SCIENTIFIC CULTURE
www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 5.1, (2026), pp. 723-735
Open Access. Online & Print

DOI: 10.5281/zenodo.12511059

THE IMPACT OF IOT-ENABLED FINTECH ADOPTION ON OPERATIONAL EFFICIENCY IN BANKING: THE MEDIATING MODERATING MODEL

Mohammad Kamal Kamel Afaneh[1]*

[1] *Collage of Business, Imam Mohammad Ibn Saud Islamic University (IMSIU).*

Received: 01/12/2025
Accepted: 02/01/2026

Corresponding author: Mohammad Kamal Kamel Afaneh (Email)

ABSTRACT

This paper explores the effects of the adoption of IoT-enabled FinTech on the efficiency of operations in banking. Structural Equation Modeling (SEM) is the method with which we analyze the information gathered among banking professionals involved in digital financial operations and service delivery with the help of technology. The hypotheses test the connections between the IoT-enabled FinTech adoption, process integration, digital risk management, and operational efficiency. The results suggest that the use of FinTech through IoT is positively related to operational efficiency. The use of IoT-based FinTech also leads to better integration of the processes and thus increases operational efficiency. The outcomes also indicate that process integration mediates the connection between the use of IoT-enabled FinTech and operational efficiency. Also, digital risk management enhances the impact of IoT-enabled adoption of FinTech on operational efficiency, which supports the moderation role. These results offer an in-depth insight into the contribution of digital financial technologies with the help of IoT to the efficiency of banks due to the integrated processes and effective risk management. The proposed study adds to the body of knowledge regarding the digitalization of banking by introducing a mediated and moderated framework that can be used to clarify the operational value of FinTech adoption that is supported by the usage of IoT. The findings would provide viable advice to bank managers who want to enhance service processes, reinforce risk management practices and attain greater operational efficiency by adopting technology.

KEYWORDS: Smart Customer Access Service Delivery, Control Enablement, Process Integration, Operational Efficiency in Banking, Digital Risk Management

1. INTRODUCTION

The use of Internet of Things (IoT)-enabled financial technology (FinTech) is revolutionizing the banking sector by altering the way banks operate transactions and service delivery, as well as how they coordinate operational processes [1]. The increasing dependence on interconnected devices, digital platforms, and smart financial systems has provided new possibilities to enhance the speed of services, accuracy of transactions, and efficiency internally [2]. With the ongoing digitalization of banks, FinTech that utilizes IoT to enhance operational workflows and competitive advantage in an increasingly technological financial context have become a significant strategic tool in making operational improvements and remaining viable in highly technological financial conditions. [3]. The banking industry has over recent years been under immense pressure to improve their operational efficiency whilst at the same time addressing the increasing customer demands, regulatory needs as well as being affected by the digital disruption. The demand of real-time financial services, the smooth flow of the processes and the integrated decision environments can no longer be maintained by the conventional banking practices [4]. In this respect, the adoption of IoT-enabled FinTech provides banks with the opportunity to connect systems, devices, and financial applications in such a way that it can facilitate ongoing data exchange and more efficient service delivery. This change is specifically applicable to the banking environment where operational effectiveness is intertwined with cost management, service quality, processing time, and reliability of the processes [5]. The issue of operational efficiency in the banking sector has become a focal point of both researchers and practitioners in the banking sector since it represents how well the institution is able to maximize its resources whilst ensuring that service performance levels are high [6]. Effective banking activities are not only reliant on highly developed digital technologies but also on the skill of the organization to integrate the processes and the complexity of the process management in different departments and across platforms. Even though banks are investing more in digital financial solutions, the anticipated operational benefits are not automatically a result of the use of technology. Instead, they rely on to what degree these technologies are integrated into organizational processes and are backed up by efficient managerial systems [7]. Process integration is one of the key channels in which the adoption of IoT-enabled FinTech can enhance operational efficiency. Process integration is the integration and coordination of banking operations, systems, and information flows in a manner that minimizes fragmentation and improves continuity of operations [8]. The fragmented processes in banking environments usually result in delays, work duplication, inconsistency in services as well as higher operational prices. In comparison, integrated processes facilitate quicker execution of transactions, enhanced coordination of the units, and more precise service results [9]. In line with this, process integration can be another essential explanatory route in which the adoption of IoT-enabled FinTech, in its role, can lead to operational efficiency. Meanwhile, the positive effects of having IoT-enabled FinTech usage come with increasing anxieties regarding digital risk. Banking organizations work in a very sensitive setting where cybersecurity risks, vulnerability of the systems, privacy, and online fraud can compromise the efficiency of the emerging technologies. With the introduction of IoT-based financial systems in banks, there is an increased significance of digital risk management in deciding whether the implementation of technology produces beneficial or limiting operation results [10]. Digital risk management can build trust on digital systems, minimize operational disruptions, and aid more reliable deployments of connected financial technologies. Thus, it can be assumed that the connection between the usage of IoT-enabled FinTech and its operational efficiency can be calmed down by digital risk management [11]. Although the topic of digital transformation in the banking sector is gaining more attention, the literature remains a significant gap in its ability to elucidate the operational efficiency through the integrated effect of IoT-enabled FinTech adoption, process integration, and digital risk management. The current literature has tended to analyze digital banking technologies in a limited view, be it the results of adoption, technology preparedness, how the technologies are used by the customers, or their financial results [12]. Relatively little focus has been given to the understanding of how the adoption of IoT-enabled FinTech enhances the efficiency of internal banking processes due to process-related effects and at different degrees of digital risk management. This loophole underscores the importance of a more holistic conceptual framework to encompass the mediating and moderating conditions in relation to operational improvement in banking [13]. The current research fills this gap by considering how adopting FinTech that involves IoT can affect operational efficiency in the banking sector and adding process integration as a mediator and digital risk management as a moderator [14]. This model offers a more detailed explanation of the creation of value through digital financial technologies in banking institutions. It goes beyond the direct-effect assumptions to acknowledge that technology adoption has an impact on efficiency not just by boosting direct operational efficiency but also by enhancing internal integration and the ability of the bank to deal with digital risks [15].

The importance of the research is manifested both theoretically and practically. Theoretically, it adds to the existing body of digital banking transformation by bridging the gap between the adoption of IoT-enabled FinTech and the organizational processes outcomes and risk governance conditions. Practically, the work can advise banking managers who need to enhance operational effectiveness by interlinked financial technologies and at the same time, make sure that the digital risks are tackled accordingly [16]. The results can also help the decision-makers to develop more integrated and risk-conscious approaches to the development of digital banking [17]. The present study also contrasts with the previous work as the mediated-moderated framework is used to reflect the complexity of digitalization in the banking industry in a more organized way. Instead of considering technology adoption as a predictive variable in isolation, it acknowledges operational significance of integration of processes inside the organization and strategic value of digital risk controls. This method gives a deeper insight into the circumstances in which the adoption of IoT-enabled FinTech can result in efficient gains in the banking industry.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1 Smart Customer Access

Smart customer access is a measure of how much banking institutions allow their customers to connect with financial services via connected, responsive and technology-based avenues [18]. Smart Customer Access in the framework of adoption of IoT-enabled FinTech is the capacity of the bank to enable customers to have constant, convenient, and smart access to financial services via mobile platforms, self-service systems, connected devices, and digitally integrated interfaces [19]. This dimension has grown to be significant in contemporary banking since customer's desire financial services to be accessible any time and across various touchpoints of digital platforms. The importance of smart customer access is that it makes banking services easier to customers, helps them to minimize waiting lines, and enhance the responsiveness of banking services [20]. When the customers have access to banking services via the effective digital channels, the institutions can release the burden on the traditional branch-based operations and redistribute the resources in a more efficient manner [21]. Consequently, intelligent access to customers will help to streamline the operational processes, reduce the number of people attending to services and enhance the use of technology infrastructure. Such results are profoundly linked with the operational efficiency in banking, which relies on the capacity to present services with precision, speediness, and reduced operational costs [22]. In terms of operational efficiency, smart customer access facilitates efficiency since it reduces manual handling and improves service transactions flowing through banking platforms. The availability of intelligent access mechanisms enables banks to service requests faster, more efficiently monitor customer activity and in a timely manner respond to service requirements [23]. Therefore, operational performance can be enhanced with the utilization of smart customer access tools as it will help to decrease the delays of the process and enhance the continuity of the services. Based on this reasoning, the following hypothesis is proposed:

H1: Smart customer access has a positive effect on operational efficiency in banking.

2.2. Service Delivery

Smart customer access is the degree to which the banking institutions provide customers with the opportunity to engage with financial services by having connected, responsive and technologically supported channels [24]. Applying IoT-enabled FinTech adoption, smart customer access is the capability of the bank to offer its customers uninterrupted, convenient, and intelligent access to financial services via mobile platforms, self-service systems, connected devices, and digitally integrated interfaces [25]. This dimension is gaining more significance in contemporary banking as the customers want to receive financial services and in several digital touchpoints [26]. The topicality of smart customer access should be seen in the ability to minimize the customer effort, shorten the waiting time, and enhance the overall responsiveness of banking services. By enabling the customers to access the banking services using effective digital networks, the institutions can take the load off the old systems based on traditional branches and can redistribute the resources better. Consequently, intelligent customer access will lead to improved workflow, reduced congestion of services, and enhanced use of technology infrastructure. These are highly correlated with operational efficiency in banking, which is determined by the capacity to provide services at the right time, speed, and at a reduced cost of operation. In terms of operation, smart customer access aids in efficiency as it reduces the use of manual effort and in the speed of service transactions on banking platforms [27]. The intelligent access mechanisms also enable the banks to serve requests faster, track customer activity better and service needs in a timely manner. Therefore, the implementation of intelligent customer access tools might enhance the performance of operations by minimizing delays in the processes and enhancing service continuity.

H2: Service delivery has a positive effect on operational efficiency in banking.

2.3. Control Enablement

Control enablement can be defined as the degree to which FinTech adoption with IoT empowerment enhances the control and management capabilities of the bank to monitor, regulate, and manage operational processes using digital systems and connected technologies [28]. Control enablement in banking environments encompasses automated monitoring devices, linked verification systems, electronic compliance checks, and automated tracking systems that aid in increasing transparency and discipline of the processes [29]. This dimension is critical since accuracy, security, and consistency are very high in banking operations. The importance of control enablement role grows with the dependence of banking institutions on complicated digital infrastructures. In the absence of effective control mechanisms, the growth of technology can generate coordination issues, gaps in monitoring and an increased vulnerability to operational errors. Strong control enablement, in its turn, assists banks in making sure that digital financial processes are in line with internal policies, regulatory expectations, and performance requirements [30]. the hypothesis is as follows:

H3: Control enablement has a positive effect on operational efficiency in banking.

2.4. Process Integration

Process integration is the extent of coordination and integration of banking activities, workflows, information systems and decision processes among units and service channels [31]. Process integration is a critical organizational prerequisite in the context of digital banking, as it aids the effective utilization of IoT-enabling FinTech apps. It also makes sure that data, transactions and service instructions are transferred between systems in a smooth manner, which helps to minimize fragmentation and improve continuity in operations [31]. Unconnected or inefficient processes within banking institutions are likely to lead to duplication of work, slow transaction, inconsistent customer experience, and increased operating expenses. Process integration solves these predicaments by promoting coherence in the stages of operations and by facilitating coordination in the financial operations [32]. The significance of the integrated processes increases as digital financial systems become more inter-related, as the value of operational operations is not merely based on technology availability but also on how well the organization implements the technology into its daily operations. Though process integration is not part of the direct hypotheses that are outlined in this model, it is a conceptually sound construct in the context of the overall framework of IoT-enabled FinTech adoption and banking efficiency. It offers a significant background towards the realization of how digital systems generate value by means of coordinated activities and structured information flow. The successful adoption of digital tools in most banking contexts relies on how well the institution can incorporate service delivery functions, control systems, and customer access mechanisms in a single operation framework.

2.5. Operational Efficiency in Banking

Banking operational efficiency is a consumer of the capacity of the bank to utilize the resources, technologies and service systems in the most optimal productivity and minimum cost, delay and process waste [33]. It stands out as one of the focal findings in banking studies since it reflects the feasibility of internal processes and the ability of the institution to provide trustworthy services amidst competitive and regulatory demands. Operational efficiency is usually linked with quicker processing of transactions, less error in services, low operating costs, and improved coordination of operations between functional areas[34]. The efficiency of the functioning of digitally transformed banking is becoming more dependent on the implementation of innovative financial technologies and the ability of the bank to structure its digital activities. Smart customer access, service delivery, and control are all significant processes by which banks can improve their efficiency by streamlining service flow, decreasing manual overhead, and enhancing the uniformity of operational performance. In turn, the operational efficiency in banking is an effective dependent variable to analyze the effects of FinTech adoption dimensions with an IoT. In the current work, operational efficiency in banking is considered the main output based on which the practical implications of digital adoption can be evaluated.

Through its analysis of the connection between it and smart customer access, service delivery, control enablement, and digital risk management, the study aims to clarify how contemporary banking organizations could transform the capabilities based on technology into quantifiable improvements in operations [35].

2.6. Digital Risk Management

Digital risk management is the activities, policies, and technological protection, by which banking institutions identify, evaluate, oversee and manage risks associated with digital operations and technologically enabled financial services [36]. Digital risk management is critical in the context of the IoT-enabled FinTech adoption since connected systems can introduce new vulnerabilities to banks associated with cybersecurity, data breaches, system failure, privacy, and digital fraud. The digital risk management is turning out to be one of the organizational prerequisites to maintaining efficiency and trust as the banking industry grows increasingly dependent on interconnected technologies. Digital risk management has a direct impact on the efficiency of the operations in banking through the minimization of disruptions, process failures, and the stable digital execution. Strong digital risk practices by banks will put them in a better position to defend against their infrastructure and system continuity and lower the cost of operational disruption. It implies that digital risk management is not merely a protective mechanism but also an efficiency-enhancing factor that will help in making operations smoother and more reliable [37]. Besides its direct influence, digital risk management can also contribute to the robustness of the interrelationship among critical aspects of IoT-based FinTech adoption and operational efficiency. The advantages of intelligent customer access, service delivery, and enabling control will likely be greater in the case that banks have good digital risk controls [38]. Without these controls, the benefits of digital adoption can be undermined by security breaches, compliance lapses, or process instability. Based on this, it is anticipated that digital risk management will play a direct and a moderating role in the research model. Based on this, the following hypotheses are put forward:

H4: Digital risk management has a positive effect on operational efficiency in banking.

H5: Digital risk management moderates the relationship between control enablement and operational efficiency in banking, such that the relationship becomes stronger when digital risk management is high.

H6: Digital risk management moderates the relationship between service delivery and operational efficiency in banking, such that the relationship becomes stronger when digital risk management is high.

H7: Digital risk management moderates the relationship between smart customer access and operational efficiency in banking, such that the relationship becomes stronger when digital risk management is high.

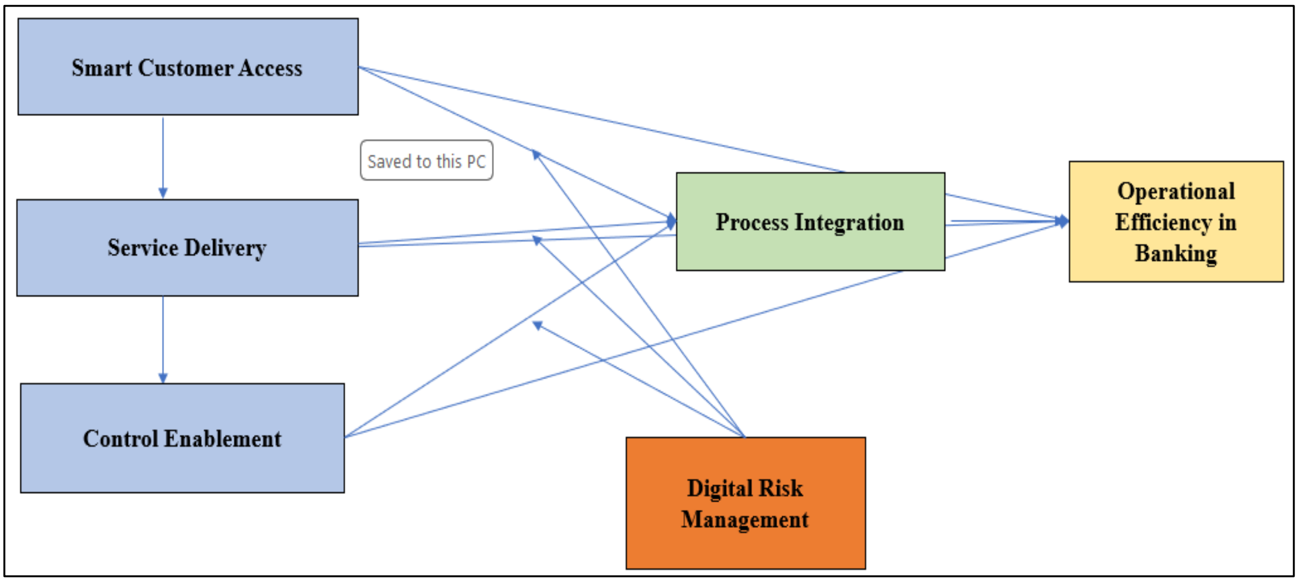

Figure 1: Research Model

3. METHODOLOGY

3.1. Research Population and Sampling

The study targeted professionals in the banking and financial technology industry, specifically those in or familiar with the IoT-based FinTech implementation, digital service operation, and banking process. It involved a wide range of people, such as branch managers, operations managers, and digital banking experts, IT officers, FinTech integration staff, risk management officers, and compliance staff who work in banking institutions. The sampling method was a stratified one, making sure that various levels within an organization, different departments, and functional areas are represented. This method led to gathering a thorough understanding of the implementation of IoT-enabling FinTech systems and the implication of this in operational efficiency in the banking industry. We decided to sample 381 respondents, which will give a statistically significant sample to study the relationship between smart customer access, service delivery, control enablement, process integration, digital risk management, and operational efficiency in banking.

3.2. Data Collection Process

The data was gathered with the help of an online questionnaire that was developed to analyze the attitudes of banking workers towards the use of IoT-enabled FinTech and its functioning effects. The questionnaire contained questions on smart access of customers, service delivery, enabling control, process integration, digital risk management and operational efficiency in banking. The respondents were advised to think of their experiences and observations in their respective institutions when responding to the survey questions. The survey was handed over via professional banking circles, institutional mailing lists, and online communication platforms applied in the financial industry. All participants were promised anonymity and confidentiality and were thereby placed in a conducive environment to give honest and informed answers.

3.3. Method of Data Collection

Structured questionnaire survey was the main mode of data collection. This approach allowed obtaining quantitative data that could be analyzed statistically and tested to confirm the hypothesis. The questionnaire was formulated meticulously in line with the purpose of the study and the conceptual model. The measurement items were all constructed in terms of a seven-point Likert scale between 1 (strongly disagree) and 7 (strongly agree). This scaling method resulted in the study eliciting the views of the respondents on the levels of the adoption of the IoT-enabled FinTech and its impact on efficiency within internal banking.

3.4. Respondents to the Questionnaire Survey

The questionnaire survey was conducted among professionals, actively involved in the operations connected with the banking activities, digital transformation, the management of service processes, and the use of technology to provide financial services. The participants were mid-level managers, senior executives, digital banking officers, digital risk management personnel, IT specialists, branch supervisors, and operational staff, and digital banking managers in the banking industry. The respondents were diverse enough to provide a multidimensional and wide-ranging picture of the impacts of the IoT-enabled FinTech adoption on the efficiency of the operations in banking institutions. The significance of this diversity is that the study has considered the technological as well as the managerial aspect and thus the input of specialists with personal experience in digital service systems and internal banking procedures is needed.

3.5. Measurement of Variables

The research variables were measured by using several items which were modified according to the banking environment and the purpose of the proposed framework, as a part of the study. The adoption of IoT-enabled FinTech was depicted by three key dimensions, i.e., smart customer access, service delivery, and control enablement. Process integration was gauged as the extent to which banking processes, information systems and workflows are integrated in terms of coordination across platforms and functions. The metric of digital risk management was the potential of the institution to recognize, track, and manage digital risks involved with linked financial technologies. The level of operational efficiency within the banking sector was gauged using indicators of the speed of transactions, the accuracy of the services, the use of resources, the consistency of the processes and the overall productivity of the operations. The multi-item construct of measurement facilitated the overall evaluation of each construct and improved the dependability of the model of analysis.

3.6. Distribution of the Questionnaire

The survey was online, and the questionnaire was sent electronically exploiting the convenience and speed of online survey services. This approach also helped the study to access respondents in different banking institutions and geographical locations. Electronic distribution also helped in targeting and communication with relevant professionals who work in operational, technological, and risk related jobs. Moreover, the online format facilitated quick data gathering, easy compilation of the responses, and had better accessibility in cases where the respondents could not be involved physically.

3.7. Importance of Respondents

The choice of the respondents representing various positions in the banking sector was crucial to gaining a holistic understanding of the working implications of IoT-enabled FinTech implementation. Earlier studies have highlighted the significance of eliciting the opinions of people who are directly engaged in digital banking systems, their operational implementation, and risk management in exploring the outcomes of technology adoption. The study by using professionals who connect or oversee related financial technologies, sought to represent the actual situation in which digital adoption impacts the efficiency of operations. Their answers proved helpful in determining how the practical effect of smart customer access, service delivery, control enablement, and digital risk management affected the banking performance on the operational level. The presence of the respondents of the technical, managerial, and control-oriented positions was the guarantee of a balanced perspective of the banking environment and the factors which define the outcomes of the operations.

3.8. Data Analysis Technique

Structural Equation Modeling with Smart-PLS was the main methods of analysis that were used in the study. This approach was deemed to be suitable since the suggested framework comprises several direct relationships, a moderate influence and several related constructs. Smart-PLS is especially relevant to analyzing the complicated research models in business and banking applied research when the task is prediction and theory creation. The analysis of data was done through the evaluation of the measurement model and the structural model. The measurement model was assessed with respect to internal consistency, convergent validity and discriminant validity. Structural model was subsequently tested to ascertain the relevance of the direct effects and moderating relationships hypothesized in the hypotheses.

3.9. Non-response Bias Analysis

To guarantee the validity of the study results a non-response bias analysis was done by comparing various groups of respondents based on the distribution and organization of respondents which were selected. The test of equality of variances and independent sample t-tests were applied by Levene to determine whether there was a significant difference between early and late respondents, and between respondents who were sampled based on various banking categories and size of organizations. This process aided in establishing whether systematic non-response patterns influenced the responses. The analysis also helped in validating the reliability of the gathered data since it established that non-response bias did not pose a significant risk to the validity of the findings.

3.10. Ethical Considerations

The research was conducted in a way that complies with the necessary ethical criteria during data collection. The survey was voluntary and the respondents were briefed on the nature of the study prior to filling out the questionnaire. They were also assured that any answered data would be kept confidential and would not be used to harm any academic research. No personal data was provided, and the data collected were analyzed in aggregated format. These steps were used to ensure integrity of the research process and to facilitate the credibility of the findings.

Table 1: Outer Loading

Variable`	Code	OL	Cronbach's alpha	CR	AVE
Control Enablement	CE1	0.858	0.866	0.911	0.714
	CE2	0.860			
	CE3	0.848			
	CE4	0.818			
Digital Risk Management	DSM1	0.923	0.887	0.910	0.718
	DSM2	0.801			
	DSM3	0.849			
	DSM4	0.813			
Operational Efficiency in Banking	OPE1	0.749	0.906	0.932	0.685
	OPE2	0.790			
	OPE3	0.899			
	OPE4	0.879			
	OPE5	0.807			
	OPE6	0.848			
Process Integration	PI1	0.846	0.906	0.930	0.728
	PI2	0.839			
	PI3	0.858			
	PI4	0.865			
	PI5	0.856			
Service Delivery	SD1	0.875	0.893	0.921	0.702
	SD2	0.890			
	SD3	0.837			
	SD4	0.861			
	SD5	0.736			
Smart Customer Access	SCC1	0.752	0.916	0.934	0.745
	SCC2	0.899			
	SCC3	0.883			
	SCC4	0.887			
	SCC5	0.892			

As shown in Table 1, the measurement model has attained satisfactory levels of indicator reliability, internal consistency reliability, and convergent validity. The assessment is based on the values of outer loadings, Cronbach's alpha, composite reliability, and average variance extracted. To begin with, all the measurement item outer loadings are within the acceptable range. Most of the items have a higher value than the recommended value of 0.708, meaning that the indicators capture a large percentage of the variance of their respective latent constructs. In the case of Control Enablement, the loadings range between 0.818 and 0.860, and item reliability is robust. Digital Risk Management also offers acceptable loading values between 0.801-0.923. In the case of Operational Efficiency in Banking, the loading is between 0.749 and 0.899, which proves that all the six items are loaded sufficiently in the construct. Process Integration has very high loadings of 0.839 to 0.865 whereas Service Delivery has 0.736 to 0.890. Equally, Smart Customer Access has good loadings of 0.752-0.899. These outcomes show that all the items have a high degree of correlation with the constructs they are designed to measure and ought to be kept. Second, all constructs have satisfactory internal consistency reliability as demonstrated by the values of Cronbach alpha. The alpha values lie between 0.866 and 0.916 with all being above the widely used alpha of 0.70. Control Enablement has an alpha of 0.866, Digital Risk Management 0.887, Operational Efficiency in Banking 0.906, Process Integration 0.906, Service Delivery 0.893, and Smart Customer Access 0.916. The values demonstrate that the elements of each construct are used to quantify the same underlying concept in a high level of consistency. Third, composite reliability (CR) values give additional information about internal consistency. The CR values are all greater than 0.90, 0.910-0.934, which is very high reliability. Specifically, Control Enablement has a CR of 0.911, Digital Risk Management has 0.910, Operational Efficiency in Banking has 0.932, Process Integration has 0.930, Service Delivery has 0.921 and Smart Customer Access has 0.934. These results support the reliability of measuring the constructs and the adequacy of the latent variables being represented by the measures. Fourth, the average variance extracted (AVE) values demonstrate that there is sufficient convergent validity in all constructs since all the values are above the point of 0.50. Control Enablement has a 0.714 AVE value, Digital Risk Management has 0.718 AVE value, Operational Efficiency in Banking 0.685 AVE value, Process Integration 0.728 AVE value, Service Delivery 0.702 AVE value, and Smart Customer Access 0.745 AVE value. Such values state that both constructs explain over half of the variance of their indicators and this fact proves that the items converge well in their measurement of their respective latent variables. In general, the findings in Table 1 show that the measurement model is statistically valid. Each construct has high outer loadings, high reliability and acceptable convergent validity. Thus, the model can be used to pass to the next phase of the analysis, such as the discriminant validity test and structural model test.

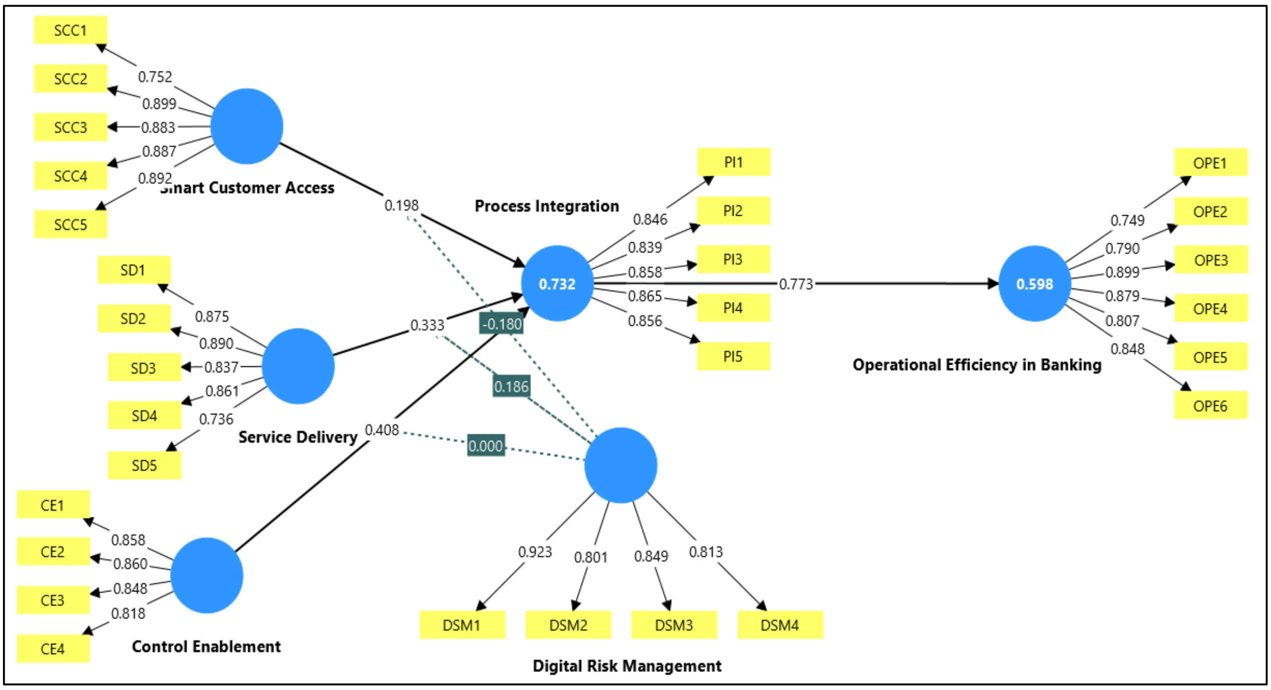

Figure 2: Measurement Model

Table 2:

Variable	Control Enablement	Digital Risk Management	Operational Efficiency in Banking	Process Integration	Service Delivery	Smart Customer Access	DRM x CE	DRM x SCA	DRM x SD
Control Enablement	0.845								
Digital Risk Management	0.084	0.847							
Operational Efficiency in Banking	0.761	0.165	0.828						
Process Integration	0.856	0.137	0.843	0.853					
Service Delivery	0.819	0.168	0.876	0.877	0.838				
Smart Customer Access	0.700	0.132	0.770	0.770	0.874	0.863			
Digital Risk Management x Control Enablement	0.052	0.106	0.066	0.070	0.081	0.091	1.000		
Digital Risk Management x Smart Customer Access	0.092	0.162	0.034	0.056	0.053	0.145	0.628	1.000	
Digital Risk Management x Service Delivery	0.058	0.053	0.158	0.105	0.076	0.049	0.745	0.732	1.000

The table shows the results of the discriminant validity of the study constructs. The diagonal values indicate the square root of the Average Variance Extracted (AVE) of all constructs and the off-diagonal values indicate the correlations among constructs. Fornell-Larcker criterion states that the discriminant validity is achieved when the diagonal of each construct is higher than the correlations with all other constructs. The findings demonstrate conflicting findings on discriminant validity. In the case of Digital Risk Management, the diagonal value (0.847) is greater than its correlations with all other constructs (ranging between 0.053 and 0.168). This shows that there is discriminant validity of this construct. Similarly, Smart Customer Access is associated with a higher value of 0.863 (the diagonal value) than most of its correlations, even though it has a correlation of 0.874 with Service Delivery, which is greater than the diagonal value. This indicates potential disadvantages and validity concern between these two constructs. In the case of Control Enablement, the diagonal value is 0.845, and the correlation with Process Integration is 0.856, which is larger than the diagonal value. This means that there is no complete support in the discriminant validity between the two constructs. On the same note, the Operational Efficiency in Banking has a diagonal of 0.828, but the correlations with Process Integration and Service Delivery are 0.843 and 0.876 respectively, which are higher than the diagonal. This means that Operational Efficiency in Banking is not different enough with respect to these constructs. Similarly, Process Integration gets a diagonal of 0.853, although its relationships with Control Enablement and Service Delivery are 0.856 and 0.877 respectively, indicating once again that it lacks discriminant validity. In the case of Service Delivery, the diagonal value is 0.838, whereas the correlations of Service Delivery with Operational Efficiency in Banking, Process Integration, and Smart Customer Access are 0.876, 0.877, and 0.874, which are higher than the diagonal value. This clearly indicates a substantial overlap between Service Delivery and these constructs. The interaction terms Digital Risk Management × Control Enablement, Digital Risk Management × Smart Customer Access, Digital Risk Management × Service Delivery have a diagonal value of 1.000, which are higher than their correlations with the rest of the constructs. This implies that the interaction terms have been obtained with discriminant validity. Nevertheless, this is not surprising since interaction terms are usually different in PLS-SEM, and they are likely to have high diagonal values. On the whole, the table shows that the discriminant validity is not completely met. Although Digital Risk Management and the terms of interaction meet the FornellLarcker condition, not all of the core constructs do. The most significant issues are found between Service Delivery and Process Integration, Service Delivery and Operational Efficiency in Banking, Service Delivery and Smart Customer Access and Control Enablement and Process Integration. These results indicate that there is a possibility of conceptual overlap in some of the constructs or some measurement items might lack adequate distinctiveness.

4. IMPLICATIONS OF THE STUDY

The results of this paper create some essential theoretical and practical implications in the digitalization of banking, namely, First, the study proves the idea that the use of IoT-enabled FinTech can improve the efficiency of operations in banking through critical technological and services-related aspects, namely, enablement of control, service delivery, and smart customer accessibility through digital channels.

Second, the positive and significant impact of control enablement on operational efficiency demonstrates that digital adoption should be seen as an internal operational phenomenon, capable of enhancing control systems and raising the quality of execution in banks, as well as reducing the number of errors and enhancing compliance levels, in general.

Third, the important role of service delivery on operational efficiency suggests that the effective and technology-enhanced service delivery is at the heart of the banking digital transformation success, not limited to technological modernization only, but to the redesign of the process of service delivery across branches, platforms, and intertwined systems.

Fourth, a positive impact of smart customer access implies that increasing the accessibility of banking services via connected digital channels can improve the overall result in terms of operational processes, as it can take the pressure off the manual banking system and distribute the operational resources more efficiently. By allowing the customers to complete transactions and communicate with services via intelligent and automated channels, the banks can relieve some of the pressure on the manual banking system and distribute the operational resources more efficiently.

Fifth, the findings regarding digital risk management have significant managerial implications of their own. Despite the fact that the direct impact of digital risk management on operational efficiency was not significant, the moderating effect of the latter suggests that effective risk controls can make digital service system design an important strategic requirement in digital banking settings.

Meanwhile, this result, combined with the negative moderating effect of digital risk management on between smart customer access and operational efficiency, indicated that more robust digital controls can at times negate the efficiency benefits of customer access systems. To practitioners this observation implies that there is a delicate balance between digital accessibility and protection against risks that need to be maintained in the design of customer access mechanisms.

Theoretically, this work enriches the literature by adding to the existing understanding of how the changes associated with the implementation of IoT-enabled FinTech can impact banking operations in a variety of dimensions instead of being a single undifferentiated construct. The presence of digital risk management as a moderator also enriches the body of existing literature on digital banking by demonstrating that the success of technology adoption will be dependent upon the organizational. The research also has policy and regulation implications in that as more banks move to IoT-based financial systems, regulators might need to promote a framework that facilitates innovation without exposing banks to digital risks that could impair their operations. Policies that promote the adoption of secure technologies, development of digital infrastructures, and the transformation of risk-sensitive services can serve to advance operational performance of banks without putting them at risk to digital threats.

Practically, the research indicates that bank management must consider IoT-enabled FinTech adoption as a strategic alliance program with technological implementation, operational redesign, and balanced customer access plan in tandem. As a result, the study offers a convenient roadmap to the organizations intending to transform their operations with digital transformation in banking.

5. CONCLUSIONS

The main purpose of the given research was to investigate how the implementation of IoT-enabled FinTech can impact the efficiency of operations within the banking environment, and the two main aspects, specifically, the immediate effect of smart customer access, service delivery, control enablement, and the moderating role played by digital risk management. Among these dimensions, control enablement proved to be the strongest predictor, which indicates the significance of digital control mechanisms, service delivery, and the provision of smart customer access to the operations of a bank as they increase operational efficiency in the banking industry. Service delivery and smart customer access also have a positive and strong impact, which indicates the operational value of fast, accurate, and technology-supported banking services. The research also analyzed the role of digital risk management as both a direct predictor and a moderator. The results showed that digital risk management does not have a significant direct impact on the operation efficiency in banks but, conversely, the role of digital risk management as a moderator is significant in two instances. First, the positive relationship between service delivery and operational effectiveness was enhanced by effective digital risk controls, and second. The contributions of the study to the literature include providing a more nuanced view of the operational effects of IoT-enabled FinTech adoption in banking by showing that not only the presence of technology changes operational efficiency; its operational outputs across specific dimensions of its adoption and organizational conditions influence the operation of risk management practices in banking.

In practical terms, the study recommends that the adoption of IoT-enabled FinTech by banks should be achieved in a balanced and well-coordinated fashion. Banks that want to enhance their efficiency, in terms of operational efficiency, should invest in digital systems that would allow them to work towards a greater control regime, a more effective service delivery, and smarter access mechanisms by customers. The study also has its limitations, despite its contribution, such as the fact that cross-sectional survey data were used, so the researchers could not make any causal conclusions over time, not all potentially relevant technological, organizational, and environmental factors were included in the model, other areas of financial services were not considered, or longitudinal designs did not capture the changing impacts of digital adoption on banking.

To sum up, this paper has shown that the application of IoT-enabled FinTech has a significant role in enhancing operational efficacy in banking, and that these relationships interact with the digital risk management practices of the bank to attain efficient, secure, and sustainable digital transformation.

REFERENCES

[1] Aguirre-Urreta, M. I., & Hu, J. (2019). Detecting common method bias: Performance of the Harman's single-factor test. *ACM SIGMIS Database: The DATABASE for Advances in Information Systems*, 50(2), 45-70.

[2] Al Naimat, A., & Liang, D. (2023). Substantial gains of renewable energy adoption and implementation in Maan, Jordan: A critical review. *Results in Engineering*, 101367.

[3] Ali, S., Yan, Q., Dilanchiev, A., Irfan, M., & Fahad, S. (2023). Modeling the economic viability and performance of solar home systems: A roadmap towards clean energy for environmental sustainability. *Environmental Science and Pollution Research*, 30(11), 30612-30631.

[4] Almashhadani, M., & Almashhadani, H. A. (2023). Translation integration in information systems and project management: A synergistic approach. *International Journal of Business and Management Invention*, 12(6), 298-304.

[5] Arora, M., & Sharma, R. L. (2023). Artificial intelligence and big data: Ontological and communicative perspectives in multi-sectoral scenarios of modern businesses. *foresight*, 25(1), 126-143.

[6] Bagga, S. K., Gera, S., & Haque, S. N. (2023). The mediating role of organizational culture: Transformational leadership and change management in virtual teams. *Asia Pacific Management Review*, 28(2), 120-131.

[7] Bahuguna, D., Kaur, J., & Singh, B. (2023). Artificial intelligence's integration in supply chain management: A comprehensive review. *European Economics Letter*, 13(3), 1512-1527.

[8] Cannas, V. G., Ciano, M. P., Saltalamacchia, M., & Secchi, R. (2023). Artificial intelligence in supply chain and operations management: A multiple case study research. *International Journal of Production Research*, 1-28.

[9] Chión, S. J., Charles, V., & Morales, J. (2020). The impact of organisational culture, organisational structure and technological infrastructure on process improvement through knowledge sharing. *Business Process Management Journal*, 26(6), 1443-1472.

[10] Dong, Z., Umar, M., Yousaf, U. B., & Muhammad, S. (2023). Determinants of central bank digital currency adoption: A study of 85 countries. *Journal of Economic Policy Reform*, 1-15.

[11] Dwivedi, Y. K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., Duan, Y., Dwivedi, R., Edwards, J., & Eirug, A. (2021). Artificial intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management*, 57, 101994.

[12] Ediagbonya, V., & Tioluwani, C. (2023). The role of fintech in driving financial inclusion in developing and emerging markets: Issues, challenges and prospects. *Technological Sustainability*, 2(1), 100-119.

[13] Ferreira, B., & Reis, J. (2023). Artificial intelligence in supply chain management: A systematic literature review and guidelines for future research. *International Joint Conference on Industrial Engineering and Operations Management*.

[14] Gichoya, J. W., Thomas, K., Celi, L. A., Safdar, N., Banerjee, I., Banja, J. D., Seyyed-Kalantari, L., Trivedi, H., & Purkayastha, S. (2023). AI pitfalls and what not to do: Mitigating bias in AI. *The British Journal of Radiology*, 96(1150), 20230023.

[15] Gomber, P., Kauffman, R. J., Parker, C., & Weber, B. W. (2018). On the fintech revolution: Interpreting the forces of innovation, disruption, and transformation in financial services. *Journal of Management Information Systems*, 35(1), 220-265.

[16] Hendriksen, C. (2023). AI for supply chain management: Disruptive innovation or innovative disruption? *Journal of Supply Chain Management*.

[17] Hunt, S. D., Sparkman Jr, R. D., & Wilcox, J. B. (1982). The pretest in survey research: Issues and preliminary findings. *Journal of Marketing Research*, 19(2), 269-273.

[18] Jalal, A., Al Mubarak, M., & Durani, F. (2023). Financial technology (fintech). In *Artificial Intelligence and Transforming Digital Marketing* (pp. 525-536). Springer.

[19] Jan, Z., Ahamed, F., Mayer, W., Patel, N., Grossmann, G., Stumptner, M., & Kuusk, A. (2023). Artificial intelligence for industry 4.0: Systematic review of applications, challenges, and opportunities. *Expert Systems with Applications*, 216, 119456.

[20] Johnson, D., Goodman, R., Patrinely, J., Stone, C., Zimmerman, E., Donald, R., Chang, S., Berkowitz, S., Finn, A., & Jahangir, E. (2023). Assessing the accuracy and reliability of AI-generated medical responses: An evaluation of the Chat-GPT model. *Research Square*.

[21] Karim, R. A., Sobhani, F. A., Rabiul, M. K., Lepee, N. J., Kabir, M. R., & Chowdhury, M. A. M. (2022). Linking fintech payment services and customer loyalty intention in the hospitality industry: The mediating role of customer experience and attitude. *Sustainability*, 14(24), 16481.

[22] Khan, A. A., Laghari, A. A., Rashid, M., Li, H., Javed, A. R., & Gadekallu, T. R. (2023). Artificial intelligence and blockchain technology for secure smart grid and power distribution automation: A state-of-the-art review. *Sustainable Energy Technologies and Assessments*, 57, 103282.

[23] Lahiya, A., & Mokodenseho, S. (2023). Examining the relationship between technological infrastructure and the quality of online education programs. *West Science Interdisciplinary Studies*, 1(02), 74-83.

[24] Madan, R., & Ashok, M. (2023). AI adoption and diffusion in public administration: A systematic literature review and future research agenda. *Government Information Quarterly*, 40(1), 101774.

[25] Nam, Y., & Lee, S. T. (2023). Behind the growth of FinTech in South Korea: Digital divide in the use of digital financial services. *Telematics and Informatics*, 81, 101995.

[26] Pandya, A., Waller, M., & Portnoy, J. M. (2022). The regulatory environment of telemedicine after COVID-19. *The Journal of Allergy and Clinical Immunology: In Practice*, 10(10), 2500-2505.

[27] Rehman, S. U., Al-Shaikh, M., Washington, P. B., Lee, E., Song, Z., Abu-AlSondos, I. A., Shehadeh, M., & Allahham, M. (2023). FinTech adoption in SMEs and bank credit supplies: A study on manufacturing SMEs. *Economies*, 11(8), 213.

[28] Richey Jr, R. G., Chowdhury, S., Davis-Sramek, B., Giannakis, M., & Dwivedi, Y. K. (2023). Artificial intelligence in logistics and supply chain management: A primer and roadmap for research. In *Vol. 44, pp. 532-549*. Wiley Online Library.

[29] Schultz, B. B. (1985). Levene's test for relative variation. *Systematic Zoology*, 34(4), 449-456.

[30] Sham, A. H., Aktas, K., Rizhinashvili, D., Kuklianov, D., Alisinanoglu, F., Ofodile, I., Ozcinar, C., & Anbarjafari, G. (2023). Ethical AI in facial expression analysis: Racial bias. *Signal, Image and Video Processing*, 17(2), 399-406.

[31] Shi, Y., Hall, N. G., & Cui, X. (2023). Work more tomorrow: Resolving present bias in project management. *Operations Research*, 71(1), 314-340.

[32] Singh, A., Kanaujia, A., Singh, V. K., & Vinuesa, R. (2023). Artificial intelligence for sustainable development goals: Bibliometric patterns and concept evolution trajectories. *Sustainable Development*.

[33] Stauder, M., Hiersche, K. J., & Hayes, S. M. (2023). Examining cross-sectional and longitudinal relationships between multidomain physical fitness metrics, education, and cognition in Black older adults. *Aging, Neuropsychology, and Cognition*, 1-15.

[34] Ulnicane, I., & Aden, A. (2023). Power and politics in framing bias in artificial intelligence policy. *Review of Policy Research*, 40(5), 665-687.

[35] Waqar, A., Othman, I., Shafiq, N., & Mansoor, M. S. (2023). Applications of AI in oil and gas projects towards sustainable development: A systematic literature review. *Artificial Intelligence Review*, 1-28.
[36] A. Caro, A. J. Mendoza, H. Noble, and K. A. Tanglao, "Influence of search engine optimization (SEO) towards purchase intention of online shoppers," Journal of Business Management Studies, vol. 6, pp. 279–285, 2024, doi: 10.32996/jbms.2024.6.3.24.
[37] R. Capitello, L. Agnoli, D. Begalli, and S. Codurri, "Social media strategies and corporate brand visibility in the wine industry," EuroMed Journal of Business, vol. 9, pp. 129–148, 2014, doi: 10.1108/EMJB-10-2013-0046.
[38] S. Acheampong, T. Pimonenko, and O. Lyulyov, "Sustainable marketing performance of banks in the digital economy: The role of customer relationship management," Virtual Economics, vol. 6, pp. 19–37, 2023, doi: 10.34021/ve.2023.06.01(2).