech is disruptive when it introduces innovative technologies and business models that challenge or replace traditional financial services, often targeting underserved market segments by offering alternatives to traditional banking and financial services (Lanto, 2021). Disruptive FinTech can shake up the industry by taking market share from incumbents and forcing them to adapt or risk becoming obsolete. Conversely, FinTech is also seen as complementary when it enhances the capabilities of existing financial systems and institutions (Antwi-Wiafe, Asante, & Takyi, 2023). Instead of directly competing with traditional banks and financial firms, complementary FinTech solutions work with incumbents to improve efficiency, expand access to financial services and enhance the customer experience. Complementary FinTech solutions strengthen the entire financial ecosystem by fostering innovation, driving efficiencies and addressing emerging customer needs without necessarily displacing traditional players. This transition from disruption to complementarity marks a new phase in the development of FinTech and its potential to harmonize financial inclusivity, particularly in rural areas.

Extant literature expounds that while product substitutability, online authentication and system scalability are recognized as important pillars of financial inclusion, there are concerns about adequately addressing these factors when adopting FinTech solutions (Rabbani, 2022). Despite their potential to improve access to financial services and security, failure to consider certain aspects of product substitutability, online authentication and system scalability could pose a challenge when adopting FinTech solutions (Gupta & Kanungo, 2022; Kandpal, 2023). Understanding and addressing these factors are critical to developing effective strategies and interventions that promote broad access to financial services, empower underserved populations, and drive inclusive economic development on a global scale. With this in mind, this paper explores the transition of FinTech from disrupting to complementing financial services and how it impacts the current imbalance in the distribution of financial services and the urban-rural divide in financial inclusion in Tanzania.

As financial inclusion initiatives evolve, the scalability of the underlying systems becomes crucial to cope with the growing number of users and different transactions (Moro-Visconti, Cruz Rambaud, & López Pascual, 2020). Efficient and scalable financial systems facilitate the seamless delivery of financial services to a larger population (Senyo, Karanasios, Gozman, & Baba, 2022). This is particularly important in the context of financial inclusion efforts in underserved and remote areas where traditional infrastructure may be limited. Scalable systems can adapt to the changing needs of different users and ensure that the benefits of financial inclusion are accessible to a broad spectrum of society (Moro-Visconti *et al*., 2020).

The rise of FinTech has significantly changed the traditional financial landscape and reshaped the way financial services are accessed, delivered and utilized. This transformation is characterized by the introduction of innovative technologies and business models that challenge traditional banking practices (Misati, Osoro, Odongo, & Abdul, 2022). However, amid this change, FinTech has also played a critical role in promoting financial inclusion, particularly among underserved and marginalized communities. While the disruptive impact of FinTech on traditional finance is clear, the simultaneous promotion of financial inclusion represents a significant and transformative aspect of its development (Dasilas & Karanović, 2023). The problem is to understand and navigate the evolving landscape in which FinTech is evolving from a disruptive force to a complementary force to harmonize financial inclusion for all. Addressing these issues is critical to ensure that the evolution of FinTech from a disruptive force to a complementary force contributes positively to the goal of harmonizing financial inclusion, especially in rural and underserved areas. The current study aimed to investigate and analyze the evolving role of FinTech in promoting financial inclusion. In particular, it aims to understand how FinTech innovations - product substitutability, online authentication and system scalability influence financial inclusion.

Theoretical Perspectives
Various theories have been used to understand and explain financial inclusion. The predominant theories to date are the Disruptive Innovation Theory and the Financial Intermediation Theory. The theory states that disruptive innovations often emerge in the form of simpler, more affordable alternatives that initially target underserved or overlooked market segments. Over time, these innovations have the potential to disrupt established industries and incumbent companies by gradually capturing market share (Lanto, 2021). The theory of disruptive innovation by

Christensen (1997) was used in this study to analyze how FinTech is reshaping the landscape of financial services, particularly in promoting financial inclusion. According to this theory, disruptive newcomers initially target an overlooked market segment by offering products or services at lower prices. As they improve their offering or technology over time, they move on to target mainstream customers (Antonio & Kanbach, 2023). Disruption occurs when these mainstream customers largely accept and adopt the new entrant's offerings. Based on these theories, there is a substitution effect concerning the financial services offered by FinTech companies and traditional banks. As technology advances, customers move from face-to-face to digital transactions due to a complementarity effect resulting from improved access to digital banking services and a better experience with new digital products, services and functionalities (Ionașcu *et al.*, 2023; Osei, Cherkasova, & Oware, 2023). The scalability of the system, online authentication and the substitutability of products each contribute to a different understanding of how disruptive innovations unfold and ultimately change markets in the context of disruptive innovation theory. In this study, disruptive innovation theory was applied to assess how scalable FinTech systems, efficient online authentication methods and substitutable financial products could help remove barriers to financial inclusion.

Financial Intermediation Theory
The theory of financial intermediation (Gurley *et al*., 1960) provides a conceptual framework for examining the functions and importance of financial intermediaries within the economy (Bongomin, Yosa, Lubega, Yourougou, & Amani, 2021). These intermediaries, including financial institutions, serve as go-betweens between savers and borrowers by receiving funds from savers and transferring them to borrowers through loans or investments (Bongomin *et al*., 2021). Financial intermediation theory examines the role of financial intermediaries such as banks and other financial institutions in facilitating the flow of money between savers and borrowers in an economy (Fernanda, Marley, & Suhendra, 2024). In this study, financial intermediation theory serves as a foundational framework to explore how FinTech innovations facilitate interactions with traditional financial intermediaries and contribute to improving financial inclusion (Molnár, 2018). This theory provides insights into the role of intermediaries in facilitating the flow of money between savers and borrowers and how FinTech initiatives complement or disrupt these traditional processes. By integrating financial intermediation theory into the study, researchers can better understand the dynamics of FinTech's transition from disruption to complementarity in promoting greater financial inclusiveness.

The combination of disruptive innovation theory and financial intermediation theory in this study provides a comprehensive approach to understanding the evolving landscape of financial services, particularly in the context of FinTech. By combining these theories, researchers can examine how modern financial institutions may interact with traditional financial intermediaries and the impact they have on financial inclusion.

Empirical Review
In the literature dealing with the introduction of FinTech in the financial sector, they were initially labeled as potential disruptors (Dasilas & Karanović, 2023). At the time, the prevailing opinion was that their growth could lead to significant changes in the financial markets (Mazikana, 2023). Other researchers, such as Dasilas and Karanović (2023), shared a similar view, emphasizing that FinTech offerings not only meet but may even exceed customer expectations. These scholars

argue that the integration of technological innovation into finance by FinTech companies is disrupting financial intermediation and negatively impacting bank profitability. In support of this claim, Phan, Narayan, Rahman, and Hutabarat (2020), using data from the Indonesian market, found that the growth of FinTech companies has a negative impact on bank performance. They interpreted this unfavourable result through the lens of consumer theory and disruptive innovation theories.

Odei-Appiah, Wiredu and Adjei (2022) conducted comprehensive research on the impact of FinTech adoption on financial inclusion in the context of the digital divide. The study utilized two established theoretical models, namely the Unified Theory of Acceptance and Use of Technology and the Digital Inequality Model. The results provided robust evidence of the positive impact of FinTech use on financial inclusion. In particular, the study highlighted the influential role of performance expectancy and enabling conditions in shaping individuals' behavioural intentions towards FinTech adoption.

The existing literature focuses on the growth of FinTech innovations and the potential disruption of financial services, for example, Cornelli *et al.* (2023); Stulz (2022); Valverde and Fernández (2020). Other studies examined how FinTech innovations would complement financial services and thus financial inclusion (Stulz, 2022; Valverde & Fernández, 2020). However, most of these studies did not focus on the contribution of system scalability, product substitutability and online authentication to enabling financial inclusion (Agarwal & Assenova, 2023; Lee, Shih, & Zheng, 2023). In realizing financial inclusion, there is a close relationship between product substitutability, online authentication and system scalability (Misati *et al.*, 2022; Mpofu & Mhlanga, 2022). A variety of financial products offer users a range of options and thus promote inclusivity. Trust in digital services is created through robust online authentication, which ensures the security of transactions. The scalability of the system is imperative to efficiently support a growing user base in financial inclusion initiatives (Senyo, Gozman, Karanasios, Dacre, & Baba, 2023). Together, these factors form a comprehensive framework that builds an inclusive financial ecosystem that meets people's diverse needs and promotes broader economic participation.

While FinTech is commonly viewed as complementary to financial institutions, some of the growing literature on financial technology points to internal competition between FinTech and domestic financial institutions (Antwi-Wiafe *et al.*, 2023). Trapanese and Lanotte (2023) theorized that financial technology could lead to financial disintermediation in economies, disrupting traditional banking practices. Similarly, Kohardinata, Suhardianto and Tjahjadi (2020) emphasize the substitution of peer-to-peer lending for bank lending in rural areas. Das (2019) also sees FinTech as a disruptive factor due to the increased costs associated with financial intermediation.

Hypothesis development
While financial innovation has long been a feature of prosperous and competitive financial systems over the centuries, recent technological advances give the impression that the situation is different (Cornelli *et al.*, 2023). Technological development and the rise of FinTech have not only significantly reduced the cost of providing financial services by facilitating mobile telephony, improving data processing capacity and promoting global connectivity, but have also attracted new, non-financial market participants into the financial sector (Hoekstra & Leeflang, 2023). One

important area where recent financial innovation has made significant progress is financial inclusion. The use of mobile phones for financial services has enabled developing countries to bypass the traditional brick-and-mortar branch model, leading to significant progress in financial inclusion (Kouladoum, Wirajing, & Nchofoung, 2022).

FinTech plays a crucial role as a facilitator in promoting financial inclusion, especially for those who are underserved or excluded from traditional banking systems. They have the potential to remove various barriers to financial inclusion by utilizing technology to provide innovative solutions based on various FinTech attributes (Asgari & Izawa, 2023). Existing literature emphasizes the critical importance of system scalability in the context of FinTech adoption. However, comparatively little light has been shed on the role of scalability in promoting financial inclusion (Moro-Visconti *et al*., 2020; Rawat, Sharma, & Goyal, 2023). Scalability refers to the ability of a system to competently and cost-effectively handle an increasing amount of work, growth, or demand. In the context of FinTech and financial inclusion, a scalable system is essential to enable the expansion of services, reach a larger user base and adapt to an evolving technological and regulatory environment (Ediagbonya & Tioluwani, 2023).

H1: The scalability of FinTech systems positively influences the extent of financial inclusion.
Over the years, financial innovation has undergone a transformative evolution in many developing countries. By and large, it has played an important role in promoting development by increasing customer convenience, streamlining spending processes and reducing banks' operating costs (Hughes & Palke, 2019; Qamruzzaman, 2023). This, in turn, has broadened the scope of financial institutions and attracted a greater diversity of participants to the financial market. The emergence of FinTech has been instrumental in creating a new category of financial services. FinTech leverages the agents and systems of third-party intermediaries to improve accessibility while minimizing service costs (Hoekstra & Leeflang, 2023). FinTech has reshaped the financial sector (Qamruzzaman, 2023), introducing sophisticated yet user-friendly tools and channels such as mobile money, ATMs, debit and credit cards, and various electronic funds transfer mechanisms (Asgari & Izawa, 2023).

Product substitutability plays a crucial role in shaping the accessibility and acceptance of financial services. FinTech contributes to financial inclusion through a wide range of financial services. The degree of substitutability depends on the extent to which these FinTech services can effectively replace or complement traditional financial products such as banking services, loans and insurance. Product substitutability and financial inclusion are triggered by the ability of innovative financial technologies to replace or complement traditional financial services (Mei, Khan, Khan, Ali, & Luo, 2022; Murinde *et al.*, 2022). However, the impact of FinTech on financial inclusion is reported to depend on the extent to which their products can effectively serve as substitutes to fulfill the various needs of individuals and businesses, especially those who have been historically underserved by traditional banking systems (Adbi & Natarajan, 2023; Mei *et al.,* 2022).

H2: The substitutability of FinTech products has a positive influence on financial inclusion.
The development of online payments, peer-to-peer (P2P) lending, artificial intelligence and blockchain are among the most important trends in the financial industry and have the potential to change the way financial services are delivered (Chung, Kim, Lee, & Oh, 2023). The

development of online payments has revolutionized the way people conduct transactions. It refers to the use of digital platforms for payments. Online payments have the potential to create new markets and make it easier for businesses to interact with customers (Zhao, 2023). Several online payment platforms have emerged in recent years, including Alipay, Apple Pay and UnionPay (Zhao, 2023). Online payments have several characteristics that differentiate them from traditional payment methods, including convenience, speed, security and cost-efficiency.

Online payments play a key role in promoting financial inclusion by providing a convenient and accessible way for individuals and businesses to participate in the formal financial system. The growth of online payments has given rise to new business models such as peer-to-peer (P2P) lending platforms. P2P lending platforms allow borrowers to access funding from a pool of individual investors, bypassing traditional lenders (Chung *et al.*, 2023; Liu, Liu, & Zhou, 2021). This has democratized access to finance, especially for underserved populations, and challenged the dominance of traditional banks. However, online payments also harbour risks, including the potential for fraud, cyberattacks and data breaches. To mitigate these risks, online payment platforms need to implement robust security measures such as encryption, fraud detection systems and two-factor authentication (Ediagbonya & Tioluwani, 2023).

Online authentication in FinTech plays a central role in promoting financial inclusion by improving the security, accessibility and efficiency of financial services for those previously underserved to participate in the formal financial system (Chung *et al.*, 2023; Morgan, 2022). FinTech utilizes online authentication methods for identity verification, allowing individuals to access financial services remotely. This is particularly beneficial in regions where traditional forms of identity verification can be difficult and allows for a more inclusive approach to customer onboarding. By using technology to streamline identity verification and account access, FinTech is helping to break down barriers and expand financial inclusion on a global scale.

H3: Online authentication in FinTech has a positive influence on financial inclusion.
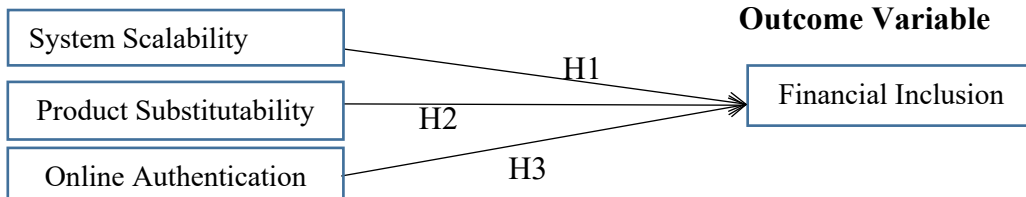
Predictor Variables

Figure 1: Conceptual framework (developed from literature review)

Methodology
Research design and procedures
The study utilized data collected through a cross-sectional research design using a semi-structured questionnaire administered to the information technology officers of the sampled financial institutions in Tanzania. An explanatory cross-sectional design was chosen because it allows for the collection of data over a shorter period. In addition, the information technology officers were selected for the study based on their role. The choice of a cross-sectional design was based on the effectiveness of data collection within a relatively short period.

The variables used in this study are assessed using several indicators as illustrated in Figure 1: system scalability (SC), product substitutability (PS), online authentication (OA) and financial inclusion (FI).

Table 1: Factor loading for constructs and composite reliability

Construct	Indicator	Loadings	t-Value	Cronbach alpha
FI	FI1- Number of active users of the start-ups' products or services	0.719		
	FI2- Solutions that are simpler, affordable, and more accessible	0.678		0.715
	FI3- Ease of access to financial products and services	0.833		
	FI4- Affordable products and services	0.694		
OA	OA1- The success rate for the authentication process	0.613		
	OA2- Satisfaction with the authentication process	0.876	5.885	0.738
	OA3- Duration for authentication process	0.763		
	OA4- Impact on the user experience	0.733		
PS	PS2- Products that target the same or overlapping customer segments	0.752		
	PS3- Products with similar pricing structures, fees, or interest rates	0.796	1.938	0.753
	PS4- Regulations and compliance requirements	0.901		
SC	SC1- System increases the number of transactions per unit of time	0.67		
	SC2- System's ability to handle a larger number of concurrent users without a significant decrease in performance	0.793	3.588	0.719
	SC3- The system enables cost-effective scalability.	0.727		
	SC4- The system's scalability upon integration with the current infrastructure	0.751		

Population and sample size
The population sought for this study were 272 Information Technology Officers, 51 from all commercial banks (BOT, 2022), and 221 from Microfinance Institutions affiliated with the Tanzania Association of Microfinance Institutions (TAMFI, 2022). The Information Technology Officers were selected for this study because they are the first and mostly to come across new technologies.

Sampling method and procedures
Based on the 272 population from financial institutions, a sample size of 162 IT Officers was derived using Taro Yomane's formula (1967) is n = N / [1 + N (e)^2], where n = sample size, N =

population of the study, and e = acceptable sampling error. Thus, grounded on the purpose of the study, a sample of 162 IT Officers residing from162 financial institutions was used in this study.

Data collection instrument and validation
The quantitative data for this study were collected using a semi-structured questionnaire designed to provide statistical results on the formulated hypotheses. The construction of the questionnaire followed nine recommended steps described by Churchill and Iacobucci (2004). The items of each variable were rated on a seven-point Likert scale. The 7-point Likert scale was chosen because the questionnaire was accepted and also provides a broader range of data points for statistical analysis, facilitating more robust data interpretation and hypothesis testing. The use of quantitative data was chosen because it provides the opportunity to generalize results and make predictions (Mohajan, 2020). Before the main study, a pilot study was conducted with 16 (10%) financial institutions to validate the questions included in the final questionnaire. The content validity indices were 0.543, 0.671 and 0.566 for system scalability (SC), product substitutability (PS) and online authentication (OA), respectively. The reliability results were 0.719, 0.753 and 0.738 for system scalability, product substitutability and online authentication, respectively. Redundant, difficult to understand and ambiguous items were removed from the final questionnaire for the main study based on the results of the pilot study.

Techniques of data analysis
The researcher entered the data collected in the field into the Statistical Package for the Social Sciences (SPSS version 26) for analysis, where a careful check for data entry errors, missing values and outliers was performed. Missing value analysis and data entry error checking were performed by generating frequencies and descriptive statistics, while boxplots were used to identify outliers within the dataset. Little's Missing Completely At Random test showed that only a few data were missing, namely less than 3. Therefore, linear interpolation, as recommended by Hair, Black, Babin and Anderson (2010), was used to replace the missing data. Furthermore, the boxplot results showed that outliers were not a significant problem in the data set, confirming its suitability for further statistical analyses. The data collected for this study was analyzed using Partial Least Squares Structural Equation Modelling (PLS-SEM) based on the coefficient of determination (R^2). The preference for PLS-SEM over other multivariate data analysis techniques stems from its ability to handle complex models, accommodate different types of data, and provide robust and interpretable results in a variety of research contexts, especially those that are prediction and exploratory (Akter, Fosso Wamba, & Dewan, 2017). The assessment of predictive effects involved calculating the significant change in the coefficient of determination between the dimensions of FinTech to explain financial inclusion.

Ethical Considerations
Ethical principles were upheld through measures such as securing voluntary participation, maintaining confidentiality, and informing participants comprehensively about the study's aims and objectives.

Results
Measurement
To assess the compatibility of the model with the data collected, a confirmatory factor analysis was carried out. The reliability of the indicators, constructs and discriminant validity as well as

the convergent and divergent validity were analyzed (Figure 2 and Table 3). The results show that the measurement model has a good fit, with most factor loadings exceeding the threshold value of 0.7 (Hair, Ringle, & Sarstedt, 2013). Construct reliability was assessed by calculating the composite reliability, with a minimum value of 0.7 being considered an indicator of satisfactory scale reliability (Hair *et al*., 2013). In addition, construct reliability was assessed using Cronbach's alpha, and all constructs scored above 0.7, indicating an acceptable level of reliability (Hair & Alamer, 2022). Convergent validity was analyzed using the average variance extracted (AVE) criterion, with all constructs having AVE values of at least 0.5, indicating a satisfactory level (Hair & Alamer, 2022). In addition, divergent validity was assessed by comparing the square root of the AVE in a diagonal with the correlation values between the constructs. The results presented in Table 2 show satisfactory divergent validity between the constructs (Fornell & Larcker, 1981; Hair *et al*., 2021).
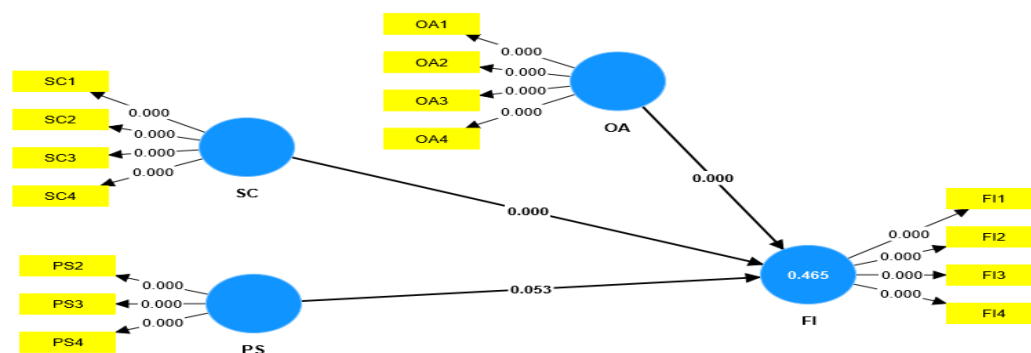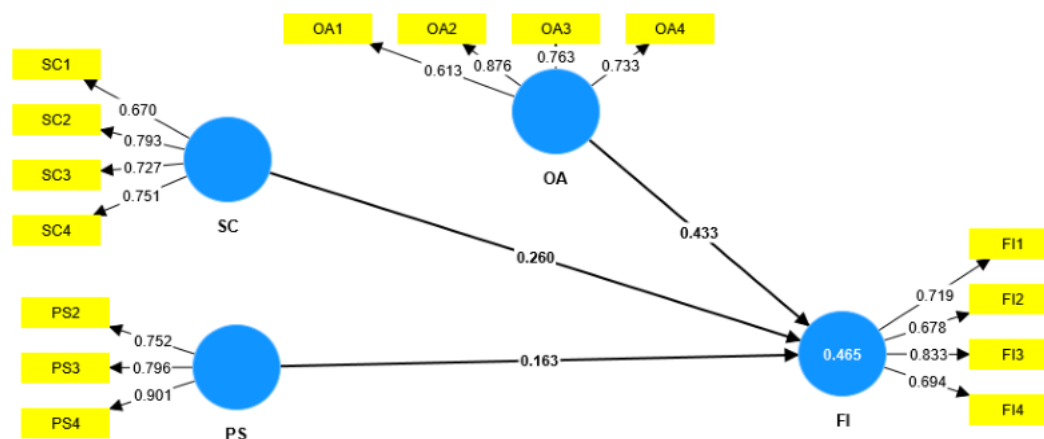

Figure 2: Measurement model

Figure 3: Structural model

Table 2: Convergent and Discriminant validity: Fornell-Larker criteria

Construct Validity	Convergent and Discriminant Validity					
	CR	AVE	FI	OA	PS	SC
FI	0.737	0.538	**0.733**			
OA	0.758	0.566	0.605	**0.752**		
PS	0.761	0.671	0.406	0.318	**0.819**	
SC	0.724	0.543	0.526	0.461	0.401	**0.737**

Table 3: Discriminant Validity: Heterotrait-Monotrait (HTMT)

	FI	OA	PS	SC
FI				
OA	0.803			
PS	0.527	0.422		
SC	0.714	0.633	0.530	

Table 4: R-square and Q-square to assess the Quality of the structure model

Variable	R^2	Q^2	VIF	f^2
FI	0.465	0.256	1.452	
SC		0.108	1.306	0.091
PS		0.129	1.562	0.041
OA		0.285	1.469	0.269

The interpretation of this table shows that the VIF values for the independent variables OA, PS and SC predict the dependent variable FI, suggesting that multicollinearity is probably not the problem. The VIF values for the independent variables OA, PS and SC predicting the dependent variable FI suggest that multicollinearity is unlikely to be the problem. The results presented in Table 4 and Figure 3 give R² values that measure the percentage of variation explained by the model in a construct and its predictive abilities. The measure of cross-validity, redundancy and commonality Q², specifically for structural equation modeling (SEM) models, are also assessed. A Q² value greater than zero for a reflective endogenous latent variable means that the model is predictively relevant for that particular construct. According to Hair *et al.* (2014), Q² = 0.02 indicates low predictive relevance, Q² = 0.15 indicates medium relevance and Q² = 0.35 indicates high predictive relevance.

In the results from Table 4, the Q² values are clearly above zero, which demonstrates the predictive relevance of the model for the specified endogenous construct. Looking at the columns of the f-square, the value of 0.269 represents the f-square effect for the predictive value of OA on FI, indicating that OA has a more significant influence on the creation of the R-square for FI. Conversely, the values of 0.091 (SC) and 0.041 (PS) indicate relatively small effects on the R-squared.

Structural model for testing hypothesis

The outcomes presented in Table 5 provide a summary of the hypothesis results for the research model. All t-statistics are expected to be significant at $p < 0.001$. If the probability value (p-value) falls below the significance level, the null hypothesis is rejected. A T-value greater than 2.63 indicates that the path is significant at $p < 0.001$, while a T-value between 2.63 and 1.96 is considered significant at $p < 0.05$ (Sergey & Tienan, 2013). Conversely, a T-value below 1.96 is not considered significant ($P < 0.001$). In this study, three hypotheses were formulated, and PLS Bootstrapping was employed to test these hypotheses.

Table 5: The summary of hypothesis results of the research model

Hypothesis	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T Values	P values	Decision
SC -> FI	0.260	0.256	0.072	3.588	0.001	Accept
PS -> FI	0.163	0.172	0.084	1.938	0.053	Reject
OA -> FI	0.433	0.433	0.074	5.885	0.001	Accept

The findings reveal that hypotheses H1 (SC->FI) and H3 (OA->FI) are accepted indicating that there is a causal relationship between system scalability, online authentication, and financial inclusion. However, hypothesis H2 (PS->FI) is rejected, signifying that the null hypothesis associated with this hypothesis is rejected indicating that there is no significant relationship between the predictor variable (PS) and the outcome variable (FI).

Important Performance Map Analysis

To provide management with insights into areas for improvement that can maximize the benefits of adopting FinTech, a Performance Map Analysis (IPMA) was conducted. The analysis utilized a four-quadrant diagram depicted in Figure 3, with the horizontal axis indicating attributes ranging from low to high importance.

Figure 4: Importance Performance Map for FinTech Adoption
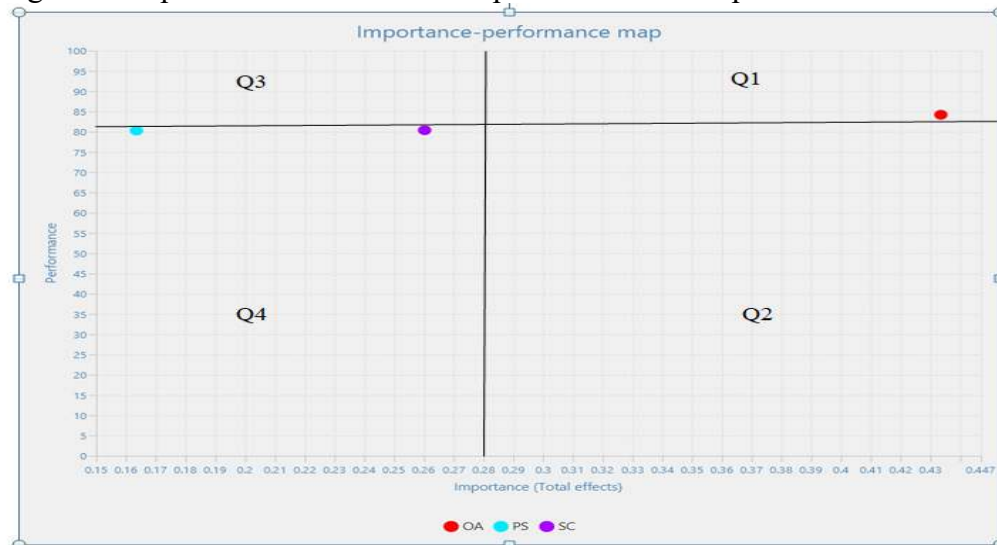
The vertical axis denotes FinTech's Adoption performance as regards attributes from poor to good performance. In this study, the construct OA falls in Q1 indicating that it is perceived as highly

important by FinTech users and is performing well in meeting their expectations. Constructs SC and PS fall under Q4 indicating that they are considered less important by FinTech users and are perceived to be performing poorly. According to Hair, Howard, and Nitzl (2020), the four quadrants are Q1 (management is fine), Q2 (something needs improvement), Q3 (too much performance for the non-important issue), and Q4 (it does not matter and no performance). The quadrants are marked based on the mean of performance and that of importance as demonstrated in IPMA Table 6.

Table 6: Important Performance Map Analysis

Construct	Performance FinTech adoption	Total effects
OA	84.201	0.433
PS	80.294	0.163
SC	80.387	0.260
Mean	81.63	0.285

Source: Field data (2023)

Discussions and Conclusions

The study aimed to provide insights into the dynamic relationship between FinTech, financial inclusivity, and the broader financial landscape, shedding light on the transition from disruption to complementarity in the financial industry. Results from Table 4.5 indicate that (β=0.260; p<0.001 and t=3.588≥1.963), which means that H1 is supported. This indicates a significant influence of SC on FI. The partial change in the financial inclusion due to a one-unit change in system scalability to operate is 0.260. It implies that scalable FinTech systems play a crucial role in supporting financial inclusion. This is supported by Lee and Lim (2021) and Goswami *et al.* (2022) who stated that, as the demand for financial services in underserved areas grows, scalable systems ensure that the infrastructure can expand to accommodate the increased demand without becoming inefficient or unreliable. The results also indicate the significant influence of OA on FI with β=0.433; p<0.001 and t=5.885≥1.963 which implies that system authentication is integral to the success of financial inclusion by providing secure and accessible means for individuals to access digital financial services thus H3 is supported.

On the contrary, the study did not confirm the influence of PS on FI hence H2 is not supported. These findings translate that there are other factors such as regulations compliance requirements and product features rather than outright substitution. Regulations and compliance requirements play a key role in shaping the substitutability of FinTech products. FinTech companies must navigate and comply with these regulations to ensure their products are viable, alternatives to traditional financial services and to foster trust among consumers and regulators alike (Xu, Bao, Zhang, & Zhang, 2021). The results indicate that β=0.163; p<0.001 and t=1.938<1.963).

Scalable FinTech systems allow for the efficient onboarding of a larger number of users. This scalability is particularly important in financial inclusion initiatives, where reaching a broad and diverse user base is a key goal. Muthukannan, Tan, Tan, and Leong (2021) propose that the strategies of decentralization, platformization, localization, and democratization employed by FinTech platform operators have a positive influence on the scalability of financial service delivery. Krishna, Krishnan, and Sebastian (2023) assert that online authentication is critical for

building trust in digital financial services. In financial inclusion, trust is vital, and secure authentication methods contribute to users' confidence in using digital platforms for their financial needs. FinTech's product substitutability is essential for financial inclusion (Muthukannan *et al.*, 2021). Scalable systems enable the expansion of FinTech products to diverse markets. The availability of secure online authentication methods ensures that these products can be accessed by a wide range of users securely.

Implications

This study has far-reaching implications as it influences policy decisions, shapes industry practices and contributes to how FinTech can best be used for inclusive and sustainable financial systems. This has remarkable implications for policymakers, especially in emerging markets, who are endeavouring to facilitate, steer and expand the FinTech revolution. Moreover, it is relevant for FinTech practitioners to shape the design of technology-enabled financial service delivery. The study offers practical design principles for the development of inclusive FinTech products. These include considerations for online authentication and system scalability to meet the diverse needs of underserved populations.

As per the Importance Performance Map Analysis chart, the results indicate that the current management strategy regarding online authentication within the FinTech sector and its impact on financial inclusion is considered adequate and satisfactory. Consequently, the study concludes that there are no significant areas that require immediate attention in terms of the positive impact of online authentication in the FinTech sector on financial inclusion. Similarly, the results for SC suggest that this hypothesis works effectively but is perceived to be excessive in addressing critical issues related to financial inclusion. This suggests that while this hypothesis works adequately, it focuses too much on aspects that are not considered critical to improving financial inclusion in the context of the study. Consequently, the study proposes that resources would be better directed toward other, more critical factors influencing financial inclusion. The theoretical contribution of the study lies in the comprehensive examination of the impact of FinTech on financial inclusion from the perspectives of system scalability, online authentication and product substitutability based on Disruptive Innovation Theory and Financial Intermediation Theory. Through this synthesis, the study provides a holistic framework for analyzing the transition of FinTech from disruption to complementarity within the wider financial landscape.

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