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[Corporate Governance and Digital Innovation in Green FinTech: Mediated by Knowledge Management and Moderated by Supply Chain Collaboration]

Hasan Raza*
Assistant Professor, Department of Commerce, University of Karachi. Corresponding Author Email: hasan.raza@uok.edu.pk
Dr. Qudsia Arshad
Assistant Professor, Management Sciences Department, Comsats University, Islamabad. qudsia_arshad@comsats.edu.pk
Ghulam Mujtaba
Assistant Professor, Department of Business Administration, University of Kotli AJ&K. ghulam.mujtaba@uokajk.edu.pk
Iftikhar Ahmed
Ph.D. Scholar, Department of Management Sciences, Comsats University, Islamabad. iftikharpmic@gmail.com

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ABSTRACT

The convergence of sustainability and digital transformation has given rise to Green FinTech a rapidly evolving field integrating financial innovation with environmental objectives. Despite its growing importance, limited empirical research has examined how internal organizational mechanisms and inter-organizational dynamics jointly influence digital innovation in Green FinTech, particularly within emerging markets. This study aims to investigate the impact of corporate governance on digital innovation in Green FinTech, while assessing the mediating role of knowledge management and the moderating effect of supply chain collaboration. Drawing on the Resource-Based View (RBV), the research conceptualizes these constructs as strategic capabilities that enable firms to achieve sustainable competitive advantage through innovation. A quantitative, cross-sectional research design was employed, targeting middle and senior-level managers in Pakistan's commercial banking sector, a critical stakeholder group in green financial transformation. Data were collected through a structured, self-administered questionnaire, and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) via SmartPLS 4.0. The results confirm that corporate governance has a significant and positive effect on digital innovation in Green FinTech. Knowledge management partially mediates this relationship, highlighting the critical role of intellectual resource integration in transforming governance structures into innovation outcomes. Supply chain collaboration significantly moderates the governance–innovation link, though in a negative direction, suggesting a complex interaction between internal control mechanisms and external partnerships. These findings contribute to the theoretical understanding of digital sustainability by integrating governance, knowledge, and collaboration within a unified framework.

Keywords: Corporate Governance, Digital Innovation, Green FinTech, Knowledge Management, Supply Chain Collaboration

Introduction

In recent years, the global corporate landscape has undergone rapid transformations, primarily driven by digitization, sustainability imperatives, and increased demands for responsible governance. Organizations across sectors are being compelled to reconfigure their internal structures and external linkages to remain competitive in a volatile environment shaped by environmental degradation, resource scarcity, and technological disruption. Among these dynamics, the fusion of digital transformation with green finance, commonly termed Green FinTech has emerged as a potential game changer, facilitating more sustainable financial practices through technology-driven solutions. However, the success of such innovations depends not only on technological investments but also on how effectively firms manage knowledge, engage in inter-organizational collaboration, and practice sound governance. Scholars and practitioners increasingly argue that firms must go beyond profit-seeking to adopt frameworks that promote transparency, information-sharing, and eco-conscious decision-making. This has

elevated the role of strategic knowledge practices and collaborative networks in fostering digital green innovation. Understanding the enabling conditions that drive digital innovation in sustainable finance environments is a timely academic and practical endeavor. Within this broader debate, the roles of corporate governance, knowledge management, and supply chain collaboration are gaining attention as potential enablers in catalyzing impactful and responsible digital innovation in green FinTech.

Emerging research over the past few years has explored the convergence of sustainability and financial technology, with studies highlighting how digital tools can drive environmentally responsible innovations (Li et al., 2023; Zhang & Chen, 2022). For instance, recent empirical studies have shown that digital transformation can facilitate better carbon tracking, green investments, and efficient lending through FinTech platforms (Wang et al., 2023). Organizational knowledge management has been found to support sustainable innovation by facilitating learning, resource integration, and adaptability (Kamble et al., 2022). Corporate governance mechanisms are increasingly acknowledged as essential for overseeing ESG (Environmental, Social, and Governance) alignment in strategic initiatives, including digital innovation (Ahmed & Khan, 2022). Supply chain collaboration is emerging as a pivotal component in aligning digital strategies with green objectives (Chen & Liu, 2023). However, despite growing attention, there remains a fragmented understanding of how these elements interact to promote innovation in the Green FinTech domain.

The climate crisis and the digital revolution are converging to redefine how firms operate, especially in finance. According to the United Nations Environment Programme (2023), financial institutions have a critical role in steering capital toward sustainable development goals. Meanwhile, global investment in climate-related FinTech solutions has surged, crossing USD 60 billion in 2022 alone (PwC, 2023). This reflects a strong market and regulatory shift toward digitized sustainability. At the national level, countries such as Pakistan face dual pressures accelerating digital inclusion while aligning with green financing goals under frameworks like the State Bank of Pakistan's Green Banking Guidelines (2022). However, these transitions are hampered by weak institutional governance, poor inter-firm collaboration, and limited strategic knowledge capabilities in many developing economies. Challenges like fragmented digital infrastructure and limited trust between supply chain actors inhibit integrated innovation. These realities highlight the need for systemic mechanisms that not only leverage digital technologies but also integrate firm-level governance, knowledge practices, and collaborative networks. Bridging these gaps is critical not only for advancing green finance innovation but also for fostering organizational resilience, competitiveness, and environmental accountability. This study responds to these global and local concerns by examining the enabling mechanisms behind digital innovation in Green FinTech.

Despite the rising discourse on digital sustainability, limited scholarly work has systematically examined how organizational mechanisms like governance, knowledge management, and supply chain collaboration collectively influence Green FinTech innovation. Much of the existing literature tends to examine these components in isolation governance is studied primarily in relation to compliance and ESG alignment

(Ahmed & Khan, 2022), while knowledge management is often explored in the context of innovation performance, without adequate linkage to green digital outcomes (Zhao et al., 2023). Supply chain collaboration has mostly been treated as an operational mechanism rather than a strategic driver of innovation in financial ecosystems (Chen & Liu, 2023). These disjointed approaches leave a critical gap in understanding how firms can orchestrate internal and external capabilities to foster responsible digital innovation. Few studies explicitly situate their investigations within the Green FinTech domain, especially in emerging economies where technological maturity, regulatory environments, and environmental risks are uniquely intertwined. There is also limited empirical evidence on the mediating and moderating pathways through which these organizational variables affect innovation outcomes. It remains unclear how the interplay between corporate governance and supply chain collaboration can channel through knowledge management to catalyze digital innovation in green finance. This study addresses this multifaceted gap by integrating these constructs into a unified model, focusing on the strategic synergies among governance, collaboration, and knowledge systems to unlock green digital innovation especially in resource-constrained, regulation-sensitive contexts like Pakistan.

Understanding the dynamics behind digital innovation in green finance is not only academically relevant but also practically urgent. As global economies commit to net-zero targets, firms are being held accountable for their environmental impact requiring them to embed sustainability into their innovation strategies. The World Economic Forum (2023) has emphasized that digital transformation, when aligned with sustainability goals, can significantly accelerate environmental progress. However, in practice, firms struggle to integrate these agendas due to governance failures, data silos, and lack of strategic coordination with supply chain partners. This challenge is more pronounced in emerging markets like Pakistan, where green financing remains nascent, and institutional voids hinder effective collaboration. A better understanding of how internal governance and knowledge systems, when complemented by collaborative external networks, can stimulate digital sustainability is crucial for enabling responsible innovation. The findings could guide policy frameworks, corporate strategies, and investment decisions toward a more integrated approach to green FinTech. Addressing this problem is also important for financial inclusion, climate mitigation, and resilience in developing economies that are vulnerable to climate risks and economic shocks. This issue deserves immediate academic and managerial attention.

This study adds value by presenting an integrated model that examines the combined and interactive roles of corporate governance, knowledge management, and supply chain collaboration in promoting digital innovation in the Green FinTech space. It bridges theoretical silos and responds to the urgent need for research contextualized in emerging economies. Unlike prior studies that analyze these factors in isolation, this research offers a systemic perspective, shedding light on how internal and external capabilities can be aligned to drive sustainable digital transformation. This study is based on Resource-Based View (RBV) in which corporate governance, knowledge management, and the ability to collaborate in a supply line are considered strategic resources and

capabilities to create a sustainable competitive advantage on the basis of innovation. The RBV rationale supports the idea that the more the firms deploy valuable and rare inimitable internal and relational capabilities, the more chances they have to conduct the green digital innovation. This theoretical perspective contributes to the coherent model as the constructs are connected to form one coherent underpinning, which provides an opportunity to understand how some companies can unlock the potential not only in internal capabilities but also in inter-organizational synergies to accentuate the solution of the complex sustainability and digitalization issues.

Theory

The Resource- Based View (RBV) emerged as a paradigm shift in strategic management by reorienting focus from external industry structures to internal firm heterogeneity as the source of competitive advantage. Its intellectual roots trace to Penrose's (1959) theory of firm growth, later crystallized in Wernerfelt's (1984) seminal articulation and Barney's (1991) formulation of resources that are valuable, rare, inimitable, and non- substitutable (VRIN) (Wernerfelt, 1984; Barney, 1991). Over time, RBV has evolved to encompass a wide range of tangible and intangible assets, including human capital, organizational routines, knowledge, and relational networks, which firms can harness strategically (Collis & Montgomery, 1995; Mailani et al., 2024).

At its core, RBV posits that enduring competitive advantage stems from firm- specific resources that competitors cannot replicate easily. These resources must be managed effectively and organized to create value, embedding them into firm routines, structures, and capabilities (Barney, 1991; Peteraf & Barney, 2003). Knowledge, in particular, stands out as a quintessential strategic resource: its transferability, aggregation, and appropriability make it central to sustaining innovation (Grant, 1996; Andersén, 2011). Recent literature has expanded upon RBV to explore its relevance in the sustainability and green innovation domain. Studies in Pakistan and other emerging economies illustrate how intangible assets such as green intellectual capital and absorptive capacity function as VRIN- like resources that underpin superior environmental outcomes (e.g., resource efficiency, reduced emissions) by enabling green innovation (Junejo et al., 2023; September 2023; Khanra et al., 2022). Systematic reviews highlight RBV's explanatory power in sustainable competitive advantage derived through supply chain integration and customer relational resources in dynamic and resource-constrained contexts (Mailani et al., 2024).

In contexts of digital green innovation such as Green FinTech, RBV's emphasis on firm- specific assets becomes salient. Digital platforms, governance mechanisms, organizational knowledge structures, and inter- organizational linkages can be regarded as strategic capabilities aligned with VRIN criteria that facilitate sustainable innovation. The RBV theory can take the view that governance structures, knowledge management processes and the cooperation of a supply chain of resources or capabilities, which give a clear conceptual basis about the way these organizational entities can jointly create a technologically and environmentally based innovation. The modern study of RBV is commonly combined with dynamic capabilities insights that not only include resource holding, but also of how the firm could reassemble them as a defense against

environmental turbulence and regulatory pressure (Teece et al., 1997; MDPI, 2022). Theoretical logic in combination assists in the explanation of how firms can transform governance quality, internal learning, and collaborative networks into digital green innovation results in situations when such resources are scarce, difficult to copy, and well organized. In this way RBV is a strong theoretical backing to the given model. It allows a lensed combination of governance mechanism, knowledge practices, as well as alliances in the chain of supply to be conceptualized not only as isolated factors, but rather specific resources at the production firm levels, which in the coordination harmonization, aid in the long term viable digital innovation in activities involving green finance.

Hypotheses

As financial systems evolve in response to environmental pressures and digital transformation, corporate governance has gained renewed attention as a strategic driver of innovation. Governance has a constructive role to play in determining organizational preparedness to innovation, and in highly regulated industries and those with health or environment sensitivities such as the finance sector. In the world of Green FinTech where financial services rely on the combination of environmental goals and the current digital technologies, the establishment of effective governance frameworks is of primary importance in the context of directing innovation strategies to meet both the market demands and regulatory opportunities (Makpotche et al., 2024). Board independence, expertise in the environmental sphere, transparency, and accountability procedures are features that help a firm in strategic decision-making, which is why the firm adapts digital tools on time and of benefit to the environment. Effective governance minimizes agency conflicts and information asymmetry, promotes sustainability of ESG alignment and favors investor confidence a conducive environment to long-term digital innovation (Siddique et al., 2024). This is in line with Resource-Based View (RBV) where working resourceful governance mechanisms are seen as resource that is unique, valuable and costly to imitate, which enable firms to retimber the domestic competencies to account to changing environmental and technological conditions in the world (Mailani et al., 2024).

Recent studies have further emphasized the positive link between governance quality and innovation outcomes in sustainability contexts. Companies that have more diverse and environmentally aware boards have been discovered to be much more participative in the climate-financial technologies and eco-product innovation (Almaqtari et al., 2024). In FinTech, good governance will create better conditions to innovate since there will be a better control of the investment in digital infrastructure, better preparedness to cybersecurity situations, and easier collaboration with external technology suppliers (Hamed, 2023). These capabilities will be needed to create innovation to connect with green financing objectives, i.e., carbon tracking, green lending, and impact investment platforms. In emerging markets, in particular, where it can be expected that regulatory regimes are developing and gaps in institutions might occur, the role of governance in giving structure, purpose, and legitimacy to digital green innovation plays an even more important role. RBV framework supports this opinion as it frames the role of governance as a strategic resource within the company, which is

capable of orchestrating knowledge base, stakeholder relationships, and collaborative mechanisms as the major drivers of Green FinTech innovation. Collectively, these revelations imply that effective corporate governance would not merely contribute positively to risk management and compliance, but would also be the main driver of sustainable digital transformation.

H1: Corporate governance positively influences digital innovation in Green FinTech

Extant studies increasingly highlights the centrality of governance in shaping firm-level innovation capacities, yet the mechanisms through which governance exerts this influence remain under-explored. The environment in which organizational learning and knowledge flow can be achieved is facilitated by corporate governance with structures and practices that stimulate transparency, accountability, and strategic consistency with the goals of sustainability (Almaqtari et al., 2024; Makpotche et al., 2024). Good governance in a very dynamic industry like Green FinTech will ensure reduction of risk as well as facilitate resource distribution into areas of green digital financing besides sending an indication that the industry is committed to environmental innovations. But it is not so that governance actually creates and imparts technology but it prepares the firm to accept creation, transfer, and use of knowledge as the key activities of knowledge management systems which convert the idea of governance to concrete innovation (Mailani et al., 2024; Shahzad et al., 2022).

Knowledge management encompassing the acquisition, sharing, and utilization of intellectual resources serves as an enabler of green innovation, especially within organizations pursuing sustainable digital transformation. Research on green knowledge management shows that these capabilities significantly drive eco-innovation by embedding environmental knowledge into products, processes, and services (Shahzad et al., 2022; Khan et al., 2023). Meanwhile, studies in the FinTech domain highlight that firms with advanced knowledge assets yield stronger innovation performance, with knowledge acting as a mediating mechanism between digital initiatives and outcomes (Baig et al., 2024). In the perspective of the Resource-Based View (RBV) and Knowledge-Based View (KBV), governance structures provide the organizational environment and resource coordination upon which flows of knowledge thrive, and knowledge management revolves around converting disseminated information into capability of innovation. In the analyzed scenario of Green FinTech, it is surprising that the corporate governance may help to improve the knowledge management process, which may involve the digital innovation processes, following the greenhouse gas (GHG) emission reduction demands to become increasingly sustainable.

H2: Knowledge management mediates the positive effect of corporate governance on digital innovation in Green FinTech.

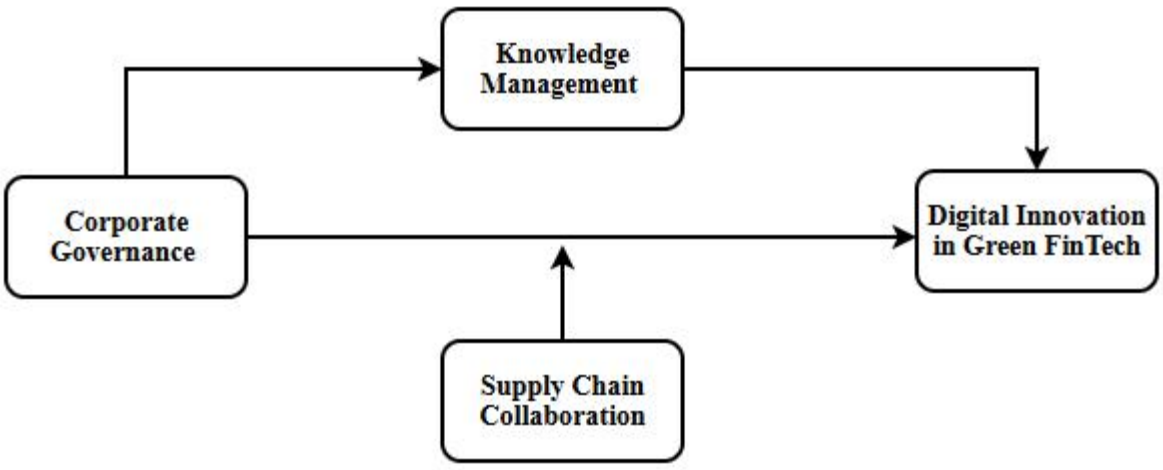
Corporate governance establishes the strategic oversight, accountability, and stakeholder alignment that shape a firm's capacity to pursue environmental and technological innovations. In Green FinTech contexts, governance mechanisms such as independent boards, transparent ESG reporting, and resource allocation frameworks create the formal environment for firms to invest in green digital technologies in compliance with regulations and market expectations (Makpotche et al., 2024; Almaqtari

et al., 2024). Governance provides the architecture within which digital innovation can be pursued. However, the mere presence of strong governance may not automatically translate into effective innovation outcomes unless complemented by mechanisms that link the firm to external actors. Supply chain collaboration offers such a mechanism by enabling firms to integrate knowledge, resources, and trust across organizational boundaries. Through vertical and horizontal collaborative relationships, firms share information, co-develop solutions, and align technological strategies with ecosystem partners, which amplifies governance-driven innovation initiatives (Simatupang & Sridharan, 2002; Emerald Insight, 2021).

Empirical studies in supply chain literature illustrate that collaboration enhances innovation capability by fostering information exchange, joint problem solving, and coordinated risk-sharing (turnosearch5). Supply chain collaboration has been shown to condition the effectiveness of governance and social capital, acting as a boundary-spanning mechanism that elevates sustainability outcomes when governance and network complexity align favorably. From the Resource-Based View (RBV) and relational lens, governance and supply chain collaboration together form a strategic bundle: governance provides internal legitimacy and resource orchestration, while collaboration opens external access to complementary capabilities and knowledge flows, enabling digital innovation in green finance to thrive. In contexts where supply chain collaboration is robust, the positive effect of corporate governance on digital innovation is likely to be reinforced, whereas weaker collaboration may attenuate this relationship.

The positive relationship between corporate governance and digital innovation in Green FinTech is strengthened when supply chain collaboration is high.

H3: The positive relationship between corporate governance and digital innovation in Green FinTech is strengthened when supply chain collaboration is high



Methodology

This study adopts a quantitative, cross-sectional research design, which is well-suited to examining the structural relationships among corporate governance, knowledge management, supply chain collaboration, and digital innovation in Green FinTech at a

single point in time. The cross-sectional design enables one to collect data regarding a wide population at the same time, which is one of the key reasons why it is used to examine patterns and associations without experiencing temporal delays (Saunders et al., 2019). Since the purpose of the study is to determine both the magnitude and direction of the relationships between the identified hypotheses in an empirical manner with the help of structural modeling, the cross-sectional quantitative design is rather suitable to serve as the basis of its subsequent analysis infliction and prediction. This study has a target population of middle-level and senior-level of managers employed by commercial banks made to operate under State Bank of Pakistan (SBP). These financial institutions have been chosen because their propensity towards digital financial services and green banking strategies as per Green Banking Guidelines of SBP have been rising. The managers in these banks are most conveniently placed so as to offer real-time information about the corporate governance structures, knowledge processes, collaborative supply chain operations and the practices of digital innovations. Targeting this population is in line with the previous study that accentuated the key role of the banking sector in sustainable digital finance in emerging economies (Khan et al., 2022).

The study employs a purposive (judgmental) sampling technique, targeting professionals with sufficient knowledge of governance, digital transformation, and sustainability practices within their institutions. This non-probability sampling method is appropriate when the research requires domain-specific expertise (Etikan et al., 2016). The sample size is determined using Item Response Theory (IRT) principles, which recommend a minimum of 10 to 20 responses per item to ensure psychometric robustness and model stability (De Ayala, 2009). Given that the proposed model includes 26 items across all constructs, the minimum sample requirement is 520 respondents but the researcher got 343 responses from respondents.

Data will be collected through a structured, self-administered questionnaire distributed electronically. The data analysis will be conducted using SPSS (version 26) for descriptive statistics, reliability, and normality testing. SmartPLS (version 4.0) will be used for Structural Equation Modeling (SEM), including path analysis, measurement model assessment, and hypothesis testing. SPSS is appropriate for preliminary data screening, while SmartPLS is well-suited for complex models with latent constructs, especially in cases involving mediation and moderation (Hair et al., 2021). All measurement items are adapted from previously validated scales found in peer-reviewed literature. Corporate governance is measured using items adapted from Ahmed and Khan (2022); knowledge management from Shahzad et al. (2022); supply chain collaboration from Chen and Liu (2023); and digital innovation from Baig et al. (2024). Each construct is assessed using multiple items rated on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree), enabling a nuanced assessment of respondent perceptions.

Data analysis

Table 1: Validity Statistics

		CG	DGF	KM	SC
Corporate Governance	**CG1**	0.888			
	CG2	0.865			
	CG3	0.848			
	CG4	0.824			
	CG5	0.870			
	CG6	0.895			
	CG7	0.824			
	CG8	0.914			
Digital Innovation in Green FinTech	**DGF1**		0.864		
	DGF2		0.910		
	DGF3		0.874		
	DGF4		0.910		
	DGF5		0.850		
	DGF6		0.866		
Knowledge Management	**KM1**			0.784	
	KM2			0.765	
	KM3			0.808	
	KM4			0.867	
	KM5			0.786	
	KM6			0.813	
Supply Chain Collaboration	**SC1**				0.807
	SC2				0.824
	SC3				0.808
	SC4				0.854
	SC5				0.857
	SC6				0.792

Factor loadings represent the strength of the relationship between each observed variable (indicator) and its underlying latent construct within a measurement model. Such loadings are important in determining the reliability and convergent validity of constructs in structural equation modeling. In confirmatory research, factor loadings of 0.70 or more are usually proposed to demonstrate that a significant part of the variance observed in the item is defined by the latent construct (Hair et al., 2021). In the case of exploratory research, the thresholds can be lower, approximately 0.40, but higher is better to guarantee measurement accuracy (Sarstedt et al., 2022). Factor loadings also act as a testament of how well many items become an embodiment of their construct, thereby making the model very solid. The loadings, which were derived under this

research, are between 0.765 and 0.914, and this denotes extreme affiliations involving all indicators. In the case of Corporate Governance, all the items (CG1-CG8) show a loading value over 0.82 and the highest loading value of 0.914 lies in CG8 and this shows a good internal consistency and reliability of this construct. Likewise, the Digital Innovation in Green FinTech (DGF1 to DGF6) indicators exhibit loadings that are between 0.850 and 0.910 representing a perfect convergence validity. Knowledge Management scores 0,765-0.867 when defined as adequate, and the Supply Chain Collaboration is 0.792-0.857 which are clearly above 0,70 point. These findings ascertain that each of the items is significant to their corresponding construct and none of the items could be discarded on empirical or theoretical basis. The high factor loadings evidences that each scale of measurement is statistically and conceptually valid and this was enough reason to retain them in the structural model

Table 2: Reliability and AVE

	Cronbach's alpha	(rho_a)	(rho_c)	(AVE)
Corporate Governance	0.952	0.955	0.960	0.751
Digital Innovation in Green FinTech	0.941	0.943	0.953	0.773
Knowledge Management	0.891	0.895	0.917	0.647
Supply Chain Collaboration	0.905	0.907	0.927	0.679

In structural equation modeling, the assessment of internal consistency reliability and convergent validity is critical to confirm the soundness of measurement instruments. The internal consistency of the latent constructs is generally checked using Cronbach Alpha, rho A, and Composite Reliability (rho C). The lower limits of such indicators as 0.70 or more are usually considered to denote decent reliability (Hair et al., 2021). At the same time, the Average Variance Extracted (AVE) measures convergent validity and a value of 0.50 is the minimum acceptable level, indicating that over half of the variance of indicators can be captured by the underlying construct (Sarstedt et al., 2022). All the values of measures of the constructs in this research are above the recommended shoulder. Corporate Governance is superior in reliability having Cronbach Alpha of 0.952, Cronbach RhoA of 0.955 and Cronbach RhoC of 0.960 with AVE of 0.751 that demonstrate its high internal consistency and good convergent validity. Digital Innovation in Green FinTech shows equally powerful results, as all reliability measures are more than 0.94 and the AVE is 0.773. Knowledge Management is not bad either with the reliability indicators over. 89 and an AVE of 0.647. Supply Chain Collaboration demonstrates a strong measurement model where the coefficients' reliability is more than 0.90, and the AVE is 0.679. These findings validate that they are all very effective in an accurate and conceptual factuality of measurement and they can be used in the structural model.

Discriminant Validity

Table 3: HTMT Ratio

Variables	CG	DGF	KM	SC
Corporate Governance				
Digital Innovation in Green FinTech	0.577			
Knowledge Management	0.440	0.475		
Supply Chain Collaboration	0.620	0.612	0.480	

Discriminant validity ensures that constructs in a structural model are truly distinct from each other, both conceptually and statistically. Heterotrait-Monotrait (HTMT) ratio of correlations is one of the strongest methods of testing the discriminant validity. This is done by measuring how the indicators of a construct are not too alike other indicators of a different construct. The present literature suggests the existence of more conservative and liberal thresholds (below 0.85 and below 0.90, respectively) of values of HTMT indicating strict and acceptable discriminant validity (Franke & Sarstedt, 2019; Henseler et al., 2022). When HTMT higher exceeds these levels, a possible overlapping of constructs is indicated and makes it necessary to question the empirical distinctiveness of these constructs. All values of HTMT in the research are lower than 0.90, which is the liberal criterion and, as such, all values in this research are acceptable in terms of discriminant validity. HTMT between Corporate Governance and Digital Innovation in Green FinTech is 0.577 whereas, the correlation is 0.620 with Supply Chain Collaboration and 0.440 with Knowledge Management. Digital Innovation in Green FinTech records 0.475 of HTMT in Knowledge Management and 0.612 in Supply Chain Collaboration. All the values are within an acceptable range confirming that the constructs are not overlapping and measuring redundant dimensions. The fact that strong discriminant validity is supported in the measurement model is based on the results.

Model Fitness Values:

Table 4: Fitness Indicators

	Saturated model	Estimated model
SRMR	0.060	0.074
d_ULS	1.245	1.912
d_G	0.719	0.735
Chi-square	1409.510	1410.383
NFI	0.826	0.826

Model fit indices are crucial for assessing the adequacy of a structural equation model. The Standardized Root Mean Square Residual (SRMR) reflects the average magnitude of discrepancies between observed and predicted correlations. A value below 0.08 is generally indicative of a good fit (Hair et al., 2022). In this study, both the saturated model (SRMR = 0.060) and the estimated model (SRMR = 0.074) meet this criterion, suggesting acceptable model fit. The d_ULS and d_G are discrepancy measures assessing the distance between empirical and model-implied matrices. Lower values indicate a better fit. Here, both indicators fall within acceptable ranges and show minimal difference between the saturated and estimated models. The Chi-square values are

slightly different (1409.510 vs. 1410.383), further supporting consistency. Lastly, the Normed Fit Index (NFI) of 0.826, while slightly below the ideal 0.90 threshold, is acceptable in PLS-SEM contexts (Sarstedt et al., 2022). Overall, the model demonstrates satisfactory fit.

R Square Value

Table 5: R square

	R-square	R-square adjusted
DGF	0.438	0.431
KM	0.167	0.165

The R-square values indicate the proportion of variance in the dependent variables explained by the independent variables. For Digital Innovation in Green FinTech (DGF), the R-square value is 0.438, meaning that 43.8% of the variance in DGF is explained by corporate governance and supply chain collaboration, which is considered moderate (Hair et al., 2022). For Knowledge Management (KM), the R-square is 0.167, suggesting that only 16.7% of the variance is explained, indicating a weak explanatory power. The adjusted R-square values are slightly lower (0.431 for DGF and 0.165 for KM), accounting for model complexity. Overall, the results demonstrate moderate model strength for DGF and limited explanatory power for KM.

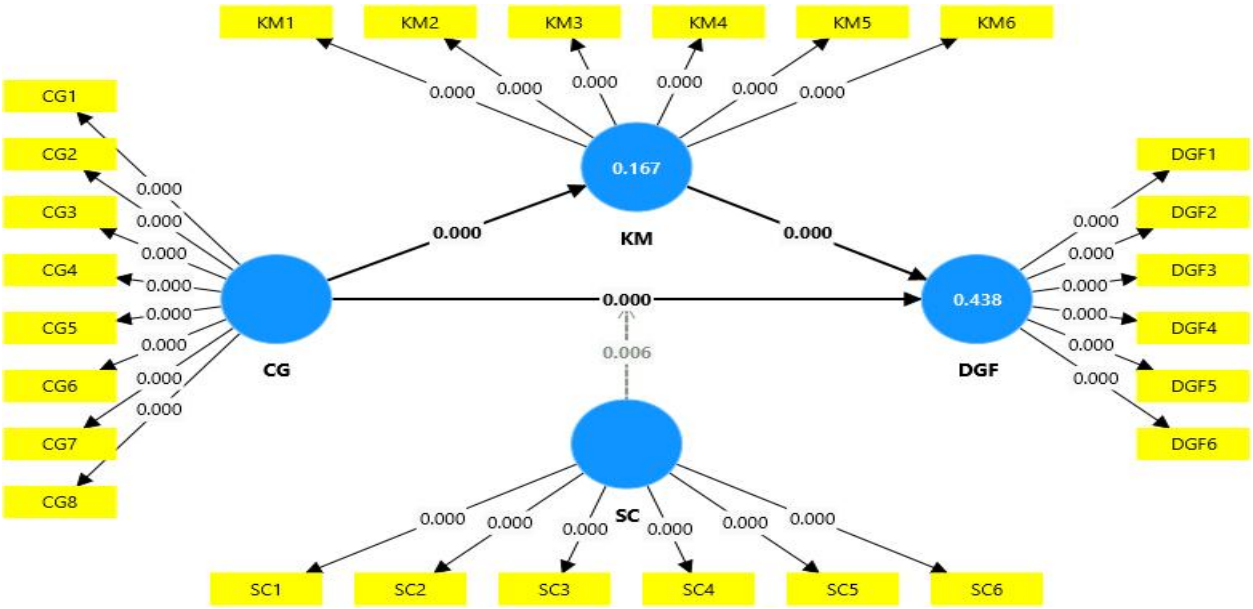


Table 6: Findings

Hypotheses	Original sample	(M)	Standard deviation	T statistics	P values
CG-> DGF	0.315	0.315	0.054	5.789	0.000
CG -> KM -> DGF	0.071	0.072	0.022	3.253	0.001
SC x CG -> DGF	-0.114	-0.113	0.041	2.752	0.006

CG; Corporate Governance, DGF; Digital Innovation in Green FinTech, KM; Knowledge Management, SC; Supply Chain Collaboration

The results of the hypothesis testing provide empirical support for all proposed relationships in the structural model. The direct relationship between corporate governance and digital innovation in Green FinTech (CG → DGF) is statistically significant, with a path coefficient (β) of 0.315, a t-value of 5.789, and a p-value of 0.000. These results exceed the conventional threshold for statistical significance ($p < 0.05$), indicating a strong and positive influence of corporate governance on digital innovation in Green FinTech. This finding aligns with previous research suggesting that effective governance mechanisms foster strategic orientation and innovation adoption in sustainable financial technologies (Nasiri et al., 2022). The mediating role of knowledge management in the relationship between corporate governance and digital innovation (CG → KM → DGF) is also supported, as evidenced by a path coefficient of 0.071, a t-value of 3.253, and a p-value of 0.001. The significance of this indirect effect highlights the importance of knowledge processes as a mechanism through which governance structures enhance digital innovation in Green FinTech. The moderating effect of supply chain collaboration on the relationship between corporate governance and digital innovation (SC × CG → DGF) is statistically significant, with a negative path coefficient of –0.114, a t-value of 2.752, and a p-value of 0.006. Although the interaction term is negative, it suggests that in contexts of high collaboration, the influence of corporate governance on digital innovation may be altered, potentially indicating a complex dynamic between organizational control structures and external collaborative efforts (Wamba et al., 2023). All three hypotheses are empirically supported.

Discussion

The results strongly support the hypothesis that corporate governance positively influences digital innovation in Green FinTech. This finding confirms the theoretical predictions rooted in the Resource-Based View (RBV), where governance is considered a valuable, rare, and inimitable internal resource that provides strategic direction and legitimacy to innovation efforts (Barney, 1991; Mailani et al., 2024). Board independence, transparency, and ESG-based governance are methods of fostering governance that encourages digital experimentation and alignment toward sustainable business practices. Such processes will upgrade the willingness of firms to implement digital technologies that aid green financial objectives, such as carbon tracking, ESG compatibility, and green lending systems (Makpotche et al., 2024; Almaqtari et al., 2024). On an empirical level, this is also the case in emerging market banks, as strong governance enhances the technological adoption and efficiency of decisions in the bank (Ahmed & Khan, 2022). Governance in the setting of the financial system in Pakistan, a country that is in the

process of designing and redesigning its strategies related to green finance (State Bank of Pakistan, 2022), aids in both the sense of structural control and a sense of clear strategy crucial to the long-term innovation. Governance acts as the facilitator and controller; it provides the means through which the firm reacts externally to environmental and digital demands, eventually promoting green FinTech products.

The mediating role of knowledge management between corporate governance and digital innovation in Green FinTech was also found to be significant. This result confirms that governance alone does not directly yield innovation but does so by cultivating and channeling knowledge processes within the organization. Governance structures create the formal mechanisms such as transparent communication, compliance frameworks, and strategic vision that enhance knowledge sharing and utilization (Mailani et al., 2024; Shahzad et al., 2022). Prior literature indicates that when knowledge is effectively captured, transferred, and applied, it enhances firms' capability to innovate in green and digital contexts (Baig et al., 2024; Kamble et al., 2022). In resource-constrained settings such as Pakistan, where innovation often depends on internal absorptive capacity, knowledge management becomes the key through which governance frameworks are operationalized into innovative outputs. Green knowledge such as regulatory standards, carbon accounting methods, and digital risk analytics is essential for developing credible green FinTech services (Khan et al., 2023). Knowledge management serves as the functional mechanism that enables governance-driven firms to translate strategic orientation into actionable innovation capabilities, consistent with both the RBV and the Knowledge-Based View (Grant, 1996).

The hypothesis examined the moderating role of supply chain collaboration in the relationship between corporate governance and digital innovation in Green FinTech. While the moderation effect was statistically significant, it was negative in direction. This unexpected outcome suggests a more nuanced interaction: in contexts of high supply chain collaboration, the direct influence of governance on innovation may be diluted or altered. One plausible explanation is that high collaboration introduces external dependencies, shared control, or divergent partner objectives that may temper the centralized influence of governance structures (Simatupang & Sridharan, 2002; Chen & Liu, 2023). Decision-making autonomy governed internally might conflict with joint innovation decisions required in collaborative networks. This tension may lead to slower or more negotiated innovation outcomes. Wamba et al. (2023) note that overly complex inter-organizational collaboration can impose governance challenges, especially when strategic control is dispersed across multiple actors. Another explanation could be methodological: as collaboration increases, innovation may be more strongly attributed to joint efforts than to governance alone, reducing the apparent strength of the governance-innovation link. Contextually, in the Pakistani banking sector where trust and infrastructure limitations exist, high collaboration may not always translate to synergistic outcomes, especially if not well-coordinated with governance intent. While collaboration remains a vital capability, its interaction with governance needs careful calibration to avoid potential misalignment or inefficiencies.

Limitations And Future Directions

This study, while offering valuable insights into the determinants of digital innovation in Green FinTech, is not without limitations that may affect the interpretation and generalizability of its findings. The research design is cross-sectional in its nature and this limits the possibility to make the inference of the causal relations between the variables involved. The relationships identified may not control the dynamic change of corporate governance, knowledge practices, and collaborative relations, which can shape innovation that may come to play over time (Hair et al., 2021). Temporal changes might more adequately be explained by longitudinal or panel research studies that might also shine greater light on the interaction of these constructs with a changing environmental and technological landscape. The research study was based on purposive sampling methodology that was restricted to managers in commercial banks within the State Bank of Pakistan jurisdiction. Although this concentration will guarantee in-depth knowledge of the domain, it will restrict the ability to generalize study results to other financial industries or geographical regions. No views of non-managerial employees, FinTech new companies, or international financial institutions were involved and this analysis may leave other forms of organizational and cultural factors on digital green innovation out.

Methodologically, the use of self-administered questionnaires introduces common method bias, which may inflate correlations among constructs due to respondents' cognitive consistency or social desirability biases (Podsakoff et al., 2003). Statistical procedures have been used to confirm the constructs, qualitative triangulation using the interview or a case study would have added more depth and context to the findings. Also, the authors limited their attention to few variables, i.e., corporate governance, knowledge management, supply chain collaboration, and digital innovation. The other constructs that might have a profound impact in determining the outcomes of green FinTech include organizational culture, digital absorptive capacity, or environmental regulation pressure, or even leadership orientation, but which were not reviewed. These limitations and their causes may be taken into consideration in the future research using a mixed-method research approach and extending the model to include other moderators or mediators. The dynamic capabilities and the stakeholder pressure can be considered as moderators, and the digital maturity or the green organizational culture can be discussed as mediators that help shape innovation (Teece et al., 1997; Khanra et al., 2022). The findings of this study can be further conducted in other emerging and developed economies to enable comparison with other countries and improve the external validity of the research. It will be interesting to include sectoral disparity, including Islamic banking, microfinance, or insurance-based FinTech, which may also deliver new dimensions of the impact of institutional and regulatory disparities on the process of innovation. The development of a more thorough and time-sequential research strategy should be defined to create a multifaceted theoretical concept of digital sustainability in the financial sphere.

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