

Digital Transformation And Sustainable Banking: Enhancing Green Finance And Fintech Adoption In Pakistan's Online Banking Sector

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ABSTRACT

This study examines the role of digital transformation in enhancing green finance and Fintech adoption within Pakistan's online banking sector, focusing on how sustainable banking practices drive technological advancement and financial innovation. Using a quantitative research approach, data were collected from 493 respondents within the Pakistani banking sector, and statistical modelling techniques were applied to analyze the relationships between green finance, digital transformation, and Fintech adoption. The findings reveal that green finance significantly influences Fintech adoption, with digital transformation serving as a key mediator that links sustainability initiatives with advancements in financial technology. While customer trust enhances confidence in digital banking, the study highlights that technological efficiency, regulatory support, and cybersecurity play a more decisive role in influencing Fintech adoption. This study offers a novel contribution by integrating sustainability with digital banking transformation, providing insights for financial institutions, policymakers, and regulatory bodies on aligning green finance initiatives with emerging Fintech solutions. By embracing sustainability-driven banking models, financial institutions can enhance financial inclusion, reduce their environmental footprint, and modernize their services—ultimately contributing to a more resilient, technologically advanced, and sustainable financial ecosystem in Pakistan.

Keywords: Digital Transformation, Green Finance, Fintech Adoption, Sustainable Banking, Customer Trust.

Introduction

In recent years, the global financial system has undergone a major transformation with the rise of Green Finance and Financial Technology (Fintech). Climate change and growing awareness of environmental sustainability have become closely associated with green finance—an approach that channels funding into environmentally sustainable projects (Akomea-Frimpong et al., 2022). As climate change increasingly disrupts economic growth, banking industries worldwide are under pressure to embrace green finance, embedding principles of sustainability and resilience into their operations. These initiatives not only mitigate environmental damage but also drive technological innovations such as Fintech-enabled online payments, electronic wallets, and blockchain technologies, which are revolutionizing banking processes.

In Pakistan, the adoption of green finance is accelerating due to regulatory incentives and a growing environmentally conscious customer base. The integration of green finance with Fintech tools is expected to improve operational efficiency and enhance customer satisfaction. For example, Fintech platforms facilitate cashless transactions, reducing the negative environmental impact associated with traditional banking systems (Madaleno et al., 2022). However, customer trust remains a critical enabler in the implementation of such technologies—especially in online payment systems, as highlighted by Huang (2022). The convergence of green finance, Fintech adoption, and customer trust thus presents a compelling research focus that addresses both environmental and technological dimensions.

Beyond operational benefits, the alignment of green finance with digital transformation supports global sustainability agendas, including the United Nations Sustainable Development Goals (SDGs). This alignment is especially relevant for developing economies like Pakistan, where financial institutions play a dual role: fostering economic growth and promoting environmental stewardship. The adoption of sustainability practices—also known as green adoption—within banks contributes to their long-term viability by minimizing environmental risks and optimizing resource use (Agrawal et al., 2024).

Despite this potential, Pakistan's banking sector faces numerous challenges in fully leveraging green finance and Fintech innovations. These include regulatory uncertainty, limited digital infrastructure, and low awareness of sustainable finance practices (Li & Umair, 2023). While Fintech platforms can reduce the carbon footprint of banking operations, their successful implementation depends on a strong digital foundation and customer readiness—areas where Pakistan continues to lag. Additionally, concerns about data privacy, cybersecurity, and the perceived reliability of Fintech solutions undermine customer trust, which is essential for borrowing, saving, or investing through digital platforms (F. Wang et al., 2021). This mismatch between the potential of these innovations and their current usability creates a barrier to sustained competitive advantage.

Moreover, the lack of integration between green finance and Fintech adoption, as well as the underexplored roles of mediating factors such as customer trust and digitalization, limits the understanding of how these elements can complement each other in building a sustainable banking sector in Pakistan. While customer trust has been recognized in the literature as a key enabler of Fintech adoption, its moderating

effect on the relationship between green finance and Fintech remains insufficiently studied. In Pakistan, skepticism towards digital platforms is common, with major concerns focused on cybersecurity, data privacy, and the reliability of technological innovations.

Previous studies have predominantly focused on technological and regulatory drivers of Fintech adoption, often neglecting the relational aspect of customer trust as a bridge between financial technology and sustainable banking (Zhang et al., 2021). Similarly, while digital transformation has been examined as a strategic tool for incorporating green finance in developed economies, its application in Pakistan's banking context remains underexplored. This fragmented analysis creates gaps in understanding how customer trust and digital advancement simultaneously affect green finance and Fintech adoption, limiting the development of actionable strategies for emerging economies.

In response, this study seeks to address key theoretical, practical, and policy questions regarding green finance, Fintech adoption, customer trust, digital initiatives, and sustainability in Pakistan's banking sector. Theoretically, it extends current literature by integrating these interrelated concepts rather than treating them in isolation. While green finance and Fintech are well-established topics globally, limited research has explored their combined impact on banking sustainability in emerging economies like Pakistan.

To fill this gap, the study investigates the mediating roles of digital transformation and customer trust in explaining how green finance influences Fintech adoption. In doing so, it contributes to global academic discourse on sustainability, innovation, and financial accessibility. It also offers insights into how banks in resource-constrained environments can align themselves with global sustainability objectives, such as those promoted by the United Nations Environment Program.

From an applied perspective, the study provides empirical evidence relevant to Pakistan's banking sector, which is grappling with digitalization, sustainability challenges, and growing competition. It highlights the potential for green finance, supported by Fintech innovations, to lower operational costs, enhance environmental performance, and improve customer satisfaction. Technologies such as blockchain, digital payment systems, and smart contracts are shown to reduce the carbon emissions typically associated with traditional banking operations (Alharbi et al., 2023). Moreover, the study emphasizes the critical role of customer trust in encouraging the adoption of digital financial platforms—particularly important in a country where trust in financial institutions is often weakened by regulatory uncertainty and security concerns.

By identifying the factors that influence trust, and clarifying how green finance and Fintech adoption interact, this research offers valuable guidance to banks aiming to enhance customer engagement, loyalty, and long-term sustainability.

Literature Review

Unified Theory of Acceptance and Use of Technology (UTAUT)

The Unified Theory of Acceptance and Use of Technology (UTAUT) is a strong model that can be used to explain the adoption of Fintech and other technologies. In tighter coupled systems, equal or greater than outsider standpoint, performance

expectancy, effort expectancy influence technology acceptance as well as social influence and facilitating conditions according to the theory developed by Lv et al. (2021). In research, new to the ideas like green finance, customer trust among others have called for the expansion of UTAUT in areas important like banking where digital transformation is vital, Xu et al. (2023). The theory supports the study objectives, specifically investigating Fintech adoption motivated by green finance and trust since the theory explains users' perception and acceptance of new technologies.

Fintech adoption in banking is aligned to green finance which entails all or any of the financial activities that support environmental sustainability. In this light, during the advancement of green technologies and arrangements, in which banks invest, the necessary framework for Fintech integration also develops. Green finance policies encourage the use of online payment systems amongst the country's banks to perform sustainably. For instance, Yang, (2021) revealed that green finance plays a crucial role in the other types of cleaners, digital platforms. This corresponds to the first research question where green finance's impact is discussed focusing on the adoption of Fintech among Pakistani banks. Building customer trust is fundamental to the achievement of financial technologies. All the green finance measures including reporting and investment in environmentally friendly products boost customers' perception of banking services.

The study of M. Li et al. (2021) found out that when more and more banks support green initiatives, the customers tend to trust such banks more as these are socially responsible, make extra efforts towards supporting ecology. The implications of green finance integration in the Pakistani banking sector, as discussed by X. Wang & Wang, (2021), make them acceptable to stakeholders as the banks' image is positively influenced this addresses the study's second purpose. Trust acts as a mediator in the successful implementation of Fintech solutions. According to M. Li et al. (2021), the probability of customers adopting a digital payment system is highly likely if customers place their trust in such a system. Trust lowers the perceived risk on online payments, particularly important in the Pakistani environment because digital literacy is unstandardized.

A major achievement of green finance initiatives in banking is digital transformation. Currently, the adoption of green technologies puts pressure on banks to leverage and adopt new Fintech solutions. Rasoulinezhad & Taghizadeh-Hesary, (2022) have identified that green finance has been instrumental in digital change where banks embraced digital change to meet sustainable development goals. Based on this objective, green finance can be directed further towards digital transformation in the banking industry of Pakistan. Fintech adoption is significantly affected by green transformation depicting organizational changes for sustainability. According to K.-H. Wang et al. (2022), the green transiting banking sector recognizes some digital products that result to low emissions for instance, online payment structures. This adoption is still in line with our customer's environmental conservation needs in banking services thus achieving the fifth objective through highlighting both the green transformation and Fintech.

Green Finance

"Green finance refers to financial investments and initiatives that promote environmentally sustainable projects and practices, aimed at supporting the transition to a low-carbon economy while addressing environmental challenges such as climate change and resource depletion." Green finance has become a crucial tool in mitigating the challenges facing the world today including climate change and use of natural resources. From the analysis of Meo & Abd Karim, (2022), it defines it as any investment flowing towards sustainable development programs, power from renewable sources, and environmental conservation undertakings. Its importance has emerged in the developing countries such as Pakistan due to the increasing rates of industrialization along with the urbanization effects on environment. The banking sector in particular plays a central role of embedding green financial products and services within the existing system Akomea-Frimpong et al. (2022). The enhancement of capital for green projects enables financial institutions to respond to the global commitments on sustainable development.

The commitment of green finance in the emerging economies has been facilitates by regulatory measures and international cooperation. H. Huang et al. (2022), call special attention to the impact of the national and the global policies, including the Paris Agreement, on the reformation of the fiscal institutions in terms of green finance. These frameworks offer the banks guideline that will prepare them to transform towards the sustainable operation. Moreover, the growing intention of the consumer to go green has resulted in banking sector giving increased importance to go green as a strategic importance. But, as has been noted in the paper, there is more to green finance adoption than just regulation and market forces.

Green finance needs customer trust to achieve its goal in organization since customers are sensitive to environmental programs and policies. Zhang et al. (2021) have pointed out that another factor that adds trust in customers is transparency accountability. Given the fact there are trust deficiencies when it comes to adopting changes in the financial products most Pakistan's new generation banks green finance becomes a chance to restore consumer's confidence. The reporting of financed projects and the communication of green-wash free benefits will in the environmental field develop consumer confidence and brand loyalty with the current and potential of clients.

It has also further extended the scale of green finance by offering new financial products or services that originate from the innovative solutions of digital transformation. Research conducted by K.-H. Wang et al. (2022) show that Fintech has nudged green finance into the customer interface via internet and mobile banking strategies. These technologies facilitate the acquisition of green loans as well as investing in green financial instruments, and therefore fills the gap between the financial firms and consumers. Green finance's innovation in financial digital technologies have a dramatic influence on the banking sector.

Digital Transformation

"Digital transformation refers to the integration of digital technologies into all areas of a business, fundamentally changing how operations are conducted, how value is delivered to customers, and how businesses adapt to evolving market demands and

opportunities." The banking sector, in particular, has benefited from the implementation of digital transformation as a key enabler of change and advancement. DT involves the use of digital technologies to redesign business transactions creating new forms of value propositions between business and customers (Ali et al., 2023). Consequently, in the context of the banking sector, the process of digital transformation is linked to the implementation of Internet banking, AI, the application of Blockchain, and cloud computing to tighten production processes and improve customers' experience (Ahmed et al., 2022). Digital transformation has become the new model of competitive advantage, a key differentiator of operations in the new economy, and a direct result of the increased technological evolution and altering customer demands all over the world.

The effect of digital change in banking is one of the aspects that has been greatly improved when it comes to customer interactions. Another study by Malik et al. (2023) reveals how through digital banking, banking platforms, mobile applications, and chatbots have brought a new paramount to customer interaction through convenience, speed, and quality to banking. In Pakistan, where internet and smartphone users are increasing day by day, digital transformation has helped banks to expand into the lower artery area resulting into financial inclusion (Hussain et al., 2022). That this transformation is anchored on agility, value creation, and the design of customer-centric processes serve as an assurance that the fourth Industrial revolution holds massive potential for banking services.

Another major area that has benefited from the efficiency in banks is operation efficiency through digital transformation. In their research study, Raza et al. (2023), points out that emerging back-office automation tools such as RPA and AI have helped to cut costs and decrease the rate of errors. These technologies have been growing popular among the banks primarily in Pakistan to effectively coordinate and manage their resources as well as to improve their various decision-making exercises, Ali et al., 2022). A look at how digital tools have been incorporated in the banking sector demonstrates the promise of such systems as vehicles of change, competitiveness, and dynamism that are all needed in a fast-developing field.

Scholars have recently shown a lot of interest on the contribution of digital transformation to risk management. Reflecting on the findings of Khan et al. (2023), the application of big data analytics and machine learning reduces risk identification, assessment and management risk in banks. These technologies avail timely information on the trends and developments in the market, consumers, as well as threats, for which banks can make efficient decisions. In Pakistan, the banking sector has been struggling with issues like fraud and Non-Performing Loans, where digital transformation has provided new techniques to bowl the country's economy out risk management more effectively.

Customer Trust

"Customer trust refers to the confidence and belief customers have in a company's reliability, integrity, and ability to deliver on its promises, ensuring consistent quality and safeguarding their interests." Customer trust plays a significant role in developing long-term relationships between them and banks as a result. It is getting to be customers' trust and confidence in terms of reliability, integrity, and competence of

financial institutions to deliver anticipated expectations. Of all industries, trust is especially important in banking given that it deals with financial services that are by nature, intangible: those who use the services have to be confident that their money and their information will be well handled and within the right standards. Customer trust has therefore even more importance in the current society where more and more services have gone digital, especially in banks whereby perceived risk determines the behavioral intentions.

This study focuses on the significance of understanding that the degree of transparency as well the level of communication needs valuable attention, when it comes to trust among banking customers. According to Qambrani, (2024), the intention and understanding of policy, fee, and procedure disclosure by banks is believed to enhance the customers' confidence in banks. In Pakistan, where consumers' trust in financial organizations tend to be low, transparency of communication has been identified as a trust-building activity. This relationship between transparency and trust gets enhanced when the banks bring in ethical faces and are willing to account for it.

Through a lens of customer trust, the digital transformation of the banking sector has been found to have impacted customer trust immensely. As Hayat, (2023) pointed out, secure and ease to use digital platforms makes users develop trust as their financial transaction and data are protected. Notice, encryption, multi-factor, and real-time notifications help to create trust as it helps to reduce the potential threats that are related to Cybersecurity. In Pakistan where the use of online payment solutions and online banking is gradually being felt these measures are vital to foster Fintech.

Customer trust is also a dependent variable of service quality and reliability. Ashraf et al. (2022) research show that it is better for customers to trust banks that have effective digital and physical interfaces. Punctuality in trades, proper book keeping and quick problem solving are all foundational factors of trust. Since in the context of Pakistani banking industry even an operational mistake can result in immense customer dissatisfaction, the institutions that manage to develop the service dominant logic are likely to gain customer loyalty.

Also, the extent of green financing programs has given color to the extent of the customer trust regarding the banking sector. According to Hayat & Hameed, (2024), to the extent that the bank takes environmental measures into consideration, the bank's ethical and social image is improved alongside the general customer trust. In Pakistan, where awareness concerning sustainability is gradually rising, banks that integrate GF into their operations do not only conform with global advocacy, but also submit to increased credibility and authenticity among consumers who are sensitive to the society.

Fintech Adoption

Fintech adoption refers to the acceptance and integration of financial technologies, such as digital payment systems, blockchain, and online banking platforms, by individuals, businesses, and financial institutions to enhance financial services and improve efficiency." Fintech adoption means the extent to which customers adopt and use financial technologies to perform some financial transactions or banking services. It has increasingly attracted researchers' attention over the past years, thanks to

technology and shifting consumer preferences. In the case of Pakistan banking industry, the Fintech constructs which include mobile banking, digital wallets and online payments are liberalizing much faster. According to Zaidi & Shah, (2023), the main customer motives, which stem from the availability and cost-effectiveness of these technological tools, is primarily accountable for their patronage. The most influential factors therefore, that has led to the adoption of Fintech are the increase in smart phone and internet use. According to Qaiser & Fahad, (2024), the use of mobile-based financial services has changed the nature and style of banked customers who can now perform transactions at any time and place.

In the context of Pakistan where mobile phone usage specifically smartphones are steadily increasing Fintech solution is facilitating interaction of financial inclusion with the conventional banking and the unbanked population. The phenomenon has been greatly supported by the increased availability of cheap data plans. Another influencing factor is trust that is needed in the provision of Fintech services. This, according to Karim et al. (2022), influences customers' decision on the extent to which they engage with digital financial platforms due to the security of those platforms. This is true more so for Pakistan where security issues and the likelihood of being ripped off discourages individuals from joining the digital economy. Saleem, (2021) stated that self-labeled secure communication and transaction platform can effectively enhance trust and develop corporate brand for the use of banks and Fintech firms. Making use of specific features like encryption, biometric check, or real-time fraud detection mixes in a major part in helping to eradicate trust gaps.

The second important driver impacting the use of Fintech includes customer experience. A number of studies including Saleem, (2021) find out that, friendly interfaces, easy site navigation, and efficient transactions induce satisfaction and hence the readiness by customers to use the digital platforms. In Pakistan with the digital literacy levels differing among humans, easy to use designs and regional solutions are pivotal for making products more accessible and acceptable. The ability to work towards adapting the Fintech technologies to recognize regional languages and culture puts the creation of platforms on a stronger ground to be embraced.

Green finance is relatively new dimension that has gained attention which defines the adoption of Fintech. Ahmed et al. (2024) argued that incorporating green finance into the digital financial platforms provide the benefits to attract eco-friendly consumer segment. As Mike and Tariq pointed out in the case of Pakistan that SI is slowly entering, Fintech solutions that refer to green behaviours in the financial sector like paperless systems and carbon will likely appeal to a wider community. That being the case, this convergence of sustainability and technology depicts the dynamism of Fintech adoption.

Hypotheses Development:

The combination of green finance and Fintech adoption is also supported by the government and regulators. It has also become possible to identify policies that support the motivation for green finance involving Fintech platforms as confirmed by Azeem et al. (2023). The adoption of Fintech in the current playing field of Pakistan's banking industry greatly depends on the creation of such frameworks, as these pave way for a sustainable environment with Pakistan's sustainable

environment. In this context, it is essential to focus on how organizations support customer needs, because business and innovation strategies of Digital Transformation and Green Finance bear great significance in determining the current customer preference. Hence, as supported by extensive literature, it is hypothesized that:

H1: There is a significantly and positive influence of green finance on fintech adoption (positive direction).

Various green finance initiatives increase the confidence-building potential of the digital platforms. Riaz et al. (2023) mention that the green finance product is more trusted by customers when it is combined with appropriate and easy to use Fintech platforms. These platforms also increase the level of awareness on sustainability through timely information on customers' contribution to this noble course. Integrated into this context in Pakistan, leveraging digital channels in banking services is becoming an important factor in winning customer confidence towards green Practices.

In addition, integration of green finance with CSR measures raises its impact on trust among people. In this regard, Rana et al. (2023) noted that customers are more likely to develop trust in the participating banks mainly due to their regional sustainability contributions. CSR activities in Pakistan are still emerging, and green finance assists banks in achieving the goal of operating as 'responsible' organizations that obtain customers with trust in mind. Based on this understanding, it is hypothesized that:

H2: There is a significantly and positive influence of green finance on customer trust (positive direction).

It was established that the application of trust is more sensitive in the case of online payment systems. Hayat, (2023) note that in the context of a bank's Fintech platform, customers are more likely to transact due to risks perceived to be lower and convenience levels to be higher. As observed in Pakistan, trust customers have in the banking institutions increases the mobile payment system adoption rate among customers in the country.

In addition, the analysis shows that trust also moderates the relationship between GF activities and Fintech uptake. The incorporation of green finance in Fintech create trust between these institutions and the customers regarding ethical and sustainability standards. Conclusively in Pakistan where Environmental concerns are turning into a priority, such trust-based relations enhance Fintech solutions. Therefore, it is hypothesized that:

H3: There is a significantly and positive influence of customer trust on fintech adoption (positive direction).

Digital transformation is most crucial when it comes to supporting green finance in the context of Fintech platforms. Sources including mobile applications, online banking platforms, and decision-making algorithms are the necessary amenities that are needed to define and execute green finance plans. This is especially the case in Pakistan, where banks are using digital platforms to get to the base of the pyramid and offer sustainable financial solutions.

However, green finance may require the engagement of the banking sector, the authority as well as Fintech companies for the development of an efficient digital environment. According to Murad & Ahmad, (2023), digital transformation helps improve efficiency in green finance and change the customer perspective through

increasing trust and efficiency results. This synergy leads to innovative solutions and allows banks of Pakistan to integrate their activity with reference to sustainable practices across the globe. Thus, it is hypothesized that:

H4: There is a significantly and positive influence of green finance on digital transformation (positive direction).

Moreover, customers have a highly sensitive factor determining the connection between green transformation and Fintech. According to Ahmed et al. (2024), as green transformation takes root in banks, environmentally sensitive customers are inclined to adopting digital payments. The integration of these platforms toward sustainability values improves customer satisfaction, trust and uptake of Fintech in the Pakistani banking context.

In return, such a relation is supported by regulatory frameworks as well as governmental incentives. Ahmed et al. (2024) explain that while the green shifts of various policies supplement the government's intentions to support green transformation financial sectors rely on Fintech. In Pakistan, these initiatives enable banks to attain enough backing to streamline the sustainable practices with advanced technologies thereby rerouting Fintech's course. Thus, it is hypothesized that:

H5: There is a significantly and positive influence of digital transformation on fintech adoption (positive direction).

However, trust reduces perceived risk in digital contexts, As a result. According to research conducted by Ahmed et al. (2024), customer perceptions of Fintech platforms as being secure and reliable are a direct outcome of their level of trust in their bank's green finance activities. The analysis of Pakistani Fintech is also based on the understanding of the state where cybersecurity issues become a primary concern and can slow down the Fintech market development in case of the lack of trust.

Another issue contributing to the intermediary of trust is that, due to complete transparency and accountability, green finance is more accruing. Customers feel safe when they can monitor the effects of their decisions on the environment, a function that can be mediated by Fintech applications. Such a combined focus on green finance and Fintech enhances the trust-based model in facilitating the extensive uptake of the concept. Thus, it is hypothesized that:

H6: Customer trust significantly and positively mediates the relationship between green finance and Fintech adoption (positive direction).

The mediating role of digital transformation is more applicable in developing countries such as Pakistan where facility of conventional banking is restricted. This gap is closed by Digital technologies since they offer Inclusive digital finance solutions in Individual's communities' financial practices as per sustainable development plans. This alignment allows the ease of moving from green finance to Fintech to create a complete and sustainable financial society. Thus, it is hypothesized that:

H7: Digital transformation significantly and positively mediates the relationship between green finance and Fintech adoption (positive direction).

Also, green adoption reduces risk in the banking sector as a measure of risk management. According to Marwat et al. (2025), the effective practices that suggest the banks adopting sustainability are as follows: It helps to address the risk arising from the environmental and regulatory changes. It supports the longevity and stability

because it guarantees customers compliance to the environmental laws and regulations, customer trust is key for any business to survive.

The adoption of green is further boosted by the increased development in the digital technologies. According to Rana et al. (2023), the importance of digital solutions to the management of green strategies by banks cannot be underestimated. In Pakistan, where the COVID-19 crisis is changing the financial sector through digital transformation, the concept of green adoption through digital platforms has also opened new prospects for sustainable banking. Thus, it is hypothesized that:

H8: There is a significantly and positive influence of fintech adoption on banking sustainability (positive direction).

The conceptual model guiding this study is illustrated in Figure 1 (adapted from Lv et al., 2021).

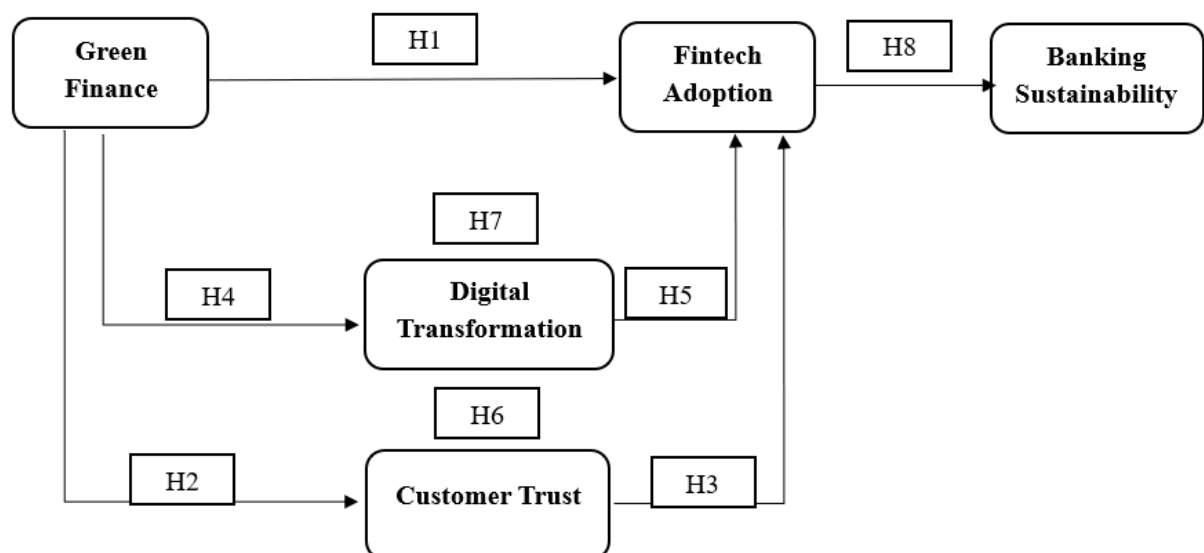


Figure 1: Theoretical Framework adapted from the Unified Theory of Acceptance and Use of Technology (UTAUT). Source: Adapted from Lv et al. (2021).

Methodology

This study aimed to examine the implications of Digital Transformation (DIG) in promoting Green Finance (GF), Fintech integration, and banking sustainability within the context of Pakistan's online banking system. A descriptive and explanatory research design was adopted, utilizing survey questionnaires for data collection. The dual approach—both descriptive and explanatory—was selected to effectively identify and analyze the impact of digital transformation on sustainable banking, particularly in relation to green finance and Fintech adoption (Agarwal & Gao, 2016). The study focused on consumers using online banking services in Pakistan. These users were considered critical stakeholders, as their feedback influences banks' decisions regarding the implementation of digital transformation initiatives and sustainability strategies (Khan, 2021).

The target population comprised various online banks operating in Pakistan, including both public and private sector institutions. From this population, 493 participants were

surveyed. The sample size was determined based on established guidelines for survey-based research and was considered adequate for ensuring reliability and generalizability of the findings, given the study's time and resource constraints (Sekaran & Bougie, 2016).

Variables and Constructs

In this study, variables were defined as the key constructs under investigation, which include independent, dependent, and mediating variables. These were measured using established scales from previous literature (Sekaran & Bougie, 2016; Lee, 2018). The primary variables are:

Green Finance (4 items): Refers to the provision of financial resources for projects or processes that are environmentally sustainable and aligned with future ecological goals.

Digital Transformation (3 items): Represents the integration of advanced digital technologies into the operations of the banking sector, fundamentally changing how value is created, delivered, and perceived in financial services.

Customer Trust (3 items): Measures the level of consumer confidence in digital banking platforms and the financial institutions providing them.

Fintech Adoption (3 items): Captures the extent to which banks integrate financial technologies into their services to improve efficiency and customer experience.

Banking Sustainability (5 items): Defined as the long-term ability of banks to maintain economic efficiency while also considering social and environmental dimensions in their operations.

By examining the relationships among these constructs, the study seeks to provide empirical insights into how digital transformation and customer trust mediate the impact of green finance on Fintech adoption and banking sustainability in Pakistan's evolving financial landscape.

Analysis

Outer Loadings

Table 1: Outer Loadings

Constructs	Original sample (O)
BS1 <- Banking Sustainability	0.817
BS2 <- Banking Sustainability	0.808
BS3 <- Banking Sustainability	0.785
BS4 <- Banking Sustainability	0.723
CT1 <- Customer Trust	0.852
CT2 <- Customer Trust	0.783
CT3 <- Customer Trust	0.822
DT1 <- Digital Transformation	0.694

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DT2 <- Digital Transformation	0.752
DT3 <- Digital Transformation	0.787
DT4 <- Digital Transformation	0.768
DT5 <- Digital Transformation	0.799
DT6 <- Digital Transformation	0.636
FA1 <- Fintech Adoption	0.837
FA2 <- Fintech Adoption	0.808
FA3 <- Fintech Adoption	0.811
GF1 <- Green Finance	0.793
GF2 <- Green Finance	0.855
GF3 <- Green Finance	0.797
GF4 <- Green Finance	0.720

Outer loadings assess the reliability and validity of indicators within each construct (see Table 1). Banking Sustainability (BS): Loadings range from 0.723 to 0.817, indicating strong reliability. Even the lowest value (0.723 for BS4) exceeds the acceptable threshold of 0.6, confirming that all indicators contribute meaningfully. Customer Trust (CT): Loadings fall between 0.783 and 0.852, with CT1 being the strongest indicator of customer trust. Digital Transformation (DT): Loadings range from 0.636 to 0.799, with DT6 (0.636) being the lowest. While still acceptable, this suggests a slightly weaker contribution compared to other indicators. Fintech Adoption (FA): Loadings consistently range from 0.808 to 0.837, reflecting high reliability. Green Finance (GF): Loadings range from 0.720 to 0.855, with GF2 having the highest impact on the construct. Overall, all outer loadings exceed the minimum threshold, confirming that each indicator significantly contributes to its respective construct.

Average Variance Extracted

Table 2: Average Variance Extracted

	Original sample (O)	P-Values
Banking Sustainability	0.615	0.000
Customer Trust	0.671	0.000
Digital Transformation	0.550	0.000
Fintech Adoption	0.670	0.000

Green Finance	0.628	0.000
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The AVE values measure how much variance is captured by each construct (see Table 2). Customer Trust (0.671) and Fintech Adoption (0.670) demonstrate strong convergent validity, exceeding the recommended threshold of 0.5. Green Finance (0.628) and Banking Sustainability (0.615) also meet validity requirements. Digital Transformation (0.550) has the lowest AVE but remains above the acceptable 0.5 level, suggesting that while adequate, there is room for improvement. Overall, all constructs meet the validity requirements, confirming they reliably measure the intended variables.

Reliability

Table 3: Reliability

	rho_c	rho_a	Cronbach Alpha
Banking Sustainability	0.865	0.797	0.791
Customer Trust	0.860	0.756	0.755
Digital Transformation	0.879	0.841	0.835
Fintech Adoption	0.859	0.754	0.754
Green Finance	0.871	0.801	0.801

Reliability is measured using composite reliability (rho_c), alternative reliability (rho_a), and Cronbach's Alpha (see Table 3). Composite reliability values range from 0.859 to 0.879, indicating strong internal consistency. Banking Sustainability (0.865), Customer Trust (0.860), and Digital Transformation (0.879) demonstrate particularly high reliability. Cronbach's Alpha values are all above the 0.7 threshold, confirming internal consistency. Digital Transformation has the highest alpha (0.835), while Customer Trust (0.755) and Fintech Adoption (0.754) have slightly lower but still acceptable values. These results confirm that the questionnaire items effectively measure their respective constructs.

Effect Size and Significance of Constructs in the Model

Table 4: Effect Size and Significance of Constructs in the Model

Constructs	F-Square	P-Values
Customer Trust -> Fintech Adoption	0.020	0.093

Digital Transformation -> Fintech Adoption	0.176	0.000
Fintech Adoption -> Banking Sustainability	1.296	0.000
Green Finance -> Customer Trust	0.973	0.000
Green Finance -> Digital Transformation	1.443	0.000
Green Finance -> Fintech Adoption	0.160	0.001

Fintech Adoption significantly impacts Banking Sustainability ($F^2 = 1.296$, $p = 0.000$), indicating a strong relationship (see Table 4). Green Finance has a major influence on Digital Transformation ($F^2 = 1.443$, $p = 0.000$), highlighting its critical role in driving banking digitalization. Green Finance also impacts Customer Trust ($F^2 = 0.973$, $p = 0.000$) and Fintech Adoption ($F^2 = 0.160$, $p = 0.001$), suggesting sustainability initiatives play a role in shaping fintech adoption and trust. Digital Transformation has a moderate effect on Fintech Adoption ($F^2 = 0.176$, $p = 0.000$), meaning advancements in digital technology contribute to fintech acceptance. Customer Trust has a weak, non-significant effect on Fintech Adoption ($F^2 = 0.020$, $p = 0.093$), indicating that trust alone does not strongly drive fintech usage.

Heterotrait-monotrait ratio (HTMT)

Table 5: Heterotrait-monotrait ratio (HTMT)

	Original sample (O)
Customer Trust <-> Banking Sustainability	0.927
Digital Transformation <-> Banking Sustainability	0.975
Digital Transformation <-> Customer Trust	1.031
Fintech Adoption <-> Banking Sustainability	0.969
Fintech Adoption <-> Customer Trust	0.972
Fintech Adoption <-> Digital Transformation	1.019

Green Finance <-> Banking Sustainability	0.952
Green Finance <-> Customer Trust	0.898
Green Finance <-> Digital Transformation	0.934
Green Finance <-> Fintech Adoption	0.992

HTMT measures discriminant validity by assessing correlations between constructs (see Table 5). Most values are below the 0.9 threshold, confirming good discriminant validity. However, three construct pairs exceed this limit: Digital Transformation – Customer Trust (1.031), Fintech Adoption – Digital Transformation (1.019), and Fintech Adoption – Customer Trust (0.972). These values suggest potential multicollinearity, meaning these constructs may be measuring overlapping aspects. Green Finance – Banking Sustainability (0.952) and Fintech Adoption – Banking Sustainability (0.969) are close to the cutoff but remain acceptable. Further analysis, such as Variance Inflation Factors (VIF), may be necessary to confirm discriminant validity.

Path Coefficients

Table 6: Path Coefficients

	Original sample (O)	P-Values	Hypotheses Results
Customer Trust -> Fintech Adoption	0.133	0.000	Accepted
Digital Transformation -> Fintech Adoption	0.442	0.000	Accepted
Fintech Adoption -> Banking Sustainability	0.751	0.000	Accepted
Green Finance -> Customer Trust	0.702	0.000	Accepted
Green Finance -> Digital Transformation	0.769	0.000	Accepted
Green Finance -> Fintech Adoption	0.339	0.000	Accepted

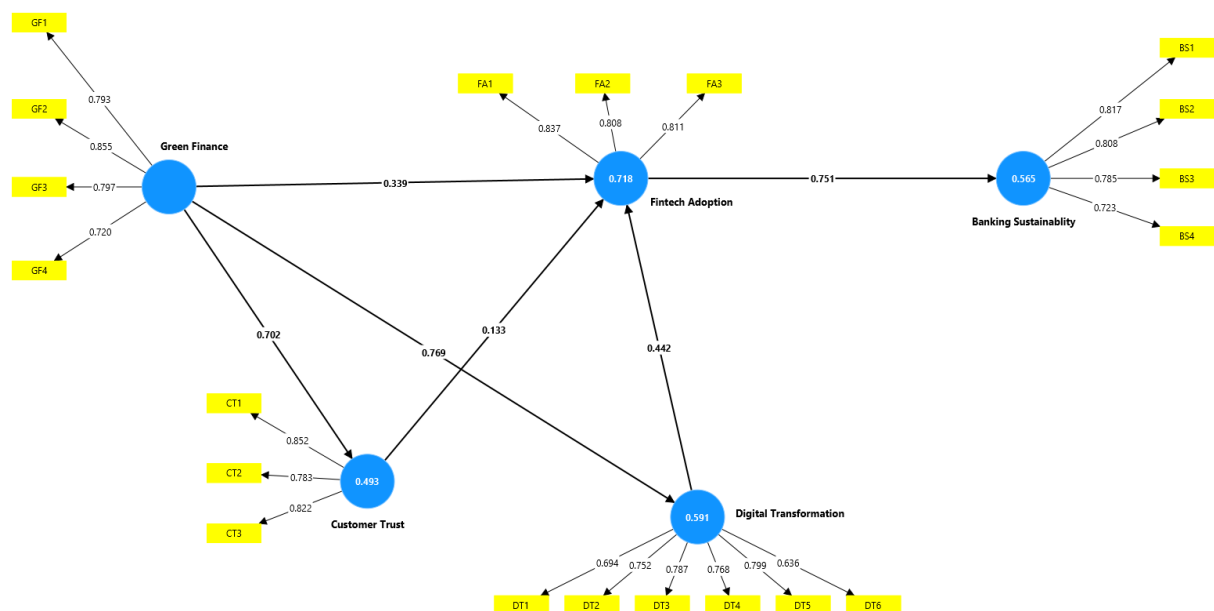
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Path coefficients measure the strength and direction of relationships between constructs (see Table 6). Fintech Adoption → Banking Sustainability (0.751, $p = 0.000$): Fintech adoption significantly enhances banking sustainability. Green Finance → Digital Transformation (0.769, $p = 0.000$) and Green Finance → Customer Trust (0.702, $p = 0.000$): Green finance initiatives drive digital transformation and boost customer trust. Digital Transformation → Fintech Adoption (0.442, $p = 0.000$): Digital innovation plays a key role in fintech adoption. Green Finance → Fintech Adoption (0.339, $p = 0.000$): Sustainable financial practices contribute to fintech growth. Customer Trust → Fintech Adoption (0.133, $p = 0.000$): Trust has a weaker influence on fintech adoption. These results emphasize that green finance and digital transformation are the main drivers of fintech adoption and banking sustainability, while customer trust plays a smaller role in fintech adoption.

Conclusion

This study provides a comprehensive analysis of how green finance influences the adoption of Fintech, digital transformation, customer trust, and overall banking sustainability within Pakistan's banking sector. The findings underscore that green finance not only supports environmental responsibility but also acts as a catalyst for technological and financial innovation. The integration of green financial policies encourages banks to adopt Fintech solutions—such as mobile banking, online payments, and digital lending—to create a more modern and inclusive financial landscape.

The results demonstrate that green finance enhances customer trust by portraying financial institutions as ethical and sustainable entities. However, trust alone is not sufficient to drive Fintech adoption. Consumers also demand convenience, security, and robust regulatory protections. This highlights the need for banks to strike a balance between their sustainability goals and technological capabilities to ensure seamless, accessible, and secure financial services.

Digital transformation emerges as a key mediator in the relationship between green

finance and Fintech adoption. Sustainable banks are investing in advanced technologies such as artificial intelligence and blockchain-based security systems to encourage the use of digital financial services. This aligns with global trends, where financial institutions leverage green finance not only as an environmental initiative but also as a strategy to improve operational efficiency and technological integration. The study further reveals that greater Fintech adoption contributes to enhanced banking sustainability by reducing reliance on paper-based transactions, lowering energy consumption, and promoting environmentally friendly practices. Thus, for the financial industry to be both sustainable and innovative, digitalization and environmental responsibility must be integrated.

Moreover, the findings indicate that while customer trust boosts confidence in using banking services, Fintech adoption is more strongly influenced by a bank's technological infrastructure and regulatory environment. Providing user-friendly platforms, cybersecurity safeguards, and regulatory compliance mechanisms is essential for increasing consumer acceptance of digital financial services.

Importantly, green finance not only promotes responsible banking but also fosters a culture where financial institutions allocate resources to sustainable development projects, green bonds, and eco-friendly investments. This suggests that green finance is a transformative force that improves banking efficiency while also supporting broader sustainability objectives.

In conclusion, integrating green finance with digital transformation initiatives will strengthen the resilience and sustainability of Pakistan's banking sector. Financial institutions should adopt a holistic approach that combines digital innovation, environmental sustainability, and consumer engagement to promote financial inclusion and economic development. Policymakers and regulatory bodies must also play a proactive role by offering market incentives, ensuring transparency, and establishing robust regulatory frameworks to facilitate this transition. Ultimately, sustainability-driven financial models present banks with an opportunity for long-term success while preserving the environment and supporting national economic stability.

Practical Implications

This study presents several practical implications for financial institutions, policymakers, and banking regulators to improve sustainability and digitalization in the banking sector. A key takeaway is the need for banks to integrate green finance strategies into their digital banking initiatives to expand financial accessibility and deepen consumer engagement.

With the rise of Fintech adoption, banks must invest in AI-powered security systems and blockchain-based transaction processing to enhance the safety, efficiency, and user experience of digital banking services. This approach aligns with the growing need to evaluate the impact of green finance on digital transformation in Pakistan's banking sector.

The transition toward paperless banking and online transactions offers significant opportunities to reduce banks' carbon footprints and promote sustainable practices. However, limited awareness and understanding of Fintech and green financial services—especially in developing economies—pose a challenge. Financial literacy programs are essential to educate consumers on the benefits of using these solutions.

Given widespread hesitancy among consumers to transition from traditional to digital banking, user-friendliness and transparency in digital services are critical. Banks should invest in customer awareness campaigns that highlight the security, efficiency, and environmental benefits of Fintech solutions.

Additionally, strong collaboration between financial institutions and regulatory bodies is needed to formulate policies that incentivize green practices, such as tax benefits for green lending and sustainability-linked products. Regulatory support will accelerate the adoption of sustainable banking models and align business strategies with global sustainability goals.

Banks can also enhance financial inclusion by using digital transformation to reach underbanked populations through mobile banking and digital lending platforms. Green finance can support the expansion of digital financial services to rural and remote areas with limited access to traditional banking. This integrated approach—combining sustainability and Fintech—offers mutually reinforcing benefits for the economy and environment.

Theoretical Implications

This study contributes to the existing body of literature on sustainable finance, Fintech adoption, and bank digital transformation by confirming that green finance is a transformative force in the banking industry. While prior studies have explored the role of green finance in promoting digital banking, this research takes a further step by clarifying the interconnectedness of green finance, Fintech, and digital transformation.

The study provides theoretical evidence that green financial policies can act as facilitators of technological advancement in the banking sector. This supports broader sustainability theories that emphasize the link between environmental responsibility and financial innovation.

Furthermore, the study contributes to the literature on customer trust, showing that while trust remains important, it is not the strongest predictor of Fintech adoption. Instead, technological efficiency, regulatory support, and ease of use play more decisive roles in encouraging consumers to embrace digital financial services. This challenges conventional assumptions and enriches ongoing debates about how best to achieve digital financial inclusion.

Additionally, the study offers new theoretical insights into the mediating role of digital transformation between green finance and Fintech adoption. While prior research has examined these factors independently, this study integrates them into a unified framework that shows how sustainability and technology interact within the banking sector. In doing so, it bridges a critical gap between Fintech adoption theories and sustainability studies, offering a more holistic view of how financial institutions can use green finance to foster innovation and inclusion.

Limitations

Despite its contributions, this study has several limitations:

Geographic Limitation: The data were collected solely from Pakistan's banking sector, which may limit the generalizability of the findings to other countries with different regulatory environments, financial infrastructures, and consumer behaviors.

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Data Collection Method: The study relied on survey data, which are subject to self-reporting biases and subjective perceptions. Future research would benefit from longitudinal studies or case-based analyses to explore the long-term effects of green finance on digital transformation and banking sustainability.

Methodological Scope: The study used a quantitative approach, which, while valuable, may not fully capture the complexity of consumer attitudes and institutional behavior. Future studies should consider mixed-methods approaches that combine qualitative interviews or focus groups with quantitative analysis for deeper insights.

Future Research Directions

Future research should explore the role of government policies and regulatory frameworks in accelerating the adoption of green finance and Fintech solutions in emerging economies. There is also a need to assess how tax incentives, subsidies, and regulatory reforms influence sustainable finance and digital transformation.

Additionally, future studies should investigate the impact of green finance on financial inclusion in rural and underserved communities, where access to traditional banking remains limited.

Further research should examine the role of emerging technologies—such as blockchain, artificial intelligence, and big data analytics—in protecting green finance from financial crimes and enhancing its efficiency. While this study emphasized digital transformation as a mediator, future work could explore specific technologies that strengthen the adoption of sustainability-oriented banking models.

By deepening understanding at the intersection of financial technology and environmental sustainability, future research can offer actionable insights for policymakers, researchers, and financial institutions striving to build a more inclusive, resilient, and sustainable financial ecosystem.

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