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# The economic impact of fintech adaptation on sustainable banking performance: The role of green finance and innovation in Indonesia

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**Abstract**
This study examines the economic impact of fintech adaptation on sustainability performance in the Indonesian banking sector, with green finance and green innovation as mediating variables. A quantitative research approach was employed, utilizing secondary data from six Indonesian banks listed on the Indonesia Stock Exchange (IDX) from 2019 to 2023. Path analysis was applied to evaluate to assess relationships among fintech adaptation, green finance, green innovation, and sustainability performance. The findings reveal that fintech adaptation significantly influences green finance but has a limited impact on green innovation and direct sustainability performance. Additionally, green finance and green innovation do not significantly mediate the relationship between fintech adaptation and sustainability performance. These results highlight the challenges of integrating fintech into sustainable banking initiatives in emerging markets. The study underscores the need for enhanced regulatory frameworks, strategic fintech adoption, and increased collaboration among financial institutions to drive sustainability efforts. Future research should explore additional factors influencing sustainability performance in banking.

Keywords: Fintech Adaptation, Sustainability Performance, Green Finance, Green Innovation, Sustainable Development.

**Abstrak**
Penelitian ini mengkaji dampak ekonomi dari adaptasi fintech terhadap kinerja keberlanjutan di sektor perbankan Indonesia, dengan green finance dan green innovation sebagai variabel mediasi. Pendekatan kuantitatif digunakan dalam penelitian ini dengan data sekunder dari enam bank Indonesia yang terdaftar di Bursa Efek Indonesia (BEI) selama periode 2019 hingga 2023. Analisis jalur diterapkan untuk mengevaluasi hubungan antara adaptasi fintech, green finance, green innovation, dan kinerja keberlanjutan. Hasil penelitian menunjukkan bahwa adaptasi fintech secara signifikan memengaruhi green finance, tetapi memiliki dampak terbatas pada green innovation dan kinerja keberlanjutan secara langsung. Selain itu, green finance dan green innovation tidak secara signifikan memediasi hubungan antara adaptasi fintech dan kinerja keberlanjutan. Hasil ini menyoroti tantangan dalam mengintegrasikan fintech ke dalam inisiatif perbankan berkelanjutan di pasar negara berkembang. Studi ini menekankan pentingnya kerangka regulasi yang lebih kuat, adopsi strategis fintech, dan peningkatan kolaborasi antar lembaga keuangan untuk mendorong keberlanjutan.

Kata kunci: Adaptasi Fintech, Kinerja Keberlanjutan, Green Finance, Green Innovation, Pembangunan Berkelanjutan.

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## 1. Introduction

The evolution of industrial revolutions, from the mechanization of Industry 1.0 in the 1700s to the human-machine collaboration of Industry 5.0, has significantly transformed global industries. Each phase of this progression has driven innovation, efficiency, and adaptation, reshaping economic and technological landscapes. The latest industrial paradigm, Industry 5.0, emphasizes advanced technologies like cognitive computing while maintaining the critical role of human involvement in production processes. These transformations highlight the necessity for industries, including banking, to integrate advanced technologies to address global challenges such as poverty alleviation and sustainability (Kumar Varshney et al., 2024; Luis-Pineda, 2024). In the banking sector, this has manifested in adopting green finance and Fintech, reshaping financial services, and aligning them with sustainability goals.

Green finance has emerged as a vital tool for promoting sustainability in the banking industry by directing investments toward environmentally friendly projects. This approach enhances environmental outcomes and improves profitability and risk management for financial institutions (Abuatwan, 2023; Basmar et al., 2024)). Regulatory frameworks further encourage transparency and the integration of sustainability into business models, enabling banks to tap into new market opportunities and attract environmentally conscious investors and consumers (Park & Kim, 2020). Alongside green finance, green innovation drives the development of sustainable business practices by fostering innovative approaches to environmental challenges. However, the effectiveness of these initiatives is increasingly tied to the adoption and adaptation of financial technology (Fintech), which plays a critical role in modernizing and streamlining banking operations.

As a transformative force in the financial sector, Fintech facilitates the integration of green finance and green innovation by enabling more efficient, transparent, and sustainable economic practices. Prior research highlights its ability to enhance operational efficiency while supporting circular economy initiatives, helping institutions achieve long-term sustainability goals (Vergara & Agudo, 2021; Siddik et al., 2023). Furthermore, Fintech has been linked to the expansion of green finance, providing opportunities for industrialized nations to drive sustainable growth (Pawłowska et al., 2022). Despite these promising findings, there remains a lack of comprehensive studies examining the interplay between Fintech, green finance, green innovation, and sustainability performance, particularly in emerging markets like Indonesia.

The Indonesian banking industry faces unique challenges as it seeks to align with global sustainability agendas, including the Sustainable Development Goals (SDGs) and the Paris Agreement (Maryantia et al., 2024). Many institutions need help to effectively integrate Fintech into sustainable banking frameworks, highlighting a critical research gap. Although previous studies have explored the individual impacts of Fintech, green finance, and green innovation, the mechanisms by which fintech adaptation fosters sustainable performance through green finance and innovation still need to be explored (Sule et al., 2024). This lack of understanding limits the ability of

financial institutions in Indonesia to fully leverage Fintech's potential in achieving sustainability objectives.

Several studies have examined the relationship between green finance and sustainability performance, producing mixed results. Mandagie et al. (2024) found that green finance significantly enhances corporate sustainability performance by encouraging firms to invest in environmentally friendly projects. Similarly, Li & Yang (2022) demonstrated that companies with higher green finance investments achieve better financial and environmental performance due to regulatory support and market incentives. However, Yafie et al. (2024) found that while green finance contributes to environmental sustainability, its impact on financial performance in the banking sector remains relatively minor. Pawłowska et al. (2022) highlighted the moderating role of green finance in aligning financial strategies with sustainability goals, reducing investment risks, and attracting ESG-conscious investors. On the other hand, Yadav et al. (2024) argued that the effectiveness of green finance depends on proper implementation and governance structures, emphasizing that weak regulatory frameworks can limit its impact on sustainability outcomes. These findings suggest that while green finance generally supports sustainability performance, its effectiveness varies based on institutional policies, market conditions, and regulatory mechanisms.

Empirical research on green innovation has also yielded diverse conclusions regarding its influence on sustainability performance. Liu et al. (2022) found that green innovation significantly enhances sustainability performance by reducing carbon emissions and improving operational efficiency. Albort-Morant et al. (2017) emphasized that firms investing in green innovation enjoy competitive advantages, improved market positioning, and enhanced corporate reputation. However, Ren et al. (2024) demonstrated that green innovation leads to better sustainability performance only when supported by strong corporate governance and financial backing. Fan & Zhou (2023) found that while green innovation fosters long-term sustainability, many firms face economic constraints and technological barriers that hinder successful implementation. Similarly, Alhomaid & Lefi (2024) highlighted that the success of green innovation strategies depends on management leadership, regulatory incentives, and industry collaboration. These studies suggest that while green innovation positively correlates with sustainability performance, its impact is contingent on financial resources, government policies, and organizational capabilities.

The impact of fintech adaptation on green finance has been explored in multiple studies, confirming a positive relationship. Guang-Wen & Siddik (2023) found that fintech significantly boosts green finance initiatives by increasing the efficiency, transparency, and accessibility of green investments. Siddik et al. (2023) demonstrated that digital financial technologies, such as blockchain, AI, and mobile banking, enhance green finance effectiveness by minimizing transaction costs and improving risk assessment for sustainable projects. Similarly, Vergara & Agudo (2021) emphasized that fintech promotes financial inclusion, allowing small and medium enterprises (SMEs) to access green financing and encouraging greater environmental responsibility. Allahham et al. (2024) found that fintech-based lending platforms

improve green finance adoption rates by offering tailored financial products for sustainable investments. Although regulatory challenges still exist, Moro-Visconti et al. (2020) suggested combining fintech and green finance can lead to significant environmental and social benefits. These findings confirm that fintech positively influences green finance, but its effectiveness depends on technological infrastructure, financial literacy, and regulatory frameworks.

The role of fintech adaptation in driving green innovation has been explored in several studies with varying conclusions. Ni et al. (2023) demonstrated that fintech adoption supports green innovation by facilitating investment in eco-friendly technologies, particularly in emerging economies. Wang et al. (2023) found that fintech-driven data analytics improve green innovation processes by providing real-time environmental impact assessments. Alsadoun & Alrobai (2024) emphasized that fintech enables financial institutions to develop and implement green financial products, stimulating sustainable business practices. Alshdaifat et al. (2024) highlighted that fintech innovations, such as blockchain and the Internet of Things (IoT), improve supply chain sustainability and enhance transparency in green finance transactions. However, Xue et al. (2022) found that fintech adaptation contributes to technological advancements that drive green innovation, but its impact is limited in industries with low digital adoption rates. These findings suggest that while fintech has the potential to enhance green innovation, barriers such as high implementation costs and regulatory uncertainty remain key challenges.

The relationship between fintech adaptation and sustainability performance has been widely studied, producing mixed findings. Joshi & Karmacharya (2024) found that fintech adoption significantly improves sustainability performance by increasing financial inclusion, reducing carbon footprints, and optimizing resource allocation. Similarly, Al Doghan & Chong (2023) demonstrated that fintech contributes to sustainability performance by enhancing green investment strategies and reducing operational inefficiencies. Hommel & Bican (2020) highlighted that fintech enhances corporate sustainability by offering innovative financial solutions such as carbon trading, digital payment platforms, and AI-driven sustainability assessments. However, Chen et al. (2024) argued that while fintech can potentially drive sustainability, its success depends on the availability of digital infrastructure and government incentives. Vergara & Agudo (2021) noted that while fintech positively influences sustainability performance, many companies struggle to align fintech innovations with long-term sustainability goals. These findings suggest that fintech adaptation positively but indirectly impacts sustainability performance, requiring supportive regulations and corporate strategies for effective implementation.

Despite extensive research on fintech adaptation, green finance, green innovation, and sustainability performance, several gaps remain unaddressed. First, most studies focus on developed economies, while research on fintech and sustainability in emerging markets, such as Indonesia, remains limited. Second, previous studies often examine these relationships separately, whereas the combined impact of fintech adaptation, green finance, and green innovation on sustainability performance has not

been sufficiently explored. Third, contradictory findings exist regarding fintech's role in driving sustainability, with some studies highlighting significant benefits while others emphasize technological and regulatory barriers. Fourth, the role of green innovation as a mediating variable in the relationship between fintech adaptation and sustainability performance remains inconclusive. Lastly, previous studies generalize results across industries, whereas sector-specific research, particularly in banking, is still developing. Addressing these research gaps, this study aims to provide a more comprehensive understanding of how fintech adaptation, green finance, and green innovation collectively influence sustainability performance in the Indonesian banking sector.

Addressing these gaps, this study investigates the influence of fintech adaptation on sustainability performance in the Indonesian banking sector, with green finance and green innovation as mediating variables. The research aims to assess the impact of green finance and green innovation on sustainability performance, analyze the role of Fintech in driving these initiatives, and explore how fintech adaptation can mediate their effects on sustainability outcomes. By doing so, this study contributes to a deeper theoretical and practical understanding of sustainable banking practices, offering actionable insights for policymakers and industry leaders. It underscores the transformative potential of integrating Fintech, green finance, and green innovation to balance financial profitability and environmental stewardship in Indonesia's banking sector.

## 2. Literature Review

### Sustainability Performance

Sustainability performance refers to an organization's ability to achieve its business objectives while maintaining long-term responsibility toward economic, environmental, and social dimensions. This performance is framed by the triple bottom line—economic growth, social equity, and environmental stewardship—emphasizing a balance between financial achievements and broader sustainability goals (Al-Abbadi & Abu Rumman, 2023). Organizations are increasingly encouraged to adopt strategies beyond short-term profitability to ensure operational sustainability over (López-López et al., 2020). Measuring sustainability performance includes structured assessments of social aspects, such as equity and community engagement; economic aspects, such as sustainable growth; and environmental factors, focusing on resource efficiency and ecological impact minimization (Bouloiz, 2020). By integrating sustainability into their business models, organizations can enhance their competitive advantage, meet stakeholder expectations, and generate long-term value (Tarnovskaya, 2023).

### Green Finance

Green finance is a financial concept that promotes environmentally friendly investments and sustainable development by creating and distributing financial products and services (Afifah et al., 2023). It encompasses financing sustainable development projects, providing loans to businesses that align with environmental principles. From a sustainability perspective, green finance supports government

objectives, such as reducing reliance on conventional bioenergy and increasing the share of renewable energy resources (Wahyudi et al., 2023). A critical component of green finance is providing financial support for environmentally focused innovations, such as adopting resource-efficient technologies and clean energy solutions (Krastev & Krasteva-Hristova, 2024). Instruments like green bonds and loans are vital for promoting sustainable industrialization, infrastructure, and innovation (Fu et al., 2023). Studies indicate that green finance fosters the growth of eco-friendly technologies and small-scale green businesses while contributing to significant carbon emission reductions, thus improving environmental quality (Zhao et al., 2024). By addressing pressing environmental challenges and promoting a sustainable future, green finance emerges as a cornerstone for achieving Sustainable Development Goals (SDGs) and fostering a greener, more inclusive global economy.

**Green Innovation**

Green innovation is developing and implementing new products, services, or processes to mitigate or eliminate negative environmental impacts. It emphasizes balancing economic growth with resource and environmental sustainability while creating synergies between development and ecological preservation (Zou & Feng, 2024). Green innovation involves designing efficient products, improving production processes to reduce energy consumption and pollution, and adopting organizational environmental management systems (Marietza & Nadia, 2021). This approach is also a strategic business initiative, offering competitive advantages, market expansion opportunities, and sustainable product development (Guinot et al., 2022). While green innovation provides numerous benefits, its implementation often needs to be improved, including high costs, limited knowledge, and resistance to change, coupled with an underdeveloped market for green products (Shahzad et al., 2022). Despite these hurdles, green innovation remains a critical strategy for achieving sustainable development by simultaneously reducing environmental impacts and enhancing organizational competitiveness.

**Fintech Adaptation**

Fintech, or financial technology, represents the integration of modern technologies into financial services to provide more efficient, accessible, and customer-oriented solutions (Siddiqui & Rivera, 2022). Combining information and communication technologies with traditional financial services, fintech delivers faster, cost-effective, and flexible financial solutions across investment, risk management, payment systems, data security, and customer interfaces (Arner et al., 2015). The adaptation of fintech involves traditional financial institutions integrating and adopting new technologies into their operations to improve efficiency, innovation, and competitiveness (Treu, 2022). This process requires significant changes in business models, operational processes, and organizational culture to accommodate technological advancements in the financial sector. Fintech's ability to enhance transparency, efficiency, and accessibility has positioned it as a transformative force in financial services, underscoring the importance of flexibility and sustainability-oriented innovation in the evolving financial landscape (Cheumar & Yunita, 2022).

Integrating fintech with sustainability-focused initiatives like green finance and innovation holds significant potential for organizations aiming to achieve sustainable growth. By adopting fintech, financial institutions can streamline green finance activities, foster green innovation, and address the pressing demands of a more digitally connected and environmentally conscious world. These technologies enhance operational efficiency and create value aligned with the broader goals of environmental, social, and economic sustainability.

**The Influence of Green Finance on Sustainability Performance**

Green finance enhances organizational sustainability performance by aligning business strategies with environmentally friendly financial practices. Companies that embrace green finance can address stakeholder needs more effectively, fostering long-term relationships with suppliers, clients, and other stakeholders, ultimately boosting their financial performance (Ye & Dela, 2023). Green finance improves financial and environmental performance and ensures accountability for pollution-related costs. By providing necessary funding for sustainability projects, green finance empowers organizations to grow in environmentally conscious ways (X. Li & Yang, 2022).

Implementing green finance encourages organizations to prioritize sustainable investments, creating long-term value in profitability and social and environmental responsibility. By accelerating innovation, green finance enables businesses to transition toward more efficient and eco-friendly production methods (Nenavath & Mishra, 2023). Moreover, financial institutions play a crucial role in promoting sustainability practices by incentivizing companies with strong sustainability performance. These incentives often translate into lower borrowing costs for sustainable companies and higher costs for those with weaker sustainability metrics (Hauptmann, 2017).

Organizations that integrate environmental protection commitments into their operations, particularly in high-growth industries, are better positioned to enhance and sustain their performance through access to green finance (Ardillah, 2020). As a key driver of sustainable business strategies, green finance encourages organizations to adopt principles that ensure long-term sustainability in today's business landscape. This leads to the formulation of the H1: Green finance has a positive influence on sustainability performance.

**The Influence of Green Innovation on Sustainability Performance**

Green innovation directly impacts sustainability performance by enabling organizations to meet environmental demands and stakeholder expectations, which can improve environmental outcomes and reduce ecological risks. Through green innovation, companies can decrease pollutant emissions and mitigate adverse environmental impacts, enhancing their reputation, market share, and customer satisfaction—all of which contribute to improved sustainability performance (Liu et al., 2024).

Empirical evidence indicates that green innovation improves business performance by fostering the development of eco-friendly products, processes, and technologies.

These innovations elevate a company's value and reputation among stakeholders and create competitive advantages in the marketplace (Yan et al., 2024). Organizations that implement green innovation consistently achieve better resource productivity, cost reductions, and emission decreases, improving industrial and environmental performance (L. Zhang et al., 2024).

Green innovation enhances corporate environmental awareness and social responsibility, producing significant economic and social value. Organizations can address emerging sustainability challenges by prioritizing green innovation while gaining a competitive edge over their peers (Albort-Morant et al., 2017). These findings support the development of the H2: Green innovation has a positive influence on sustainability performance.

**The Influence of Fintech Adaptation on Green Finance**

Fintech adaptation has revolutionized the integration of green finance into conventional financial services. Innovations such as green bonds, which cater to risk and return criteria for sustainability-minded investors, and using fintech to support green banking initiatives exemplify the transformative potential of financial technology (Guang-Wen & Siddik, 2023). Research shows that fintech enhances the effectiveness of green finance by improving financial structures, increasing efficiency, and fostering environmental protection (Nenavath & Mishra, 2023).

Through innovative platforms and solutions, fintech adaptation simplifies financial processes and expands access to sustainable investment opportunities. This enables companies and individuals to develop and implement eco-friendly financial products and services more easily (Alsadoun & Alrobai, 2024). In addition to driving investments in sustainable projects, fintech creates a more efficient and responsive financial ecosystem capable of addressing environmental challenges.

While fintech presents unique opportunities, challenges such as data privacy concerns, regulatory ambiguity, and the need for improved collaboration and standardization among stakeholders remain significant (Afua Addy et al., 2024). Nevertheless, fintech is essential in advancing environmental goals by increasing the availability of green finance, which supports ecological conservation and promotes sustainable economic recovery (Y. Q. Zhang, 2023). These insights lead to the formulation of the H3: Fintech adaptation has a positive influence on green finance.

**The Influence of Fintech Adaptation on Green Innovation**

Fintech, as a blend of financial services and advanced technology, provides practical solutions by reducing barriers and enhancing efficiency in service delivery (Nenavath & Mishra, 2023). The adaptation of fintech motivates organizations to adopt environmentally friendly technologies, fostering both financial and environmental sustainability. As a primary driver of economic development, inclusion, social stability, and integrity, FinTech builds innovative digital ecosystems that support sustainable development (Vergara & Agudo, 2021).

By facilitating efficient and sustainable access to financial services, fintech accelerates green innovation, encouraging investments in research and development (Al Doghan & Chong, 2023). This ease of financial access motivates organizations to invest in environmentally focused projects, expediting the adoption and development of green innovations. Technologies like blockchain, supported by fintech, enhance the quality and scope of green innovation by enabling recycling, reuse, and circular production systems (Alsadoun & Alrobai, 2024).

Empirical evidence underscores FinTech's positive influence on green innovation by efficiently allocating resources to eco-friendly initiatives, thereby improving environmental performance through innovative financial mechanisms (Tehseen et al., 2023). This dual role of fintech—as an enabler of financial inclusion and a driver of green innovation—creates ecosystems conducive to sustainable economic growth. Based on these insights, the H4: Fintech adaptation has a positive influence on green innovation.

**The Influence of Fintech Adaptation on Sustainability Performance**

Fintech offers unique advantages over traditional financial institutions, enabling companies to achieve competitive sustainability performance through enhanced accessibility and operational efficiency (Hommel & Bican, 2020). As a transformative element in financial services, fintech enhances businesses' competitive positioning by enabling faster, more efficient access to capital and resources. Recent years have seen fintech gain significant attention for its potential to accelerate sustainable economic growth (Pawłowska et al., 2022).

Empirical studies highlight fintech's critical role in promoting circular economic practices and improving organizational sustainability performance (Siddik et al., 2023). By integrating circular economy principles into business strategies, fintech serves as an enabler of sustainable growth. The industry's unique characteristics and rapid global investment growth have positioned fintech as a key player in advancing sustainability objectives (Vergara & Agudo, 2021).

Research further shows that fintech adoption positively impacts sustainability performance by improving environmental outcomes for businesses. Strong financial access is a moderating factor, ensuring that fintech's benefits are fully realized to support long-term business sustainability (Al Doghan & Chong, 2023). This leads to the H5: Fintech adaptation has a positive influence on sustainability performance.

**The Influence of Fintech Adaptation on Sustainability Performance through Green Finance**

The alignment between financial sustainability and fintech creates opportunities for businesses to adopt more sustainable practices by leveraging green finance (Vergara & Agudo, 2021). Fintech innovation addresses environmental issues and improves productivity in high-pollution industries by facilitating environmentally friendly loans and investments. These initiatives promote greener growth and ecological conservation (Siddik et al., 2023).

Fintech has been shown to significantly contribute to sustainability performance by providing innovative, eco-friendly financial solutions that support green finance (Moro-Visconti et al., 2020). Integrating advanced technologies, such as blockchain, IoT, and big data, further enhances the efficiency and transparency of green finance mechanisms. These technologies enable businesses to align with global sustainability goals, such as the Paris Agreement and SDGs (Zia et al., 2024).

Additionally, fintech expands the reach and depth of green finance, reducing capital costs and promoting sustainable business models, projects, and policies that positively impact the economy, environment, and society (Cen & He, 2018). Fintech's role in supporting environmental protection and climate change mitigation provides opportunities for industrialized nations to achieve sustainable growth (Pawłowska et al., 2022). Consequently, the H6: Fintech adaptation positively influences sustainability performance through green finance.

**The Influence of Fintech Adaptation on Sustainability Performance through Green Innovation**

Green innovation, emphasizing advanced technologies and sustainable practices, addresses the dual objectives of economic growth and environmental stewardship. By enabling sustainable practices, fintech fosters green innovation, directly enhancing organizational sustainability performance (Vergara & Agudo, 2021). Fintech facilitates green innovation by creating an environment conducive to technological advancements and eco-friendly practices, aligning corporate strategies with global sustainability goals.

Fintech has significantly reduced barriers to financing and expanded funding channels, promoting green innovation in organizations. This development supports sustainable growth by encouraging businesses to adopt environmentally friendly technologies and practices (Z. Chen, 2024). Studies reveal that fintech adoption positively influences green innovation, which, in turn, enhances environmental performance and long-term sustainability (Tian et al., 2023).

By catalyzing green innovation, fintech enables organizations to holistically address environmental and economic challenges, ensuring sustainable development. These findings lead to the formulation of the final H7: Fintech adaptation positively influences sustainability performance through green innovation.

## 3. Research Method

This study employs a quantitative approach to test hypotheses and analyze the relationships between fintech adaptation, green finance, green innovation, and sustainability performance. Quantitative methods allow for the measurement and statistical analysis of variables to understand and predict phenomena systematically. This research adopts a deductive approach, using existing theories to construct hypotheses. Secondary data gathered from annual reports, sustainability reports, and other official publications of Indonesian banking companies listed on the Indonesia Stock Exchange (IDX) from 2019 to 2023 form the basis of this analysis. The study

focuses on banks that have adopted fintech and integrated green finance and green innovation practices into their business strategies, with each bank serving as a unit of analysis.

This study utilizes secondary data obtained from the official websites of banking companies listed on the Indonesia Stock Exchange (IDX). The systematic sampling method was employed to ensure that the selected companies met the research objectives. The initial population consisted of 43 banking companies listed on the IDX during 2019–2023. From this population, 22 companies were excluded for not consistently publishing sustainability reports, and 15 were excluded for not providing relevant information on fintech adaptation. After applying these criteria, six companies were selected, resulting in 30 observations over five years. These companies fulfilled all the requirements for the study, including fintech adoption and the integration of green finance and green innovation in their operations.

Table 1 provides an overview of this study's key variables, operational definitions, indicators, and measurement scales. Each variable represents a specific aspect of the research focus, ensuring that the concepts under investigation are systematically and quantitatively captured. The variables include Fintech Adaptation, which measures the level of adoption and usage of financial technology services; Green Finance, which evaluates the proportion of investments allocated to environmentally sustainable projects; Green Innovation, which reflects a company's expenditure on eco-friendly innovation; and Sustainability Performance, which assesses a company's effectiveness in reducing environmental impacts. All variables are measured using a ratio scale to provide precise and standardized quantitative data for statistical analysis. This structured approach ensures the reliability and validity of the data collected, contributing to the robustness of the research findings.

Table 1. Variables, Operational Definitions, Indicators, and Measurement Scales

| Variable | Operational Definition | Indicator | Scale |
|---|---|---|---|
| Fintech Adaptation | The level of adoption and usage of fintech services by customers in the financial sector. | $\frac{\text{Number of Fintech Service Users}}{\text{Total Number of Customers}} \times 100$ | Ratio |
| Green Finance | The proportion of investment allocated to projects that support environmental sustainability. | $\frac{Total\ Investment\ in\ Green\ Projects}{Total\ Investment} \times 100$ | Ratio |
| Green Innovation | The level of company expenditure on the development and application of environmentally beneficial innovations. | $\frac{Total\ Expenditure\ on\ Green\ In}{Total\ Revenue} \times 100$ | Ratio |
| Sustainability Performance | The company's effectiveness in minimizing negative environmental impacts. | $\frac{Total\ Carbon\ Emissions}{Total\ Revenue}$ | Ratio |

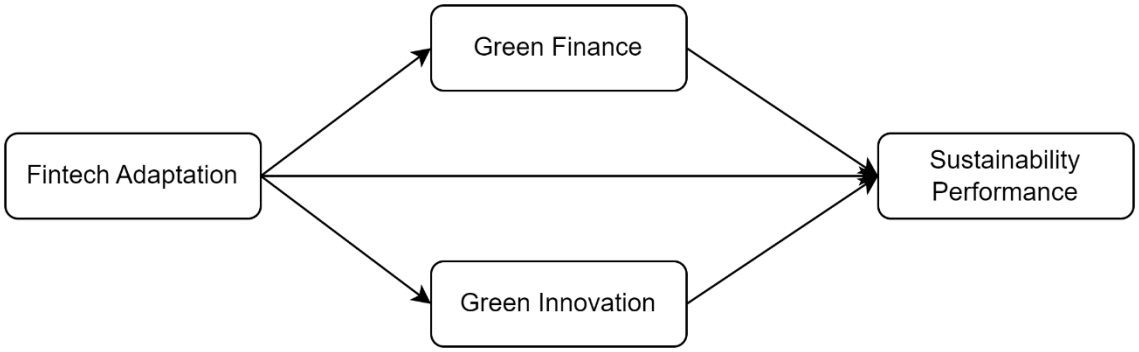


Figure 1. Path Analsysis Model

Data analysis is conducted using path analysis, which is supported by SPSS software to process large datasets efficiently and accurately. Hypotheses are tested by analyzing the relationships among the study variables, using p-values to determine the statistical significance of the results. This methodology provides a structured framework to assess the impact of fintech adaptation on sustainability performance, mediated by green finance and green innovation, in the Indonesian banking industry.

## 4. Results and Discussion

### *4.1. Results*

The hypothesis testing evaluated the direct effects of fintech adaptation on sustainability performance and the indirect effects of green finance and green innovation. The results showed varying levels of explanatory power for each variable within the model. The coefficient of determination ($R^2$) revealed that green finance explained only 0.1% of the variance in sustainability performance, while green innovation accounted for 4.8%. Fintech adaptation moderately influenced green finance (21.2% of variance explained) but had a weaker impact on green innovation (2.2%). These findings indicate that additional variables outside the model significantly contribute to sustainability performance.

Table 2. T-test Result

| | Hypotheses | t-value | p-value |
|---|---|---|---|
| H1 | Green finance -> Sustainability Performance | -0.168 | 0.868 |
| H2 | Green Innovation -> Sustainability Performance | -1.188 | 0.245 |
| H3 | Fintech Adaptation -> Green Finance | 2.746 | 0.010 |
| H4 | Fintech Adaptation -> Green Innovation | 0.430 | 0.430 |
| H5 | Fintech Adaptation -> Sustainability Performance | -0.937 | 0.357 |

Table 2 shows the results of T-tests for individual paths indicated that green finance and green innovation did not significantly affect sustainability performance, with p-values exceeding the 0.05 threshold. However, FinTech adaptation positively affected green finance ($t = 2.746$, $p = 0.010$), suggesting that FinTech is crucial in enhancing green financial practices. Conversely, the effect of fintech adaptation on green innovation and direct sustainability performance could have been more significant, highlighting limitations in its influence on these aspects.

Table 3. Sobel Test Result

| | Hypotheses | z-value |
|---|---|---|
| H6 | Fintech Adaptation -> Green Finance -> Sustainability Performance | -0.168 |
| H7 | Fintech Adaptation -> Green Innovation -> Sustainability Performance | -0.657 |

Table 3 shows the Sobel test assessed the mediating effects of green finance and innovation in the relationship between fintech adaptation and sustainability performance. The Sobel test yielded a Z-value of -0.168 for green finance, below the critical value of ±1.96, indicating an insignificant mediating effect. Similarly, green innovation showed a Z-value of -0.657, also below the necessary threshold, suggesting that it does not significantly mediate the relationship. These findings imply that neither green finance nor green innovation significantly bridges the influence of fintech adaptation on sustainability performance.

The study demonstrates that while FinTech adaptation positively influences green finance, its impact on green innovation and direct sustainability performance is limited. Furthermore, the mediating roles of green finance and innovation in this relationship are statistically insignificant. These results highlight the need to explore additional factors and variables that may better explain the dynamics of sustainability performance in the banking sector. The findings underscore the complexity of achieving sustainability goals and the necessity of a multifaceted approach that integrates other critical elements alongside fintech adaptation.

### *4.2. Discussion*

**Green Finance and Sustainability Performance**

This study found no significant impact of green finance on sustainability performance, challenging prior research findings, such as Mandagie et al. (2024), which emphasized green finance as a critical factor in enhancing corporate sustainability. The divergence in results may stem from unmeasured variables, such as the level of regulatory support, the scope of green finance initiatives, and organizational understanding of sustainable finance. Theoretically, green finance is positioned as a promising strategy for addressing environmental degradation while supporting sustainable development. However, its effectiveness relies heavily on proper implementation and strong regulatory backing, as highlighted by Indonesia's OJK Regulation No. 51 of 2017, underscoring sustainable financial policies' role (Hasanah & Hariyono, 2022).

The mixed outcomes in green finance's effectiveness across sectors further underline this finding. While the energy sector has effectively leveraged green finance to overcome funding barriers and enhance productivity (GUO), the banking sector's green finance activities, such as *Green Daily Operations*, show relatively minor contributions to sustainability performance (Yafie et al., 2024). These observations indicate that, despite its potential, green finance alone may not substantially improve corporate sustainability performance. Instead, its impact must be amplified through a holistic approach combining supportive policies, stakeholder engagement, and

collaborative initiatives. Effective long-term implementation, coupled with adequate policy frameworks and organizational commitment, is crucial to maximizing green finance's potential as a sustainable transformation tool.

**Green Innovation and Sustainability Performance**

Similarly, this study found that green innovation does not significantly influence sustainability performance in the banking sector. Despite efforts to implement eco-friendly financial products, energy-efficient digital services, and operational sustainability adjustments, these initiatives have yet to yield substantial impacts on banks' overall sustainability performance. This result suggests that green innovation in the banking sector requires strategic support, regulatory incentives, and executive-level commitment to achieve more meaningful contributions to sustainability outcomes.

Contrary to these findings, previous studies, such as M. Liu et al. (2024), indicated that green innovation could improve financial performance and operational efficiency while reducing environmental impacts. These discrepancies may reflect the unique complexities of the banking sector, including stringent regulations, high competition, and a general reluctance to adopt green innovation without guaranteed returns (H. Li et al., 2023). External factors such as regulatory pressures and market incentives also significantly shape the effectiveness of green innovation. For instance, X. Chen et al. (2024) observed that ESG-focused green innovations can enhance corporate performance. However, their impact diminishes for companies with strong reputations, where the urgency for adopting innovations may be lower.

The challenges of green innovation implementation, including internal resistance and resource limitations, further complicate its effectiveness (Puschmann et al., 2020). Saudi et al. (2019) emphasized the importance of managerial leadership and organizational culture in fostering successful green innovation initiatives. While this study did not find a direct impact of green innovation on sustainability performance, the findings highlight the necessity of integrating green innovation within a broader sustainability framework. This integration should include enhanced regulatory support, economic incentives, and cross-sector collaboration to create an ecosystem conducive to green innovation. By addressing these factors, green innovation retains the potential to serve as a critical catalyst for driving more resilient and impactful sustainability outcomes in the banking sector.

**Fintech Adaptation and Green Finance**

This study demonstrates a significant relationship between fintech adaptation and green finance, highlighting fintech’s critical role in promoting sustainable financial practices. Digital financial technologies, including electronic payments and green financing, have effectively driven resource allocation toward sustainable projects. By accelerating the transition to a greener and more inclusive economy, fintech supports both market needs and long-term environmental and social sustainability objectives.

Specifically, fintech enhances green finance by improving transparency and efficiency in sustainable investments. Technologies such as blockchain and crowdfunding play a pivotal role in mitigating greenwashing, tracking green

investments, and enabling inclusive financing for environmentally friendly projects (Guang-Wen & Siddik, 2023; Vergara & Agudo, 2021). These innovations facilitate global community involvement in green projects, breaking down geographic and financial barriers to create broader access to sustainable funding. Moreover, fintech empowers startups and traditional financial institutions to expedite green project financing and improve operational efficiency (Puschmann et al., 2020).

Advanced analytics, such as big data and artificial intelligence (AI), allow fintech to measure sustainability risks, refine investment strategies, and monitor environmental impacts in real time (H. Liu et al., 2022). These capabilities enhance accountability among financial institutions and bolster their credibility with investors and stakeholders. Furthermore, AI and machine learning enable data-driven approaches to evaluate sustainability risks and ensure funding aligns with sustainability goals (Tian et al., 2023). Fintech also bridges funding gaps for smaller green projects, such as renewable energy and sustainable agriculture initiatives, cementing its role as a key catalyst in achieving global sustainability targets and fostering resilient, inclusive business models in the green economy.

**Fintech Adaptation and Green Innovation**

Contrary to expectations, this study found that fintech adaptation does not significantly influence green innovation. This finding suggests that while fintech remains a prominent trend across various sectors, its impact on sustainable innovation has yet to materialize in measurable outcomes. This result contrasts with prior studies, such as (Alsadoun & Alrobai, 2024), which found a positive correlation between fintech and environmentally friendly initiatives, underscoring its potential to support sustainability efforts in the financial sector.

Theoretically, fintech can drive green innovation through technologies like blockchain, the Internet of Things (IoT), and AI, which enhance transparency, efficiency, and sustainability analytics. These tools could significantly streamline green financing processes and improve environmental impact reporting (Kwong et al., 2023). However, their effectiveness depends on supportive regulatory frameworks, technology adoption rates, and market readiness. Despite fintech's ability to reduce greenwashing risks and improve transparency, challenges such as low adoption rates and inadequate regulatory support hinder its broader integration into sustainability strategies (Guang-Wen & Siddik, 2023).

To amplify fintech's impact on green innovation, comprehensive policies must facilitate the integration of financial technologies with sustainability initiatives. Cross-sector collaborations, more significant investments in green technology research and development, and financial education to develop innovative green financial products are crucial. For instance, Ni et al. (2023) highlighted the importance of fintech in supporting regional green transformation through advanced information technology. Enhanced integration of fintech within sustainability strategies will likely yield more substantial contributions toward long-term sustainability objectives at both organizational and industry-wide levels.

**Fintech Adaptation and Sustainability Performance**

This study found no significant relationship between fintech adaptation and sustainability performance, indicating that fintech's potential to enhance sustainability in the banking sector still needs to be utilized. This contradicts earlier findings that highlight fintech's positive influence on environmental and social initiatives, where it is recognized as a key enabler for sustainable practices in the financial sector (Alsadoun & Alrobai, 2024). The lack of significance in this study suggests that factors beyond fintech adaptation, such as financial literacy, organizational culture, and regulatory support, influence the variability in sustainability performance.

Theoretically, fintech is well-positioned to support sustainability performance through inclusive and efficient financial services, such as green crowdfunding and blockchain-enabled carbon credit trading. These technologies promote transparency, equity, and responsible investment aligned with Environmental, Social, and Governance (ESG) criteria (Vergara & Agudo, 2021). However, the insignificant results may be attributed to the nascent adoption of fintech, short-term profit focus, or inadequate integration of fintech with corporate sustainability strategies (Joshi & Karmacharya, 2024). A more strategic implementation of fintech, aligned with practice-based frameworks like the Practice-Based View (PBV), could yield more substantial contributions to sustainability by integrating fintech into green supply chains and enhancing access to sustainable financing for small and medium enterprises (Siddik et al., 2023). Collaborative efforts between public and private sectors and targeted regulatory incentives are critical for maximizing fintech's potential in fostering long-term sustainability.

**Role of Green Finance in the Fintech-Sustainability Link**

The mediation analysis revealed that green finance does not significantly mediate the relationship between fintech adaptation and sustainability performance. While fintech adaptation positively influences green finance, green finance itself exhibited a negative coefficient in its relationship with sustainability performance. This counterintuitive finding suggests inefficiencies in allocating green finance or misalignment with sustainable innovation principles, as previously noted by similar studies (Naz et al., 2023).

The lack of significant mediation aligns with prior research that questions the sufficiency of green finance alone in driving sustainability outcomes (Joshi & Karmacharya, 2024). Factors such as internal inefficiencies, inadequate alignment of green finance policies with sustainability goals, and underutilized funds in environmentally impactful projects might explain this discrepancy. While green finance is theoretically positioned to support sustainability by fostering green investments and mitigating environmental risks, practical challenges such as inefficient policy execution and insufficient innovation support still need to be improved in the Indonesian banking sector.

This study's findings emphasize the need to explore alternative mechanisms through which fintech adaptation influences sustainability performance. Variables such

as green innovation, operational efficiency, and regulatory compliance may significantly mediate this relationship. Additionally, the high variability in the data, as indicated by the significant standard error (SE_b = 6.172), suggests that broader sample sizes and refined methodologies are essential for a more accurate assessment of green finance's role in sustainability. The banking industry's reliance on technology-driven efficiency, operational dynamics, and management policies appears to influence sustainability performance more than green finance alone.

To address the complexities of achieving sustainability goals, sustainability strategies in the banking sector should integrate green finance with other transformative initiatives, such as technological innovations, regulatory reforms, and cross-sector collaborations. These integrated approaches could ensure that green finance effectively complements fintech adaptation in fostering meaningful sustainability outcomes.

**Role of Green Innovation in the Fintech-Sustainability Link**

The findings of this study indicate that green innovation does not serve as a significant mediator in the relationship between fintech adaptation and sustainability performance. This suggests that green innovation needs to effectively bridge the link between fintech adaptation and improved sustainability outcomes in its current implementation. These results align with prior research, such as those of Joshi & Karmacharya (2024), who found that green innovation had minimal impact on the relationship. However, they contradict studies like those of Maldonado-Guzmán (2024) and Alsadoun & Alrobai (2024), highlighting the potential of green innovation as a significant mediating factor. The disparity in findings may be attributed to unmeasured contextual factors such as the adoption rate of environmentally friendly technologies or regulatory support for sustainability initiatives.

Although fintech adaptation positively influences green innovation (with a coefficient of 0.056), the effect is minimal. This limited impact could be due to challenges in integrating fintech with green innovation in the Indonesian banking sector. Technologies like blockchain and the Internet of Things (IoT), known to enhance transparency and sustainability data management (Kwong et al., 2023), still need to be utilized. Rather than sustainability integration, the sector's primary focus on operational efficiency and financial inclusion further limits fintech's role in driving green innovation. Additionally, green innovation's negative coefficient in its relationship with sustainability performance suggests significant barriers such as risk aversion, regulatory hurdles, and high implementation costs (Idrus et al., 2024).

These barriers often shift the focus of green innovation to compliance and corporate image enhancement, rather than directly improving profitability or energy efficiency. Similar findings from Anggraini & Arieftiara (2023) emphasize that structural and operational challenges hinder the broader adoption of green innovation within the Indonesian context.

## 5. Conclusion

This study explored the influence of fintech adaptation on sustainability performance in the Indonesian banking sector, with green finance and green innovation as mediating variables. The findings reveal that while fintech adaptation positively influences green finance, its impact on green innovation and direct sustainability performance is limited. Additionally, the mediating effects of green finance and green innovation in the relationship between fintech adaptation and sustainability performance are statistically insignificant. These results underscore the complexities and challenges in aligning financial technology with sustainability goals, particularly in emerging markets like Indonesia.

The findings have several practical implications for stakeholders in the banking industry and policymakers. First, financial institutions should enhance their adoption of advanced financial technologies to improve the effectiveness of green finance initiatives. Second, regulators should establish robust frameworks and incentives to support green innovation and integrate fintech into broader sustainability strategies. Lastly, banking institutions should foster collaborations between technology providers, regulators, and sustainability experts to ensure that fintech investments translate into measurable sustainability outcomes.

This study has several limitations. The small sample size, limited to six banking institutions, may need to be more robust to the generalizability of the findings to the broader banking sector in Indonesia or other emerging markets. Additionally, the study relies on secondary data, which might need to fully capture nuanced factors influencing sustainability performance, such as organizational culture and leadership dynamics. Lastly, the cross-sectional nature of the data limits the ability to analyze long-term trends and impacts.

Future research should consider expanding the sample size and including a diverse range of financial institutions to improve generalizability. Longitudinal studies could provide deeper insights into the long-term impacts of fintech adaptation on sustainability performance. Moreover, exploring additional mediating variables, such as regulatory frameworks, market incentives, and stakeholder engagement, could offer a more comprehensive understanding of the interplay between fintech, green finance, green innovation, and sustainability outcomes. Finally, future studies should examine sector-specific dynamics to effectively identify tailored strategies for integrating fintech with sustainability initiatives.

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