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FINTECH INNOVATION AND GREEN INVESTMENT EFFICIENCY: THE MEDIATING ROLES OF FINANCIAL INCLUSION AND SUSTAINABLE GOVERNANCE

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Abstract

The accelerating climate crisis has emphasized the importance of channeling capital into sustainable and environmentally responsible projects. Financial technology (FinTech) has come about to enhance the effectiveness of green investments through the provision of accessibility, transparency, and innovation in the financial systems. The efficiency of green investment powered by FinTech innovation has not been well-explored, especially in the areas where sustainable finance and digital transformation are still developing. This paper examines the impact of FinTech innovation on the efficiency of green investments using financial inclusion and sustainable governance as mediating variables. It used a quantitative cross-sectional design where primary data were gathered with chief executive officers, finance directors, and sustainability managers of manufacturing and financial companies that have been involved in green-oriented initiatives in the major industrial centers in Pakistan, such as Lahore, Karachi, Faisalabad, and Islamabad. Out of 410 distributed questionnaire, 303 valid responses were used by using Partial Least Squares Structural Equation Modeling (PLS-SEM). The model evaluated the direct effects of FinTech innovation on green investment efficiency and the

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indirect effects through the financial inclusion and sustainable governance. Findings indicate that FinTech innovation has a great impact on improving the efficiency of green investment both directly and indirectly. Financial inclusion is a mediating variable because it extends access to digital financial tools and resources are mobilized towards sustainable projects. Sustainable governance enhances institutional responsibility, regulatory adherence, and strategic inclusion of green goals, augment the effectiveness of green investments.

Keywords: FinTech innovation, green investment efficiency, financial inclusion, sustainable governance, sustainable finance.

Introduction

Global economic systems have undergone profound structural transitions shaped by digital transformation, sustainability imperatives, and increasing environmental uncertainty. Governments, industries, and financial institutions are grappling with how to balance economic growth with ecological responsibility, particularly as concerns regarding climate change intensify. In this shifting environment, technological progress has largely transformed the manner in which financial services are provided, regulated and used and has led to a reconsideration of the role of financial services in fostering sustainable developmental directions. One of the most commonly mentioned aspects by scholars is that emerging digital infrastructures have ceased to be peripheral means and have become core processes that transform access to resources, increase transparency and reform institutional roles (Hou et al., 2024; Wang et al., 2024). At the same time, the increased focus on environmentally responsible economic operation has brought the debate to the role of financial systems supporting low-carbon transitions, responsible investment, and strengthening governance structures based on the sustainability objectives (Deng et al., 2024). Due to the efforts of nations to comply with the international commitments like the Paris Agreement and Sustainable Development Goals (SDGs), the relationships between digital

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transformation, financial accessibility, and environment-friendliness of investment have gained greater importance in the academic and policy discussions (Rani et al., 2025). Through these debates, it is clear that there is a need to establish how the changing financial and technological ecosystems can impact on the larger environmental and economic resilience.

According to the recent literature, there are major improvements in the understanding of how digital financial systems infuse on environmental and economic consequences. The empirical research indicates that financial solutions based on technology can help in better resource allocation, environmental performance, and more environmentally friendly economic activity in industries and regions (Teng and Shen, 2023; Liu et al., 2022). The studies indicate also that the sustainable investment behaviour can be strengthened with the help of financial accessibility and digital infrastructures, as well as the environmental efficiency can be improved especially in the emerging economies, which aim to decarbonize (Zhang et al., 2024; Hou et al., 2024). Moreover, research on the adoption of digital finance and green financial instruments has documented that it has a positive impact on the sustainability of the environment and corporate performance (Guang-Wen and Siddik, 2023; Khan et al., 2025). In spite of these lessons, the agreement is still incomplete, with the results being inconsistent based on the institutional settings, regulatory factors and maturity of financial technologies. These contradictions show the necessity of further research on the mechanisms of interaction of digital transformation with the sustainability-oriented governance and investment outcomes.

The international issue of climate change, resource scarcity and environmental degradation has subjected the economies to unprecedented pressures to shift to more greener and efficient investment patterns. Recent international sustainability reports show that most nations especially in Asia, Africa and South America are still grappling with the inability to intersect their economies with the environmental goals because of poor institutional

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frameworks and inadequate access to green financing systems (Deng et al., 2024; Wang et al., 2024). At the same time, the financial inequalities still exist, and millions of people and companies do not have access to the major financial systems and cannot be involved in the economic programs aimed at climate (Hou et al., 2024). These difficulties are also enhanced by the fact that the digitalization process is not evenly distributed, and gaps exist between technologically advanced economies and those that are yet to build the infrastructure to accommodate digital financial ecosystems (Rani et al., 2025). On the national level, emerging economies experience complicated policy requirements as they endeavor to improve efficiency in the environment and attract sustainable investments with the restrictions of governance imposed and the institutional bottlenecks. With growing global climate objectives, the necessity to disclose how digital developments, money involvement and administrative framework intersect and have an impact on the results of environmental investment are becoming all the more pressing. These issues are directly related to the research problem since they point out the structural and systemic obstacles to the sustainable economic transitions.

Although the focus has grown among scholars, there have been a number of gaps in the interpretation of how modern financial and technological trends can be translated into success in environmental investment. To begin with, the available literature offers disjointed information regarding the interaction between digital financial systems and environmentally oriented investments, and, in many cases, authors discussed the individual elements instead of the interrelated mechanisms that define the green economic performance (Zhang et al., 2024; Teng and Shen, 2023). Second, although it is indicated that digital transformation can be used to drive more sustainable financial flows, the processes by which institutional and governance structures can affect such processes are understudied, especially in developing economies where regulatory frameworks are changing very fast (Hou et al., 2024; Guang-Wen and Siddik, 2023). Third, despite the

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fact that environmental efficiency has become an issue of primary policy concern, there is very little information on how multi-level financial and governance factors are involved in enhancing investment efficiency in green sectors. A large part of the literature available analyzes environmental performance on a general level, failing to evaluate the role of digital infrastructures and governing dynamics in the creation of investment-specific efficiency (Ren et al., 2024; Wang et al., 2024). Moreover, the increasing complexity of sustainable finance through the processes of digitalization, climate commitment, and internationalization is in need of a more sophisticated analytical methodology that reflects the multidimensional nature of factors affecting the green transformation of the economy. The existing research is inclined towards the use of limited empirical models that fail to combine financial, technological, and institutional factors in a single model (Deng et al., 2024; Rani et al., 2025). This, in turn, leaves a urgent necessity to explore the avenues in which digital financial ecosystem and governance condition interplay to shape environmentally consistent investment performance. This gap must be filled to improve the development of theory and policy in the new sustainability environment.

The knowledge of the dynamics that determine the environmentally oriented investment efficiency is crucial to the realization of the global sustainability targets and policy interventions. With the increasing focus of countries on the implementation of SDGs in the areas of climate action, responsible consumption, innovation, and resilient infrastructure, it becomes essential to reinforce the environmental performance of financial and institutional systems (Wang et al., 2024). The enhancement of investment efficiency in the green sectors is of great importance especially in developing economies where the scarcity of fiscal resources and institutional weaknesses tend to hamper the effective allocation of resources. The international organizations are putting more stress on the fact that sustainable development is conditional upon the capacity of financial systems to finance low-carbon

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transitions, and to provide wide financial access, and strengthen governance practices that enhance transparency and accountability (Hou et al., 2024). There is a need to have strong empirical evidence to enable policymakers to come up with frameworks that can incorporate technological innovation in conjunction with sustainable investment agendas especially in areas where there are acute climatic vulnerabilities. Furthermore, with the global markets moving toward environmentally friendly investments, companies and organizations should modify their financial policies to stay on the competitive edge and meet the requirements of the stricter environmental policies (Zhang et al., 2024). The importance of research problem solution hence has both academic, policy, and practical importance since it provides a critical insight into how economies can be better equipped to resist the environment due to better financial, technological, and governance systems.

This paper is part of the growing sustainability discourse because it has incorporated the financial, technological and governance aspects into one analytical platform. The current research is more comprehensive in explaining the effects of digital transformation and institutional conditions on environmental investment outcomes compared to the existing studies, which investigate these domains separately (Deng et al., 2024; Hou et al., 2024). The study contributes to the theory by explaining how modern financial ecosystems enable the efficacy of green economies. It is also practical in the sense that it produces evidence which is pertinent to policymakers, investors and institutions that aim at promoting pathways to sustainable development. The research is likely to produce a significant theoretical and practical contribution through depicting the ways in which digital transformation and governmental framework affect environmentally-oriented investment performance. It is adding to the sustainability and financial innovation literature and educating the policy strategies that can improve green economic transitions. The analysis is informed by the modern views of sustainable finance and institutional theory that focus on the combined effects of the

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technological intervention, financial engagement, and governance structures on the organizational and economic performance (Rani et al., 2025; Wang et al., 2024). This framing offers a solid basis on which to discuss the interrelated channels by which the contemporary financial ecosystems are playing environmental sustainability.

Theoretical Foundation

Sustainable Finance Theory provides the intellectual grounding for examining how financial systems, institutional structures, and regulatory mechanisms contribute to environmentally responsible economic activity. The theory is based on the early discussion of socially responsible investment and ecological economics because when scholars attempted to explain how financial markets might be organized to encourage long-term environmental stewardship instead of short-term maximization of profits. Previously being considered in terms of ethical investing and corporate social responsibility, the theoretical framework has been expanded to encompass more issues of climate risk, green financial instruments and regulatory governance. With the increasing popularity of sustainability issues on the international level, the theory incorporated the knowledge of both institutional economics and environmental policy, focusing on the role of rules, norms, and financial frameworks in determining the distribution of capital to environmentally friendly activities. Sustainable Finance Theory in modern scholarly literature has also been refined, with massive regulatory changes as well as the worldwide movement towards climate-consistent economic strategies. Recent research explains the impact of policy-based interventions on financial participants and the market behavioral change. Ahlstrom and Monciardini (2022) show that the introduction of sustainable finance policies in the European Union has resulted in both developments and conflicts, showing how institutional forces influence the theory of putting the theory into practice. Setyowati (2023) demonstrates that the effectiveness of the implementation of sustainability-oriented financial mechanisms is also predetermined by

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governance structures in emerging economies, which speaks of the versatility of the theory in the context of different institutional settings. These contemporary tests put emphasis on the fact that sustainable finance is not just a normative ideal but an institutionalized structure that is adjusted with the shift in policy settings.

The applicability of the theory to the current work is that the theory focuses on the effects of the financial structures, regimes, and the quality of institutions as it affects both environmental and economic performance. The Sustainable Finance Theory assumes that the efficacy of environmentally-oriented investment is determined by the correspondence between financial innovation, governance structures, and the sustainability aims in general. This idea is supported by recent empirical knowledge. Research has shown that sustainable finance systems influence investment choices, risk allocation and corporate conduct, which impact directly on environmental achievement and green economic revolution (Cremasco & Boni, 2024; Sajid et al., 2023). Additionally, studies explain that financialization and technological strengths in relation to climate conditions engage with sustainability systems to decide whether the financial systems alleviate or intensify the environmental stresses (Li et al., 2022). These results indicate that sustainable finance represents a theoretical and practical framework according to which the distribution of green capital and the promotion of environmental efficiency can be perceived. Sustainable Finance Theory is the conceptual framework of this study because it provides a detailed account of how the environmentally related economic activity is directed by financial, regulatory, and institutional factors. It sheds light on the processes by which modern financial ecosystems can affect sustainable development outcomes and gives a consistent analytical framework on how to analyze the dynamics behind the topic of the research.

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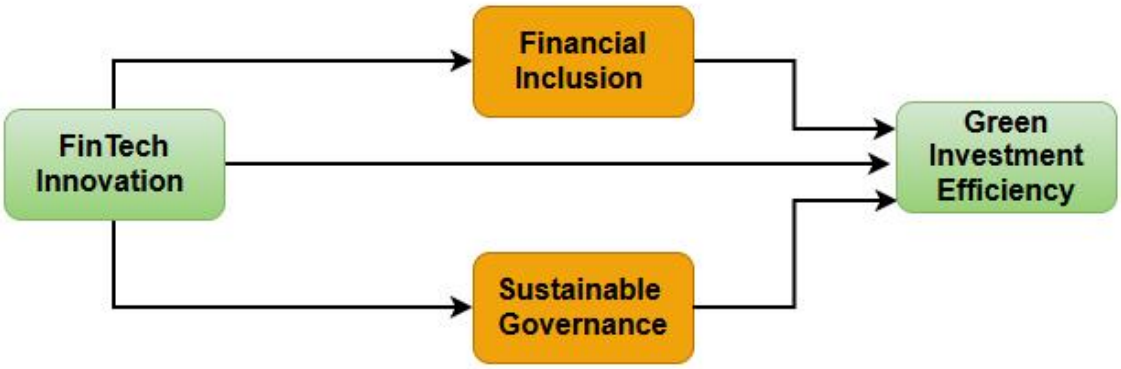

Figure 1: Research Model

Hypotheses

Advances in digital financial technologies have become increasingly intertwined with global sustainability agendas, particularly as financial systems transition toward mechanisms that prioritize efficiency, transparency, and environmentally responsible investment. Researchers note that new directions of ecological change have been established in the distribution of capital by financial actors through regulatory changes and institutional transformations in the frameworks of sustainable finance (Ahlstrom and Monciardini, 2022; Setyowati, 2023). In this dynamic condition, current empirical studies note that digital financial infrastructures have the potential to widen the pace of sustainability orientated investment by extending information flow, reducing transaction costs, and increasing access to environmentally friendly financial products (Al Doghan & Chong, 2023; Hou et al., 2024). The Sustainable Finance Theory confirms this opinion by assuming that the efficiency of the environmentally oriented capital allocation that is supported by the innovation of the financial system can be reinforced in case of efficient governance (Sajid et al., 2023). Nevertheless, even with an increasing consensus, research findings are mixed in contexts, with certain researchers indicating that technological progress can lead to an unequal level of investment in case regulatory structures are not robust enough (Cremasco

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and Boni, 2024; Li et al., 2022). Such discussions emphasize the importance of the empirical confirmation of the mechanisms according to which the technological changes determine the effectiveness of the environmental investment.

Similar academic debates consider how technologically improved financial systems can overcome the traditional obstacles to financing environmental projects such as information asymmetry, low participation of investors and inefficiencies in deploying green capital. There is an indication that ecosystems of digital finance enhance the quality of investment decisions, the allocation of funds in an environmentally responsible manner, and sustainable growth paths in various economies (Deng et al., 2024; Teng and Shen, 2023; Muhammad et al., 2022). Moreover, research also shows that financial technologies may help to increase monitoring, uncertainty reduction, and green investment pipelines, which will lead to more efficient investment processes (Lv & Xiong, 2022; Sadiq et al., 2024). These understandings echo with theoretical postulation that structural innovations in finance provide the enabling conditions to achieve more successful sustainability outcomes. Based on this theoretical rationale and empirical findings, there is a direct positive relationship that is anticipated between the level of technological development in the financial systems and the effectiveness of a more environmentally friendly investment. Therefore, it is hypothesized that:

H1: FinTech innovation positively influences green investment efficiency.

FinTech innovation has emerged as a transformative mechanism that reshapes financial systems, enhances transparency, and accelerates the allocation of capital toward sustainable activities. Recent literature demonstrates that FinTech services like online payments, blockchain, and algorithmic credit evaluation are the key to enhancing the efficiency of the financial sector and facilitating sustainable financial transitions (Al-Okaily et al., 2021; Muhammad et al., 2022; Magableh et al., 2025). With the increased

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regulatory and market pressures, sustainable finance mechanisms based on FinTech have become significant worldwide, which contributes to the necessity of inclusive financial ecosystems that facilitate the proliferation of green investments (Ahlstrom and Monciardini, 2022; Setyowati, 2023). Empirical evidence is rapidly accumulating to point to the fact that FinTech has a positive effect on environmental and investment performance, namely it increases financial inclusion, that is, the access of individuals and firms to formal financial services (Liu et al., 2022; Hou et al., 2024). Increased financial inclusion lowers the barriers to financing, ease of access to credit, and makes it possible to engage more deeply in green financial instruments, making the effective application of environmentally oriented investments more efficient (Sajid et al., 2023; Zhang et al., 2024). This mechanism is particularly crucial in the case of emerging economies when the financing gap can become an impediment to the smooth transfer of funds into green technologies and low-carbon development investments (Rani et al., 2025; Wang et al., 2024).

Empirical evidence also indicates that FinTech innovation reinforces the breadth and depth of financial accessibility, serves digital credit markets, green lending platforms, and products that increase the efficiency of green investments (Guang-Wen and Siddik, 2023; Lv and Xiong, 2022; Deng et al., 2024). An example is that credit scoring models, which are enabled by FinTech, and digital inclusion platforms mitigate information asymmetry and enhance the chance that environmentally positive projects are properly funded (Bongomin et al., 2018; Zhou et al., 2022). Besides, digital financial inclusion improves the ability of firms and households to engage in sustainable investment ecosystems to guarantee that the green financial flows are used more efficiently (Li et al., 2022; Sadiq et al., 2024). Through the reduction of gaps in financial access, FinTech, in turn, leads to the efficiency of green investment decisions, which are consistent with the overall timeline of sustainable finance reform to enhance the quality of the environmental

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outcome (Cremasco and Boni, 2024; Al Doghan and Chong, 2023). With this evidence, financial inclusion is a focal route whereby FinTech innovation determines the efficiency of green investments. FinTech solutions need not necessarily lead directly to environmentally efficient investment performance: they can achieve their effect by making financial systems more accessible, affordable, and engaging in green financing. Therefore, financial inclusion is likely to mediate the connection between FinTech innovation and green investment efficiency. The following hypothesis is proposed:

H2: Financial inclusion mediates the relationship between FinTech innovation and green investment efficiency.

Sustainable governance has become a central pillar in shaping the trajectory of modern financial systems, particularly as economies pursue strategies that align technological transformation with environmental responsibility. Regulatory frameworks, institutional quality, transparency and sustainability-oriented oversight are governance structures that determine the effectiveness of financial innovations to produce environmentally efficient investment outcomes (Ahlstrom and Monciardini, 2022; Setyowati, 2023). With the increasing pace of FinTech applications in financial markets, its capability to favor green investing results is more and more determined by the existence of powerful governance systems that guarantee accountability, regularization, and alignment with the sustainability goals (Cremasco & Boni, 2024; Magableh et al., 2025).

FinTech innovations have the potential to optimize the governance procedures through the increase of the availability of information, the enhancement of monitoring capabilities, and the possibility of real-time data-based assessment of environmental hazards (Muhammad et al., 2022; Deng et al., 2024). Digital solutions like blockchain systems, artificial intelligence, and green digital platforms offer systems of enhancing transparency and mitigating information asymmetry, which will support governance systems intended to guide capital to environmentally responsible activities (Khan et al.,

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2025; Lv and Xiong, 2022). These improvements to governance play an important role in improving legitimacy, integrity, and performance of green investment ecosystems, specifically where markets are exposed to institutional voids or fewer regulations (Sajid et al., 2023; Li et al., 2022). Research also indicates that sustainable governance is a moderator and mediator of the association between financial technologies and the environmental performance. The empirical evidence demonstrates that the increase in transparency and reporting facilitated by FinTech results in the overall increase in adherence to sustainability policies, the decrease in the risk of greenwashing, and the implementation of environmental accountability mechanisms (Bonsu et al., 2025; Hidayat-ur-Rehman, 2025). In the same way, the sustainability-based systems of governance like environmental disclosure frameworks, sustainability leadership, and sustainability practices in organizations strengthen the decision-making process that emphasizes the efficiency of green investment (Al-Zawahreh et al., 2019; Balasubramanian and Balaji, 2022). These systems will allow the well-directed flow of FinTech-enabled financial streams to credible and meaningful green projects instead of speculative or misaligned investments.

Moreover, the governance systems become a channel through which FinTech innovations can impact the rest of the sustainability environment. There is an indication that efficient environmental management enhances the connection between FinTech use and the performance of green investment by making sure that the technological advancement is incorporated into organized structures of sustainability (Ren et al., 2024; Sadiq et al., 2024). Simultaneously, the mechanisms of digital governance will help to enhance the accountability and the capacity of firms to meet sustainability standards, making green investments more efficient (Guang-Wen and Siddik, 2023; Wang et al., 2024). In these processes, sustainable governance will transform technological benefits of FinTech into practical environmental investment results, which strengthens its role as a key mediating process. All these facts

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point to the fact that sustainable governance has a significant role in converting FinTech innovation into an effective green investment. FinTech instruments create the technological ability of sustainability integration, and governance structures offer the structural and institutional procedures that would inform, authorize and streamline such investments. Based on this, sustainable governance is anticipated to mediate the association between FinTech innovation and green investment efficiency. The following hypothesis is proposed:

H3: Sustainable governance mediates the relationship between FinTech innovation and green investment efficiency.

Methodology

This study adopts a quantitative, cross-sectional research design to examine the relationships among FinTech innovation, financial inclusion, sustainable governance, and green investment efficiency. Quantitative methodology will be appropriate to test theory-based hypotheses and assess latent constructs by the use of statistically observable measures to ensure objectivity, reproducibility, and analytical accuracy (Hair et al., 2022). The cross-sectional design allows collecting data at one point in time to model the complex structural relationships and is suitable in the situations when the variables are considered relatively stable in the short-term (Creswell and Creswell, 2023). Recent methodological research also suggests cross-sectional quantitative designs as the study of financial technologies, sustainability outcomes, and governance-related constructs since it focuses on generalized empirical data and multivariate analysis (Gurdur & Aslan, 2022). Therefore, the design will offer a strict base on which to evaluate the combined impact of FinTech innovation in sustainable financial systems.

The population to be targeted includes managers, financial officers, sustainability officers, and investment decision-makers who are either in the environmentally sensitive industries or work in the industrial sector where a majority of industries are energy consuming and polluting, like chemicals,

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textile, machinery, and food processing industries. These are particularly pertinent sectors since they often have a green investment practice, fall under the sustainability reporting regulations, and are increasingly adapting digital financial technologies (Hou et al., 2024; Wang et al., 2024). The purposive sampling approach is adopted to make sure the respondents are knowledgeable enough in organizational finance, technological applications, and sustainability decision-making procedures. The choice of the sample size is made on the basis of the recommendations of the Item Response Theory (IRT) that state that the minimum number of observations that must be used to conduct a latent variable model is 10-15 observations per item in order to guarantee the stability of the parameters and the absence of bias in the estimation (De Ayala, 2022). Considering the overall size of measurement items, a sample size of about 350 respondents is considered sufficient, which aligns with the best practices in structural equation modelling (Hair et al., 2022) and the analysis utilised 303 responses, since some of the questionnaires lacked responses to certain questions. The SPSS and SmartPLS are used to conduct data analysis in two phases.

Measurements

Everything is rated using a 7-point Likert scale of 1 = strongly disagree through 7 = strongly agree in accordance with existing guidelines on capturing subtle attitudinal and perceptual data in sustainability and financial studies (Hair et al., 2022). The validated, theory-based scales are used to operationalize all constructs in the study adapted to the previous scholarly works. The FinTech innovation is assessed with the help of a four-item scale based on Al-Okaily et al. (2021). The financial inclusion incorporates five questions that have been modified according to Liu et al. (2022). The measurement of sustainable governance is five-item scale, according to Balasubramanian and Balaji (2022) and Ahlstrom and Monciardini (2022). The scale of green investment efficiency is measured with a six-item scale that was modified by Ren et al. (2024) and Hou et al. (2024).

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Data Analysis

Table 1: ***Regression Weights***

Variables		FI	FT	GI	SG
Financial Inclusion	**FI1**	0.771			
	FI2	0.850			
	FI3	0.855			
	FI4	0.724			
	FI5	0.834			
FinTech Innovation	**FT1**		0.903		
	FT2		0.912		
	FT3		0.925		
	FT4		0.867		
Green Investment Efficiency	**GI1**			0.875	
	GI2			0.908	
	GI3			0.871	
	GI4			0.918	
	GI5			0.854	
	GI6			0.862	
Sustainable Governance	**SG1**				0.838
	SG2				0.842
	SG3				0.837
	SG4				0.858
	SG5				0.859

The loading of factor items displayed in all four constructs is above the widely recognized standard (0.70) which means that the indicator reliability and the item-construct relationships were satisfactory (Hair et al., 2022). Financial Inclusion shows a range of loadings of 0.724 to 0.855 that indicates steady convergent validity and that the respondents have a clear differentiation

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among the different dimensions of access, use, and quality of financial services. Loadings of FinTech Innovation are extremely high (0.867-0.925), which demonstrates that the indicators represent an internally consistent construct as well as the level of technological maturity and the degree of adoption that is inherent in the financial processes of firms. In the same way, Green Investment Efficiency has high loadings between 0.854 and 0.918, which means that measurement items capture well the ability of firms to invest in environmentally efficient results, as per the current measurement standards in the sustainability studies (Li et al., 2022). The loadings of Sustainable Governance are 0.837 to 0.859, and it can be concluded that there is a strong internal consistency and correspondence to the theory in terms of organizational governance structures that facilitate sustainable practices (Cremasco & Boni, 2024).

Table 2: ***Reliability Analysis***

	Cronbach's alpha	**(rho_a)**	**(rho_c)**	**(AVE)**
Financial Inclusion	0.866	0.868	0.904	0.654
FinTech Innovation	0.924	0.927	0.946	0.814
Green Investment Efficiency	0.943	0.944	0.954	0.777
Sustainable Governance	0.901	0.902	0.927	0.717

All constructs have good psychometric quality in the form of the statistics of reliability and convergent validity. The value of alpha and rhoA of each variable are above the 0.70 mark, which indicates high internal consistency and stability of the measurement items (Hair et al., 2022). The composite reliability (rhoC) values are between 0.904 and 0.954 and this is an additional indication of precision in measuring the constructs and low measurement error. The total constructs values of the Average Variance Extracted (AVE) exceed the recommended minimum of 0.50, ranging between 0.654 and 0.814.

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This demonstrates a high convergent validity, that is, a large percentage of each set of indicators explains a lot of variances of the corresponding construct (Hair et al., 2022).

Table 3: ***Discriminant Validity***

	FI	FT	GI	SG
Financial Inclusion				
FinTech Innovation	0.462			
Green Investment Efficiency	0.441	0.596		
Sustainable Governance	0.494	0.656	0.617	

The correlations among the constructs indicate meaningful and theoretically consistent relationships. Financial Inclusion demonstrates the moderate positive correlations with FinTech Innovation (r = 0.462), Green Investment Efficiency (r = 0.441), and Sustainable Governance (r = 0.494), indicating that financially inclusive systems are more likely to be accompanied by technological progress, investment behavior that is environmentally friendly, and improved governance systems. FinTech Innovation can be most closely related with Sustainable Governance (r = 0.656), then with Green Investment Efficiency (r = 0.596), which suggests that innovative financial technologies are strongly associated with governance practices that place sustainability in the first place and with investments that enhance the environmental performance. Also, there exists positive correlation between Green Investment Efficiency and Sustainable Governance (r = 0.617), whereby companies with better sustainability-oriented governance systems have a better opportunity of investing resources into efficient green investments.

Table 4: ***Model Fitness Values***

	Saturated model	Estimated model
SRMR	0.056	0.073
d_ULS	0.663	1.108
d_G	0.407	0.420

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Chi-square	719.002	723.905
NFI	0.856	0.855

The model fit indices indicate that the structural model demonstrates an overall acceptable level of fit according to established PLS-SEM criteria. The SRMR values for both the saturated model (0.056) and the estimated model (0.073) fall below the recommended upper threshold of 0.08, suggesting a satisfactory approximation between the observed and model-implied correlations (Hair et al., 2022). The d_ULS and d_G values for the saturated and estimated models are also within reasonable proximity, indicating that the discrepancies between empirical and predicted covariance matrices are not substantial. The chi-square values for both models are comparable, reflecting stability in model estimation, although chi-square itself is known to be sensitive to sample size. The NFI indices for the saturated (0.856) and estimated (0.855) models exceed the commonly referenced minimum acceptable level of 0.80, demonstrating that the proposed model provides a good incremental fit relative to a null model.

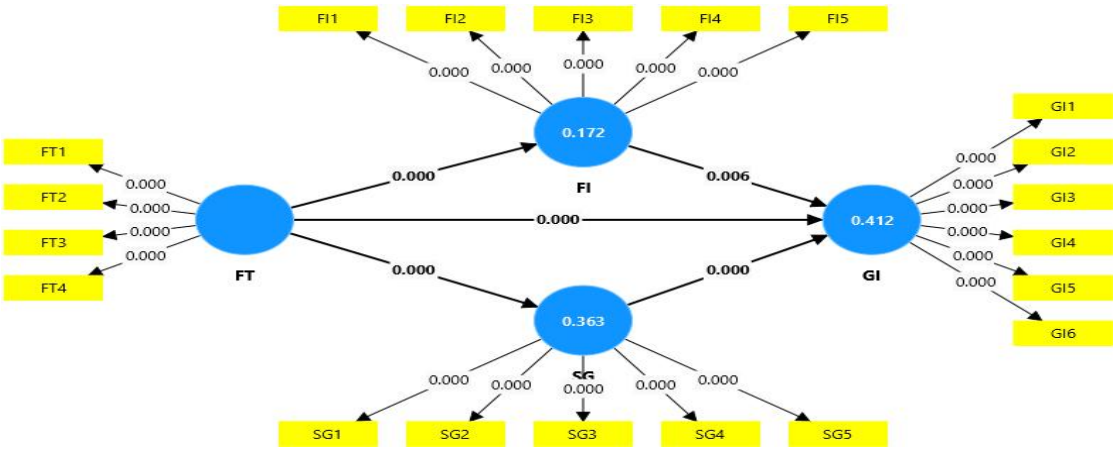

Table 5: ***Hypotheses Results***

	Original sample (O)	**Standard deviation**	**T statistics**	**P values**
FT -> GI	0.304	0.062	4.886	0.000
FT -> FI -	0.055	0.022	2.498	0.013

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> GI				
FT -> SG -> GI	0.199	0.043	4.668	0.000

The structural path results indicate that FinTech Innovation has a significant and positive direct effect on Green Investment Efficiency (β = 0.304, $p < .001$), demonstrating that technological advancements in financial services enhance firms' capacity to allocate resources efficiently toward environmentally sustainable investments. The indirect effect through Financial Inclusion is also significant (β = 0.055, $p = .013$), confirming that FinTech Innovation promotes Green Investment Efficiency partly by expanding access, usage, and quality of financial services thereby strengthening the mediating role of Financial Inclusion. Sustainable Governance exhibits a strong and significant mediating effect (β = 0.199, $p < .001$), suggesting that governance structures aligned with sustainability principles amplify the positive influence of FinTech Innovation on green investment outcomes.

Discussion

This study examined how FinTech innovation influences green investment efficiency and whether financial inclusion and sustainable governance function as mediating pathways. The findings show a significant positive direct effect of FinTech on green investment efficiency, alongside two significant indirect effects: a smaller but meaningful mediation through financial inclusion and a larger mediation via sustainable governance. These results are interpreted hypothesis by hypothesis in the following discussion, with respect to the Sustainable Finance Theory and recent empirical studies. FinTech innovation has a positive direct impact on the efficiency of green investments (H1) in accordance with theoretical assumptions that technological innovations in the sphere of financial intermediation reduce the costs of transactions, enhance information flows, and facilitate the effective matching of capital to productive green projects (Zhou et al., 2022; Lv and Xiong, 2022). Our finding, empirically, is in line with other studies that found

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digital financial tools, digital payments, algorithmic credit scoring, and platform finance enabled faster and more precise investment decisions and increased the capacity of firms to find and fund opportunities that are productive in the environment (Teng and Shen, 2023; Muhammad et al., 2022). Regarding the Sustainable Finance Theory, FinTech is an enabling financial design capable of repositioning capital towards the goals of sustainability given that technological opportunities are used to reduce the frictions that tend to hinder green investment (Sajid et al., 2023). The size and importance of the direct effect in the present research indicate that, despite having considered the mediating institutional processes, FinTech offers quantifiable efficiency benefits in the way green capital is distributed and deployed a conclusion which validates earlier studies that have found out the direct impact of FinTech on enhancing investment efficiency (Lv et al., 2022; Zhou et al., 2022).

Financial inclusion (H2) as a mediating factor was also supported but relatively small and suggested that some of the positive impact of FinTech on green investment efficiency is mediated through access to financial services. The mechanism is consistent with the logic that inclusive financial systems would expand the group of prospective investors and borrowers, the exclusion-based bottlenecks to small and medium enterprises, and the increase in the liquidity of the viable green projects (Liu et al., 2022; Hou et al., 2024). The importance of such an indirect route supports the research that reveals that financial inclusion is one of the avenues through which digital finance can affect sustainability outcomes (Al Doghan and Chong, 2023; Zhang et al., 2024). The comparatively low mediated effect, in its turn, could be a contextual constraint: in most contexts, the quality of inclusion initially increases the scope of access, but might not automatically turn into large-volume and high-quality green investments without additional incentives, product design, or financial literacy (Bongomin et al., 2018; Hidayat-ur-Rehman, 2025). That is, access can be democratized using FinTech, but to

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translate the access into effective, large-scale green investment, other capacity-building, green financial products, or risk-sharing factors are often needed, which mitigate the magnitude of financial mediation of inclusion that is evident here (Sadiq et al., 2024; Rani et al., 2025).

The concept of sustainable governance (H3) proved to be a better mediator than financial inclusion, which suggests that the structures of governance regulate regulatory clarity, disclosure standards, institutional supervision, and anti-greenwashing mechanisms have a decisive role in transforming FinTech capabilities into effective green investments. This finding aligns with recent studies that have determined that regulatory frameworks and governance dynamics have an important impact on the efficacy of sustainable finance reforms (Ahlstrom and Monciardini, 2022; Cremasco and Boni, 2024). Filled with rich datasets, better traceability, and higher monitoring capabilities, FinTech tools are prone to be misapplied or bring few environmental advantages, unless they are credibly governed to set standards, verify effects, and hold people accountable (Setyowati, 2023; Li et al., 2022). In this field, empirical research focuses on the fact that the positive environmental impact of FinTech is reinforced through governance enhanced environments, institutionalizing transparency and incompatibility of incentives to generate green results (Ren et al., 2024; Sadiq et al., 2024). The relatively higher mediation through governance of our results is arguably due to the pivotal role of institutional quality in transforming FinTech-based informational benefits into legitimacy and high-impact green investments highlighting that technology is not only needed but also required to achieve sustainability benefits. These hypothesis-based interpretations support a theoretical view where FinTech is an enabling factor whose effects on the efficiency of environmental investment depend on systemic factors especially the quality of governance and to a lesser extent the inclusive access. In practice, the findings imply that policymakers and the leaders of the financial sector must go down both avenues: encourage the innovations of FinTech, but

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enhance the regulatory frameworks (disclosure regulations, supervision systems) and develop inclusive green financial solutions that would direct the positive outcomes of the expanded access to effective green capital utilization (Ahlstrom and Monciardini, 2022; Al Doghan and Chong, 2023; Liu et al., 2022).

Many caveats moderate these conclusions which are methodological and contextual. The cross-sectional design restricts causal reasoning and might not resolve individual adaptation of changes at different time periods, including how original-inclusion advantages in the future lead to greater resulting green investment communicability (Hair et al., 2022). The energy-intensive manufacturing sectoral concentration in measurement and context may also be key to effect sizes; hopefully the governance-mediated pathway might be even more important in jurisdictions with underdeveloped governance (Setyowati, 2023; Wang et al., 2024). Longitudinal studies and intercountry comparisons would facilitate in decoupling both temporal sequencing as well as institutional heterogeneity. These constraints notwithstanding, the study provides evidence that FinTech sustainability potential is realized via the institutional means, including governance first of all, and presents an empirically based roadmap to the realization of the technological innovation and efficient sustainable finance policy (Zhou et al., 2022; Cremasco & Boni, 2024).

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